



# Sustainable aquaculture through the One Health lens

Prof Grant D. Stentiford, Healthy Seafood Lead Cefas



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# Healthy seafood



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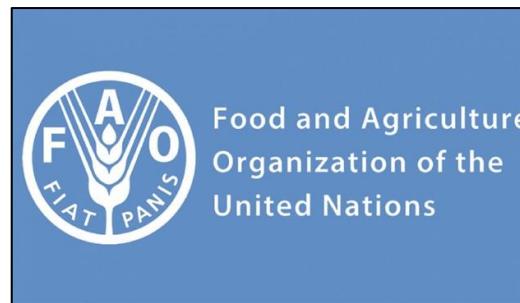


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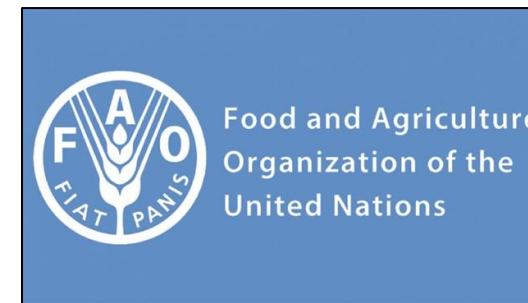
International Centre of Excellence in Seafood Safety



Collaborating Centre for Emerging  
Aquatic Animal Diseases



Reference Centre for  
Antimicrobial Resistance (AMR)



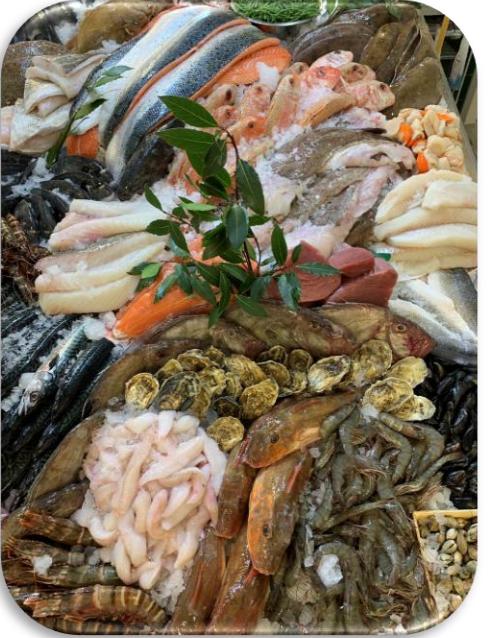
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SUSTAINABLE AQUACULTURE FUTURES



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Protein from fisheries and aquaculture forms a significant element in global diet

Known and emerging disease is the biggest production hazard for sustainable global aquaculture



Microbial and chemical hazards present in seafood threaten the health of human consumers

Seafood consumption profiles differ by nation with risk dependent on current and future patterns



Food and Agriculture Organization  
of the United Nations

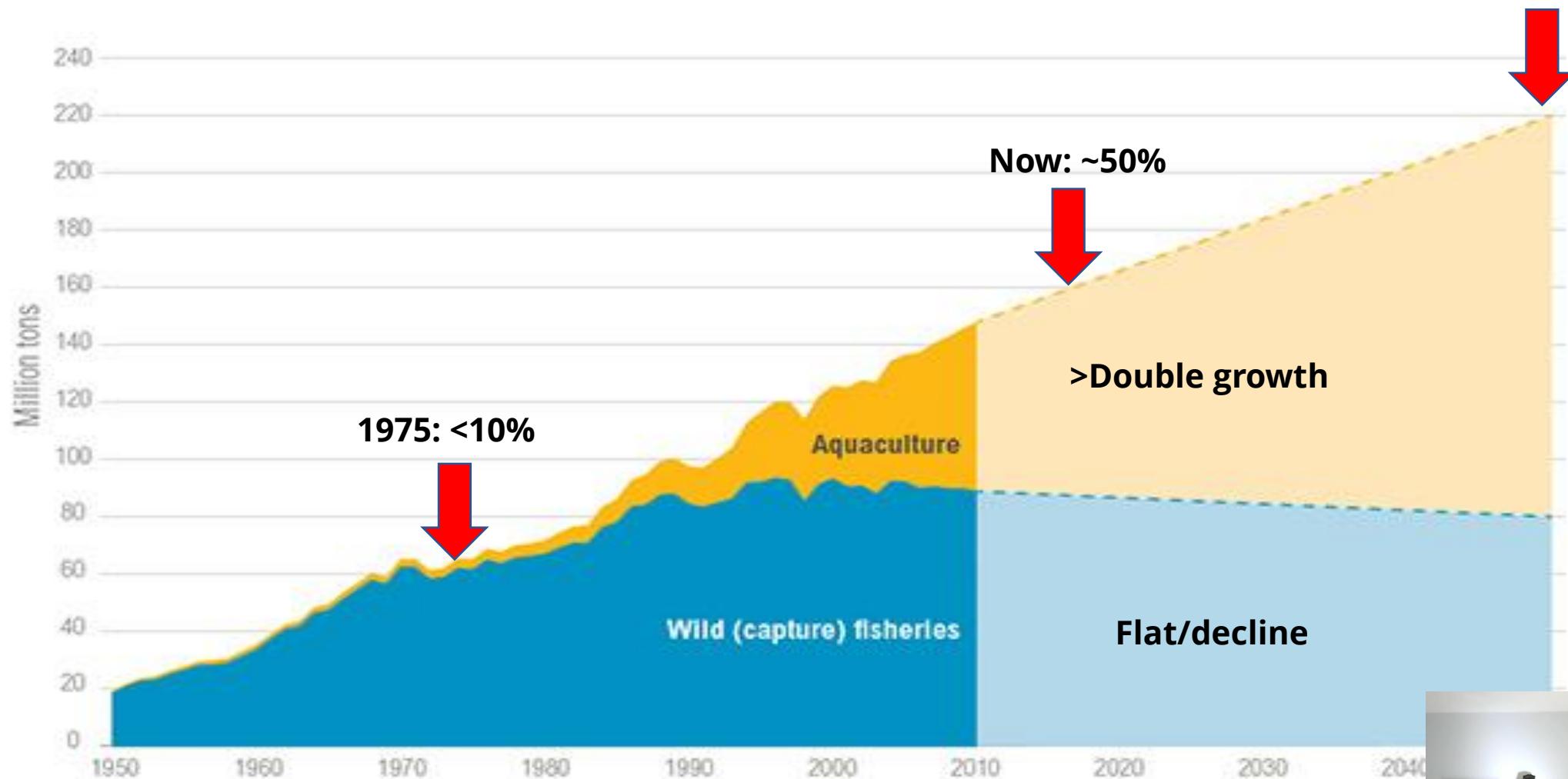


Food and Agriculture Organization  
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## Aquaculture Is Expanding to Meet World Fish Demand

2050: 70%

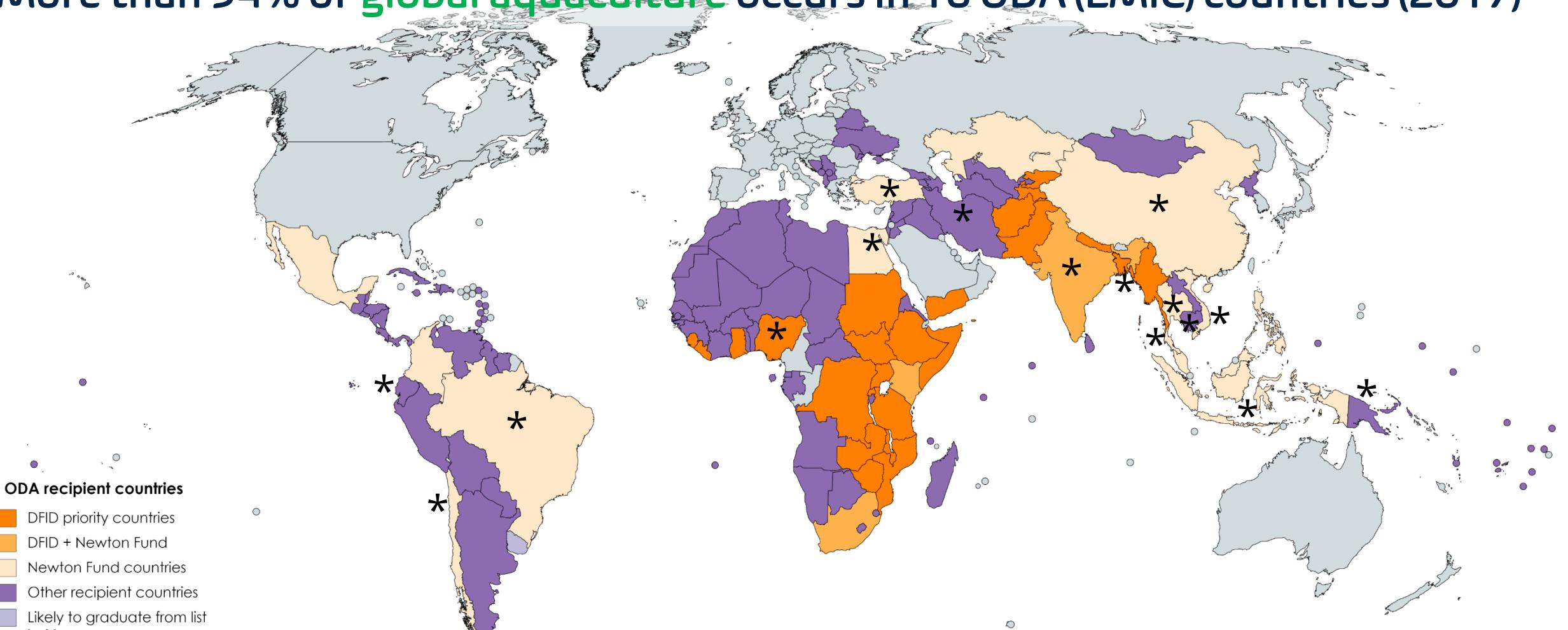


Source: Historical data 1950–2010: FAO. 2014. "FishStatJ." Rome: FAO. Projections 2011–2050: Calculated at WRI, assumes 10 percent wild fish catch between 2010 and 2050, and linear growth of aquaculture production at an additional 2 million tons per year between 2011 and 2050.

See [www.wri.org/publication/improving-aquaculture](http://www.wri.org/publication/improving-aquaculture) for full paper.



More than 94% of global aquaculture occurs in 16 ODA (LMIC) countries (2017)



...with majority of industry expansion to 2017



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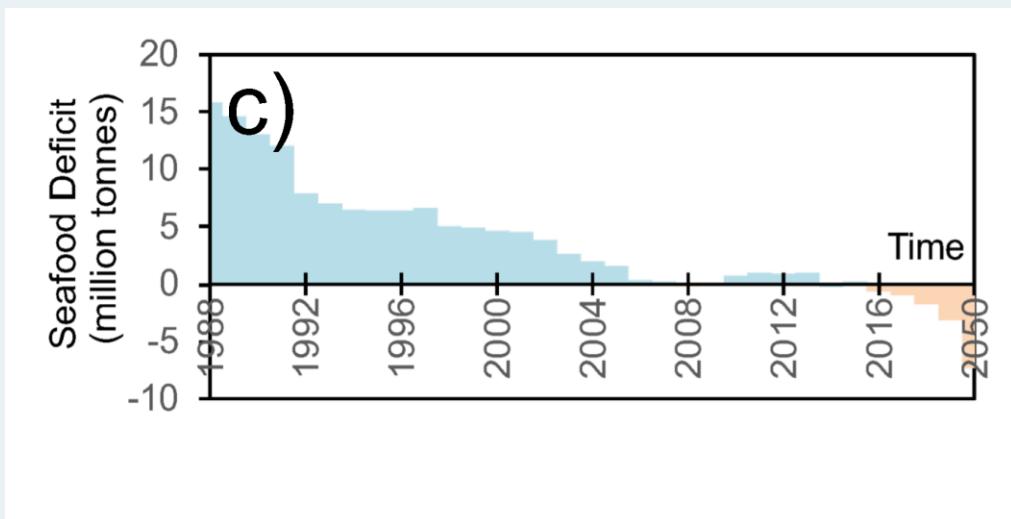
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# Mind the gap

...the majority of ICES nations lack long-term strategies for aquaculture, with few plans accounting for climate change and an increasing gap between future production and consumption – potentially 7 million tonne seafood deficit by 2050\*



# Understanding the potential for discrete aquaculture sectors to provide food should be a critical element in sustainable food production and consumption planning at individual nation level

2021 Thilsted



WORLD FOOD PRIZE FOUNDATION



**Shakuntala Haraksingh Thilsted**

TRINIDAD & TOBAGO AND DENMARK

Dr. Shakuntala Haraksingh Thilsted, native of Trinidad and Tobago and a citizen of Denmark, will receive the 2021 World Food Prize for her groundbreaking research, critical insights and landmark innovations in developing holistic, nutrition-sensitive approaches to aquaculture and food systems. By bringing together interdisciplinary and international collaborators, she drove transformations in aquatic food systems to deliver improved nutrition, resilient ecosystems and secure livelihoods for millions of vulnerable people across the globe.

*Dr. Shakuntala Haraksingh Thilsted, Global Lead for Nutrition and Public Health, WorldFish, said, "I am truly honored to receive the 2021 World Food Prize, and I am deeply humbled to be placed in such distinguished ranks as those of past laureates. Aside from personal joy and gratitude, as a scientist, I feel this award is an important recognition of the essential but often overlooked role of fish and aquatic food systems in agricultural research for development. Fish and aquatic foods offer life-changing opportunities for millions of vulnerable women, children, and men to be healthy and well-nourished."*



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# One Health Aquaculture



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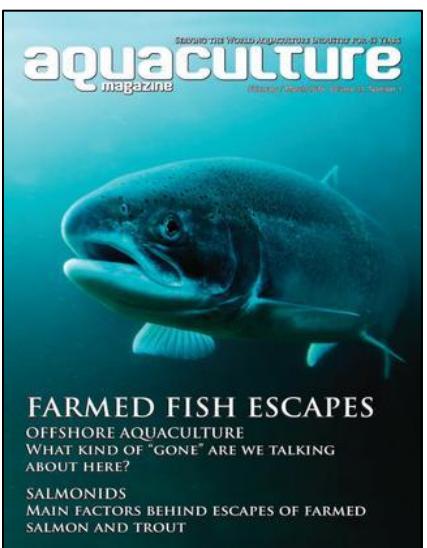
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Cefas

# Sustainability is not a given



**WTO upholds South Korea ban on some Japan seafood imports over Fukushima nuclear disaster**

Members of a South Korean citizens' group applaud Friday in Seoul following the World Trade Organization's decision in favor of continuing an import ban on Japanese seafood. KYODO

2019년 4월 12일(금) 오전 11시 / 광화문 정부종합청사 앞

일본 수산물 WTO 분쟁 국민안전이 승리했다

GREAT CHINA NORTHEAST ASIA SOUTHEAST ASIA SOUTH ASIA OCEANIA MIDDLE EAST ENVIRONMENT MAY 4, 2019

Members of a South Korean citizens' group applaud Friday in Seoul following the World Trade Organization's decision in favor of continuing an import ban on Japanese seafood. KYODO

NATIONAL

Mangroves are regarded as powerhouses of carbon storage. Photo: Mongabay

Shrimp farms threaten Myanmar's remaining mangroves

**ASIA TIMES**

GREAT CHINA NORTHEAST ASIA SOUTHEAST ASIA SOUTH ASIA OCEANIA MIDDLE EAST ENVIRONMENT MAY 4, 2019

Mangroves are regarded as powerhouses of carbon storage. Photo: Mongabay

Shrimp farms threaten Myanmar's remaining mangroves

**Salmon farming in crisis: 'We are seeing a chemical arms race in the seas'**

Rare only 40 years ago, farmed salmon is now taken for granted in our kitchens. But the growth of the industry has come at great cost

▲ The salmon farming industry has grown at breakneck speed since the 1970s. Photograph: Alamy

**E**very day, salmon farmers across the world walk into steel cages - in the seas off Scotland or Norway or Iceland - and throw in food. Lots of food; they must feed tens of thousands of fish before the day is over. They must also check if there are problems, and there is one particular problem they are coming across more and more often. Six months

Australian Marine Conservation Society

PROTECTING AUSTRALIA'S OCEAN WILDLIFE SINCE 1965

**RED RATING FOR TASMANIAN FARMED ATLANTIC SALMON: INDUSTRY PUSHING ENVIRONMENT TOO FAR, TOO FAST**

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seafood business news from beneath the surface

BRUSSELS 2019 HOME PRICES SPECIES COMPANIES DOWNSTREAM UPSTREAM BACK

**ABC NEWS SAN DIEGO**

South Bay News North County News San Diego News East County News Podcast: Today's Headlines

NEWS > LOCAL NEWS

**Californians warned not to eat certain oysters after outbreak of illness**

Posted: 1:42 PM, May 07, 2019 Updated: 9:42 PM, May 07, 2019 By: Zac Self

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**10News Leaders AWARD**

**Environment**

**Wild salmon population 'at crisis point' with catches in Scotland at lowest level on record**

Open-net farming blamed for rise in parasitic sea lice affecting wild stocks

Harry Cockburn | Wednesday 24 April 2019 06:15 | 112 comments

Wild Atlantic salmon has been off the menu since December 2018 when the country's last netting station closed down due to lack of fish. (Getty)

**The Guardian**

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**Shrimp sold by global supermarkets is peeled by slave labourers in Thailand**

An investigation follows the trail of shrimp prepared by captive workers in squalid factories into the supply chain for food outlets in the US, Asia and Europe

2,694 views | May 6, 2019, 06:00am

**It's Time For Aquaculture To Start Kicking Its Drug Habit**

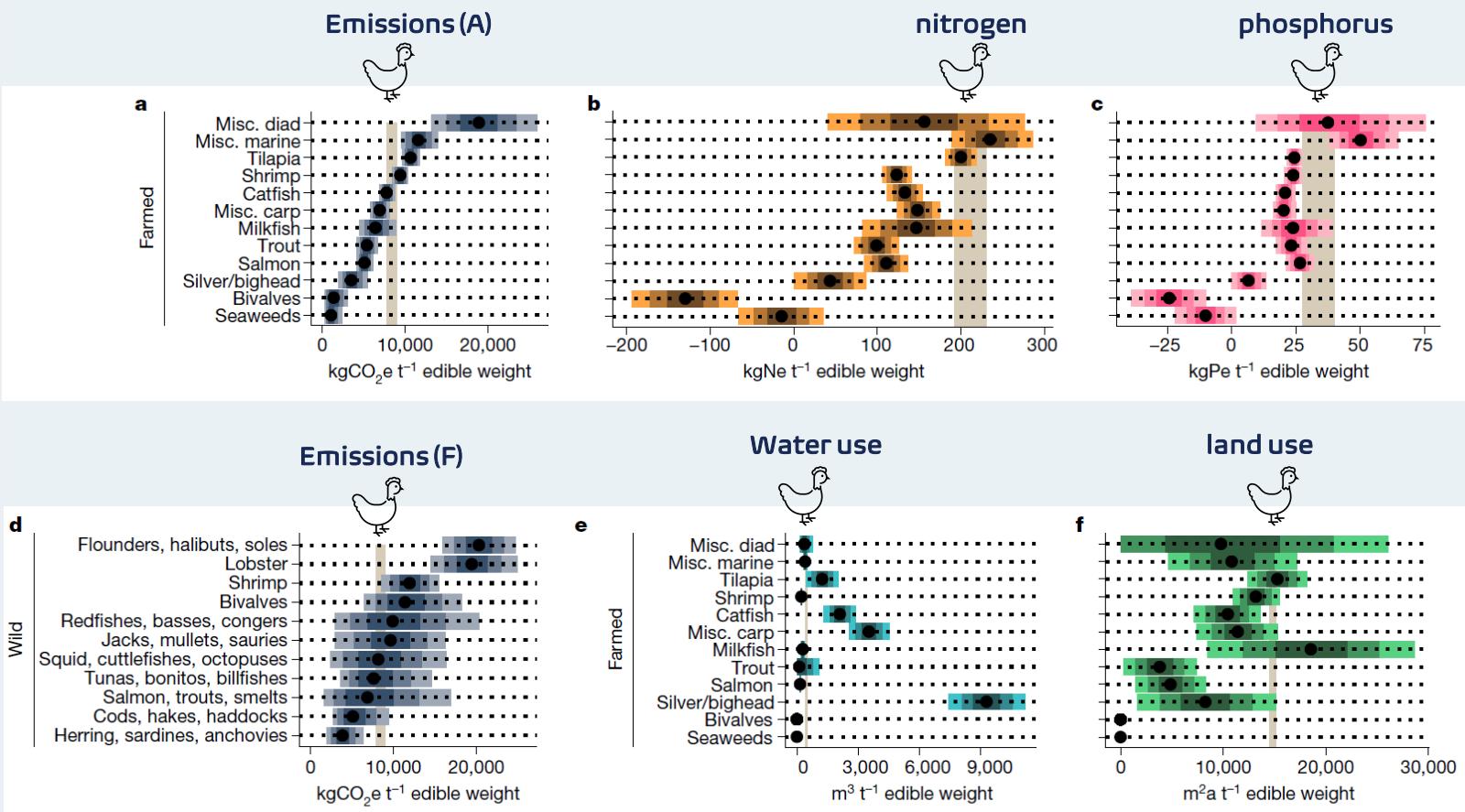
Maisie Gantler Contributor Food & Drink I care for food sustainability, especially as it relates to seafood.

By Undercurrent News May 6, 2019 09:33 BST

**Indian shrimp farmers need to move away from antibiotics, says industry leader**

ABC News

# Relative performance



Gephart et al. (2021). Environmental performance of blue food. Nature 597, 360-366

Standardised 'stressor' method

GHG, N, P, FW use, land use per tonne edible weight

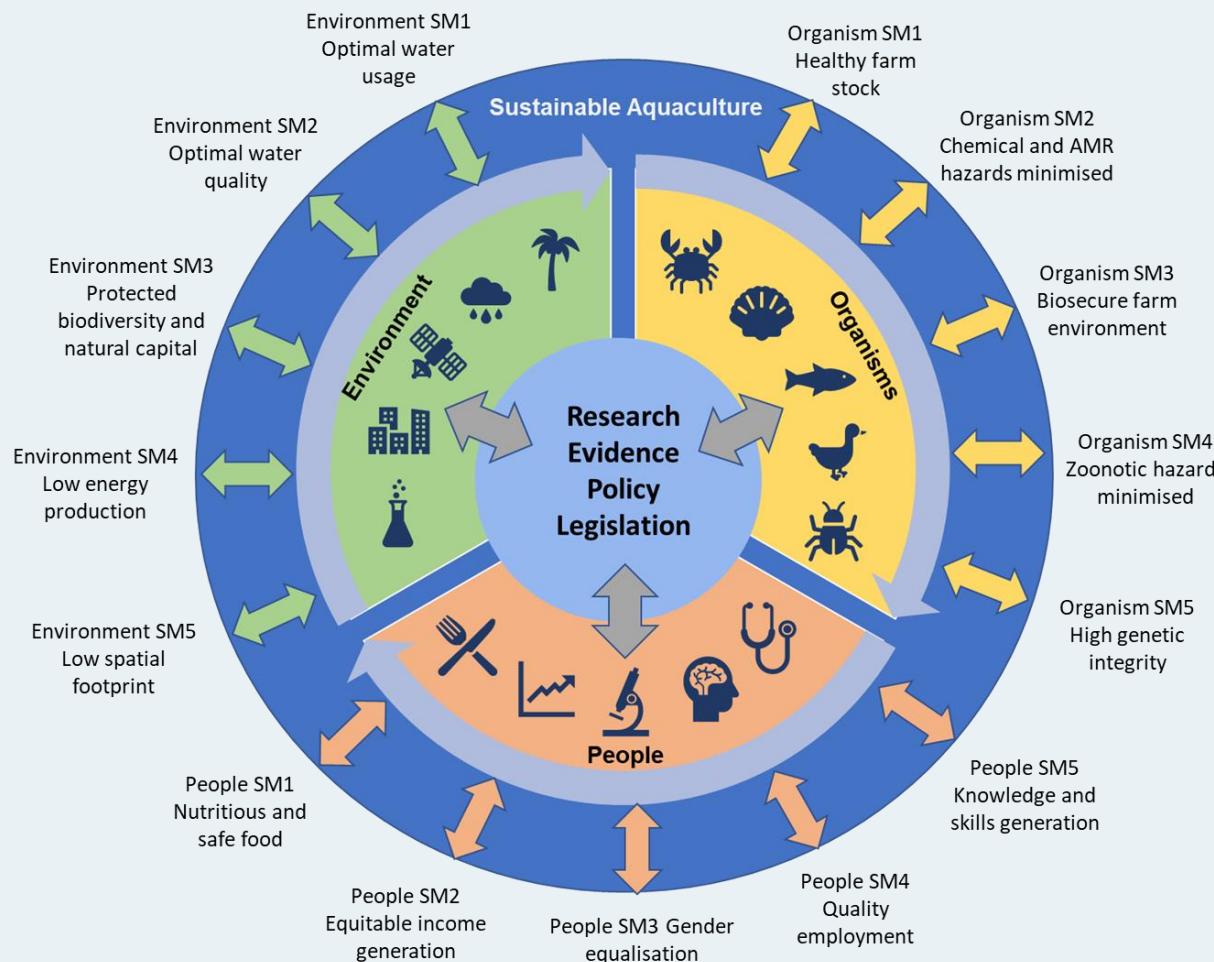
Used chicken as benchmark

Non-fed/extractive species lowest

Fed aquaculture emissions mainly from feeds, fishery emissions mainly from fuel



# One Health Aquaculture\*



Volume 1 Issue 8, 1 August 2020



## One Health aquaculture

Aquaculture, the farming of aquatic animals and plants, is one of the fastest developing food sectors globally, and in recent years has become the main source of fish available for human consumption. Applying the principles of One Health – the interconnectedness of human, animal and planetary health – could well support enhanced sustainable production in aquaculture; facilitating food and nutrition security, poverty alleviation, economic development and the protection of natural resources.

See Stentiford et al. show less

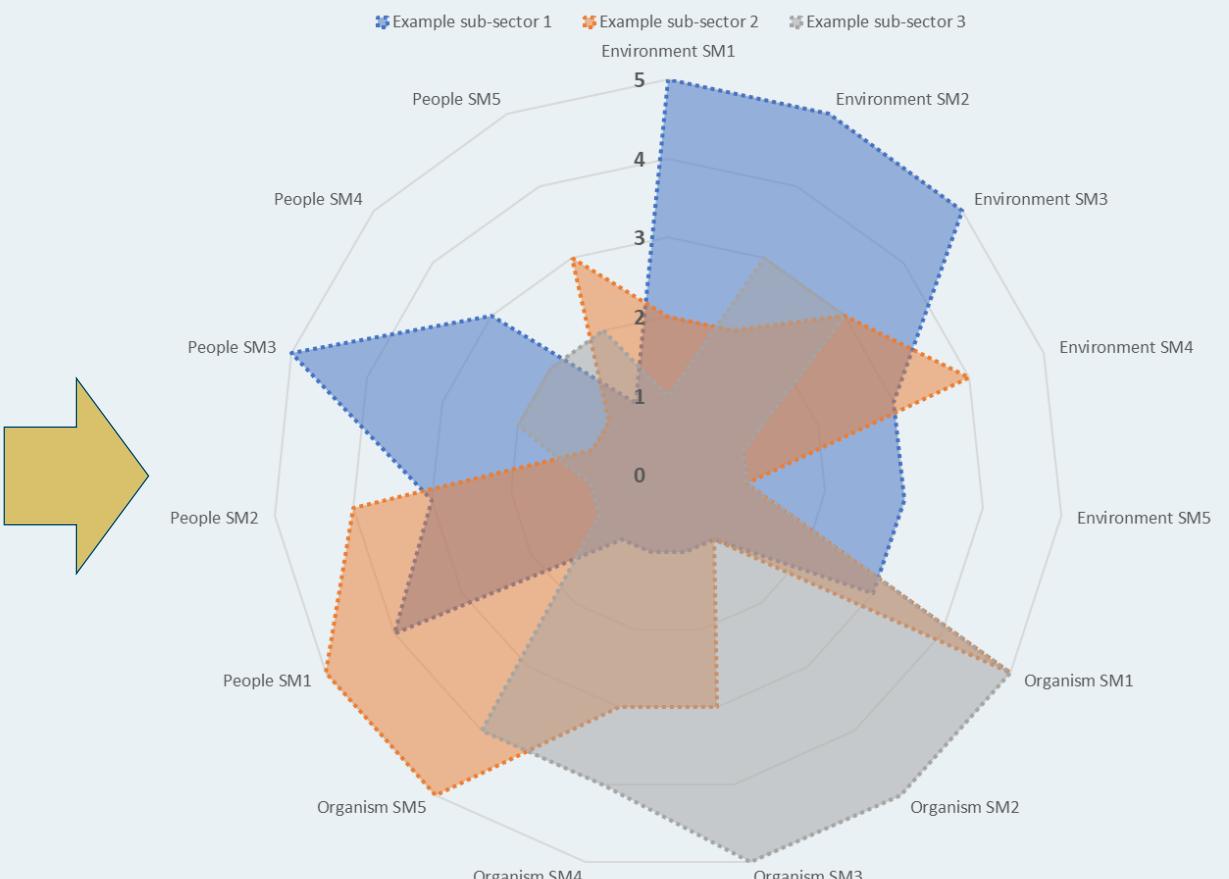
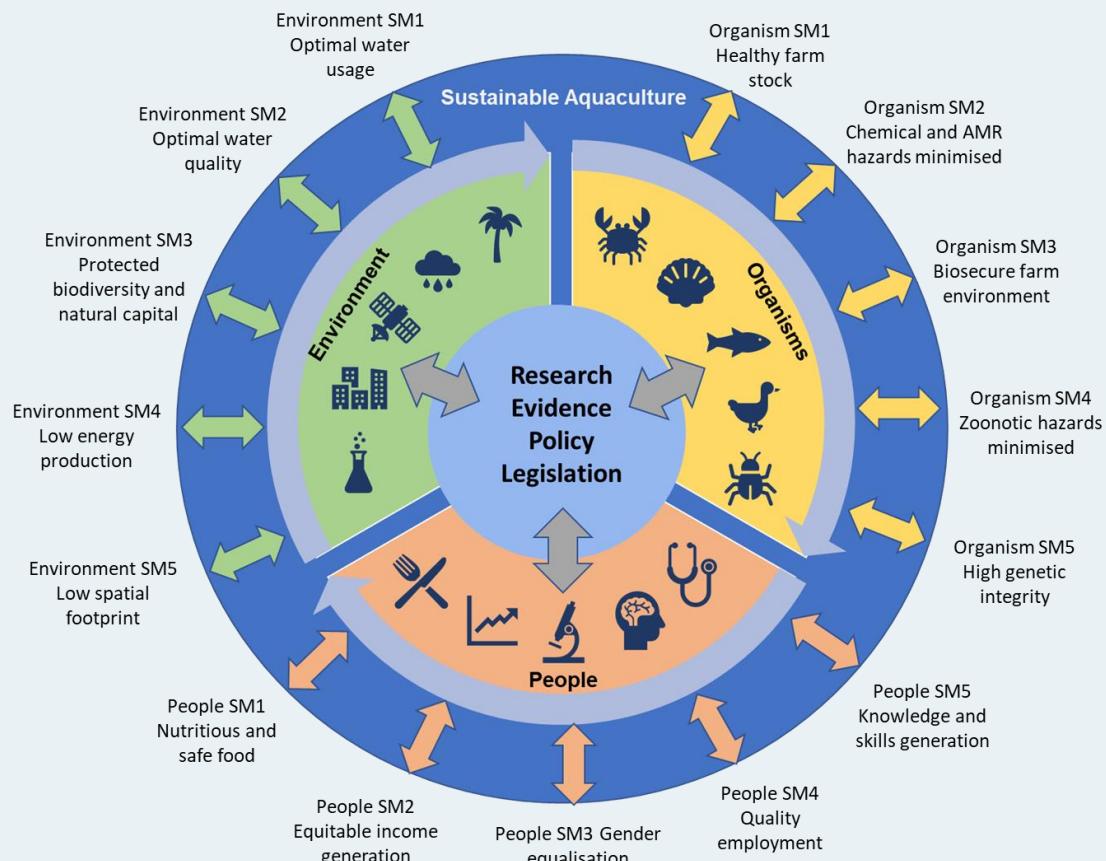
## One Health aquaculture - everyone's business

'Aquaculture has evolved into a major global food sector. Rapid growth necessitates **an evidence and policy makeover** fit for a doubling of output by 2050. A One Health approach, drawing on a **broad expertise** outside of traditional aquatic disciplines is now needed to realise its full potential'

<https://sustainabilitycommunity.springernature.com>



# A policy-evidence makeover



# Priority setting

*'You've used up potentially large amounts of resource to get absolutely nowhere'*

- Animal health and food safety are critical early elements in any OHA strategy
- Capacity to detect and control for known/new hazards underpins stable and safe production/trade
- Failure to control creates instability and utilises significant animal-human-environment capital without tangible outcome (food/income)

Sustainable nutrition  
outlook



Seaweed farmers in Tanzania tend to their crops. Not only is seaweed a nutritious food

## Cultivating a sea change

Can aquaculture overcome its sustainability challenges to feed a growing global population? By Sarah DeWeerdt

Nature 588, S60-62

[www.nature.com/articles/nature25770](http://www.nature.com/articles/nature25770)



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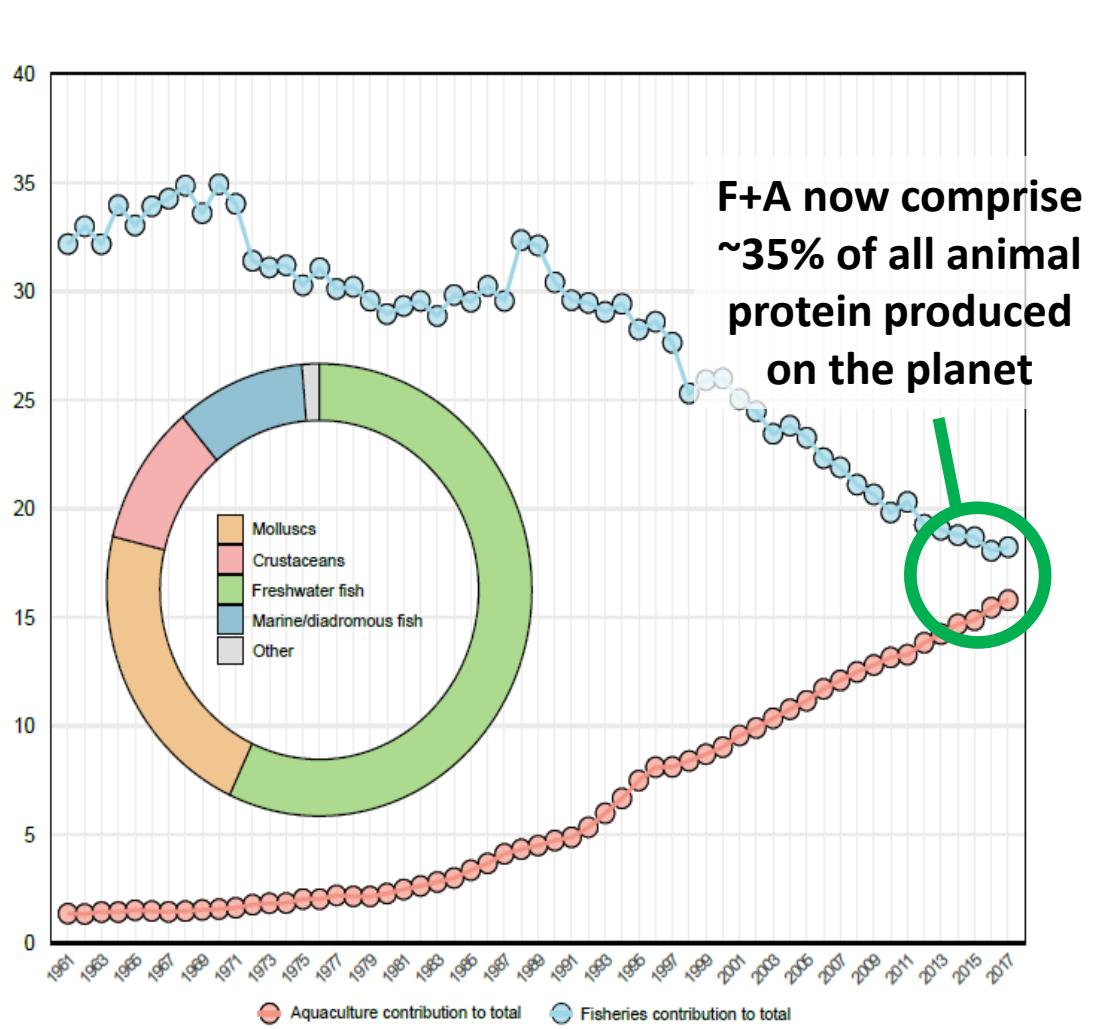
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# Beyond pathogens - An 'All Hazards' approach

Aquaculture  
doubling by 2050



Animal Production (metric tonnes per annum)

200,000,000

150,000,000

100,000,000

50,000,000

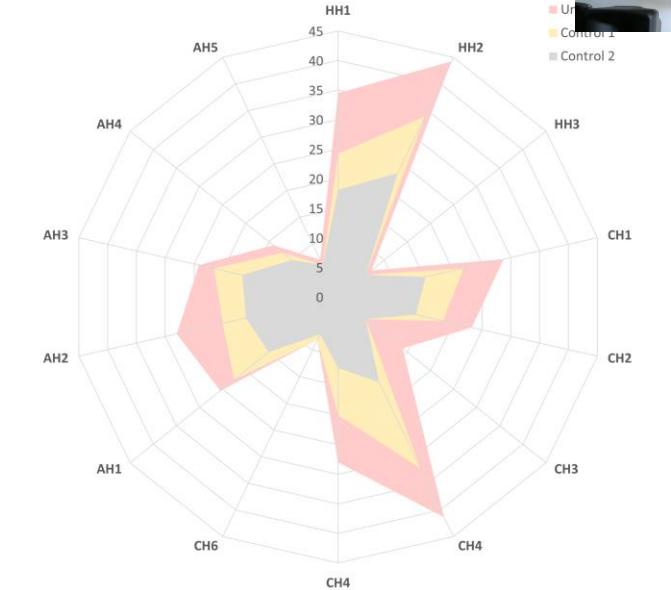
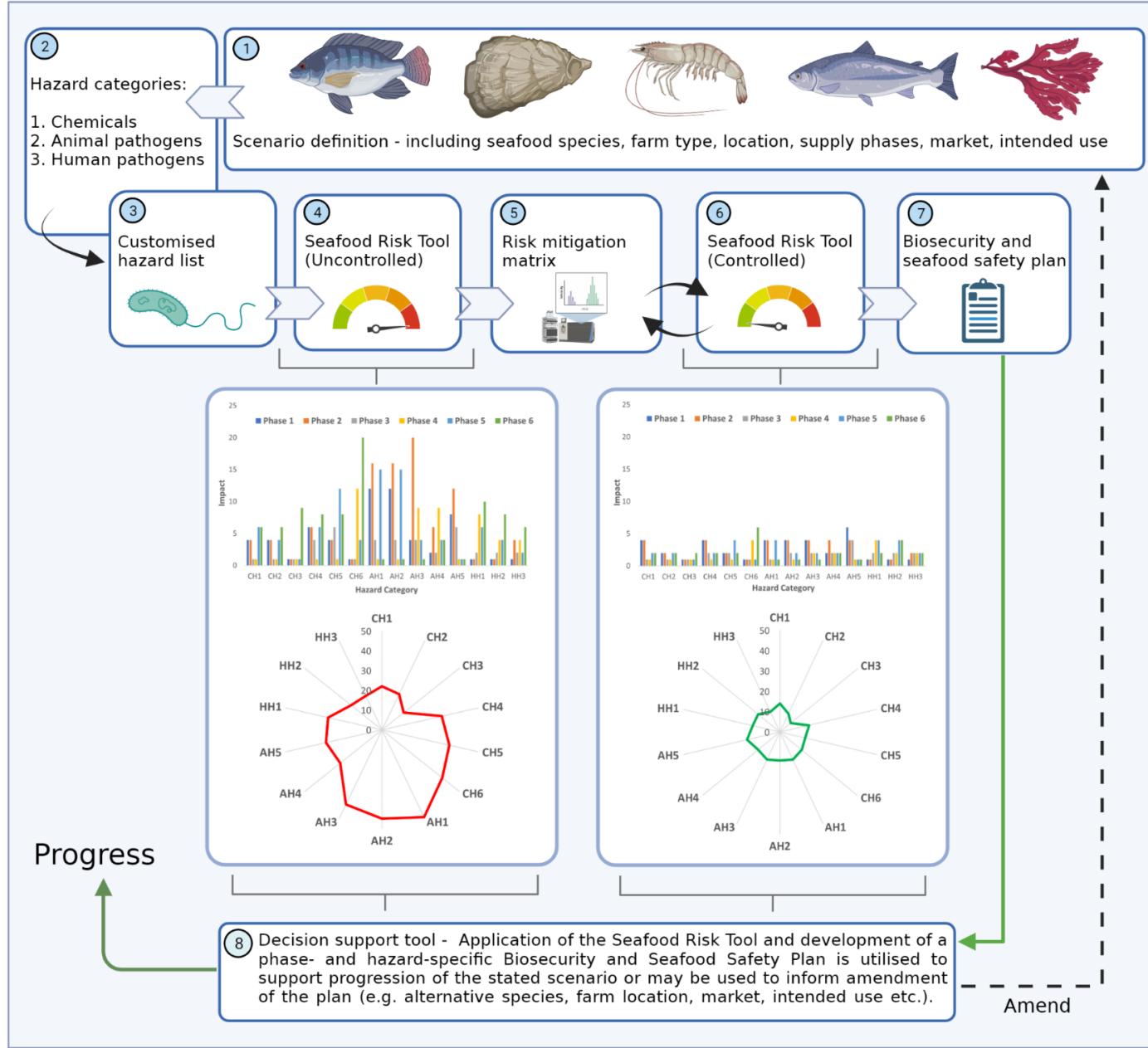
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1960 1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024

A ← B → C

FW fish showing  
biggest increase





*'While predominant scientific, policy and public discourse has orientated around the potential impact of aquaculture on aquatic systems, much less consideration has been paid to the impact that land-based human activities have on contaminating those aquatic habitats that will be increasingly relied upon to provide human dietary protein in coming decades'*

Emergency harvest at shrimp farm, Thailand, 2018

## A perspective on health and disease



# The past 20

# Health, infection and disease in...



## Wild and farmed crustaceans



## Wild and farmed molluscs



## wild and farmed

# Some specifics



*Enterospora canceri* n. gen., n. sp., intranuclear within the hepatopancreatocytes of the European edible crab *Cancer pagurus*

G. D. Stentiford\*, K. S. Bateman, M. Longshaw, S. W. Feist



*Enterocytozoon hepatopenaei* sp. nov. (Microsporida: Enterocytozoonidae), a parasite of the black tiger shrimp *Penaeus monodon* (Decapoda: Penaeidae): Fine structure and phylogenetic relationships

Somjintana Tourtip<sup>a</sup>, Somjai Wongtripop<sup>b</sup>, Grant D. Stentiford<sup>c</sup>, Kelly S. Bateman<sup>c</sup>, Siriporn Sriurairatana<sup>d</sup>, Jittipan Chavadej<sup>a</sup>, Kallaya Sritunyalucksana<sup>d</sup>, Boonsirm Withyachumnarnkul<sup>a,d,\*</sup>



Decay of the glycolytic pathway and adaptation to intranuclear parasitism within Enterocytozoonidae microsporidia

Dominic Wiredu Boakye,<sup>1</sup> Pattana Jaroenlak,<sup>2,3</sup>  
Anuphap Prachumwat,<sup>4</sup> Tom A. Williams,<sup>5</sup>  
Kelly S. Bateman,<sup>5</sup> Ornchuma Itsathitphaisarn,<sup>2,3</sup>  
Kallaya Sritunyalucksana,<sup>4</sup> Konrad H. Paszkiewicz,<sup>1</sup>  
Karen A. Moore,<sup>1</sup> Grant D. Stentiford<sup>6\*</sup> and  
Bryony A. P. Williams<sup>1\*</sup>



*Hepatospora eriocheir* (Wang and Chen, 2007) gen. et comb. nov. infecting invasive Chinese mitten crabs (*Eriocheir sinensis*) in Europe

G.D. Stentiford<sup>a,\*</sup>, K.S. Bateman<sup>a</sup>, A. Dubuffet<sup>b</sup>, E. Chambers<sup>a</sup>, D.M. Stone<sup>a</sup>



A Nested PCR Assay to Avoid False Positive Detection of the Microsporidian *Enterocytozoon hepatopenaei* (EHP) in Environmental Samples in Shrimp Farms

Pattana Jaroenlak<sup>1,2</sup>, Piyachat Sanguanrut<sup>2,3</sup>, Bryony A. P. Williams<sup>4</sup>, Grant D. Stentiford<sup>5</sup>,  
Timothy W. Flegel<sup>2,6</sup>, Kallaya Sritunyalucksana<sup>3,6</sup>, Ornchuma Itsathitphaisarn<sup>1,2\*</sup>



PEARLS

Ultimate opportunists—The emergent *Enterocytozoon* group Microsporidia

Grant D. Stentiford<sup>1,2\*</sup>, David Bass<sup>1,2,3</sup>, Bryony A. P. Williams<sup>2,4</sup>

The shrimp microsporidian *Enterocytozoon hepatopenaei* (EHP): Biology, pathology, diagnostics and control

Thawatchai Chaijarasphong<sup>a,b</sup>, Natthinee Munkongwongsiri<sup>c</sup>, Grant D. Stentiford<sup>d,e</sup>,  
Diva J. Aldama-Cano<sup>a,c</sup>, Kwanta Thansa<sup>c</sup>, Timothy W. Flegel<sup>a,f</sup>, Kallaya Sritunyalucksana<sup>c</sup>,  
Ornchuma Itsathitphaisarn<sup>a,g,\*</sup>



Now >100 publications on EHP....



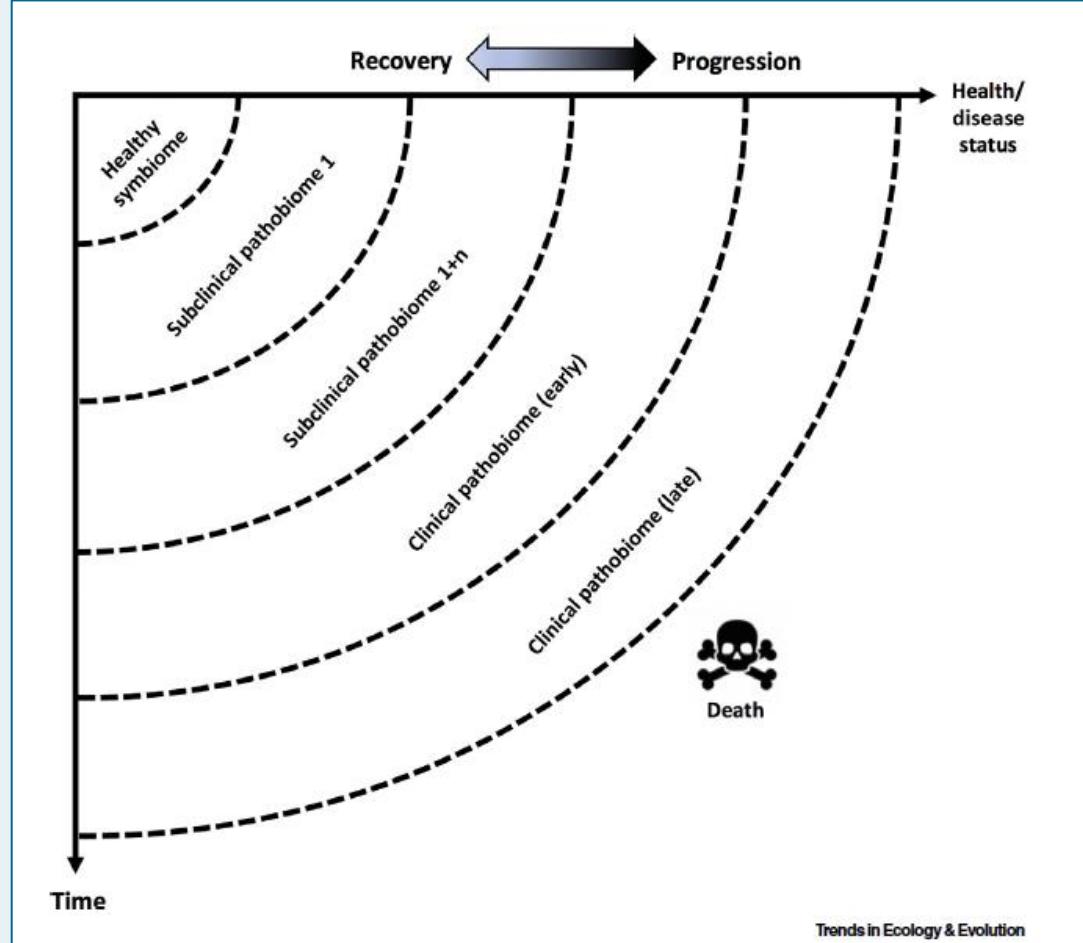
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# The next 20?



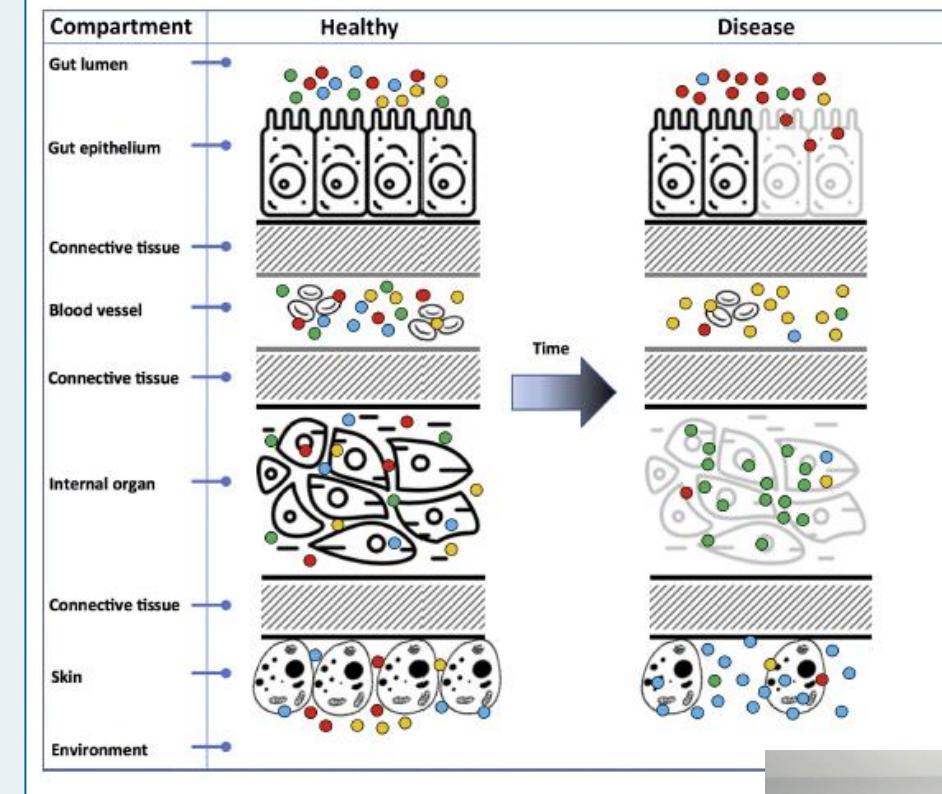
Trends in Ecology & Evolution

CellPress  
REVIEWS

Review

## The Pathobiome in Animal and Plant Diseases

David Bass,<sup>1,2,3,✉,\*</sup> Grant D. Stentiford,<sup>1,2,✉</sup> Han-Ching Wang,<sup>4,5,✉</sup> Britt Koskella,<sup>6,✉</sup> and Charles R. Tyler<sup>2,7</sup>



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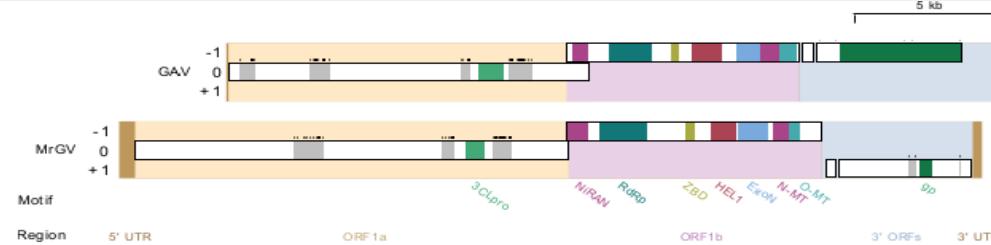
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Article

## A Novel RNA Virus, *Macrobrachium rosenbergii* Golda Virus (MrGV), Linked to Mass Mortalities of the Larval Giant Freshwater Prawn in Bangladesh

Chantelle Hooper <sup>1,\*</sup>, Partho P. Debnath <sup>2,\*</sup>, Sukumar Biswas <sup>3</sup>, Ronny van Aerle <sup>1,4</sup>, Kelly S. Bateman <sup>1,4</sup>, Siddhawartha K. Basak <sup>2</sup>, Muhammad M. Rahman <sup>2</sup>, Chadag V. Mohan <sup>5</sup>, H. M. Rakibul Islam <sup>6</sup>, Stuart Ross <sup>1</sup>, Grant D. Stentiford <sup>1,4</sup>, David Currie <sup>3</sup> and David Bass <sup>1,4,7</sup>



**Figure 3.** Schematic illustration of linear *Macrobrachium rosenbergii* Golda Virus (MrGV) and gill-associated virus (GAV) genomes and proteomes. Open reading frame (ORF) 1a is set as reading frame zero and genomes are split into five sections: 5' untranslated region (UTR), ORF1a, ORF1b, 3' ORFs and 3' UTR. Transmembrane (TM) regions are shown in grey with predicted TM helices shown as black bars above these regions. Predicted protein motifs are a 3C-like protease (3CLpro), nidovirus RdRp-associated nucleotidyltransferase (NiRAN), RNA-dependent RNA polymerase (RdRp), zinc-binding domain (ZBD), superfamily 1 helicase (HEL1), 3'-5' exoribonuclease (ExoN), S-adenosylmethionine (SAM)-dependent N7- and 2'-O-methyltransferases (N-MT and O-MT, respectively) and glycoproteins (gp).

*Use of sequencing technologies to detect and describe cryptic pathogens*



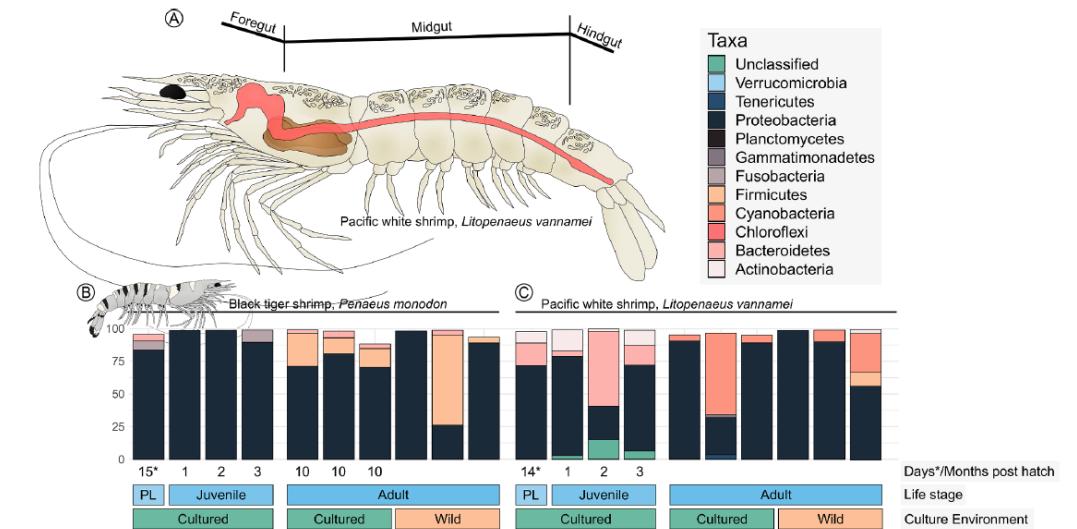
Contents lists available at ScienceDirect

Journal of Invertebrate Pathology

journal homepage: [www.elsevier.com/locate/jip](http://www.elsevier.com/locate/jip)

Understanding the role of the shrimp gut microbiome in health and disease

Corey C. Holt <sup>a,b,c,d,\*</sup>, David Bass <sup>a,c</sup>, Grant D. Stentiford <sup>a,c</sup>, Mark van der Giezen <sup>b,c,e,\*</sup>



*Shift to focus on microbial conditions conducive to health rather than just disease*



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EMBEDDING ONE HEALTH TO  
SUPPORT AQUACULTURE  
PRODUCTION DURING



# Current work – Thailand



APPLIED STUDIES

WILEY  
Journal of the  
World Aquaculture Society

Testing of a pond-side molecular diagnostic tool  
for the detection of white spot syndrome virus  
in shrimp aquaculture

PLOS PATHOGENS

OPINION

New Paradigms to  
Aquaculture Disease

Grant D. Stentiford<sup>1</sup>\*, Kallaya Sri  
P. Williams<sup>1</sup>, Boonsirm Withyach



# Current work – Tanzania



Biosecurity policy and legislation for the global aquaculture industry

Iona Campbell<sup>1</sup> · Cicilia S. B. Kambey<sup>2</sup> · Jonalyn P. Mateo<sup>3</sup> · Sadock E. Flower E. Msuya<sup>4</sup> · Grant D. Stentiford<sup>5,6</sup> · Elizabeth J. Cottier-Cook<sup>1</sup>



# Summary

Aquaculture is part of the food system

Hence, sustainability must be considered relative to other sectors comprising the system

A One Health approach can be 'designed in' to food sectors/systems (incl. aquaculture)

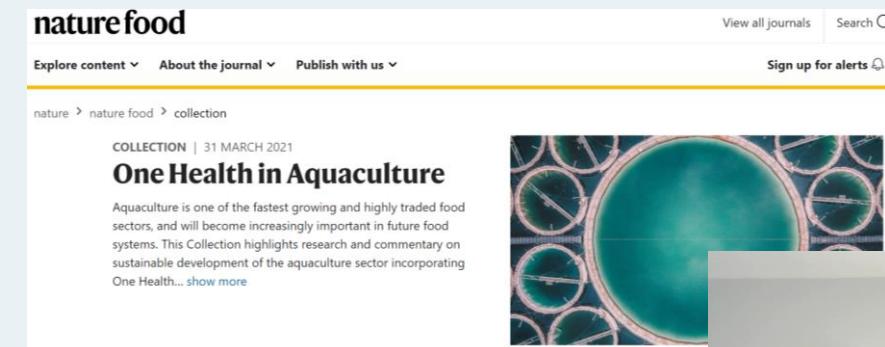
Wider science-policy expertise needed across organism/environment/human health outcomes

Enhanced role for national government is implied – farming in national waters

Environmental protection integral to enabling safe/sustainable food from aquaculture

Read more about One Health Aquaculture:

<https://www.nature.com/collections/jbbahhegac/>



# Get in touch

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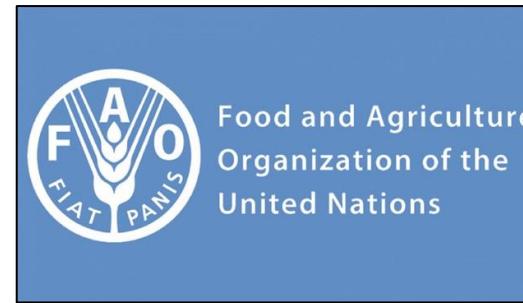


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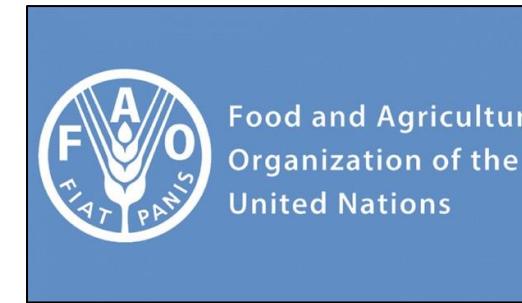
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Antimicrobial Resistance (AMR)



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