

Disease Interactions and Pathogen exchange between farmed and wild aquatic animal populations - a European network

# Risk analysis and disease modelling -

## What can they contribute?



Ed Peeler

Centre for Environment, Fisheries and Aquaculture  
Science

- 
- 
- 

## Outline

- Definitions
- Approaches and methods
- Examples
- Advantages
- Conclusions

- 
- 
- 

Risk analysis is ...

*the scientific evaluation of biological risks and their potential consequences*

- 
- 
- 

“Mathematical models are..

*...no more and no less than tools for  
thinking about things in a precise way “*

Anderson and Nokes (1997) Mathematical models of transmission and control; chapter  
18 of the Oxford Textbook of Public Health, third edition, vol. 2

- 
- 
- 

Mathematical models can..

...provide insights into factors that control the transmission dynamics of infectious agents

- 
- 
- 

## Model construction...

.. conceptual reduction of complex biological or population based process into a simple idealised sequence of events

# SIR and RA model

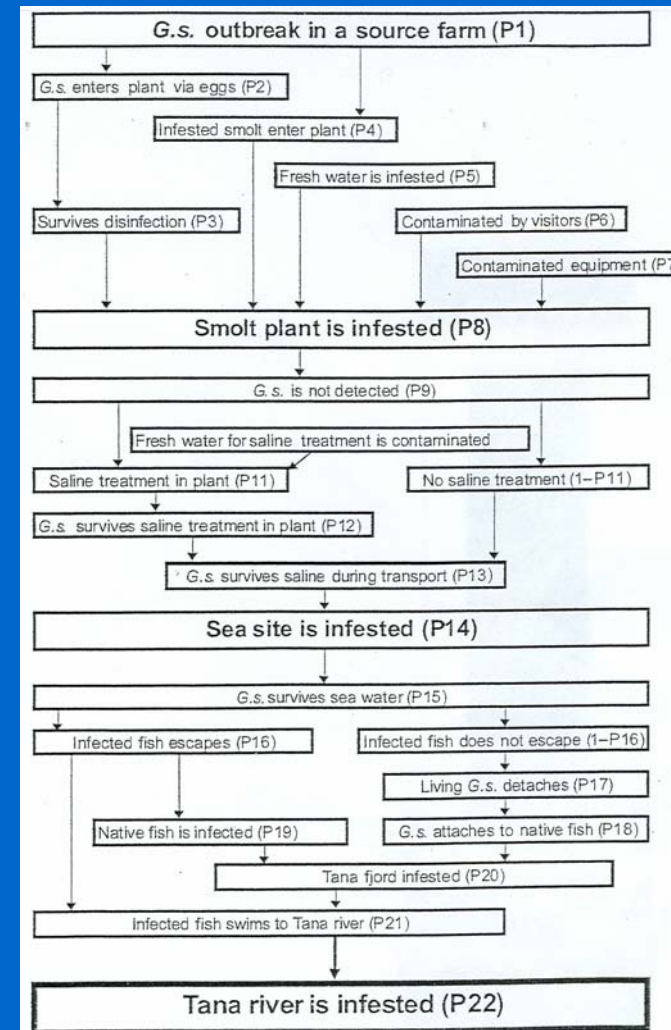
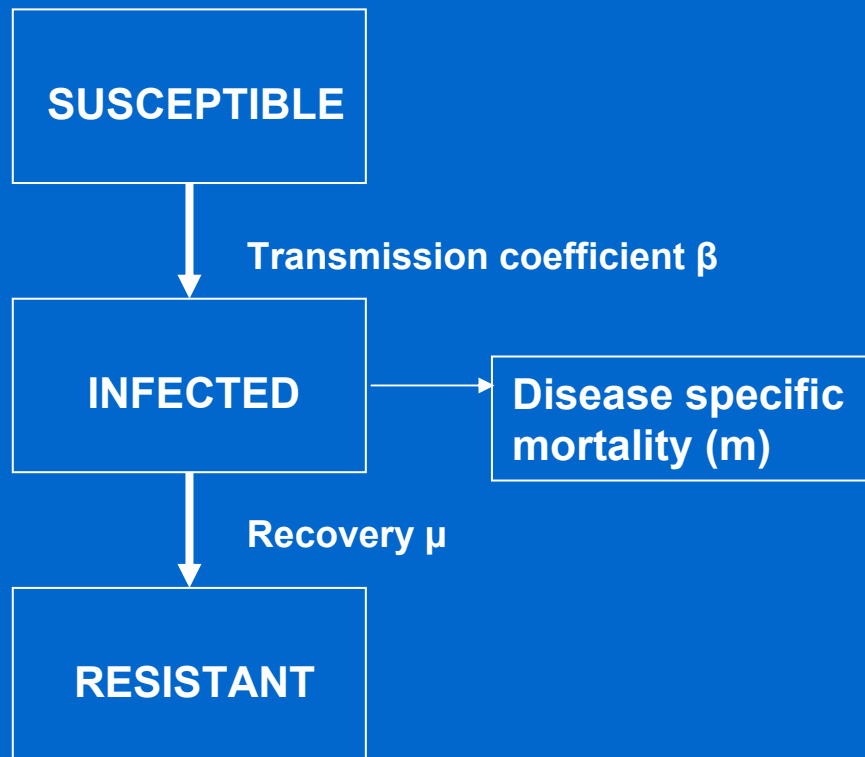


Fig. 1. Scenario tree for the introduction of *Gyrodactylus salaris* (G. s.) to the Tana river.

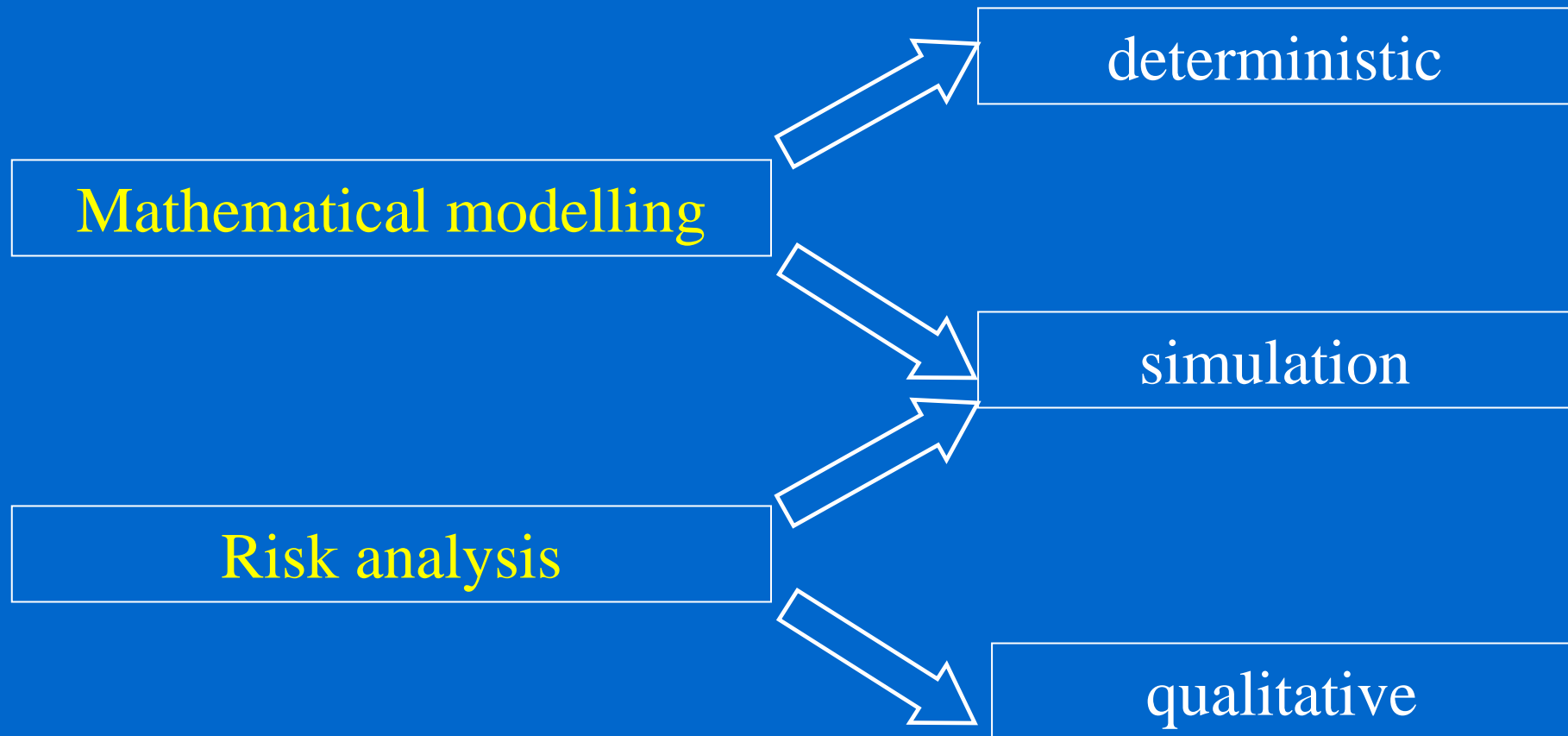
- 
- 
- 

## Pathway analysis

“By breaking down the overall risk into its various components ..... a risk assessment is designed to focus debate on the specific risk steps which must be met before a disease introduction occurs”

Stuart MacDiarmid

# Approaches



- 
- 
- 

## Mathematical modelling

- Mathematics is the most precise language available
- Once a problem is formulated in mathematical language, the logical consequences of assumptions can be followed

•  
•  
•

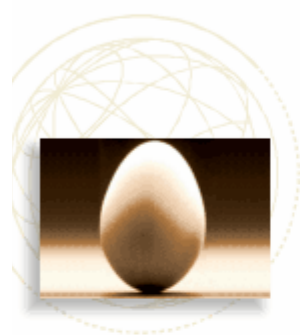
## Quantitative simulation modelling

- Probabilities are used for each step
- Ranges of probabilities can be used to reflect uncertainty and true variability
- Simulation randomly samples from the distributions of all the inputs

•  
•  
•

## Applications of risk analysis

- Import risk analysis
- Disease spread and biosecurity
- Risk based surveillance



SANITARY AND PHYTOSANITARY MEASURES: INTRODUCTION

# Understanding the WTO Agreement on Sanitary and Phytosanitary Measures

May 1998

### Contents

- [Abbreviations](#)
- [Introduction](#)
- [Questions and answers](#)

The **Agreement on the Application of Sanitary and Phytosanitary Measures** (the "SPS Agreement") entered into force with the establishment of the World Trade Organization on 1 January 1995. It concerns the application of food safety and animal and plant health regulations.

This introduction discusses the [text of the SPS Agreement](#) as it appears in the [Final Act of the Uruguay Round of Multilateral Trade Negotiations](#), signed in Marrakesh on 15 April 1994. This agreement and others contained in the Final Act, along with the General Agreement on Tariffs and Trade as amended (GATT 1994), are part of the treaty which established the World Trade Organization (WTO). The WTO superseded the GATT as the umbrella organization for international trade.

### Abbreviations

- Codex** The [FAO/WHO Joint Codex Alimentarius Commission](#)
- FAO** The [Food and Agriculture Organization](#) of the United Nations
- GATT** The General Agreement on Tariffs and Trade, established in 1947. The abbreviation is used both with reference to the legal text and to the institution
- GATT 1994** The General Agreement on Tariffs and Trade, as

- 
- 
- 

Risk analysis can be used to..

"...ensure that sanitary and phytosanitary measures are based on an assessment,..., of risks to human, animals or plant life and health..."<sup>1</sup>

<sup>1</sup> Sanitary and Phytosanitary Agreement (World Trade Organisation)

- 
- 
- 

## Import risk analyses are..

- Required by SPS for measures more stringent than agreed under international guidelines
- Undertaken for trade or legal reasons
- SPS recognises OIE as international body responsible for setting animal health standards

- 
- 
- 

## OIE approach

- **hazard identification**
  - pathogens
- **release assessment**
  - the pathways of introduction
- **exposure assessment**
  - pathways for exposure
- **consequence assessment**
  - potential biological, environmental and economic consequences

- 
- 
- 

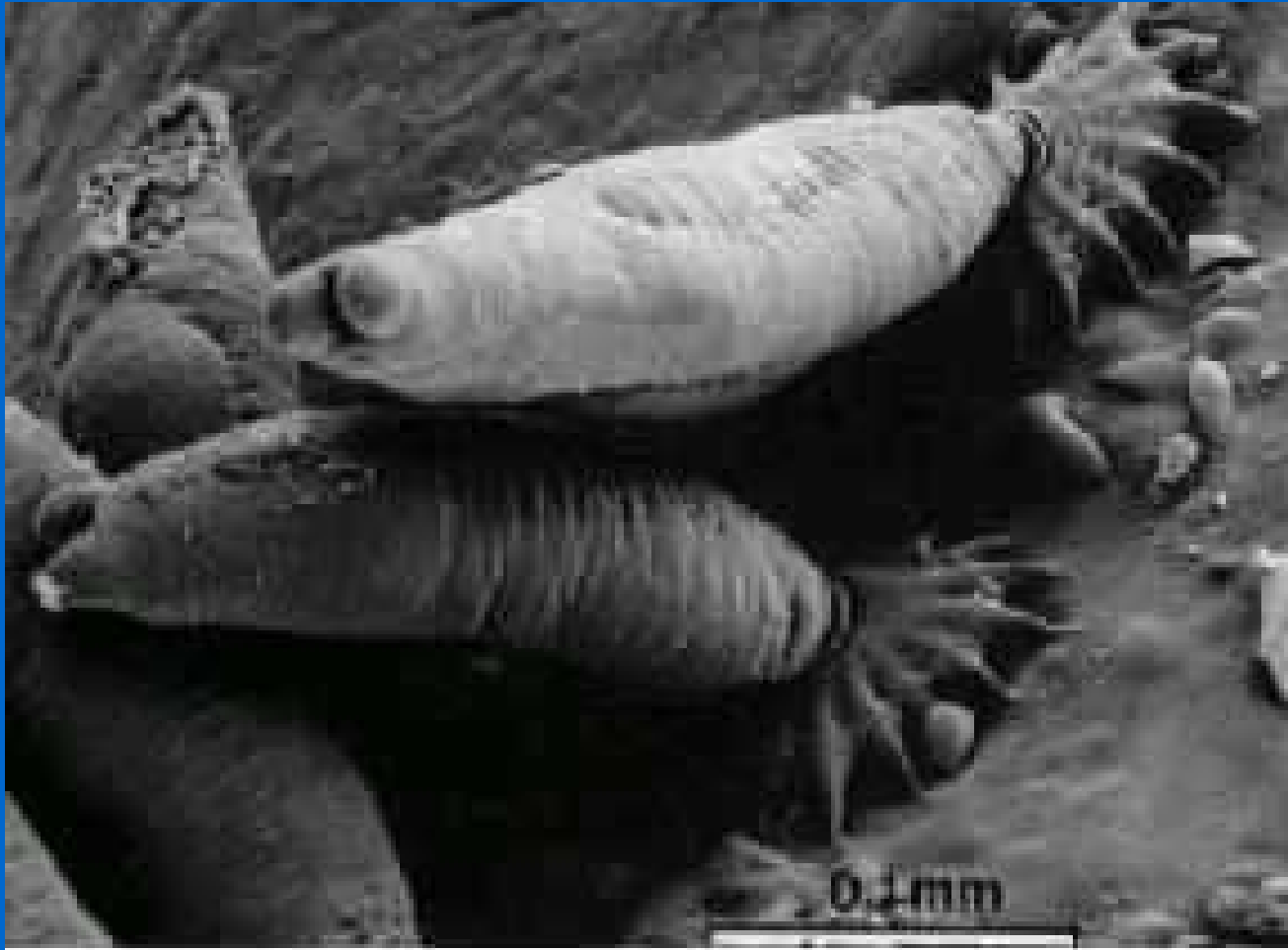
## Other applications of risk analysis?

Can the OIE import risk analysis methodology be applied in other areas of fish health management?

Is it suitable for the study of disease interaction & pathogen exchange?

- 
- 
- 

# *Gyrodactylus salaris*



courtesy of Dr Tor Atle Mo

- 
- 
- 
- 
- 
- 
- 
-

•  
•  
•

## *Gyrodactylus salaris*

- Spread from a farm to a wild population in the Tana river - Paisley et al 1999
- Spread from salmon stocked into the Drammen river to wild salmon populations in neighbouring rivers - Hogasen & Brun 03

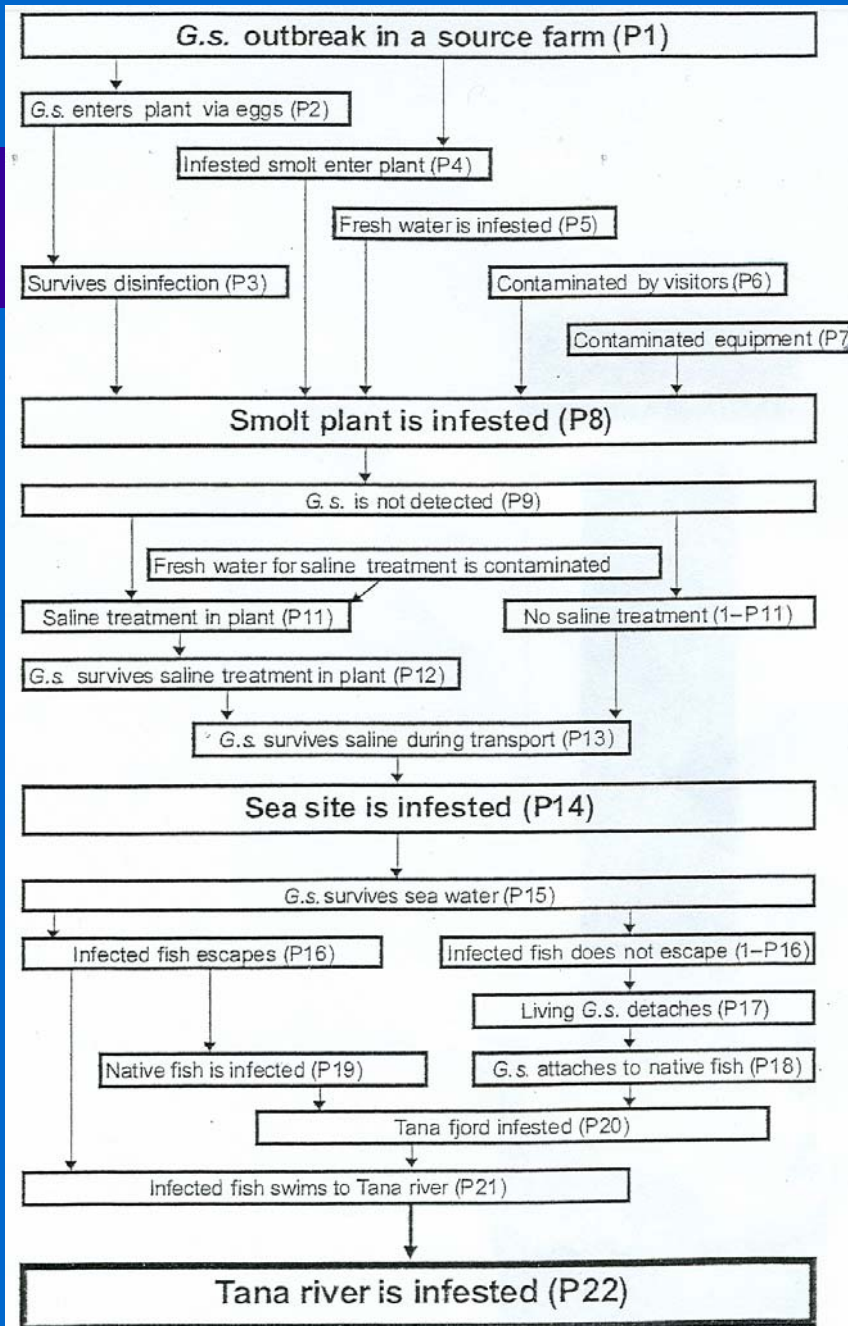


Fig. 1. Scenario tree for the introduction of *Gyrodactylus salaris* (G. s.) to the Tana river

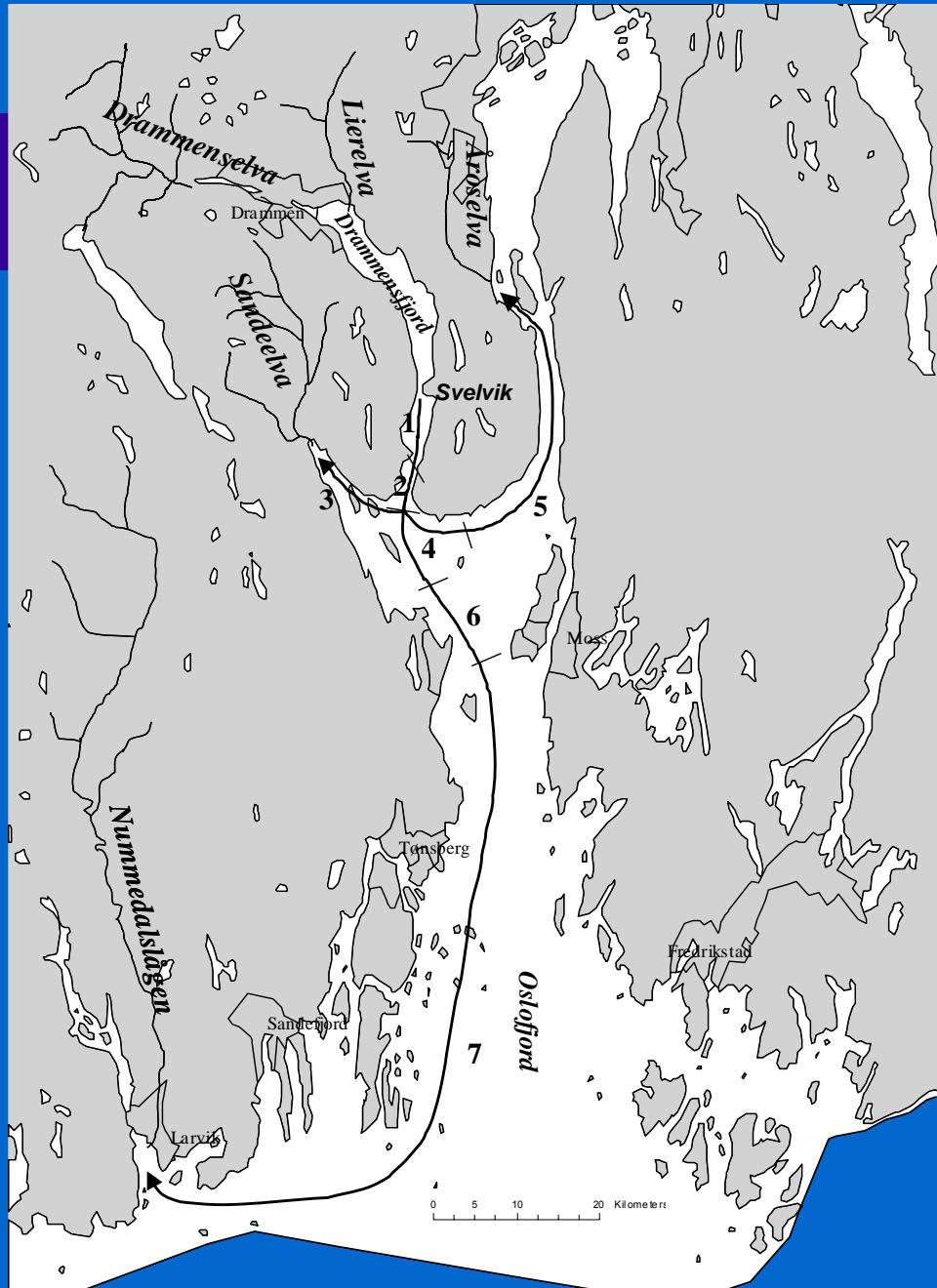
Vol. 57: 247–254, 2003	DISEASES OF AQUATIC ORGANISMS Dis Aquat Org	Published December 29
------------------------	--	-----------------------

# Risk of inter-river transmission of *Gyrodactylus salaris* by migrating Atlantic salmon smolts, estimated by Monte Carlo simulation

H. R. Høgåsen, E. Brun\*

Section of Epidemiology, National Veterinary Institute, PO Box 8156, Dep, 0033 Oslo, Norway

**ABSTRACT:** The possibility of *Gyrodactylus salaris* infection of wild North Atlantic salmon *Salmo salar* spreading to new rivers poses a major threat in Norway. This freshwater parasite can survive for some time in brackish water, and it has been suggested that smolts leaving infected rivers could transport vital parasites to new rivers. A Monte Carlo simulation model was used to estimate the risk that infected smolts would ascend a new river. Data from an infected watercourse in Norway, where the salmon population is maintained constant by cultivation, were used. The model included information on prevalence of infection, hydrographical conditions, survival of *G. salaris* in brackish water,



- Swimming speed & depth
- Salinity
- Distance
- Number of fish stocked
- Probability of entering neighbouring river
- etc.

•  
•  
•

## Applications of mathematical models

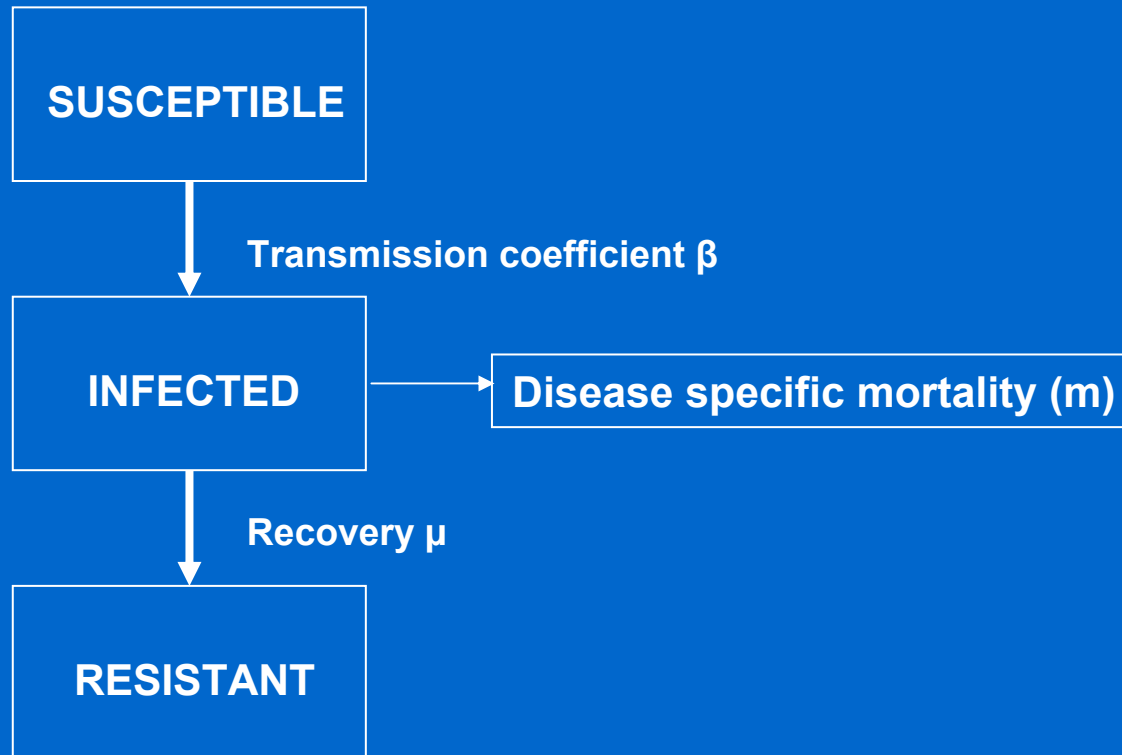
- HIV / AIDS
- Childhood immunisation programmes
- BSE / NvCJD
- Control strategies for FMD (UK 2001)

- 
- 
- 

## Aquatic animal examples

- Spread of pilchard herpes virus
- Epidemiology of bacterial kidney disease
- Spread of notifiable diseases in the UK
- Movement of live fish as a vector for disease spread

# SIR transmission model



## Equations

1.  $dS/dt = -\beta SI$

2.  $dI/dt = \beta SI - (m+\mu)I$

3.  $dR/dt = \mu I$

- 
- 
- 

## Key epidemiological parameters

### Transmission coefficient ( $\beta$ )

- Rate of contact between susceptible and infectious individuals and likelihood that transmission will result from contact
- Reflects host, environment and pathogen factors

### The basic reproductive number ( $R_0$ )

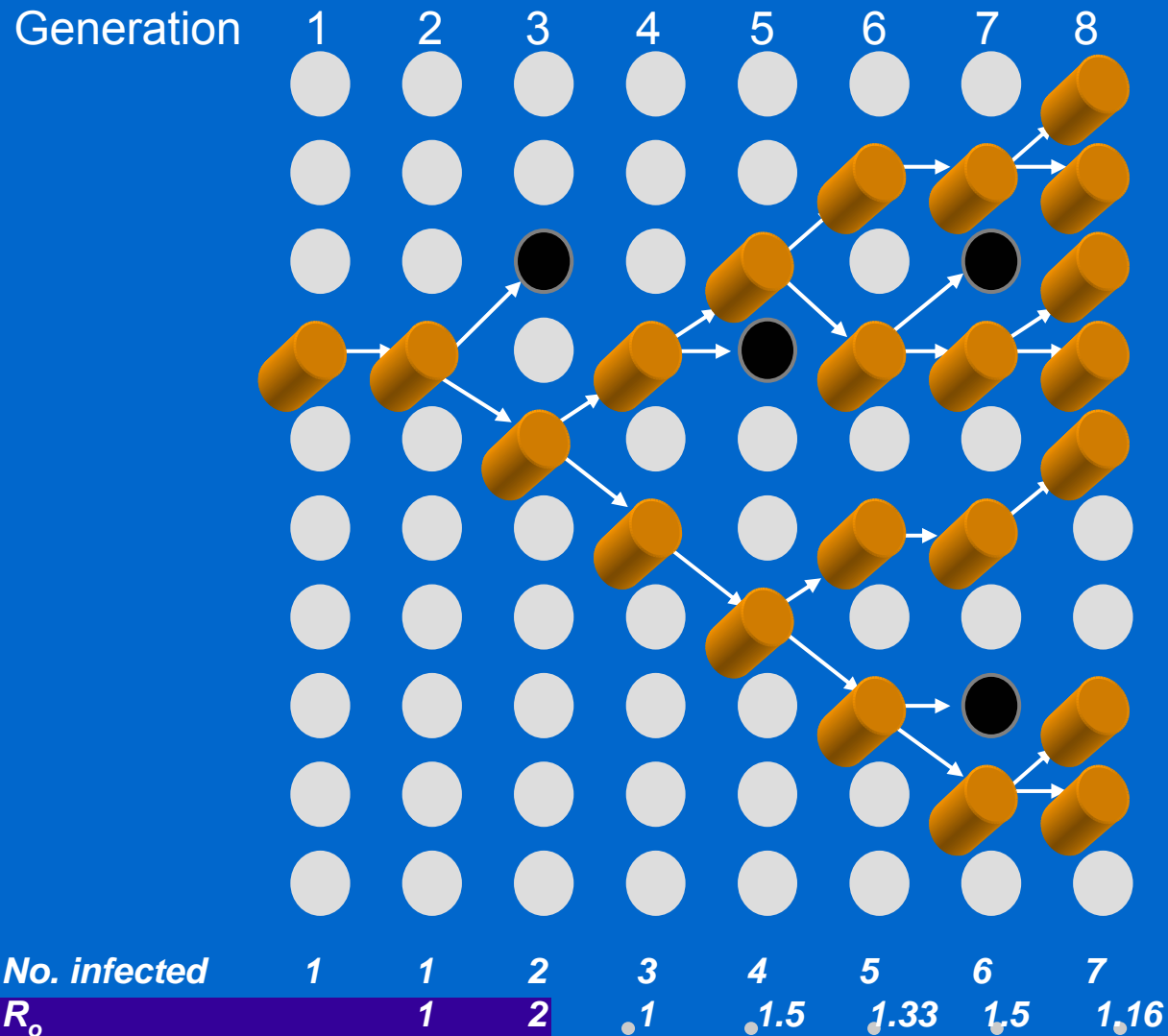
- number of secondary infections per infected
- $R_0 > 1$  Pathogen will spread
- Function of  $\beta \cdot [S] / \text{Duration of infectiousness}$

### • Force of infection ( $\lambda$ )

- Risk of a susceptible becoming infected per unit time

- 
- 
- 

# Basic reproductive number ( $R_0$ )



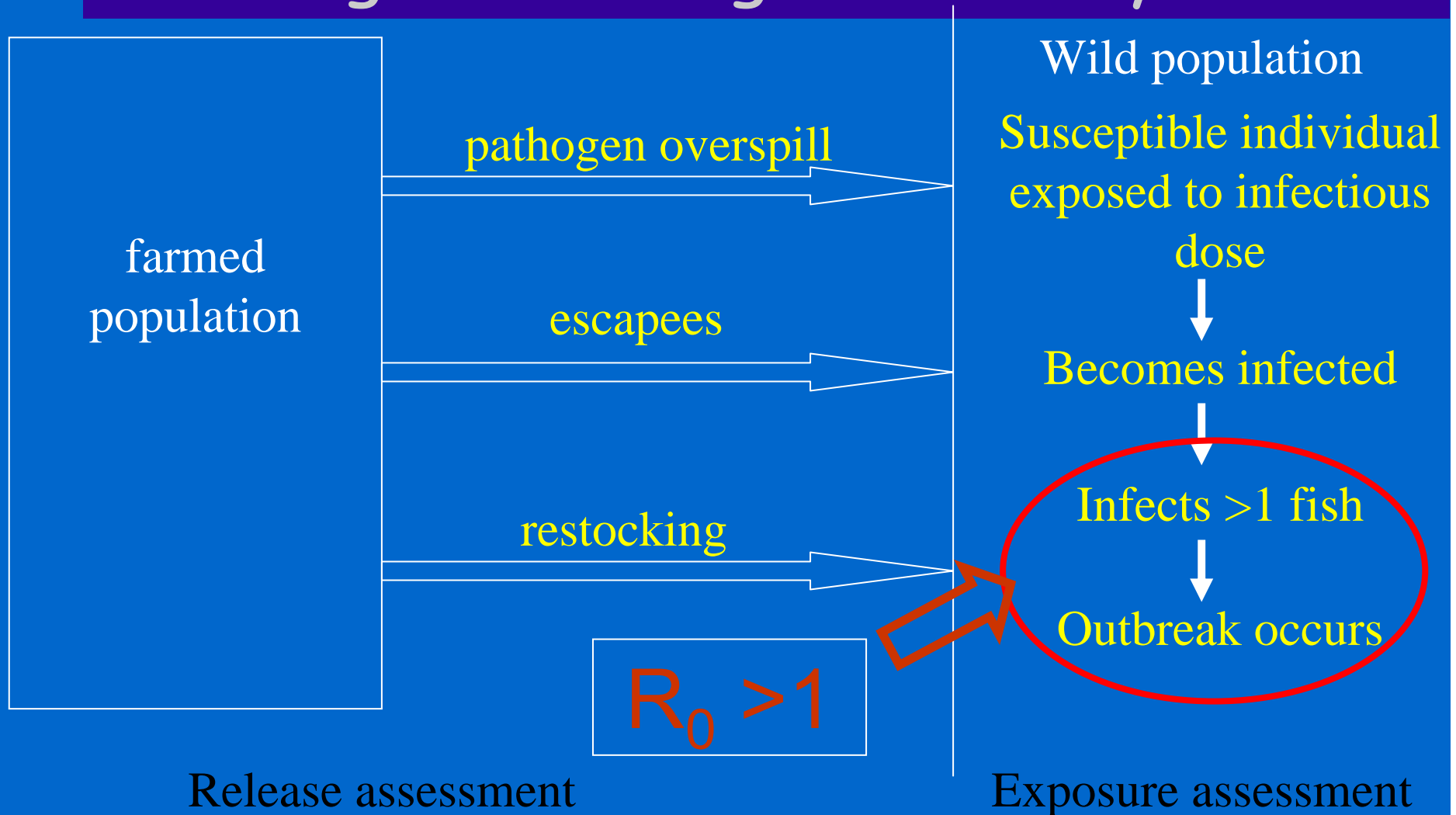
•  
•  
•

$R_0$

$R_0$  a function of

- Population of susceptibles
  - $\beta$  - transmission coefficient
  - Duration of infectiousness
- •  
•  
•  
•  
•  
•  
•

# Pathogen exchange risk analysis



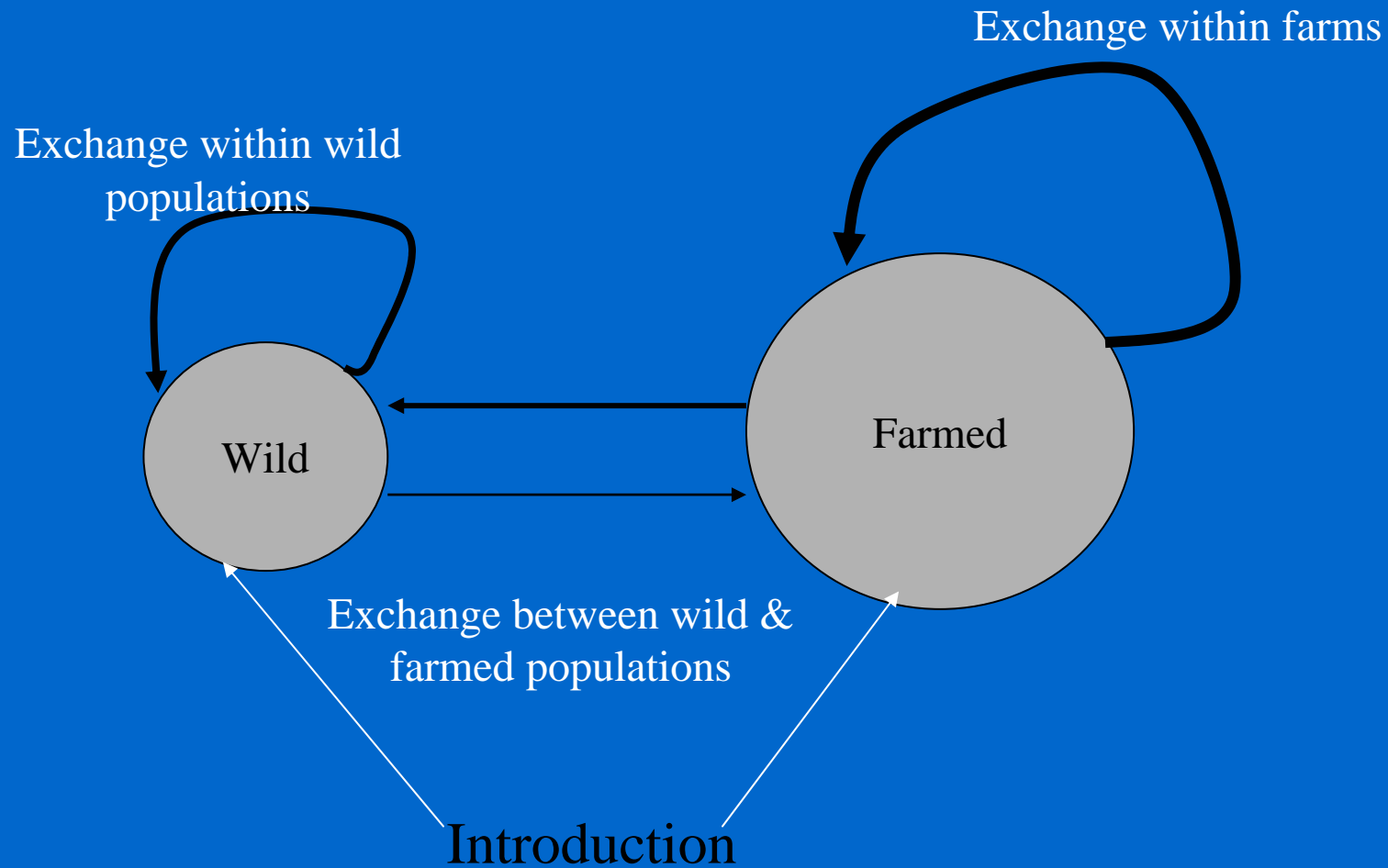
- 
- 
- 

## Exposure and $R_0$

Following introduction (release),  
exposure will only result in a disease  
outbreak will only occur if  $R_0$  is  
greater than 1.

- 
- 
- 

# Model of pathogen exchange



- 
- 
- 

## Advantages of models

Objective  
Defensible  
Transparent  
Quantitative  
Predictive

•  
•  
•

## Contribution of modelling

### Identification of dominant processes

- Interpretation of epidemiological findings
- Design of field studies
- Design of control programmes and biosecurity

- 
- 
- 

## Conclusions

### Risk analysis and mathematical modelling

- are complementary approaches
- are tools for decision making
- have considerable potential in both research into and control of pathogen exchange

- 
- 
- 

## Challenges for DipNet

Modelling approaches to studying disease interaction

- Demonstrate the potential
- Develop approaches
- Promote their use
- Identify future research

- 
- 
- 

## Acknowledgements

- Sandy Murray
- Edgar Brun
- Tor Atle Mo
- Larry Paisley

•  
•  
•

## Work Package 2

- Ed Peeler, Weymouth
- Sandy Murray, Aberdeen
- Ann Thebault, Paris
- Edgar Brun, Oslo
- Armando Giovaninni, Teramo
- Mark Thrush, Weymouth