Practical and theoretical research aspects around IPM approaches and decision support systems

Crawford Revie
Centre for Veterinary Epidemiology Research
AVC / UPEI / Canada
Overview

‡ “IPM Approaches”
+ would prefer simply refer to “sea lice control”

‡ “Practical and theoretical”
+ inspired by paper with Peter A. Heuch & George Gettinby
Overview

‡ Decision Support System (DSS)
† ‘we’ have to take decisions on a range of issues related to the management of sea lice
† for many of these ‘gut responses’ will no longer suffice – we need support
† the problems and data sets associated with them are complex and in reality require fully functional systems to be adequate
What types of things do we need decision support for?

‡ success of TX / development of tolerance
‡ advice on control/intervention strategies
  + timing / combinations / novel options
‡ predicting future lice trends/levels
  + what should you ‘expect’
‡ ‘early warning’ indicators
  + cage-level ‘hot-spots’
  + trigger conditions
‡ assist regulatory process
  + compliance in monitoring (NB provincial vets – weekly report)
  + submission of TX summaries (Dept. of Env. ‘automatically’)

Sea lice multi-nation meeting (Trondheim, 2013)
Functional DSS

‡ What is needed for a successful DSS

† address real questions that require support
† engage with end-users

† good quality data
† appropriate models
† intelligent approaches
Adding ‘intelligence’

‡ Historically: 2 major/differing approaches

† model-driven
† data-driven

† a little aside – Google (Translate)
Adding ‘intelligence’

† The need to understand language
  † effective query response
  † voice-based data entry
  † language/machine translation

- a non-trivial task!!
Language translation

[Image 1: Sign in Chinese and English:
小小烟蒂危害大
树木见了都害怕
A lighted dog-end may burn a wooded land.

Image 2: Can of bottled water with Chinese text.
It’s only a word

*Aeroflot advert:*
Introducing wide *boiled* aircraft for your comfort.

*Hotel elevator, Paris:*
Please leave your *values* at the front desk.

*Hotel lobby, Bucharest:*
The lift is being fixed for the next day.
During that time we regret that you will be *unbearable*.

*Detour sign in Kyushu, Japan:*
Stop: Drive *Sideways*. 
Dressing up the language

Outside of Hong Kong tailor:
Ladies may have a fit upstairs.

At a tailor shop in Rhodes:
Order your summers suit. Because when big rush we will execute customers in strict rotation.

At a Bangkok dry cleaner's:
Drop your trousers here for best results.
To your good health

On a South African building:
Mental health prevention centre.

Advert by a Hong Kong dentist:
Teeth extracted by the latest Methodists.

Outside Doctor's Office in Rome:
Specialists in women and other diseases.
Language is confusing

*Athens hotel:*
Visitors are expected to complain at the office between the hours of 9 and 11 A.M. daily.

*In Nairobi restaurant:*
Customers who find our waitresses rude ought to see the manager.

*In an East African newspaper:*
A new swimming pool is rapidly taking shape since the contractors have thrown in the bulk of their workers.

*In a Norwegian cocktail lounge:*
Ladies are requested not to have children in the bar.
Better (m/c) translation

‡ Logic / Rules / Grammar / etc.

‡ Probability (Searle’s *Chinese Room*)
Lost in translation
Adding ‘intelligence’

‡ For sea lice DSS
   ‡ model-driven? / data-driven?

‡ examples:
   ▪ temperature patterns on sites
Water temperature profiles

\[ T^\circ = 9.8 \times \sin\left(\left(64\pi t/365\right) - 0.4\right) + 7.1 \]
Water temperature profiles

\[ T^\circ = 9.8\times\sin(\frac{64x2\pi t}{365}) - 0.4) + 7.1\]

Temperature (°C)

-5 0 5 10 15 20 25
mai-08 jun-08 jul-08 aug-08 sep-08 okt-08 nov-08 des-08 jan-09 feb-09 mar-09 apr-09 mai-09

Modelled
Observed
Water temperature profiles

- % Fertilization & Hatchability
- % Settlement
- % Metamorphosis

Percentage of individual transferring to a new phase (%)

Temperature (°C)

Abundance (settlers·cm⁻²)

Modelled settler
Observed recruits

Sea lice multi-nation meeting (Trondheim, 2013)
Adding ‘intelligence’

‡ For sea lice DSS

‡ model-driven? / data-driven?

‡ examples:

- temperature patterns on sites
- connectedness to neighbouring sites

‡ often need **both** models and data
What are models for?

‡ clearer thinking
‡ understanding/using data
‡ designing novel experiments
‡ challenging accepted assumptions
‡ predicting likely results under a variety of different scenarios
‡ optimising outcomes
Use of models in disease control

Christley *et al* (2013) “Negotiating Uncertainty in Infectious Disease Modelling” (FMD)

“...models will never be able to *accurately* predict if, or when, a particular person, farm or community will become infected...”

“...it stresses is the importance of the scientific modelling that was done to project forward from any point during the outbreak as to what the outcome would be given various control scenarios.”
Use of models in disease control

Christley *et al* (2013)

“...can be used to *explore* the expected impact of alternative control strategies.”

“...modelling, in its broader sense, is becoming more capable of making a difference in what’s generally called data synthesis...”

“...model output at the farm-level has such high levels of uncertainty that the results at that scale are of limited utility...”
Individual-based model of evolution of pesticide resistance in sea lice


M L Groner¹, R Cox¹, G Gettinby² and C W Revie¹

¹ Department of Health Management, Centre for Veterinary and Epidemiological Research, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PE, Canada
² Department of Mathematics & Statistics, University of Strathclyde, Glasgow, UK
### Data in models (parameters)

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<thead>
<tr>
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<th>Treatments</th>
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<th>Population Dynamics</th>
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<tr>
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<td>nFemaleEggsHatching2 nMobile</td>
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</table>

- **Chalimus/ Salmon:** 123
- **Preadult/ Salmon:** 123
- **Adult Male/ Salmon:** 123
- **Gravid Female/ Salmon:** 123
Life history parameters

‡ Lice stage development speed/success
  + what lice stages?
  + how important is temperature?
  + what a ‘reasonable’ assumptions about attachment?

‡ Reproductive potential
  + sex ratios
  + levels of (co)aggregation

‡ ‘Tipping point’ versus continuous growth?
  + most models show a point of exponential ‘take off’
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**CVER**

Sea lice multi-nation meeting (Trondheim, 2013)
Treatment parameters

‡ Point-treatments (bath / well-boat)
  + efficacy estimates (variable by application type?)
  + different across life stages?
  + affected by sea water temperature?

‡ In-feed options
  + more complex to model different efficacies
  + resistance first explored in detail here (EMB)

‡ Continuous treatment options
  + uncertainties (with wrasse / other biological control)
  + technical uncertainty with newer options
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**Sea lice multi-nation meeting (Trondheim, 2013)**
Genetic parameters

† Genetic mechanism being modelled will determine level of detail required
  † multiple / single locus
  † cross-resistance (to what? / how much?)

† Can ‘strategic’ use of treatments slow (or even reverse) emergence of resistance?

† How to capture influence of refugia?
Individual-based model of evolution of pesticide resistance in sea lice

Initial Results:

Temperature influences the rate at which resistance evolves as does the number of treatments used.

Results vary with each iteration, so modelling needs to be scaled up to look at ‘average’ effects.
Parameters – what’s missing?

### Genetics
- nSusceptible
- nHeterozygous
- nResistant
- ResistanceFitnessDiscount
- ResistanceBenefit

### Environment
- Temperature_Cool
- Temperature
- Temperature_Warm
- TemperatureFall

### Treatments
- Treatment
- dayOfFirstTreatment
- TreatmentEnd
- dayFirstTreatment
- nTreatments
- TreatmentTrigger
- nTreatmentData
- TxSchedule
- TreatmentOn
- InfeedStart
- InfeedOn
- InfeedEnd
- nInfeeds
- InFeedDuration
- InFeedEfficacy

### Population Dynamics
- nFemaleEggsHatching1
- nFemaleEggsHatching2
- ExternalEggsSusceptible
- ExternalEggsResistant
- ExtEggRate
- PropExtEggsResistant
- hostPopulationSize
- nFemale
- nMobile
- nChalimus
- nPreadult
- nGravid1
- nGravid2
- nMaleAdult
- CopepodidAttachmentProbability

### Colors
- Yellow: Chalimus/ Salmon: 123
- Orange: Preadult/ Salmon: 123
- Red: Adult Male/ Salmon: 123
- Green: Gravid Female/ Salmon: 123

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Sea lice multi-nation meeting (Trondheim, 2013)
‘Internal’ vs ‘External’

‡ Many models assume that farm infestation is largely self-inflicted/self-reinforced
   + even if true, still needs external ‘trigger’
‡ Others argue that external pressures dominate level of infection seen on farms
   + BC (wild fish) / Chile (neighbouring farms)
‡ External view requires hydrodynamic models
‡ ‘Truth’ may be a combination of both sources
   + requires the creation of more complex models or an increased capacity to integrate across scales/types
The need for ‘Open Data’

‡ What is it?

STAMFORD, Conn., August 22, 2012

Gartner Says Big Data Makes Organizations Smarter, But Open Data Makes Them Richer

Open Data on the Agenda for Gartner Symposium/ITxpo, October 21-25, Orlando, Florida

Whereas "big data" will make organizations smarter, open data will be far more consequential for increasing revenue and business value in today’s highly competitive environments, according to Gartner, Inc.

"Big data is a topic of growing interest for many business and IT leaders, and there is little doubt that it creates business value by enabling organizations to uncover previously unseen patterns and develop sharper insights about their businesses and environments." said David Newman, research vice president at
The need for ‘Open Data’

‡ What is it?
+ linked / managed (automatically) / machine readable

‡ Advantages
+ encourages data re-use
The need for ‘Open Data’

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The need for ‘Open Data’

‡ What is it?
  + linked / managed (automatically) / machine readable

‡ Advantages
  + encourages data re-use
  + avoids needless duplication
  + quality checking
Data Quality

‡ Dose: 2.5mg / kg
‡ Patient Weight: 72 kg
‡ Patient Age: 4 years
## Data Quality

‡ Location of BC salmon farms (B.A. region)

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Data Quality

Location of BC salmon farms (B.A. region)
The need for ‘Open Data’

‡ What is it?
  + linked / managed (automatically) / machine readable

‡ Advantages
  + encourages data re-use
  + avoids needless duplication
  + quality checking

‡ Data must be *used* to maintain integrity/value

‡ Concerns – data will be ‘used’ against owner
  + BAMP data and Alex Morton’s *Lotto fish*
Concerns over ‘Open Data’

Photo: Lice From Fish Farms Killing Wild Salmon

Sea lice infest a juvenile pink salmon.

A new study of Canadian, ocean-based salmon farms shows that sea lice from the farms swarm the waters around them, forcing young wild fish to swim through clouds of the lice on their way out to sea. Lack of scales, young salmon are especially vulnerable to the parasites.
Concerns over ‘Open Data’

Of 177,152 fish from 2004-2012, only 125 had three or more adult females \(\sim 0.07\%\)

but ... 2004 was an very ‘atypical’ year

From all other years \((N=8)\) only six fish had \(>2\) AF...

but Morton’s claim was, “lice from fish farms”?

\[ \Rightarrow L. \textit{salmonis} + \text{adult females} + (\neq 2004) \]

Only two fish from 156,920 \(\sim 0.0013\%\)
Openness in modelling

http://tinyurl.com/wrassemodel

Popl. Projection Matrices

All $R$ code released with paper
‘Take-home’ messages

1. We now know enough to build DSS that can have impact + time to move beyond research and into practice

2. Need to maintain data flows / sharing + refine parameters + validate models + learn from our mistakes

3. Be realistic about potential / limitations of models

4. Be careful not to over-interpret statistical significance + develop useful ‘rules of thumb’

5. Gain confidence by building incrementally on success