V. FACILITY DESIGN PROCESS

A. INTRODUCTION

Designing an intensive fish production facility involves much input and requires many decisions.

I. Of primary importance.
   1. Quantity and quality of the water source.
   2. Desired production: species, numbers, and purpose.

II. Questions to consider.
   1. Does the source water require pre-treatment? Should it be specific pathogen free?
   2. Is some level of re-circulation acceptable?
   3. Do we need bio-security measures?
   4. What is to be the level of monitoring, alarms, back-up, and automation?
   5. What level and kind of rearing water treatment is desired?
   6. What level of effluent treatment is required? (Regulations, available technology).

III. Numbers (values) must be selected relative to specific production and design parameters.
   1. Maximum permissible rearing densities (MD).
   2. Oxygen requirement per unit of food (OF).
   3. Ammonia generated per unit of food (TANF).
   4. Maximum permissible, safe, concentration of unionized ammonia (MUA).
IV. Other choices.

1. Type of rearing unit desired (plug-flow or circulating).
2. Minimum/maximum size and number of rearing units.
3. Indoor or outdoor rearing (biosecurity, predation).

V. Consider the fish culturist (worker).

1. Pleasant work environment (light, noise, smell, break room, etc.).
2. Manageability
   a) Feed handling (storage, moving, feeders, etc.).
   b) Fish handling (sorting, moving, harvesting, treating, etc.).
   c) Sanitation (hosing, floor drains, wash basins, etc.).
   d) Rearing tank (depth, diameter, equipment, etc.).
   e) Overall equipment need (identify with input from fish culturist).
3. Laboratory space (proper equipment).
4. Heavy equipment storage and maintenance space.

VI. Visitor/educational facility (managing visitors).

1. Especially appropriate for public fish hatcheries.
2. Important public relations function. "Aquaculture is agriculture," a concept not well understood by the general public. Ignorance never serves society well!

Obviously there are many components and details to consider when designing a "complete" aquaculture facility. This workshop's focus is on production capacity and rearing space requirements based on water quantity, quality, and production program/goals.

A step-by-step process is used to arrive at a rational design concept. Major driving forces are parameter values selected by the "client." Probably the most significant concept is the flow, space, and operational relationship expressed as loading (Ld), density (D), and rearing unit water turn-over or exchange rate (R) presented in unit I:
\[ Ld = (D \times 0.06)/R; \quad D = (Ld \times R)/0.06; \quad R = (D \times 0.06)/Ld \]

B. Design Process

The following sample scenario utilizes a set of arbitrarily selected parameters.

I. The water (a somewhat ideal source to keep things simple).

The source water is a 10,000 lpm (2642 gpm) spring. It has a constant temperature of 14°C (57°F), a pH of 7.6. These two, pH and temperature result in an ammonia fraction of 1.0% of the total ammonia nitrogen.

The water has no fish in it, it is specific pathogen-free. The dissolved oxygen concentration is 10.0 mg/l. The water does not require pre-treatment (no gas supersaturation).

II. The production program.

Rainbow trout are to be reared to 500 g (1.1 lb) each for the food market. The production program starts with feed trained fingerlings at a size of 1.25 g (W = 1.25). Their condition factor (k) is 0.010 resulting in a length of 5.0 cm \[ L = (W/k)^{1/3} \].

The fish will be reared indoors to a length of 15 cm, a weight of 34 g (6" and 13.4/lb). This is phase I of the rearing program. Their temperature unit growth rate is 0.0055 cm, the daily length increase is 0.077 cm \[ \Delta L = TUG \times ^{\circ}C \].

The feed conversion during the indoor rearing period is 1.0. After phase I rearing is complete, the fish are moved to the outdoor rearing system for grow-out to 500 g. This is phase II. During phase II, the k-factor is 0.012 and the feed conversion is 1.2. The TUG value is

3
0.0050, the $\Delta L = 0.070$. Phase I spans a period of 130 days ($t = 130$), phase II 281 days ($t = 281$) 
[$t = (L_t - L_i)/\Delta L$]. For a final weight of 500 g, the length is 34.7. It requires 411 days to complete 
the full rearing cycle (RC). Because a new group of fingerlings enters the facility once a year, the 
system supports two cohorts simultaneously for a 46-day period each rearing cycle. It will be 
assumed that a new cohort enters the facility on March 1st each year.

Phase I fish move outdoors on July 10 (March 1 + 281 d). From April 18 through July 9 there are no phase II fish in the system (82d). Facility is used inefficiently.

III. Design.

1. **Selected parameters**
   a) Oxygen required per kg food per "day" is 250 g (OF = 250).
   b) TAN generated per kg food per "day" is 30 g (TANF = 30).
   c) TAN concentration per AO used is 0.1 mg/l (TANC = 0.1).
   d) Maximum allowable unionized ammonia concentration is 0.025 mg/l 
      (MUA = 0.025). Recall: %UA = 1.0.
   e) Maximum rearing densities are 60 kg/m$^3$ for phase I, 96 kg/m$^3$ for phase II 
      (MD = 60 and 96).
   f) The %BW feeding level is $(2 \times \text{°C})/(W/k)^{1/3}$.

2. **Values derived from 1: a through f "choices."
   a) Maximum available oxygen is 25 mg/l [$MAO = (MUA \times 1000)/%UA$].
   b) Feeding level in %BW for phase I, at end of rearing period, is 1.87% 
      $[(2 \times 14)/15]$.
   c) Maximum loading for phase I, at end of rearing period, is 5.38 kg/lpm 
      [$MLd = (MAO \times 100)/(OF \times %BW)$].
   d) Feeding level in %BW for phase II, at end of rearing period, is 0.81% 
      $[(2 \times 14)/34.7]$. 

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c) Maximum loading for phase II, at end of rearing period, is 12.4 kg/lpm.
f) Phase I maximum weight per fish to maximum loading ratio is 34 to 5.4 or 6.3 to 1.0.
g) Phase II W to Ld ratio is 500 to 12.3 or 40.6 to 1.0.
h) The ratio's 6.3 to 40.6 (1.0 to 6.4), represent the ratios of maximum flowrates (MQ) required for phase I and phase II at the end of their rearing period.
i) Maximum flowrate required for phase I is 1351 lpm [MQ = TQ/(sum of ratio)] and in our case this is: [MQ = 10,000/(1 + 6.4)]. This leaves 10,000 lpm - 1351 lpm for phase II. It's maximum flowrate is 8649 lpm.
j) Maximum biomass for phase I is 7268 kg [MBM = (MQ x MLD)] or: MBM = 1351 x 5.38.
k) Maximum biomass for phase II is 106,383 kg [MBM = 8649 x 12.3].
l) These respective biomasses represent 213,765 and 212,765 fish [# Fish = (MBM/Wg) x 1000].
Note: The differences in numbers are the result of rounding values.
m) Rearing volume required for phase I is 121 m³, for phase II 1108 m³ [MBM/MD].

3. **Rearing volume to rearing unit design and operation.**
Recall: [(Ld = D x 0.06)/R] and [D = (Ld x R)/0.06].
a) The exchange rates (R values) for phase I and phase II, based on flowrate and rearing volume, are 0.67 and 0.47 respectively [R = (Q x 0.06)/RV]. Important: These flow rates are to provide a maximum available oxygen of 25 mg/l, the incoming DO must therefore be as high as 31 mg/l if a minimum residual DO of 6.0 mg/l is required.
Recall the MLD for phase I is 5.38 and the MD is 60 [R = (96 x 0.06)/5.38 = 0.67]. For phase II: [R = (96 x 0.06)/12.3 = 0.47].
b) Too high AO! Assume AO of 5.0 DOᵢₙ = 11.0. Requires a serial reuse of
five passes: 5+5+5+5+5. Total rearing volume per rearing unit (RV) for phase I is 24.3 m³ (121/5). For phase II it is 221.6 m³ (1108/5).

c) The resulting exchange rates are 3.35 and 2.35 respectively for phases I and II \[ R = (Q \times 0.06)/RV \]. The new loadings are: 1.076 and 2.46 \[ Ld = (5 \times 100)/(250 \times \%BW) \] \[ R = (60 \times 0.06)/1.076 = 3.35 \]
\[ R = (96 \times 0.06)/2.46 = 2.35 \].

4. **Select plug-flow rearing unit**

Criteria: For phase I, velocity must be 2.0 cm/s or greater \( (v \geq 2.0) \), for phase II 3.0 cm/s or greater \( (v \geq 3.0) \). Also the length to width ratio must be 10 (or more) to 1 \( (\geq 10 \text{ to } 1.0) \).

a) Plug-flow rearing unit design for a ratio of l to w of 10 to 1.0 is:
\[ w = \sqrt{(RV)/(10 \times d)} \] For a depth of 0.8 m \( (d = 0.8) \) and a rearing volume of 24.3 m³ for phase I, the l x w x d is 17.4 m x 1.74 m x 0.8 m.

b) The resulting velocity is 1.62 cm/s \[ (v = (1 \times R)/36) \] \[ v = (17.4 \times 3.35)/36 = 1.62 \].

c) Velocity does not meet the criterion of 2.0 or more cm/s. Must either increase l or R (see equation above). Cannot change the rearing volume (RV) because of maximum density criterion of 60 kg/m³. Cannot change the flow rate either because of the loading value. Since D, Ld, and R must balance, cannot change the R value.

d) Change the length (but not the RV) to 21.49 m \[ (l = (v x 36)/R) \] \[ l = (2 x 36)/3.35 = 21.49 \]. The new width is now 1.41 m \[ (w = (RV)/(l x d)) \]. The l to w ratio is 13.5 to 1.0. This makes the total linear distance of the four sides 1.2 times as long. From a total of 38.2 m to 45.7 m. The cost will be greater, but hydraulically better, more channel-like design.

e) Phase II dimensions are 52.6 m x 5.26 m x 0.8 m. The velocity is 3.4 cm/s \[ v = (52.6 \times 2.34)/36 = 3.4 \]. Meets the velocity criterion of 3.0 or more cm/s. Good hydraulics, but not self-cleaning.
5. **Select circular rearing units**

Criteria: Exchange rates from 1.5 to 2.5; diameter not to exceed 9 m (±30'). Can introduce super-saturated dissolved oxygen concentrations up to 150% saturation. Saturation is 11.0 mg/l, 150% of saturation is 16.5 mg/l.

The velocity is independent of the flowrate, but to accomplish proper hydraulics for self-cleaning requires the right designs for intake and outlet (Unit IV).

a) Use a three-pass serial design. The AO value is 8.3 mg/l (25/3), the DO<sub>in</sub> is 14.3 mg/l (± 135% sat.).

b) Phase I rearing unit volume is 40.3 m<sup>3</sup> (121/3) for an operating depth of 1.5 m, the diameter is 5.85 m (19.1') [diameter = 2√RV/(Π x d)]. The R value is 2.0.

c) If six units are desired (split the flow) the diameter is 4.1 m (13.5'). No change in R value.

d) The new loading is 1.78 [Ld = 8.3 x 100)/(250 x 1.87)] Check: [R = 60 x 0.06)/(1.78) = 2.0] Balance!

e) Phase II rearing unit volume is 369.3 m<sup>3</sup> (1108/3). For an operating depth of 1.5 m, the diameter is 17.9 m (58'). Tank is too large! For six units the diameter is 12.5'.

f) Options: Six units with a depth of 2.85; diameter is 9.0 m. Want to keep depth at 1.5 m or less. Consider 12 units (either 4 x 3 for AO or 8.3 or 3 x 4 for AO of 6.25). Diameter for d = 1.5 is 8.85 m. This is acceptable.

IV. There are other options.

1. **Design:** Partial Recirculation (Unit VI).

2. **Program:** Sequential Rearing Strategy (Unit VIII).
The designed production program for feeding fingerlings of 1.25 g to harvest size of 500 g once per year represents the batch culture approach. This occurs commonly in "conservation" hatcheries that mimic the natural life cycle of the species reared. The result is inefficient use of the facility, because much of the time the biomass is far below the maximum carrying capacity.

This facility, theoretically, can "process" a maximum of 1000 kg feed per day. This number is derived from the maximum AO value of 25 mg/l and the maximum available flowrate of 10,000 lpm:

\[ MF/d = (MAO \times Q_r) / (OF) \]

At the end of phase II, the maximum biomass is 106,383 kg, the feeding level is 0.81% BW. Daily feed fed is 862 kg. By this time phase II fish (213,000) have been reared for 45 d. At a daily length increase of 0.077 cm these fish gained 3.46 cm in length, which makes them 8.46 cm long. The weight for this length is 6.05 g and their obvious biomass is 1290 kg (213,000 fish @ 6.05 g) for a total daily feed requirement of 60 kg. The maximum daily feed requirement is 922 kg (862 kg + 60 kg), which is near the maximum of 1000 kg. Let us assume that we can feed 1000 kg per day every day throughout the year. To do so would require the removal of the daily gain each day, namely 800 kg for a feed conversion of 1.25. To do this 365 days per year would result in an annual output of 292,000 kg. How close can we come to the 1000 kg feed per day on a year-around basis? This will be discussed in the next unit which addresses sequential rearing strategies.
Facility Design Process

Requires **Input** and **Decisions** (Choices)

I. **Water Source**: Quantity; Quality

II. **Production**: Species; Goals

III. **Discussion**:

1. Need pre-treatment? $\text{N}_2, \text{O}_2, \text{O}_3$; etc.
2. Specific pathogen free?
3. Bio-Security?
4. Recirculation?
5. Monitoring, Alarms, Automation, etc.
6. Effluent/Regulations
IV. Numbers (Values) to Select
1. Max. Permissible Rearing Densities (MD)
2. Oxygen Required Per Unit Food (OF)
3. TAN Generated Per Unit Food (TANF)
4. Maximum Acceptable Unionized Ammonia Concentration (MUA)

V. Other Choices
1. Type of Rearing Unit (Plug-flow versus Circulating)
2. Minimum/Maximum Size and Number of Rearing Units
3. Indoors/Outdoors (Biosecurity; Predation)
VI. Consider the Fish Culturist (Worker)

1. Pleasant work environment (light, noise, smell, breakroom, temp., etc.)

2. Manageability
   a) Feed handling (storage, moving, feeders, etc.)
   b) Fish handling (sorting, harvesting, treating, etc.)
   c) Sanitation (hosing, floor drains, wash basins, etc.)
   d) Rearing tank management (depth, diameter, equipment, etc.)
   e) Overall equipment need (identify needs)
3. Laboratory space (equipment)
4. Storage; garages, workshop

VII. Visitor/Educational
1. Public Fish Hatcheries
2. Visitor Control
3. Public Relations

Many details, components, to designing a “complete” aquaculture facility. This workshop’s focus is on production capacity and rearing space requirements, and uses a step-by-step process to derive at a rational design.
The Process (An Exercise)

The Most Significant Concept:
Flow-Space-Operational Mode Relationship

\[ Ld = \frac{D \times 0.06}{R}; \quad D = \frac{(Ld \times R)}{0.06}; \quad R = \frac{(D \times 0.06)}{Ld} \]

The Exercise (Process)

Assumption I

Water: 10,000 lpm (2642 gpm)
Temp. Constant: 14°C (57°F)
pH 7.6 (%UA = 1.0)
Alk. 200 mg (CaCO₃)
No Fish: S.P.F NO:N₂ Supersaturation
DO = 10.0 mg/l
Production: Rainbow Trout

\[ W_1 = 1.25 \text{g} \quad L_1 = 5.0 \text{cm} \quad (k = 0.010) \]
\[ W_H = 500 \text{g} \quad L_H = 34.6 \text{cm} \quad (k = 0.012) \]

Phase I (Indoors):

1. \( W_1 = 3.40 \text{g} \) (5.0 - 15.0 cm)
2. \( TUG = 0.0055 \text{cm} \)
3. \( \triangle L = 0.077 \text{cm} \) (14°C)
4. \( FC = 1.0 \)
5. \( MD = 60 \text{ kg/m}^3 \) (3.75 lb/ft³)

Rearing Cycle Phase I:

\( (15 \text{cm} - 5 \text{cm})/0.077 \text{cm} = 130 \text{d} \)
Phase II (Outdoors):

1.  34g — 500g  \( k = 0.012 \)
2.  15cm — 34.6cm  \( TUG = 0.005\text{cm} \)
3.  \( \Delta L = 0.070\text{cm} \)
4.  \( FC = 1.2 \)
5.  \( MD = 96\text{kg/m}^3 \)  \((6\text{ lb/ft}^3)\)

Note: 1.0 lb/ft\(^3\) = 16 kg/m\(^3\)

Rearing Cycle Phase II: \((34.6 - 15)/0.070 = 280\text{d}\)

Complete RC: 130 + 280 = 410d  \((RC = 410)\)
Program Specifics:

1. New Batch Enters March 1
2. Move Outdoors July 10 (3/1 + 130d)
3. Harvest April 16 (7/10 + 280d)
4. 4/17 – 7/9 No Phase II Fish (81d)
5. Phase I + II Overlap 45d (410 – 365)

Note: *Facility is Used Inefficiently.

Discussion: Batch versus Sequential
Selected Parameters/Values

1. OF = 250g
2. TANF = 30g
3. TANC/BO = 0.1 mg/l
4. MUA = 0.025 (%UA = 1.0)
5. MD  Phase I = 60 kg/m³
6. MD  Phase II = 96 kg/m³
7. %BW = (2 × ⁰C)/(W/k)¹/³  2 × 14⁰ = 28
Values Derived From Previous “Choices”

1. \[ \text{MAO} = 25 \left( \frac{\text{MUA} \times 1000}{\%\text{UA}} \right) \]

2. \[ \%\text{BW End Phase I} = 1.87\% \left( \frac{2 \times 14}{15} \right) \]

3. \[ \text{MLd End Phase I} = 5.38 \text{ kg/lpm} \left( \frac{\text{MAO} \times 100}{\text{OF} \times \%\text{BW}} \right) \]

4. \[ \%\text{BW End Phase II} = 0.81\% \left( \frac{2 \times 14}{34.6} \right) \]

5. \[ \text{MLd End Phase II} = 12.3 \text{ kg/lpm} \]

6. \[ \text{Phase I W to Ld} = 34 \text{ to } 5.4 = 6.3 \text{ to } 1.0 \]

7. \[ \text{Phase II W to Ld} = 500 \text{ to } 12.3 = 40.6 \text{ to } 1.0 \]
8. Phase I to Phase II Ratio's: 6.3 to 40.6 
   1.0 to 6.4

9. Ratio 1.0 to 6.4 Are Maximum Flow Rate Ratio's for Phase I to Phase II (MQ – I to MQ – II)

10. \[
    \frac{TQ}{\text{(Total Q)}} \quad \text{Sum Ratios} = \frac{10,000}{1.0 + 6.4}
    
11. MQ – I = 1351 \text{lpm} \quad MQ – II = 10,000 – 1351 = 8649 \text{ lpm}

12. MBM – I = 7268 \text{ kg} \quad (MQ \times MLd) \quad (1351 \times 5.4)

13. MBM – II = 106,383 \text{ kg} \quad (8649 \times 12.3)
14. # Fish – I = 213,765

15. # Fish – II = 212,765

16. RV – I = 121 m³

17. RV – II = 1108 m³
Rearing Volume Relative To Rearing Unit Design and Operation

Recall:

\[
Ld = \frac{D \times 0.06}{R} \quad D = \frac{Ld \times R}{0.06} \quad R = \frac{D \times 0.06}{Ld}
\]

1. \( R \) – Values (exchange rate)
   - Phase I = 0.67
   - Phase II = 0.47

From:

\[
R = \frac{Q \times 0.06}{RV}
\]

\( Q \) = flow rate
\( RV \) = rearing volume

Note: These flow rates must deliver a MAO of 25

\( DO_{in} = 25 + 6 = 31 \text{ mg/l} \)
Recall:  \[ MLd - I = 5.38 \quad MD - 1 = 60 \]

\[
R = \frac{60 \times 0.06}{5.38} = 0.67 \quad \text{(Balance)}
\]

\[ MLd - II = 12.3 \quad MD - II = 96 \]

\[
R = \frac{96 \times 0.06}{12.3} = 0.47 \quad \text{(Balance)}
\]

2. Above value for \( DO_{in} \) too high. (31 mg/l)

Next: Select Rearing Unit Type
A. **Plugflow (Raceway)**

**Criteria:**

1. \( v - I \geq 2.0 \text{ cm/s} \)
2. \( v - II \geq 3.0 \text{ cm/s} \)
3. \( \text{DO}_{in} = 11.0 \ (\text{AO} = 5) \)
4. \( L \text{ to } W \text{ Ratio} \geq 10 \text{ to } 1.0 \)

**Design Formula:**

\[
W = \sqrt{\frac{RV}{10 \times d}}
\]

- \( RV = L \times W \times d \)
- \( L = 10W \)
- \( RV = 10W \times W \times d \)
- \( RV = 10W^2 \times d \)
- \( W = \sqrt{\frac{RV}{10 \times d}} \)
$RV - I = 24.3 \text{ m}^3$  
(per raceway)

$\left\{ \begin{array}{l}
5 - \text{Pass Series From} \\
\frac{MAO}{AO} = \frac{25}{5} = 5
\end{array} \right.$

Select $d = 0.8 \text{ m}$  
(2.6’)

Raceway: $L \times W \times d = 17.4 \text{ m} \times 1.74 \text{ m} \times 0.8 \text{ m}$

From: $W = \sqrt{\frac{24.3}{10 \times 0.8}} = 1.74$

$v = 1.62 \text{ cm/s}$  
(Does not meet criterium.)

(needs 2.0 cm/s or more)
\[ v = \frac{(L \times R)}{36} = \frac{17.4 \times 3.35}{36} = 1.62 \]

\[ R = \frac{Q \times 0.06}{RV} = \frac{1351 \times 0.06}{24.3} = 3.35 \]

\[ v = 1.62 \quad \text{Must be minimum 2.0} \]

1. Either Increase L or R

\[ \begin{aligned} v &= \frac{L \times R}{36} \end{aligned} \]

Can’t change RV (D = 60), Can’t change Q (Ld)

Can’t change R (These 3 must balance.)
2. Change L to 21.49 m (NO changing RV!)

\[ L = \frac{v \times 36}{R} = \frac{2 \times 36}{3.35} = 21.49 \]

The New Width: 1.41 m

\[ W = \frac{RV}{L \times d} = \frac{24.3}{21.49 \times 0.8} = 1.41 \text{ m} \]

L to W Ratio: 15.35 to 1.0

Linear distance of 4 sides is greater.
Increase from 38.2 m to 45.7 m (1.2 x)

Higher cost but Good Hydraulics – Channel Shape.
RV - II = 221.6 m³  (1108/5)

\[ W = \sqrt{\frac{221.6}{10 \times 0.8}} = 5.26 \]

L to W to d = 52.6 \times 5.26 \times 0.8

\[ R = \frac{Q \times 0.06}{RV} = \frac{8649 \times 0.06}{221.6} = 2.34 \]

\[ V = \frac{L \times R}{36} = \frac{52.6 \times 2.34}{36} = 3.4 \text{ cm/s} \]

Meets velocity criterium of 3.0 cm/s or more.
Good Hydraulics. Not Self-Cleaning.
B. Circular Units

Criteria: R Values: 1.5 – 2.5
DIA: 9 m or Less (Up to 30’)
DO Super Sat. Up to 150%
(Sat. DO = 11.0 mg/l – 150% = 16.5 mg/l)
d = 1.5 m (Approximate)

Velocity Independent of Flow Rate
Intake – Outlet Design – Self-Cleaning
Design:

1. Three-Pass Serial  \( AO = 8.3 \) \((25/3)\)
   \( \text{DO}_{in} = 14.3 \)  \( \%\text{SAT} = \pm 135 \)

Phase I:  \( RV = 40.3 \text{ m}^3 \) \((121/3)\)

For \( d = 1.5 \)

\[
DIA = 2 \sqrt{\frac{RV}{\pi d}} = 5.85 \text{ m} \quad (19')
\]

\[
R = 2.0 \left( \frac{1351 \times 0.06}{40.3} \right) = 2.0
\]

Six Units:  \( DIA = 4.1 \text{ m} \) \((13.5')\)

Must Split The Flow.  \( R \) the Same!
Phase II: \( RV = 369.3 \text{ m}^3 \) (1108/3)

For \( d = 1.5 \)

\[ \text{DIA} = 17.9 \text{ m} \quad (58') \]

Too Large Diameter

For Six Units:

\[ \text{DIA} = 12.5 \text{ m} \quad (41') \]

Still Too Large!

Desire to Keep Depth at 1.5 m.

Options:

a) 12 Units \( 4 \times 3 \) \( (AO = 8.3) \)

b) 12 Units \( 3 \times 4 \) \( (AO = 6.25) \)

\[ \text{DIA} = 8.85 \text{ m} \quad (29') \]

Acceptable

Other Options? Other Ideas?
Different Approaches (Techniques/Programs)

1. Partial Recirculation (Unit VI)
2. Sequential Rearing (Unit VIII)

Introduction to Sequential Rearing

1.25 g – 500 g Batch Culture – Once-A-Year
Practiced in “Conservation” Hatcheries.
Inefficient Facility Use.

The described facility can “Process” a maximum of 1000 kg feed per day.

\[
MF/d = \frac{(MAO \times Q_T)}{OF} = \frac{25 \times 10,000}{250} = 1000\text{kg/d}
\]
Feed 1000 kg/d       FC = 12.5       FE = 80%

Daily gain in fish flesh: 800 kg
365 d/yr x 800 kg = 292,000 kg/yr.
Must remove the daily gain daily.

Not practical – But…. how close can we come to
1000 kg feed per day every day of the year.

Requires sequential rearing strategy- new cohort
(Batch, Group) enters the facility frequently –
How many times? What is practical, manageable?
What are the facility requirements?

Will Discuss in Unit 8.