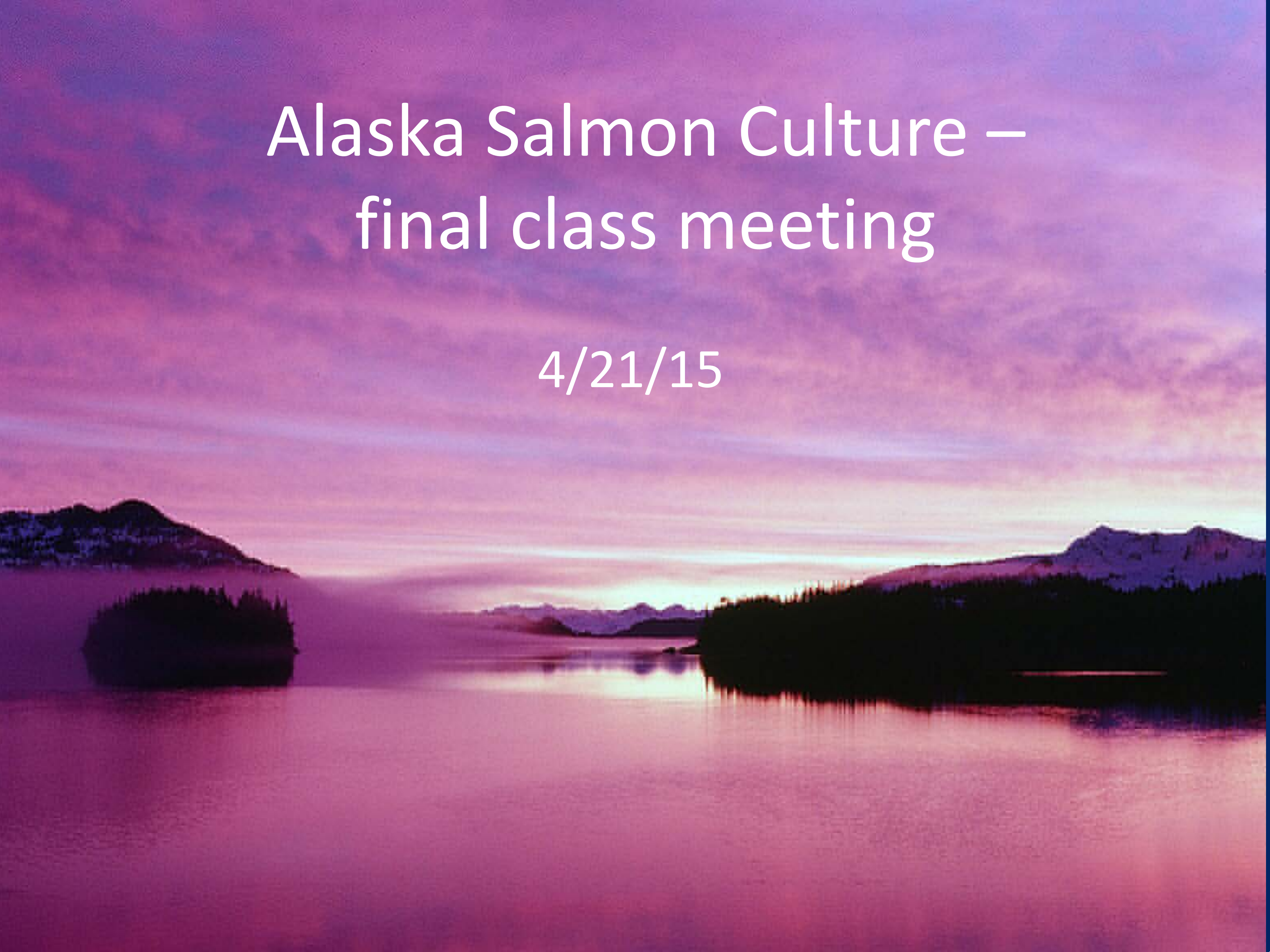
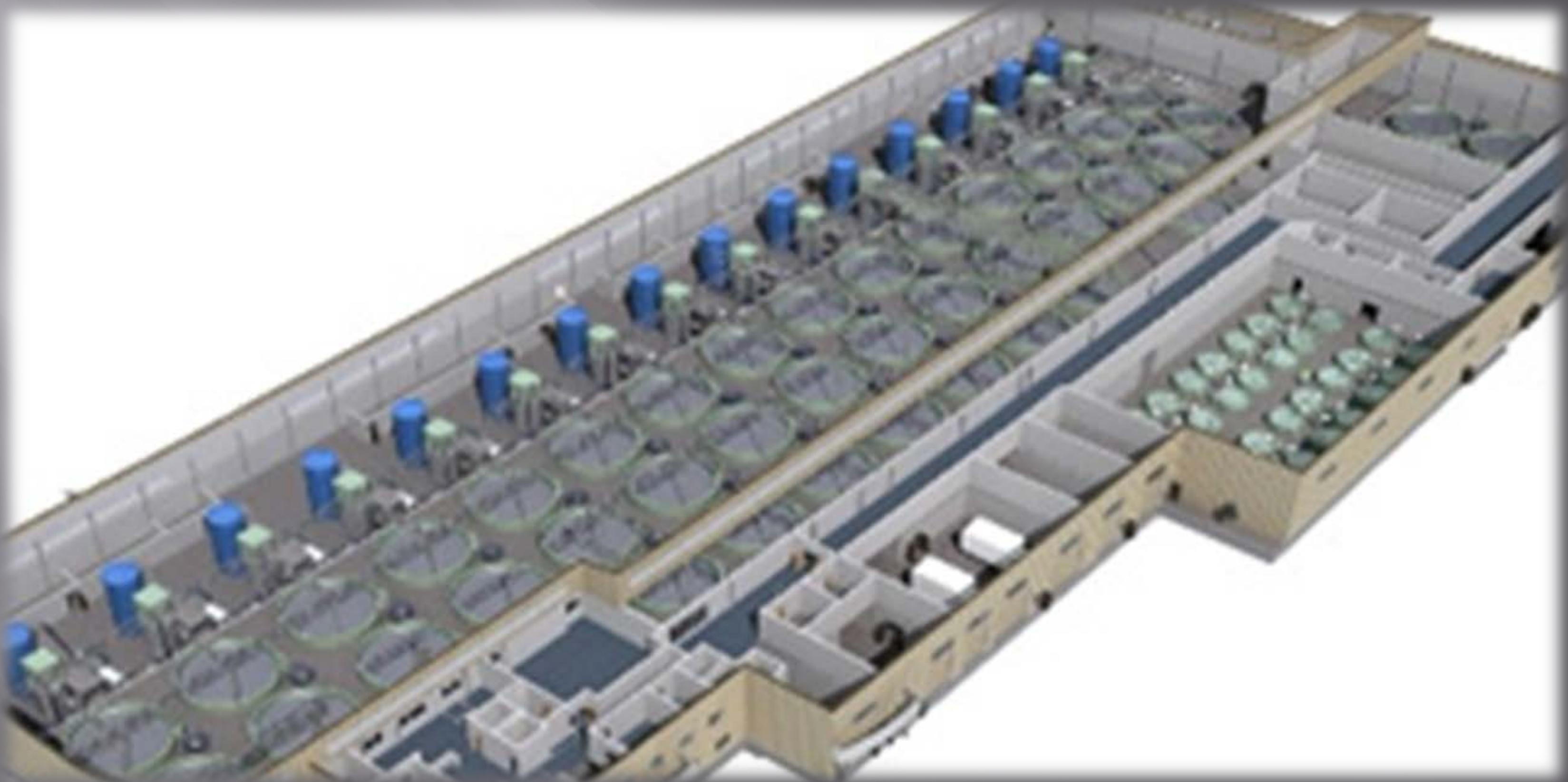


Alaska Salmon Culture – final class meeting

4/21/15

RECIRCULATING AQUACULTURE SYSTEMS

William Jack Sportfish Hatchery operated by ADFG



3 Types of culture systems

1. Flow through
2. Partial re-use
3. Recirculation

So – why would a facility want to reuse/recirculate water?
List the reasons:

Why would a hatchery want to re-use water?

Here's one example….

NUTS & BOLTS

BY KC HOSLER

Phased Evolution from Flow-through to Recirculation: A case study

Whether due to project capital limitations, uncertainty in future market stability, or nervousness about the technical complexity or mechanical risks associated with recirculation systems, it is often not feasible or desirable to jump right into a recirculation system when a new facility is being constructed. For many, it is more palatable to evolve from a low-tech to a high-tech system. A common scenario is when the hatchery owners may have inherited an aging flow-through facility or may have constructed a facility with no intention of needing recirculation, but have been motivated towards recirculation to reduce water use, improve control, or reduce production costs.

Regardless of the reason, hatchery facilities are evolving towards the use of partial reuse and recirculation technologies and, in many cases, starting with the existing infrastructure makes more sense than starting fresh. The solution employed during recent improvements at Target Marine Hatchery in Sechelt, British Columbia provides a good case study in facility evolution.

Target Marine Hatchery was originally constructed in 1986 as a flow-through facility for the production of various salmonid species, primarily chinook, coho and Atlantic salmon. The original facility incorporated both troughs and fiberglass combi tanks for early rearing and large fiberglass tanks for smolt production. Water came from a series of wells and the nearby Grey Creek.

Target Marine was an early adopter of recirculation technology as it built two stand-alone recirculation systems adjacent to the original culture systems in 1999 and 2001 for salmon smolt and sturgeon production. Although the bulk of the company's production has been moved into the new recirculation cells, the original outdoor fiberglass rearing tanks continue in use.

When it came time to expand production, Target Marine considered improvement of the existing tank field to be a more economical and quickly executable solution than constructing a new facility.

PHASE 1

Phase 1 of the project, executed in 2007, was designed to convert the 9 m diameter x 1.5 deep rearing tanks from flow-through (FTAS) to partial reuse (PRAS). The intent of this conversion was to alleviate the water shortage that occurred during summer, which resulted in unacceptably low exchange rates in the tanks, high carbon dioxide and low oxygen levels. A solution was developed that added flow to each culture tank through the addition of a pumped reuse loop drawing relatively clean water from high in the culture tank water column. To accomplish this, a screened drain box was added to the sidewall of each tank as an intake for the pumped flow. This effectively converted each tank from a single drain design to a Cornell-style dual-drain tank.

Dual-drain culture tanks provide significant advantages over single drain tanks as they promote mixing, oxygen distribution, and solids removal. The flows from the existing tank bottom drains were left unmodified to continue flushing solid and dissolved wastes from the tank.

Phase 1. Partial re-use treatment systems showing tank connection, pump, and gas transfer tower.

The re-use treatment system consisted of a drawn air CO_2 stripper followed by a Low Head Oxygenator (LHO) arranged in one space-efficient tower design. The CO_2 stripper is used to balance the gases within the reuse water, simultaneously removing carbon dioxide and adding oxygen to a near saturated condition. Water was pumped directly from [redacted]

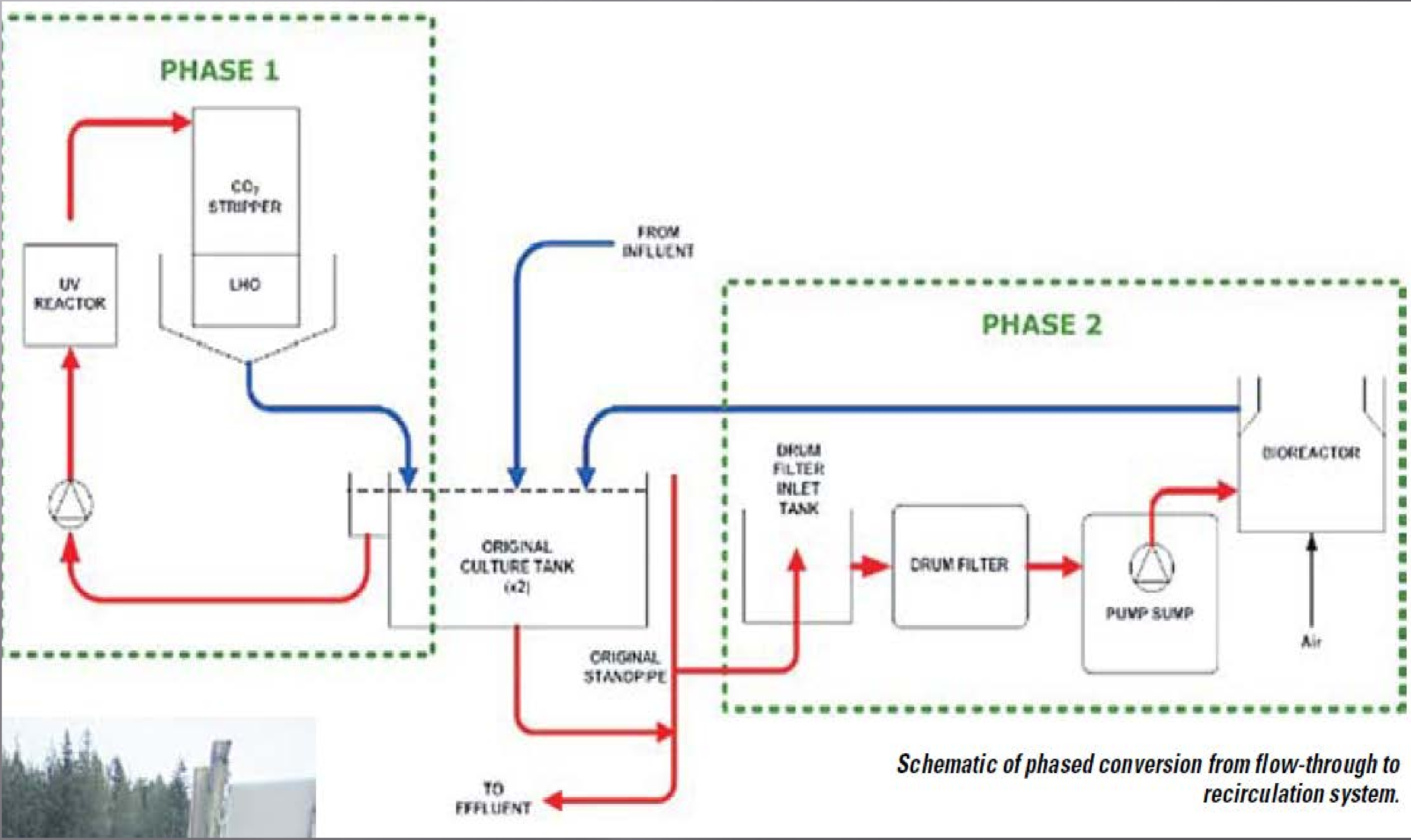
By adding the phase 1 PRAS treatment equipment, the hydraulic retention time (HRT) of the tanks was reduced from 180 minutes to 72 minutes, while reducing influent flow rates by 50%. Adding the reuse flow increased the total flow through the tanks from 944 to 2374 lpm allowing for a significant increase in production. The installation of high efficiency carbon dioxide removal and oxygenation equipment further increased the production capacity of the system through improved water quality, and has reduced reliance on inefficient in-tank diffuser systems.

PHASE 2

The objective of Phase 2 of the conversion was to increase the reuse rate, allowing for further water conservation and improved control over culture conditions. As reuse rates increase, the reduced exchange of system water allows untreated contaminants such as ammonia and suspended solids to concentrate in the system. In this phase of the work, additional treatment processes were incorporated to reduce the concentration of these contaminants, converting the PRAS into a full RAS. One set of two tanks was selected for piloting of the Phase 2 conversion with the intention of further implementation if the design proved successful.

Since the Phase 1 treatment system was designed to treat only the side drain flow from the tanks, the Phase 2 treatment system was designed to recapture most of the water leaving the bottom drain of the tank which had been, until then, discharged directly to effluent. The treatment system design incorporated Microscreen drum filtration

Phased approach to water reuse/recirculation



Schematic of phased conversion from flow-through to recirculation system.

The results

Parameter (for 2 Tank System)	Units	Original FTAS	Phase 1 PRAS	Phase 2 RAS
Tank volume	m^3	170	170	170
Total Flow Rate	lpm	944	2373	4205
Side Reuse Flow Rate	lpm	0	1893	1893
Bottom Reuse Flow Rate	lpm	0	0	2271
Influent Flow Rate	lpm	944	480	42
Tank HRT	minutes	180	72	40
Reuse Rate (by flow)	%	0%	80%	99%
System Volume Changes per Day	#	8.0	4.1	0.4

What's the cost?

- **Mechanic / Hydraulic: horsepower to watts**
- **One horsepower is equal to 746 watts**
- **What is a kilowatt-hour?**
  A kilowatt-hour (kwh) is a unit of electrical energy equal to the energy delivered by the flow of one kilowatt (1,000 watts) of electrical power for one hour. (A 100-watt bulb burning for 10 hours will use one kilowatt-hour of energy.)
- **For new equipment purchase consider:** Capital cost + shipping + installation + routine operation + maintenance
- **Increased labor costs to raise more fish**
- **Additional training**?   **More water quality monitoring**

AELP / Juneau Rates

The following rates are in effect as of April 1, 2013. The current Regulatory Cost Charge is $0.000568/kWh for all accounts. The current Power Cost Adjustment is $0.011494/kWh for all rates except 95 and 25.

RATE	DESCRIPTION	NOV-MAY PEAK	JUN-OCT OFF-PEAK
10	**General Residential**		
	Energy charge per kWh	$0.1194	$0.0982
	Customer charge per month	$8.88	$8.88
10-D	**Residential with demand**		
	Energy charge per kWh	$0.0580	$0.0506
	Customer charge per month	$11.49	$11.49
	Demand charge per kW	$11.11	$6.72
20	**Small Commercial**		
	Energy charge per kWh	$0.1157	$0.0920
	Customer charge per month	$18.80	$18.80
20-D	**Small Commercial with demand**		
	Energy charge per kWh	$0.0665	$0.0589
	Customer charge per month	$27.16	$27.16
	Demand charge per kW	$12.73	$8.52
24	**Large Commercial**		
	Energy charge per kWh	$0.0611	$0.0573
	Customer charge per month	$99.24	$99.24
	Demand charge per kW	$14.30	$9.11

Sitka Rates →

Could not find Ketchikan rates…..they imply they have the lowest rates in AK!

Chapter 15.01
ELECTRIC UTILITY POLICIES

* * *

15.01.020 Electrical rates.

* * *

B. Residential Services.

* * *

2. Energy Charges.

First 1,000 kWh	$0.0800 per kWh
1,001 to 2,000 kWh	$0.0850 per kWh
2,001 to 3,000 kWh	$0.1200 per kWh
Over 3,001 kWh	$0.1600 per kWh
Customer Charge is $15 per Month – Minimum Bill ~~Charge~~ is $35.00 per month	

~~First 200 kWh~~	~~$0.1417 per kWh~~
~~201 kWh to 1,000 kWh~~	~~$0.0801 per kWh~~
~~Over 1,000 kWh~~	~~$0.0918 per kWh~~
~~Minimum Charge is $21.25 per month.~~	

C. General Service – (Commercial, Industrial and Government.)

* * *

2. Energy Charges.

First 500 kWh	~~$0.1417~~ $0.0755 per kWh
501 kWh to 10,000 kWh	$0.0900 ~~$0.0903~~ per kWh
10,001 kWh to 100,000 kWh	$0.0900 ~~$0.0850~~ per kWh
Over 100,001~~0~~ kWh	$0.0900 ~~$0.0750~~ per kWh
Customer Charge is $39.00 - Minimum Bill ~~charge~~ is $50.00 ~~$21.25~~per month	

3. Demand Charges.

First 25 kW	No Charge
Over 25 kW	$4.50 ~~$3.90~~ per kW

What's the payoff?

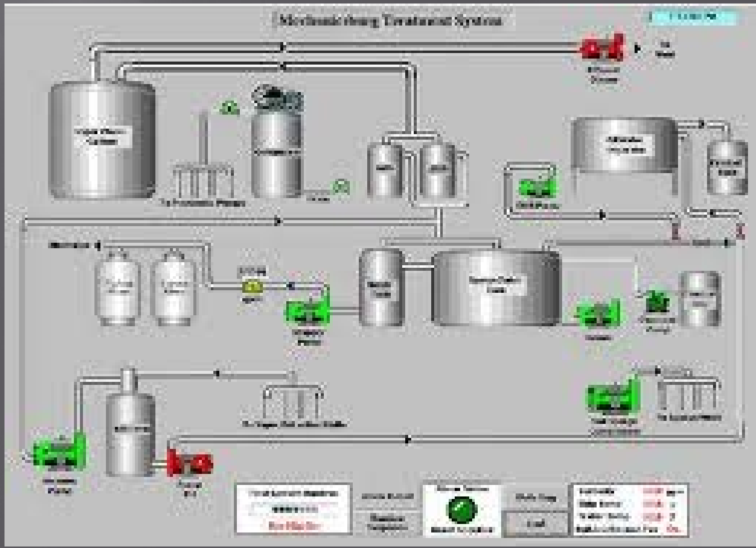
- Let's say you could raise an additional 100k coho if you reused water:
  - 100k smolts released
  - 8% marine survival
  - 8,000 adult coho return
  - 8# average = 64,000# fish
  - $1.10/# = $70,400/year

Intro to Recirculating Aquaculture Systems

- Advantages of RAS
  - Reduced water use
  - Designed to clean and reuse (waste management)
  - Allow fish production for species outside their natural range
  - Allow greater control over the rearing environment
    - Temperature
    - pH
    - Ammonia
    - Oxygen
  - More sites available than intensive flow through systems

Disadvantages

- High capital costs
- Generally located indoors
- Production levels must be high to reduce cost
- High production levels equate to catastrophic losses in the event of system failure
- Need to build in redundant systems
- Well trained conscientious employees
- Increased operational costs; reliance upon machinery



RAS

- Intensity of system is expressed in the amount water that is recirculated
- A 95% intensive RAS uses 5% makeup water
- For every 10,000 lpm 500 will be makeup water
- The makeup water adds oxygen and dilutes excreted metabolic waste

RAS steps

1. Remove large solids
2. Remove suspended solids
3. disinfect
4. Bacteria break down nitrites and convert to non-toxic nitrates
5. Pull off carbon dioxide
6. Add oxygen

In RAS our old friends need to be dealt with….

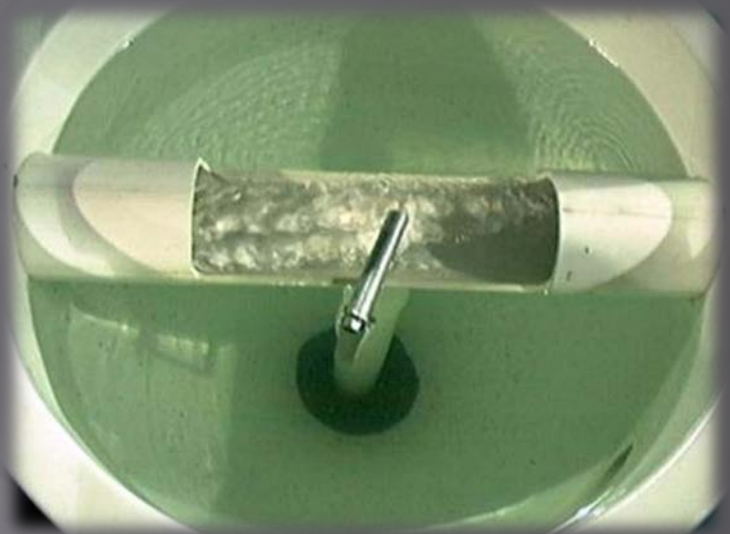
1. Ammonia – through biological filtration
2. Carbon Dioxide – aeration, CO_2 strippers
3. pH – adding chemicals
4. Oxygen – add gas
5. You have to pay very close attention to these guys with RAS!

Two basic types of bacteria which break down fish waste

- Autotroph – An organism capable of making nutritive organic molecules from inorganic sources
  - *Word origin:* from the Greek autos = self and trophe = nutrition
- Heterotroph - An organism that is unable to synthesize its own organic carbon-based compounds from inorganic sources, hence, feeds on organic matter produced by, or available in, other organisms
  - *Word origin:* G. héteros: the other of two, other, different + G. trophos: feeder
- What is meant by "organic" here?

Solids Removal – prior to biological filtration

Swirl separator



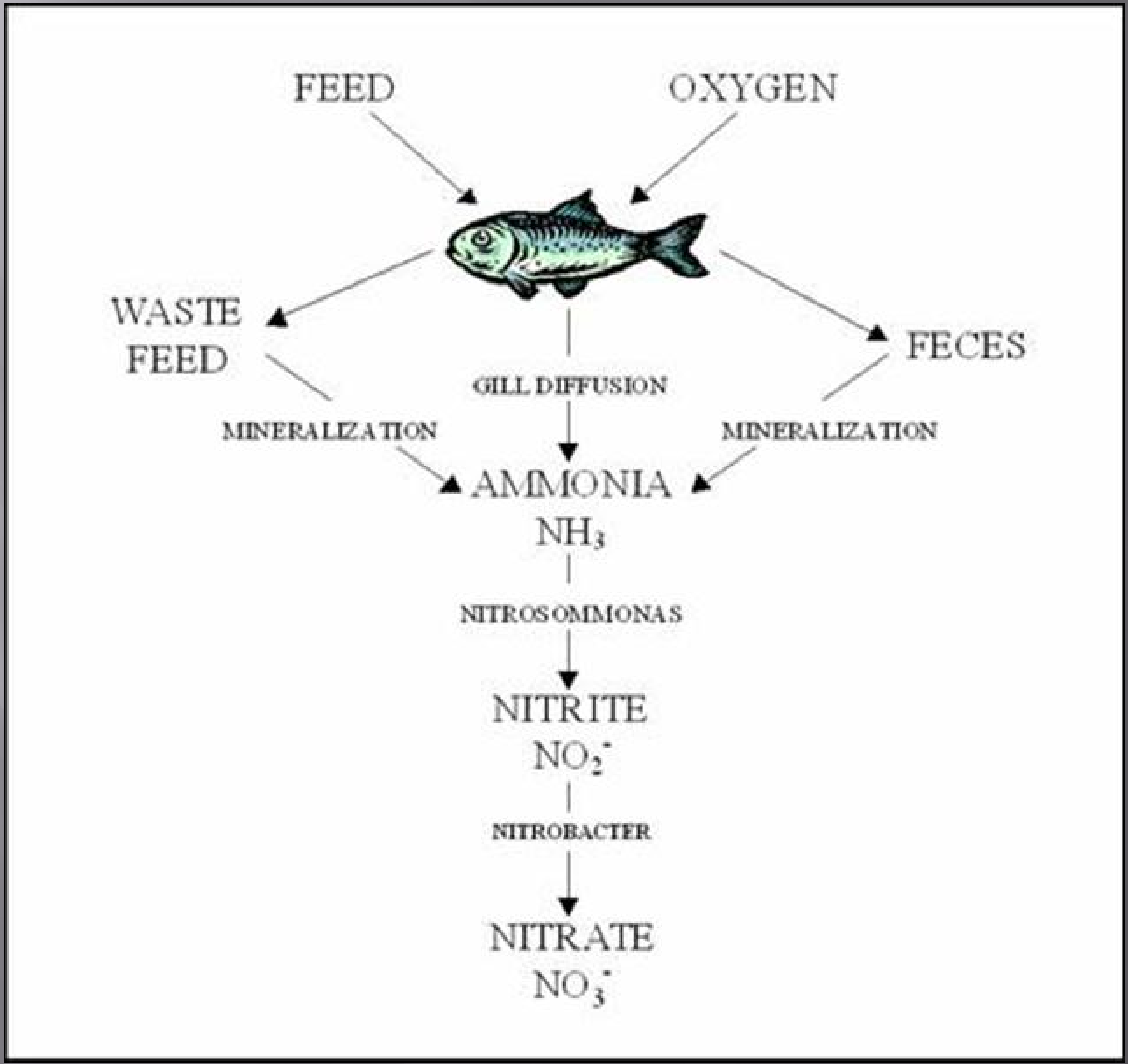
- Suspended and dissolved solids need to be removed
- Solids in the RAS provide food for hetertrophic bacteria
- Heterotrophic bacteria
  - Dependent on organic matter for food
  - Interfere with oxygen diffusion in the biofilter to nitrifying bacteria
  - Diminish oxygen available to nitrifying bacteria and fish
  - Can overload and plug biofilter

Drum filter

Biological Filtration

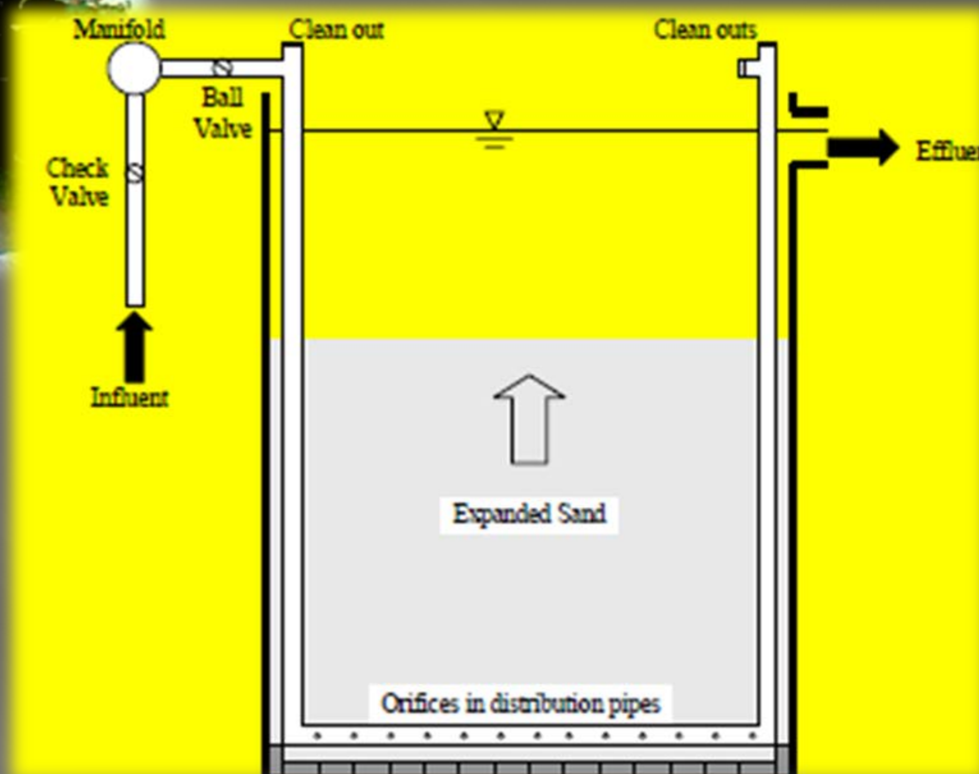
- Toxic ammonia is converted to non-toxic nitrate by bacteria that naturally appear in response to the presence of ammonia
- The bacteria attach to substrate in the RAS
- Enough surface area needs to be provided to permit enough bacteria to grow to adequately remove ammonia
- The two types of autotrophic bacteria are *Nitrosomonas* and *Nitrobacter*

Metabolic waste reduction



Fluidized sand bed filter

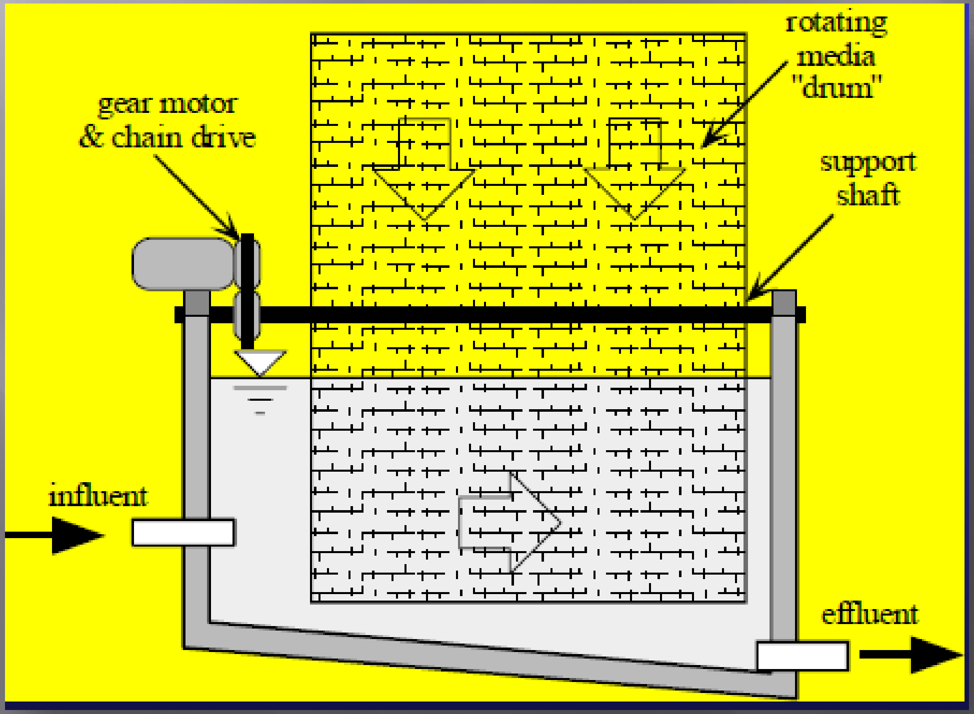
Sand media has a high <u>specific surface area </u>and therefore require less volume of media than other biofilter types



Types of Bio-Filters

- Rotating biological contactor
  - External
  - Internal

In-tank RBC
airlift driven



RBC
motor driven

Types of Bio-filters

- Submerged filters
  - Simple
  - Inefficient
- Trickling filters
  - Simple
  - Aerates

Submerged filter

Carbon Dioxide strippers

- Many types
- Must remove CO_2 to prevent build-up
- Can be simple or complex

Alkalinity and pH

- Bacteria in the biofilter use CaCO3 to convert ammonia into nitrate, reducing the alkalinity and pH

- Maintaining alkalinity at 50-100mg/l by the addition of lime or baking soda will keep free CO2 levels below 20 mg/l. The baking soda reacts with carbon dioxide to form harmless bicarbonate ions.

Bicarbonate Drip

- Rationale
  - CO_2 removal (<20 mg/L)
    - from respiration
  - Buffering
    - nitrification is an acidifying process
- Purpose
  - Adds alkalinity to water

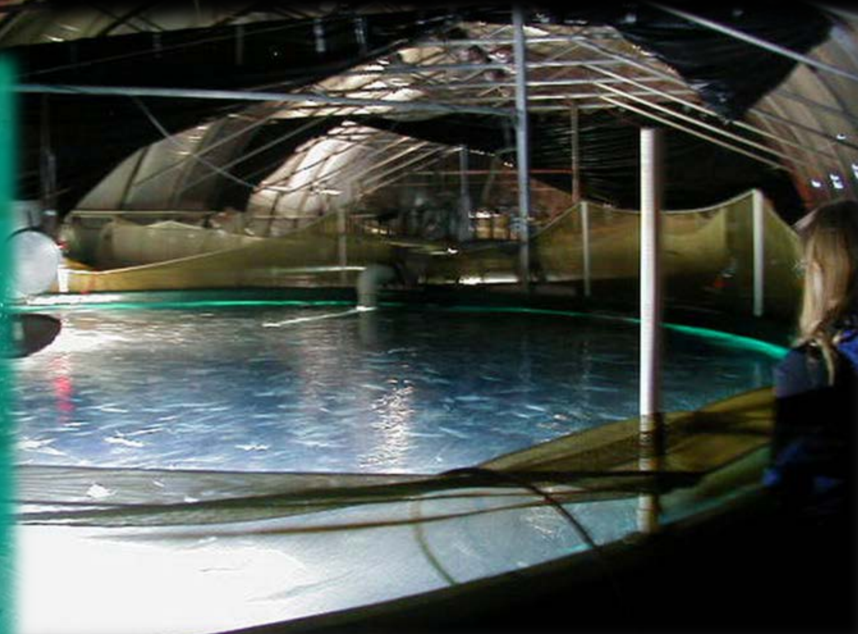
EXAMPLES OF RECIRC SYSTEMS

Sometimes there's not much water to work with…..

Energy efficient incubation water
Partial re-use

Recirc of water for eyeing eggs is relatively easy

BC fish farms – 95% recirculation



Juvenille atlantic salmon in recirc water

Drum filter -→

Adding sodium bicarb

Biofiltration


THE
Langley
CONCRETE
GROUP
604-533-165
C789

Environmental monitoring is essential in recirc systems

Tie critical levels to an alarm system

Drum filter and infusion of calcium bicarbonate

Sturgeon farming!

Atlantic salmon brood holding

Fin Fish II, Spring 2015
Exam 3
4/21/15
Due: no later than 5/1/15 by 5pm
Name ______________________________________

1. We talked about a few aspects of predator control in fresh and saltwater net pen systems. For this question, read the article *Predators and Salmon* by Donald J Dodds which you can find under Course Content/Resources. The article pertains to the salmon fishery in Oregon. Answer the following questions:
   a) what fish species are listed as predators which can be found in AK?
   b) what bird species are listed as predators which can be found in AK?
   c) what mammal species are listed as predators which can be found in AK?
   d) which of these predators were found to have the greatest impact on salmon? How many salmon are found to be impacted in this study?
   e) What are the author's conclusions? Do you agree/disagree? State your reasoning.
   f) Does this model apply in Alaska? Think about some of the situations mentioned in the study and consider if the author's assumptions fit our situation.

20pts

2. Go to http://www.akvagroup.com/products/cage-farming-aquaculture and take a look at the various types of fish culture cages the company offers. Compare and contrast steel vs. plastic cages. Address the following:
   a) Durability/longevity
   b) Options available
   c) Size and shape variations
   d) Security from severe weather
   e) If price was not a factor, why would you choose one over the other (no correct answer here)

15pts

3. Read the article http://www.alaskadispatch.com/article/biologists-look-ocean-clues-alaska-king-salmon-collapse and follow the lead to a short discussion of Pacific Decadal Oscillation. Answer the following:
   a) what effects does PDO have on the ocean?
   b) How does PDO impact Chinook returns in AK? In the Pacific NW?
   c) In this article what other possible factors might be at play in explaining the decreased abundance of AK Chinook?

15pts

4. Describe a fluidized sand bed filter system (biofilter) and address the following issues/questions:

a. what is the principle application for this type of filtration?

b. describe the transformation process of nitrogenous waste from toxic to non-toxic; what bacteria are involved in this process?

c. what water chemistry parameters can have a significant impact on balancing these systems? What steps can be taken to keep these factors in check? **15pts**

5. Read over pages 1-12 in CIAA's *Hidden Lake Smolt Manual* found under Course Content/Resources. Address the following:

a) List some factors affecting smolt movement downstream

b) List some of the physical changes occurring in sockeye and coho smolt

c) What equipment is necessary to have on hand while enumerating smolt at Hidden Lake?

d) What are some of the other species one might see during this operations and how would you identify them? **15pts**

6. Go to http://www.w-m-t.com/ and find out what the heck "IMF" and "MB3 Moving Bed Media" are. For each, list:

a) What their function is

b) Basic description for how they operate

c) An application for them **10pts**

7. Regarding smolt outmigration: several Alaska PNP's have projects on barriered lakes. Choose one and list the following:

a) The name of the PNP and location of project

b) A short summary of the project – what is the barrier and how does the project deal with it?

c) List some of the tasks which are associated with this project (water quality monitoring? Enrichment?, sampling methods? **10pts**

Bonus question:

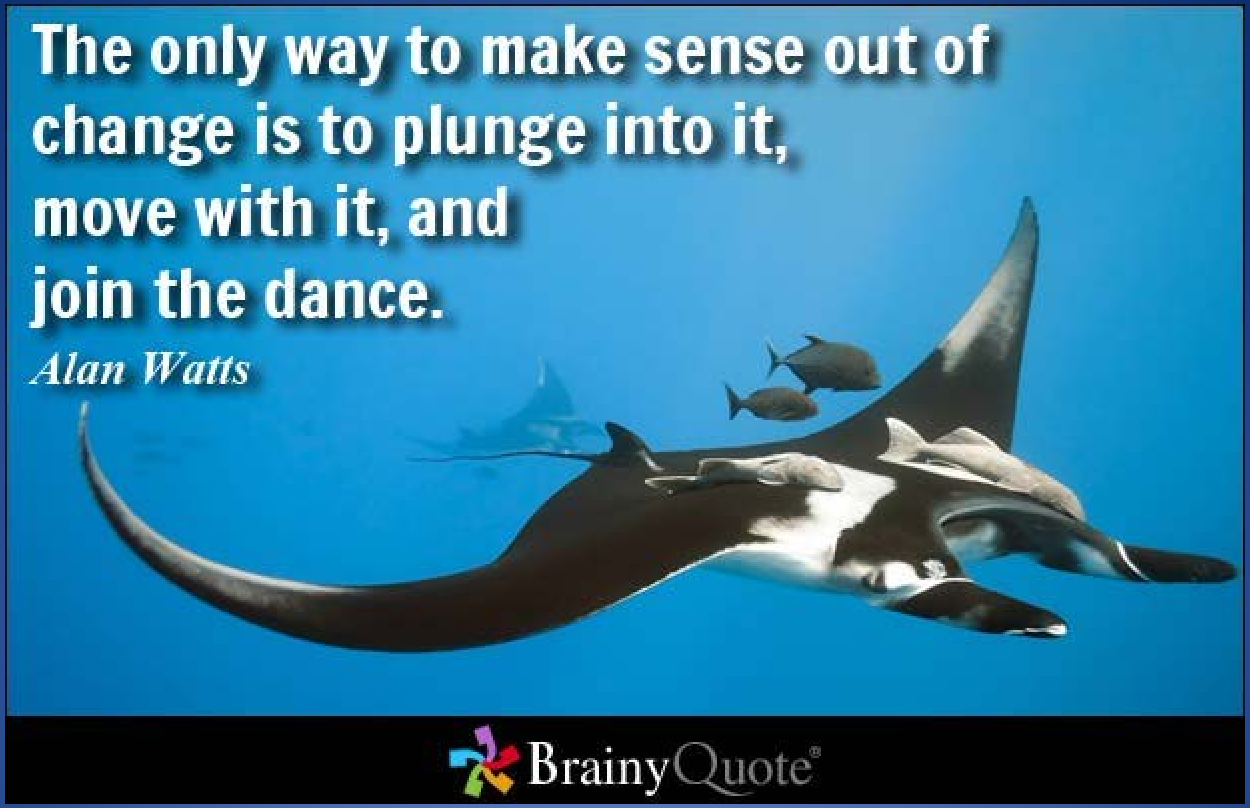
What is an "Opphengstau"? Would you give one to your dog? Cat? Co-worker?

Hint: saw it on the AKVA site…..I need a specific answer! **5pts**

Changes…………

Consider the following:

- Professional development for yourself
  - Your boss wants you to know the Big Picture
  - Thinking ahead
- The industry needs up and coming employees to function
- The best managed fisheries in the world needs dedicated/well-trained personnel



Watch the video “What if Money Was No Object” video (Course Content/Videos)