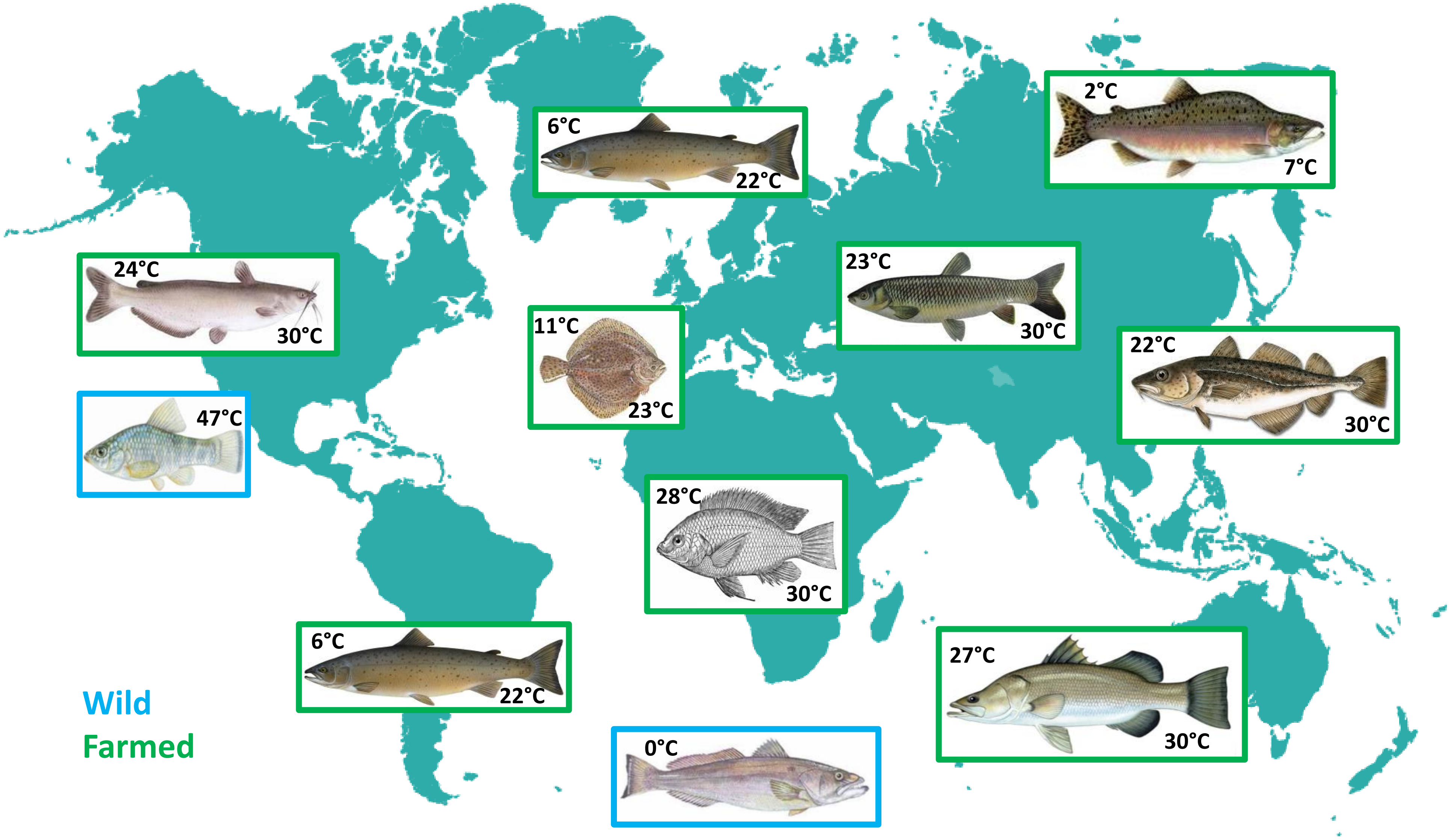
Impact of climate change on fish defences against infectious diseases

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

INRAE

Colloque santé globale et nouveaux flux de risques 2020
(Impacts des changements climatique et anthropiques)

- 34, 300 fish species, > combined number of all other vertebrate species
- Marine, brackish and freshwater, anadromous, catadromous

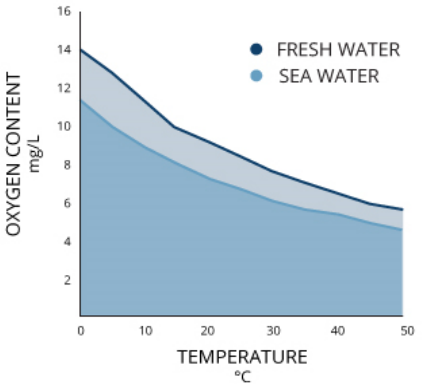


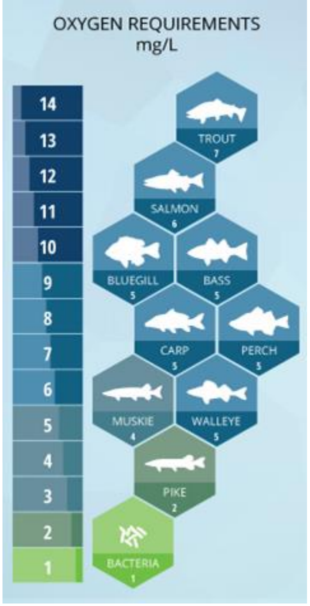
AQUATIC ENVIRONMENT

greater instability in abiotic factors affecting physiology

TEMPERATURE

O_2





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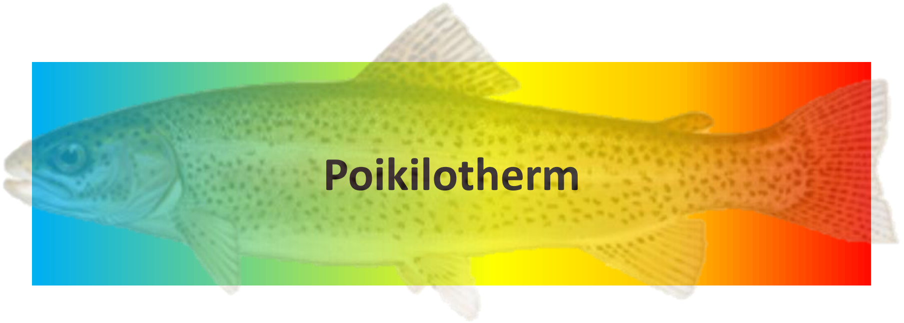
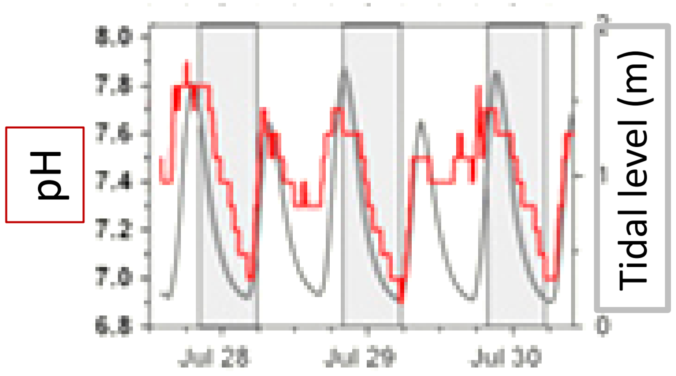




Baumann et al. (2015)

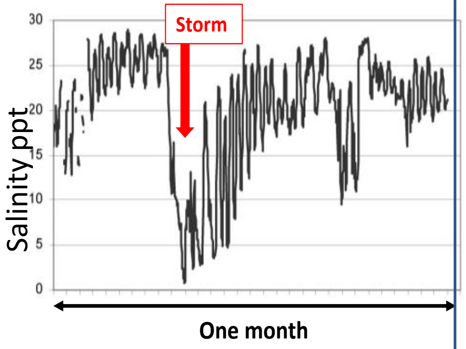
Salinity

Increased salinity

- evaporation
- freezing sea water

Decreased salinity

- precipitation
- river runoff
- Groundwater
- melting ice



Importance of fish and fisheries

Controlling food webs
- Grazing on primary producers
- Predation on animals
- Food for top predators

Ecosystem engineering
- Bioturbation of sediment
- Bioerosion of substrate

Participating to nutrient cycles
- Nutrient excretion and egestion
- Nutrient transport
- Decomposition of carcasses

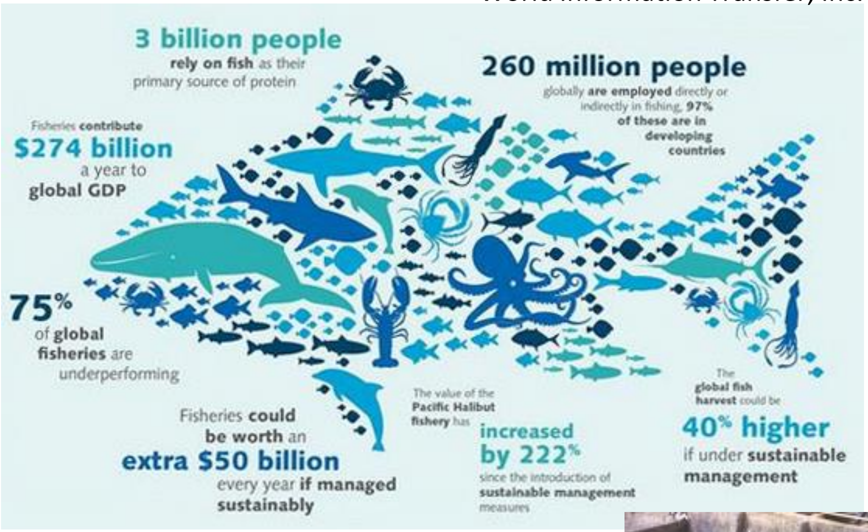
Villéger et al. (2017)


Example of Anodonta (river mussel) : dependent on fish to complete life cycle (parasitic larvae)

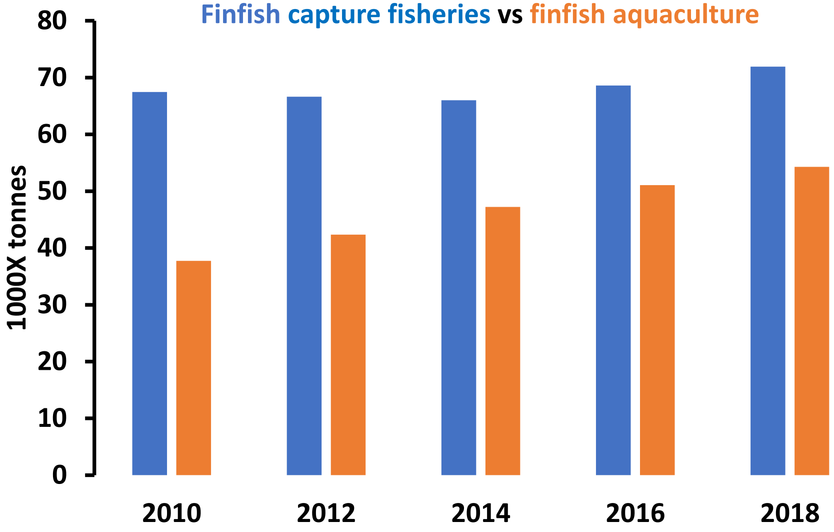
Ieshko et al. (2016)

Ecosystem

World Information Transfer, Inc.



Food-producing sectors



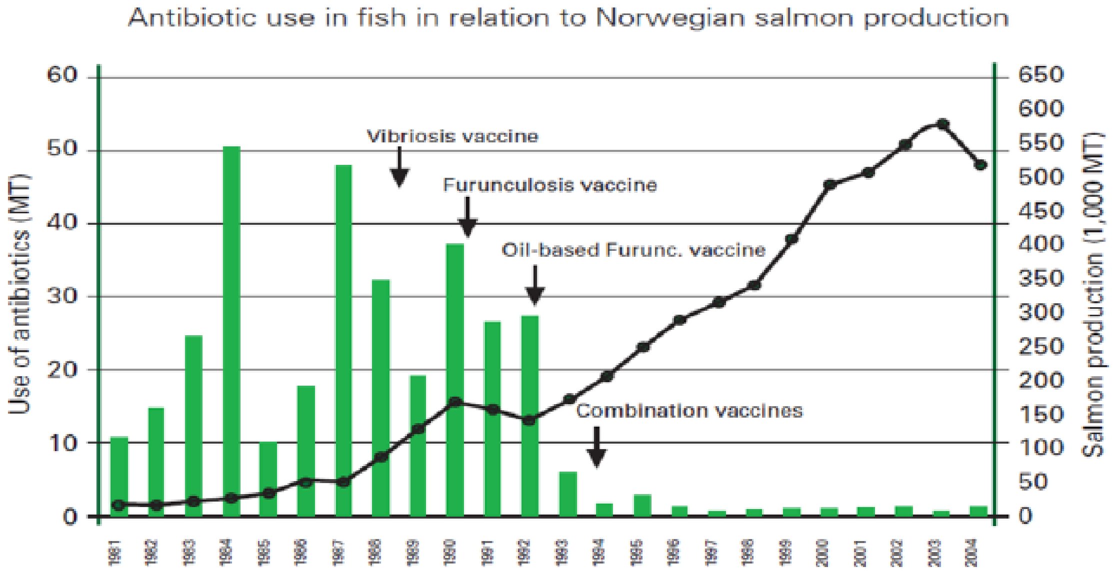
Data from FAO (2020)

FAO.org

Antimicrobial Resistance

- High level of AMR in aquaculture sector in many countries and correlated with warmer waters
- Metadata analysis shows that MAR (Multi-Antibiotic Resistance) indices correlate with MAR indices from human clinical bacteria, temperature and countries' climate vulnerability
- Majority of antimicrobials administered to aquatic farmed animals disseminate to nearby environments favouring AMR development

Reverter et al. (2020); Alves Resende et al. (2020)



Fredrick Witte; MSD (figure); Sommerset et al. (2005)

Furunculosis affected fish

Zoonoses

Mycobacterium spp. *
Streptococcus iniae
Clostridium botulinum
Vibrio vulnificus
Lactococcus garvieae

Gauthier (2015); Meyburgh et al. (2017)

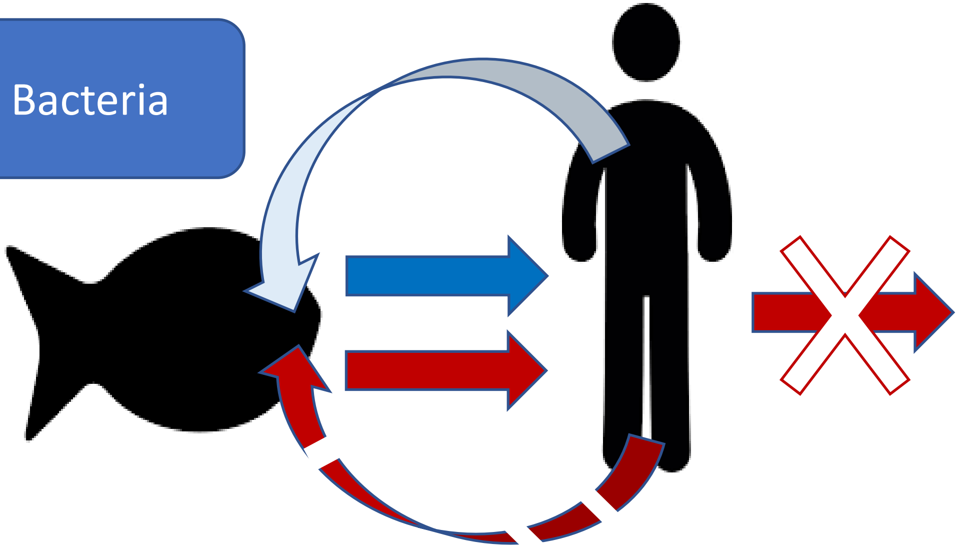
- diarrhoea, vomiting, dehydration
- endocarditis, peritonitis meningitis in human

* few studies with strong epidemiological links between fish and human

~~Virus~~

~~Fungi~~

Bacteria



Trematode | Cestode | Nematode

- intestinal, pancreatic, bronchial disease, allergic reaction
- cancerous or precancerous growths

Bao et al. (2017); Shamsi (2019)

Diphyllobothriosis; liver/intestinal flukes; Anisakiosis

Fish immune response and climate change effects

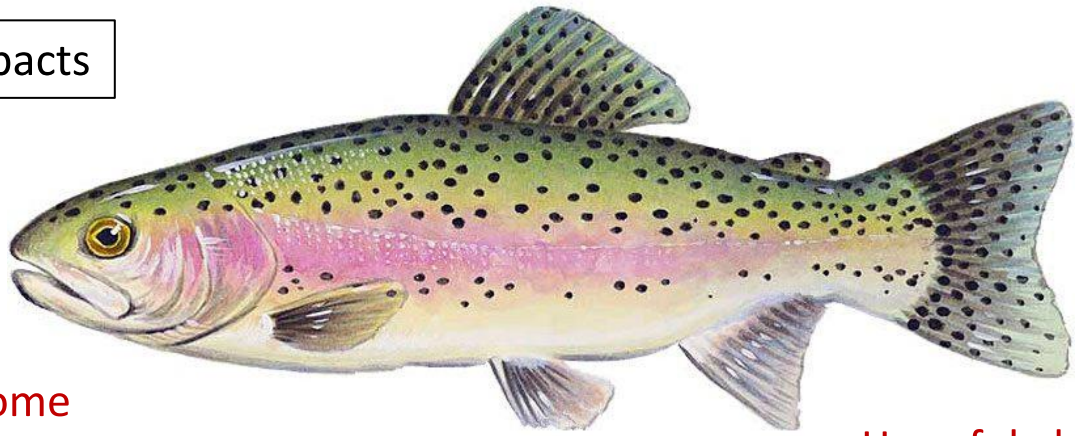
Main components of immune system similar to mammals

- Innate responses: leukocytes, proinflammatory, anti-viral, respiratory burst, lysozyme
- Adaptive response: B-cells, antibody generation, cytotoxic T-cells
- Specialised mucosal tissues, mucosal antibody IgT

Mucosal surfaces (skin, gills, gut): first line of defence

- Mucins; antimicrobials; humoral and cellular immune factors (specialised)

Climate change impacts



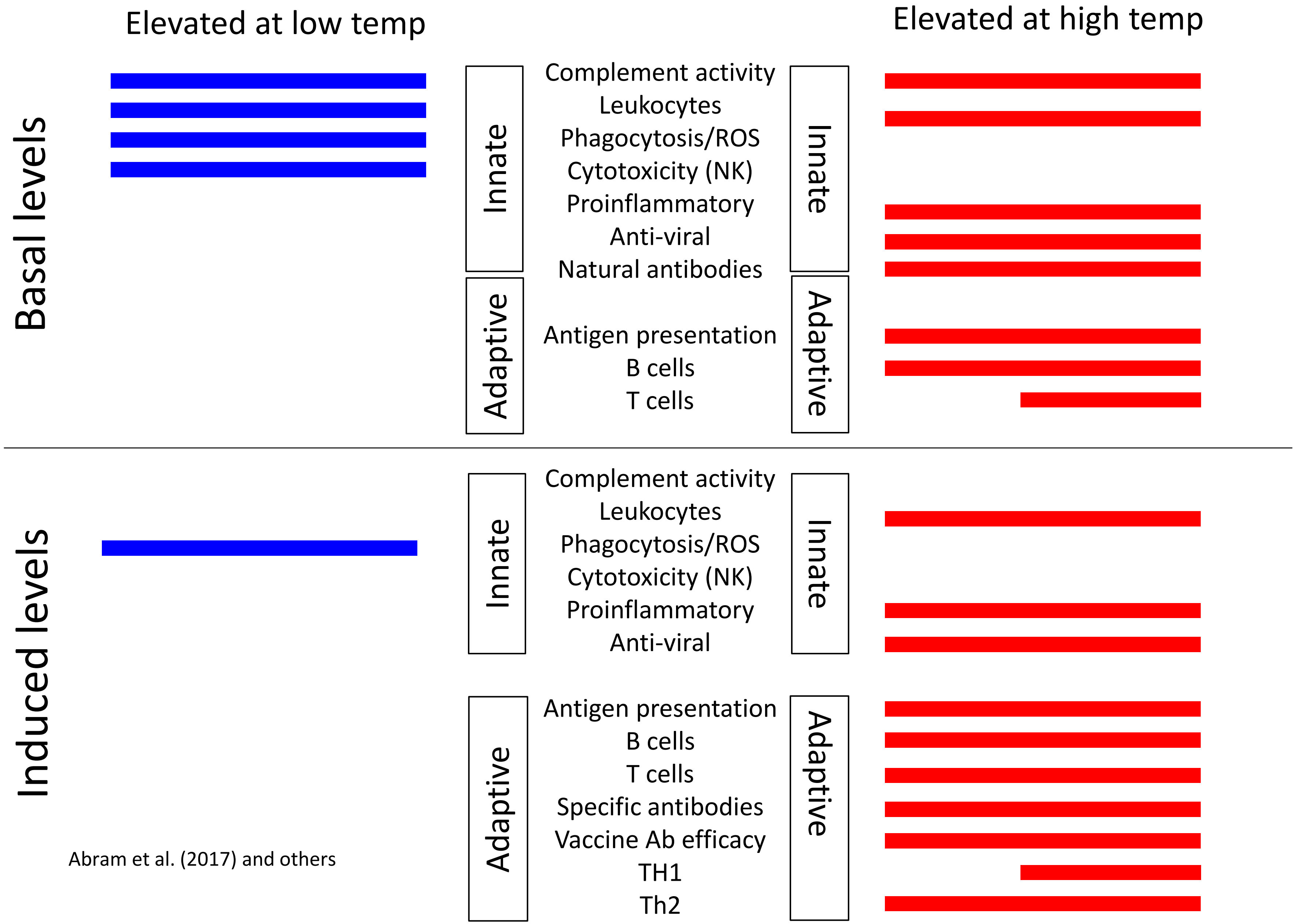
Available diet
- modified mucins
- bacterial attachment

Modified microbiome
- good/bad
- reduced bacterial diversity
- predominance of pathogenic species

UV
- good/bad
- sterilising
- lesion &pathogen entry

Harmful algal blooms
- stress
- lesions
- hypoxia

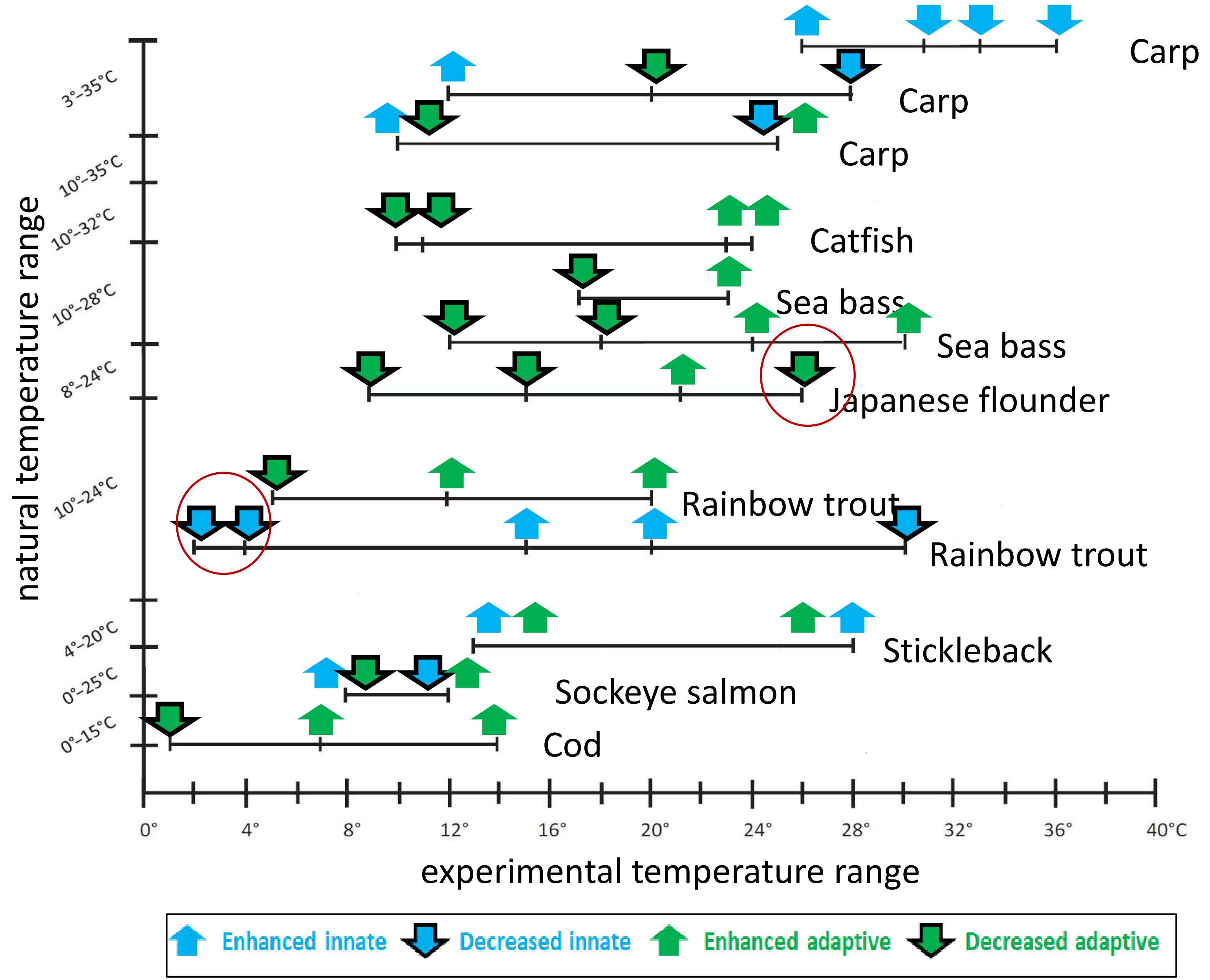
Temperature effect on fish immune parameters



Abram et al. (2017) and others

Optimal temperature for immune responses varies with species

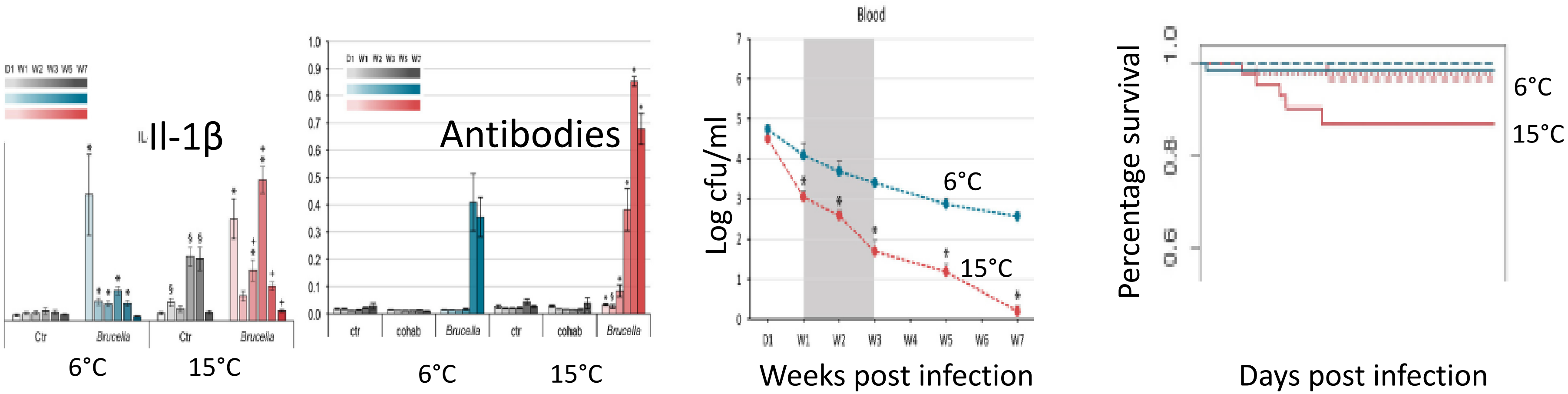
Dittmar et al. (2014)



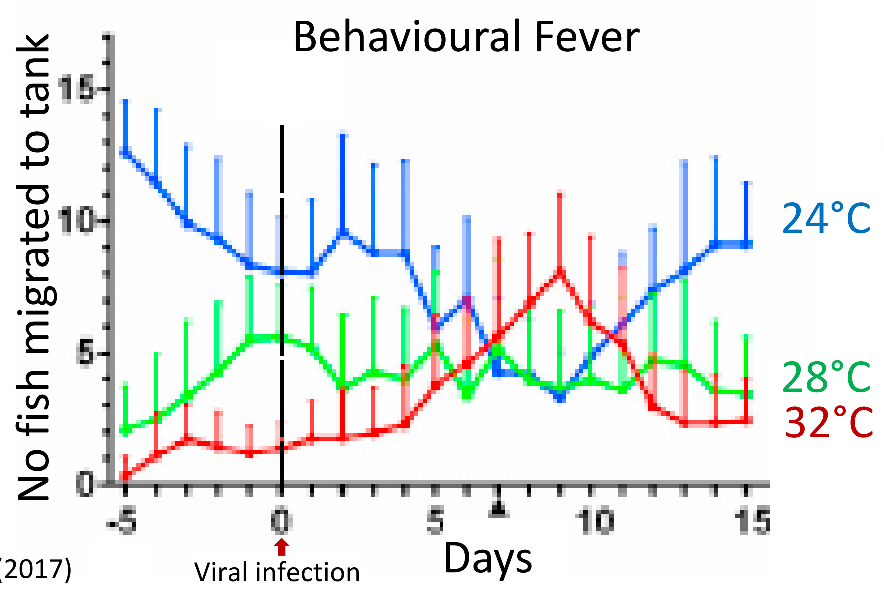
Hyperthermia – resulting in detrimental immune response?

Brucella infection of Atlantic cod held at 6°C and 15°C (hyperthermic)

Larsen et al. (2018)

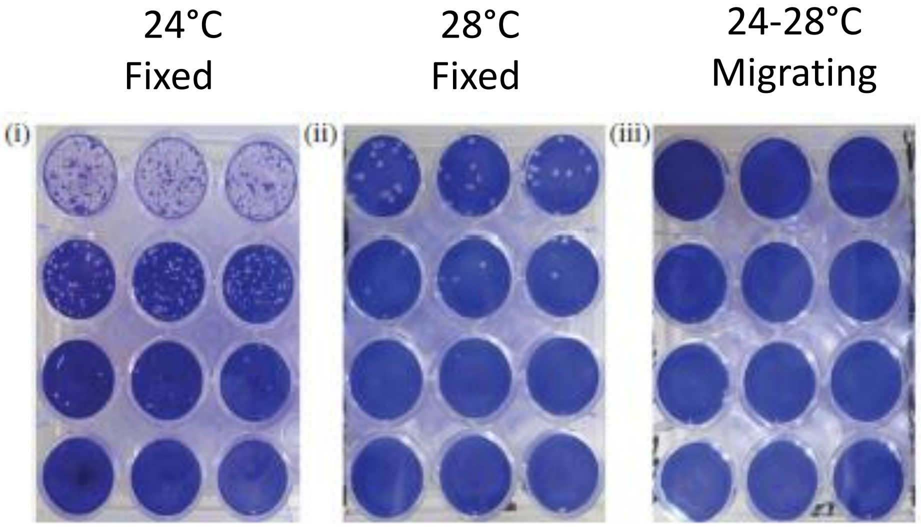


Higher proinflammatory and antibody levels over 5 weeks of infection at 15 ° C (red); higher clearance rate of *Brucella*, yet lower survival.



Rakus et al. (2017)

Viral infection



Cytopathic effect

Boltana et al. (2013)

Concluding remarks

- climate changes affect fish immune responses
- higher temperatures, within host range, should increase magnitude of immune response
- changes in immune response may be more effective for viral infection than for bacterial
  (trend as seen in experimental viral and bacterial fish challenges)
- changes in immune response may improve control of low level environmental pathogens, but not likely to counteract increased pathogen pressure overall
- temperatures exceeding thermal range may clear pathogen but damage fish in process

Pathogen	type	Disease
Salmonid alphavirus	V	<11°C
Spring viraemia of carp virus	V	10–17°C
Koi herpesvirus	V	16–28°C
Flavobacterium psychrophilum	B	<10°C
Yersinia ruckeri	B	>8°C
Renibacterium salmoninarium	B	>13
Lactococcus garvieae	B	>16°C
PKD parasite	P	>15°C
V virus; B bacteria; P parasite		

- many aquacultured fish species already grown at high temperatures to favour growth
  - therefore margin for additional increase in temperature without detrimental effect is small

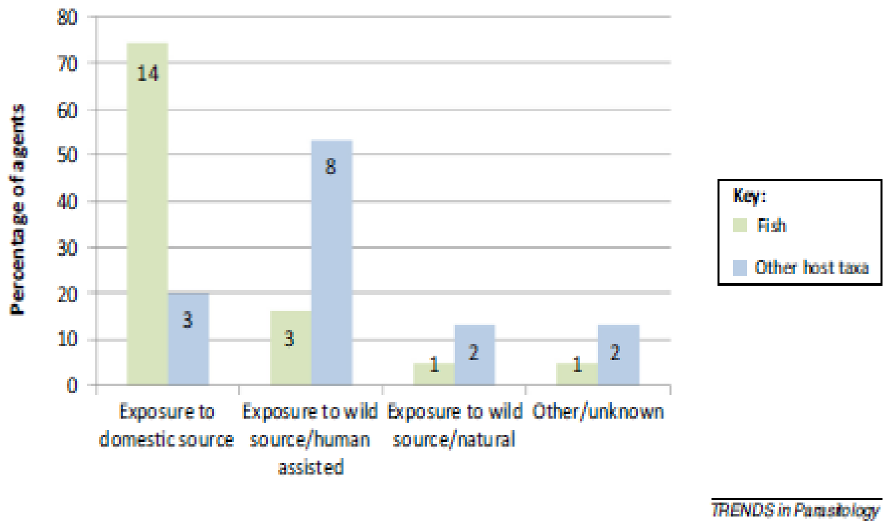
Concluding remarks

- diseases are emerging, but little consensus that these linked to climate change/changes to host response
- some capacity for artificial genetic selection to thermal tolerance in aquacultured fish
  - thermal tolerance enhanced over 3 and 15 generations for sticklebacks and rainbow trout
- improved farmed fish health will benefit wild fish health

Teixeira & Taylor (2020); Tompkins et al. (2015)

- additional studies required on multifactorial effects on immune response
- robust metadata analysis complicated by small size of research community and multiple fish models

Disease in freshwater wild fish populations



Primary drivers of disease emergence from 2000 onwards

(few publications met selection criteria for inclusion in analysis)

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