CHIFSS
CII-HUL Initiative on Food Safety Sciences

Quantitative Microbiology Tools and Applications

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University of Tasmania

tia
TASMANIAN INSTITUTE OF AGRICULTURE

UTAS

TIA is a joint venture of the University of Tasmania and the Tasmanian Government

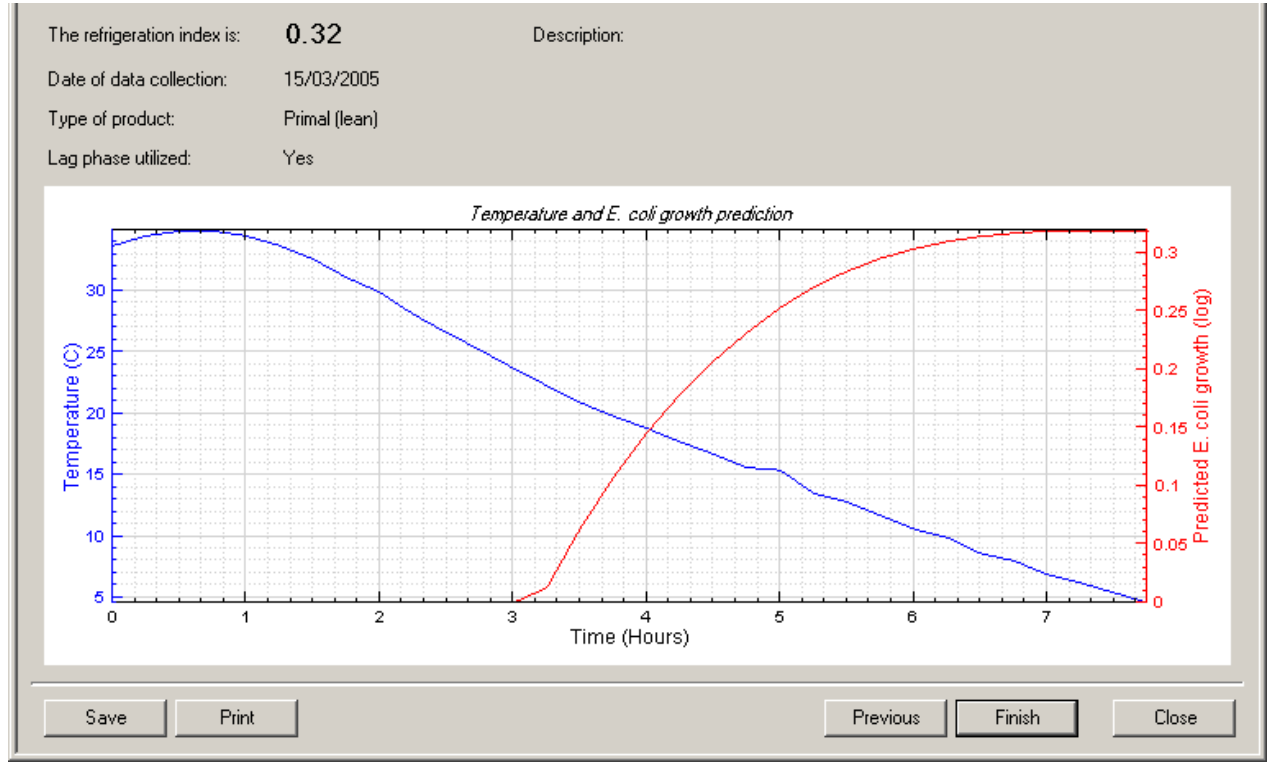
Tasmania
Explore the possibilities

CHIFSS
CII-HUL Initiative on Food Safety Sciences

Outline

- Overview of Quantitative/Predictive Microbiology
- Benefits of QM/PM
- Types of models
- Producing models
- Examples of QM/PM tools
- Model applications
- ComBase

Predictive Microbiology



Predictive models

Represent ***condensed knowledge***, which

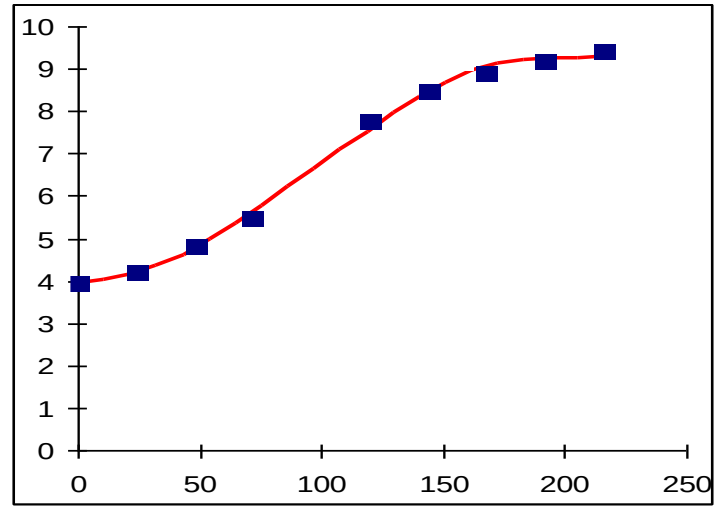
- describe microbial behavior in different environments
- help us better understand and manage the ecology of foodborne microorganisms

$$\frac{dx}{dt} = \frac{q(t)}{q(t)+1} \cdot \mu_{\max} \cdot \left(1 - \left(\frac{x(t)}{x_{\max}}\right)^{m}\right) x(t)$$

Predictive microbiology

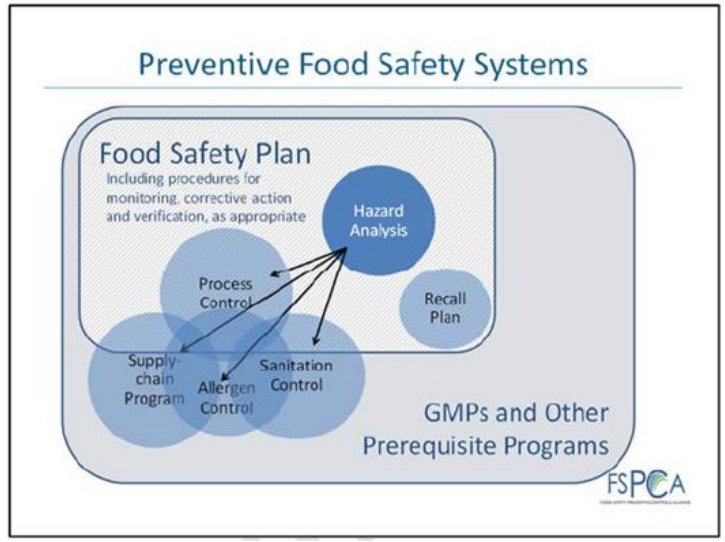
Assumes microbial behavior is:

- reproducible
- quantifiable by characterizing environmental factors



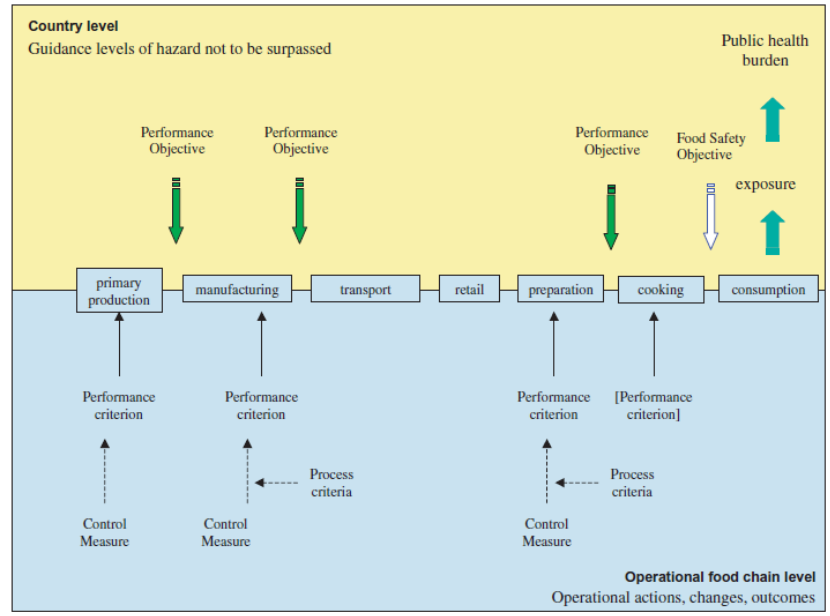
Drivers and Benefits of Quantitative Microbiology

Food Safety Modernization Act



Food Safety Objectives

$$H_0 + \Sigma I + \Sigma R \leq FSO$$



L.G.M. Gorris / Food Control 16 (2005) 801–809

Risk management

A successful risk management system relies on information about how environmental conditions affect the behavior of microbial hazards.

…this information reduces uncertainty.

…and equally important

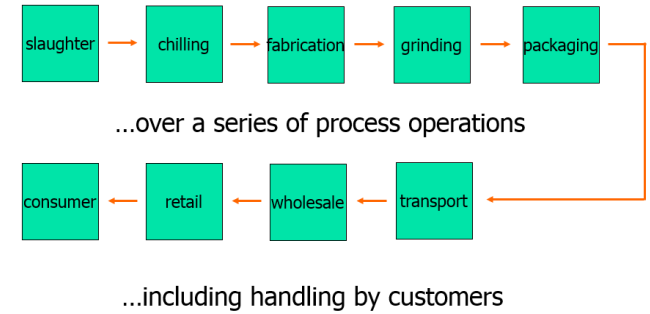
prescriptive → *outcome-based*

flexibility

Benefits

- Producing Food Safety/HACCP Plans
- Identifying Preventive Controls and Critical Limits
- Designing challenge studies
- Developing regulatory standards
- Minimizing microbiological testing
- Identifying factors that control microbial viability

  (e.g. temp, aw, pH, and others)



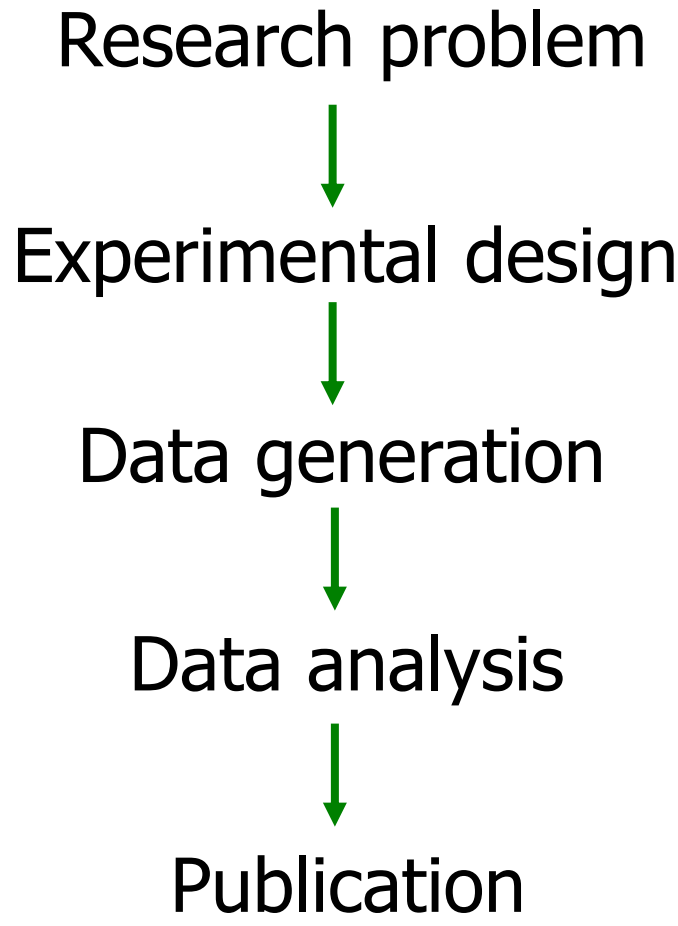
Other associated benefits

- Predictive microbiology brings together persons with diverse but complimentary skills, including microbiologists, technologists, mathematicians, engineers, statisticians and other disciplines.

- Excellent approach for capacity-building

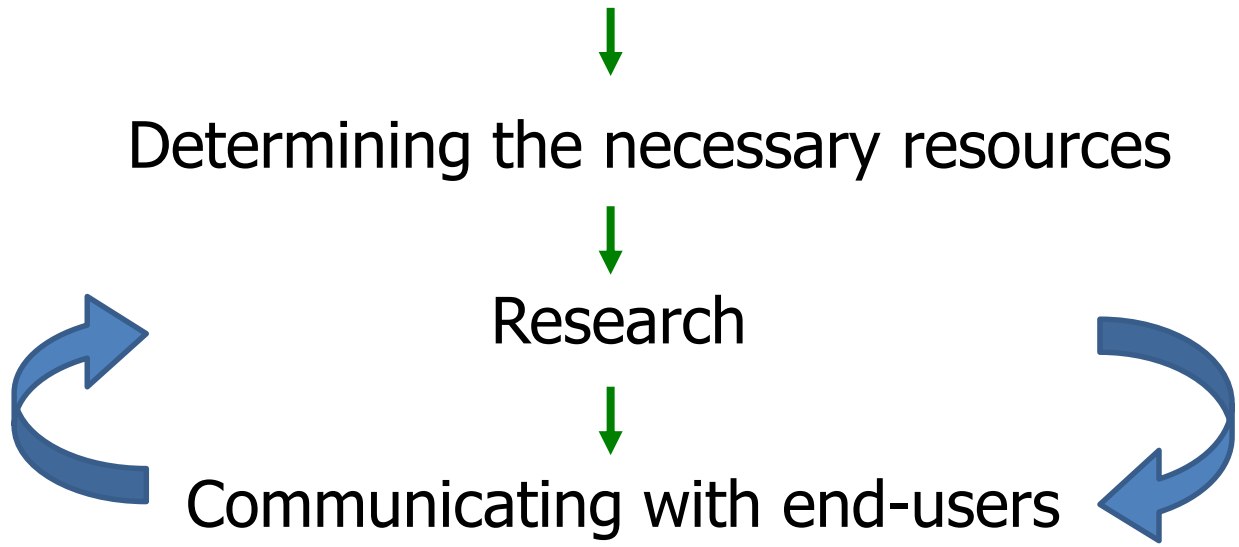
How can we be sure that we are producing the most effective models?

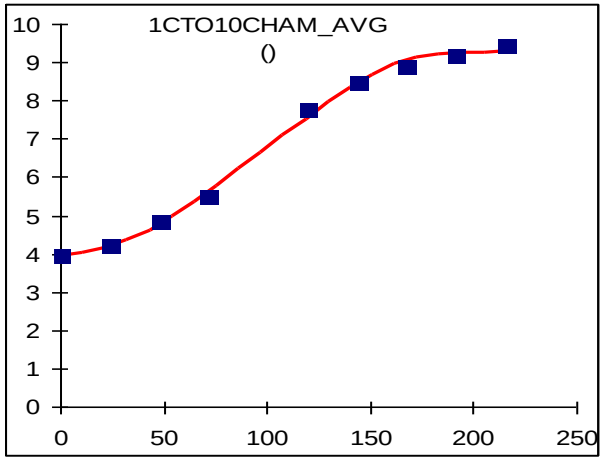
Technical Aspects of Applied Research

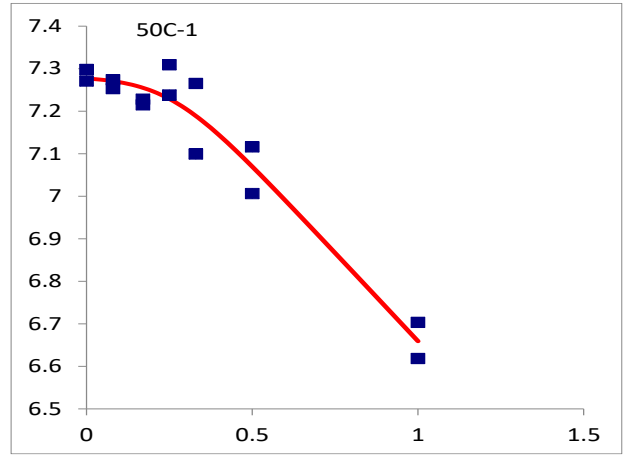


Outcomes of Applied Research

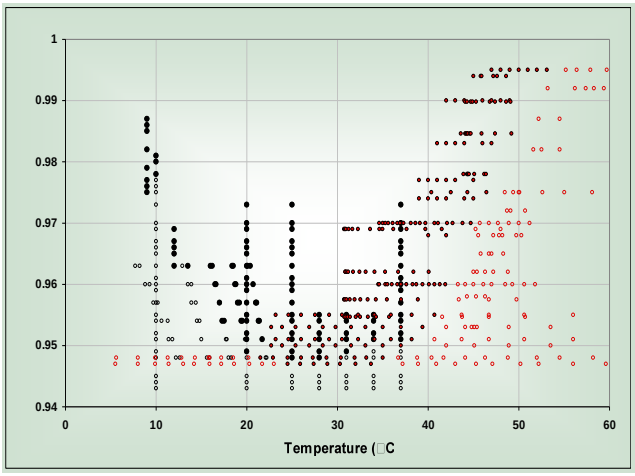
Interacting with all end-users of the model
(defining the intended outcomes)

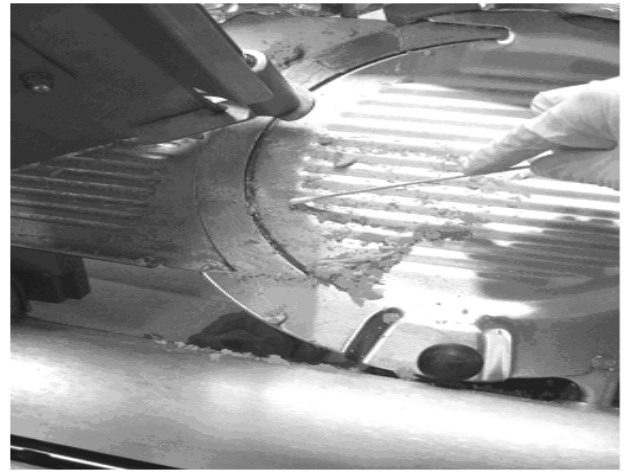






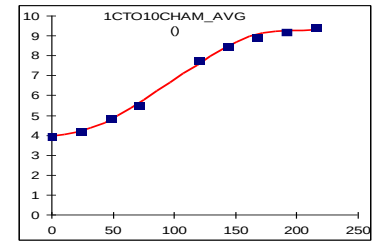
Types of Predictive Models



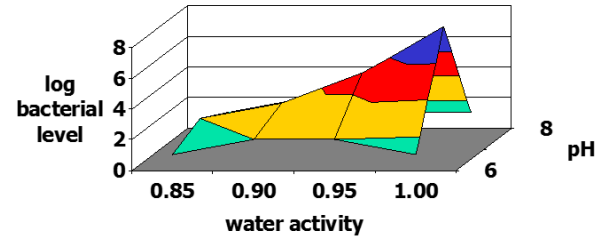


Steps in Model Production

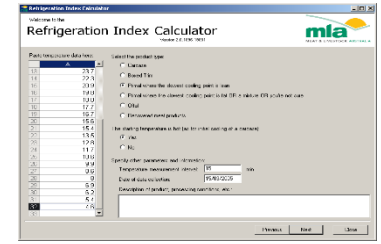
- Primary



- Secondary



- Tertiary



Experimental design

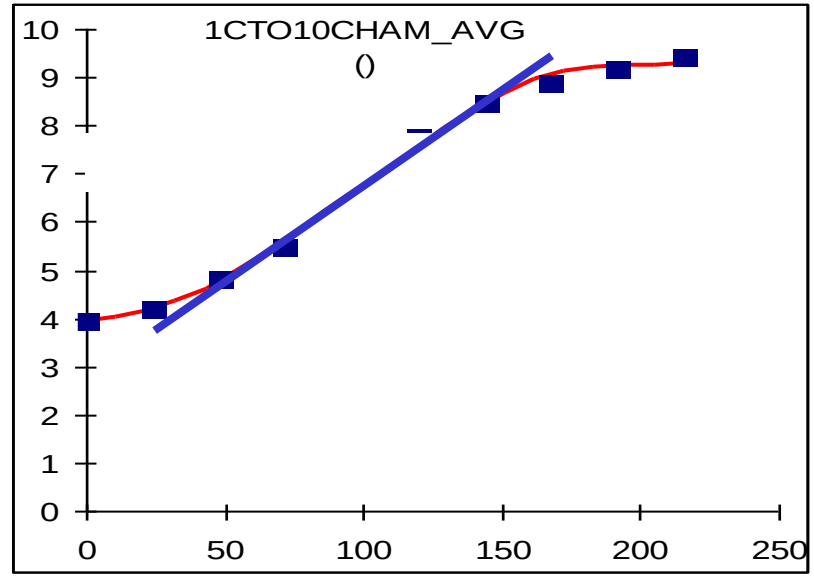
Extrinsic factors

- temperature
- atmosphere (e.g. packaging gas, humidity)

Intrinsic factors

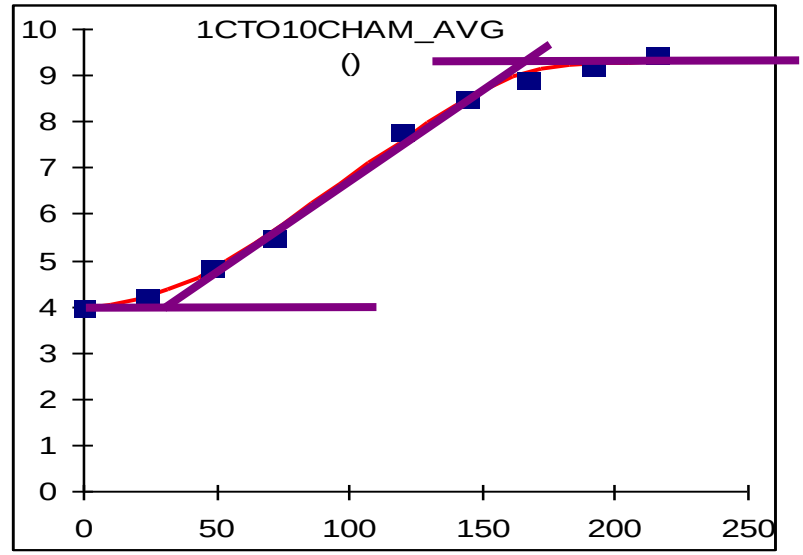
- food matrix
- pH
- water activity
- additives (e.g. NaCl, acidulants)

Growth



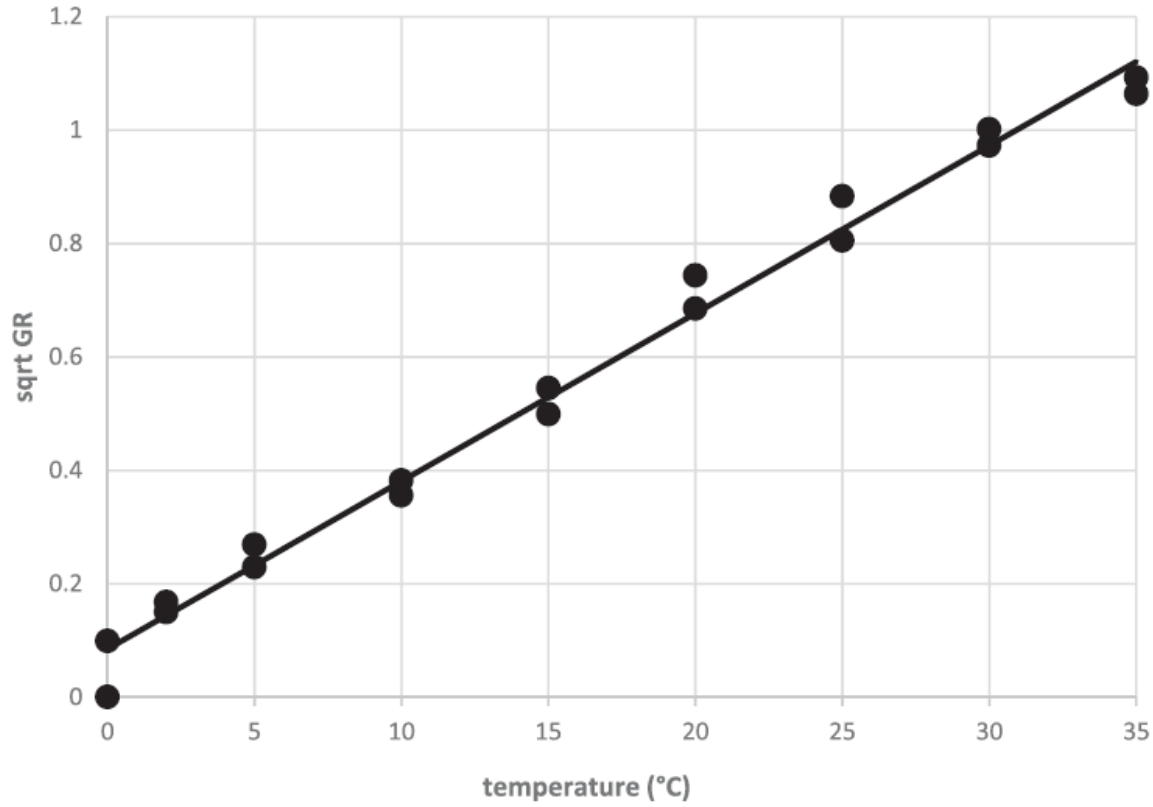
Kinetic parameters

- **Lag phase** — ***lag phase duration***
- **Growth** — ***growth rate***
- **Stationary phase** — ***maximum population density***

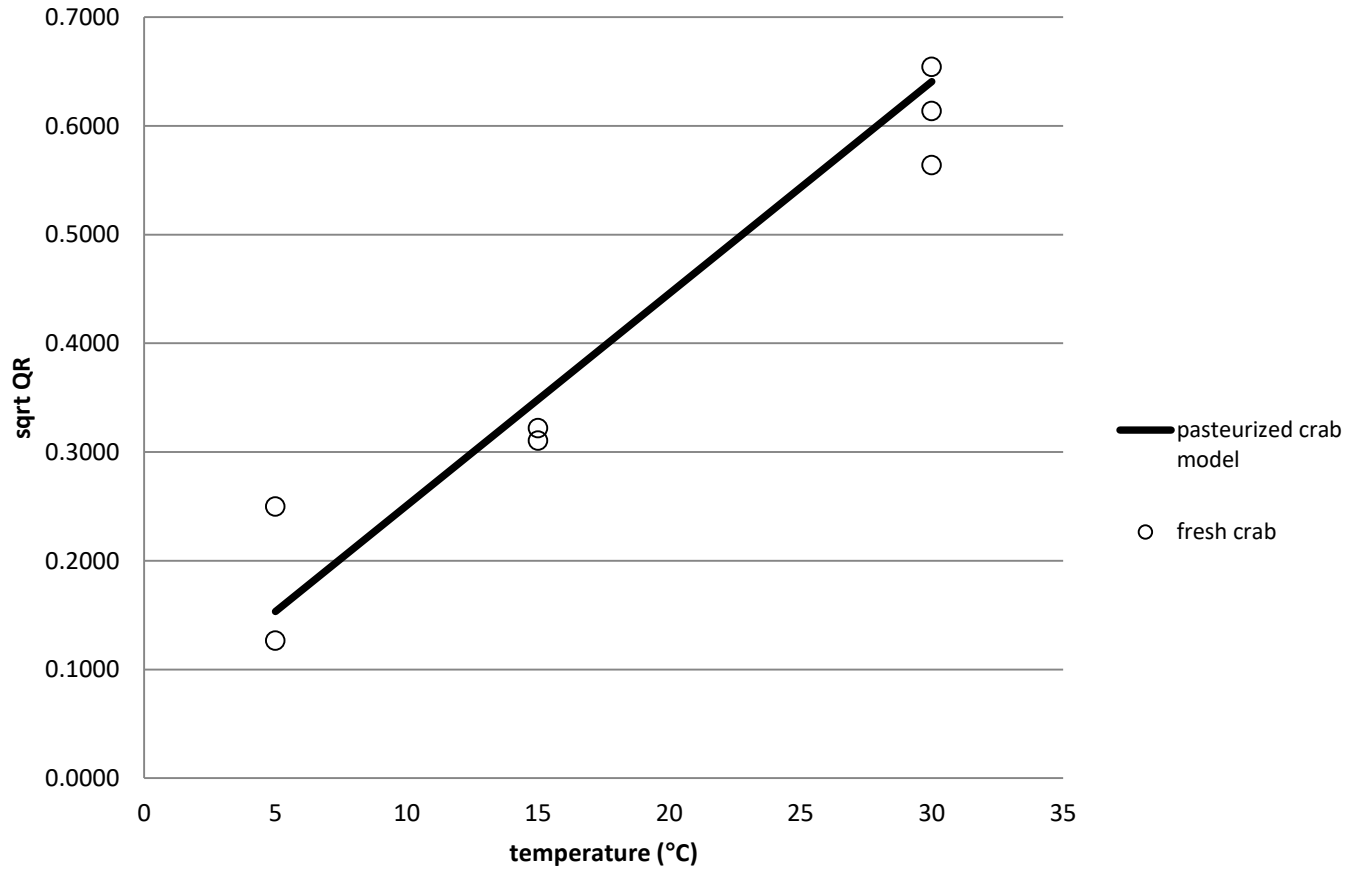


SECONDARY MODELS

Change in parameter(s) as a function of environmental change



Measuring Model Performance
(validation)

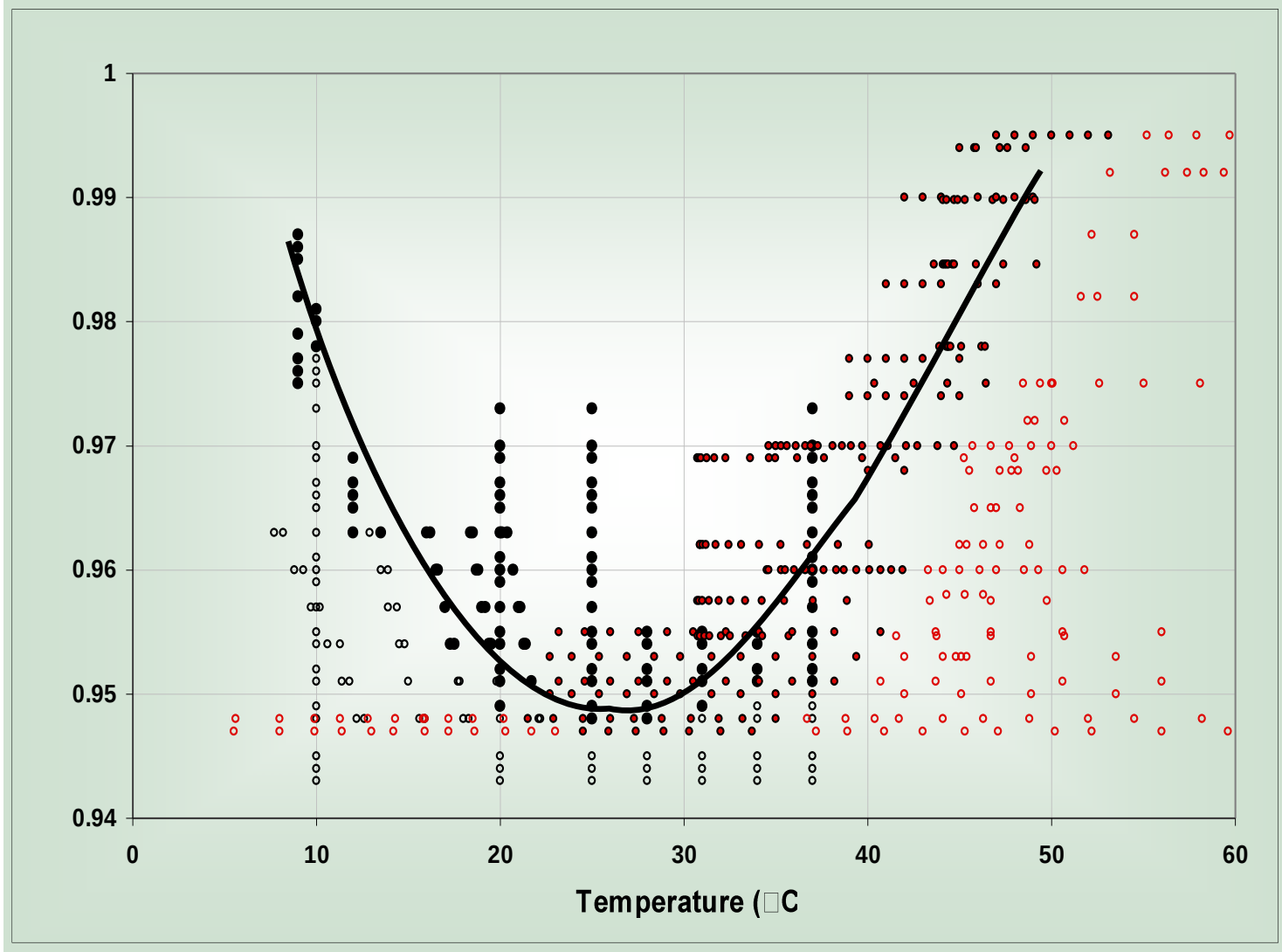


Probabilistic models

Growth/No-growth boundaries

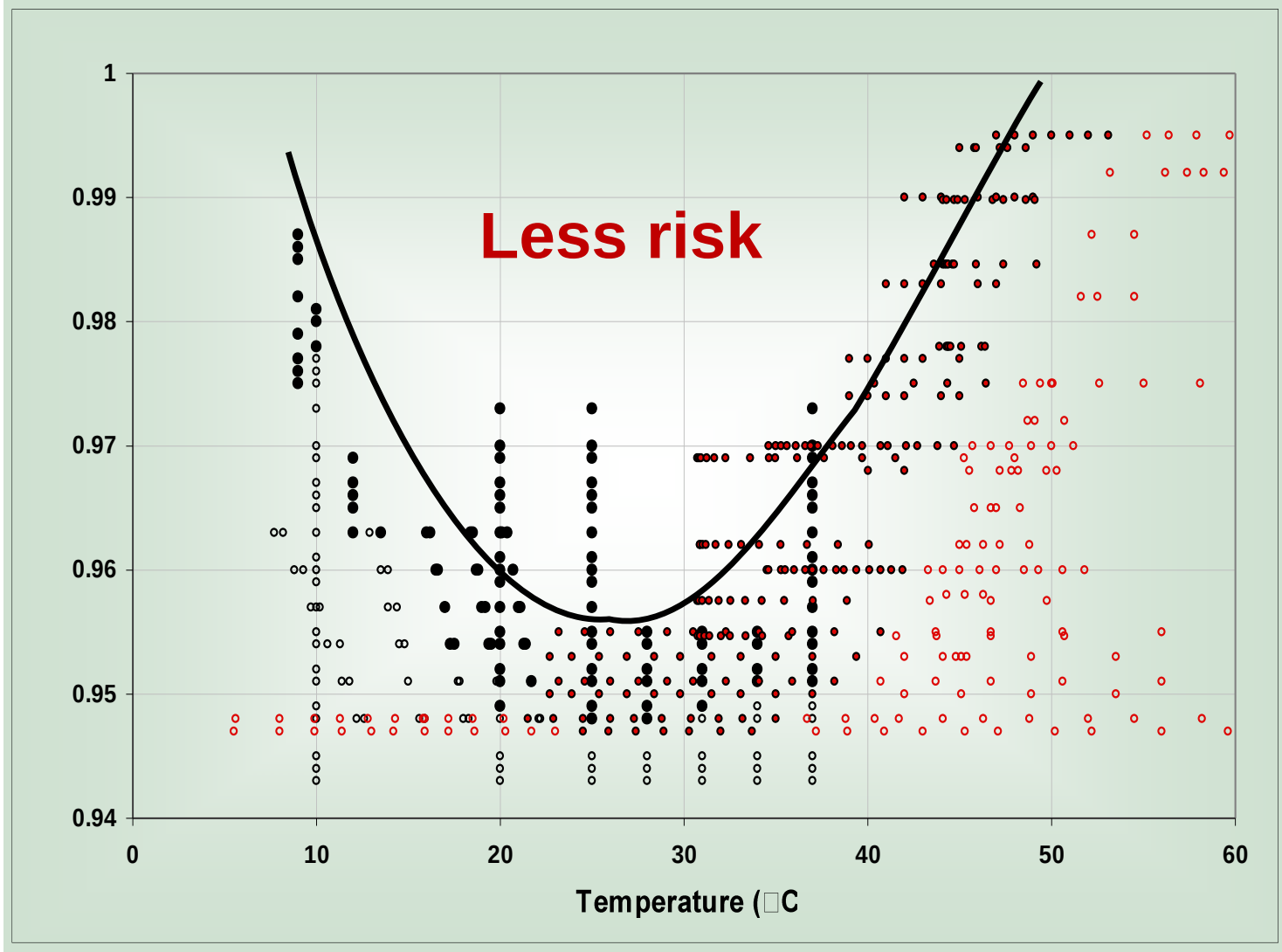
(e.g. product development)

Growth/No-Growth



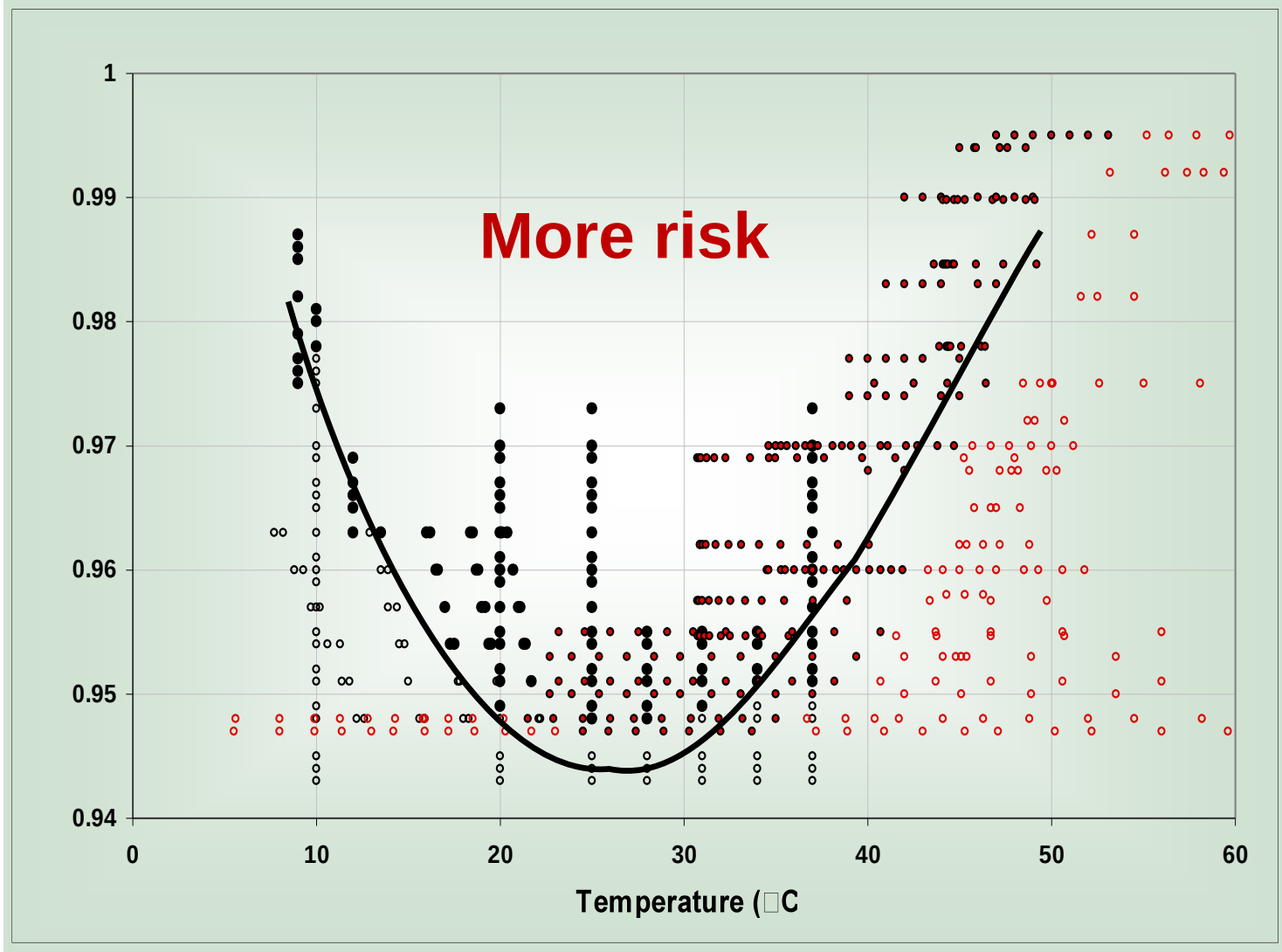
Adapted from Ross

Growth/No-Growth



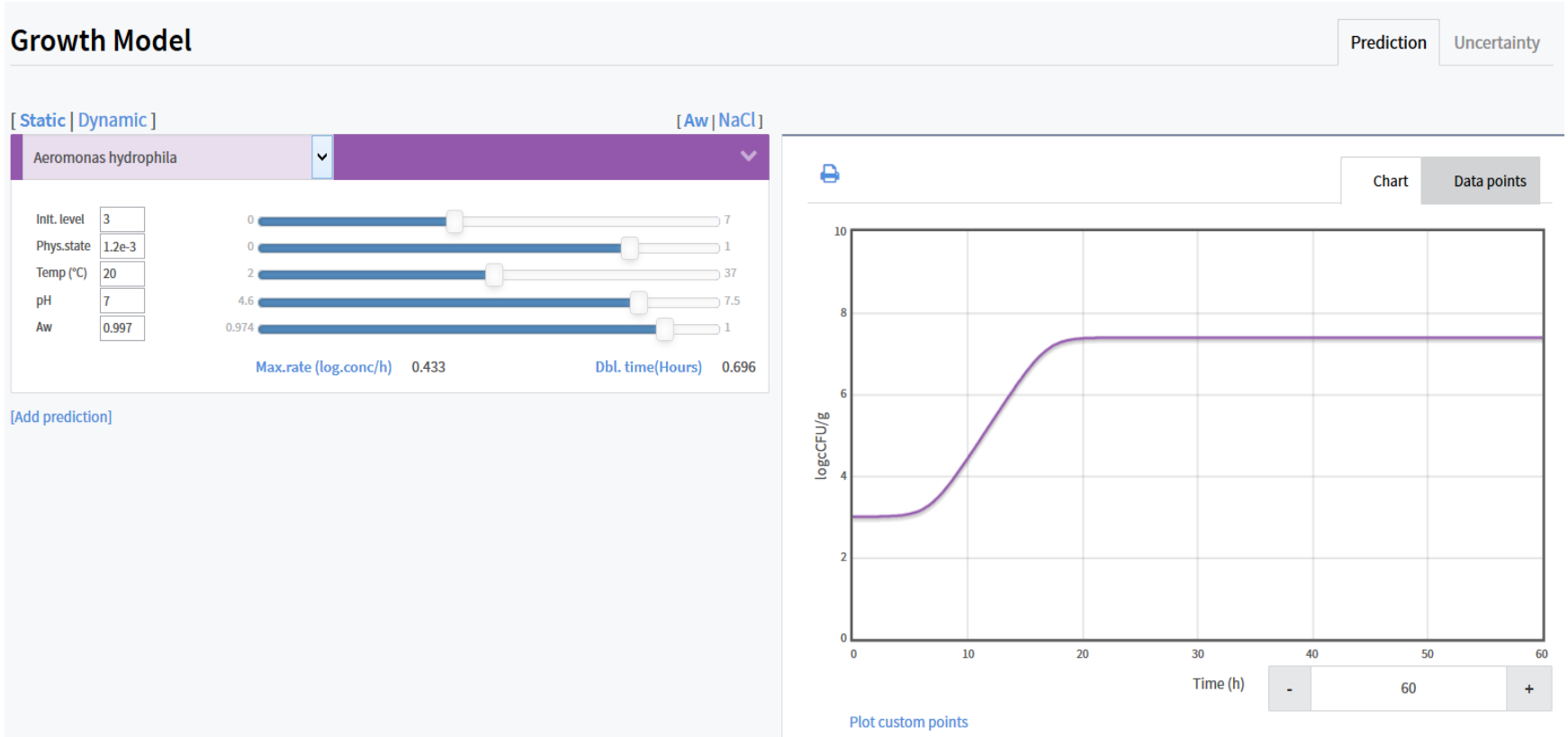
Adapted from Ross

Growth/No-Growth

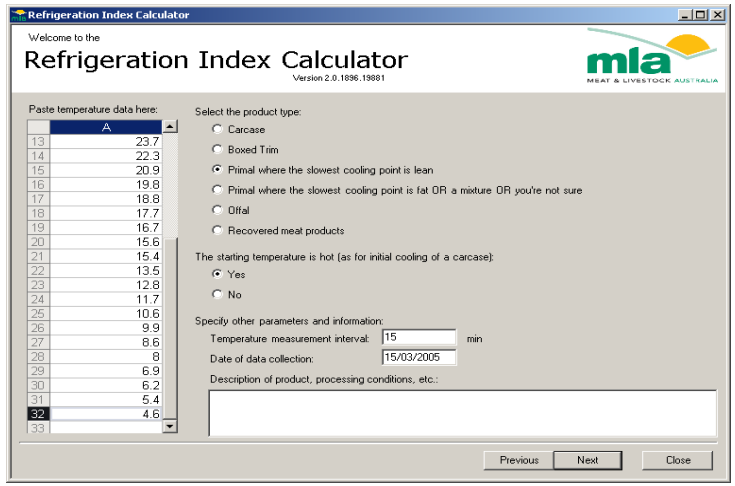


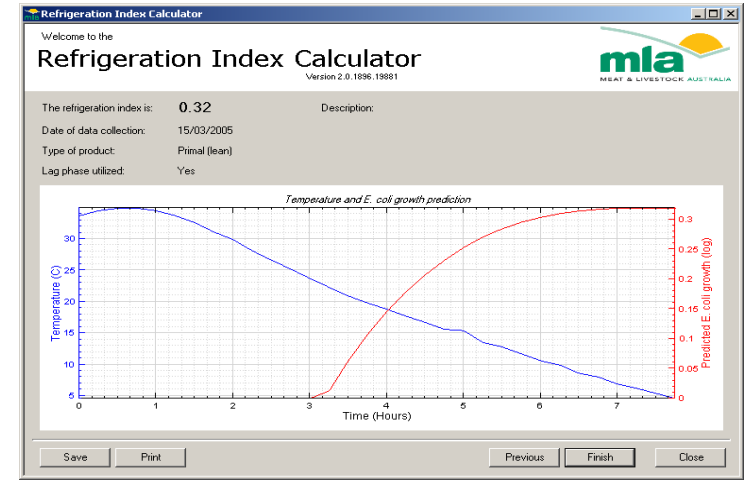
Adapted from Ross

TERTIARY MODELS

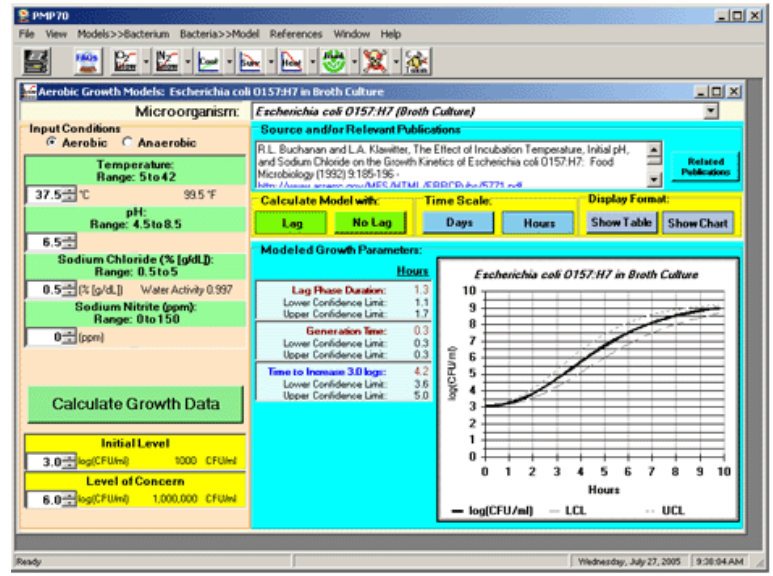


$$GR\ (\log cfu/h) = -0.0146 + 0.0098T - 0.0206L - 0.2220D - 0.0013TL - 0.0392TD + 0.0143LD + 0.0001T^2 + 0.0053L^2 + 2.9529D^2$$


Refrigeration Index Calculator
Welcome to the
Refrigeration Index Calculator
Version 2.0.1896.19881
mla
MEAT & LIVESTOCK AUSTRALIA
Paste temperature data here:
A
13 23.7
14 22.3
15 20.9
16 19.8
17 18.8
18 17.7
19 16.7
20 15.6
21 15.4
22 13.5
23 12.8
24 11.7
25 10.6
26 9.9
27 8.6
28 8
29 6.9
30 6.2
31 5.4
32 4.6
33
Select the product type:
Carcase
Boxed Trim
Primal where the slowest cooling point is lean
Primal where the slowest cooling point is fat OR a mixture OR you're not sure
Offal
Recovered meat products
The starting temperature is hot (as for initial cooling of a carcase):
Yes
No
Specify other parameters and information:
Temperature measurement interval: 15 min
Date of data collection: 15/03/2005
Description of product, processing conditions, etc.:
Previous
Next
Close


Refrigeration Index Calculator
Welcome to the
Refrigeration Index Calculator
Version 2.0.1896.19881
mla
MEAT & LIVESTOCK AUSTRALIA
The refrigeration index is: 0.32
Description:
Date of data collection: 15/03/2005
Type of product: Primal (lean)
Lag phase utilized: Yes
Temperature and E. coli growth prediction
Temperature (C)
Predicted E. coli growth (/g)
Time (Hours)
Save
Print
Previous
Finish
Close

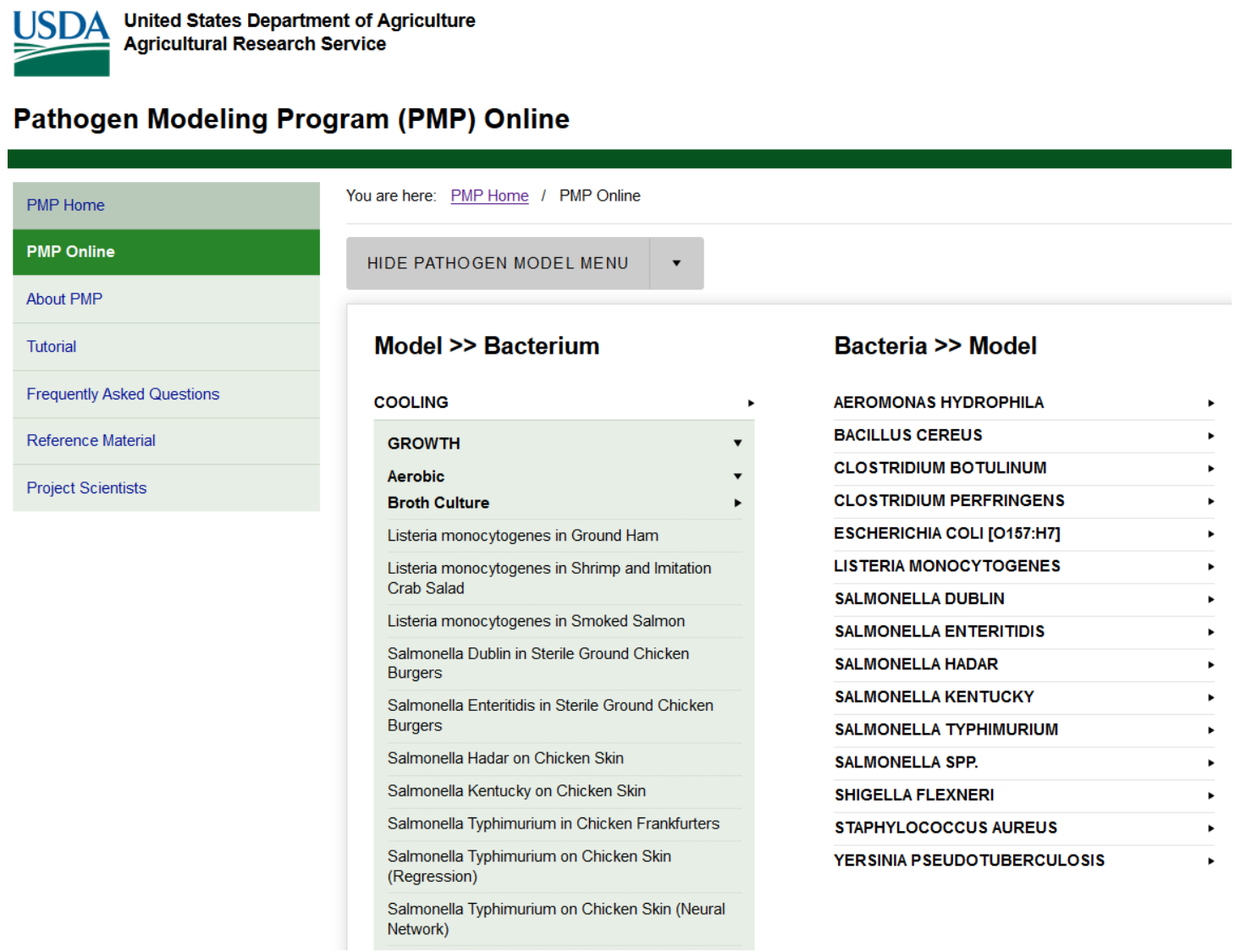
Examples of common model interfaces



Food Spoilage and Safety Predictor (FSSP)

ComBase

Pathogen Modeling Program



Pathogen Modeling Program

United States Department of Agriculture
Agricultural Research Service

Pathogen Modeling Program (PMP) Online

- PMP Home
- **PMP Online**
- About PMP
- Tutorial
- Frequently Asked Questions
- Reference Material
- Project Scientists

You are here: PMP Home / PMP Online

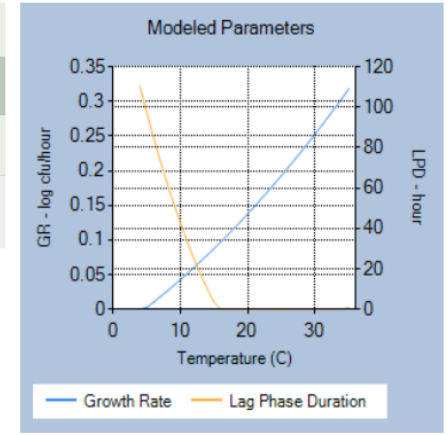
SELECT A PATHOGEN MODEL ▸

Growth of Listeria monocytogenes in Ground Ham Containing Sodium Lactate and Sodium Diacetate

Input Conditions

Sodium Lactate Range: 1.0% - 4.2%	1.0	
Sodium Diacetate Range: 0.05% - 0.2%	0.05	

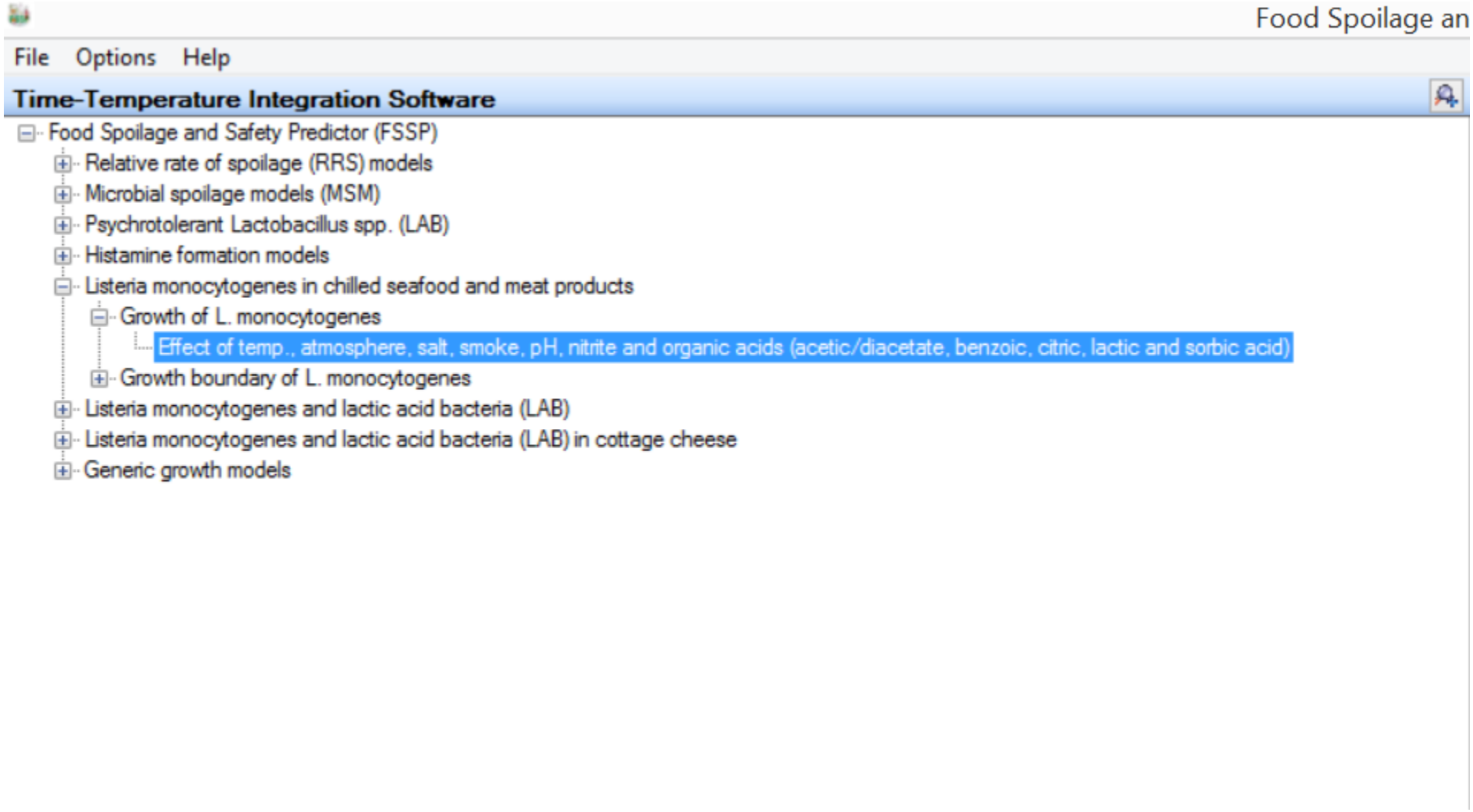
CALCULATE



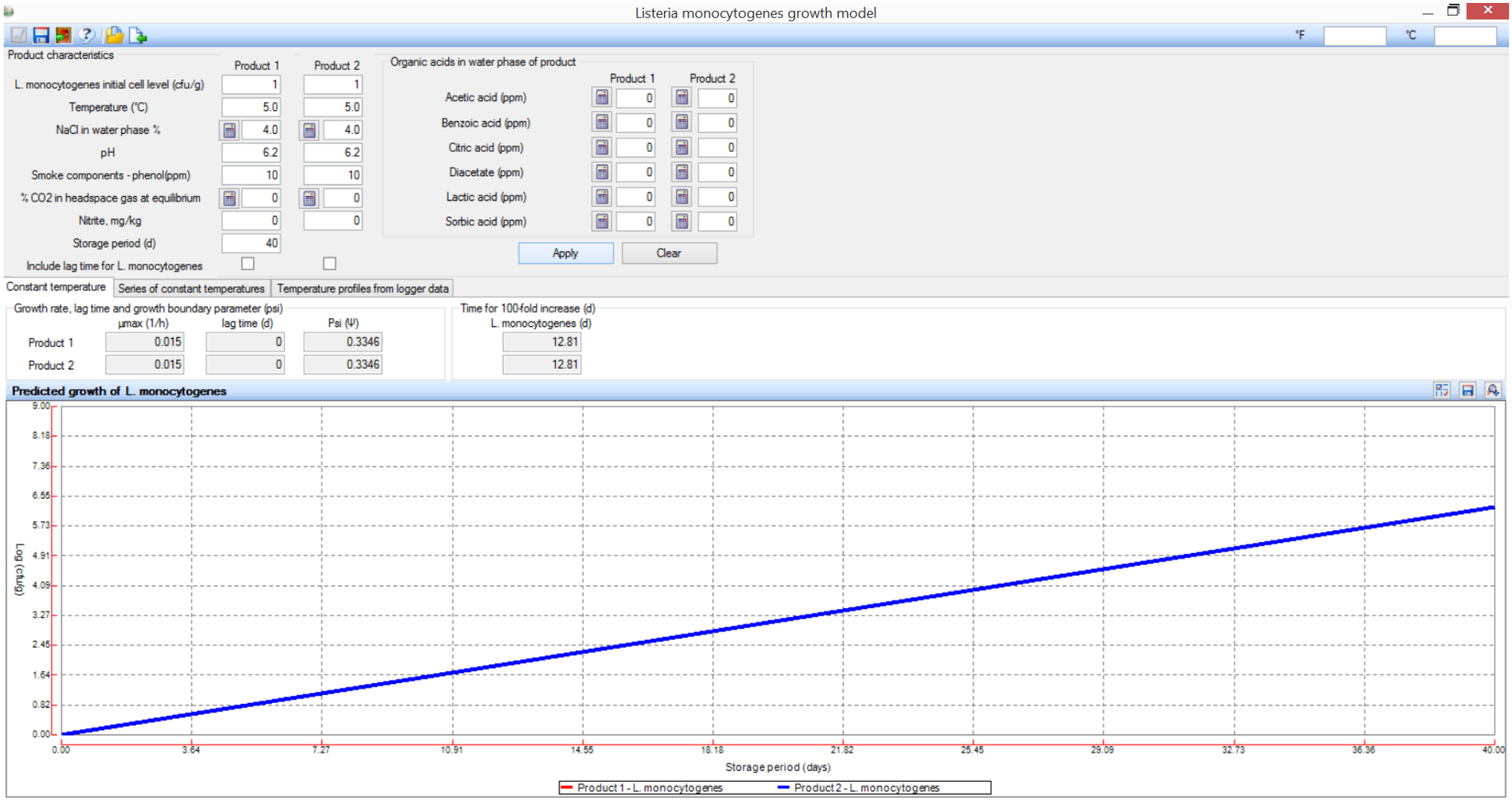
MODELED PARAMETERS

Temp (C)	GR (log cfu/h)	LPD (h)
4.0	0.000	110.5

Food Spoilage and Safety Predictor



Food Spoilage and Safety Predictor



Case Studies

Examples of models to assist with food safety decisions

- USDA *Clostridium perfringens* cooling model
- Meat & Livestock Australia Refrigeration Index
- *Vibrio parahaemolyticus* in oysters

What pathogen-food combination are important in India?

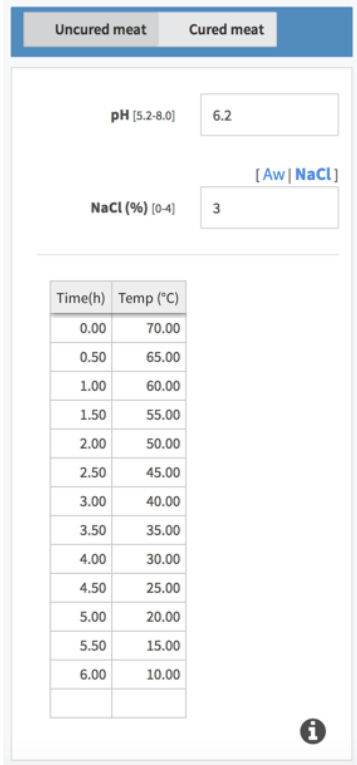
USDA *Clostridium perfringens* cooling model

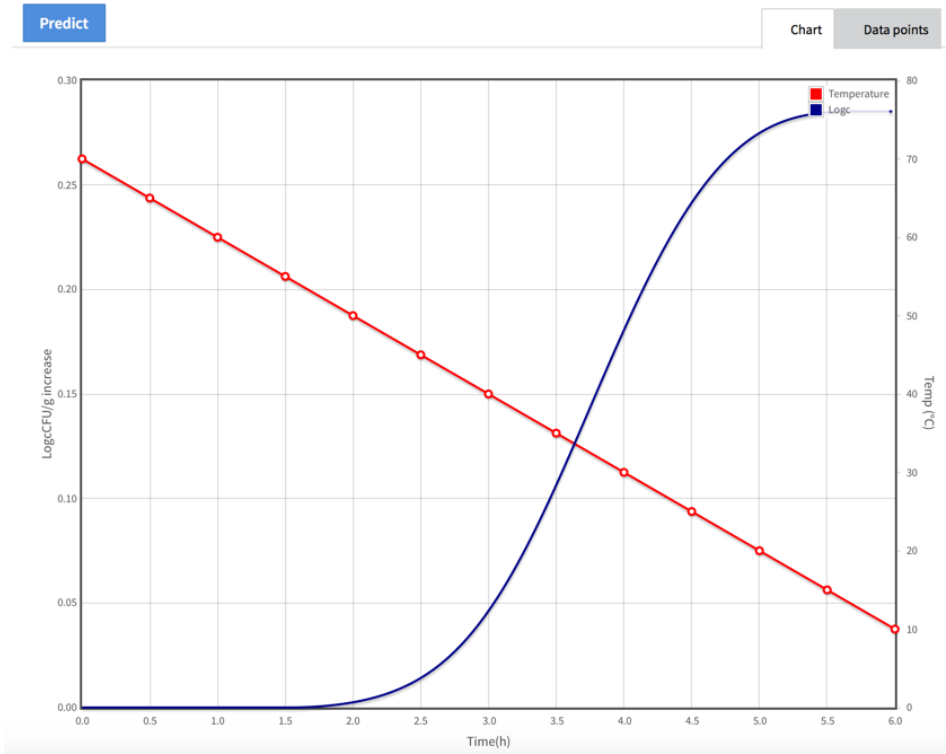
How can food companies validate the effects of temperature deviation when cooling meat primals, *without a lot of product testing*?

Perfringens Predictor

- Previous regulation was highly prescriptive
- Sampling plans and testing were not cost-effective
- An outcome-based model was developed through a government-industry partnership
- Accepted criteria of <1 log growth of *C. perfringens* after the cooling profile

ComBase Perfringens Predictor





0.29 log growth

<1 log growth

Meat & Livestock Australia
Refrigeration Index

Boxed primals and trim
destined for export

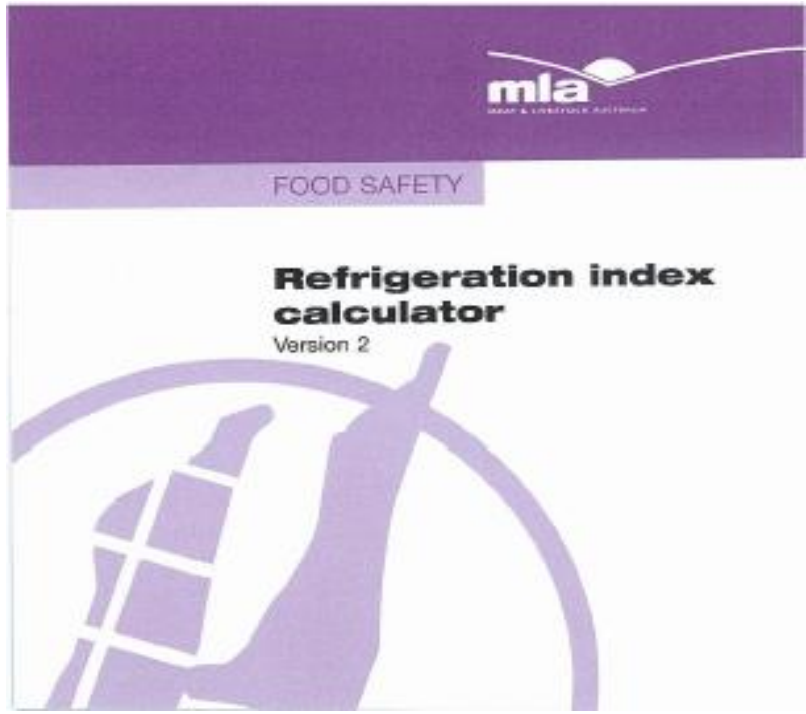
How can meat cooling profiles be accessed so that product can be more quickly exported?

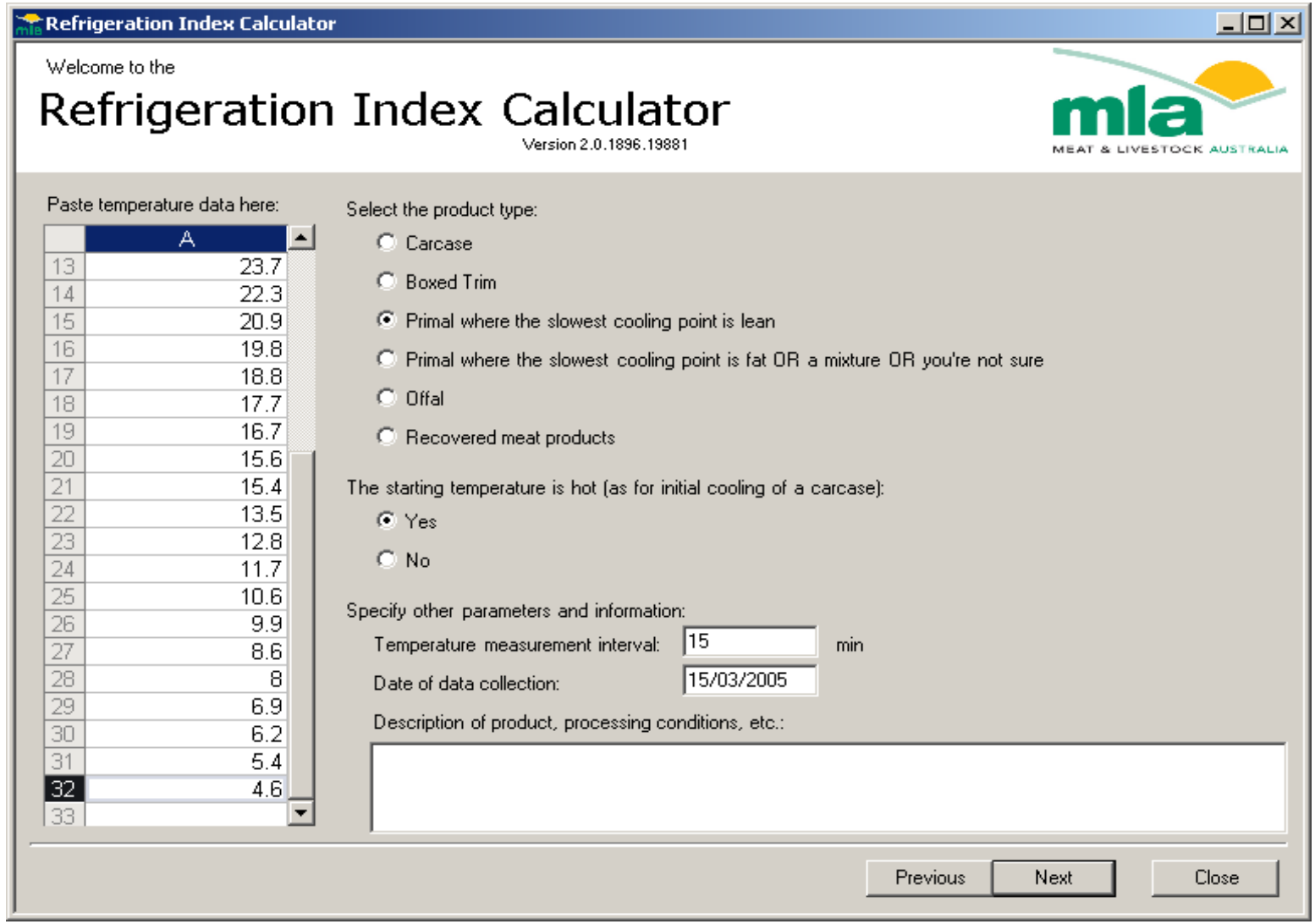
Refrigeration Index (RI)

- The meat industry wanted to package hot-boned beef trim for export.
- Australian export regulation required carcases to be cooled to 7° C in < 24 hours
- A more flexible and less prescriptive approach was developed.
- A predictive model was produced and validated via a government-industry-university partnership.
- The Refrigeration Index predicts potential growth of *E. coli* based on a growth model

RI now part of Australian food safety law for meat

Export Control (Meat and Meat Products) Orders 2005

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Paste temperature data here:
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13 23.7
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23 12.8
24 11.7
25 10.6
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27 8.6
28 8
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31 5.4
32 4.6
33
Select the product type:
Carcase
Boxed Trim
Primal where the slowest cooling point is lean
Primal where the slowest cooling point is fat OR a mixture OR you're not sure
Offal
Recovered meat products
The starting temperature is hot (as for initial cooling of a carcase):
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No
Specify other parameters and information:
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Date of data collection: 15/03/2005
Description of product, processing conditions, etc.:
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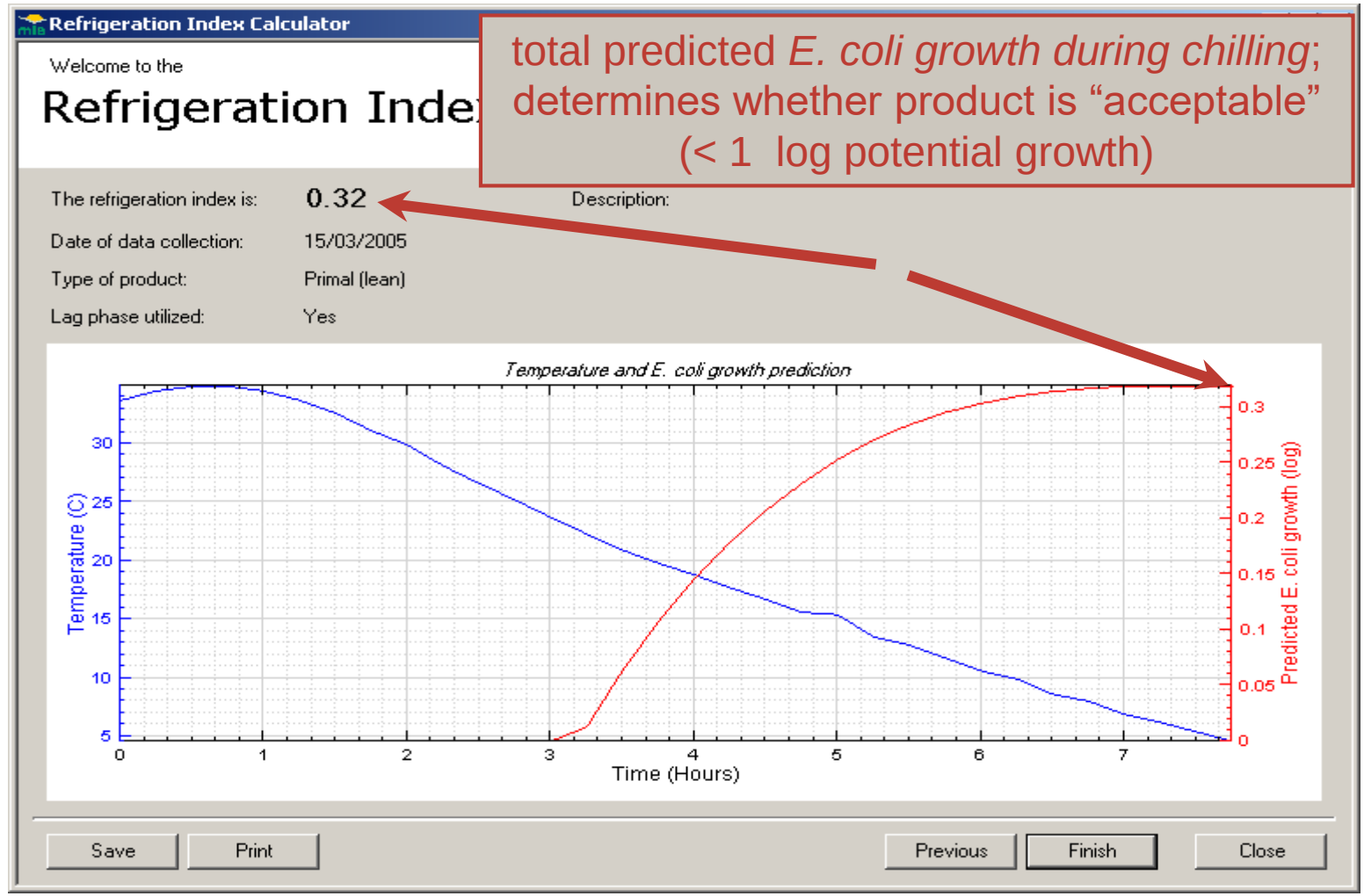
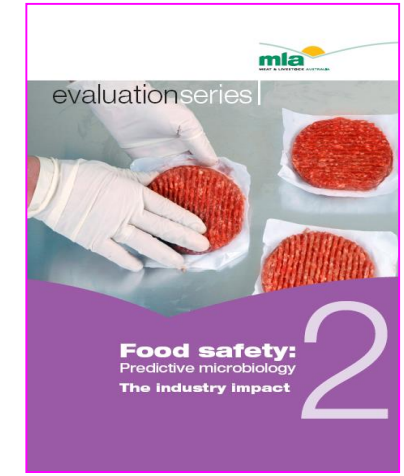
Next
Close

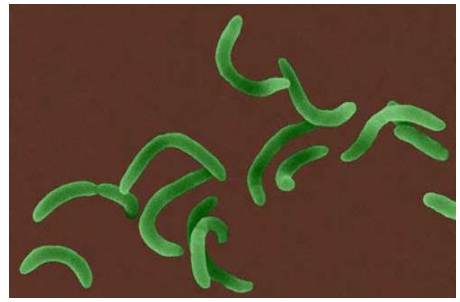

Refrigeration Index Calculator
Welcome to the
Refrigeration Inde
total predicted *E. coli growth during chilling*; determines whether product is "acceptable" (< 1 log potential growth)
The refrigeration index is: 0.32
Description:
Date of data collection: 15/03/2005
Type of product: Primal (lean)
Lag phase utilized: Yes
Temperature and E. coli growth prediction
Temperature (C)
Predicted E. coli growth (log)
Time (Hours)
Save
Print
Previous
Finish
Close

Benefits

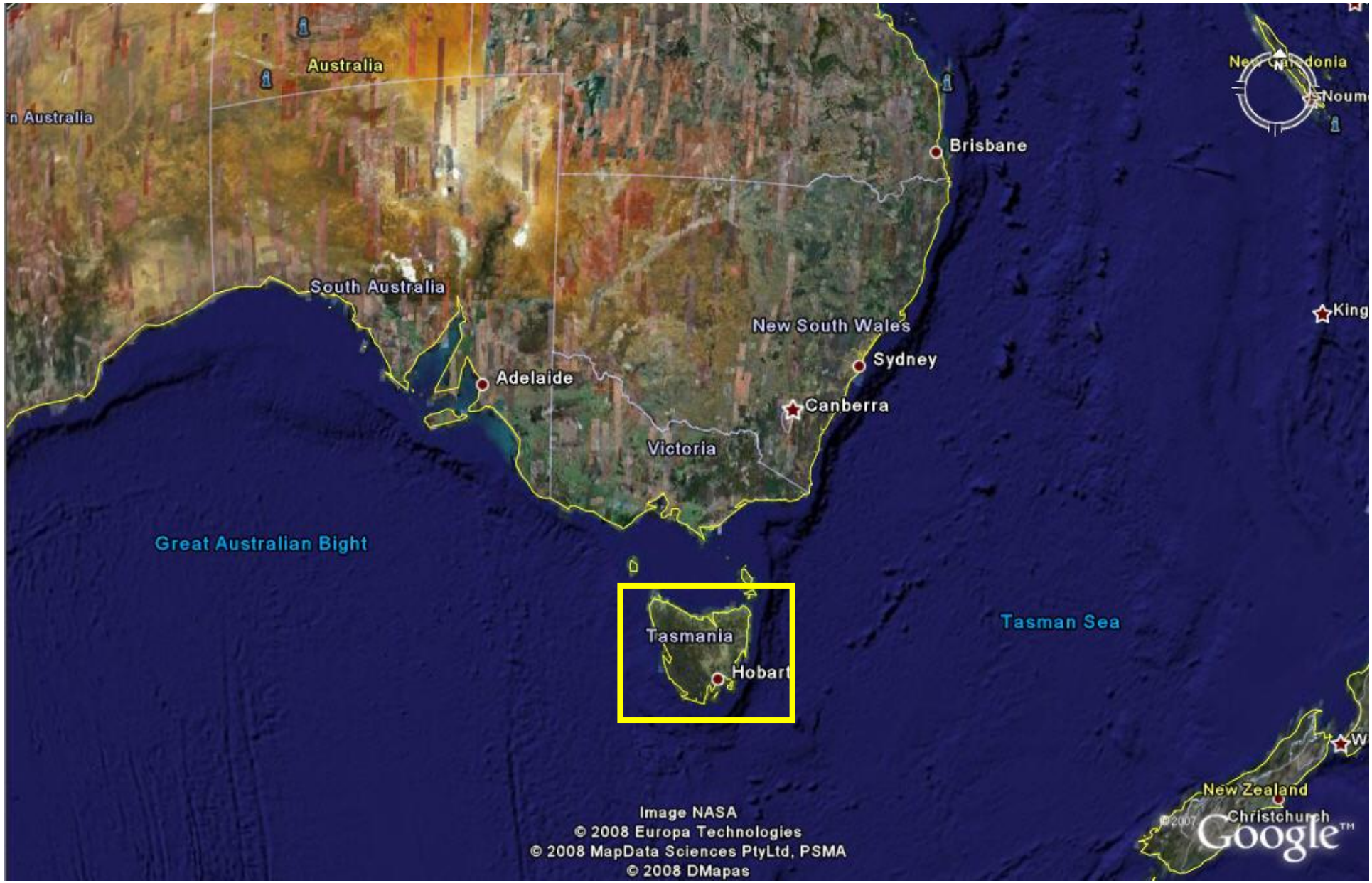
- Australian Centre for International Economics showed a benefit-cost ratio of 11.5
- $161.7 million increase in Australia's GDP over a 30-year period
- $281 million in social benefits over the 30-year period



Vibrio parahaemolyticus and oysters supply chains



Problem: How can companies reduce uncertainties in supply chains?


Australia
Brisbane
South Australia
New South Wales
Sydney
Adelaide
Canberra
Victoria
Great Australian Bight
Tasmania
Hobart
Tasman Sea
New Zealand
Christchurch
Image NASA
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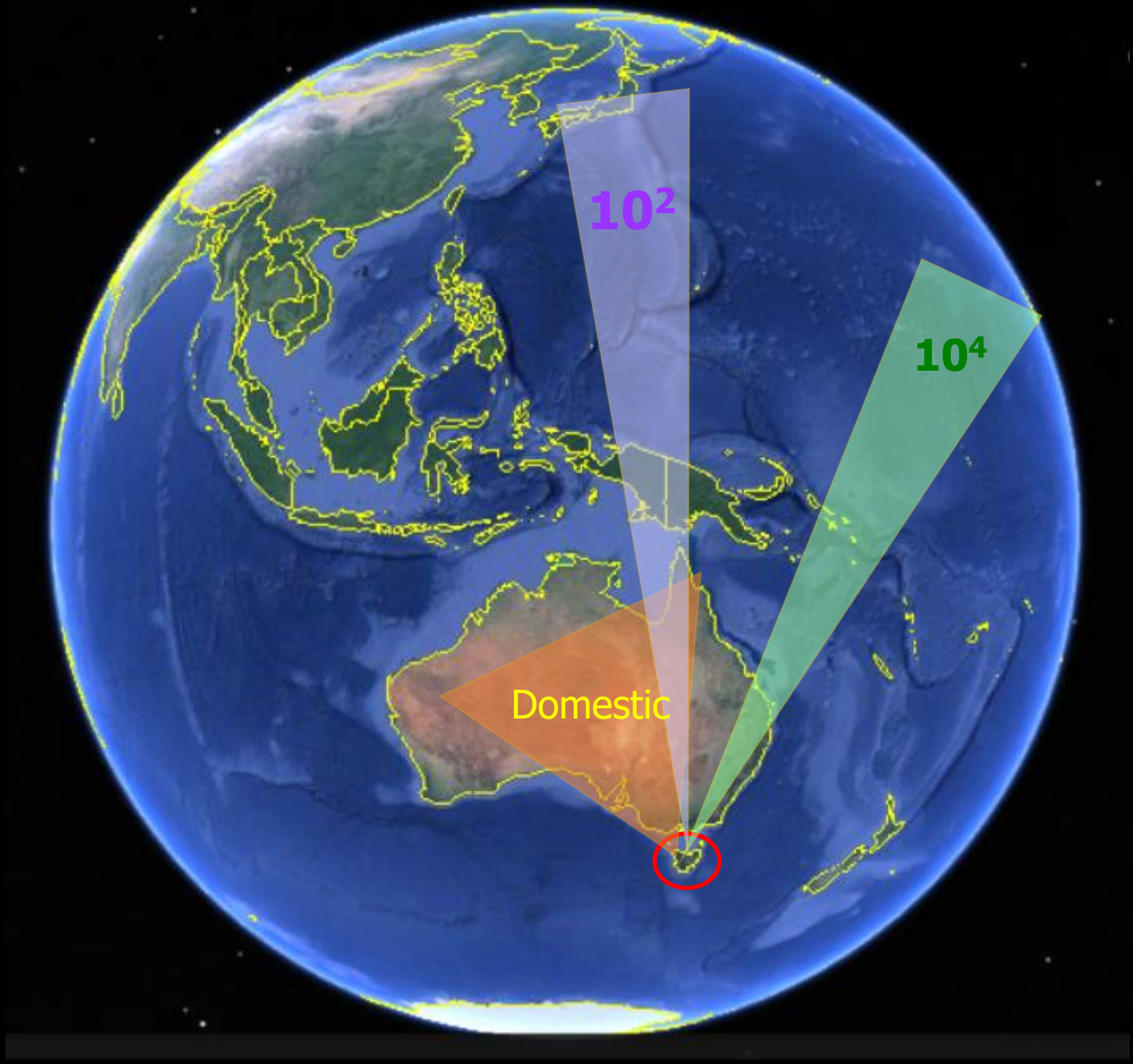
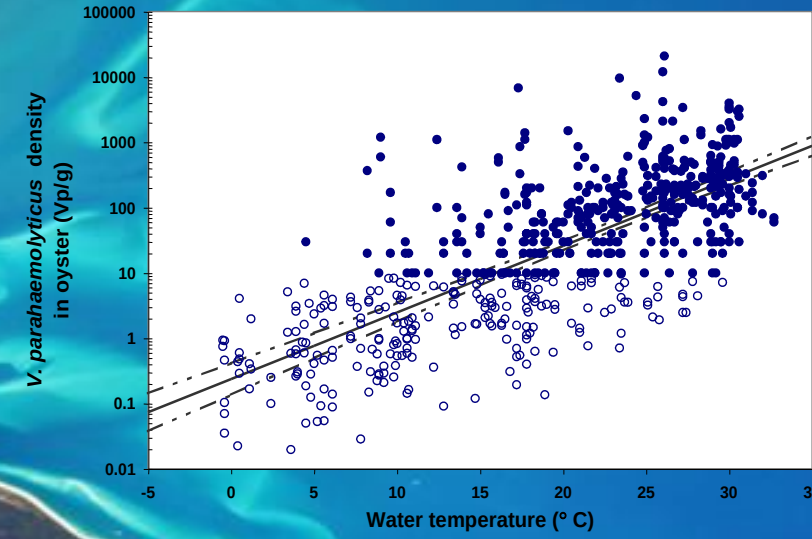

10^2
10^4
Domestic

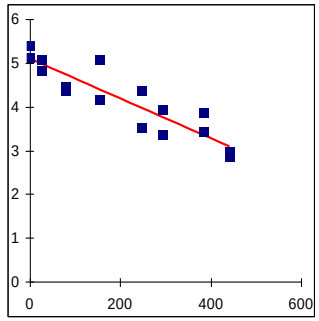
V. parahaemolyticus

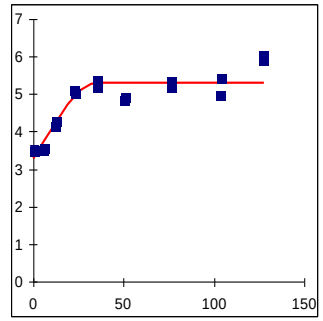
2->3% salt

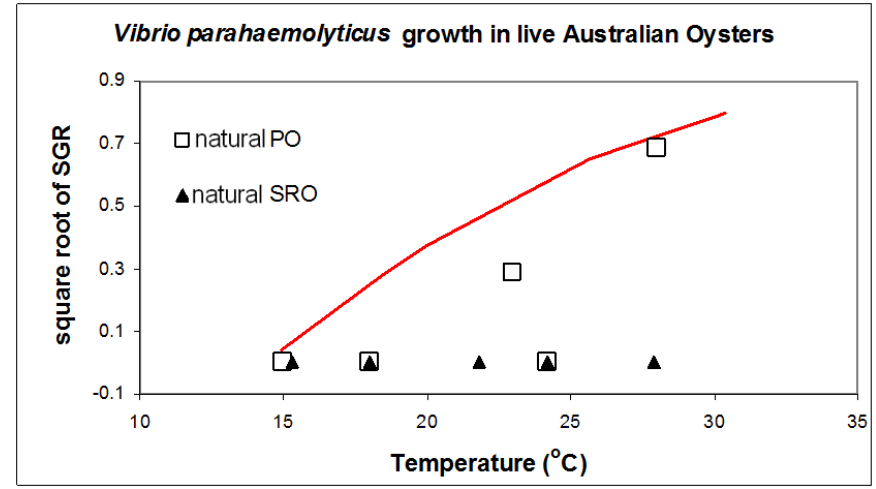


Model development

- *V. parahaemolyticus* growth kinetics measured from 4 - 30°C
- Growth (>15°C) and death rates (<15°C) determined
- Models tested (validated) against naturally-occurring Vp

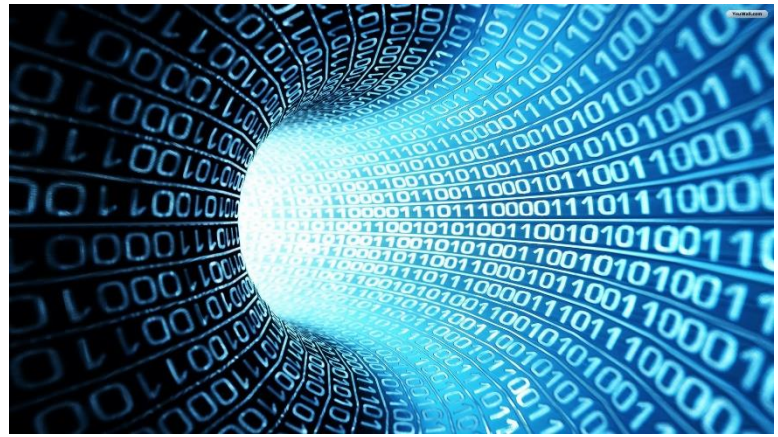






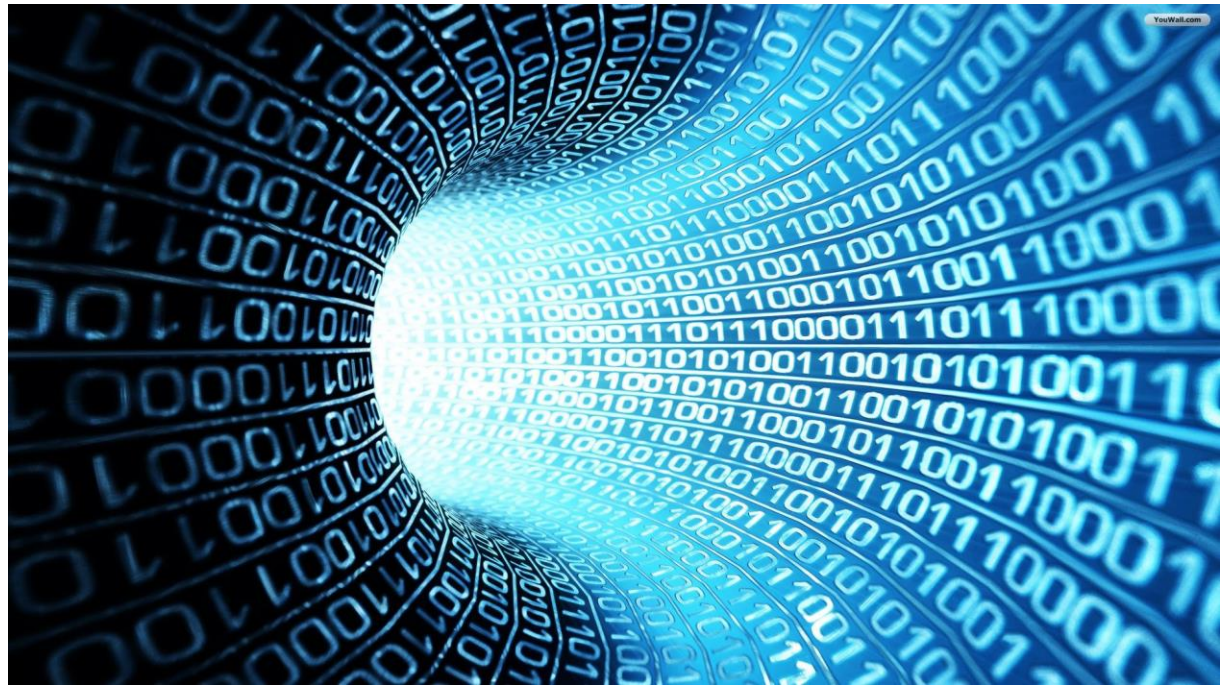
http://vibrio.foodsafetycentre.com.au/

Integrating Sensors and Predictive Models



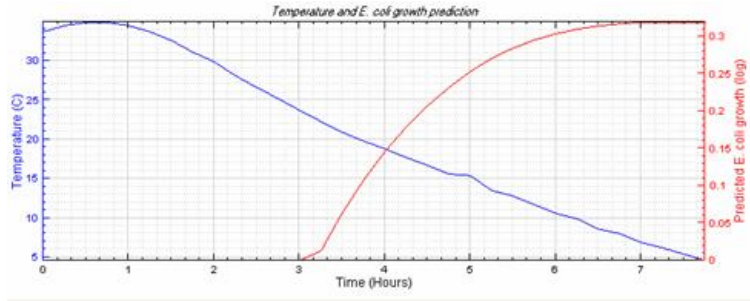
Currently, predictive models are not commonly used in real-time (or even retrospectively), due to lack of data capture.

Sensors are a solution.



Integration of Time Temperature Indicator (TTI) sensors with predictive models for consumer-direct delivery of food products

√growth rate = 0.0303 x (temp-13.37)



ComBase

(www.combase.cc)

ComBase

Home | About | ComBase team | Donate data | FAQ | Contact us

Access ComBase

ComBase is the world's largest, freely-accessible database of quantified microbial responses in diverse food environments.

Freely accessible | 60,000 + records | 42,000 + users

Login/Register

Supported by

USDA United States Department of Agriculture Agricultural Research Service

tia

UNIVERSITY of TASMANIA

A Web Resource for Quantitative and Predictive Food Microbiology

It includes:

- A systematically formatted database of quantified microbial responses to the food environment with more than 50,000 records
- ComBase Predictor and Food Models – to predict the growth and inactivation of microorganisms in food

www.combase.cc

News, Events and Jobs

- 10th International Conference on Predictive Modelling in Food
- Event: IAFP 2015 European Symposium on Food Safety: 20-22nd April 2015, Cardiff, Wales.

See all

Predictive Microbiology and Risk Assessment

Goals

- Support the development of science-based risk management systems by
  - Engaging with the international food microbiology community
  - Providing robust data that describe how food safety and spoilage organisms respond to food environments.

Applications

- Growth/thermal and non-thermal inactivation
- Shelf-life
- Hazard identification
- Product development
- Process deviations

Data Submission

ComBase needs your data

The real success of ComBase is dependent upon the goodwill of those providing data to further populate the database. ComBase is always looking to expand its database with the addition of growth and inactivation curves particularly within food matrices.

How to submit your data

ComBase data must be formatted in a specific way before they can be included in ComBase.

We strongly encourage you to contact Mark Tamplin at mark@combase.cc, before formatting your data.

We provide a **ComBase demo for Excel** that includes an Excel demo file of data and macros that allows you to check if your data format has the proper syntax. Please unzip the file and open it in Excel 2007 or higher. The zip file includes a manual in PDF.

News, Events and Jobs

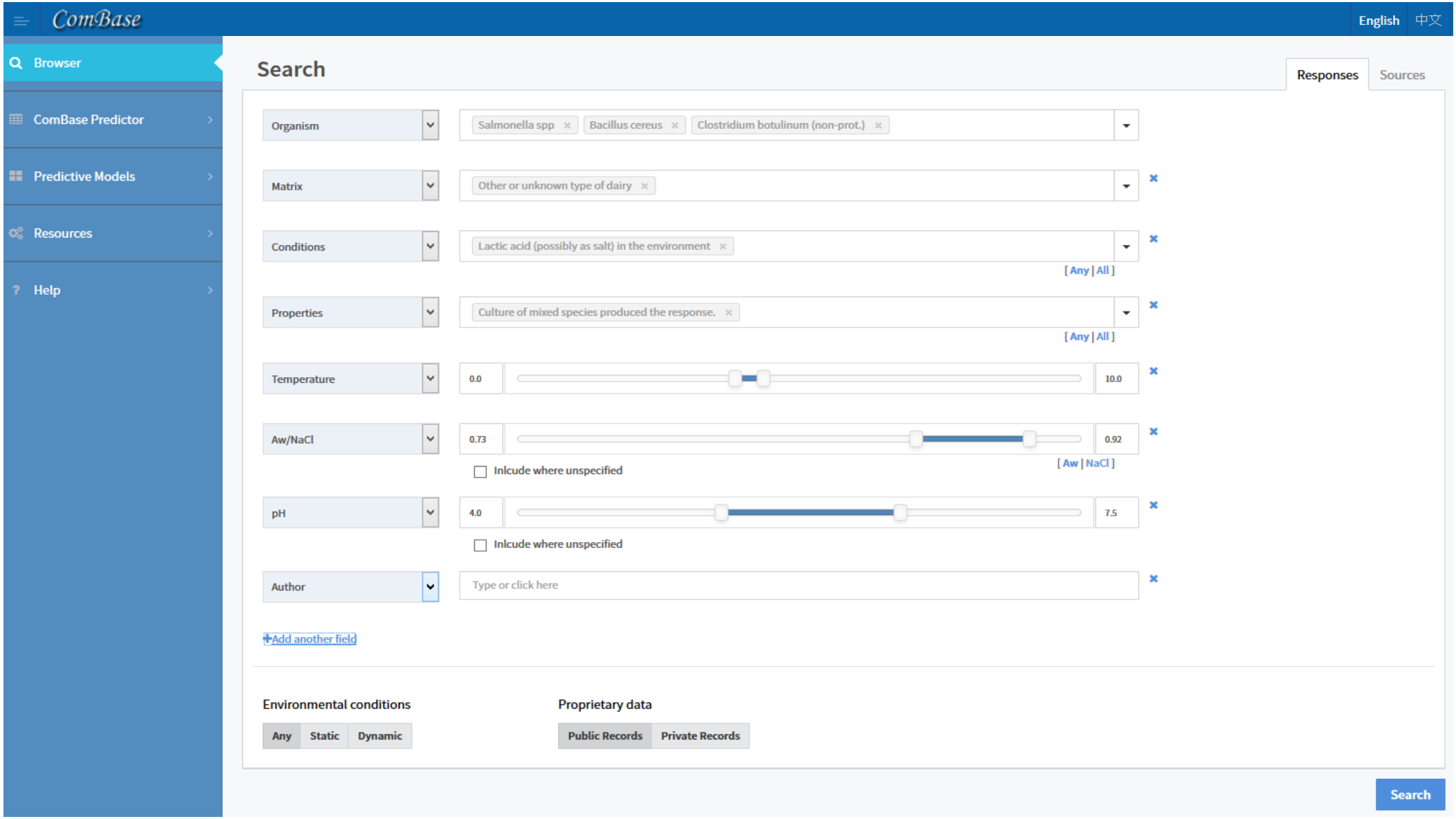
› Event: IAFP 2017 European Symposium on Food Safety: 29-31 March 2017, Brussels, Belgium

Read more...

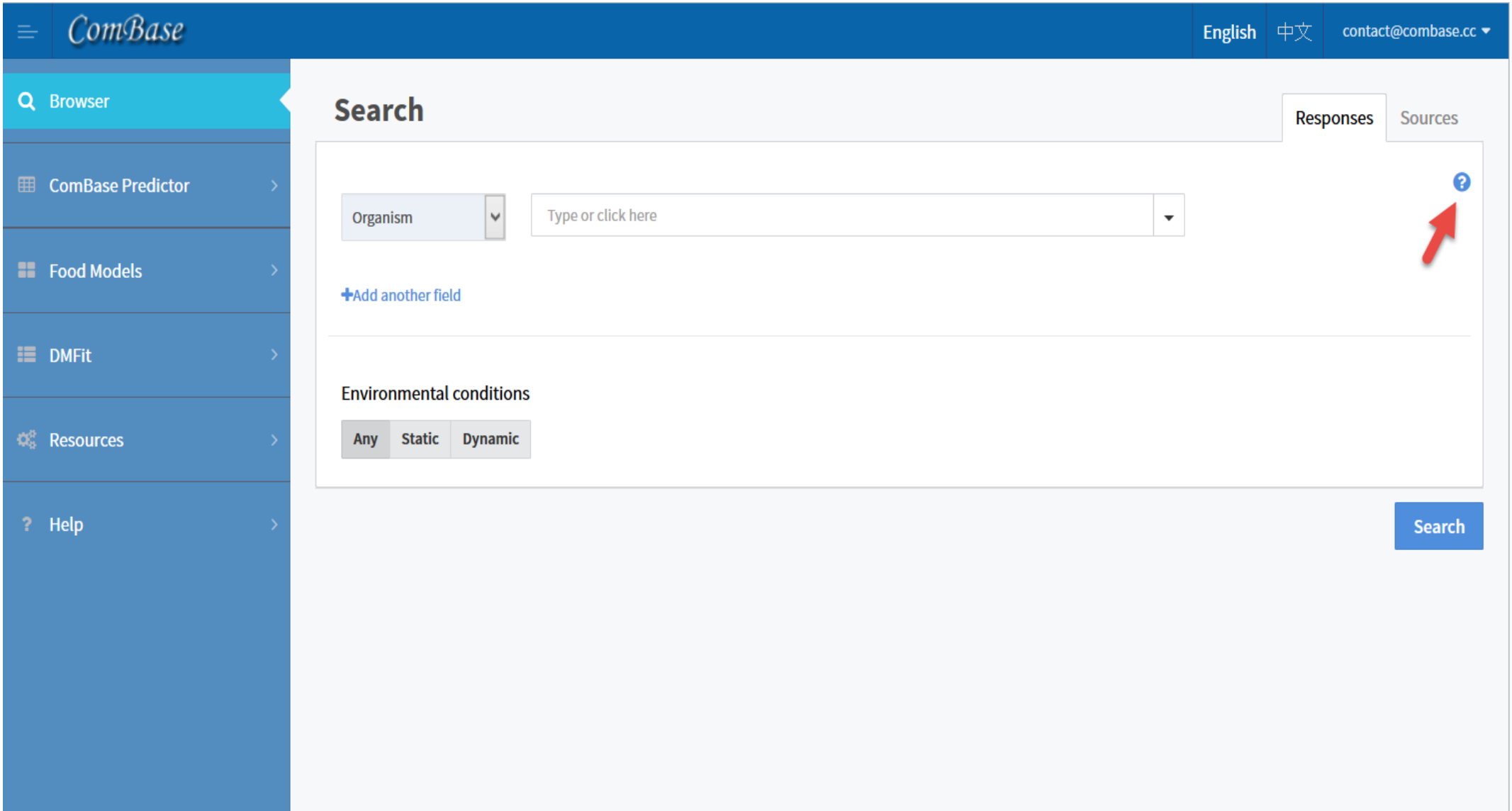
Predictive Microbiology and Risk Assessment News

- Degradation Kinetic Models and Inactivation of Pathogenic Microorganisms by Dimethyl Dicarbonate in Fresh Mmandarin Juice
- Salmonella Survival Kinetics on Pecans, Hazelnuts, and Pine Nuts at Various Water Activities and Temperatures
- Risk Assessment or Assessment of Risk? Developing an Evidence-Based Approach for Primary Producers of Leafy Vegetables To Assess and Manage Microbial Risks

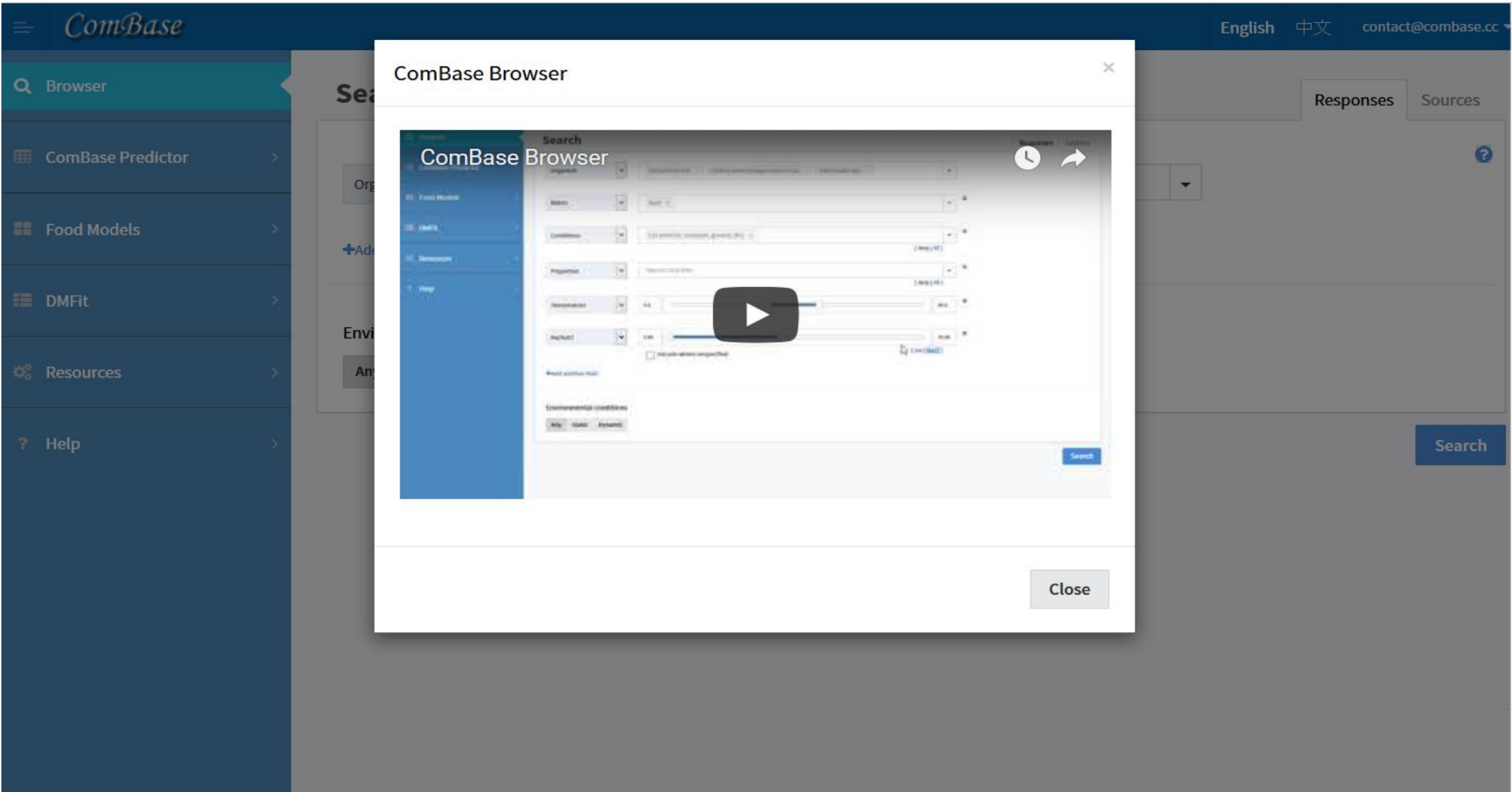
ComBase Browser



Tutorial - Browser



Tutorial - Browser



ComBase Browser

← Back to search

Search results [11995 records]

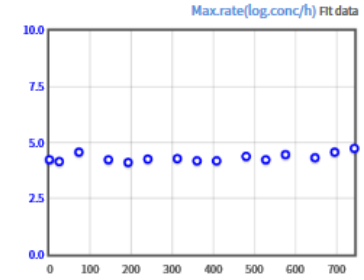
Export ?

Organism (Ascending)

1/1200

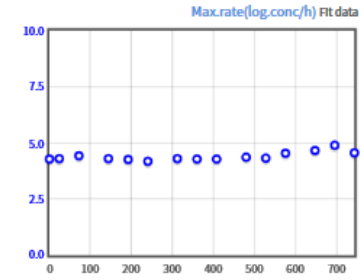
1. ***Listeria monocytogenes/innocua*** **in ground beef**

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	20
Record downloads	2



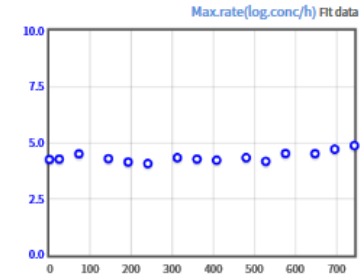
2. ***Listeria monocytogenes/innocua*** **in ground beef**

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	11
Record downloads	3



3. ***Listeria monocytogenes/innocua*** **in ground beef**

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	7
Record downloads	4



Record statistics

← Back to search

Search results [11995 records]

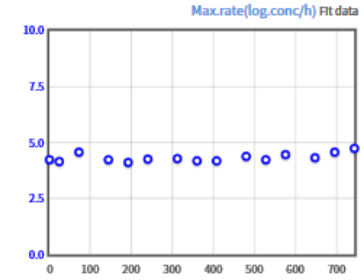
Export ?

Organism (Ascending)

1/1200

1. ***Listeria monocytogenes/innocua*** **in ground beef**

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	20
Record downloads	2



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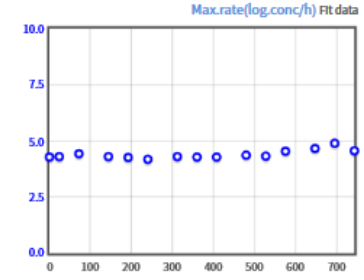
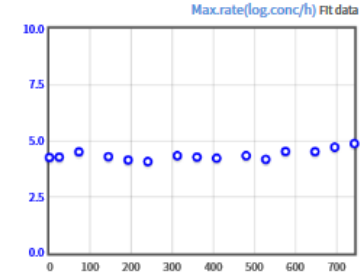
Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	11
Record downloads	3



3. ***Listeria monocytogenes/innocua*** **in ground beef**

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	7
Record downloads	4



Record views and downloads

ComBase Browser

← Back to results

Previous | Next

Export to csv

Bacillus cereus in broth

ID: *GMW_1055*

Matrix	Culture medium
Temperature (°C)	10
Aw | NaCl	0.997 (assumed)
pH	7

Source
Choma (et al.), 2000: Effect of temperature on growth characteristics of Bacillus cereus TZ415

Conditions

Properties

Further specifications
Strain(s): T2415

Details
No details specified

Measurement
By colony counts.

Record views/downloads*

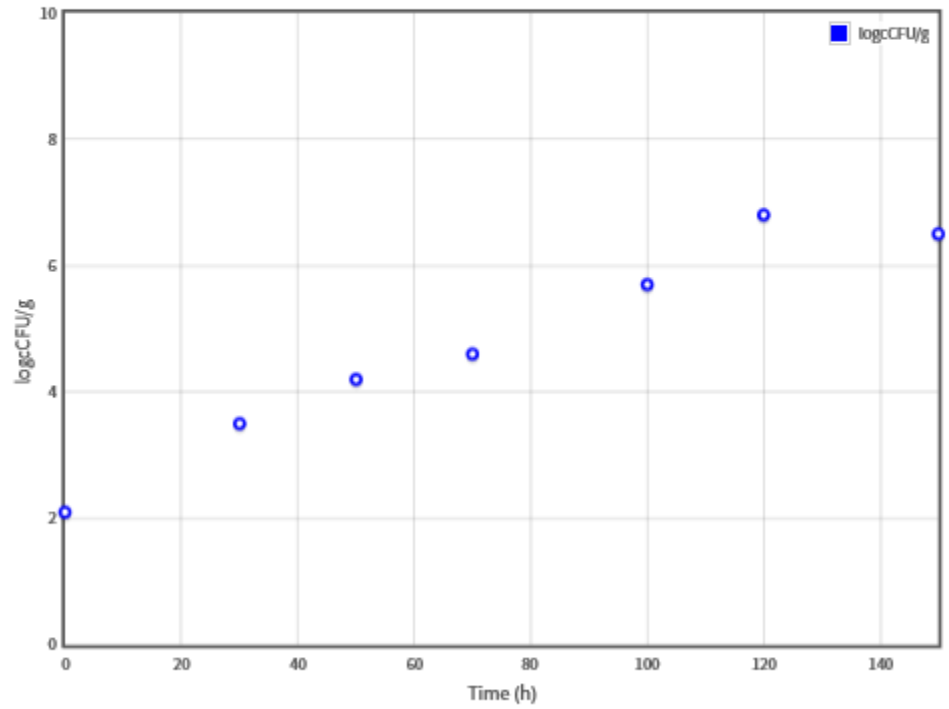
Viewed	6 times
Downloaded	2 times

*since September, 2017

Max.rate(logc.conc/h) Fit data

Chart | Data

Prediction | Fit



ComBase Browser

← Back to results

Previous | Next

Export to csv

Bacillus cereus in broth

ID: *GMW_1055*

Matrix	Culture medium
Temperature (°C)	10
Aw | NaCl	0.997 (assumed)
pH	7

Source
Choma (et al.), 2000: Effect of temperature on growth characteristics of Bacillus cereus TZ415

Conditions

Properties

Further specifications
Strain(s): T2415

Details
No details specified

Measurement
By colony counts.

Record views/downloads*

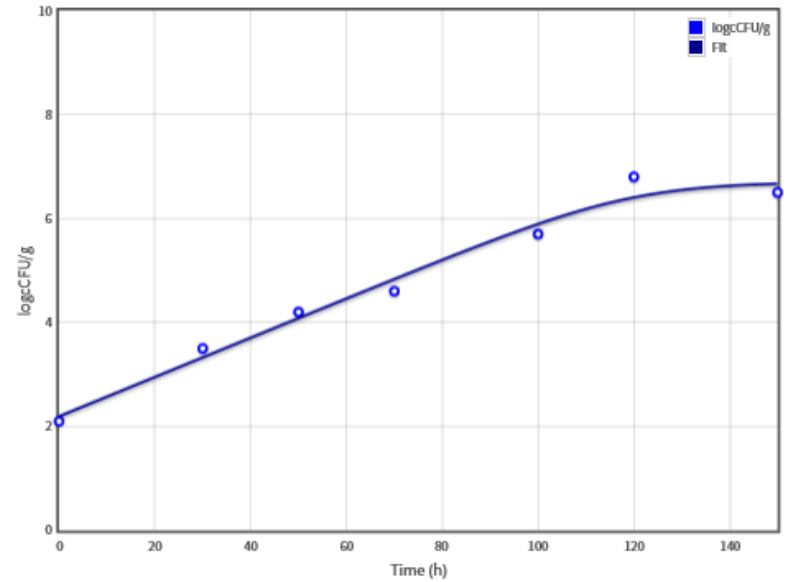
Viewed	6 times
Downloaded	2 times

* since September, 2017

Max.rate(logc.conc/h) Fit data

Chart | Data

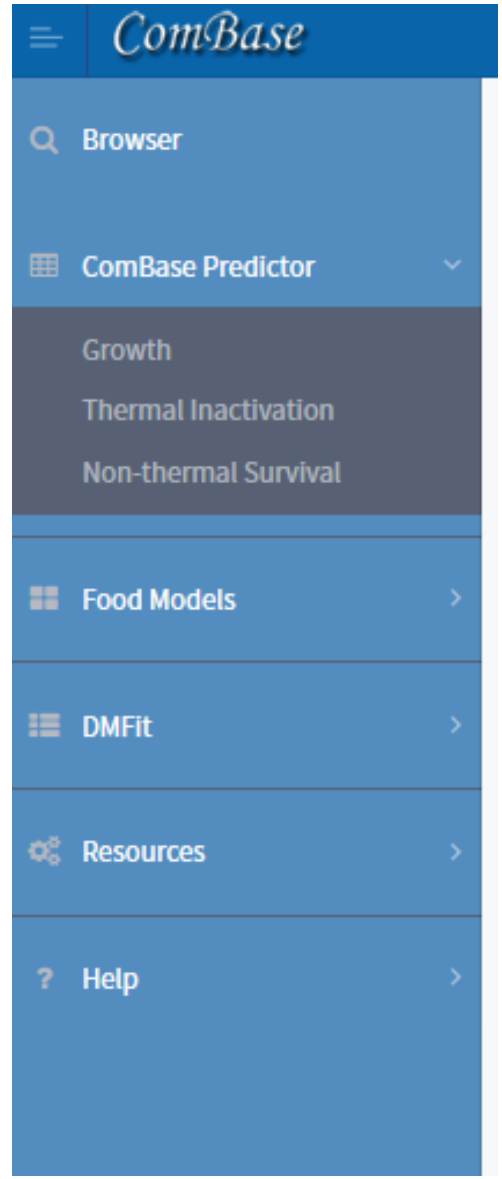
Prediction | Fit



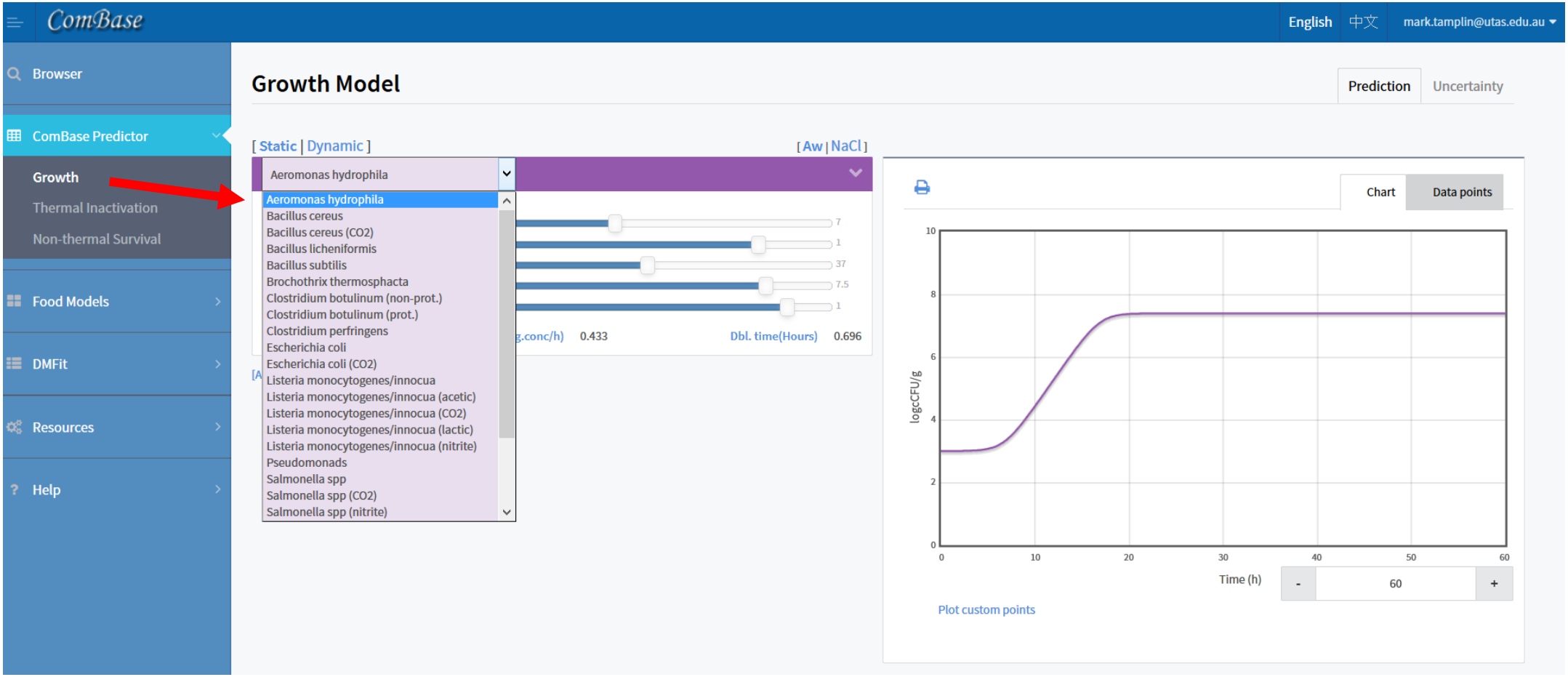
Baranyi and Roberts Model (no lag) [fit]

R-square:	0.971
SE of Fit:	0.287
Initial value	2.194 ± 0.232
Max. Rate	0.0378 ± 0.00402
Final Value	6.7 ± 0.302

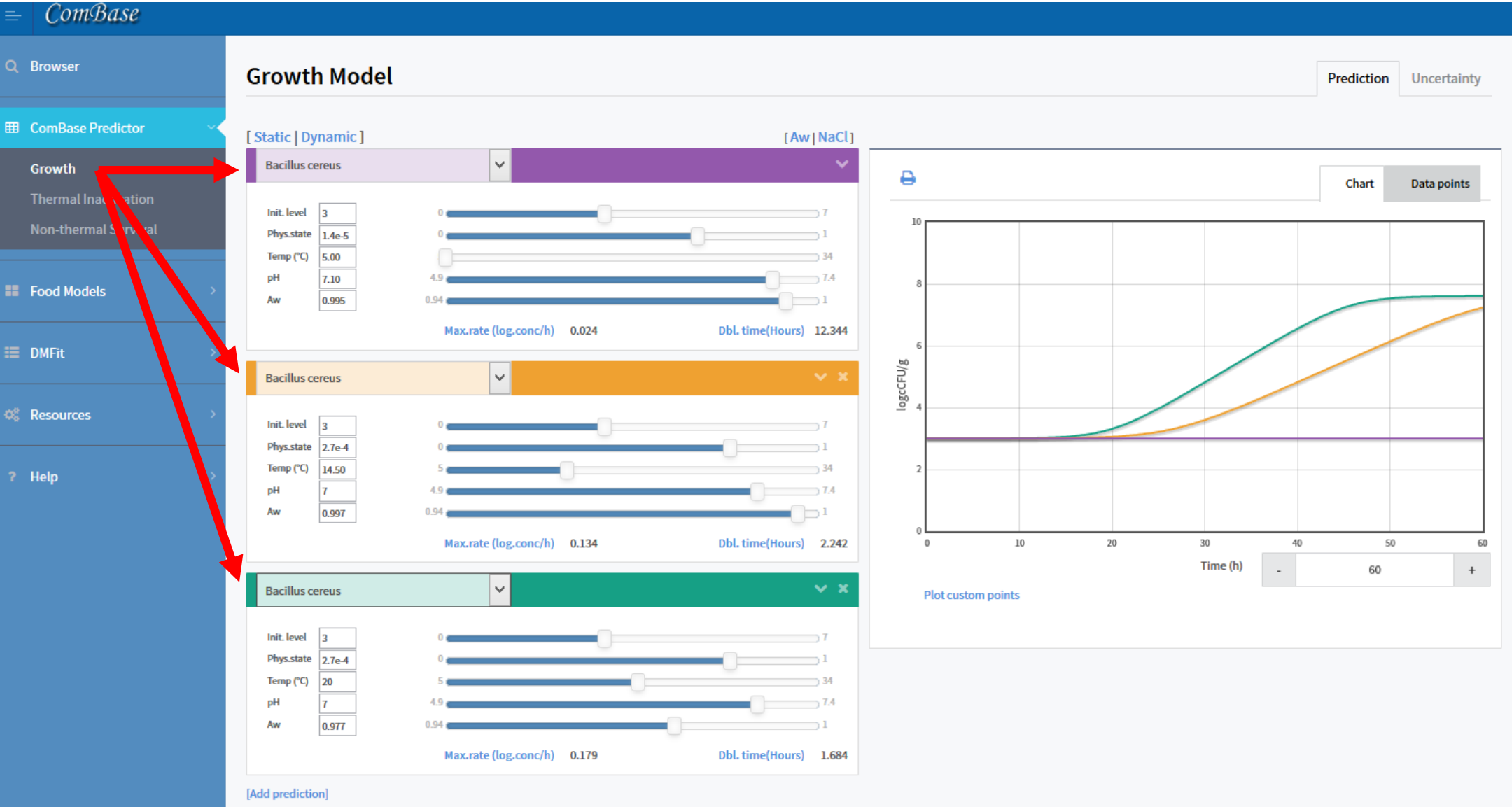
ComBase Predictor



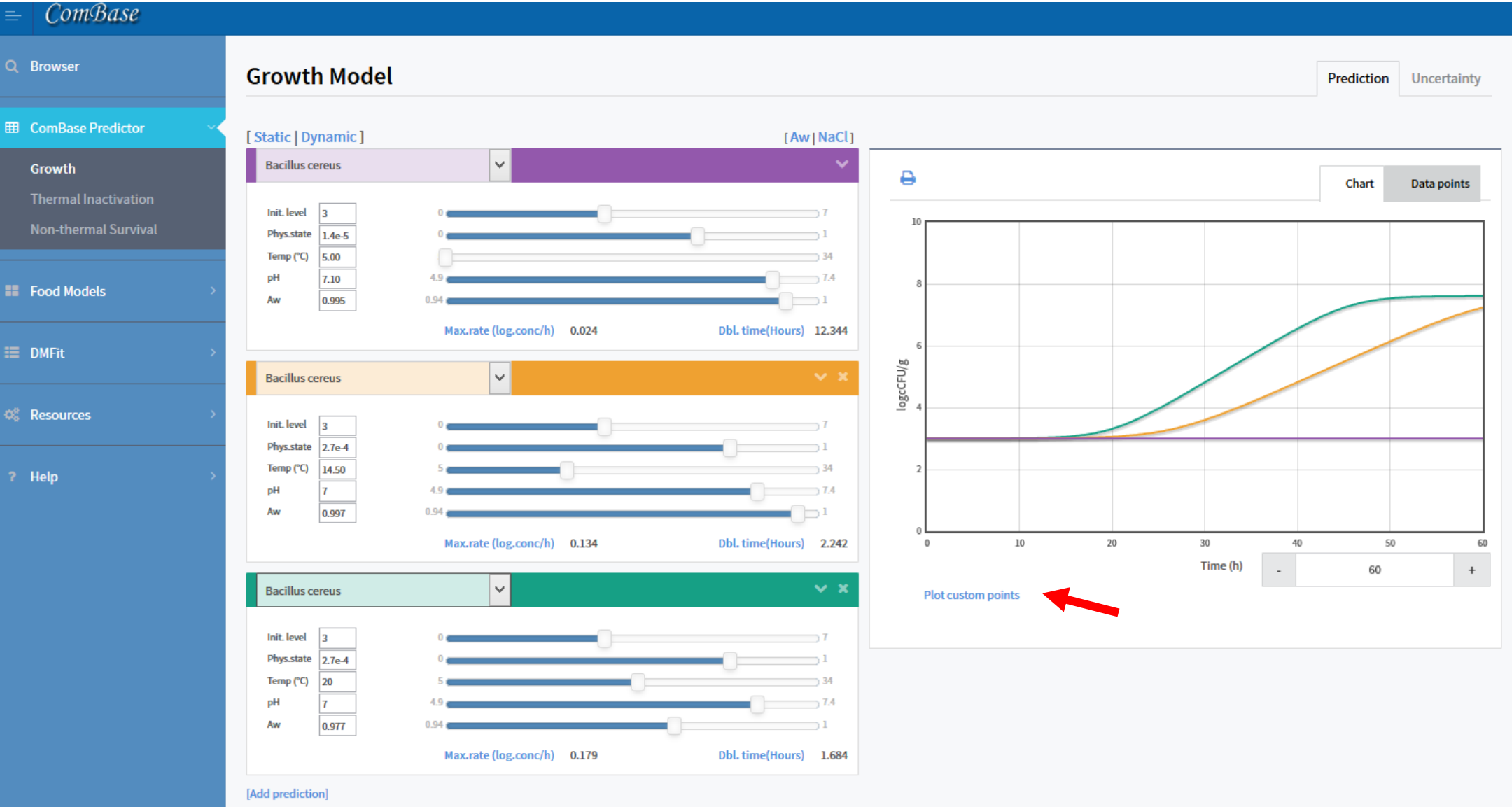
Growth Models



Growth Models



Customized data



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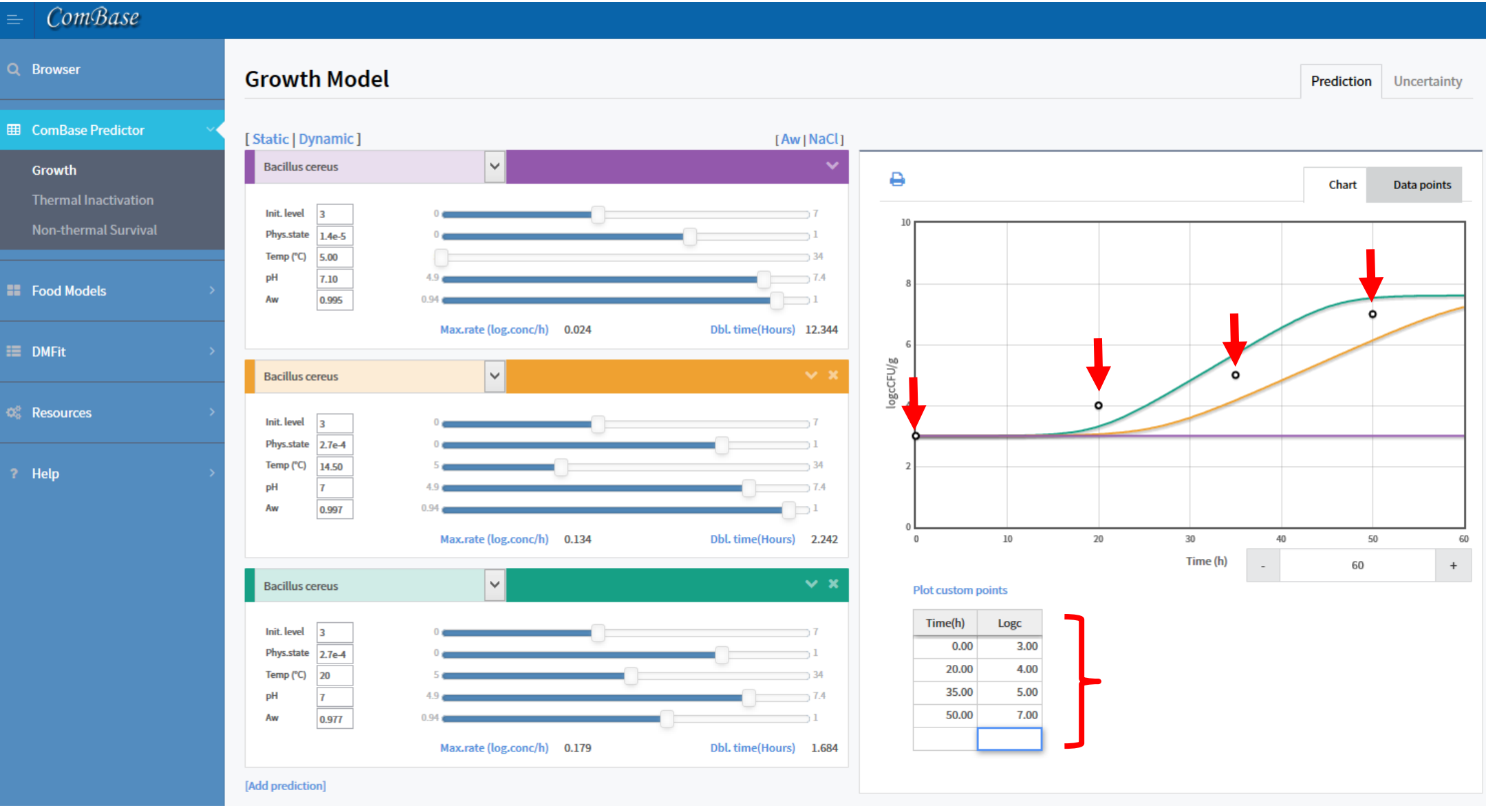
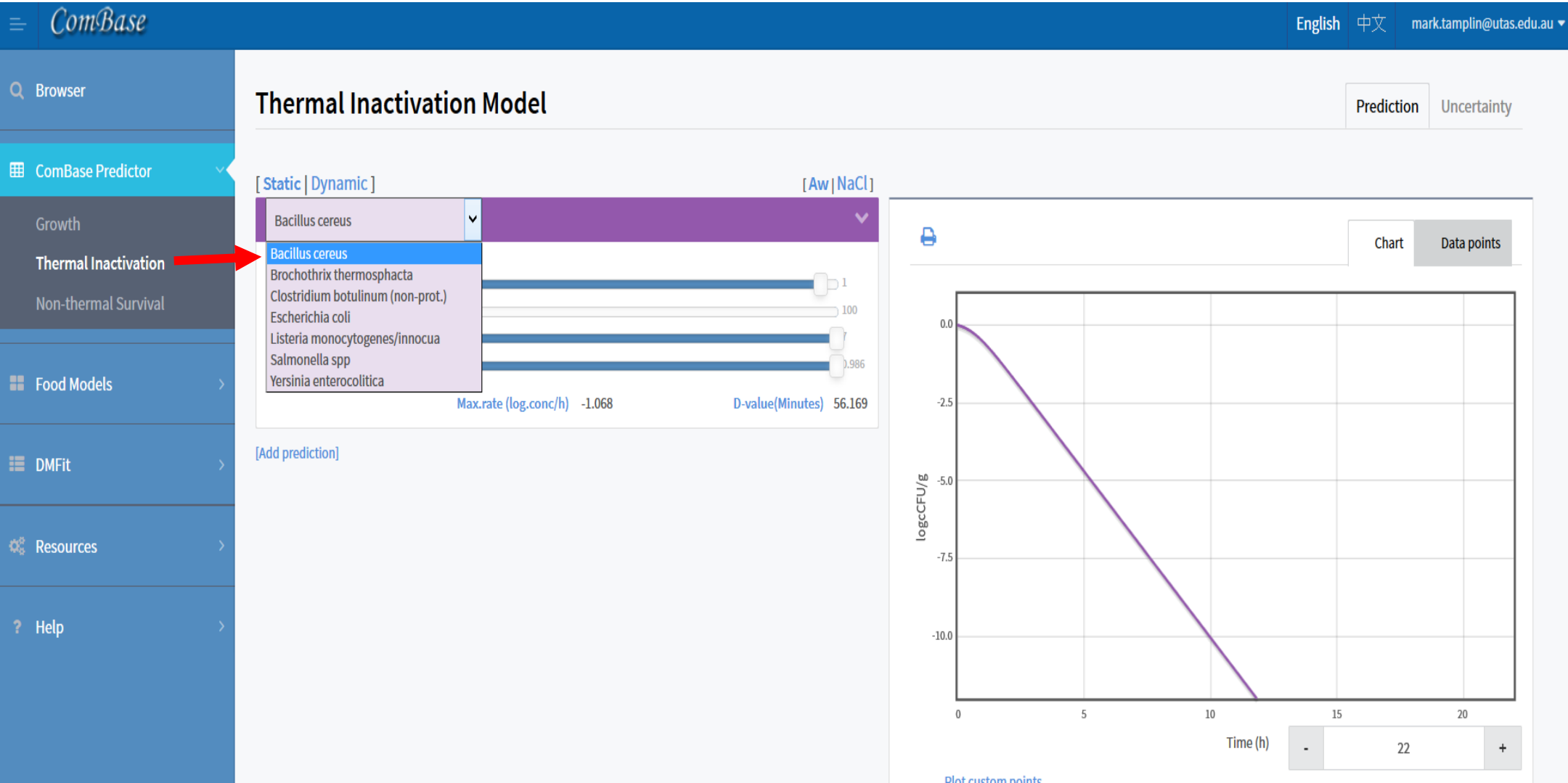
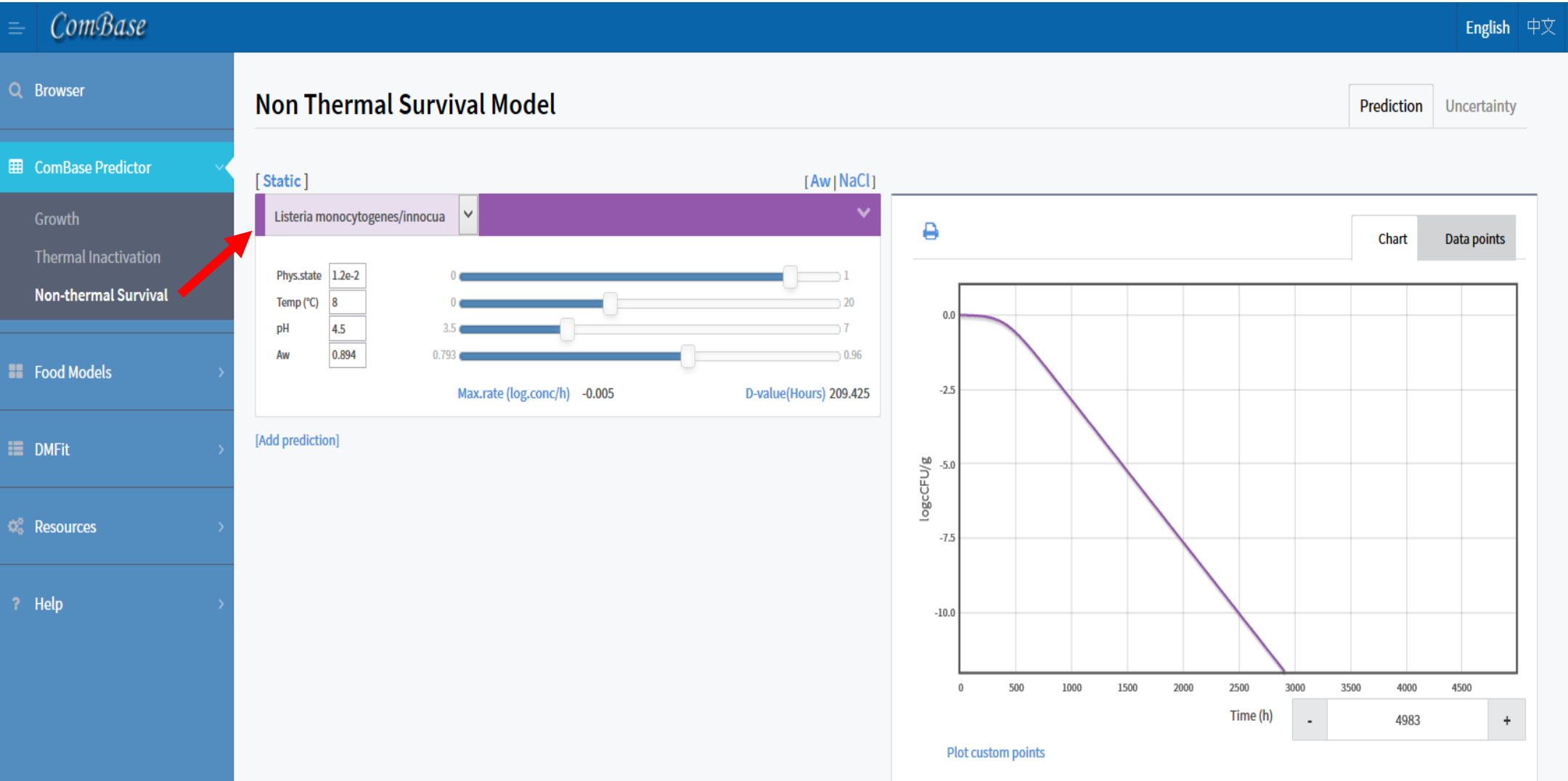


Thermal inactivation



Non-thermal inactivation



Perfringens Predictor

ComBase

- Browser
- ComBase Predictor
- Food Models
  - Perfringens Predictor
  - Salmonella in egg
- DMFit
- Resources
- Help

Perfringens Predictor

Uncured meat | Cured meat

pH [5.2-8.0] 5.2

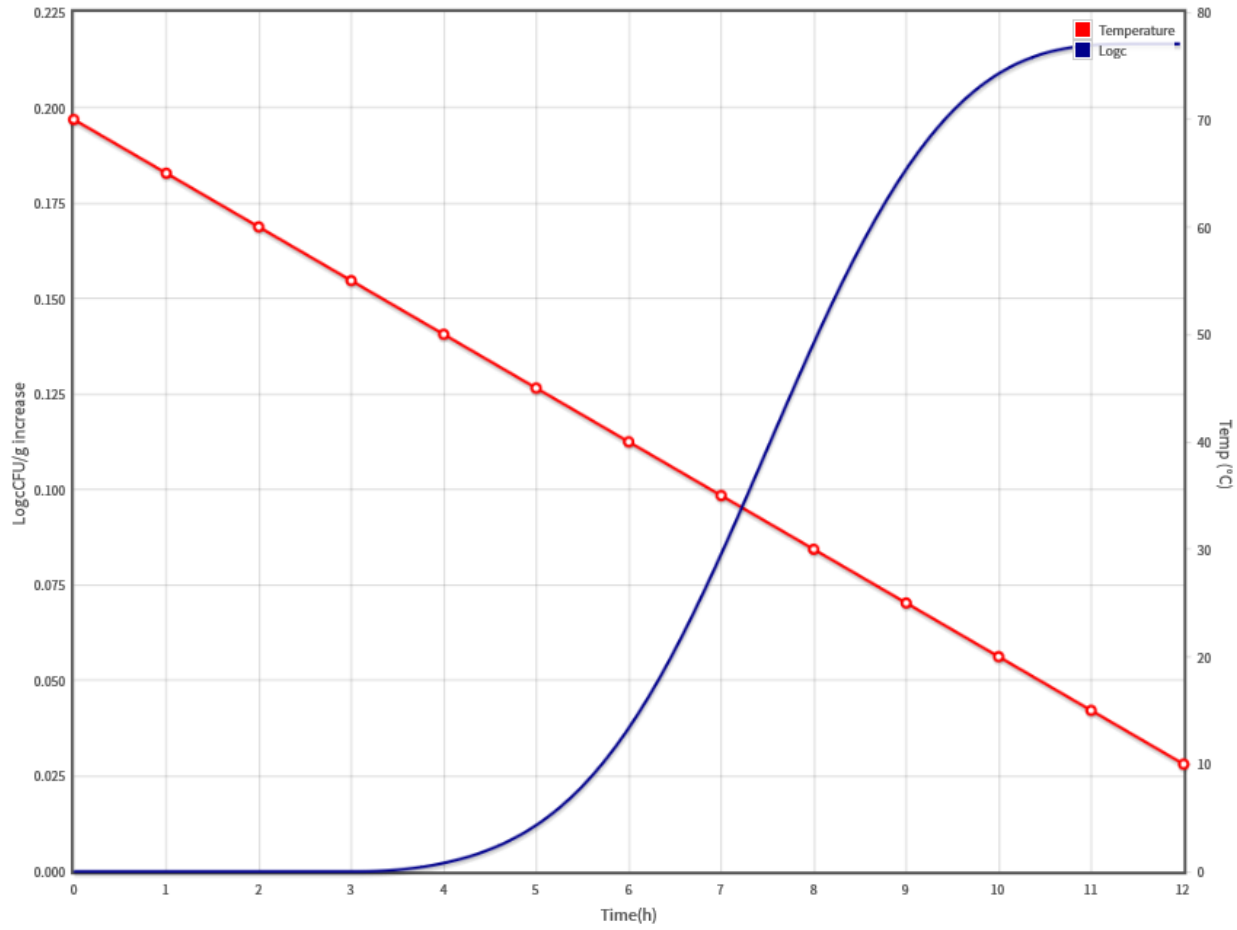
[Aw | NaCl]

NaCl (%) [0-4] 2

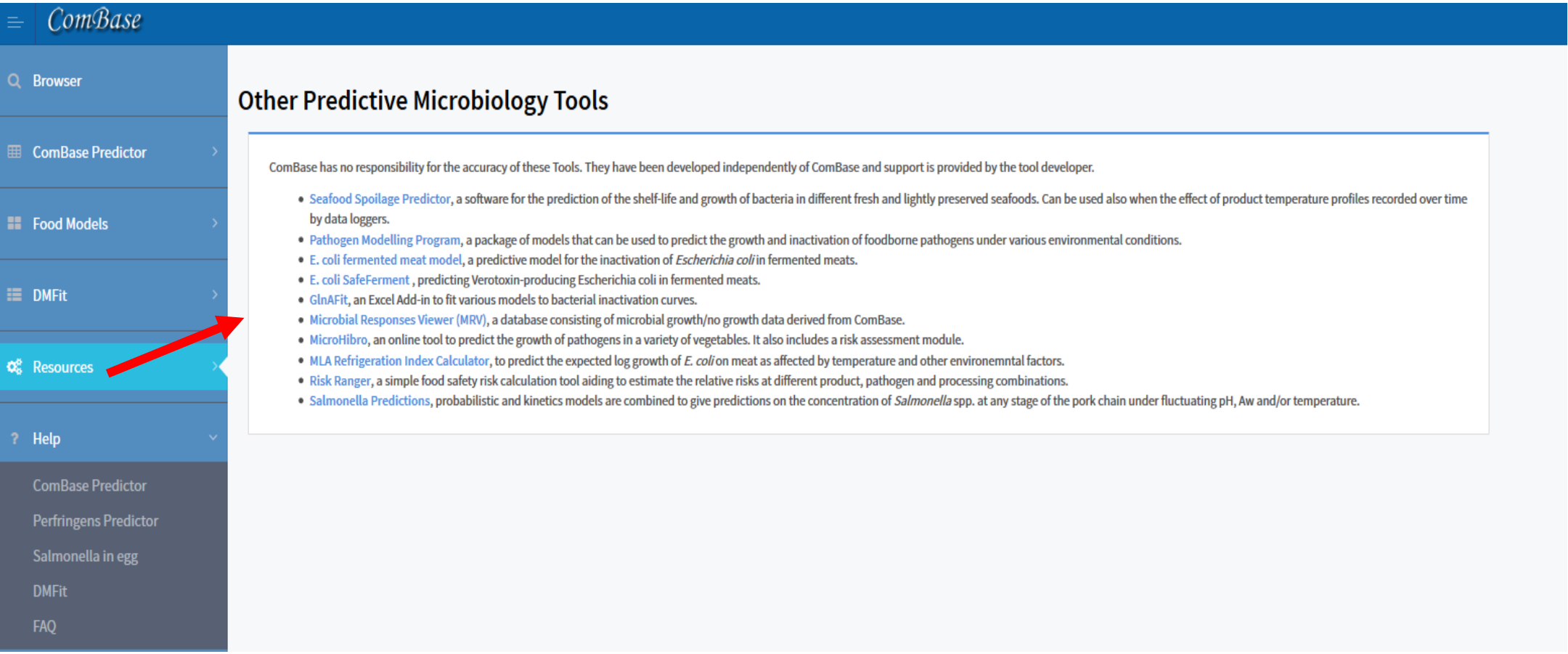
Time(h)	Temp (°C)
0.00	70.00
1.00	65.00
2.00	60.00
3.00	55.00
4.00	50.00
5.00	45.00
6.00	40.00
7.00	35.00
8.00	30.00
9.00	25.00
10.00	20.00
11.00	15.00
12.00	10.00

Predict

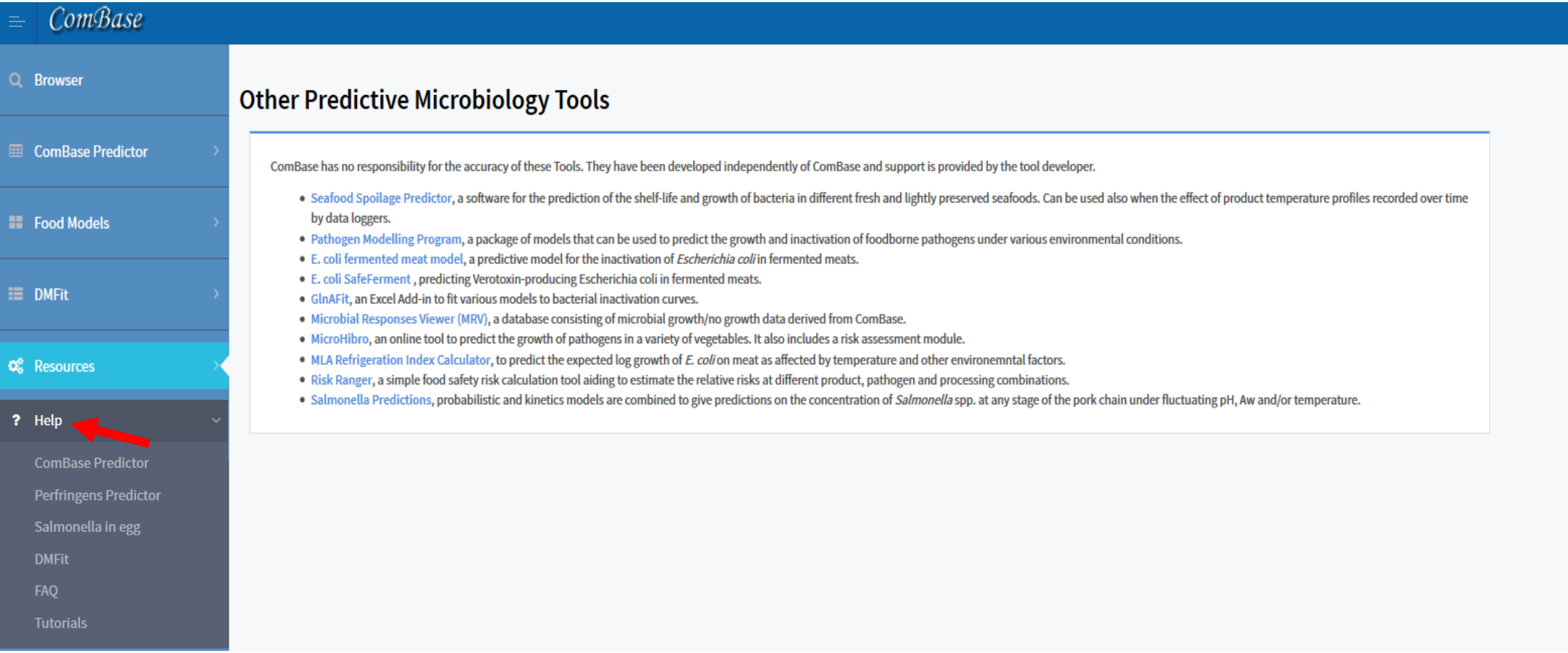
Chart | Data points



Links to other model resources



Help Functions



Thank you for your attention.