Fish Health Management and Biosecurity for Recirculating Systems

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Effective Biosecurity

- Reduces risk of pathogen introduction
- Reduces risk that pathogens will spread throughout the facility
- Reduces conditions that increase susceptibility to infection and disease (e.g. reduce stress)

Effective Biosecurity

** *Planning begins with facility design* **

- Includes consideration of
  - Placement of doors
  - Placement of disinfection areas
- Ventilation – to control insects, dust and aerosol transfer (also can use barriers)
- Type and layout of rearing units

Facility Design

- Design a facility that will reduce stress on the fish, even beyond water quality considerations
  - Keep treatment equipment & culture tanks in different rooms
  - Reduce activity around tanks

Courtesy Jim Michaels

Stress Response

- Initial alarm reaction
  - Activate pituitary-interrenal axis
  - Release catecholamine (eg. Adrenaline) & corticosteroid (eg. cortisol) hormones
  - Compensatory cardiovascular & blood chemistry changes
- Stage of resistance
  - Physiological systems successfully compensate
  - Acclimation achieved
  - Note energy cost for compensation, growth may be reduced
- Stage of exhaustion
  - Duration or severity of the challenge exceeds tolerance limits, no more acclimation possible, physiological changes no longer benefit the animal
  - End result – impaired immune protection (from increased cortisol), infectious disease may occur

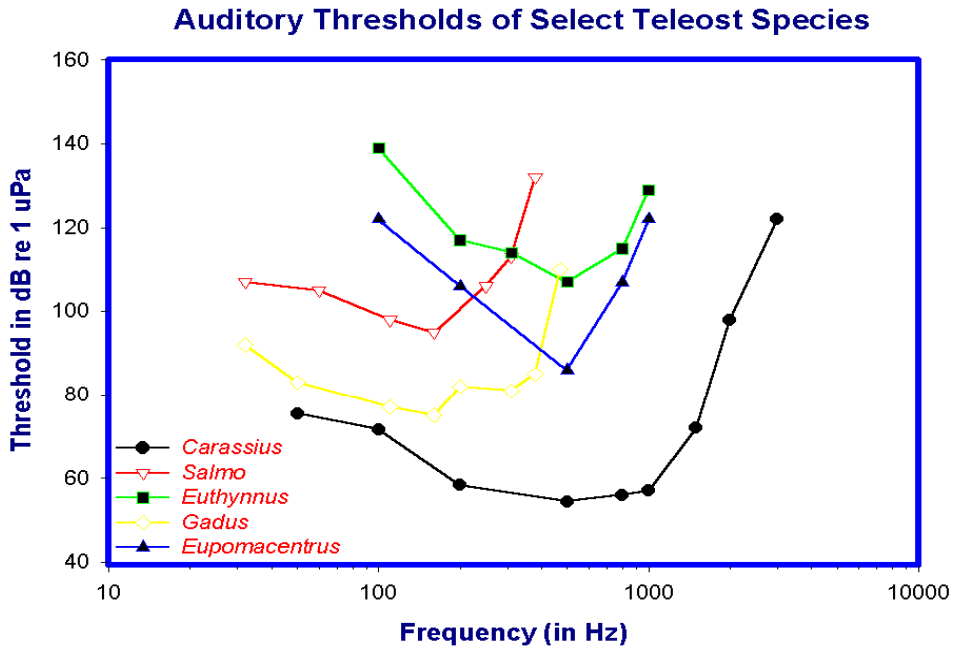
From Wedemeyer,1996

Facility Design

- Reduce noise & vibration
  - Use vibration isolation between
    - pumps & pipes
    - motors & floor
    - tank & floor

Sound

- Most fish species detect sounds up to 500 to 1,000 Hz, with best hearing from 100 to 400 Hz (Some specialists (eg. goldfish, catfish can detect sounds to over 3,000 Hz, with best hearing from 300 to 1,000 Hz)



MS-trans (fig. 5)

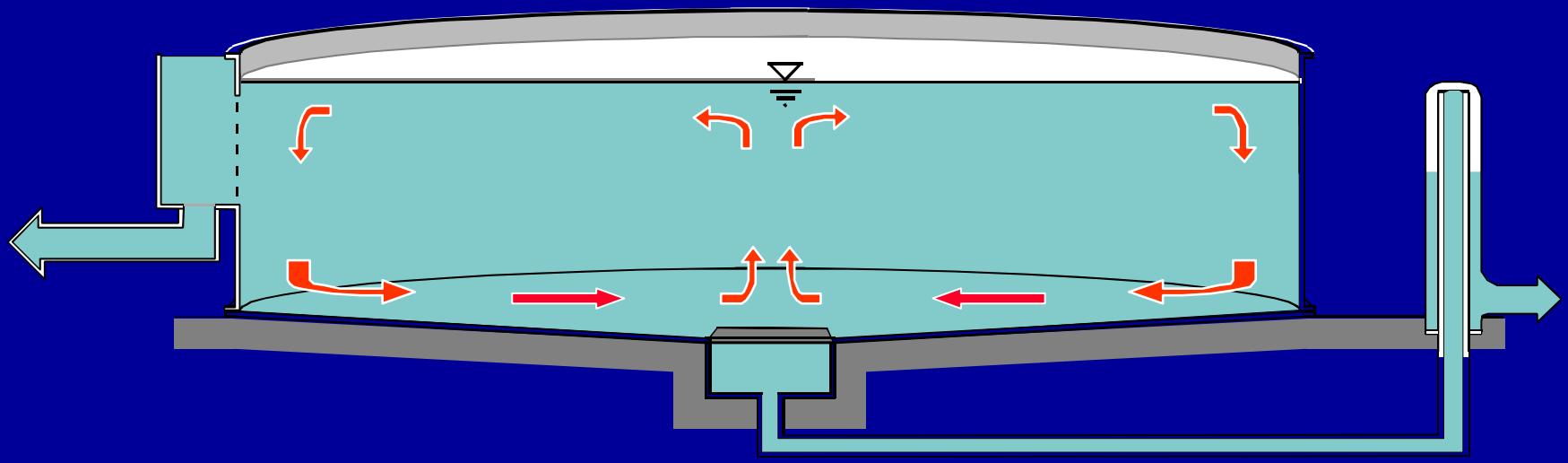
Facility Design

- Reduce Noise & Vibration
  - Bart et al. (2001. Aq.Eng.) – First characterization and quantification of noise levels in intensive aquaculture systems
    - High frequency noise – electrical motors, oscillating and collapsing air bubbles, aeration, water pump action (ie., 1-2 kHz; SPL from 100 to 115 kB (re: 1µPa))
    - Low frequency noise – water flows, ground vibrations, tank wall vibrations, electrical pumps (ie., 25-1000 Hz; SPL from 125 to 135 dB (re: 1 µPa))
  - Davidson et al. (In Press. Aq.Eng.) – Quantifies methods to reduce noise in fiberglass tanks

Circular Tanks & Solids Removal

- "Cornell type" Dual-Drain Culture Tanks
- Advantages:
  - self cleaning
  - rapid solids fractionation
  - uniform environment
  - optimum rotational velocity
    - for swimming fish
  - flow distributes feed & fish

Circular Tanks: Radial Flow



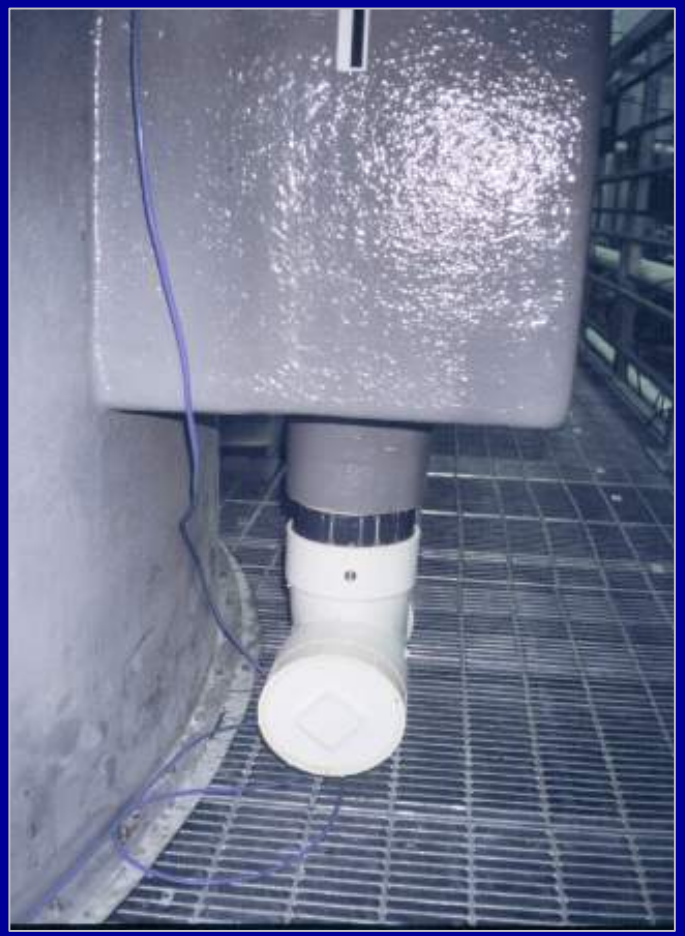
- Primary rotating flow creates secondary radial flow:
  - transports settleable solids to bottom center
  - creates self-cleaning tank
- Addition of a side-wall drain to withdraw majority of flow free from solids

Circular Tanks w/o Rotation

- Solids must be “mucked-out” of tank

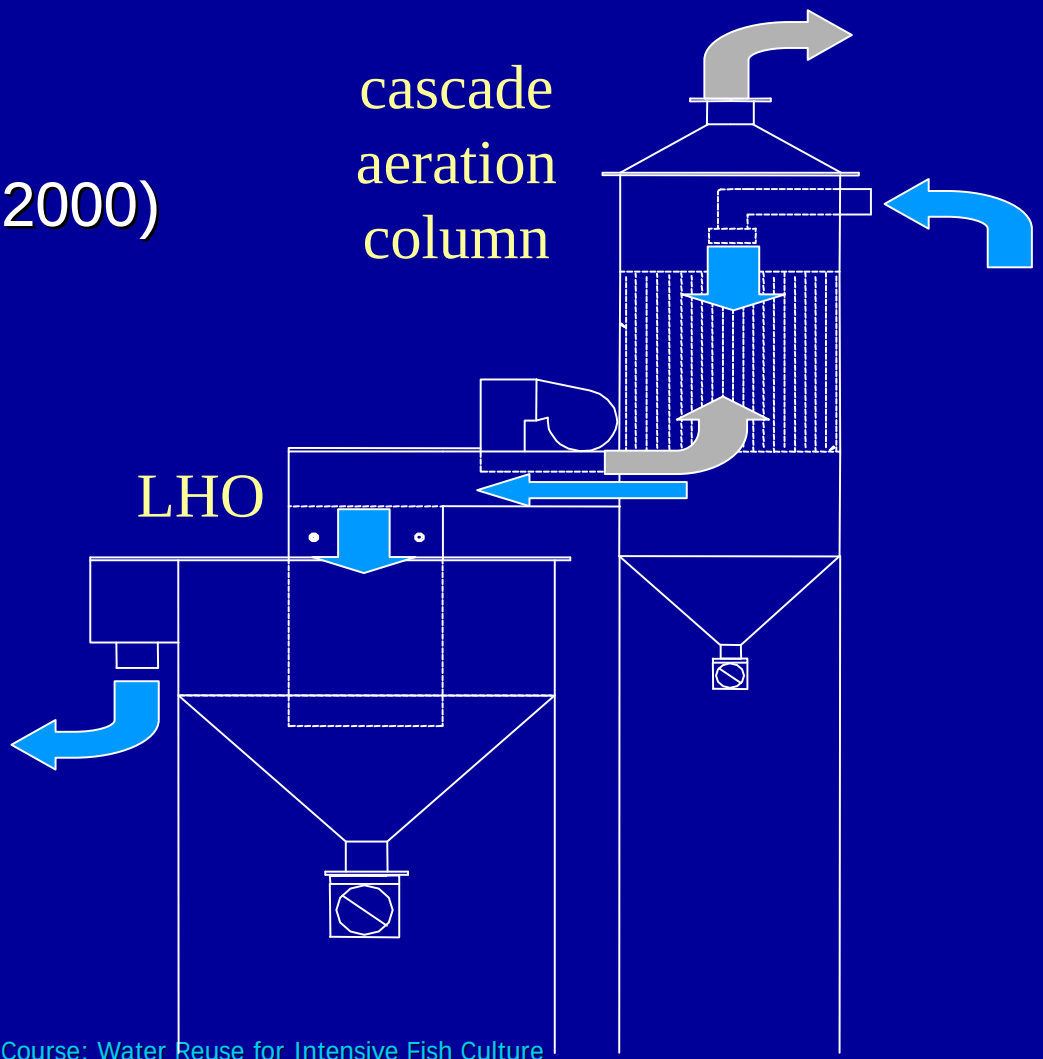
Clean Outs and Cone-bottom Unit Processes

- **Solids should not build up in any part of system:**
  - Easy to clean
  - Unit processes (CO_2 stripper, LHO, biofilter) designed to be cleaned (e.g. cone-bottom, ability to drain)
  - Include features to ease solids removal from system (e.g. clean outs)

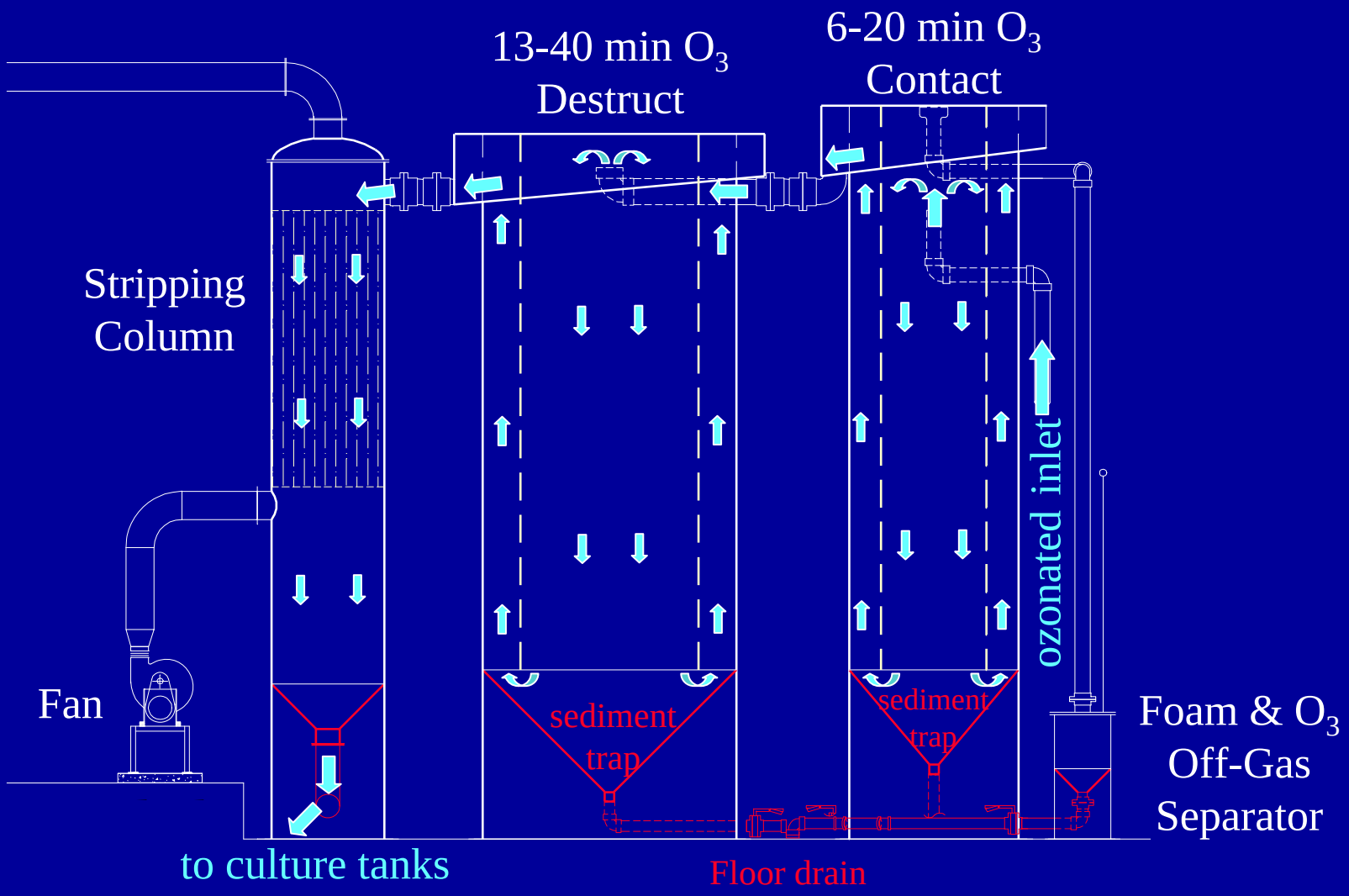


Clean-Out Locations in all Sumps

- CO_2 & O_2 Control
  (Summerfelt et al., 2000)



Clean-Outs for Ozone Contacting

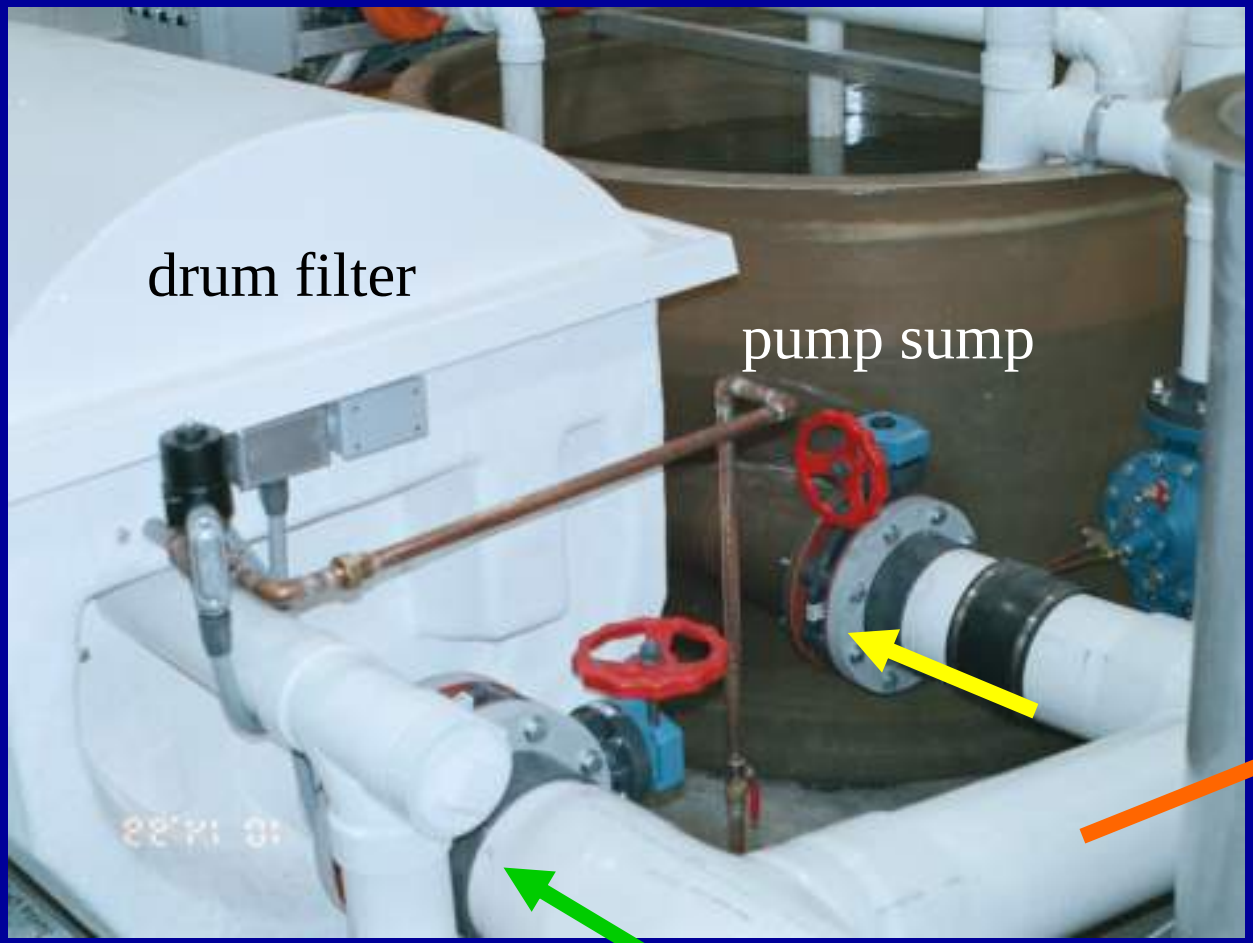


Lamar NFH (PA)

Isolation of system components

- Tanks and unit processes that can be taken off line & drained out of system
  - For cleaning while the rest of the system is operating, then discharge out of the system
  - For chemical treatment of individual tanks, discharge to a chemical drain

Bypass Piping:



- Drain piping should be plumbed to allow drum filter bypass to direct flow to:
  - Drain (away from RAS)
    - during cleaning events
  - Pump sump
    - When servicing drum filter

Mort Removal

- Design features to remove dead fish
  - “Mort Flush”
    - Quantify mortality
    - Reduce pathogen load on system
    - Remove weak/moribund fish for examination

Avoid use of wood, unless disposable

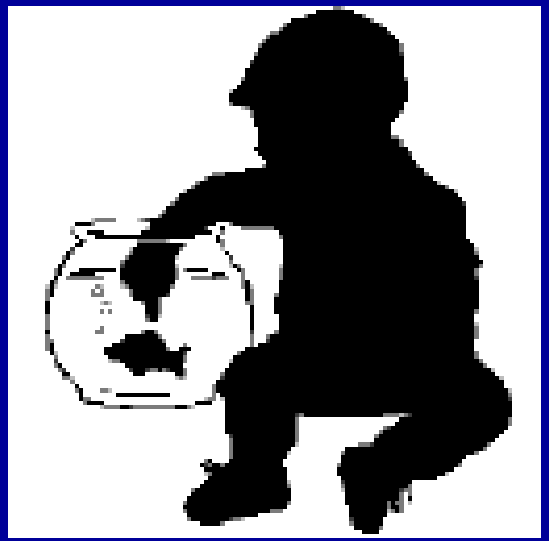
- Equipment used for sequential cohorts

- PVC sheets instead of wood sheets

Metal

Plastic
Inexpensive & Easy to Disinfect

I. Practices to Reduce the Risk of Pathogen Introduction



Opportunistic vs. Obligate Pathogens

- Obligate pathogens
  - Require animal host to replicate
  - Viruses (IPNV, IHNV, VHSV and OMV in salmonids); bacteria (bacterial kidney disease, furunculosis?, enteric redmouth disease)
- Opportunistic pathogens
  - Do not require animal host to replicate – nutrition from organic material
  - Naturally occur in soil and water
  - May also be part of the natural microbial population in the fish (e.g., the gastro-intestinal tract)
  - Includes the species associated with bacterial gill disease, coldwater disease, columnaris disease, and the motile aeromonads. Opportunistic parasites include *Trichodina*, *Chilodonella*, *Epistylis* and *Ambiphyra*. The fungi can also be considered opportunistic pathogens.

Water Supply

- Develop a specific-pathogen-free water supply
  - Exclude entry of aquatic vertebrates & invert.
  - Use ground water supplies when possible
    - can be pathogen free, but not always
    - a better choice than a surface water, if iron, H_2S or other contaminants are not a problem

Water Supply

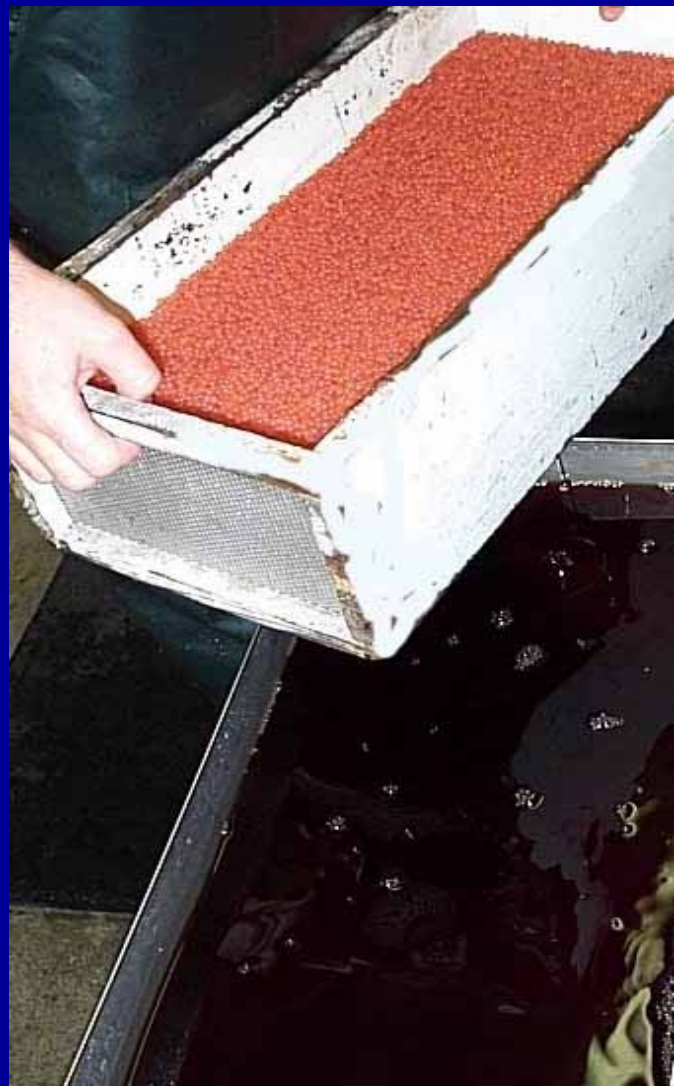
- Capture ground water before it becomes contaminated

Water Supply

- Disinfect a water supply that is not specific-pathogen-free

Prevent Eggs & Fish from Introducing Pathogens

- Use certified pathogens free eggs when possible
  - surface disinfect eggs upon arrival



Prevent Eggs & Fish from Introducing Pathogens

- Avoid introducing extensively reared fingerlings, i.e. those reared in ponds
- Quarantine fish brought from other facilities (certified or not)
  - Avoid introduction of delivery water
  - Use separate culture areas and monitor for pathogens of concern during the quarantine period

Feed

- Live food
  - Presents a serious risk of contamination with pathogens - should be cultured as specific-pathogen-free, never used directly from the natural environment
- Commercial dry feeds
  - Steam-pelleted – 160-180 F (71-82 C)
  - Expanded – 180-200 F (82-93 C)
  - Extruded – 220-350 F (104-177 C)
- Lyophilized feed
  - Many microorganisms survive lyophilization well

Prevent Introduction of Pathogens

- Enclose the facility
  - Secure facility from entry of mammals & birds

Prevent Introduction of Pathogens

- Develop standard operating procedures for staff that prevent pathogen introduction from the surroundings, e.g.
  - Hand washing
  - Work boots dedicated to culture area
  - Net & equipment disinfection tubs
  - Foot baths
  - Floor is always considered non-biosecure

People Management

- Strategically schedule culture activities (work on most vulnerable stages first, minimize number of personnel working on a group of fish, leave sick for last)
- Disinfect vehicles before driving up to facility

People Management (cont.)

- Visitor parking at periphery of facility grounds
- Restrict facility access to a minimum number of people
- Minimize number of tours and limit to small, easily managed groups
- Maintain log book

People Management (cont.)

- Visitors (at aquaculture facility w/in past 48 hours) – remove clothes, put on coveralls and disinfected boots, wash with antibacterial soap
- Instruct visitors not to touch, or lean on, anything in culture room
- Change footbaths and disinfect floors after every tour

Visitor Control

Footbath

Quarantine

- Planned early in the design of the facility
- Separate building, room or area with independent, isolated culture system
- Q period accounts for incubation and development times for targeted pathogens
- Water temperature kept at upper end of fish species optimum range to speed up pathogen life cycles

Quarantine (cont.)

- Observe new arrivals for abnormalities in appearance and behavior, sample and examine
- Throughout Q period, sample normal and abnormal fish, examine
- Hold fish at culture densities they will encounter in production system

Quarantine (cont.)

- Wash hands and arms before going between quarantine and production area. Disinfect footware. Change clothing.
- Save work in Q area as last element of the work day
- Use Q equipment only in the Q area
- Acclimate fish to production system water by introducing it to quarantine before transfer out of quarantine

II. Practices to Reduce Pathogen Spread

Meticulous husbandry

Husbandry

- Install deep foot baths, clean and change frequently
- Wash hands and arms before entering fish culture area and as change work with groups of fish
- Easily accessible disinfectant and rinse areas (e.g., for buckets, nets, meters)

Disinfection area

Husbandry (cont.)

- Store clean equipment in a clean area
- Even for recycle loop, treat each tank as a discrete rearing unit, minimize potential for cross-contamination
- Disinfect tanks and equipment before use with a different group of fish

Husbandry (cont.)

- Regard floor as contaminated, manage accordingly
- Clean floors frequently
- Inspect and clean all parts of system frequently
- Exclude pets, rodents, birds, other vertebrates and insects from culture area

Husbandry (cont.)

- Minimize the number of different personnel working with a group of fish
- Unaffected tanks should be worked on before affected tanks
- Care for young fish before older fish
- Equipment touching the floor should not contact fish culture water
- Fish that jump from tank to floor should be humanely killed, not returned to tank

Disinfectants

- Factors affecting disinfection process
  - Type
  - Concentration
  - Temperature
  - Contact Time
  - pH
  - Presence of soil/organic matter
  - Number of organisms
  - Type and growth phase of organism

Definitions

- Surfactant – 'SURFace ACTive AgeNT' - a molecule that lowers suface tension; contain both hydrophobic and hydrophilic components so are semi-soluble in both organic and aqueous solvents; the hydrophobic component sticks to grease and dirt while the hydrophilic section sticks to the water; active ingredient in soap
- Disinfectant – eliminates virtually all recognized pathogenic microorganisms; an agent that kills or inactivates >99.99% of disease causing microorganisms, may not kill spores
- Sanitizer – an agent that decreases the load of microorganisms (not necessarily pathogenic)

Virkon-Aqua (potassium monopersulfate)

Broad spectrum (inactivates IPNV)?	Yes
Inactivated by soil/organic matter?	?
Non-toxic fish?	Depends on dilution
Non-toxic humans?	As powder can be respiratory and eye irritant
Corrosive?	To metals but not netting
Surfactant activity?	Yes (including bacterial biofilms)
Leaves active residue?	?
Stable?	Dissipates very slowly
Tests for active chemical residues?	?
Safe for environment	Regs., breaks down to harmless organic salt

III. Practices to Reduce Susceptibility to Infection and Disease

Culling

- An important strategy to reduce transmission of pathogens
- Should include sick (as long as cause is infectious) as well as dead fish
- Cull at least once per day
- Fish should be killed humanely, not allowed to die from suffocation

Additional Strategies

- Changing flow to increase turnover rates
- Density manipulation

Why are infectious disease outbreaks more likely to occur in the RAS?

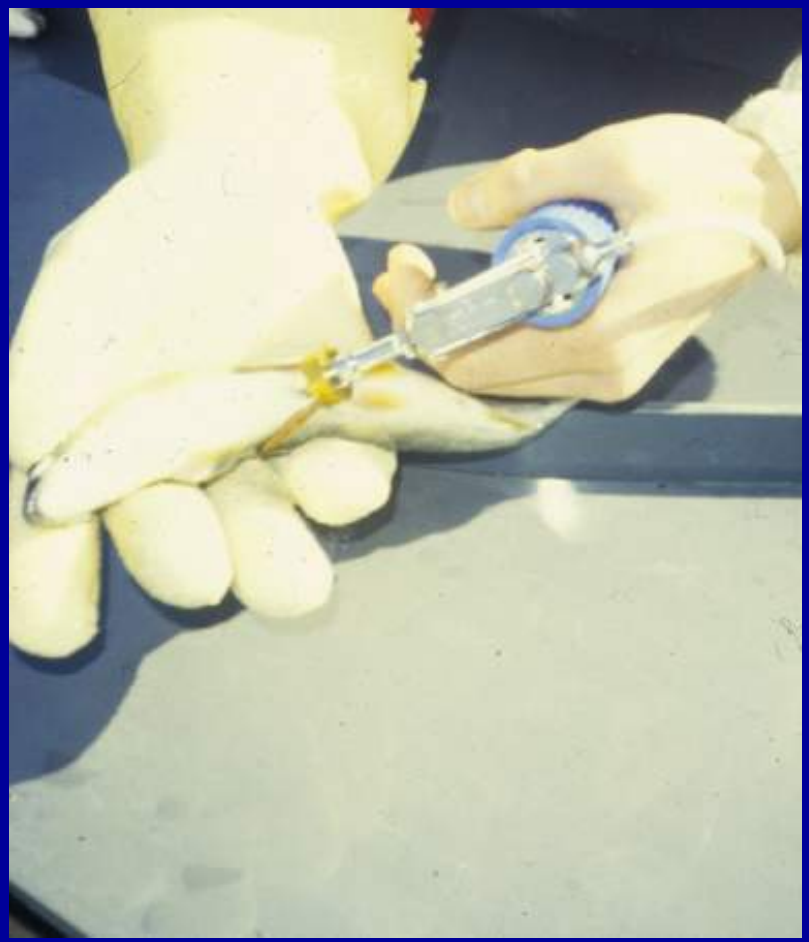
- Fish loading densities greater than those used in pond or serial reuse systems
- Continuous production strategies
- Prolonged water retention in system provides extended residence time that allows for growth of opportunistic and overtly virulent pathogens
- Relatively more stressful environment

Why does it matter (costs)?

- Costs
  - Diagnosis, response, diversion of management and labor, underutilization of production facility
  - Direct losses from mortality
  - Reduced quality of survivors
  - Inability to replace stock
  - Restricted market for healthy stock because of damage to reputation and missed markets
  - Restriction of movement orders
  - Facility closure orders

Strategies for a Strong Immune System

- Optimum nutrition
- Fish should be from optimum year class brood stock
- Gentle handling to reduce stress and injury
- Vaccination



Know normal vs. abnormal behavioral and physical signs for stress and illness

Fish health monitoring allows early detection of a problem

- Tank windows
- Two locations
  - where healthiest fish would be
  - where sick fish would congregate

Behavioral and Physical Signs for Stress/Illness

- Movement
  - Weak, erratic, lethargic swimming
  - Abnormal reaction to external stimuli such as noise or movement
  - Scratching, flashing, rubbing against tank walls or bottom
  - Twitching, darting, spinning or jumping out of water
  - Crowding at inflent water supply
  - Swimming upside down
  - Gasping at water surface

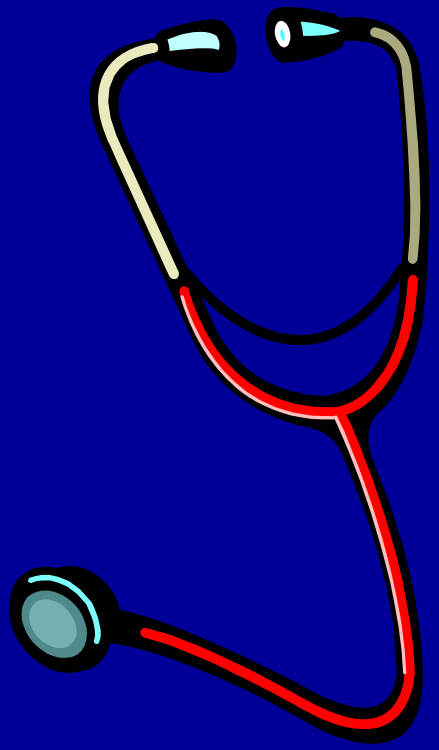
Behavioral and Physical Signs for Stress/Illness

- Feeding
  - Not feeding
  - Reduced feeding (detected by system TAN and growth curves as well as observation)
- Breathing
  - Decreased or increased rate of opercular movement

Behavioral and Physical Signs for Stress/Illness Physical Condition

- Visible lesions or sores
- Cloudy eyes, protruding eyes
- Gills swollen, white, pink or pale red, eroded, puffy, bloody, brown
- Scale loss
- Swollen abdomen
- Diarrhea
- Excess mucus on skin/gills (check for excess mucus on tank screens)
- Spots, fungus on skin
- Unusual coloration on body surface
- Flared opercula
- Frayed fins or tail
- Bubbles in eyes, skin, gills

IV. Diagnosis



Supplies/Equipment for Fish Health Laboratory

- Compound microscope (with 10X ocular and 4X, 10X, and 40X objectives)
- Slides, cover slips
- Dissecting kit (for large and small fish)
- Anesthetic (e.g., tricaine methane sulfonate (MS-222))

Diagnosis

- An accurate diagnosis is essential
  - Determines treatment regimen (whether, and which, chemotherapeutants should be used)
  - Treatment based on hunches results in wasted time and money and further degradation of the fish
  - Incorrect diagnosis prevents development of an effective strategy to prevent recurrence

Treatment

- Disease from water quality more likely in a biosecure recirculating system (slow turnover rate)
- If chemical treatment is necessary, effect on biofilter must be considered (design system for biofilter bypass during treatment)
- When treating the whole system, slow turnover rate means chemical might need to be applied at a lower concentration for a longer period
- Take individual tanks off-line for bath or flow-through treatment

Biosecurity programs should be dynamic, re-evaluate and change as necessary