#GOALConf18

Reputation at Risk: How Animal Welfare, Antimicrobial Resistance and Social Responsibility Are Shaping Consumer Perception

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Power of Collaboration

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Liz is a professor at the University of Warwick's School of Life Sciences. She is involved in the study of bacteria in soil and survival of pathogenic bacteria in the environment. Her expertise is in the detection, quantification and analysis of soil microbial communities, including the identification of pathogen reservoirs outside of their hosts. She earned her Ph.D. from the University of Liverpool.

Antimicrobial resistance and aquaculture

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AMR is a global issue

World Health Organization

unicef

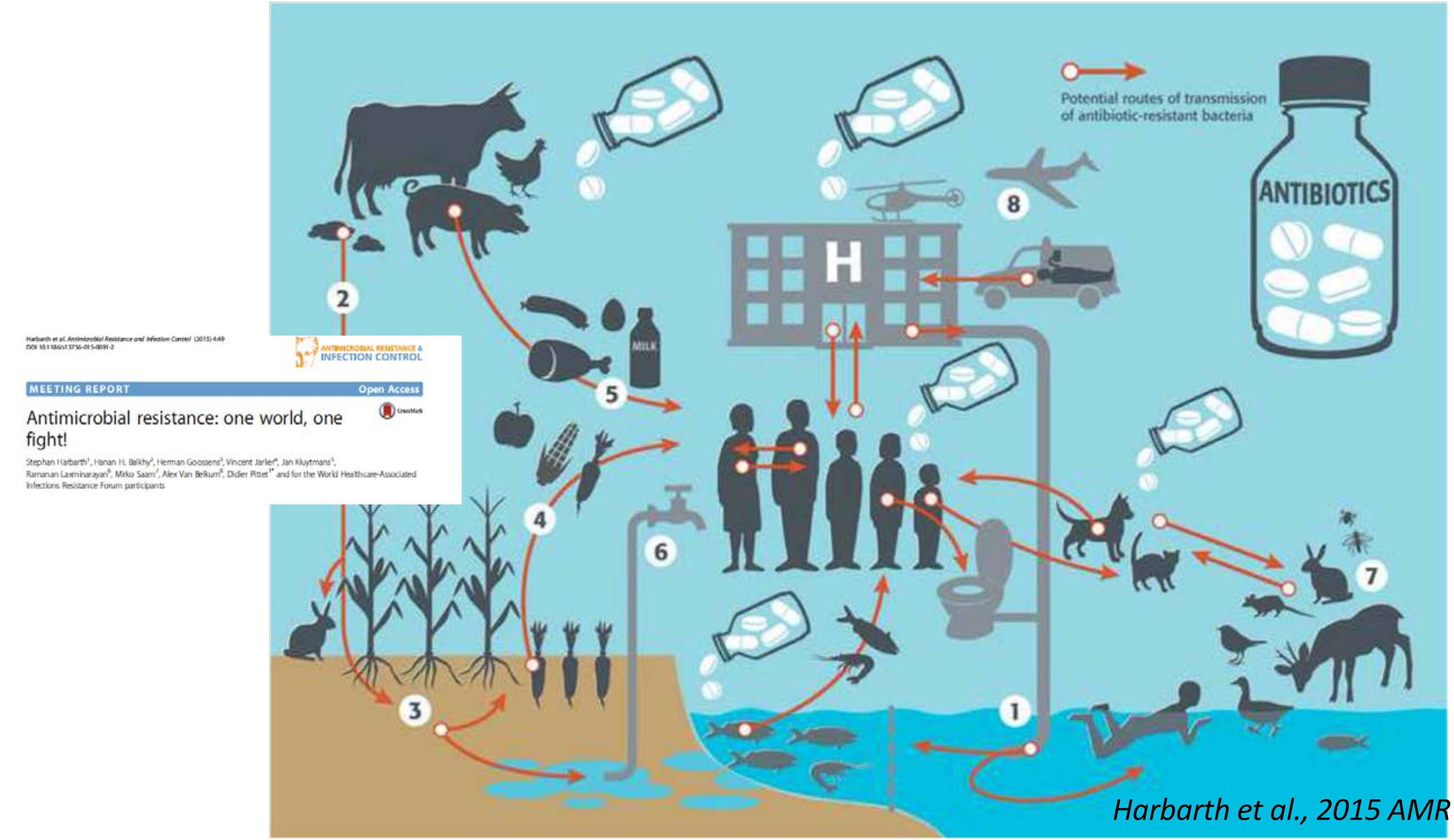
TACKLING ANTIMICROBIAL RESISTANCE:

Supporting national measures to address infection prevention and control and water, sanitation and hygiene in health care settings

Antimicrobial resistance (AMR) presents a significant threat to human health. World leaders have agreed that tackling AMR will require addressing both health and agriculture concerns with a focus on prevention. Improving **infection prevention and control (IPC)** and **water, sanitation, and hygiene (WASH)** is one of the five objectives in the World Health Organization's (WHO) AMR Global Action Plan. Nowhere is reducing infection more important than in health care facilities. Joint, immediate action to address IPC and WASH is essential.

WHO 2017

One health perspective



Harbarth et al. Antimicrobial Resistance and Infection Control (2015) 4:49
DOI 10.1186/s13756-015-0091-2

ANTIMICROBIAL RESISTANCE & INFECTION CONTROL

MEETING REPORT Open Access

Antimicrobial resistance: one world, one fight!

Stephan Harbarth[1], Hanan H. Balkhy[2], Herman Goossens[3], Vincent Jarlier[4], Jan Kluytmans[5], Ramanan Laxminarayan[6], Mirko Saam[7], Alex Van Belkum[8], Didier Pittet[1*] and for the World Healthcare-Associated Infections Resistance Forum participants

Harbarth et al., 2015 AMR & Infect Control

Characteristics of antibiotic use (ABU) in aquaculture

- Aquaculture systems are complex and dynamic, with many factors driving the (mis)use of antibiotics
- ABU in aquaculture is different to that in humans and livestock, since it is administered directly in to the aquatic environment usually through medicated feed
- Antibiotics and feed are often supplied separately in aquaculture. This means that farmers have to mix the antibiotics with the feed, resulting in a high risk of occupational exposure
- Fish do not metabolise antibiotics effectively, and it has been estimated that 75% of the antibiotics fed to fish will be excreted back in their active form in to the aquatic environment through faeces
- Aquaculture systems are often linked to the natural water environment, facilitating contamination of the environment and waterways, and having the potential to lead to the emergence and dissemination of ABR further than terrestrial livestock systems

Growth of food animal production > thirty years from 1980 and aquaculture sector in 2014

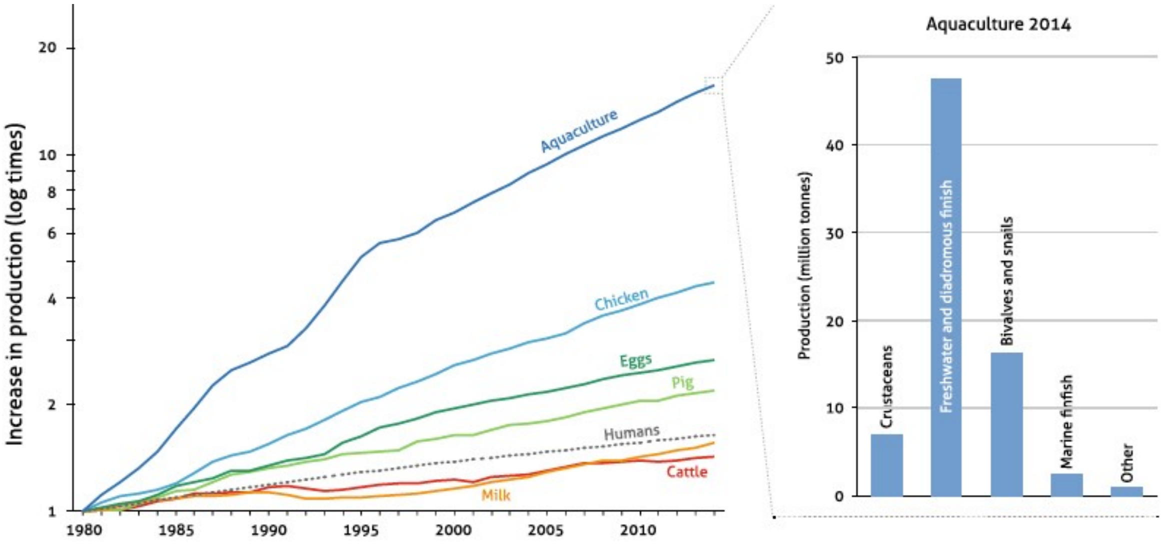


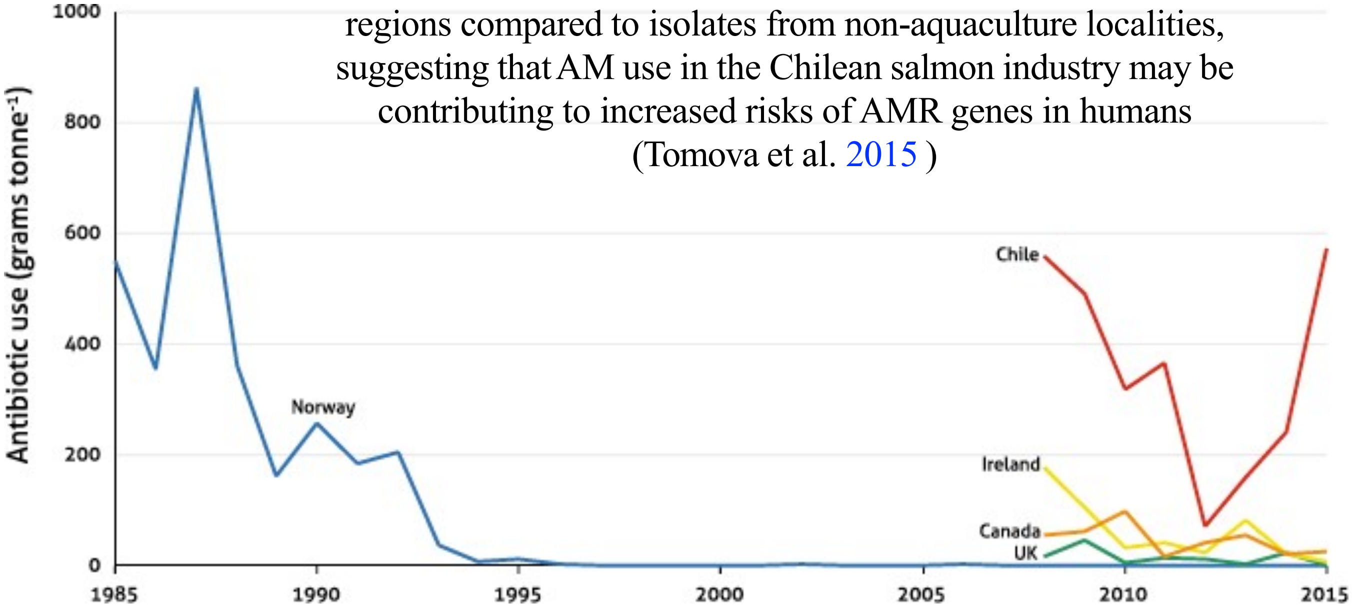
Fig. 1 Proportionate growth of the human population, aquaculture, poultry, pigs, and cattle between 1980 and 2013, and the present composition of the aquaculture sector *Source* (FAO 2016a; The World Bank 2017; FAO 2016b)

Springer

Henriksson etal., 2017 Sustain Sci.

Antibiotic use in Atlantic salmon farming- major producers

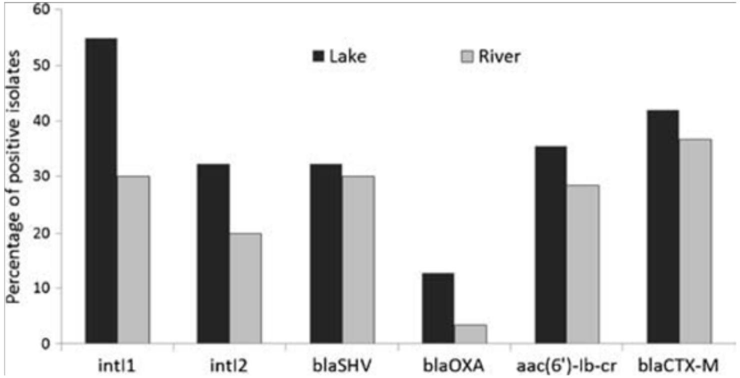
Significantly higher frequencies of AMR genes in urinary *Escherichia coli* isolates from Chileans living in aquaculture regions compared to isolates from non-aquaculture localities, suggesting that AM use in the Chilean salmon industry may be contributing to increased risks of AMR genes in humans (Tomova et al. 2015)



Tomova et al. 2015

Elevated AMR in bacteria from farmed fish

ARG biomarkers farming



Rivers and lakes in Pune, India

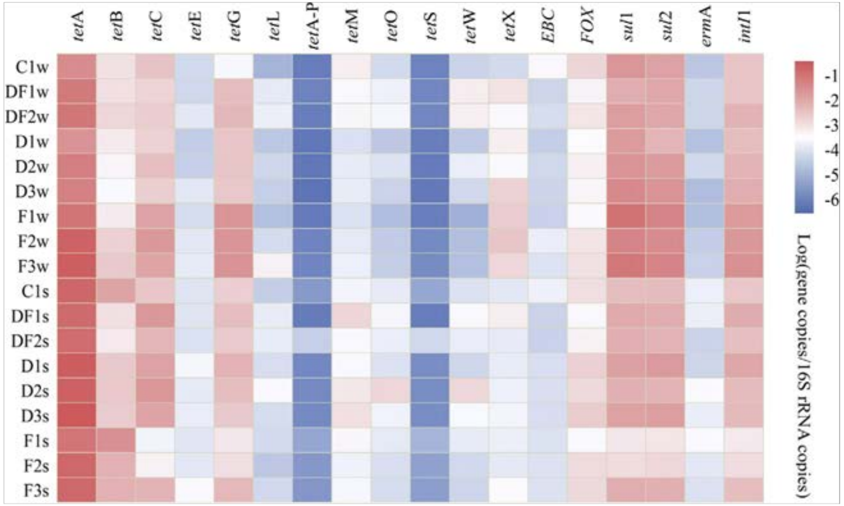


Fig. 3. A "heat map" of resistance genes in eighteen samples. Sample names were abbreviated with letters representing pond and sample type: capital C, DF, D and F (control pond, duck-fish pond, duck pond and fish pond) and lower case w and s (water sample and sediment sample). The different colored cells represent the Log (relative abundance) values of genes. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

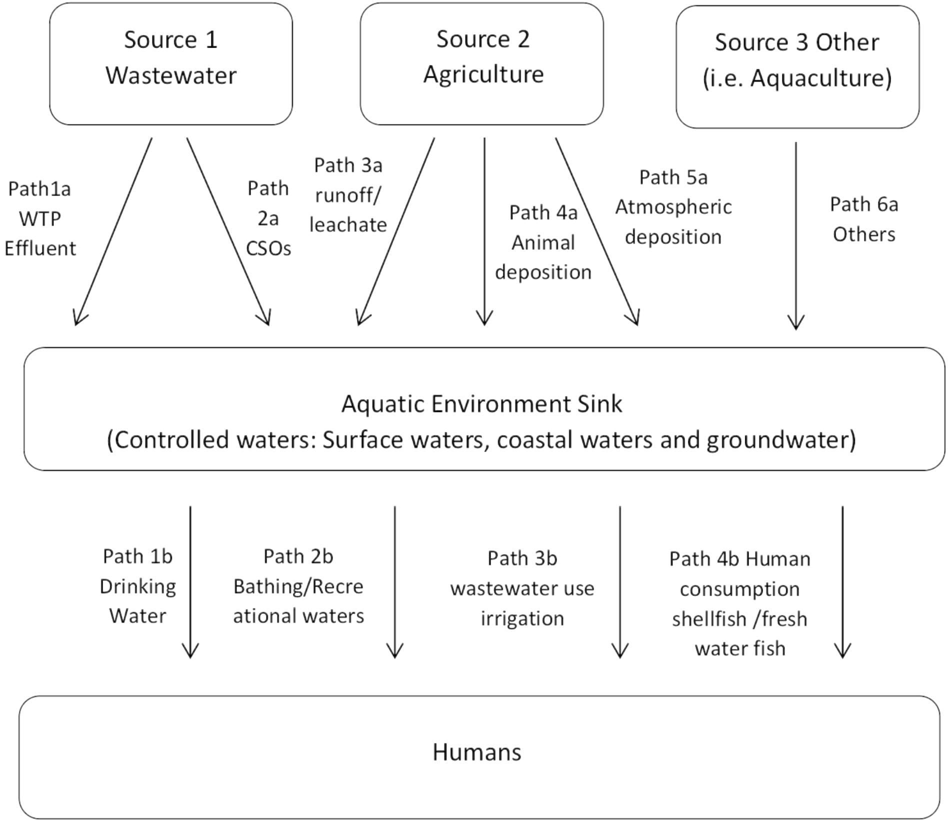
Pearl river delta, South China

Marathe et al. J. Biosci. 41(3), September 2016, 341–346
Indian Academy of Sciences 341

Huang et al., Chemosphere 2018

Report for Defra UK Gov

Systems Map AMR/ARGs Flows



Source 1
Wastewater

Source 2
Agriculture

Source 3 Other
(i.e. Aquaculture)

Path1a
WTP
Effluent

Path
2a
CSOs

Path 3a
runoff/
leachate

Path 4a
Animal
deposition

Path 5a
Atmospheric
deposition

Path 6a
Others

Aquatic Environment Sink
(Controlled waters: Surface waters, coastal waters and groundwater)

Path 1b
Drinking
Water

Path 2b
Bathing/Recreational waters

Path 3b
wastewater use
irrigation

Path 4b Human
consumption
shellfish /fresh
water fish

Humans

James et al., 2018 draft report commissioned by Defra UKGov

Thames Investigation

-69 sites located along the Thames catchment were chosen for sampling.

-Sampling begins at the source of each tributary and continues along the tributary where potential sources of AMR (eg. WWTPs and fish farms) are located.

🟨 Routinely monitored by CEH

🟥 Extra sites chosen for study

qPCR Targets

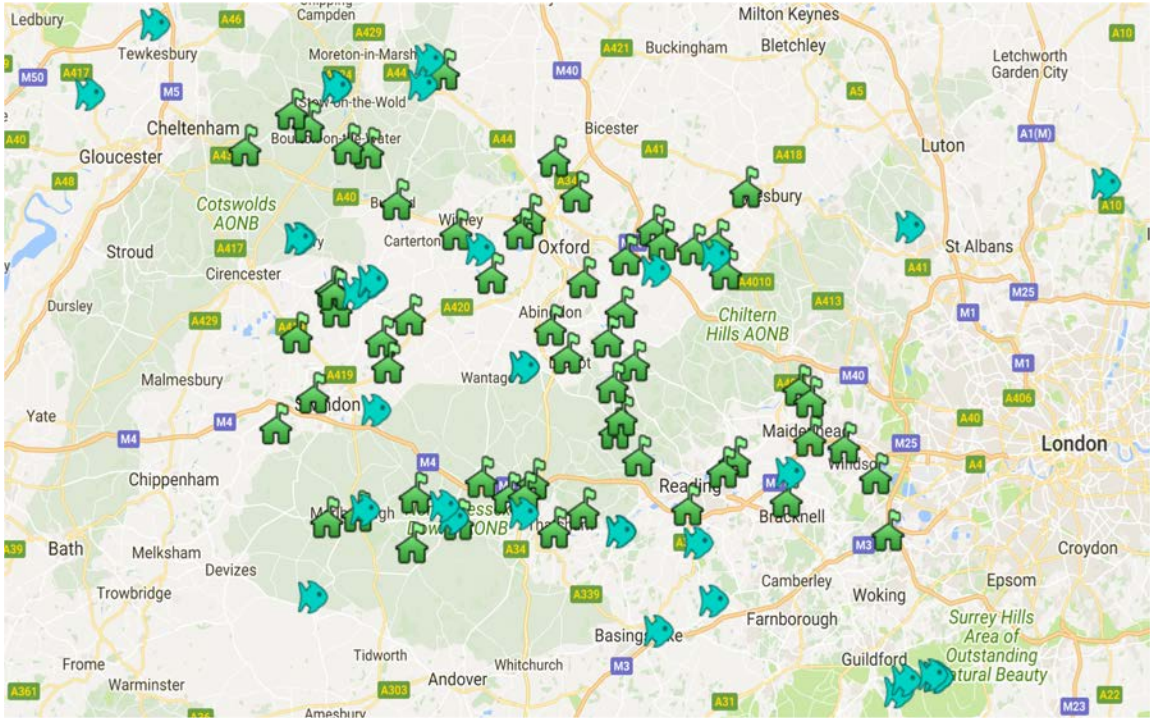
Gene Target	Resistance to/Marker
16S rDNA	bacterial marker
IntI1	class 1 integron
QacE	quaternary ammonium compounds
TetM	Tetracycline
RuBac	Ruminant assoc. Bacteroides
HuBac	Human assoc. Bacteroides
QnrS	fluoroquinolones
ErmF	erythromycin (macrolide)
CTX-M (Group 1)	CTX-M-1 and 15 (beta lactams)
E. coli	faecal contamination
Enterococci	faecal contamination

-DNA was purified from triplicate samples and qPCR was used to determine resistance loads at each site.

-16s rDNA amplicon sequencing on all sites

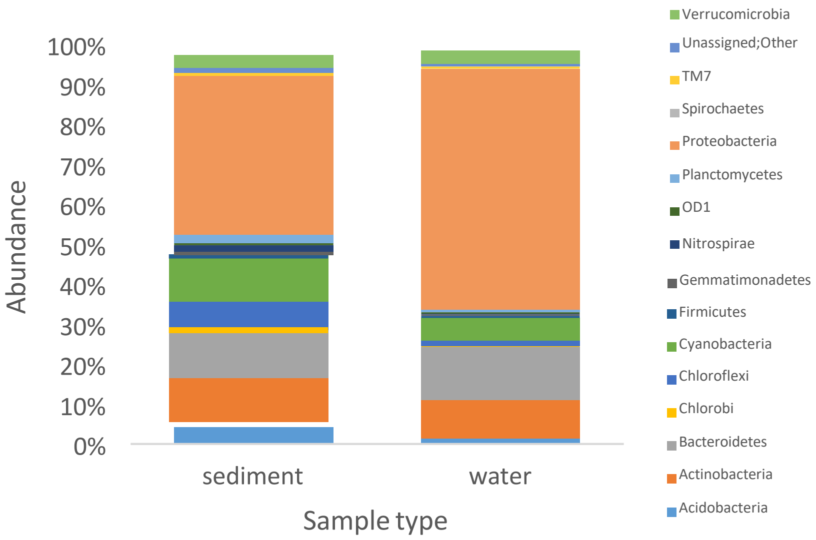
-Metagenomes on 20 core sites

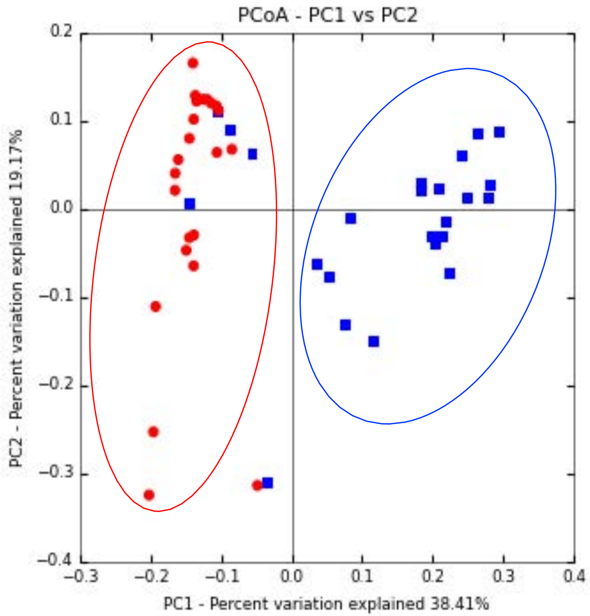
Location of fish farms and wastewater treatment plants



Sampling Planktonic and Benthic Phases

-Planktonic and benthic phases differed significantly in phyla abundance.
-Benthic phases displayed higher bacterial diversity compared to planktonic phase





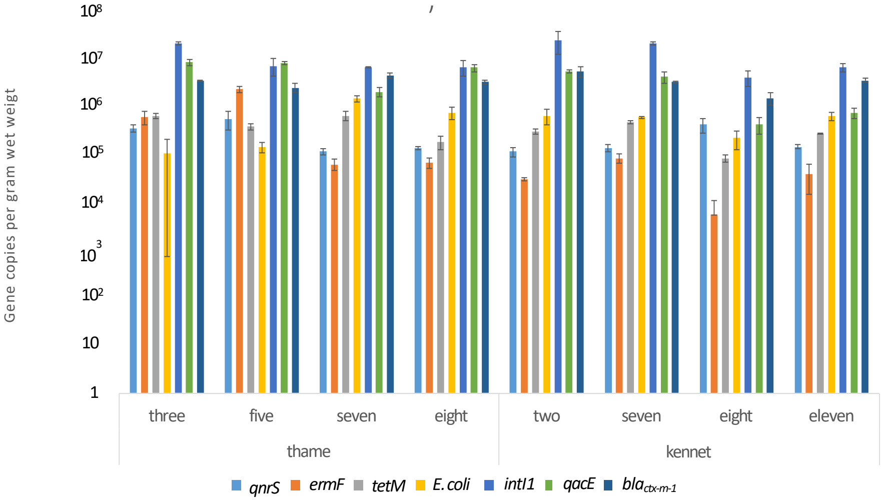
Red=sediment; blue= water

Gemma Hill

Benthic phase contains higher bacterial loads

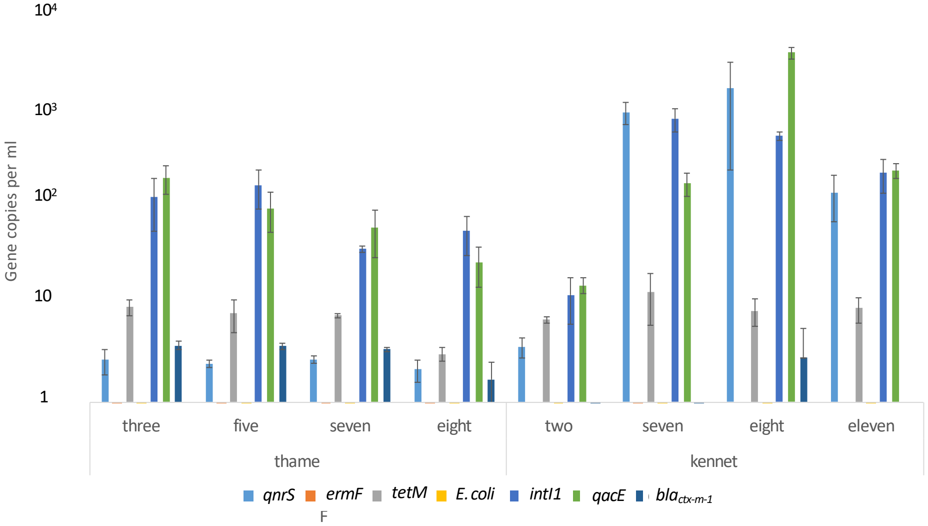
Benthic

Total bacterial load: 10^8cells/gram



Planktonic

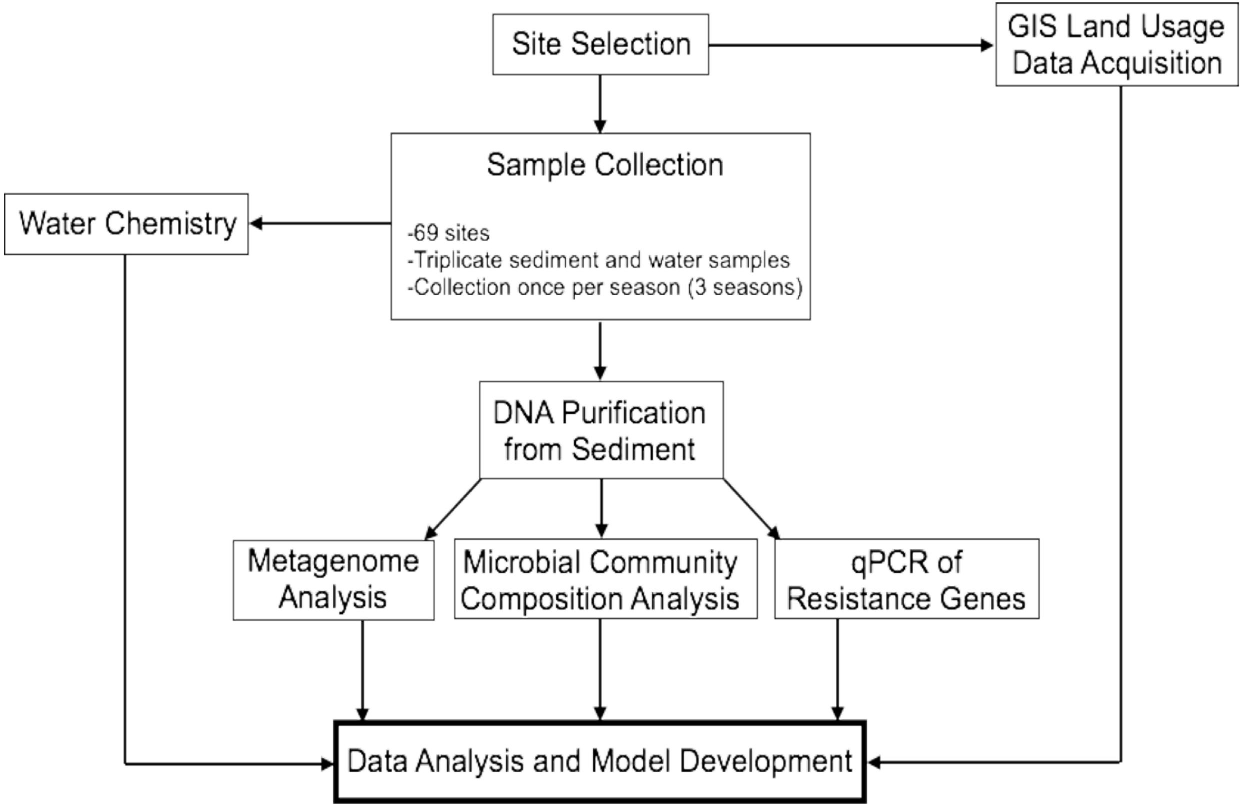
Total bacterial load: 10^4cells/ml



Benthic phase constitutes a greater reservoir for ARGs than planktonic phase

Gemma Hill

Approach



Site Selection

GIS Land Usage Data Acquisition

Sample Collection

-69 sites
-Triplicate sediment and water samples
-Collection once per season (3 seasons)

Water Chemistry

DNA Purification from Sediment

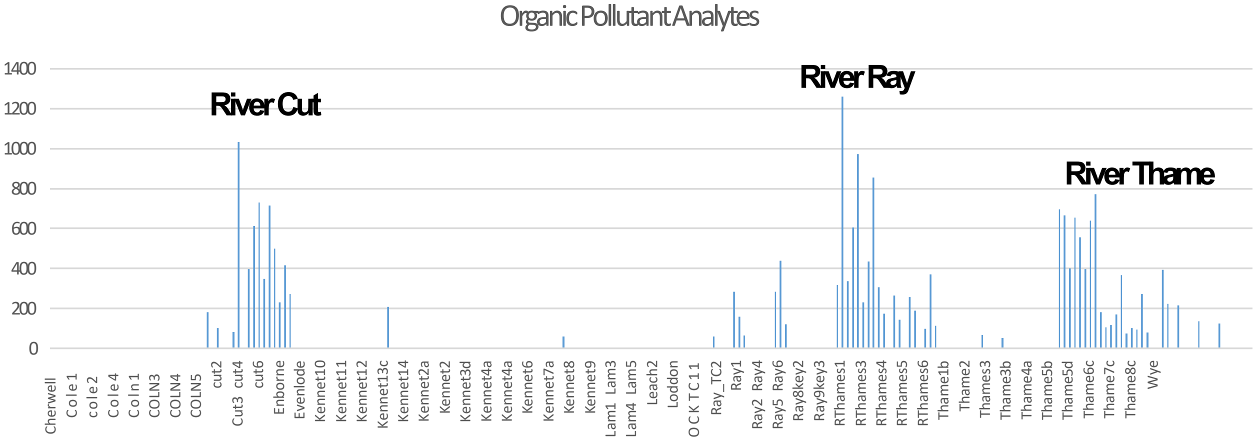
Metagenome Analysis

Microbial Community Composition Analysis

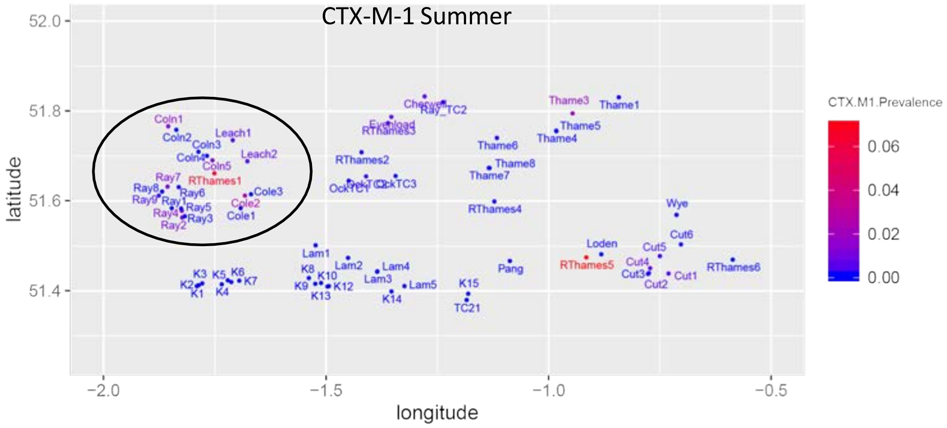
qPCR of Resistance Genes

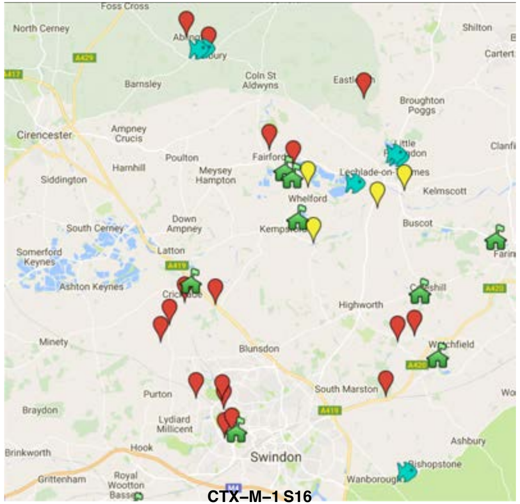
Data Analysis and Model Development

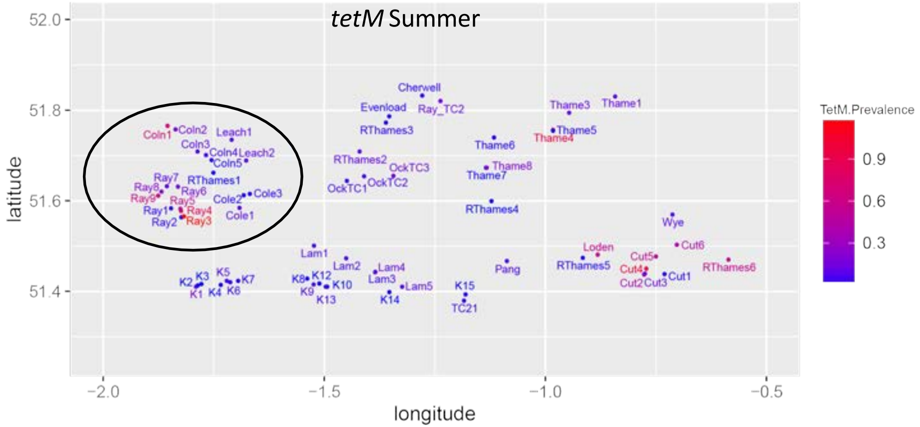
Summary of abundance of organic pollutant analytes Three seasons

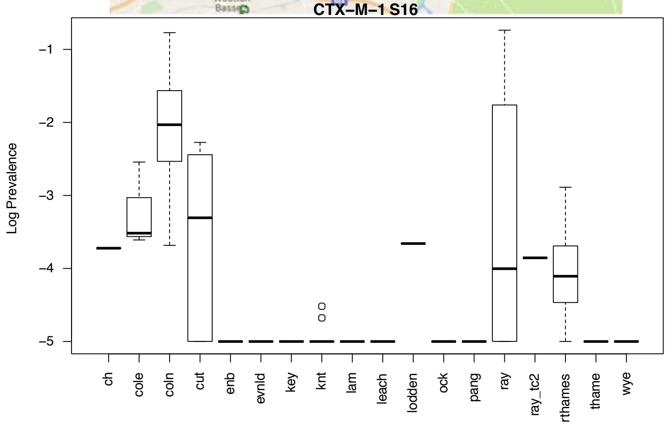


Prevalence of CTX-M-1 (Group1) / *tetM*

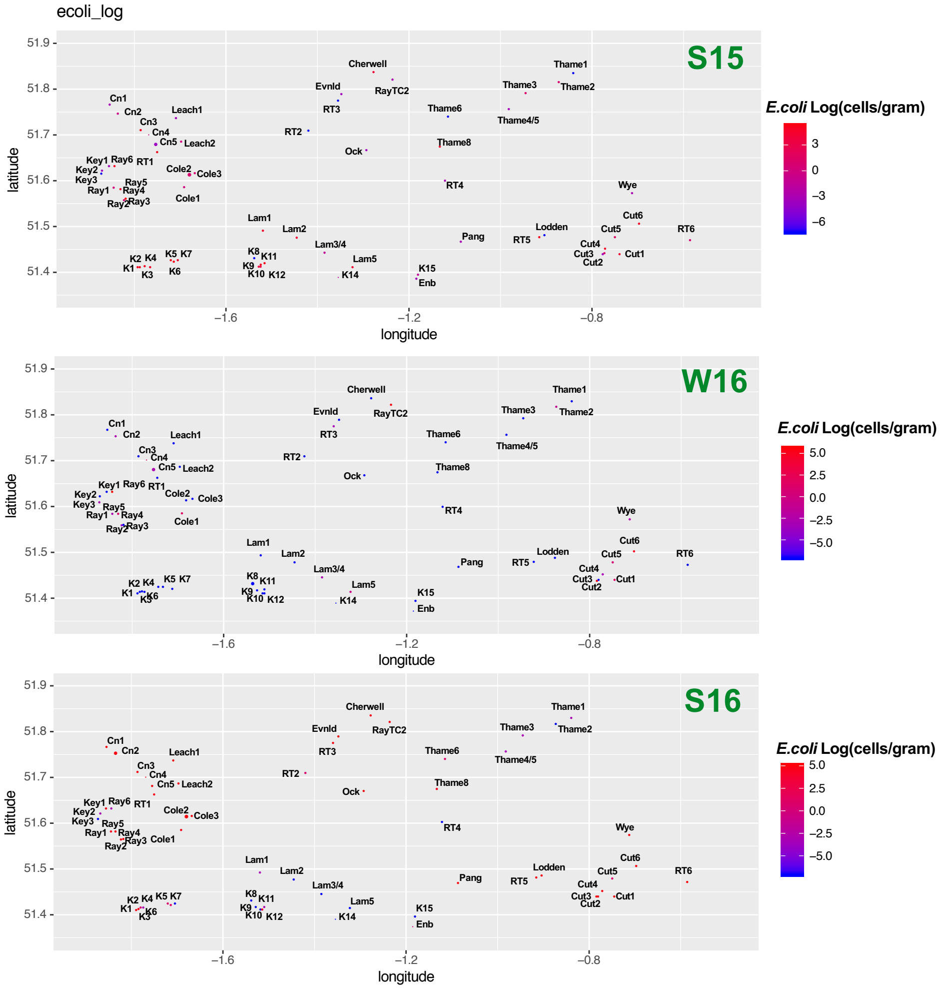


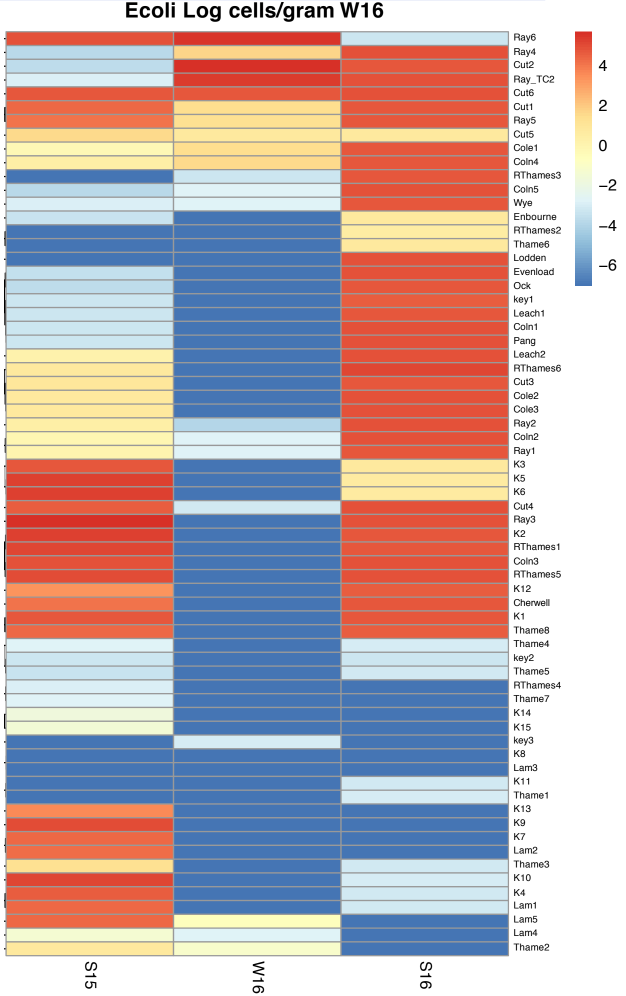




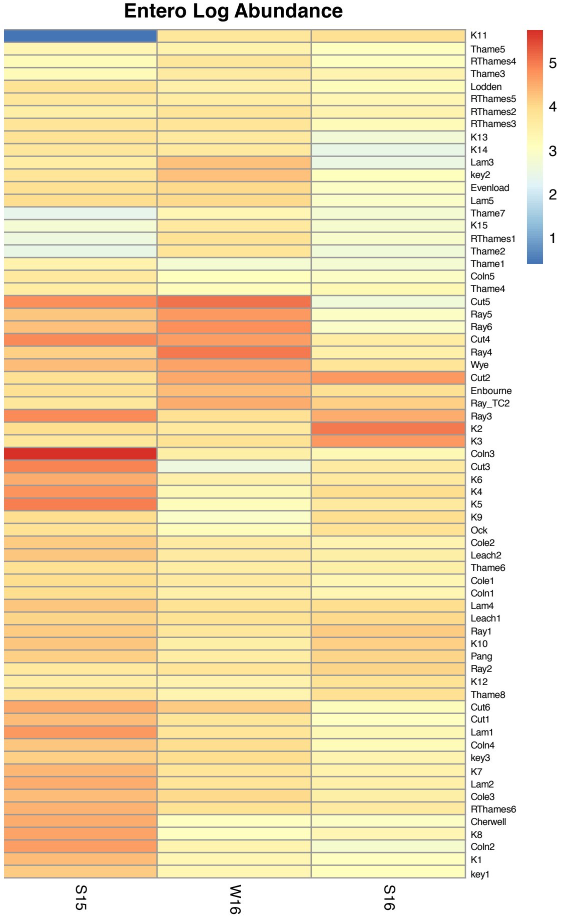


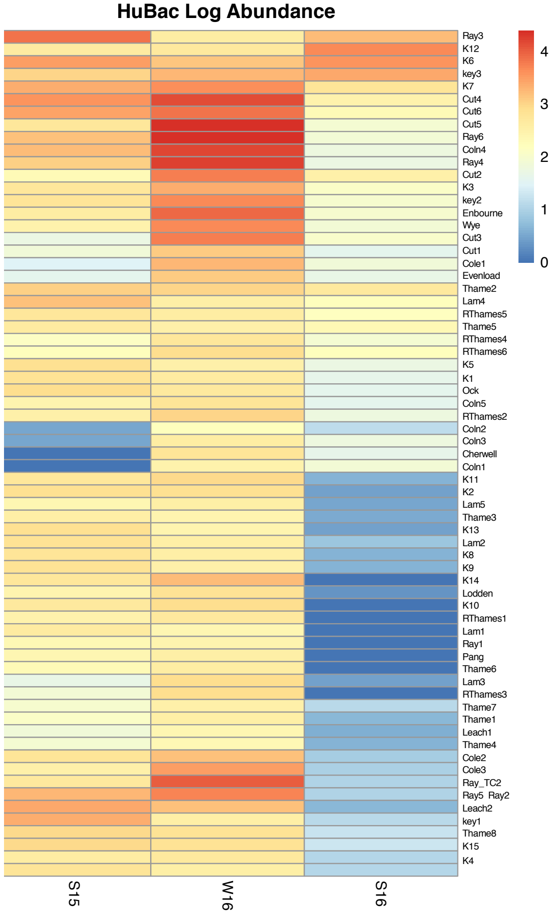
E. coli : (*uidA* gene) Faecal Contamination Indicator

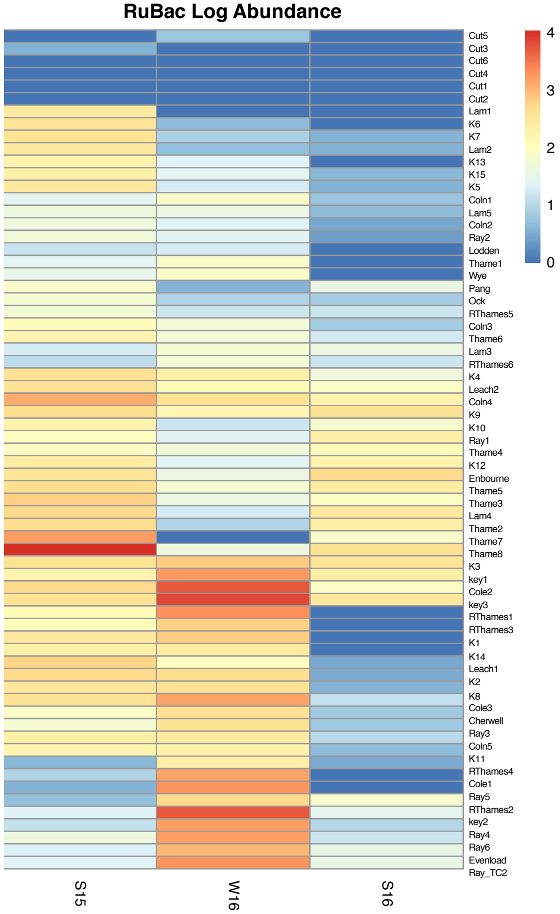




Human or animal origins?


Entero Log Abundance

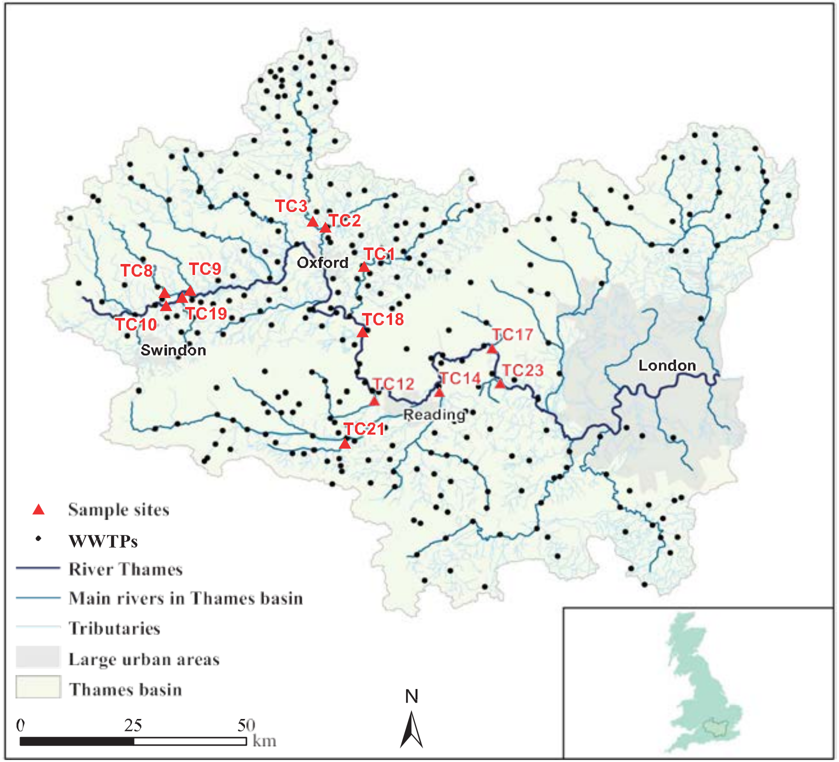

HuBac Log Abundance


RuBac Log Abundance

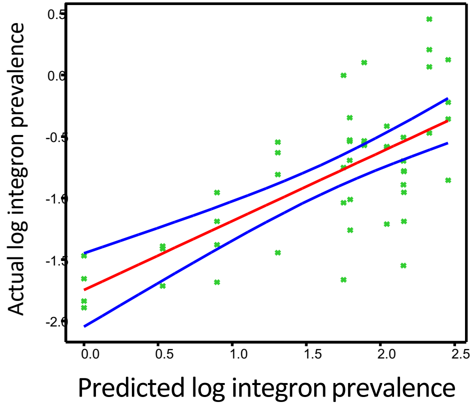
HuBaC and RuBac: Seeing differences between abundance of each within various tributaries

Previous model work on the Environmental Resistome: Thames Catchment

The Thames catchment consists of ~66500 miles of sewer and 350 WWTPs that treat 4.2 billion litres of sewage everyday.

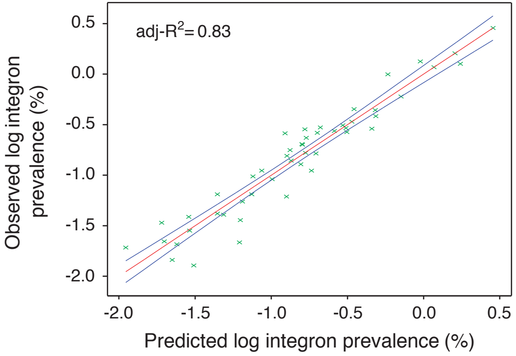


WWTP only



Explained 49 % of variance: R^2 adjusted → (0.49) P < 0.01

All metadata



Explained 82. 9 % of variance : R^2 adj (0.83) P < 0.01

Amos et al., 2015. The ISME Journal, 9, 1467–1476

In conclusion

Alternatives to ABU

Vaccines*
Probiotics*
Improved microbiomes
Animal husbandry
Improved sanitation
Identification of drivers of AMR

*Shrimp farming, viral diseases white spot syndrome virus (WSSV) use GMO *Bacillus subtilis* spores that display the VP28 capsid protein of WSSV and when administered in feed appears to protect against white spot disease. Protective mechanism unclear; shrimp are not thought to produce antibodies, but presentation of the viral antigens does produce some level of specific immunity. *Hoelzer et al., Vet Research 2018*

Improving the natural defences :

initiate innate and subsequent adaptive immune responses, e.g. triggering the host’s pattern recognition receptors

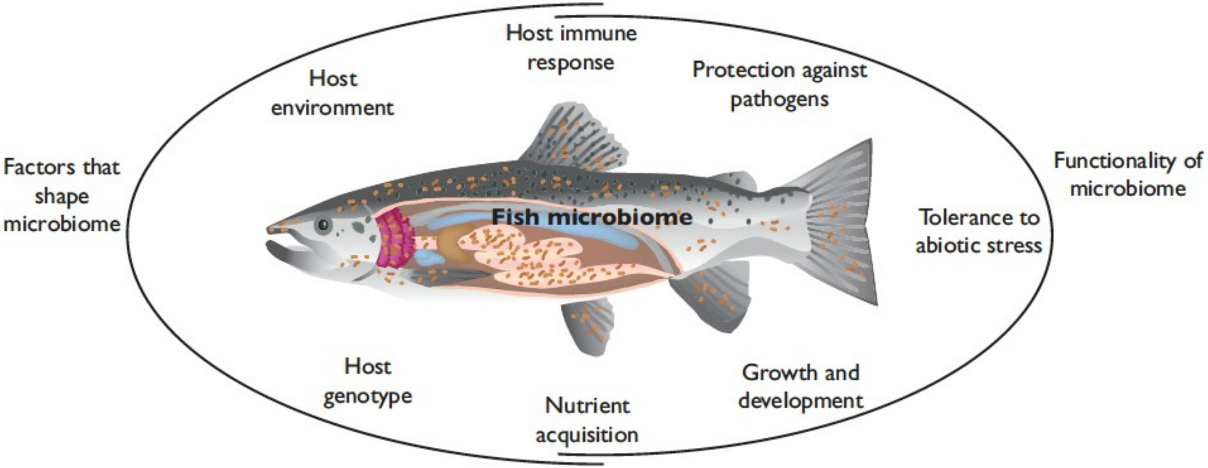
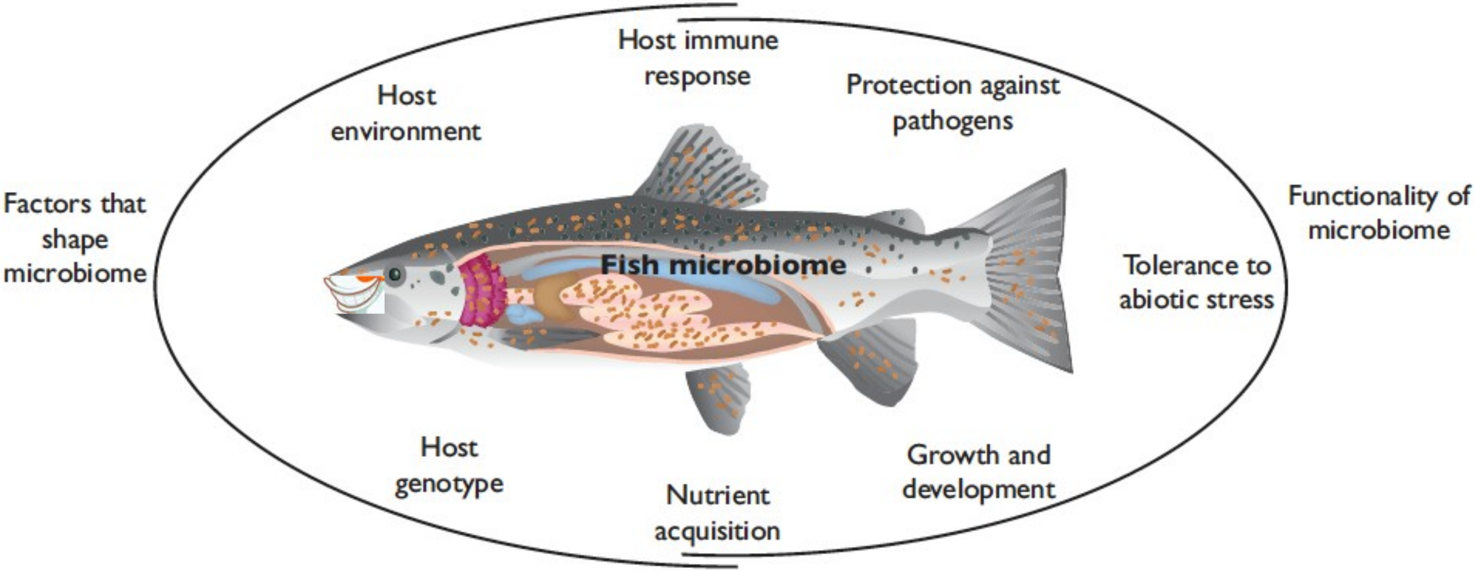


Figure 1. Schematic overview of different life-support functions of the fish microbiome and the impact of the host and ambient environment on the microbiome diversity, assembly and functions.

De Bruijn et al., FEMS Microbiol Ecol. 2018


Factors that shape microbiome
Host environment
Host immune response
Protection against pathogens
Functionality of microbiome
Fish microbiome
Tolerance to abiotic stress
Host genotype
Nutrient acquisition
Growth and development

University of Warwick
Professor Liz Wellington
Dr Chris Quince
Dr Jennie Holden
Dr Seb Raguideau
Dr Hayley King
Dr Gemma Hill
Séverine Rangama

University of Exeter
Dr Will Gaze
Dr Lihong Zhang
Konrad Paszkkiewicz
Suzanne Kay

Rothamsted Research
Dr Andrew Mead

Hong Kong University
Dr Tong Zhang

University of Birmingham
Professor Peter Hawkey

CEH, Wallingford
Dr Andrew Singer
Dr Mike Bowes
Holly Tipper

Thames Water
Howard Brett