Lecture 1: Hatchery Design/Construction

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HATCHERY DESIGN

PRELIMINARY DESIGN CONSIDERATIONS

- PLANNED CAPACITY
- CAN IT BE BUILT ON THE SITE?
- ABSTRACTION OF SEAWATER FROM OCEAN
- HATCHERY COMPONENTS
- SPECIAL ISSUES (e.g., DISEASE)

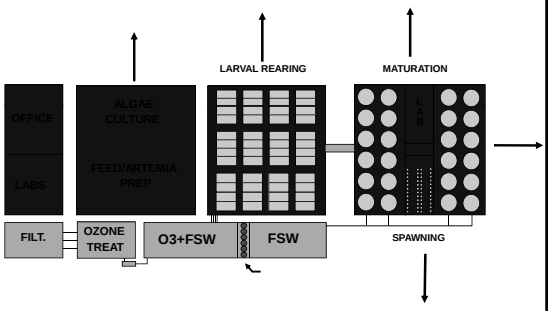
PRELIMINARY CONSIDERATIONS Planned Capacity

- Hatcheries gauged by production capacity
- Design must accommodate some perceived market (your own, external, combination)
- Seasonal capacity
  - Indonesia: just before rainy season, same in Central America
- Variable demand: all at once, staggered???

PRELIMINARY CONSIDERATIONS
Planned Capacity

- Flexible design w/potential for expansion
- Economics might indicate benefit of constructed fully-expanded version, partially outfitted
- Expansion facilitated by modular design:
  - Addition of rearing “galleries”
  - Undeveloped “spaces” adjacent to ongoing areas
  - Basic concept: share walls (2 walls cost more)

Example of Modular Expansion



PRELIMINARY CONSIDERATIONS
Determining Planned Capacity

- Capacity described in millions of postlarvae per month:
  - Large: 80M+ per month
  - Medium: 40-60 M per month
  - Small: 20-30M per month
  - Pilot: 10M per month
- Most are on the small side of small
- Most don’t produce year-round, but ramp up for stocking seasons

PRELIMINARY CONSIDERATIONS
Determining Planned Capacity

- Major determinants:
  - farmers position on type of fry required
  - availability of wild-caught fry
- Hard to predict, must arrive at some happy medium
- Who gets the postlarvae? You or others????

PRELIMINARY CONSIDERATIONS
Determining Planned Capacity

- If not vertically integrated, you must undertake some form of market analysis
  - Saturation level
  - Types of PL's demanded, age, etc.
  - Buyers?
- Hatchery markets are very competitive
- Who are the competitors?
- What are their strengths (i.e., technology)
- Weaknesses (e.g., bad rep, inconsistent production, disease, etc.)

PRELIMINARY CONSIDERATIONS
Determining Planned Capacity

- If all sales are internal:
  - Meet with farm production managers (what are their needs for the future?)
  - What is their production strategy for the next two years?
  - Is this strategy likely to change
- External sales:
  - Meet with processors to gauge demand
  - Will disease impact demand?
  - Climate change (El Niño, etc.)
- Does demand require my own hatchery???

PRELIMINARY CONSIDERATIONS
Calculating Capacity

- If vertically integrated, capacity is derived from farm productivity
- Other assumptions:
  - same species of postlarvae
  - direct stocking vs. intermediate phase (i.e., nursery)
  - Stocking density (i.e., level of grow-out technology
- Work backwards from total yearly farm production:
  - Farm capacity in lbs/yr → kg/yr → g/yr
  - Total g/yr/mean wet weight shrimp (g) = total shrimp/yr
  - Total shrimp/yr divided by mean pond survival = total PLs/yr
  - Total PLs/yr → total PLs/month)

Hatchery Site Selection: basic considerations

- Must be located on the ocean
- Requires high quality oceanic seawater
- Must be as close to target farms as possible
- Shut-down risk is greater than farm and must be planned for
- Requires high proportion of skilled labor
- If containing a maturation facility, it must also have quarantine facility and/or be close to a source of broodstock
- Must have year-round accessibility

HATCHERY SITE SELECTION
Source of Water

- This is the most critical parameter (everything else in engineering!)
- Most coasts appear to have many sites, but in actuality don't
- Site and intake have to be protected with stable water quality
- No seasonal variation

Map courtesy of Lonely Planet

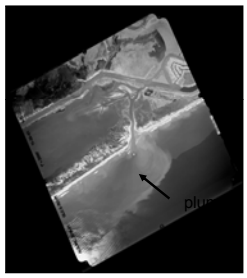
HATCHERY SITE SELECTION
Water Quality

- Clear water ≠ good hatchery water
- Could be clear because of pollutants (i.e., won't support life)
- Water temperature: species dependent (26-32ºC ppt for shrimp)
- pH: 7.8-8.2 (for most marine species)

G. Treece in action in Indonesia

HATCHERY SITE SELECTION
Water Quality

- Salinity: species dependent (25-34 ppt, for shrimp)
- Salinity: no sudden changes (watch out for freshwater plumes)
- Suspended solids (< 50 mg/L)
- Total organic carbon (< 10 mg/L)
- Dissolved organic material (DOM; < 5 mg/L)
- Solids = more investment in water treatment, more operational costs



Colorado River Delta

Toxicity of Selected Heavy Metals (ppb)

96hr LC50	Safe Level
80-420	10
2,000-20,000	100
300-1,000	25
320	25
1,000-40,000	100
10-40	0.1
1,000-10,000	100

Toxicity of Selected Pesticides

Threshold Level
10-500 µg/L

1-10 mg/L

0.1-10 mg/L

0.1-10 mg/L

0.05-5.00 mg/L
0.05-500 mg/L

Hatchery Water Quality Factors (Colt and Huguenin)

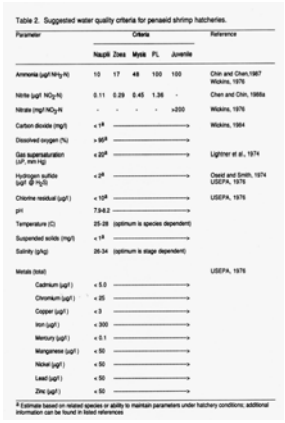
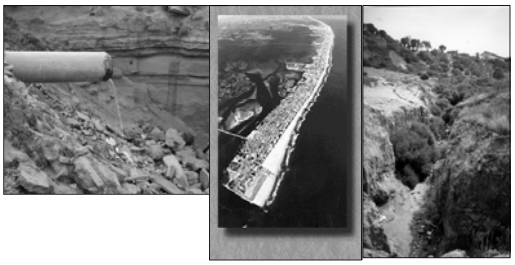


Table 2. Suggested water quality criteria for penaeid shrimp hatcheries.

Parameter	Criteria					Reference
	Nauplii	Zoea	Mysis	PL	Juvenile	
Ammonia (µg/l NH_3-N)	10	17	48	100	100	Chin and Chen,1967 Wickins, 1976
Nitrite (µg/l NO_2-N)	0.11	0.29	0.45	1.36	-	Chen and Chin, 1988a
Nitrate (mg/l NO_3-N	-	-	-	-	>200	Wickins, 1976
Carbon dioxide (mg/l)	< 1[a]	⟶				Wickins, 1984
Dissolved oxygen (%)	> 90[a]	⟶				
Gas supersaturation (∆P, mm Hg)	< 20[a]	⟶				Lightner et al., 1974
Hydrogen sulfide (µg/l @ H_2S)	< 2[a]	⟶				Oseid and Smith, 1974 USEPA, 1976
Chlorine residual (µg/l)	< 10[a]	⟶				USEPA, 1976
pH	7.9-8.2	⟶				
Temperature (C)	25-28 (optimum is species dependent)					
Suspended solids (mg/l)	< 1[a]	⟶				
Salinity (g/kg)	26-34 (optimum is stage dependent)					
Metals (total)						USEPA, 1976
Cadmium (µg/l)	< 5.0	⟶				
Chromium (µg/l)	< 25	⟶				
Copper (µg/l)	< 3	⟶				
Iron (µg/l)	< 300	⟶				
Mercury (µg/l)	< 0.1	⟶				
Manganese (µg/l)	< 50	⟶				
Nickel (µg/l)	< 50	⟶				
Lead (µg/l)	< 50	⟶				
Zinc (µg/l)	< 50	⟶				

[a] Estimate based on related species or ability to maintain parameters under hatchery conditions; additional information can be found in listed references

Watch out for the Following



SITE PHYSICAL CHARACTERISTICS

- How accessible is the site?
  - Road?
  - Right of way?
  - Has implications towards transport, provision of electricity, etc.
- Appropriate elevation?
  - Tidal surge issues with respect to water source

SITE PHYSICAL CHARACTERISTICS

- Vegetative cover (density, diameter, protected?)
- Topography (often non-issue due to small area, w/ponds is another issue)
- Surface area (Can the site accommodate all planned activities?
- Expansion potential (Can the site be expanded or do I go over the edge of a cliff?!)
- Abstraction of seawater (most difficult engineering issue, identify protected area with consistently good water quality)

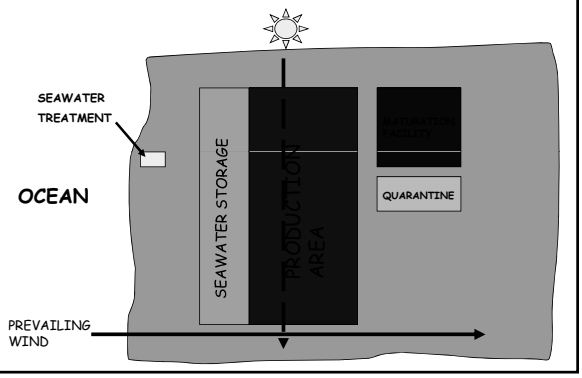
SITE PHYSICAL CHARACTERISTICS

- Availability of energy (quality, capacity, dependability)
- Building materials (availability, price, variability)
- Heavy construction equipment (availability, price, suitability)
- Ask yourself: Can I build what I need on-site, do I have to purchase or, do I have to import?
- Import issues

FACILITY LAYOUT

- Orientation to ocean and path of sun
- Seawater treatment (usually between the ocean and the facility)
- Do I need natural lighting?
  - Longitudinal axis of indoor/outdoor algae culture room is parallel to typical path of sun
- Avoiding airborne contamination, disease

Orientation of Facilities



FACILITY LAYOUT

- Isolate “sensitive” areas from potentially contaminating areas (separate from main body of hatchery)
- Restrict commerce among hatchery areas to bare minimum
- Sensitive facilities (e.g., quarantine) require their own seawater treatment and aeration systems (reduces potential for contamination)

RESTRICTIVE-INTERACTIVE CONCEPT

- All employees must go through changing room to enter facility proper
- Use outside corridors, avoid common entrances
- Seawater/air systems interact with all areas (except quarantine)
- Algae production ↔ larval rearing ↔ postlarval rearing
- Quarantine ↔ maturation ↔ larval rearing

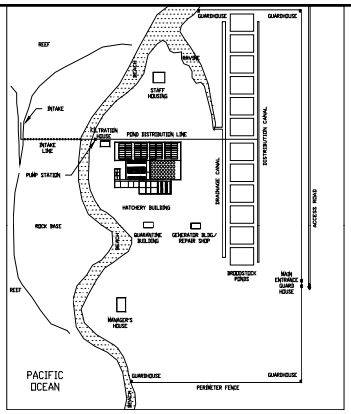
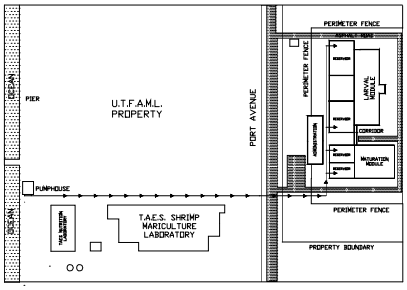


Figure 3. Conceptual Layout of Hatchery Complex



DRAWING 5: SEAWATER CONNECTION BETWEEN TAES AND SEA-GEMS

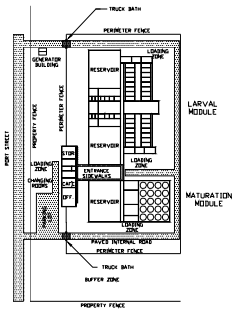


Figure 2. Overall Layout of Hatchery Complex

PLANNING INTERACTION

STEPS

1) Biologist should prepare a biological program of requirements (POR) with conceptual designs
2) Biologists review the POR with engineers, contractors, etc.
3) Engineers develop their own POR (often what you want to do, they can't build)
4) Engineers/contractors develop construction-ready drawings
5) Both parties review final drawings and achieve consensus
6) Contractor proposes a construction schedule/payment schedule

CONSTRUCTION COSTS

- contract should itemize construction costs:
  - Production areas = \$80-120/m^2
  - Greenhouses = \$35-100/m^2
  - Re-enforced structures (reservoir) = \$100-120/m^2
  - Housing = \$100-120/m^2
- Obtain your own quotes on construction materials, compare them to the bid level
- Prepare contract with delay clauses, limit contracts

CONSTRUCTION COSTS

- Contractor should be large enough to start various areas of the hatchery simultaneously
- Separate contracts for the building proper, seawater line and housing
- This causes construction of one area to be less dependent on the cashflow of the contractor.
- Many contractors take your initial payment and use it to start other jobs.
- In foreign countries, watch out for potential bottlenecks (e.g., strikes, etc.)

OTHER CONSTRUCTION ISSUES

- Contractors in different countries don't build the same way (examples):
  - **U.S. scenario:** level terrain → dig beams → run plumbing → pour slab → build walls → construct roof → pull wire → dry wall, etc.
  - **Central American:** level terrain → dig beams → build walls → construct roof → pour slab → run plumbing → pull wire (largely block construction, only rafters/trusses are wood)

OTHER CONSTRUCTION ISSUES

- Develop schedule of activities (Gant Chart)
- Share walls whenever possible/practical
- Separate/isolate sensitive areas (e.g., maturation, quarantine)
- Use space heating, convection with high ceiling to remove heat in non A/C areas
- Lower ceilings in air-conditioned areas (algae production)
- Insulate A/C areas
- Use natural lighting whenever possible