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ENVIRONMENTAL SUSTAINABILITY AND INNOVATIVE TECHNOLOGIES IN SMALL-SCALE FISHERIES AND AQUACULTURE

MODULE ~~EPISODE~~ 2

AQUACULTURE

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MODULE 2: MARINE AQUACULTURE

UNIT 1: · FiSh Health and Welfare in AQ

Based on work by Dr. S. Zrnčić in WPT2-3.2 Training and Capacity Building, Split (HR), 14/06/2019

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FISH WELFARE AND DISEASES

- Potential appearance of illness and disease tied to fish general welfare
- Health management of aquatic animals done through series of measurements through which farmers try to reduce the appearance and spread of diseases
- The following premises should be met in order to achieve healthy populations:
  - Use only **disease-free** organisms in farming, coming from known nurseries;
  - Reduce the **stress** (through good holding conditions, good hygiene practices);
  - Allow for **good condition** of the farmed animals through optimal feeding
  - Prevention and control of disease through **vaccination** and approved medicines;
  - Therapies according to **expert advice**, following the prescribed procedures closely;
  - Appropriate **removal of dead or infected animals**;
  - **Reporting significant losses** due to disease.

FISH WELFARE INDICATORS

BIOTIC

- Fish density
- Food and feeding
- Genetics
- Health and health maintenance (diseases)

ABIOTIC

- Water quality parameters, such as: oxygen content, pH, salinity, temperature
- Farming techniques
- Cage or tank design
- Handling procedures
- Sorting procedures

ACHIEVING GOOD INDICATORS
Optimal biotic & abiotic factors

Abiotic factors - Environment

Oxygen (O_2)

- Fish can physiologically adapt to variations in O_2 levels
- O_2 consumption (O_2 kg^{-1} h^{-1}) increases depending on temperature, activity, food consumption and stress, and decreases with size
- Depends on farming infrastructure, in cages during high temperatures periods can ba a limiting factor
- At 40% saturation, food intake and growth significantly affected
- At temperatures above 24°C and saturation <80%, food quantity should be reduced, as fish (sea bass) cannot digest food, instead it just passes through digestive tract

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Ammonia/Ammonium (NH_3/NH_4^+)

- High fish density and insufficient water circulation can lead to accumulation in non-ionised (ammonia, NH_3) and ionised form (ammonium, NH_4^+)
- NH_3 is more toxic, but the ration between the two depends on total nitrogen, pH, temperature and salinity
- Sub-lethal doses can cause damage to gills, lower general immunity, increase sensitivity to certain diseases
- In marine environment, ammonia rarely causes decrease in welfare

Water Flow and Exchange

- Insufficient water flow leads to NH_4^+ and other metabolites
- Caused by unsuitable locality or farming practices (fouling)
- Indicator: O_2 levels in cages

Light

- Important factor in larval growth & development, sexual maturation food intake
- Manipulation can induce or postpone spawning

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Abiotic factors - Farming Techniques

Fish Handling

- Weighing, sorting, counting, medicinal baths, net changes, transferring to transport tanks

1. Careful planning and execution by qualified staff
2. Anaesthesia if longer that 30 s out of water
3. Concentrating fish stressful, max. 2 hours
4. Fasting 24 to 48 h before handling
5. Monitoring of dissolved O_2 in water
6. Clean (cage) nets
7. Check for skin lesions and scale loss

Catching Fish

- ESFA, 2009:

1. Asphyxia out of water
2. Chilling with ice or water-ice mix

- Preceding procedures

1. Fasting
2. Fish density increase
3. Removal from water

- All three endanger welfare, the greates risk:

1. Very high density
2. Long period of increased density
3. Exposure to air

Biotic factors - Farming Conditions

Population Density

- Biomass/volume
- Not a walfare prerequisite, but can have an effect on it:
  - Positive: social instinct
  - Negative: effect on water quality
- Fish condition and water quality monitoring
- Prevention on welfare deterioration
- In higher densities, attention must be on behaviour and appearance of fish, as well as water quality

Aggresion & Competition

- Post-larval objects and cages with fry → potential aggression and/or cannibalism
- Prevention: uniform fry sizes, appropriate stock density and adequate water flow

Animal Attacks

- Birds: attack and damage fish, also transfer disease pathogens from digestive tract of predatory birds
- Protective nets not effective agains all bird species (e.g. cormorants)

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Biotic factors - Food & Feeding

- Larvae feeding – sensitive developmental stage, important that larvae get enough of quality live food do preserve welfare and development
- Ongrowing stage less sensitive – food availability to avoid aggression
- Inadequate food composition can lead to deformation and slower development
- Adequate food quantities should be provided to prevent stress and behaviour changes, including food competence, cannibalism in larval and ongrowing stages
- Fish have the ability to regulate daily food intake based on nutritional and energetic needs
- With seabass, better results with limited access to food
- Food storage important, especially during the warm period, so as to avoid nutritional value degradation, which could, in turn, cause disease caused by vitamin or micro-element deficiencies

Biotic factors - Health

Health/welfare depends on the following:

- Careful farming site selection
- Environmental monitoring to achieve optimal environmental growth conditions
- Clear division of duties and responsibilities at the farm
- Staff education and training
- Selection and breeding programme planning
- Effective note-keeping and archiving
- Good hygiene practices
- Regular fish monitoring
- Regular veterinary check-ups
- Regular biomass estimations
- Keeping distress at minimum
- Planning for fish collecting and sorting
- Management control of Good Production Practices

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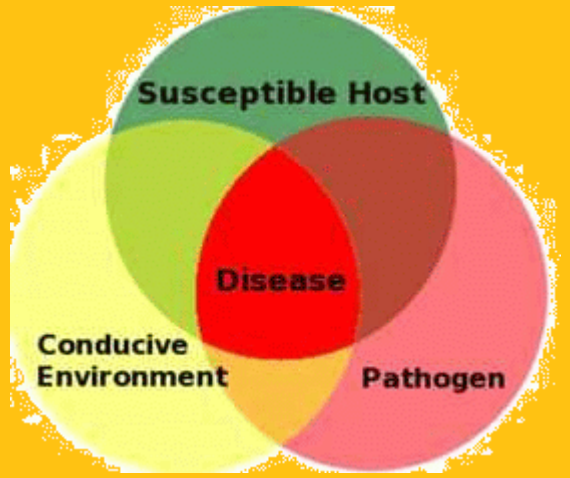
APPEARANCE OF DISEASE

- **Disease:** disturbance of normal state of the organism with a specific cause and recognisable symptoms, i.e. the reaction of the organism to various internal or external factors
- According to etiology, diseases can be divided in two categories:

1. Diseases caused by **abiotic** factors (environmental conditions, poisoning, eating disorders, etc.)
2. Diseases caused by **biotic** facotrs (viruses, bacteria, fungi, parasites, prions)



Disease Triangle

Image by: Earlycj (CC BY-SA 3.0)

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BIOSAFETY

- Set of actions and measures undertaken by a region, counry, aquaculture producers' union or an individual producer in order to protect natural water resources, fishery, aquaculture, biodiversity and/or farmed stocks and people dependent on them from potential negative influences stemming from introduction and spread of serious diseases of aquatic organisms (FAO, 2009)
- Denotes a set of management and physical measures intended to mitigate the risk of pathogen introduction or their spread in the aquatic animal populations or the environment (OIE, 2018).

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BIOSAFETY - MEASURES, ACTIVITIES, PROCEDURES

- Prevention of introduction and spread of pathogens in communicable and parasitic diseases (bacteria, viruses, fungi) through:
  - ✓ Reducing risk of introduction of disease
  - ✓ Reduce spreading within the farm and to other farms to minimum
  - ✓ Improve general health
  - ✓ Protect the economic value
  - ✓ Prevent introduction of new diseases
  - ✓ Protect human health (zoonoses)

MODULE 2: MARINE AQUACULTURE

UNIT 1: SUSTAINABLE AQUACULTURE THROUGH USE OF BIODEGRADABLE MATERIALS IN MUSSEL FARMING

Based on the results of the Adriatic IPA ECOSEA project

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ISSUE WITH PLASTICS IN MUSSEL AQUACULTURE

- „Plastic" ropes (commonly nylon or polyamide) are used in mussel aquaculture to provide a base where mussels can attach and grow
- (Parts of) plastic ropes can get lost during heavy storms and/or handling during maintenance operations
- People worldwide are becoming increasingly aware of the dangers of plastic waste and, especially, microplastics, and biodegradable alternatives are being being sought

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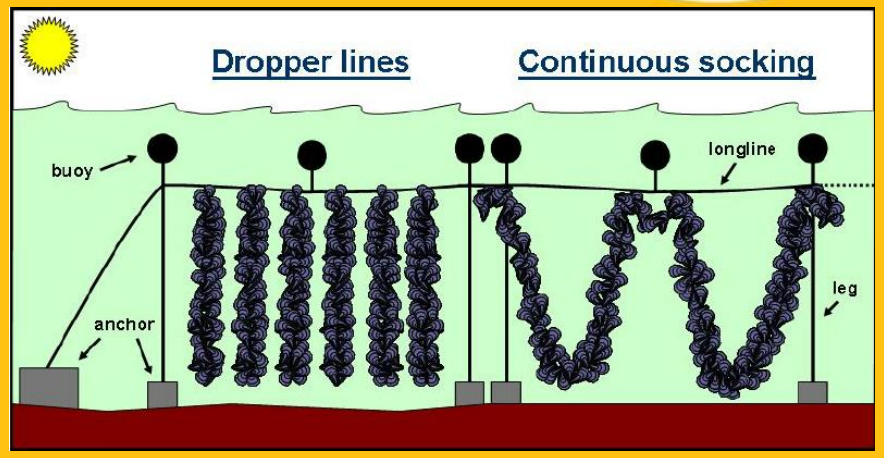
DROPPER LINES VS. CONTINUOUS STOCKING

- Dropper lines ‘traditional’, continuous stocking ‘New Zealand’ method
- Premise is similar, a rope is pushed through a socking pipe (mussel sock, „mussock”) attached to a longline
- Rope provides a medium for the mussels to attach themselves using bissus thread, mesh holds the mussels until they are attached, eventually they grow through the mesh openings



From: McKindsey CW, Anderson MR, Barnes P, Courtenay S, Landry T & Skinner M, (2006) *Effects of Shellfish Aquaculture on Fish Habitat,* CSAS Research Document 2006/011, 84 pp. IISN 1499-3848

DROPPER LINES VS. CONTINUOUS STOCKING (*cont'd*)

- Dropper lines simpler, do not require specialised technology
- Continuous stockings require specialised technology (for pushing rope through socking pipe)
- Easier to use once technology is available

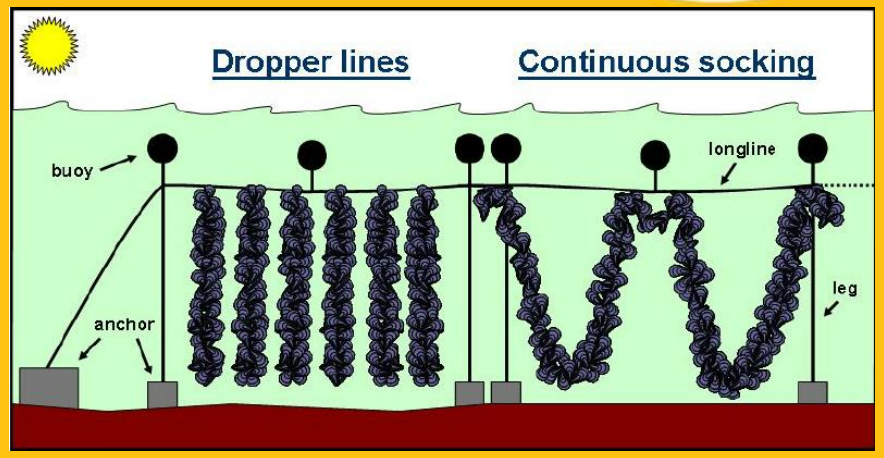


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Image: Automatic Mussel Seeder (Ancso Engineering Ltd., https://ansco.co.nz/mussel-processing/mussel-farming-equipment/mussel-seeders/)

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USE OF BIODEGRADABLE MATERIALS

- „Plastic" ropes and socks replaced by cotton ones
- Cotton dissolver in marine environment in a matter of months
- Methods and materials first tested and used in New Zealand (hence the term 'New Zealand method'), but also in other countries (Chile, Italy, the Netherlands, Turkey)

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PROS & CONS

- Pros
  - ✓ Use of biodegradable materials
  - ✓ Can be fully automated

- Cons
  - ✓ Mussels farmed using this method tend to grow uniformly in size less than when using ‘traditional’ plastic ropes and socks
  - ✓ Initial investment (compared to dropper line technology) is higher

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