Understanding Antimicrobial Resistance and Biosecurity in Aquaculture

FAO candidate Reference Centers on AMR and Aquaculture Biosecurity

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Preventing bacterial diseases in Aquaculture

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Focus of health management is 90% prevention (health Care) 10% treatment (Sick Care)

Health care

- Part of daily management- Proactive
- Investment moderate and planned
- Fish homeostasis optimized may result in better growth

Sick Care

- Damage control- reactive
- Takes effect after losses have started
- Costs can be high and unplanned
- Fish homeostasis is out of balance- likely long-term effects

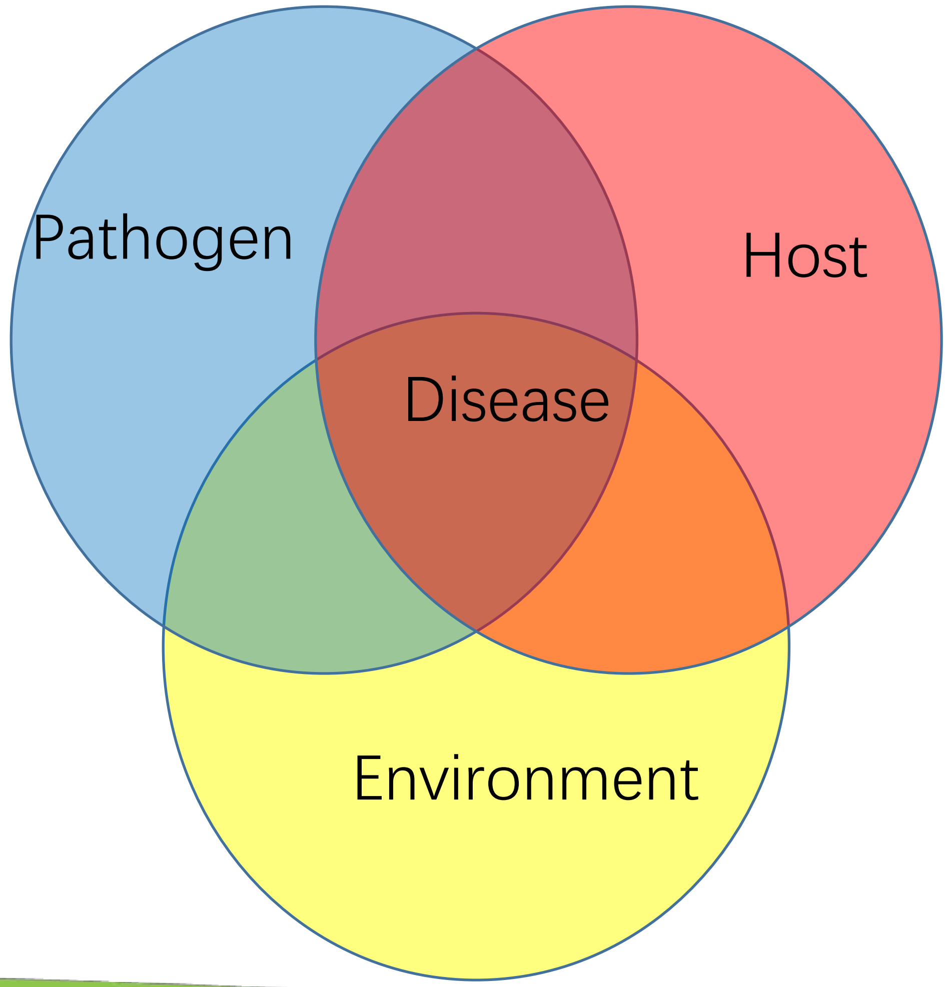
Disease prevention starts at the planning stage

- Site selection
  - Soil Chemistry- Alkalinity, hardness, trace elements, contaminants (affect stability and make up of microbial community and influence homeostasis of fish)
  - Water source- (biosecurity, temperature, volume, nutrients, contaminants)
  - Location- local stressors, predatory bird roosting sites, flyways, proximity to aquaculture or wild fisheries, Cages-tidal flushing proximity to other aquaculture and prevalence of toxic algae
- Facility Design-
  - Pond depth and orientation with prevailing winds affects rate of temperature change and diffusion of gasses
- Fish
  - Genetics- selection for disease and stress resistance

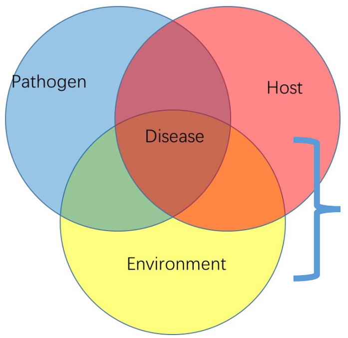
Disease prevention- reduces need for antibiotics

Health care- management to reduce chances of disease. All components of the aquatic ecosystem are dynamic and interconnected.

Sick care- Management of a disease to minimize the impact after it has started. If you don't correct underlying cause disease will reoccur after treatment



The environment-host interaction



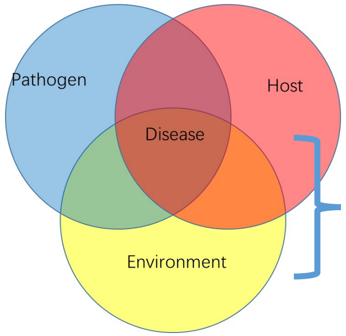
- Stress- host response to perceived danger. Response optimizes survival/ repair of damage but reduced immunity.

  Minimize perceived threat-

  - Anesthesia
  - Cover tanks and minimize noise when moving

  Minimize duration and frequency of stress

  Minimize impact of stress- handle during cool periods, adjust salinity and calcium levels to minimize impact of gill perfusion and reduced kidney function



The environment-host interaction

Physical Injury- Breaks natural barriers to infection

Mucus prevents colonization by bacteria

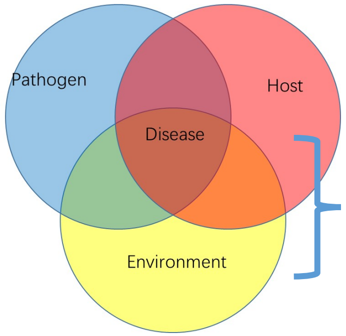
Physical barrier, mucus flow and sloughing , antimicrobial peptides

Epidermis and Dermis- cells and connective tissue prevent systemic invasion

Minimize injury-

- Handle in cushion of water, use wet smooth surfaces and don't overload nets and buckets.
- Use size appropriate feed to reduce mouth abrasions
- Actively suppress predation and aggression

The environment-host interaction



Water Chemistry/ Temperature

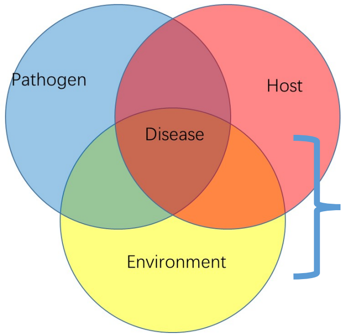
Perceived threat- Stress (Low oxygen, temperature shock)

Organ and tissue insult-

- Hypoxia and acidosis cause cell damage and necrosis- (low oxygen, hyperthermia)
- Oxidative stress and membrane damage- cause anemia- (Nitrite, hypothermia)
- Ammonia- gill damage

Minimize damage- monitor water quality, aerate well before DO becomes stressful, chloride levels to prevent nitrite toxicity, temperature acclimate fish when moving.

The environment-host interaction



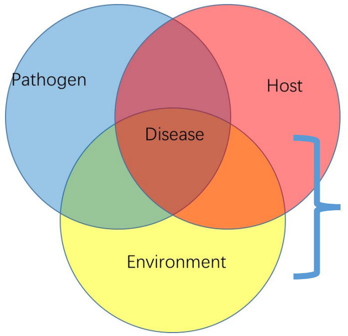
Temperature

Low temperature- suppressed acquired immune response

Temperature- shift – reduced immunity and defenses during adaptation

Optimize health before temperatures fall (nutrition, water chemistry), maintain high hardness, feed when possible

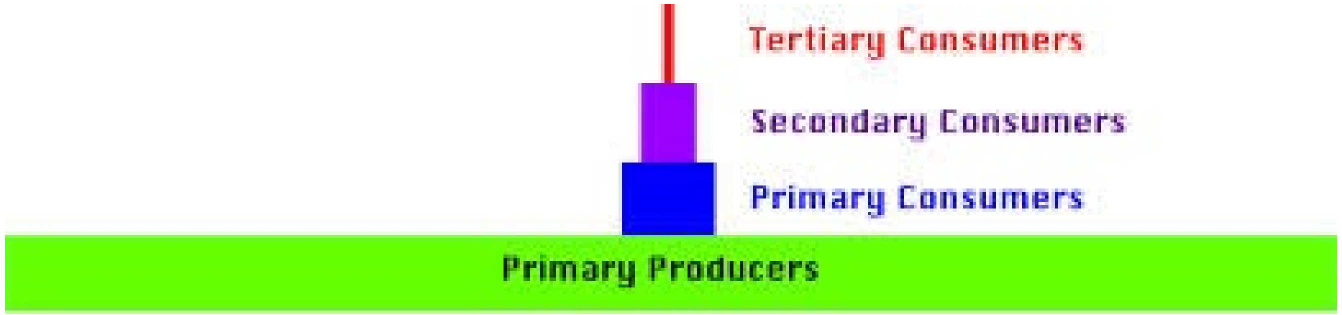
The environment-host interaction



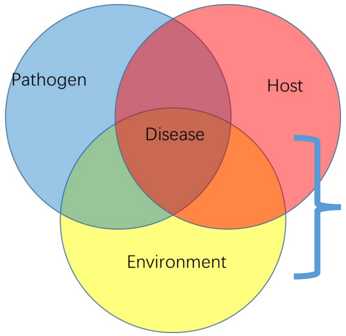
Biological Factors- host and pathogens are part of the Aquaculture ecosystem

The microbial biomass (alga and bacteria) in the pond is 20x the fish biomass- microbes control the pond

A healthy/diverse ecosystem provides stability



The environment-host interaction



Algal and Microbial toxins- Cyanobacteria, Dinoflagellates, *Prymnesium, Clostridium*

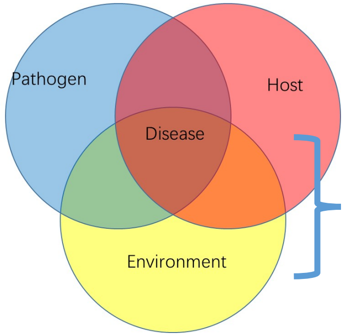
- Directly impact fish- damage tissues and affect components of the immune system

Physical influence-

- Diatoms can damage gill epithelium
- Alga and bacterial matrix provide substrate for pathogens

-Manage ponds to promote diversity and minimize negative components- selective herbicide use, filter feeders

The environment-host interaction



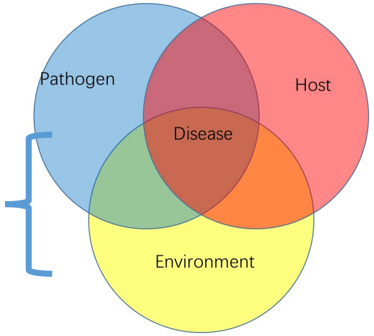
Predisposing pathogens- many microbial disease outbreaks can be linked to parasite infestation. Often macrofauna are alternate hosts.

- Oligochaetes- host myxozoa
- Gastropods- host trematodes
- Zooplankton- host cestodes and nematodes

Targeted control for problematic parasites

https://agresearchmag.ars.usda.gov/2002/sep/snail/

The environment-pathogen interaction



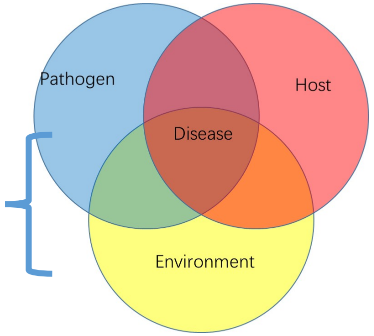
Many microbes are opportunistic pathogens of fish. The environment can influence the pathogen prevalence.

Reservoirs- many bacterial pathogens can grow or be sequestered in mollusks, zooplankton, other vertebrates (amphibians, reptiles, fish, birds and mammals) or in biofilms.

Also, decomposing fish or feed can provide a substrate for pathogen growth.

Biosecurity plans need to consider these reservoirs in fallowing, disinfection and movement of water and soils

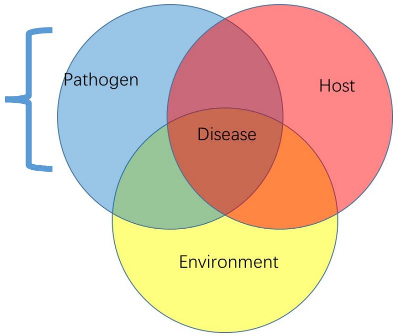
The environment-pathogen interaction



Water temperature and chemistry (especially salinity) can influence a microbial pathogens ability to survive in the environment.

If possible, these parameters can be optimized to reduce the pathogen presence but if not, this can influence implementation of management protocols.

The pathogen

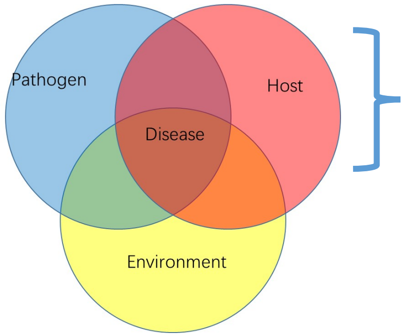


Biosecurity-

- Non-endemic pathogens can be effectively managed by avoidance
- Non-endemic pathotypes and AMR biotypes can be managed by avoidance

Requires biosecurity plan, effective diagnosis and monitoring and quarantine protocols

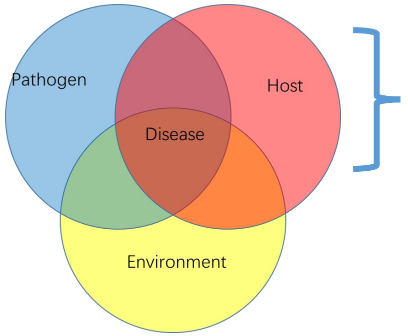
The host



A healthy host can effectively control most infections – limiting the effect of infection to mild disease. Furthermore, after primary exposure or vaccination, protection is enhanced.

- Feed must be fresh and nutritionally complete.
- Effective vaccines given when immune response is good, can prevent bacterial diseases and viral diseases (many bacterial caused losses can be attributed to a predisposing infection from another agent).

The host

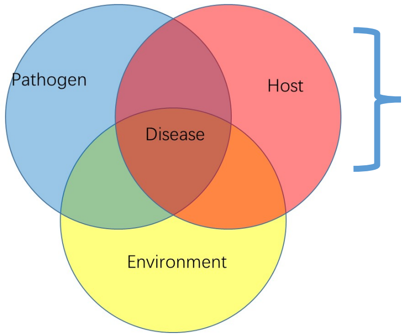


The host innate defenses can be optimized to respond to bacterial pathogens.

Immune enhancing agents such as glucans (fungal cell wall components), nucleic acids, bacterial cell wall components and chitin can stimulate the innate immune response.

- Short term- heightened presence of responsive innate defenses
- Long term- leukocyte training- longer changes in gene expression that allows a better response (Petit & Wiegertjes 2016).

The host



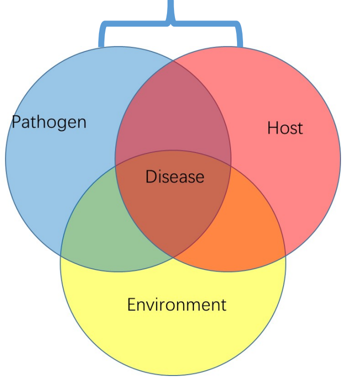
The host can be seen as a microbial ecosystem. The microbiome of the gill, skin and gut can influence the ability of the pathogenic bacteria to colonize the fish. Management to optimize the natural flora can reduce bacterial diseases.

- Prebiotics- non-nutritive feed additives that feed the beneficial gut bacteria (Peterman et al., 2020)
- Probiotics- the addition of beneficial bacteria to seed the gut

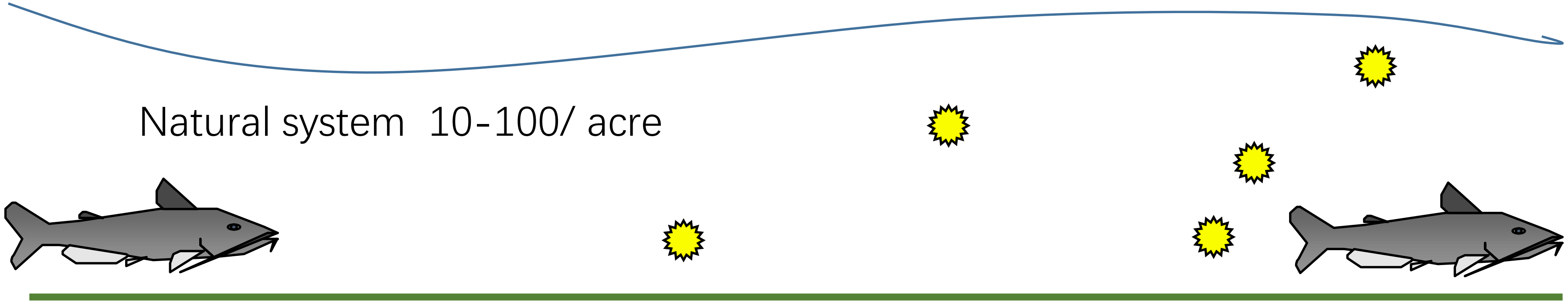
- Minimize use of antibiotics- this disturbs the natural flora, increasing levels of proteobacteria including potential pathogens (Carlson et al., 2015; Navarrete et al., 2008)

The host-pathogen interaction

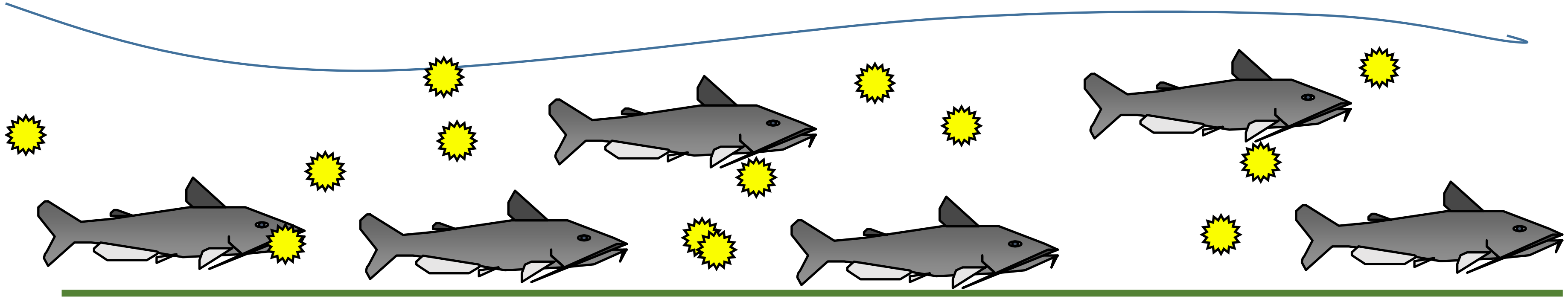
Fish Density= Pathogen density



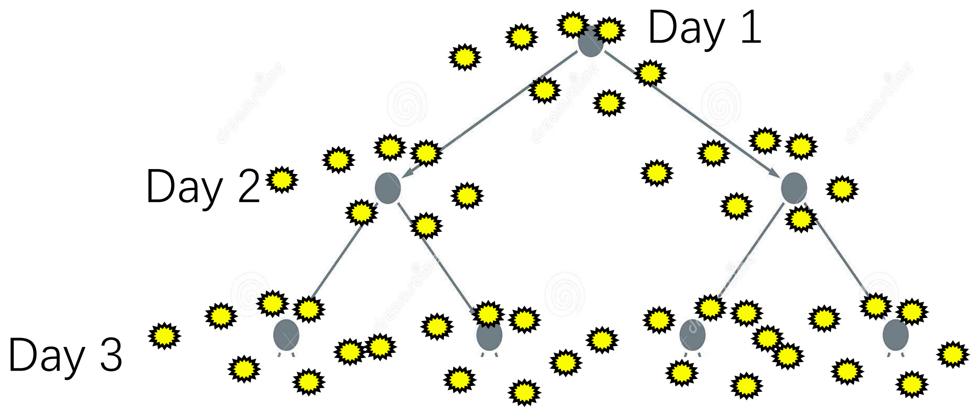
Natural system 10-100/ acre



Aquaculture system 3000-10,000/ acre



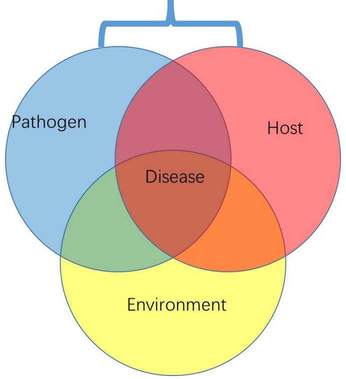
Time at density



1. Dissemination from carriers ~0.5-1 day
   - Immune suppression
   - Pathogen multiplication
   - Shedding
2. Amplification- first round of replication in new host 1-3 days
   - Incubation-infection, target tissue
   - Shedding

❖Minimize time held in crowded conditions

The host-pathogen interaction



Minimize transmission

Fecal oral- give time for gut to clear before feeding (Wise & Johnson, 1998), also before handling.

Minimizing- interaction (social distancing) during an infectious disease outbreak

- Don’t feed (if not using antibiotics)
- Don’t crowd

Minimize cannibalism- remove dead and dying fish if possible


Photo: Dr. Torrans

Management focus depends on stage

- Young fish- high density, Naïve. Management much more intense. Prepare for first exposure
  - Vaccinations
  - Immune stimulants
  - Avoid stressors, nutrition and water quality
  - Minimize pathogen load and spread

- Older fish- previous natural exposure to endemic pathogens
  - Focus on maintaining immunity and suppressing predisposing conditions

Sick Care

When prevention fails, must rapidly respond to disease outbreak

- Recognition of disease event
- Rapid accurate diagnosis
- Evaluate predisposing factors
- Treat as appropriate and optimize environment to allow recovery.
- Use high biosecurity to reduce spread

Conclusion

- Health care is continuous and must be a part of all steps in aquaculture.
- Preventing disease reduces antibiotic use and improves the chances of it being effective when needed.
- Several producers rely solely on management- marketing an antibiotic free product.
- Much research needed to identify predisposing factors and remediation methods.

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Thank you!

- References:

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