PUNTLEDGE RIVER HATCHERY

Workshop
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Puntledge River Hatchery
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Ponding

When and How?

ATU's (Accumulated Thermal Unit's) Best guideline for determining eyed eggs, alevin hatch to fry development Temperatures directly influence development. Warmer water speeds up development Colder slows down development.

1. -ATU's are (daily mean average temperature) * (number of days incubating). For example: If Chinook eggs were fertilized and placed in an incubator and the mean temp. was 10.0C. over a period of 30 days, you would have an ATU of 300. (avg. 10.^{O}C * 30 days = 300 ATU's)
2. -Water Temperatures can be manipulated to accelerate or decelerate groups for early or late ponding.
3. -Well water usually warmer in winter and cooler in summer, i.e.: Rosewall Hatchery
4. -Surface water influenced by ambient outdoor temperatures.
5. -Finding the mean daily temperature and using this for ATU's recording.
6. -This may help you find the best time to take your daily temperature. If you can take temperatures every *Vz* hr. for a 24 hr. period and average them for a mean daily average. Then find the best time of day for taking temperatures that match the mean average. This may change during seasons but will be close enough for your needs. (If you are utilizing well water, the temperature will not typically fluctuate during the day but will weekly and monthly)
7. -As you fluctuate from 10C - no longer a true ATU. e.g. 17C will not add up to a true ATU reading, and similarly 2C will not either.

Development Stages in ATU's (Puntledge Hatchery Guideline only!!!)

Species	Eyed	Plant	Hatch	Buttoned Ponding	Release
Pink	230	440	563-592	1100-1400	1335
Chinook	268		495-562	960-990	1565-2100
Coho	252		446-530	761	4491-5088
Chum	236	440	500	812	1289
Steelhead	203		366-380	550-682	3597-4405
Cutts	150-200		300	500-600	

Emergence Conditions and Fry Quality

When alevin development nears the "buttoned up" stage and it is close to the time of emergence, the conditions in the Incubator can affect the timing and survival of the emerging fry. When conditions are not optimum, alevins will try to leave the incubator before they are ready to exist as free—swimming fry. This is a sign of bad conditions in the incubator and remedial action may be necessary.

Conditions which result in early emergence

1) Low oxygen
2) High temperature/ low temperature
3) Disease — high fungus infection
4) High mortality — ammonia build-up from decaying alevins

5) Low flows
6) High silt build-up or silty water
7) Density- more room needed as they develop

The result of fry emerging early is that they are entering the stream environment early. The emergence from the streambed in nature is timed to coincide with spring zooplankton blooms in the ocean for ocean migrating fry, in lakes for sockeye, and it coincides with good food availability in streams for stream utilizing species such as Coho and Chinook.
Releasing fry early results in them entering an environment that is not suitable for their survival. They don't grow well, and if they don't find food early in their life, they do not learn to eat and will soon die.

Predation is also a major problem for early emerging fry because the food sources are limited and they are more susceptible to being eaten.

Fry size at emergence is important because problems can be created later on during the rearing or the natural period of growth of fry.

Problems that can result from small, poor quality fry;

1) Small mouthparts mean small food necessary — small food clogs gills;
2) Slower growth — have to feed them longer;
3) Longer holding means they are more susceptible to disease;
4) Smaller size means they are more easily eaten by a larger number of predators;
5) Size range — causes problems in rearing;
6) Pinheading — they don't grow.

Size range

When fry are small and reluctant to eat food presented in commercial form, some end up growing big and some very small. If size range gets big enough, the big ones eat the little ones. Sampling the population to get a good average size is more work because the small ones are easier to catch. Food sizes must be mixed. Feed rates may not be accurate. On the whole, a large range in sizes of fish causes many problems and should be avoided. One way to avoid it is to release the first emerging and the late emerging, and only keep the large number that emerge at the peak of emergence.

Pinheads

When fry are just emerging from the gravel, they must learn to eat. They usually learn by having a lot of small particles of food available and by seeing other fish eating. When fry are very small and are poor quality, they are reluctant to eat small food. Eventually they lose their ability to learn how to eat.

If fry do not eat or they eat infrequently, they gradually use up their body tissues and end up with a large head compared to their body. These are generally called "pinheads", although the original name referred to fish without proper mouthparts, which gradually wasted away.
All of these problems can be avoided if optimum conditions are maintained and proper emergence timing is followed by frequent feedings of small sized food

*Pinheads might also be caused by late ponding of fry.

Checking fry for Buttoned up bellies.

ATU's should be monitored and when approaching ponding stage (buttoned-up) a check should be carried out.
1. Check random heath tray by inspecting 25-100 fry in a 250-500ml beaker with 5cm water. **Slit on belly buttoned up,** still has up to 15% yolk sack left. Do not rush or pond too early
2. If unsure fill a 5-10 gallon pail % full w/ water and add 50-100 fry. Let them sit for 2-7 min. and see if 75-100% swim to surface. If they sit on the bottom put em back for a day or 2.
3. Remember that if you mix female eggs in incubators you will have large and small egg sizes. This relates to development. Large eggs longer duration small eggs shorter.
4. Grading females or eggs by size will give you a more uniform ponding and rearing fry size.
5. Try ponding in shallow tanks to allow swim up bladder to adjust. If you are using circulars or cap troughs you might try draining *Vi* of tank and add newly ponded fry. This will allow for swim up bladder to adjust and keep them from getting sucked on to screens while tank is filling.
6. Be gentle with newly ponded fish they are being subjected to stress and do not need more.
7. Let them adjust (hands off) for a day before feeding commences. And little amounts of feed several times a day.
8. If using a transport tank, make sure adequate oxygen levels and don't over saturate.

9. If ponding a large group into a raceway or large container. Be sure they are ready by putting a few thousand fry in and see what happens in 5-10 minutes.
10. Remember **not to** feed the bottom of tanks, as it will only create more work for you and more stress on fish by adding sediment to wastes. This equates to more screen cleaning and vacuuming.
11. At Puntledge we sometimes wrap a rubber strap (cut strips off tire tube) around each heath tray and place up to 10 trays in a tank with wheels. This keeps them in water from heath stack to ponding container.
12. We also installed a heath tray cassette system for a truck transport tank that will accommodate 20 trays per trip.
13. Ponding table was designed for transferring fish from heath trays into raceways.
14. A Bucket funnel is also a method for ponding a few trays.

PUNTLEDGE RIVER HATCHERY PRODUCTION

2001 SUMMER CHINOOK ATU'S

ATU's at 1st pick **260**

2nd pick - 350.0

ATU's at shocking 250

Alevin pick-

PONDED

DATE	TEMP	Lot #1	Lot # 2	Lot # 3	Lot # 4	Lot # 5	Lot # 6	Lot # 7	Lot # 8	Lot # 9	Lot # 10	Lot # 11
# EGGS	C.	ET Oct 4	ET Oct 5	ET Oct 8	ET Oct 11	ET Oct 12	ET Oct 17	ET Oct 18	Oct 23	oct.24	oct.26	oct.29
01-Oct	15.3											
02-Oct	15.2											
03-Oct	15.0											
04-Oct	14.8	**14.8**										
05-Oct	14.6	29.4	**14.6**									
06-Oct	14.6	44.1	29.2									
07-Oct	14.4	58.4	43.6					**12.8**				
08-Oct	13.9	72.4	57.5	**13.9**				25.7				
09-Oct	13.8	86.2	71.4	27.8				38.4				
10-Oct	13.7	100.0	85.1	41.5				51.0				
11-Oct	13.8	113.8	98.9	55.3	**13.8**			63.2				
12-Oct	13.7	127.4	112.6	69.0	27.4	**13.7**		75.3	**12.1**			
13-Oct	13.5	140.9	126.1	82.5	40.9	27.1		87.2	24.0	**12.0**		
14-Oct	13.4	154.3	139.5	95.9	54.4	40.6		99.1	35.9	23.8		
15-Oct	13.3	167.7	152.8	109.2	67.7	53.9		110.7	47.5	35.4		
16-Oct	13.2	180.9	166.0	122.4	80.9	67.1		122.0	58.8	46.7	**11.6**	
17-Oct	12.9	193.7	178.9	135.3	93.8	80.0	**12.9**	133.0	69.8	57.8	22.9	
18-Oct	12.8	206.5	191.7	148.1	106.6	92.8	25.7	144.0	80.8	68.7	33.9	**11.1**
19-Oct	12.9	219.4	204.6	161.0	119.5	105.7	38.6	154.7	91.5	79.4	44.9	22.0
20-Oct	12.7	232.1	217.3	173.7	132.2	118.4	51.3	165.3	102.1	90.1	55.6	32.7
21-Oct	12.5	244.7	229.8	186.2	144.7	130.9	63.8	176.0	112.8	100.7	66.2	43.4
22-Oct	12.2	256.9	242.1	198.5	157.0	143.2	76.1	186.5	123.3	111.2	76.9	54.0
23-Oct	12.1	269.0	254.2	210.6	169.0	155.2	88.1	196.8	133.6	121.6	87.4	64.5
24-Oct	12.0	281.0	266.1	222.5	181.0	167.2	100.1	207.2	144.0	132.0	97.7	74.9
25-Oct	11.8	292.8	278.0	234.4	192.8	179.1	111.9	217.3	154.1	142.0	108.1	85.3
26-Oct	11.6	304.4	289.6	246.0	204.4	190.7	123.5	227.1	163.9	151.9	118.2	95.3
27-Oct	11.3	315.7	300.9	257.3	215.7	201.9	134.8				128.0	105.2
28-Oct	11.1	326.7	311.9	268.3	226.8	213.0	145.9					
29-Oct	11.0	337.7	322.9	279.3	237.7	224.0	156.8					
30-Oct	10.7	348.4	333.6	290.0	248.5	234.7	167.5					
31-Oct	10.6	359.1	344.2	300.6	259.1	245.3	178.2					
01-Nov	10.7	369.7	354.9	311.3	269.8	256.0	188.9					
02-Nov	10.5	380.2	365.4	321.8	280.2	266.5	199.3					
03-Nov	10.3	390.5	375.7	332.1	290.6	276.8	209.6					
04-Nov	10.4	400.9	386.1	342.5	301.0	287.2	220.1					
05-Nov	10.0	411.0	396.1	352.5	311.0	297.2	230.1					
06-Nov	9.9	420.8	406.0	362.4	320.9	307.1	240.0					

ATU UPDATES

Stock	Date	Temp. C. ~ current	Lot #1	Lot #2	Lot #3	Lot #4	Lot #5	Lot #6	Lot #7	Lot #8	Lot #9	Lot #10	Lot #11
Pinks	28-Feb	5.0 ET date-	1206.3 Sep.30	1190.9 Oct.1	1175.8 Oct.3	1160.8 Oct.4	1131.4 Oct.6	1088.4 Oct.9	1074.6 Oct.10	1060.9 Oct.11	1047.1 Oct.12		
Sum.Chin.	28-Feb	5.0 ET date-	1160.8 Oct.4	1146.0 Oct.5	1102.4 Oct.8	1060.9 Oct.11	1047.1 Oct.12	979.9 Oct.17	967.1 Oct.18	903.9 Oct.23	891.8 Oct.24	868.0 Oct.26	845.1 Oct.29
Fall Chin.	28-Feb	5.0 ET date-	1221.5 Sep-30	1190.9 oct.02	1160.8 oct.04	1088.4 oct.09	1074.6 oct.10	1006.5 oct.15	993.2 Oct-16	916.1 oct.22			
Chum	28-Feb	5.0 ET date-	891.8 oct.24	868.0 oct.26	834.1 oct.29	823.1 oct.30	801.8 nov.01	529.4 nov.03	529.4 nov.06				
Coho	28-Feb	5.0 ET date-	680.5 nov.13	622.9 nov.19	587.1 nov.23	553.1 nov.27	507.2 Dec.3	458.8 Dec.10					

PRIMARY FISH CULTURE PARAMETERS

GENERAL

The primary water quality parameters are important to the successful operation of most hatcheries. With the exceptions of temperature and total gas pressure, the values of these parameters are adversely affected by the fish culture processes themselves. Table 1 lists these parameters and indicates how their values are changed by fish culture processes.

TABLE 1
IDEAL VALUES FOR INFLOW WATER AND EFFECTS OF FISH REARING ON WATER QUALITY PARAMETERS

Parameter	Ideal Value for Inflow Water	Effects of Fish Rearing		
		Increase	Decrease	Cause of Change
Dissolved Oxygen	100% saturation		X	- consumed by fish for metabolism
Ammonia	non detectable	X		- an excretory product of fish
PH			X	- depressed by an increase in carbon dioxide
Dissolved carbon dioxide	saturation	X		- a product of fish respiration
Non filterable residue	non detectable	X		- unconsumed fish food and fish feces
Hydrogen Sulphide	non detectable	X		- decomposition of pond sludge
Nitrate	non detectable	X		- incomplete nitrification in biofilters, decomposition of pond sludge

The carrying capacity of a hatchery water supply (weight of fish supported per unit of water flow) is directly dependent upon the constraints imposed by these parameters. Low dissolved oxygen levels and elevated ammonia levels are the most common limiting factors. To maximize the carrying capacity, the "perfect" inflow water to the hatchery would have the ideal values given in Table 1. However, to determine the carrying capacity of a "real" water supply we need to know the values at which the carrying capacity of the water is constrained. These

are the values at which fish health becomes seriously jeopardized.

The criteria discussed in the following sections attempt to define the threshold levels that begin to influence fish health. These criteria are therefore applicable to all **water** within the hatchery that is supporting fish.

In setting realistic values for inflow water, the hatchery designers should consider the changes in water quality within the hatchery. The benefits of increasing carrying capacity due to high quality water should be weighed against the cost of water treatment to improve water quality.

Temperature

Rearing Low Temperatures

Establishment of feeding is a major concern when initiating rearing at low temperatures. Special starter diets may be required to improve palatability and to minimize losses due to non-feeding fry (West Coast Fish culture Ltd, 1983). Minimum acceptable temperatures for this critical stage of rearing will vary, depending on diet and other factors. Approximate "criteria" can be suggested from BC hatchery experience.

At the Puntledge Hatchery on Vancouver Island, difficulties in feeding newly ponded Chinook have occurred at 3.5oC, whereas only minimal difficulties occurred at 4.00C (Qenoe, pers comm). Minimum acceptable temperatures for BC south coast Chinook and chum hatcheries have been suggested to be 4.50C for Chinook and 4.00C for chum (Anderson, pers comm).

Rearing Upper Temperatures

The upper lethal temperature for the five species of pacific salmon and steelhead trout is 25^0 or 10C (Brett, 1952, Bell, 1973). However, there are several factors other than direct mortality, which should be considered in establishing an upper temperature limit for a particular salmonid hatchery.

1) Growth Rate

For a given feeding rate, growth rate increases gradually with increasing temperature up to an optimum level, and then declines rapidly. Increasing the feeding rate up to the maximum ration increases the growth rate further and also shifts the optimum temperature higher. Growth vs temperature curves for juvenile Chinook salmon are shown in Figure 2. Brett et al. (1982) have determined that Chinook growth rates at maximum ration decline at temperatures greater than $18/19^0$C.

2) Rearing Pond Loading Density

Temperature increases reduce allowable pond loadings per unit flow rate as follows:

a) oxygen consumption is increased to support an elevated rate of metabolism

b) oxygen availability is reduced due to the lower saturation concentration and smaller allowable oxygen drop from pond inflow to outflow.

For example, pond temperatures of 13°C would reduce typical pond loading densities to approximately 40/50 percent of typical allowable loading densities at 8°C (McLean, pers comm). A high temperature period in late summer could therefore be the factor controlling the maximum numbers of fry reared at a facility with a limited water supply.

3) Disease

The severity and risk of occurrence of several common fish diseases (eg. furunculosis) increases with higher temperatures. However, adequate control of disease prior to high temperature periods and maintenance of low loading densities can allow successful rearing of Chinook, Coho and Steelhead at average temperatures of as high as 22°C for periods of as long as a few weeks (Genoe, pers comm).

4) Temperature Dependent Toxicity

If a water supply contains a significant level of ammonia, metals or other contaminants with temperature dependent toxicities, temperature limits should be set to minimize risks from toxic effects.

5) Smoltification and Migratory Behaviour

Elevated water temperatures may be used to accelerate growth and shorten the normal time needed to produce smolts. However, rearing temperature has a strong influence on smoltification and migratory behaviour.

In some species (eg. Coho) elevated rearing temperatures not only accelerate the onset of smolting but also hasten parr-reversion so that the duration of the smolting period is shortened and there is very little latitude in release time (Wedemeyer et el. 1981). In other species, (eg. steelhead trout) temperature acceleration of growth at temperatures as low as 15°C may cause inhibition of smoltification. Wedemeyer et al. (1981) recommend a maximum of 15°C for rearing of Coho and Chinook (1300 for steelhead trout), with a reduction in temperature to below 1200 at least 60 days prior to release to prevent premature smolting and parr reversion.

TOTAL GAS PRESSURE

Criteria

The general recommendation is that total dissolved gas pressure in hatchery water supplies should not exceed 103% of the existing atmospheric pressure. Gas bubble disease has been observed in alevins and fry in certain hatchery environments when total gas pressure has been in the range of 101 to 105%. Because gas bubble disease does not always occur at these low total gas pressure levels, further research is required to define the conditions that result in significant mortalities.

Calculation and Measurement

Total gas pressure is the sum of the partial pressures created by dissolved gases in solution. Although all gases can contribute to total gas pressure, only oxygen and nitrogen commonly create the excessive partial pressures that cause gas bubble disease. For example, a carbon dioxide concentration of 25 mq/L in water at 1000 would only exert a partial pressure of 0.01 atmospheres. If all other dissolved gases were at equilibrium with atmospheric pressure, the total gas pressure of the water would be about 101%.

-Total gas pressure is normally expressed as a percentage' and is calculated from percent saturation levels of the gases in water and their molecular percentage in air as follows:

Total Gas Pressure (%) = 0.2096 + 0.7901 Sn_2+ Ar + 0.0003 Soo_2

So_2, is the saturation level of dissolved oxygen in percent

SN_2 + Ar is the saturation level of nitrogen and argon in percent

Soo_2 is the saturation level of carbon dioxide in percent

If CO; levels are known to be high, then the contribution of 002 to total gas pressure should be taken into account. More commonly, the CO_2 term in the above equation is insignificant and 8002 can be assumed to be 100%.

Routine measurement of total gas pressure is performed with a tensionometer, which requires proper technique to obtain reliable results. The accuracy of the instrument is difficult to verify except by analyses of the individual component gases. The accuracy of the Novatech tensionometer that is commonly used in British Columbia has been stated to be ± 7 mm Hg or approximately ± 1% total gas pressure (Corman, pers comm).

Causes of Excessive Total Gas Pressure

Excessive total dissolved gas pressure can be caused by four main processes:

1.Injection of Air into Water under Pressure Gas solubility increases with water pressure so that water can be supersaturated in dissolved gases when pressure is reduced from an elevated value to atmospheric.

2-Heating of Water Gas solubility decreases with an increase in temperature. Therefore, water saturated with a gas at a certain temperature will become supersaturated if the temperature is increased. Figure 3 illustrates the solubility of nitrogen and oxygen in water as a function of temperature variation.

3. Excessive Biological Productivity . Photosynthesis during algal blooms can produce supersaturation in oxygen.

4.Biochemical Transformations in Groundwater. Denitrification of nitrate produces nitrogen gas and decomposition of organic matter can reduce oxygen and produce carbon dioxide, hydrogen sulphide, methane and ammonia.

More specifically, a hatchery water supply could become supersaturated with dissolved gases in the following ways:

1 .Injection of Air into Water under Pressure air entrainment into pipelines or pumps (Harvey and Smith 1961)
supersaturation by certain aeration devices (eg. use of aspirators that discharge into plunge pools or use of devices that discharge compressed air into pipelines or tanks)
water spillage at dams and waterfalls when entrained gases are carried to depths in plunge pools

2.Heating of Water
discharge of hot springs or power plant cooling water
-heating of hatchery water supplies
solar heating of the water in the region of the thermocline in a lake (Harvey 1967)
solar heating of water in shallow streams or rivers

3-Groundwater
groundwater can be supersaturated with nitrogen, carbon dioxide, methane, hydrogen sulphide and/or ammonia.

Reduction in total dissolved gas pressure in water is achieved by either formation of bubbles or direct release to the atmosphere from the water surface.

Release of dissolved gases from water is controlled mainly by water turbulence and the surface area of the air/water interface. Spontaneous formation of bubbles generally requires a high degree of supersaturation, and diffusion through liquid is slow. Thus, supersaturated water in a quiescent pond or storage tank would release gases very slowly, whereas supersaturated water in a turbulent shallow stream would release gases at a greater rate. Gas transfer equipment is generally required when total gas pressure is excessive (SIGMA 1979, McLean and Boreham 1980, Fidler, 1983).

Signs of Gas Bubble Disease

Excessive total dissolved gas pressure can cause gas bubble disease (perhaps better termed trauma) in which bubbles form within the body of the fish. Gas bubbles can also form on the surface of newly hatched fry, causing them to rise to the surface: or bubbles may form in the mouth, resulting in suffocation. Bubbles may also form in the yolk sac of fry (Weitkamp and Katz 1980).

In juvenile salmonids, the most common external sign of gas bubble disease is bubbles or blisters under the skin of the fish, primarily between the fin rays, although they may also be found on the head, in the lining of the mouth and in the caudal fin. The first external sign of gas bubble disease is formation of bubbles along the lateral line, although this is not easily recognized and therefore often missed (Weber and Schiewe 1976). Exophthalmia, or pop-eye, may or may not be present but is often indicative of chronic rather than acute gas bubble disease. The

advanced stage of gas bubble disease is often accompanied by hemorrhages frequently at the base of the paired fins. Bubbles or emboli in blood vessels in the gill may be a cause of death.

Factors Affecting Occurrence of Gas Bubble Disease

The occurrence of gas bubble disease is affected by numerous factors including physiological differences among life stages, blood pressure and other characteristics of the blood (National Academy of Sciences, 1974). Hydrostatic pressure, oxygen/nitrogen ratios, intermittent exposure, temperature and hardness may also affect the occurrence and severity of gas bubble disease. Salmonids vary greatly in their tolerance to supersaturation, and a portion of this variability may be related to genetic differences between stocks of the same species (Cramer and Mclntyre 1975).

Life Stage and Supersaturation Susceptibility

Susceptibility to supersaturation is life stage dependent. Tolerance shifts from very high in eggs, to very low in larval and juvenile stages, and increases again, with adults being the most tolerant free-swimming life stage (Weitkamp and Katz 1980). Nebeker et al. (1978) demonstrated similar findings with steelhead trout, in that eggs, embryos and pre-swim-up larvae were more resistant than swim-up alevins and later stages. In other steelhead trout studies, exposure of eggs and alevins to 110% total gas pressure (1200 and 10 mg/L hardness as Ca003) resulted in 13% alevin mortality in 53 days. No significant egg mortality was noted, indicating that the eggs were more resistant than alevins (Jensen 1980). Rucker and Kangas (1974) found that Chinook and Coho fry were susceptible to gas bubble disease, while eggs were not harmed by air or nitrogen supersaturated waters up to 128% saturation (highest tested).

Hydrostatic Pressure

Gas supersaturation decreases by about 10% per metre of increase in water depth and therefore increases in hydrostatic pressure oppose bubble formation. However, hydrostatic pressure compensation would usually have little effect in shallow incubation and rearing facilities. For example, to reduce a total gas pressure of 110% to the young salmonid threshold level of 102-103% would require a hydrostatic pressure of 70 cm of water. Slightly deeper water depths can reduce the risk of gas bubble disease.

Oxygen-Nitrogen Ratios

Gas bubble disease can be caused by supersaturation of either nitrogen, oxygen or both. However, if oxygen-nitrogen ratios are varied, mortality does not necessarily correlate linearly with total gas pressure. Nitrogen is biologically inert whereas oxygen is biologically active; the difference in biological activity may be responsible for some of the observed effects. For example, formation of bubbles in the blood due to increases in gas pressure may be more related to the supersaturation of dissolved nitrogen than to dissolved oxygen because of the capacity of hemoglobin to bond oxygen and transport it to other locations in the body (Randall, pers comm). On the other hand, the formation of bubbles in tissue and body cavities from direct diffusion of gases from the water would likely be related to both oxygen and nitrogen supersaturation (Fidler, 1983).

Several Investigators (Rucker and Kangas, 1974; Meekin and Turner, 1974; Rucker, 1975;
Dewiey and Ebel, 1975) have examined the importance of variations in the oxygen-nitrogen partial pressure ratios on the lethal effects of total gas pressure. These studies have shown that mortality from gas bubble disease at constant total gas pressure can be reduced by increasing the oxygen-nitrogen partial pressure ratio. For example, Rucker (1975) found that mortality at a

constant 119% TGP (total gas pressure) was reduced significantly when the $0_2/N_2$ ratio was changed from 159961109% to 173%/105%. This result appears to indicate that mortality was more directly related to the level of dissolved nitrogen supersaturation than to total gas pressure. Studies have also shown that the dissolved oxygen level plays an important role in the occurrence of gas bubble disease. For example, Dawley and Ebel (1975) found that the mortality at a constant dissolved nitrogen level (116.0%) was reduced significantly when the dissolved oxygen level was reduced from 98.8% to 88.2% (total gas pressure was reduced from 112.1% to 110.0%). It has also been reported that oxygen alone can produce gas bubble disease, but only at very high oxygen supersaturation levels (300% or greater) (Weitkamp and Katz, 1980).

A review of the available literature of oxygen-nitrogen ratios leads to the following conclusions:

1. Both dissolved nitrogen and dissolved oxygen can contribute to gas bubble disease. However, the relative importance of the individual gases may be related to the mode and location of bubble formation.
2. It is probable that most fish could tolerate higher levels of total gas pressure if the major portion of the excess gas were due to dissolved oxygen supersaturation.
3. Until further definitive experimental work is completed, water quality should continue to be evaluated in terms of total gas pressure criteria, without specification of critical oxygen-nitrogen ratios.

Intermittent Exposure

Fish may be able to tolerate intermittent exposure to increased levels of supersaturation since recovery can occur during periods of reduced supersaturation (Weitkamp and Katz 1980). Meekin and Turner (1974) found that juvenile Chinook salmon and steelhead could repeatedly tolerate 122% TOP for 16 hours providing they were returned to 100% TOP for eight hour periods between exposures.

TGP and Temperature

In general, temperature indirectly influences TOP by changing the solubility's of the dissolved gases. Furthermore, tolerance to elevated TOP decreases at higher temperatures as indicated by Jensen (1980) who found that long term exposure of alevins to 110% TOP at 12°C resulted in

significant mortality whereas no mortalities were found at 8 and 100C. Mortalities were due to severe growth deformities caused by large bubbles that formed in the alevins' mouth cavities shortly after hatch[1]. These bubbles were also noted in the alevins at the lower temperatures, but they did not result in deformities or increased mortalities.

TGP and Hardness

In studies that exposed steelhead eggs and alevins (from fertilization to yolk absorption) to a TOP of 110% at 12°C in waters with total hardness of 10 and 100 mg/L as CaC03, Jensen (1980) noted that significant alevin mortality occurred at a hardness of 10 mg/L but not in the water with a hardness of 100 mg/L. Inch's Creek Hatchery has experienced gas bubble disease in Coho alevins at relatively low levels of TOP (100.5-101.5%), and nitrogen (102-103%) (Harding, pers comm) that may be related to the low total hardness of 8 mg/L as CaC03. While the above evidence is limited, it would appear that alevins might be more susceptible to gas bubble disease in very soft water than in moderately hard water.

Discussion and Rationale for Criteria

Salmonids in hatchery environments are inherently more susceptible to gas bubble disease than are wild fish and therefore require special criteria because of two major factors:

1.Hatchery fish are held at shallow water depths where hydrostatic pressure does little to oppose bubble formation.

2-Exposure of hatchery fish to elevated levels of dissolved gases is frequently continuous and for long periods. Therefore, even slow-developing bubbles can interfere with vital physiological functions.

The deleterious effects of low levels of TOP observed at a few hatcheries Indicate that any increase in TOP above saturation may involve a risk of gas bubble disease. However, it should also be noted that several hatcheries are operating successfully with continuous TOP levels in the order of 103%. Because TGP levels of 10) can be achieved by relatively economical aeration systems, and because the risk of significant mortalities at this level appears to be low, 103% is recommended as the maximum accepted total gas pressure level.

The levels of total gas pressure reported to cause deleterious effects on fish vary greatly and the relative importance of the numerous factors affecting the occurrence of gas bubble disease is poorly understood, supersaturation of nitrogen is a very common occurrence in well water supplies at B C hatcheries, further research on the causes of gas bubble disease is required to develop better criteria.

DISSOLVED OXYGEN

Criteria

Dissolved oxygen criteria are presented below for three age classes of developing freshwater salmonids.

Fertilization to Eyed Egg Stage

The minimum dissolved oxygen level within an incubator should be maintained above 6.0 mg/L 0_2 (Rombough, pers comm).

Eyed Egg Stage to Hatch

The minimum acceptable dissolved oxygen level for eyed embryos increases with increasing water temperature. Levels should be maintained above those given in Table 4.

TABLE 4- MINIMAL ACCEPTABLE DISSOLVED OXYGEN CONCENTRATION WITHIN INCUBATOR VS TEMPERATURE FOR EYED EGG STAGE TO HATCH[1]

Temperature ©	Minimum Oxygen Concentration Within Incubator (mg/L $O_{2)}$	
2.5	8.5	
5.0	9.5	
7.5	10.3	
	10.02	11.2
12.52	12.0	

1 The criteria are based on Chinook egg requirements as determined by Rombough (pers comm.). A limited amount of testing has shown that these criteria should be protective of other salmonids.

2 The water temperature should not exceed 10^0C for eggs near hatching as oxygen

concentrations of greater than 100 percent saturation are required to prevent a reduction in oxygen uptake.

Post hatch and Free-Swimming Stage.

TABLE 5 DISSOLVED OXYGEN CRITERIA FOR POST HATCH AND FREE-SWIMMING STAGES (Davis, 1975)

Protection Level	Description	Dissolved Oxygen Concentration (mg/L)
A	few members of the fish population will likely exhibit effects of low oxygen.	7.8
B	The average member of the fish population will start to exhibit symptoms of oxygen distress.	6.0
C	A large portion of the fish population will be affected. The deleterious effect may be severe if the oxygen minimum is prolonged beyond a few hours.	4.3*

*Protection Level C has been established assuming other deleterious substances are absent or well below critical levels. However, if the dissolved oxygen concentration is depressed from relatively high levels to Level C by fish metabolism, then ammonia end carbon dioxide levels will be elevated. The combined toxic effects of high ammonia and carbon dioxide and low DO's can be expected to result in severe fish health problems.

Introduction

Dissolved oxygen (DO) is essential and in many cases the limiting factor in determining the carrying capacity of a hatchery water supply. Reduction in DO affects many physiological, biochemical and behavioural processes in fish. Some of these effects include reduced growth and food conversion efficiency, Impaired-swimming performance, enhanced lethal effects of texicante, and anomalous development of eggs and larvae. The oxygen level where such effects first become apparent, ie. the incipient oxygen response threshold can be used as the basis for derivation of oxygen criteria.

Post Hatch and Free-Swimming Stages

Davis (1975) reviewed the response thresholds and minimum oxygen requirements of salmonids and other aquatic life and developed dissolved oxygen criteria for safeguarding freshwater salmonid populations. These criteria were based on consideration of several sub lethal effects and appear to be appropriate for application to hatchery water systems for post hatch and free-swimming life stages.

In Davis (1975) three levels of protection (A, B, C) define the risk of occurrence of sub lethal effects. Little or no risk of harmful effects is incurred if dissolved oxygen is maintained above level A (7.8 mg/L). Practical considerations may necessitate depression of dissolved oxygen to level B (6.0 mg/L) for short periods but at the expense of incurring some risk of harmful effects. The criteria presented by Davis (1975) (and by the previous edition of this manual) were expressed as percentage saturation values over a range In temperatures. If expressed as concentrations, these criteria specified a level A concentration of 7.8 mg/L 0_2 for temperatures greater than 150C; this value is

identical to the level A given by Table 5. However, Davis (1975) specified somewhat greater concentrations for temperatures less than 15°C. At 10, 5 and 0°C the level A criteria, expressed as concentrations at normal sea level pressure, were 8.6, 9.7 and 11.1 mg/L, respectively. These criteria were set to ensure that a constant oxygen tension (partial pressure) gradient was maintained at the lower temperatures.

The revised criteria in Table 5, for a given level of protection, specify a single minimum concentration criterion to be utilized at all temperatures. Increased concentrations to maintain a constant oxygen tension gradient at temperatures less than 15°C do not appear to be required because of the following factors:

1. The dissolved oxygen requirements of fish for metabolism decrease at lower temperatures. Although the rate of diffusion of oxygen across the gills and into the blood is also reduced at lower temperatures, the decrease in rate of oxygen consumption is greater than the decrease in the rate of diffusion (Randall, pars comm).

2. The affinity of hemoglobin for oxygen increases at lower temperatures and the oxygen transport system within the fish is facilitated (Randall, pers comm).
3. Data presented by Davis (1975) indicate that oxygen concentration response threshold is not clearly related to temperature. Ott at al. (1980) determined that the critical oxygen tension (Pc) for rainbow trout was the same at 10°C and 15°C. Response thresholds for free-swimming stages may actually be slightly lower at lower temperatures (Rcmbough, pars 00mm). Further research is required to define the relationship between oxygen response threshold and temperature over the full temperature range found in British Columbia hatcheries.

Implications and use of Criteria

The revised criteria presented above have implications for efficient water use and temperature management as follows:
1)A very high level of oxygen saturation (depending on temperature) is required for only about one third or less of the incubation period (prior to and during hatch). During the initial incubation and post hatch periods, when oxygen concentration requirements are lower, the carrying capacity of the water could be increased, or alternatively, the energy expended to aerate the water supply could be reduced.
2)The critical oxygen concentration criteria establish a maximum acceptable temperature of about 10 11 °C for the period prior to and during hatch.

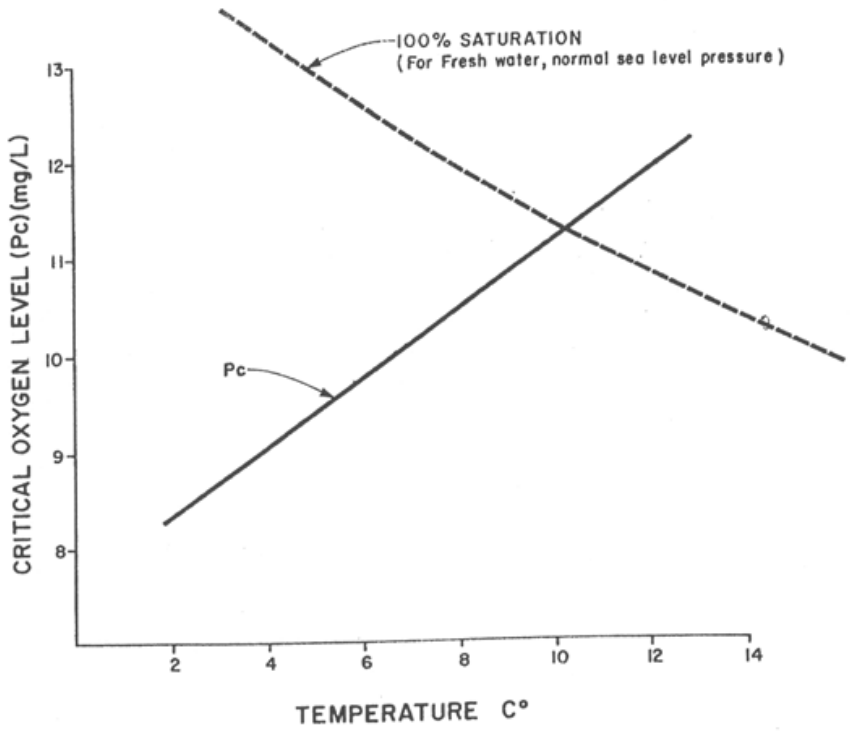
Hatchery operators applying DO criteria should keep in mind that the criteria levels are the minimum acceptable levels for the individual organism, and that large variations in DO can occur within an incubator or rearing pond due to nonuniform flow distribution. Maintenance of the criteria levels at the outflow of a given incubating or rearing unit may not necessarily ensure

that criteria levels are being adequately maintained within the unit. Dissolved oxygen can be expressed in terms of concentration (mg/L), percent saturation, or partial pressure (mm Hg). Solubility is a function of temperature, atmospheric pressure and salinity (see tables in Hitchman, 1978). Figure 3 gives oxygen solubility for freshwater at normal sea-level pressure.

Rationale for Criteria Fertilization to Hatch

The incipient oxygen response threshold for salmonid eggs and larvae can be determined experimentally. During development, eggs maintain a constant rate of oxygen uptake if DO levels are high. As the environmental DO level declines (eg. in a Heath stack) a point is reached where further decline in DO results in reduced oxygen uptake by the egg. The DO level at which oxygen uptake rate just begins to diminish is called the critical DO level (P_o) (Figure 4). pc levels provide criteria for defining minimum DO requirements, since DO levels below P_o can result in a number of adverse consequences for the embryo, such as reduced growth and rate of development (Rombough, 1981).
P~ varies with species, stage of development, perfusion velocity and temperature. Dr P Rombough, of the Pacific Biological Station, Nanaimo, BC has conducted a series of experiments to determine the effect of these factors on oxygen uptake rate and P_o. Although the results of these experiments are preliminary and are not yet published, they are of importance in the development of improved criteria and therefore have been utilized in this manual. Figure 5 shows how the critical oxygen level (Pa) varies with the stage of egg and larvae development. Pc increases steadily from fertilization to a period just prior to hatch when oxygen concentration requirements reach a maximum. Although the oxygen uptake rate of the organism continues to increase after hatch, Pc decreases abruptly and lower DO Levels do not affect uptake.
For the period from fertilization to eyeing, a minimum level of 6 mg/L O_2 should maintain an adequate safety margin above Pc* For the period prior to and during hatch much higher DO concentrations are required, and the effect of temperature on the saturation concentration becomes a limiting factor.

*Figure 6 shows the relationship between Pc and temperature for Chinook eggs just prior to hatch. At temperatures greater than about 1000, the oxygen concentration will fall below Pc and result in reduced oxygen uptake even if 100 percent saturation is maintained.



SOURCE: Dr. P. Rombough, Pacific Biological Station, Nanaimo, B.C.

RELATIONSHIP BETWEEN CRITICAL OXYGEN LEVEL (Pc)
AND TEMPERATURE FOR CHINOOK EGGS JUST PRIOR TO HATCH

FIGURE 6

The proposed criteria for eyed stage to hatch (Table 4) were taken from pc vs temperature data for Chinook eggs just prior to hatch. The criteria should be protective of other species because pc values for Chinook have been found to be generally higher than other species tested (Rombough, pers comm).

Post Hatch and Free-Swimming Stages

Davis (1975) reviewed the response thresholds and minimum oxygen requirements of salmonids and other aquatic life and developed dissolved oxygen criteria for safeguarding freshwater salmonid populations. These criteria were based on consideration of several sub lethal effects and appear to be appropriate for application to hatchery water systems for post hatch and free-swimming life stages.

In Davis (1975) three levels of protection (A, B, C) define the risk of occurrence of sub lethal effects. Little or no risk of harmful effects is incurred if dissolved oxygen is maintained above level A (7.8 mg/L). Practical considerations may necessitate depression of dissolved oxygen to level B (6.0 mg/L) for short periods but at the expense of incurring some risk of harmful effects. The criteria presented by Davis (1975) (and by the previous edition of this manual) were expressed as percentage saturation values over a range in temperatures. If expressed as concentrations, these criteria specified a level A concentration of 7.8 mg/L 0_2 for temperatures greater than 1500; this value is identical to the level A given by Table 5. However, Davis (1975) specified somewhat greater concentrations for temperatures less than **1500.** At 10, 5 and $O^{O}C$ the level A criteria, expressed as concentrations at normal see level pressure, were 8.6, 9.7 and 11.1 mg/L, respectively. These criteria were set to ensure that a constant oxygen tension (partial pressure) gradient was maintained at the lower temperatures.

The revised criteria in Table 5, for a given level of protection, specify a single minimum concentration criterion to be utilized at all temperatures. Increased concentrations to maintain a constant oxygen tension gradient at temperatures less than 1500 do not appear to be required because of the following factors:

1. The dissolved oxygen requirements of fish for metabolism decrease at lower temperatures. Although the rate of diffusion of oxygen across the gills and into the blood is also reduced at lower temperatures, the decrease in rate of oxygen consumption is greater than the decrease in the rate of diffusion (Randall, pers comm).

Ammonia

PH

Carbon Dioxide

Non-Filterable Residue (Suspended Solids)

Hydrogen Sulphide

Nitrite

General Water Quality Parameters

Conductivity
Filterable Residue (Total Dissolved Solids)
Colour and Turbidity
Hardness
Alkalinity
Chlorides, Sulphates and Nitrate
Phosphate
Fluoride
Silica

Other Cautions
Sodium and Potassium Total Organic Carbon

Metals

Cadmium
Copper
Zinc
Chromium
Lead
Mercury
Nickel
Selenium
Silver
Iron Manganese
Aluminum

Other Contaminants

Chorine
Cyanide
Arsenic
Fecal Coliforms
Pesticides
Oil and Grease

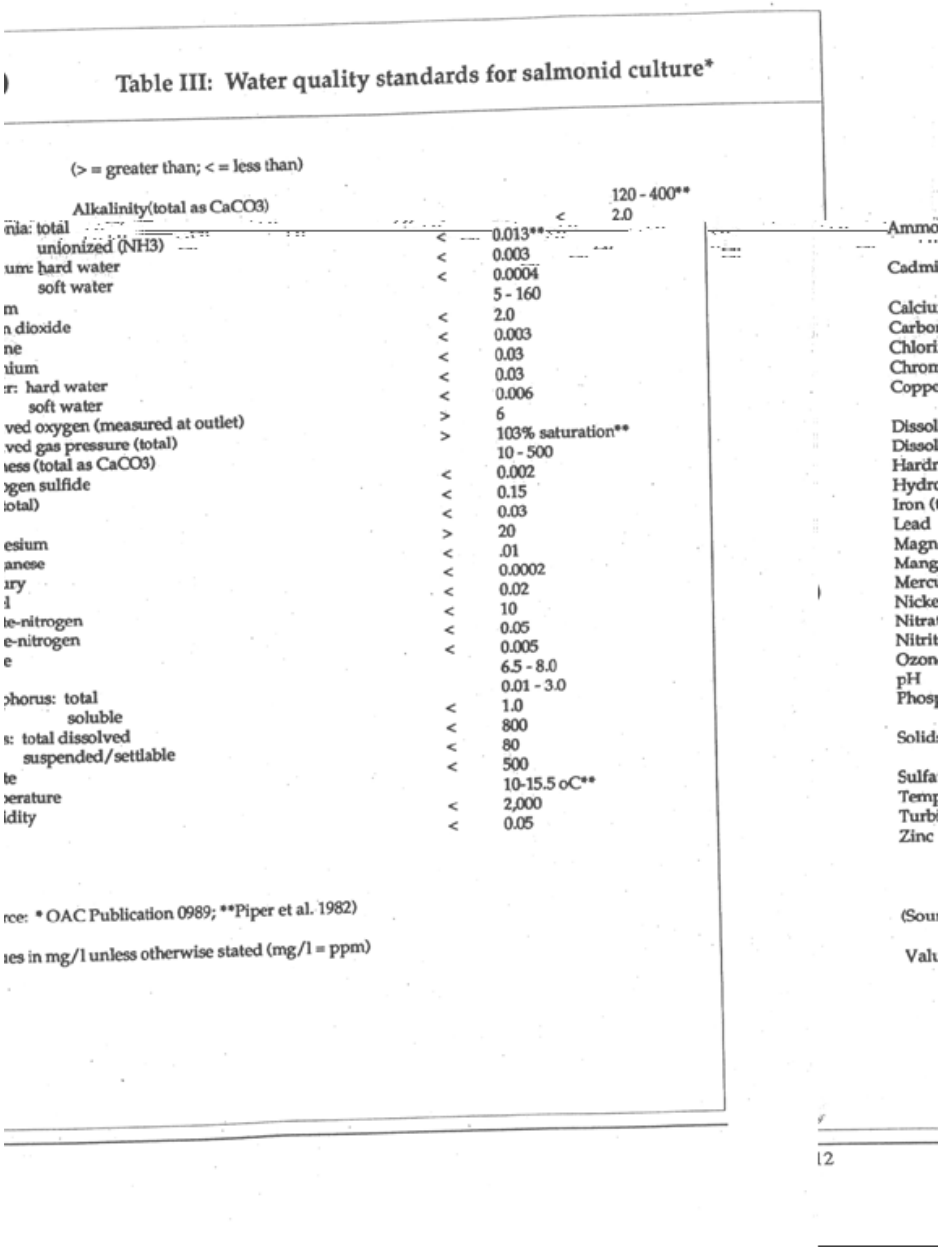


Table III: Water quality standards for salmonid culture*

(> = greater than; < = less than)

Alkalinity(total as CaCO3)		120 - 400**
ria: total	<	2.0
unionized (NH3)	<	0.013**
um: hard water	<	0.003
soft water	<	0.0004
m		5 - 160
n dioxide	<	2.0
ne	<	0.003
ium	<	0.03
r: hard water	<	0.03
soft water	<	0.006
ved oxygen (measured at outlet)	>	6
ved gas pressure (total)	>	103% saturation**
ness (total as CaCO3)		10 - 500
gen sulfide	<	0.002
otal)	<	0.15
	<	0.03
esium	>	20
anese	<	.01
ry	<	0.0002
	<	0.02
le-nitrogen	<	10
e-nitrogen	<	0.05
e	<	0.005
		6.5 - 8.0
phorus: total		0.01 - 3.0
soluble	<	1.0
s: total dissolved	<	800
suspended/settlable	<	80
te	<	500
erature		10-15.5 oC**
idity	<	2,000
	<	0.05

rce: * OAC Publication 0989; **Piper et al. 1982)

ues in mg/l unless otherwise stated (mg/l = ppm)

Ammo
Cadmi
Calciu
Carbo
Chlori
Chrom
Coppe
Dissol
Dissol
Hardn
Hydr
Iron (
Lead
Magn
Mang
Merc
Nicke
Nitra
Nitrit
Ozon
pH
Phos
Solid
Sulfa
Temp
Turbi
Zinc
(Sou
Valu

12

Feed workshop topics

1) Calculate feed rate, how and why.

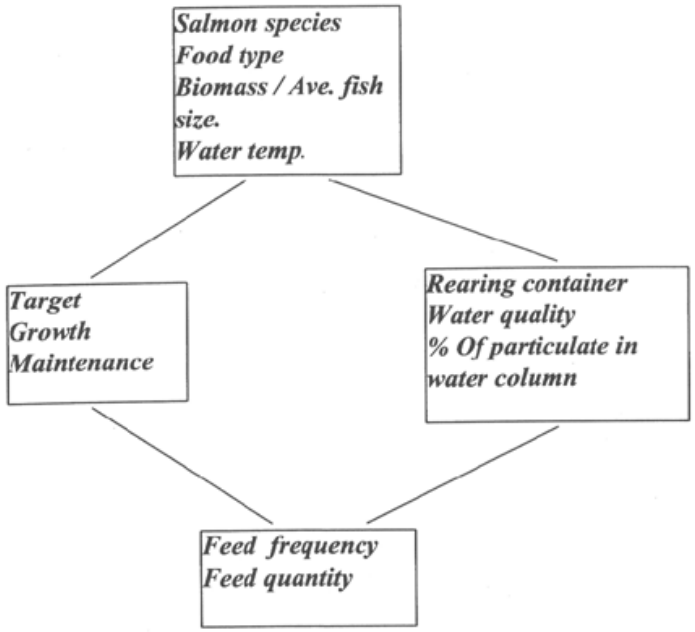
2) Frequency and food per feeding.

3) Factors in fish growth.

4) Food conversions.

5) Condition coefficient.

Feed workshop notes



Food calculation examples

Biomass = total number offish x. average weight offish.

A pond with 10,000 Coho at an average of 4 grams each = a biomass of 40,000grams or 40 kg.
If water temp. is 8.5 degrees the Ewos recommended feed rate = 1.64 % of biomass (see Ewos feed rate sheet at end of chapter) Biomass = 40 kg so 40 x 1.64% = 0.656 kg of ewos 1.2mm.

A pond with 150,000 Coho at 10 grams each = ——kg of biomass.

If water temp = 9.5 degrees recommend ewos feed rate =——% Food size = ———.

FEED RATE CALCULATIONS How Much Food to Feed

Method (1) Satiation feeding.

Satiation feeding means providing as much food as fish will eat, many times during the day. Each time food is thrown to the fish, watch to make sure that it gets eaten before it sinks to the bottom. Eventually the appetite of each individual is satisfied at each feeding.

Method (2) Calculate feed amounts from published feed rate chart. Feed rate charts were determined by feeding fish various amounts of food, trying to keep all other conditions constant. The amount of food that resulted in maximum growth is reported on the feed chart as percentage of body weight per day. If you feed more than the maximum feed rate (that is the chart feed rate), then you are probably wasting food. The fish will eat more than the maximum amount of food, but will not necessarily grow faster; it goes in one end and out the other.
Method (3) Combination of (l) and (2) or "Feed the fish, not the pond," or Optimum feed rate. This method starts with a feed amount calculated from feed rate tables that give a feed rate in percent body weight per day, depending on temperature and fish weight. Calculate the amount of food and then, while you are feeding, watch to make sure it is all eaten.

Why calculate feed rates

1) The published feed rate is the maximum amount of food to feed fish of a certain size at a specific temperature. This rate of feeding has been found by feeding many different amounts of food and recording the amount, which results in maximum growth. Fish will eat more food, but the extra food will not result in more growth because the fish cannot digest it fast enough. It will go in one end and out the other. Feeding more than feed rate chart can result in food being wasted because the fish lose their appetite and can result in problems resulting from poor water quality due to decaying food.
2) The published feed rate is what is expected for the conditions offish size and temperature. If your fish eat more and grow fast, it’s O.K. If your fish eat less, then something might be wrong:

- Disease;
- Bad food;
- Bad water quality;
- Predator’s -birds, mink;
- Some other stress -disturbances, pond management technique. _ Inventory discrepancy

It gives you a standard to compare your fish's performance to.

3) When satiation feeding without comparing it to a published feed rate, it is not easy to predict food requirements. Food requirements usually increase faster than is expected as temperatures rise and fish grow. **Keeping up to** the fish's need for food is very critical **in** maintaining maximum growth.

4) Sometimes it is very difficult to see if fish are getting the food you throw to them:

- Cloudy water;
- Deep ponds;
- Crowded ponds.

Satiation feeding under these conditions will result in under— feeding which is harmful to the fish and results in smaller fish at release.

With any of the above methods it is essential to record the amount of food fed and the increase in fish size in order to manage fish growth properly.

6.b. Mean Temperature

The water temperature affects fish greatly because they are cold blooded. When calculating temperatures for feeding over a period of time, there will always be fluctuations. Use mean temperatures for feed rate calculations (a *max—mm* thermometer is helpful, a thermograph even better).

Use judgment when calculating a feed rate when temperatures are increasing. It may be necessary to use the highest mean temperature observed. Similarly, if temperatures are decreasing, use the lowest mean temperature observed.

6.e. Optimum vs Maximum Feed Rate

The feed rate on the chart is the maximum feed rate that salmon are physiologically able to digest and use for maintenance and growth under ideal conditions. In normal hatchery routine it is not likely that salmon fry will be able to eat and grow at the maximum rates.

Hatchery practices that affect fish growth:

1) Feeding;
2) Sampling;
3) Crowding in smooth walled containers;
4) Cleaning ponds;
5) Disturbances such as walking past ponds.

For these reasons a compromise is necessary to get healthy fish that grow at a satisfactory rate or optimum growth rate. To obtain optimum growth, a feed amount slightly less than maximum must be determined.
The usual values that are observed are:

Chinooks 80% of maximum growth rate;
Coho 60% of maximum growth rate;

Chum 50% of maximum growth rate.

As long as you "feed the fish, not the pond," you will correct a situation where underfeeding exists. Overfeeding is also a problem.

Feeding at or above the maximum feed rate can produce negative metabolic effects. An increased metabolic rate at maximum feed rates results in increased ammonia production from only partly digest

Too much ammonia in rearing trough water alters the pH of the water and decreases the blood's ability to transport oxygen and a decrease in the gills' ability to transport oxygen into the blood and carbon dioxide out of the blood.

The increase in activity is normal up to a point of about 70% of the maximum feed rate. After this point, the fry become "hyperactive", where the increased activity causes an imbalance of oxygen and carbon dioxide in the blood caused by a thickening of the gill filaments. There is a consequent increase in ammonia production. The fry enter an oxygen "debt" situation that requires energy to overcome, so less energy is available for growth.

Feeding more than the maximum feed rate can result in poor growth and dangerous water quality situations. For very small fish the wastage of food seldom results in fry getting too much to eat, so maximum feed rates can be used along with satiation feeding. For longer rearing periods (Coho) and larger fish sizes, optimum feed rates must be used instead of maximum feed rates.

The maximum feed rate table should still be used because it gives you an awareness of the maximum growth capabilities of your fish.

6.f. Amount of Food per Feeding

The total fish weight times the feed rate gives the total food per day. To find out how much to feed for each feeding, divide the total food per day by the number of feedings in one day or the feeding frequency.

Weigh out the food once each day. There are two methods used:

1) Weigh out the total amount of food to be fed to a rearing container in one bucket. Feed from that bucket using a cup that gives the proper amount for one feeding;
2) Weigh out individual amounts for each feeding for each rearing container. This method is fine if there are only a few rearing containers to feed.

The method you use must be consistent and must be done separately for each trough, pond, etc. It is important to do it separately because different ponds have different numbers offish and may react differently to being fed, i.e. different growth rates and food requirements. Set up a system and make sure that everyone that will be feeding fish, including weekend relief workers, knows how to use the record sheets and fills in the information.
Frozen food like OMP does not need to be thawed out before feeding unless you are feeding large pellet sizes (3/16" or W) to pen— reared fish. For smaller pellet sizes a short thawing period of one—half hour is O.K. but any longer and the food starts to decompose and lose its vitamin C. If you measure out the total day's food, keep it frozen until feeding time.

There should be one sheet for each container because:

- Containers get individual treatment;
    - They get diseases individually;
    - They have their own flow, temperature, light, and disturbance experience.

Simple environmental conditions can make a difference:

- Near a door;
- Near windows;

- First fed each day;
- Sampling, cleaning experience.

When feeding newly ponded fry always wait 24 hrs before first feed. This will allow sufficient time for fry to swim up and fill their swim bladders, with out getting food mix in. If ponding fry in container with already ponded fry feeding should be halted for 24 hrs.

Record the actual amount fed, either directly onto the individual sheet for each container, or in the appropriate space on your Diary, and then transfer it when summarizing feeding for the period.
The rearing period is from one sample to the next length, weight sample. If you feed more or less than the amount calculated, don't just record the calculated amount.

The actual amount of food fed is important because, if fish start going off their feed, then you should look for the cause of it.

For example:

- Excess disturbance;
- Too much cleaning;
- Too much sampling;
- Predators;
- Bad food;
- Wrong size of pellets;
- Natural food coming in from other sources.

Water quality:

- Low dissolved oxygen;
- Supersaturated water;
- High ammonia;
- High silt;
- High or low temperatures.

If the fish in a container consistently eat more or less food than is calculated, then:

1) You could be wasting food, or

2) Your estimates offish size or numbers could be wrong. Remember: "Feed the fish, not the pond."

Be aware of your fish's appetite. Feed them more than the calculated amount if they are still hungry, or feed them less than the calculated amount if they no longer chase the food. If you are feeding the pond, then you are calculating a feed rate and dumping the food into the pond without watching to see if it is getting eaten.

Do not be afraid to vary the feed amounts to adjust to your fish's appetite and your rearing conditions.

6.j. Factors Affecting Growth

The purpose offish rearing facilities is to increase the size of fry in a controlled environment so that the fish, when released at the proper time, will be better able to survive the wild environment and return as adult fish. The strategy is based on specific time and size at release for various species. A good hatchery environment provides the conditions necessary for fish growth. A good hatchery manager manipulates this environment to achieve the time and size at release goals set for his particular stock.

Factors which have a minor effect on fish growth are usually not a limit to fish growth but when combined in a particular manner they can become limiting.

Environmental factors:

1) Light;
2) Water quality;
3) Disease history;
4) Predation;
5) Cannibalism;
6) Colour of pond.

It is a usual practice to create an environment where environmental factors do not limit the amount of growth that a fish achieves. Instead, major factors, which determine growth, are either manipulated to achieve the growth desired or the maximum growth potential is achieved.
Growth is measured by finding out how much weight a fish gains over a period of time and comparing the gain in weight to the original weight. Because it changes each day, as the fish gets larger, it is usually called growth rate.

Major factors which affect fish growth:

1) Temperature;
2) Fish length and weight;
3) Amount of food fed (feed rate);
4) Growth (previous experience is important);
5) Food conversion (efficiency of use of food);
6) Flow of water through container (carrying capacity);
7) Condition coefficient (relationship between length and weight of fish indicates fish fitness);
8) Number of fish in container (loading density).

In the course of rearing fish from fry to release these factors can be manipulated to achieve below maximum potential if growth is too fast or the hatchery manager can increase growth with a good understanding and an ability to optimize fish growth by controlling the major influencing factors.

Temperature

Fish are cold—blooded which means that they maintain their body at the temperature of the water they live in. It means they don't need a lot of insulation. If they tried to keep their bodies warm, the water would absorb the heat because it is such a good heat transmitting material; it would spread the heat around. So being cold—blooded is beneficial if you live in the water. Being cold—blooded, fish are greatly affected by changes in the temperature of their environment. Each species has its own growth pattern which responds to changes in temperature.

For each species there is one temperature at which it grows the fastest. This is its optimum temperature. At temperature above and below the optimum temperature, the fish grows slower.

At very high temperatures:

1) Digestion rate increases;

2) The efficiency of food being converted to body tissue decreases because a lot of energy is used for fast heart rate, high breathing rate;

3) Body processes break down -heart, respiration, liver, blood -at extremely high temperatures.

At low temperatures:

1) The passage of food through the fish is slow;
2) Not all the food is digested because the digestive chemicals or enzymes do not work as well.

Temperature can be used to manipulate the growth of the fish.

Unfortunately it is often too expensive to heat water, but if varying water temperature sources are available they can be used to control growth.

6.1. Conversion

When fish eat the food, most of the components of the food are used to grow body tissues. Some of the food energy is used for swimming, breathing, and heartbeat, and some is not useable and is excreted in feces. If proper and accurate records are kept, it is possible to determine how much of the food that is being fed is going into growth and how much is used up by breathing, swimming, heartbeat, feces, and wasted food.

Good records allow the fish culturist to determine how much food was used for growth and how much was wasted in swimming, breathing, fighting, and plain old overfeeding.

Good records mean:
1) Good samples -representative, random, offish weights when empty at beginning of period and end of period. If fish are fed it can increase their weight by 5—10%;

2) Good record of the amount of food actually fed -not the calculated feed rate.

Food conversions of 1.5 are average for very small fry at emergence because a lot of food is wasted as it sinks to the bottom. When fry are 1 gram in size the conversions should be close to 1.0 when using O.M.P

With the dry foods now in use conversions are as high as 0.65/0.70 to 1.00

High food conversion

1) Food may be wasted -too fast feeding, too much food being fed;

2) Number offish in pond is underestimated so total weight gain is underestimated;

3) Food quality is low;

4) Low level disease;

5) Some stress is present -high temperature, low temperature, too much cleaning, too much silt, low oxygen levels;

6) Pond is overloaded -either too many fish or not enough water;

7) Wrong food size;

8) Sample error;

9) Fish are having trouble converting food to body tissue.

Low food conversion

1) Amount of food fed is not as high as estimated check food weight measurements;

2) Number offish in container is overestimated; so calculated total weight gain is more than actual weight gain.

3) Sample error -a few extra large fish were sampled;

4) Cannibalism -fish are growing faster because they are eating other fish;

5) Extra food sources -flies, stream insects coming in with the water supply.

Good food conversion 1.0 to 2.5 for moist feed With dry feeds 0.65 to 1.0

Good food conversion means that the food being fed is being converted into body tissue. It does not mean that fish are growing well. If fish are fed less than the maximum, food conversions should be good because food should be the limiting factor. If conversions are not good when fish are fed less than the maximum then some other factor is controlling growth.

Good food conversion means that food is not being wasted. Even if fish are fed less than maximum it does not automatically mean that the food is getting into the fish. If the food is not spread out over the rearing area so that all fish get a chance to eat it, food can be wasted very easily.

6.m. Condition coefficient

The condition coefficient is a means of determining how well your fish are utilizing the food you feed them. It is a way of comparing fish weight and fish length. The formula is based on repeated observations of weight and length so that the number, which results from the calculation, should be the same number each time.

The value of condition coefficient (C.C.) varies from stock to stock and from season to season. Without background information it is not possible to tell if fish are doing well or not. Some

past experience must be used to judge what is a good C.C. and what is a bad one.

When a disease outbreak occurs, the C.C. does not necessarily change. For some diseases and parasites, the C.C. will change significantly, before symptoms of disease are visible. It is another way of keeping track of your fish health.

The average C.C. as we calculate it is only a general indicator. A more sophisticated method is to calculate individual C.C.

Increasing C.C.

1) Fish are getting fatter;

2) Possibly fish are getting more food than is necessary;

3) Fish may not be getting enough exercise. Decreasing C.C.

1) Fish are growing longer faster than they are gaining weight;

2) Fish are using body tissues for respiration and swimming;

3) Fish may need more food;

4) Fish may be smelting.

High C.C.

At release Coho should have a good body shape. If they have been fed too much in the last few weeks before being released, they will be sluggish and have large deposits of body fat. There is evidence that body fat decreases survival in steelhead smolts, possibly because they do not recover as well from the stress of release.

6. Unequal Growth

In any population offish, some are more aggressive than others, and they get to the food before the rest. There are also some that are pretty stupid and don't seem to go after the food. The result is that there are large ones and small ones along with a bunch in the middle -the average.

This does not cause problems for short—term rearing such as chum, Chinook, and pinks, but for Coho this can become quite a problem.

Avoiding unequal growth or size discrepancies

1) Crowd fry for first few days to initiate a good feeding response;

2) When feeding make sure that all the fish get a chance to eat some food; keep feeding until none are hungry;

3) Spread food out over the whole water surface;

4) Mix food sizes to match the fish sizes.

Correcting unequal growth

If fish size discrepancies develop quickly then it may be necessary to take corrective measures.

1) Reduce size of food so small fish grow more;

2) Reduce number of feedings but prolong each feeding so that all fish get as much as they can eat;

3) Reduce densities in rearing containers so there is less competition.

Safety concerns: When feedings by hand always wash afterwards
Feed is a food substance and botulism and salmonella can be contracted form it

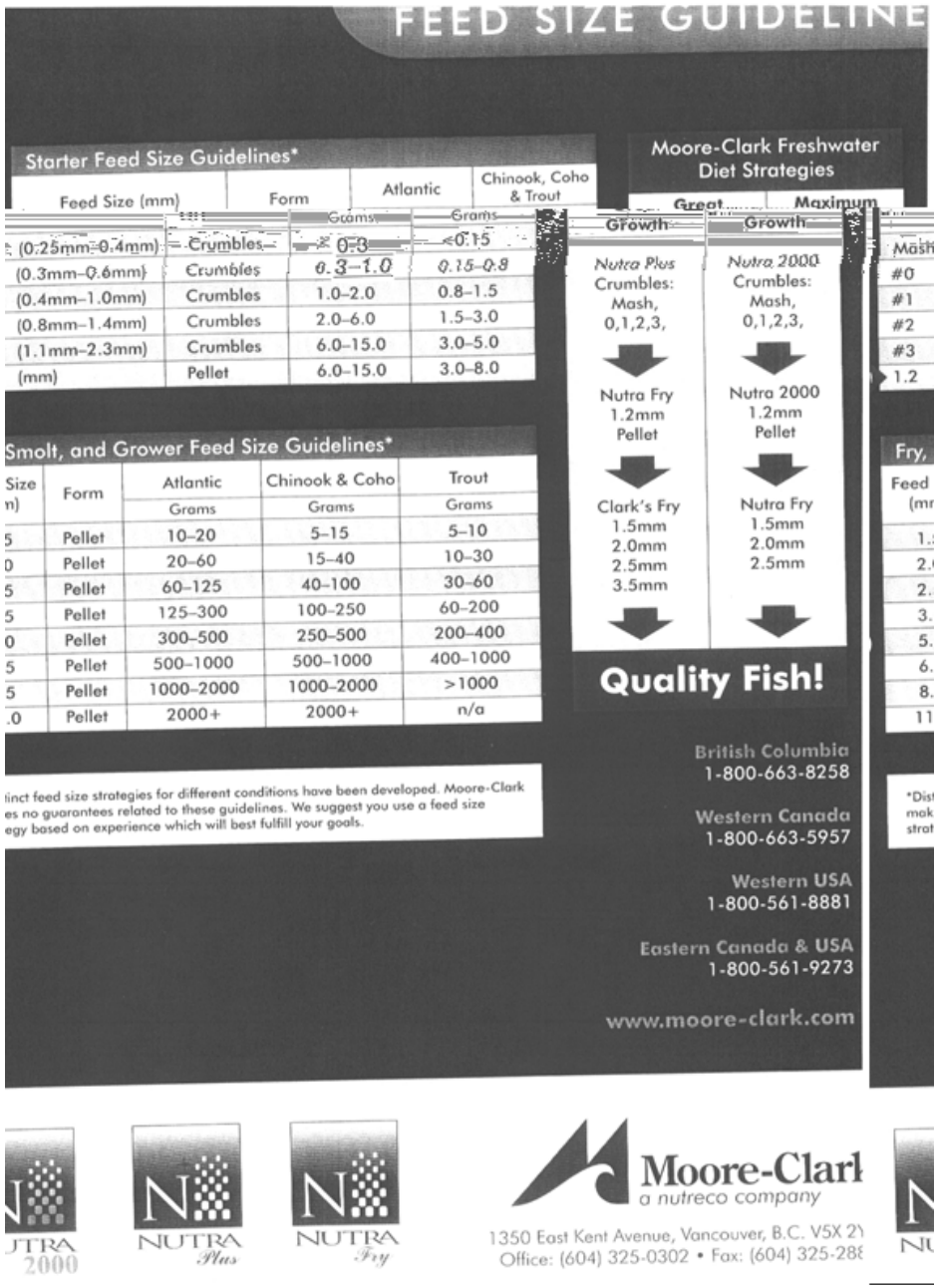
Moore-Clark
a nutreco company

FEED RATE GUIDELINES FOR PACIFIC SALMON*

FEEDING RATES = % FISH BIOMASS PER DAY

TEMPERATURE		FISH SIZE							
D		< 0.8	0.8 - 1.5	1.5 - 3.0	3.0 - 8.0	8.0 - 15	15 - 40	40 - 100	Grams
egrees F	Degrees C	> 570	570 - 300	300 - 150	150 - 55	55 - 30	30 - 11	11 - 5.0	Fish / lb
36	2	0.8	0.7	0.6	0.5	0.4	0.2	0.1	
37	3	1.1	1.1	1.1	0.8	0.7	0.4	0.3	
39	4	1.4	1.3	1.2	1.1	0.9	0.6	0.4	
41	5	1.7	1.7	1.6	1.4	1.1	0.8	0.6	
43	6	2.2	2.0	1.8	1.6	1.3	1.1	0.8	
45	7	2.5	2.4	2.1	1.9	1.5	1.2	0.9	
46	8	2.8	2.6	2.4	2.2	1.8	1.4	1.0	
48	9	3.0	2.8	2.6	2.4	2.0	1.6	1.2	
50	10	3.2	2.9	2.7	2.6	2.2	1.8	1.3	
52	11	3.4	3.1	2.9	2.8	2.4	1.9	1.4	
54	12	3.6	3.3	3.1	2.9	2.6	2.1	1.6	
55	13	3.9	3.6	3.4	3.2	2.8	2.3	1.7	
57	14	4.2	3.9	3.7	3.5	3.1	2.4	1.8	
59	15	4.5	4.3	4.0	3.7	3.3	2.6	2.0	
61	16	4.8	4.7	4.3	4.0	3.5	2.8	2.2	
63	17	5.1	5.1	4.8	4.5	3.7	3.0	2.3	
64	18	5.4	5.4	5.3	5.1	4.0	3.1	2.4	

*THIS CHAR
ACTUAL RE
JULY 2000.
RT IS INTENDED AS A GUIDE ONLY.
SULTS WILL VARY BETWEEN SITES AND SPECIES.


FEED SIZE GUIDELINE
Starter Feed Size Guidelines*
Feed Size (mm)
Form
Atlantic
Chinook, Coho & Trout
Grams
Grams
(0.25mm–0.4mm)
Crumbles
0–3
<0.15
(0.3mm–0.6mm)
Crumbles
0.3–1.0
0.15–0.8
(0.4mm–1.0mm)
Crumbles
1.0–2.0
0.8–1.5
(0.8mm–1.4mm)
Crumbles
2.0–6.0
1.5–3.0
(1.1mm–2.3mm)
Crumbles
6.0–15.0
3.0–5.0
(mm)
Pellet
6.0–15.0
3.0–8.0
Smolt, and Grower Feed Size Guidelines*
Size
n)
Form
Atlantic
Chinook & Coho
Trout
Grams
Grams
Grams
5
Pellet
10–20
5–15
5–10
0
Pellet
20–60
15–40
10–30
5
Pellet
60–125
40–100
30–60
5
Pellet
125–300
100–250
60–200
0
Pellet
300–500
250–500
200–400
5
Pellet
500–1000
500–1000
400–1000
5
Pellet
1000–2000
1000–2000
>1000
.0
Pellet
2000+
2000+
n/a
linct feed size strategies for different conditions have been developed. Moore-Clark
es no guarantees related to these guidelines. We suggest you use a feed size
egy based on experience which will best fulfill your goals.
Moore-Clark Freshwater Diet Strategies
Great Growth
Maximum Growth
Nutra Plus Crumbles: Mash, 0,1,2,3,
Nutra 2000 Crumbles: Mash, 0,1,2,3,
Nutra Fry 1.2mm Pellet
Nutra 2000 1.2mm Pellet
Clark's Fry 1.5mm 2.0mm 2.5mm 3.5mm
Nutra Fry 1.5mm 2.0mm 2.5mm
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Mash
#0
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#2
#3
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Office: (604) 325-0302 • Fax: (604) 325-288

EWOS Canada Ltd.

Recommended Feeding for Pacific Salmonids
EWOS Micro, Transfer, Smolt, Alpha and Pacific

Feeding rates (% biomass / day) for fish size ranges (in grams and fish per pound) as follows														
EWOS Feed			EWOS Micro			Micro, Smolt& Pacific	EWOS Transfer, Smolt, Alpha and Pacific							
Feed Size			#0	#1	#2	1.2 mm	1.5 mm short-cut	1.5 mm	2.0 mm			3.0mm			
Min. Fish Weight grams			0	0.2	1.5	3	5	12	25	40	50	80	110	150	200
Minimum fish per pound				*2270*	*302*	*151*	*91*	*38*	*18*	*11*	*9*	*6*	*4*	*3*	*2.5*
Max. Fish Weight grams			0.2	1.5	3	5	12	25	40	50	80	110	150	200	250
Maximum fish per pound			*2270*	*302*	*151*	*91*	*38*	*18*	*11*	*9*	*6*	*4*	*3*	*2.5*	*2*
WATER TEMPERATURE Celsius & Fahrenheit	1 - 2	34-36	1.07	1.03	0.99	0.95	0.79	0.72	0.67	0.64	0.61	0.44	0.25	0.18	0.14
	2 - 3	*36-37*	*1.30*	*1.19*	*1.12*	*1.08*	*1.02*	*0.93*	*0.82*	*0.78*	*0.74*	*0.56*	*0.37*	*0.24*	*0.22*
	3 - 4	37-39	1.70	1.36	1.26	1.25	1.23	1.12	1.00	0.96	0.94	0.72	0.49	0.35	0.29
	4 - 5	*39-41*	*1.85*	*1.49*	*1.38*	*1.34*	*1.32*	*1.26*	*1.14*	*1.11*	*1.09*	*0.89*	*0.62*	*0.43*	*0.36*
	5 - 6	41-43	2.00	1.62	1.51	1.45	1.40	1.35	1.23	1.20	1.19	0.98	0.71	0.52	0.43
	6 - 7	*43-45*	*2.11*	*1.72*	*1.56*	*1.49*	*1.44*	*1.39*	*1.28*	*1.28*	*1.23*	*1.06*	*0.80*	*0.62*	*0.54*
	7 - 8	45-46	2.22	1.86	1.64	1.56	1.51	1.44	1.36	1.33	1.28	1.14	0.95	0.77	0.65
	8 - 9	*46-48*	*2.41*	*2.11*	*1.80*	*1.64*	*1.60*	*1.48*	*1.44*	*1.38*	*1.36*	*1.22*	*1.05*	*0.84*	*0.72*
	9 - 10	48-50	2.61	2.40	1.94	1.73	1.67	1.56	1.50	1.44	1.41	1.28	1.14	0.88	0.78
	10 - 11	*50-52*	*2.78*	*2.59*	*2.06*	*1.84*	*1.76*	*1.63*	*1.56*	*1.48*	*1.46*	*1.33*	*1.24*	*0.94*	*0.86*
	11 - 12	52-54	2.93	2.78	2.23	1.95	1.85	1.71	1.61	1.54	1.51	1.44	1.30	1.03	0.93
	12 - 13	*54-55*	*3.13*	*2.97*	*2.40*	*2.16*	*2.01*	*1.80*	*1.67*	*1.58*	*1.53*	*1.50*	*1.36*	*1.12*	*1.02*
	13 - 14	55-57	3.29	3.16	2.58	2.38	2.18	1.83	1.72	1.64	1.58	1.53	1.42	1.14	1.03
	14 - 15	*57-59*	*3.45*	*3.35*	*2.84*	*2.59*	*2.43*	*1.95*	*1.78*	*1.73*	*1.69*	*1.56*	*1.48*	*1.15*	*1.05*
	15 - 16	59-61	3.56	3.49	2.96	2.72	2.44	1.95	1.78	1.71	1.64	1.53	1.48	1.11	0.99
	16 - 17	*61-63*	*3.07*	*3.03*	*2.49*	*2.30*	*2.10*	*1.77*	*1.62*	*1.55*	*1.49*	*1.43*	*1.29*	*0.93*	*0.83*

The above figures are meant as a recommendation only, actual feeding rates will vary by site and species.

Version 11.0 DFO, ON Priv

EWOS Canada Ltd

7721-132nd Street

#212- 1720-14th Avenue

EWOS - 2000 BROOD FOOD REQUIREMENT/ORDERING

Summer Chinook

Fish Size	#	gain/fish	biomass gain	conv.	food req.-Kg.	food size	$/Kg	cost $
.45 - 1.5	420K	1.0	420.0	0.7	294	# 1	2.95	867.3
1.5 - 2.5	410K	1.0	410.0	0.7	287	# 2	2.95	846.65
2.5 - 5.0	400K	2.5	1000	0.7	700	1.2 mm	2.45	1715
5.0 - 7.0	400K	2.0	800.0	0.7	560	1.5 short	2.20	1232
			2630.0	1.12	1841.0			4660.95

Rearing Container

Each container has its own characteristics:

— Width, depth, length;

— Volume;
— Water mixing patterns, water replacement time;
— Water velocity; and,
— Sediment transport.

The suitability for rearing fish depends on

1) Shape
round, square, long and narrow that determines volume when depth is considered (m3 or litres, 1,000 L = lm3).

2) Flow of water
The inflow and outflow patterns can be modified by how much water is passed through the pond and how it is delivered and taken away:

Point discharge of inflow;
Discharge at depth. Flow is measured in litres per minute (1pm)

3) Fish size (weight) and number offish you want to rear can determine the suitability of a container for fish culture. The combination offish number and size determines the total body weight offish in kilograms (kg).

The combinations of 1, 2, and 3, are referred to as:

Carrying capacity = weight/flow = kg/lpm
Loading density = weight/volume = kg/rn3

Determining carrying capacity and loading density.

Information needed for each rearing container:
Total fish weight (kg);
Total food fed;
Dissolved oxygen at inflow;
Flow (1pm) Rearing volume.

Capilano trough

The Capilano trough was originally designed for rearing Coho and steelhead fry at Capilano hatchery because they only had large concrete burrows ponds for rearing. Their space was limited to walkways above the burrows ponds and they only needed rearing space for a few months until there was room in the burrows ponds. They were not intended for long term rearing to large size.

Advantages of Capilano troughs

1) Water flows in one direction in one end and out the other —making it a raceway flow pattern;
2) Good for small fish that need high water quality;
3) Easy for feeding — all parts of the trough can be reached;
4) Since water comes in one end and out the other, there is a gradient of water quality from good to bad. When fish get stressed they seek out the better quality water.

Disadvantages of Capilano troughs

1) Water flow configuration moves excess food to downstream end but does not clean it out — cleaning requires time to siphon or sweep food and feces down to one end and flush it out;
2) Surface area is too small for rearing fish past 5 grams;
3 Larger fish can jump out easily;
4) Aluminum troughs reflect sunlight and cause fish to be very frantic;
5) Fish get scared by their own reflection.

Notes on use of Capilano troughs

1) Crowd fry in top half of trough for a two-week period at ponding to initiate feeding. Allow fry access to the whole trough after they are actively feeding;
2) Use covers when troughs are outdoors to reduce glare;
3) Siphoning feces and excess food is less stressful than lowering water levels when cleaning — water levels can be lowered if fish are not chased around with a brush;
4) When small fish are ponded, lower flows can be used but when fish are two grams the full 240 1pm should be used and the full depth of trough used.

Calculation of numbers and flow using loading density and carrying capacity

A Initial ponding — up to 2 grams — low flow — reduced water depth. The method is the same for any shape container:
1) Determine volume of rearing container;
2) Volume x loading density == total weight of fish;

3) Total weight offish / carrying capacity = flow needed.

Example

1) Determine volume = L * W * D 640cm x 640cm x 30cm Volume = 1,555,200cm 3(l, 000,000cm3 1m) 1.555m3
2) Volume x loading density == 1.555m3 x 32.35 kg/m3 = 50.3 kg offish. If this volume is to be used up to 2 gram size the maximum number of fish at 2 grams is: 50.3kg = 50,300 grams / 2 = 25,150 fish.
3) Total weight of fish carrying capacity = flow needed. 50.3kg / .5kg/lpm =100 1pm minimum.

B To keep fish larger then 2 grams the water depth must be in creased to 45cm.

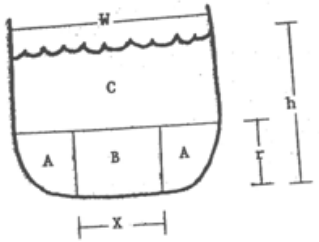
Example

1) Volume = 640*82cm x 45cm = 2,332,800cm3 = 2.3m
2) Volume x loading density == total weight of fish;
for Chinook 2.3m3 x 32.35 kg/m3 = 75.5 kg offish using lower loading density.
75.5kg of fish at 2gm 37,733 fish at5gm==15,100fish.
For other species using higher loading density; 2.3in3 x 47.8 kg/m3 = 110 kg
110 kg offish at 2 gin 55,000 110 kg of fish at 5 gin 22,000
3) Total fish weight ± carrying capacity flow needed. 75.5kg /. 5 kg/lpm = 150 1pm 110 kg / .5 kg/lpm = 220 1pm

Volume of Capilano Troughs

If the troughs are to be loaded to maximum then it is necessary to calculate volumes accurately. This requires taking into account the curve to the bottom of the treugh.

Note: Behavioral interactions result in the maximum loading of Capilano troughs to be 23,000 fish.



$$\text{Volume} = \text{length} \times \left(\underbrace{\frac{\pi r^2}{2}}_{A} + \underbrace{Xr}_{B} + \underbrace{(h-r)W}_{C} \right)$$

Exchange rate in Capilano troughs

$$\text{Exchange rate} = \frac{\text{flow (1pm) x 60 mm/hour}}{\text{volume of trough}} = \text{changes per hour}$$

$$= \frac{120 \text{ 1pm x 60 mm}}{1{,}555 \text{ L}} = 4.6 \text{ changes per hour}$$

$$= \frac{220 \text{ 1pm x 60 mm}}{2{,}300 \text{ L}} = 5.8 \text{ changes per hour}$$

Circular tubs

Circular tubs are very versatile because of the possibilities for water inlet and outlet hook-ups. The flow characteristics are much different than raceway troughs. Instead of the fresh water coming in at one end and flowing out at the other, the fresh water mixes with the water in the pond. This results in slightly poorer flow characteristics because it is not possible for fish to move to areas of better water quality. In a raceway trough the fish move upstream to the water inlet and it is possible to see when water quality is getting low.

Circular pools are very efficient at cleaning out feces and excess food because of the vortex of water travelling out the outlet. Excess food and feces gradually move to the centre of the pond and if a horizontal screen is used, the water is carried out of the pool without any sweeping or siphoning.
Because the incoming water mixes with the water in the pool the weight of fish per volume of water (loading density) is lower than for Capilano rearing troughs.

Advantages of Circular Pools

1) Easier to keep clean than raceway troughs;
2) Circular swimming is more natural for species such as Coho because they do not bunch up like in raceway troughs;
3) Good for rearing small numbers of Coho to smolt size.

Disadvantages of circular pools

1) Difficult to get in and out when sampling and brushing sides clean;
2) Water quality is averaged between incoming and outgoing water quality because of mixing.

Notes on the operation of circular pools

1) Because it is more difficult to get fish out of circular pools it is best to load pools with the final number offish to be reared without having to divide the population. This is true for all rearing containers but it is more crucial with circular pools.
2) Water depths can be low to start but should be quickly increased to accommodate larger fish. At ponding, the depth can be increased and the flows decreased to result in quiet water;
3) As loading density approaches maximum it may be beneficial to lower the water depths so that water does not stay in the pool for as long a time. Lowering the depths increases the flushing effect. This would only be done for emergency situations where water quality is poor;
4) The quantity of water that flows through circular pools usually controls the number of fish that can be reared in them. Screen area should be kept large so it takes Longer to plug up. Drain size should be large. When ordering circular pools, ask for a sump in the middle at least 30 cm square and with at least a four inch pipe for a drain;
5) When the outflow of pools becomes restricted by leaves or dead fish the pool will begin to overflow. A separate overflow should be installed near the top of the pool to allow fish to escape to the stream rather than be stranded on the ground;
6) Pools should be shaded when in the open to reduce light intensity but should not be kept in the dark. See Loading Criteria Handout for numbers of fish in circular pond.

Burrows Ponds

The Burrows ponds that are used at many hatcheries had an interesting origin. The inventor of the Burrows pond was trying to improve the flow characteristics of some rearing ponds that were too big. The water flow pattern was not sufficient to result in self—cleaning. The ponds were so big that the feces and waste food settled to the bottom. The Burrows pond solved that problem by making them circulating flow with vanes to keep the velocity high enough on the outside edges to move food to the inside where it is flushed out with out—going water.
Another reason for the design of Burrows ponds is to try to create a velocity for fish to swim against. Exercised fish are healthier than fish that don't have to swim.

Raceways

Another solution to the problem of maintaining the quality of water flowing in a rearing pond is to have large volumes of water in a flow— through configuration. There still must be proper outlet structures to cause the wastes to be carried out instead of settling. Relative dimensions are usually 30:3:1 and inlet and outlet should cover the full width of the pond.

Advantages of gravel or concrete raceways

1) Generally better water quality can be maintained because exchange rates are high;
2) Large numbers of fish can be reared in one rearing container;
3) Less labour is required for cleaning one container if it is set up properly;
4) Larger fish can be accommodated by large raceways.

Disadvantages of gravel or concrete raceways

1) Wastes settle into gravel spaces and cannot be removed;
2) It is difficult to sample large ponds properly;
3) Grading large ponds is difficult;
4) Removal offish from gravel ponds usually results in some staying behind.

Notes on operation of raceways

1) Crowding of emerging fry is essential to get good feeding responses;
2) Water inlet and outlet configuration should move solids out of raceway.
If solids settle to bottom, depths can be reduced or flows increased to keep solids moving out of raceway;
3) Velocities can be lower for small fish but should be increased so fish must swim.
Velocities of 30 cm/sec at 200 are optimum for Coho rearing. Exercised Coho are more resistant to fatigue.

Loading density and carrying capacity of raceway channels

One of the problems with giving loading rates for raceways is that the shape and the water flow characteristics of the channel play a fairly major part in the number offish that can be reared. The values that are given are ones that have proven to be safe for those channels that are being used at many different hatchery sites. For a new rearing channel, the flow characteristics must be studied care fully to determine if their rates apply.
There is a program, which can be used to determine the loading density (volume loading) and carrying capacity (flow loading) of a particular raceway channel, but some parameters are required in order to calculate these values. Data for the critical loading period is needed. Heaviest loading occurs in the late Spring just prior to smolt release when the largest and most fish are held or in the early Fall when high water temperatures and high feed rates cause high metabolic rate.

Design Biologists with major facilities or your Technical Advisor can work out the loadings if you provide this data for the critical period:

1) High average temperature;
2) Feeding rate (as percent of Stauffers feed rate);
3) Fish size.

If sufficient data is available the procedure can be completed for year round by supplying a complete temperature regime and a fish size chart.

Netpen rearing

Rearing salmon in net pens poses a different set of problems because the water flow cannot be controlled and the use of different parts of the pen can result in fish being more concentrated than in controlled—flow rearing containers. Experience at a particular site is the best guideline. No one can predict how their experience will hold for a new water body.

Advantages of net pens

1) No water system is needed — no pipes to break — no intakes to get plugged;
2) Large areas can be used for rearing fairly cheaply — all that is needed is a net and a float;
3) Large size fish can be reared without the need for large water flows and rearing containers.

Disadvantages of net pens

1) No control of water flow — cannot increase flows under poor conditions;
2) Sometimes water temperatures become a problem when temperatures are over 16 ^{O}C diseases can occur very easily;
3) Nets can foul and reduce water flow;
4) Predators are attracted by unclean pens;
5) A different kind of environmental influence can cause problems wind, waves, and currents.

Notes on operation of net pens

1) Pens can be as deep as you want but fish use at feeding is a limiting factor — consider that fish do not use more than the top 1-meter during feeding;

2) In lakes, nets should be deep enough to allow fish to use cool water in the hottest part of the summer (maybe 6 meters deep);
3 When stocking nets with Coho smolts the densities should not exceed 500 smolts/m and the densities will have to be reduced as fish biomass increases;
4) Never load net pens with more than 16 kg/m (1 Ib/ft) considering the top 1 meter at feeding time, unless very large fish are reared (over 100 grams) and then they may use the full depth of the pen;
5 Keep net mesh size as large as possible so that water circulation is at a maximum.

Fish size	Mesh size, stretched mesh
0.5 to 1 g	1/8" or marquisette
lg to3g	1/4"
3gtol0g	1/2"
10 g to 35 g	3/4"
35gtol50g	1"

6) Change nets to keep water circulation at a maximum. Net changes may have to be done just prior to maximum temperatures to avoid handling fish during the hottest part of the year;
7) Use herring seine stretched on frames to stop bird predation;
8) Floatation — many types available, it depends on your materials and resources logs, topper floats, plastic food barrels, styrofoam blocks;
9) Coho should not be ponded into saltwater net pens until day length and temperature are increasing in February and fish size is 10 grams.

Oxygen Requirements

Much of the reason for coming up with guidelines for the numbers of fish per volume (carrying capacity) and the amount of wafer flow for *those, fish* (toading *density] is* because of the requirements offish for oxygen. Oxygen is the component of air that the fish needs to survive, to digest food. To be able to swim and all other body processes.

Oxygen + Food == Energy + Wastes — Excess food
-C02
-Ammonia
-Feces

The water coming into the rearing container delivers oxygen and carries away the wastes.

Fish obtain oxygen from the water. Air dissolves in water and so there is oxygen and nitrogen and small amounts of Carbon dioxide in the water. The fish obtains oxygen from the water by diffusion of oxygen into the blood across the gills. The process of diffusion of oxygen into the blood depends on the amount of oxygen in the water.

Diffusion depends on the partial pressure of oxygen in the water being higher than the partial pressure in the blood. There must be a gradient of oxygen partial pressure from the water

to the blood.

Notes about oxygen solubility

1) Cold water contains lots of oxygen;
2) Warm water contains small amounts of oxygen;
3) Oxygen in water is measured in mg/litre which is the same proportion as parts per million.

Nitrogen

The other major component of air is nitrogen. It does not have an affect on fish at normal stream conditions. Nitrogen does not stay dissolved in water very well. When air and water is put in a pipe and then under pressure, the air dissolves in the water. When the water is released from the pipe and returns to normal pressure, the air that is dissolved in the water wants to come out — this is known as super—saturated water.
The super—saturated water begins to loose the nitrogen faster than oxygen because the nitrogen does not stay dissolved in the water as easily as oxygen. When the nitrogen comes out of solution it forms bubbles.

When fish breathe in super—saturated water, they also breathe in the nitrogen. It starts to come out of solution inside the fish, causing bubbles in the blood. This is called gas—bubble disease.
The supersaturated water begins to loose the nitrogen faster than oxygen because the nitrogen does not stay dissolved in the water as easily as oxygen. When the nitrogen comes out of solution it forms bubbles.
When fish breathe in supersaturated water, they also breathe in the nitrogen. It starts to come out of solution inside the fish, causing bubbles in the blood. This is called gas—bubble disease.

Carbon Dioxide

The smallest component of air is carbon dioxide. Carbon dioxide is highly soluble in water so it seldom has an effect on fish. Because there is so little of it in the water compared to the amount that is in the fish, it is always leaving the fish and going into the water. It usually is carried away by the flow.

Carbon dioxide can become a problem during transport when the water is not changed. Carbon dioxide reduces the ability of the blood to carry oxygen so the fish can't get enough oxygen even if oxygen concentrations are high.

When oxygen availability is reduced

1) Breathing rate increases flow across the gills;
2) Heart rate increases — to maintain oxygen uptake.

Fish can resist or tolerate reduced levels of oxygen for short periods. The increased breathing rate and increased heart rate uses up energy and so the reserves for the following are reduced:

1) Swimming;
2) Feeding;
3) Avoiding predators;

4) Growth.

This results in a need for more food. More food means that the food conversion gets bad (that is, more food needed to maintain growth). So if food conversion is increasing maybe it is a need for oxygen.

Oxygen use

Sockeye fingerlings — oxygen requirements at 200C. (Ref. #40):

Feeding — maximum ration	450	mg/kg/hr	Feeding — maintenance ration	300	mg/kg/hr	Migrating up vigorous river	625 mg/kg/hr
Aggression	180	mg/kg/hr					

The minimum oxygen level that affects fish respiration and growth is measured in the oxygen content of water in mg/l. This value is used instead of the percent saturation because at higher temperatures the percent saturation must be higher because of the reduced ability of water to carry oxygen.

The amount of distress suffered by a group offish varies considerably between individuals. To determine safe levels the effects of reduced oxygen have been defined in terms of Protection Levels (A, B, C). The oxygen content in mg/l required by a protection level is not affected by temperature.

Level A — One standard deviation above the mean.
— A few members of a group of fish will show effects of low oxygen at or above this level.
— This is considered ideal conditions.

Level B — The 'average member of a group offish starts to show symptoms of oxygen stress.
— Some risk exists at this level if oxygen minimum period is prolonged beyond a few hours.

Level C — A large portion of the fish community maybe affected.
— Deleterious effect may be severe if prolonged for more than a few hours.
— This level should only be used as a minimum if fish are marginal or dispensable.

Oxygen and loading

Most of the control of rearing container carrying capacity and loading density is related to oxygen content. In larger size fish it may be affected by behaviour and it also is affected by ammonia from feces. These other parameters are difficult to measure and so oxygen content has been used to monitor water quality.

It is possible to load rearing containers to higher levels but oxygen’s must still be maintained. Oxygen levels above 4.3mg/l at 15 OC are required for growth to continue even at high flushing rates. When oxygen’s are reduced to 2.5 mg/1 there is zero growth.
Dissolved oxygen should not be less than 6.5 mg/1 nor less than 5.5 mg/1 at any one time over 24 hours (similar to protection level B 6.0 mg/l).

Measuring dissolved oxygen

Demonstrate use of Mach and Winkler oxygen determination kits —mention taking samples at maximum temperature, just after feeding- replicated samples.

The amount of oxygen needed per day is proportional to the amount of food that fish eat. For each kilogram of food eaten, fish need one-quarter kilogram of oxygen.

Food + Oxygen — Carbon dioxide + energy + waste.

Energy is used for:

Swimming;
Breathing;
Heartbeat;
Liver function;
Kidney function;
Digestion;
Growth;
Reproduction.

Materials needed: Feed rate chart, oxygen solubility table, water requirement data sheet, data on fish size, numbers, etc.

Example: Fish size 10g, 10,000 fish, temperature 100C, water 100% saturated at inflow.

1) Find total fish weight; 10g x 10,000 fish 100,000g

2) Find total food per day; total fish weight x feed rate 100,000g, c 2.83% = 2,830g of food.

3) Find dissolved oxygen inlet requirements in milligrams per day.

4) Find average weekly dissolved oxygen at inlet at 10c— 11.33 mg/1.

5) Subtract minimum dissolved oxygen allowed in outlet water = 6 mg/l. 11.33 mg/l — 6 mg/l 5.33 mg/1 available oxygen.

6) Determine daily flow required, inlet dissolved oxygen requirements 4- oxygen available, 707,500mg 4- 5.33 mg/l = 132,739 litres/day.

7) Required flow = daily flow /1,440
132,739 litres/day /1,440 minutes/day = 92.21/mm.

NOTE: These are minimum flows required. If loading densities call for more flow, more flow is needed.

Minimum oxygen concentration occurs when activity is at its highest, water temperatures are highest and food accumulation and feces are at a maximum.

If not enough water is available for a short period of time; reduce feed rates to maintain water quality and to partially alleviate low oxygen problems. This is particularly important at temperatures above 16 ^{0}C.

Activity and oxygen consumption

Standard metabolic rate — Breathing, sound asleep.
Maintenance rate — Swimming in calm water, not feeding, not growing.
Active rate — Extreme emergency situations, burst speed.

One stressful situation such as pond cleaning or sampling can cause the fish to go into maximum oxygen consumption rate. Avoid cleaning and sampling at high temperatures.
Water flow is important in fish culture because water brings oxygen and takes away feces, ammonia, excess food, and carbon dioxide. The measurement of flow to rearing containers should be a routine thing. The proper flows should be worked out for the numbers offish that are being reared and these values should be written into the hatchery manual. Every employee should know how to calibrate the flows and should know how to fix a no—flow situation; otherwise it is a risk to the fish.

All flows should be measured in litres per minute (1pm).

1 litre =1,000 millilitres
1 millilitre 1 cubic centimetre (Ice, 1cm x 1cm x 1cm)
1 m = 100cm x 100cm x 100cm =1,000,000 cc
1,000,000 cc= 1,000,000ml
1,000,000 ml- 1,000 L
1m-1, 000 L

The flow rate (litres per minute) determines the amount of oxygen there is available in a period of time.

Carrying capacity

The total weight offish that can live in a container is related to the water flow (kg/lpm). Carrying capacity = weight per flow (kg/lpm)

Handout and exercise on calculating carrying capacity.

Most important:
— Oxygen consumption;
— Oxygen level of incoming and discharge water;
—Size of fish;
— Temperature. Important:
— Activity level of fish;
— Sex, and sexual development;
— Season;
— Feces and waste products (ammonia);
— Species;
— Type of food, method and timing of feeding;
Activity level varies with:
— Fish size;
— Water temperature;
— Oxygen concentration;
— Pond flow characteristics — velocity, depth, volume;
— Hatchery procedures;
— Physiological state offish — happy, stressed, hungry, well fed, etc. Carrying capacity is limited by:
— Oxygen consumption;
— Accumulation of metabolic wastes;
— Amount of oxygen consumed and the quality of metabolic products are proportional to the amount of food fed.

So this is why calculating flows from food fed and oxygen supply and demand is useful in fish culture.

Variable carrying capacity

As temperature increases, the amount of oxygen it carries decreases. This means that there is less oxygen available for fish.

As temperature increases the weight offish held for each litre of water coming in must decrease. Therefore as temperature increases the carrying capacity decreases.

Loading density

Fish need space for food and space for shelter. In a hatchery environment, food is supplied but individual space is needed especially in aggressive species such as Coho, cutthroat, Steelhead and Chinooks.

Loading density is the value used to measure how much space is available and is measured in kilograms offish in each cubic meter of rearing space.
Oxygen and temperature must be within acceptable limits so therefore the amount of flow and carrying capacity must be below the maximum limits.
When these other factors are below their limits then the fish per volume can be considered.
Loading density (kg/m) is lower for small fish and the value increases for large fish. Because the total weight of large fish is much greater. The actual volumes needed to rear larger fish are much larger.
Never pond small fish at maximum loading density. Always calculate the loading density for the largest size offish to be reared at the end of the rearing period. Then stock rearing container with the maximum capacity at the size of the end of the rearing period.

If you have problems determining carrying capacity and loading density:

1) Ask your Technical Advisor

2) Ask your Technical Advisor to get help from the hatchery staff

Usually there is a critical period that you are most worried about. Provide the data:

1) High average temperature;
2) Feeding rate (as a percentage of Stauffers feed rate);
3) Fish size.

They will give you loadings that are determined by oxygen requirements and are calculated in the Apple computer. You will have to work out the volume and flow you need.

Exchange rates and Velocity

These are characteristics of the rearing container size and shape and the water flow and depth. Sometimes the water depths must be manipulated to result in sufficient changeover in the rearing water to keep oxygen high and to remove wastes.

There was a period in fish rearing design that the changeover was not considered important. The rearing containers were built very large and deep to get as much volume as possible. This resulted in large volumes, which also required large flows to keep conditions within required limits.

The current ideas are that for different size fish there is an optimum depth of rearing pool. If the water is not deep enough the fish feel exposed. If it is deeper than the optimum it is wasting money because higher flows are needed to keep the larger volume of water clean.

The exchange rate is the relationship between the volume of water in the pond and the volume of water flowing into the pond per unit time. The number of changes in an hour depends on the flow into the pond.

$$\text{Exchange rate} = \frac{\text{water flow (1pm) x 60 mm. } \pm \text{ l, 000 } {}_{3}(\text{l/m})}{\text{rearing container volume (m)}}$$

or

$$\text{Exchange rate} = \frac{\text{Loading density (kg/m) x .06}}{\text{Carrying Capacity (kg/lpm)}}$$

The second calculation is not as direct but results in the same number of changes per hour.

Standard
Exchange rate should be at least two changes per hour for salmonid rearing. Adult holding exchange rate must be greater — up to four changes per hour.

Velocity

The actual velocity of water flowing in a rearing container is hard to measure because the friction of the sides of the rearing pond slow the water down along the sides and bottom. The apparent velocity is usually what is used.

For rectangular rearing container:

Apparent velocity (cm/see) = Length *(m)* x 100cm/m x exchange rate (changes/h) 3,600 seconds/hr

For circular pools, the velocity depends on the angle that the water flows in. The velocity must be determined by what is comfortable for the fish and what removes the waste materials. Fish can find the velocity they want because it varies from the outside of the pool to the inside.

Velocity required to move solids

It has been found that the minimum velocity that allows solids to settle is 3.3cm per second. Only if the rearing pool is large enough and deep enough to accumulate all of the waste for the rearing period should the solids be allowed to settle in the pond. The method of release is also important because if these wastes are stirred up, they will use up all the oxygen. Only if release is by voluntary movement should wastes be allowed to build up.

It is better from a disease—Control standpoint that all wastes and feces are carried out with the out flowing water or be removed periodically.

Lower Site Raceways							
One Stoplog				Two Stoplogs			
Depth on Crest				Depth on Crest			
Inches	Cm.	CFS	LPM	Inches	Cm.	CFS	LPM
0.5	1.3	0.22	371	0.5	1.3	0.44	743
0.75	1.9	0.37	619	0.75	1.9	0.74	1238
1	2.5	0.59	990	1	2.5	1.19	1980
1.25	3.2	0.82	1362	1.25	3.2	1.63	2723
1.5	3.8	1.11	1857	1.5	3.8	2.22	3713
1.75	4.4	1.41	2352	1.75	4.4	2.82	4703
2	5.1	1.71	2847	2	5.1	3.41	5694
2.25	5.7	2.00	3342	2.25	5.7	4.00	6684
2.5	6.4	2.37	3961	2.5	6.4	4.75	7921
2.75	7.0	2.67	4456	2.75	7.0	5.34	8912
3	7.6	3.11	5198	3	7.6	6.23	10397
3.25	8.3	3.49	5817	3.25	8.3	6.97	11635
3.5	8.9	3.93	6560	3.5	8.9	7.86	13120
3.75	9.5	4.30	7179	3.75	9.5	8.60	14358
4	10.2	4.75	7921	4	10.2	9.49	15843
4.25	10.8	5.19	8664	4.25	10.8	10.38	17328
4.5	11.4	5.71	9531	4.5	11.4	11.42	19061
4.75	12.1	6.16	10273	4.75	12.1	12.31	20546
5	12.7	6.67	11140	5	12.7	13.35	22279
5.25	13.3	7.19	12006	5.25	13.3	14.39	24012
5.5	14.0	7.64	12749	5.5	14.0	15.28	25497
5.75	14.6	8.16	13615	5.75	14.6	16.32	27230

CFS	LPM	CFS	LPM
0.25	417	5	8345
0.5	835	5.25	8762
0.75	1252	5.5	9180
1	1669	5.75	9597
1.25	2086	6	10014
1.5	2504	6.25	10431
1.75	2921	6.5	10849
2	3338	6.75	11266
2.25	3755	7	11683
2.5	4173	7.25	12100
2.75	4590	7.5	12518
3	5007	7.75	12935
3.25	5424	8	13352
3.5	5842	8.25	13769
3.75	6259	8.5	14187
4	6676	8.75	14604
4.25	7093	9	15021
4.5	7511	9.25	15438
4.75	7928	9.5	15856
5	8345	9.75	16273
5.25	8762	10	16690

Puntledge hatchery lower site Feb 14/02

Container	Lt	Width	Depth	M3	#fish	Wt	Biomass	Den Kg/m3
RW2c	9.1	4.56	1	41.5	643501	0.6	386.1	9.30
Rw2f	9.1	4.56	1.07	44.4	1101098	0.48	528.5	11.90
Rw1f	9.1	4.56	1.06	44.0	932189	0.5	466.1	10.60

Container	cm	Lpm	# fih	Wt	# fih	Wt	Biomass	Loading Kgs/Lpm
RW1	6.5	3960	932189	0.5			466.095	0.12
RW2	6	3342	643501	0.6	1101098	0.48	914.628	0.27

Puntledge hatchery lower site Feb 14/02 Fill-in Boxes

Container	Lt	Width	Depth	M3	#fish	Wt	Biomass	Den Kg/m3
RW2c	9.1	4.56	1		643501	0.6		
Rw2f	9.1	4.56	1.07		1101098	0.48		
Rw1f	9.1	4.56	1.06		932189	0.5		

Container	cm	Lpm	# fih	Wt	# fih	Wt	Biomass	Loading Kgs/Lpm
RW1	6.5	3960	932189	0.5				
RW2	6	3342	643501	0.6	1101098	0.48		

Seapen rearing workshop topics

1) Research needs for seapen rearing.

2) Saltwater challenge.

3) Fish handling.

4) Rearing in netpens.

5) Safety.

6) Plankton sampling.

Seapen rearing workshop notes

Research needs for seapen rearing:

Costs: transport, feed, equipment, manpower.

Natural migration timing for the different salmon species: Pink, Chum, Chinook, and Coho. (this will help in judging when to transport smelts to pen site and when to release)

Smolt readiness:
A visual check for scales, fading of par marks,
Again checking with natural migration.
Expose a small number of shoots at first to sea pen environment in cage so that survival can be easily checked.)
Conduct actual experiment by introducing small amounts offish to different concentrations of salt (See salt water challenge next page.)

Vaccination:
Yes / No (depending on species and conditions)
Ie. Puntledge vaccinates Chinook smolts against vibrio.
Size at vaccination, and water temp.
Method ie. Immersion (low dilutions of killed bacteria culture for short periods of time) bath (high dilutions for longer periods) spray, injection, and oral.

Water quality;
Salinity, Oxygen Water temp. receiving & holding.

Density:
Size of pen (cubic meters)
Number of smolts and desired size at release, (make sure you leave room for growth.)
It is best to use only the top meter of the pen for density calculations.

Advantages to seapen rearing:
Longer rearing period (larger fish at release)
Allows fish to adjust to new conditions while in the relative security of pens.
Better survival (due to bigger fish)
Avoid predators during downstream migration.

Salt water challenge testing

Salt water challenges can be used as a gauge of the fish's progress towards smoltification as well as provide information that can be used from year to year as a yardstick to determined the optimal transfer time for the smolts to seawater.

The test must be reliable and relatively straightforward in order to use as a baseline.

1) The seawater challenge test developed at the Pacific Biological Station uses the measurement of blood sodium levels as an indicator of smoltification.

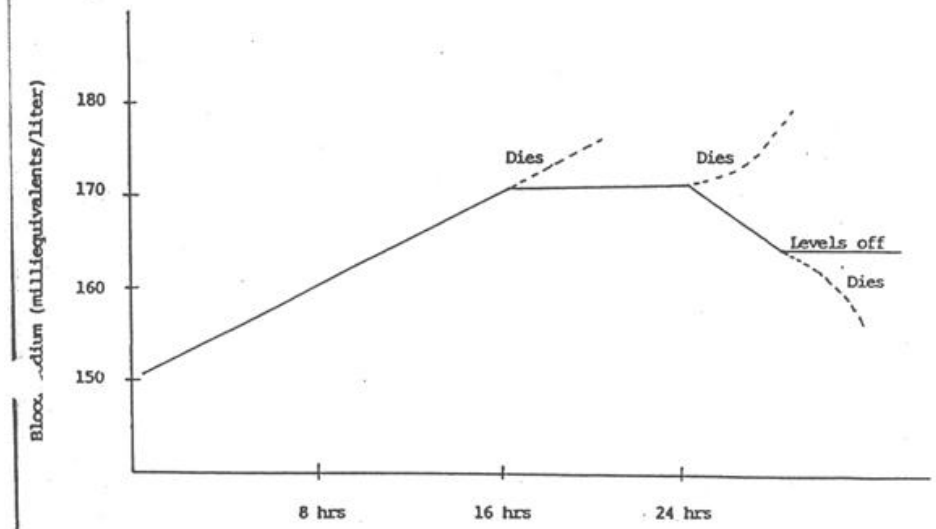
2) Weight loss of the fish after 24 hours in salt water is another measurable parameter that again correlates well with blood sodium levels.
3) Another method is to hyper challenge fish to a range of salinity all the way up to 35 to 40 parts per thousand and measure resulting mortalities.

Figure 1 illustrates generally how fish's blood sodium level will change over the course of the 24-hour period and beyond. It shows that the blood sodium level will typically be 150 milli-equivalents in fresh water. Upon entry into salt water, the blood sodium level will rise during the first hours. It will then either stabilize a 170 milli-equivalents or continue to increase whereupon the fish will die. After about 2 - 3 days the blood sodium level will decrease to about 165 milli-equivalents.

Thus, if the blood sodium level of the fish is 165 - 170 milli-equivalents after 24 hours, it is a very likely indication that it will be able to adequately osmoregulate in seawater and survives the stress of this event.

FIGURE 1

GENERALIZED BLOOD SODIUM LEVEL VS. TIME FOR SALMON SMOLTS



Fish handling

All methods and techniques should be performed in a manner that attempts to minimise fish handling, damage and stress.

Make sure all transport and transfer equipment is in good working condition before starting any fish handling.

Loading the transport units:
Do it fast and with care.
Starvation period's prier to transport should be as long as possible without causing damage to the fish. (Two days is a good target)

Transport and monitoring:
During loading and transport keep monitoring water and fish condition.
Visual checks can be performed during loading and throughout the transport trip.
Hyperactivity, sluggishness, discoloration, unusual distribution, gasping at surface, are indicators of less than optimal condition. There should be a fairly immediate dive response upon the opening of a viewing door.
Oxygen levels should be monitored at all times.

Rearing

Try to load pens to the final load rate, so thinning will not be required at a later date.

Feeding:
Begin feeding day after transfer. The fish may double their weight every two weeks. Fish feeding should be fairly aggressive in net pens feeding should be carried throughout the day. Use feeding conversion chart to determine quantity of food needed. (keep in mind they will eat more in good seapen conditions.)

Net cleaning: Clean net daily as algae build up is fast and net mesh is usually very small. A good flow must be maintained in the pens at all times. Pick morts daily, as predators shush as dogfish, seals will smell any build up of morts and chew the mesh.
Predator netting or flagging tape on string hanging over the surface of the water will help reduce predation from above.

Safety

Be aware of and use the safety equipment that has been provided.
Work in pairs if possible. Wear personal floating devices.
Have first aid kit at pen site. You may consider a portable communication device.
If the use of a small boat is required to get to pen site, make sure operators are trained in its operation.

PLANKTON SAMPLING FOR SALMON FRY RELEASES.

DAVE EWART, FISH CULTLIRIST, QUINSAM HATCHERY.

INTRODUCTION

In recent years, a program of plankton sampling called " Plankton Watch " has been developed by the United States National Marine Fisheries Service and the Alaskan Department of Fish and Game. This was inspired by similar programs being conducted at Japanese Salmon Hatcheries. The program involved the co-operation of Alaskan facilities in performing weekly plankton and temperature sampling to determine trends which could affect survivals of Pink and Chum Salmon fry. It had been observed that fry survivals were significantly greater in fish released into zooplankton blooms. As a response to this, private aquaculture groups have adopted parts of the " Plankton Watch " program, and now use zooplankton abundance as the

major criteria
for releasing their Pink and Chum fry in Alaska.
In correspondence with Mr. Richard Mattson. a hatchery manager for Prince William Sound Aquaculture Corporation. (P.W.S.A.C.), I received detailed Instructions for setting up a similar plankton-sampling program for Quinsam Hatchery. This particular group, which produces over 100 minion Pink fry per year from one hatchery alone, has had a significant increase in survival rates from groups of fed Pink fry released directly into a zooplankton bloom versus those released randomly (although I was unable to gather any hard data to support this, other than personal communications.). P.W.S.A.C. attempts to rear as many fry as possible and then release into zooplankton blooms determined by twice weekly sampling the fry are manipulated through incubation with temperature control to try and release as close to a bloom as possible. With experience, P.W.S.A.C. personnel can estimate in-season, the zooplankton bloom peak within a week period, and thus schedule fry releases. They do not attempt to identify and classify organisms very closely, but merely note dominant organisms. They also note relative sizes and maturity of the dominant species, since they tend to be the most plentiful at the bloom peak. Another important event to be noted is the transition period between the phytoplankton and zooplankton blooms. It has been found that the period when zooplankton density overtakes that of phytoplankton precedes the zooplankton bloom by two to three weeks. The actual peak is typically found to last @one week. and Is readily apparent in terms of density and (composition of zooplankton to phytoplankton. In Alaska, this usually occurs in late April and early May, upon which the density of zooplanktons quickly and significantly drops off. with a mixed phytoplankton and zooplankton sub-peak continuing on until early June.

METHOD

The method described here and used by P.W.S.A.C. is a " quick and dirty " approach to a far more detailed one that was undertaken by " Plankton Watch ". For our purposes, two factors are of main interest. The % composition of phytoplankton to zooplankton, and the relative density of the plankton types. For sampling, a standard .5 metre conical plankton net using a 250 micron mesh size is recommended; (figure 1). I used a.3 metre, 63 micron mesh net, because it was all that was available. This smaller mesh net probably caught smaller plankton than was necessary, it was used exclusively throughout the sampling program, thus the catch was representative of plankton abundance and trends from sample to sample. Sample stations are chosen at representative locations within a mile of the release site. Once we were concerned with releasing Pink salmon fry, a sample station was chosen 1/4 mile out from Tyee Spit into Discovery Passage where it was known that Pink fry utilised as a rearing area. When dealing with other species, a sample site should be chosen in relation to where it was known these fish would rear in the wild.

The replicate 20 metre deep vertical hauls were done at this site at least once per week. In addition, temperature, salinity, weather conditions, and tide were recorded. Samples from the plankton net were rinsed and poured into sample bottles and taken back to Quinsam Hatchery for analysis. There, they were concentrated into a 250 millilitre graduated cylinder, mixed with neutral formalin and salt water, then allowed to settle for no more than 24 hours. To speed up the settling process, I added @ 2 mls. of a *10%* liquid detergent solution. When the plankton had settled, a measurement of the settled matter was taken in millilitres. The plankton was then mixed up and a sub-sample pippetted out and placed on a slide for observation under a dissecting microscope. A Sedgwick-Rafter cell is recommended to observe and record numbers and species of plankton. For our purposes, a rough estimate was made from the sub-sample, of the % composition of phyto to zooplankton. The settled volume was used to determine relative density of plankton in the volume of seawater hauled by the net using the following equation:

$$D = \frac{S}{Vs}$$

D= Relative density of plankton
Vs= Volume of sea water filtered
S= Settled volume of plankton
Vs= (volume of plankton net in metres cubed) x depth x number of replicates.

The % composition of phyto to zooplankton is the important indicator in determining if a zooplankton bloom was about to occur, and the relative density is a good indicator as to the abundance and strength of the bloom in comparison with other samples.
bailing In Discovery Passage started on April 2 1987, and ended June 1 1987. At that time, 14 samples had been collected, with a minimum of one per week. The sampling procedure took @ one hour for one person to do, spread out over a regular work period. The results indicate that there was a definite phytoplankton bloom starting in early April, and then tapering off. With zooplankton abundance increasing and peaking @ three weeks later during the last week In April and first week of May. (table 1 & figure 2). The zooplankton abundance then significantly decreases, and a mixed phyto/zooplankton period is found up until late May when a definite phytoplankton bloom occurs again. This pattern of blooms follows very closely to the one described to me by P.W.S.A.C.'s Richard Mattson. The Zooplankton bloom occurs in late April/early May, and is preceded by a phytoplankton bloom three weeks earlier. The dominant zooplankton by far is the Calanoid Copepod (figure 3), which are very common in marine waters. Being curious as to what wild Pink fry would feed on in the wild, I phoned Fisheries Biologist Steve McDonald at the West Vancouver Lab. He has done stomach analysis on juvenile Salmon captured in the Campbell River area. And although there has been little work done on Pink fry, he was confident that Pinks would feed readily on Copepods and any other zooplankton that are small enough to fit into their mouths. Chum fry are known to use Copepods as a primary food source in the wild.

SUMMARY

This year. Quinsam Hatchery raised @ three million Pink fry in net pens in the Camphell River estuary, as part of an on-going rearing program. Plankton sampling was conducted to compile background data for future use as release criteria. It was a coincidence this time that the zooplankton bloom matched our release date, as our usual release criteria is based on the date given to us to have our pens removed from the marina. Hopefully, the added edge of having a bountiful supply of natural feed available will enable these fish to survive at even better levels. The possibility of releasing unfed fry into zooplankton

blooms may be attainable with the use of temperature control during incubation, and the manipulation of early and late egg-take lots. The best time this year to have released fry at Quinsam, (using the zooplankton bloom criteria) was the last week in April. Whether or not this will have a significant effect on overall survival will have to be determined in 1988 when the adults return, and will be difficult to attribute to this alone, because there were no special marked groups set aside to evaluate It. It would be Interesting In the future to mark two groups of fed fry and release one into a zooplankton bloom, and the other into the period after or before. This would evaluate the benefits of using this for release criteria. My personal feeling is that releasing fry into an environment, which is abundant in natural food, makes common sense, rather than releasing fish with no Idea if the natural food chain can support them at that time.

REFERENCES

" MANUAL FOR ESTUARINE ENVIRONMENTAL AND ZOOPLANKTON STUDIES •'. Hauser, William J.
Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and
Development. Anchorage Alaska.

Personal Communications, Richard Mattson. Hatchery Manager, Prince William Sound Aquaculture Corporation, P.O. Box 1110, Cordova Alaska, 99574.

Personal Communications. Steve McDonald, Department of Fisheries and Oceans, West Vancouver oratory, Vancouver B.C.

" A GUIDE TO MARINE COASTAL PLANKTON AND MARINE INVERTEBRATE LARVAE ". Smith, Deboyd L.. Kendall/Hunt Publishing Company. 2460 Kerper Boulevard. Dubuque Iowa, 5200.

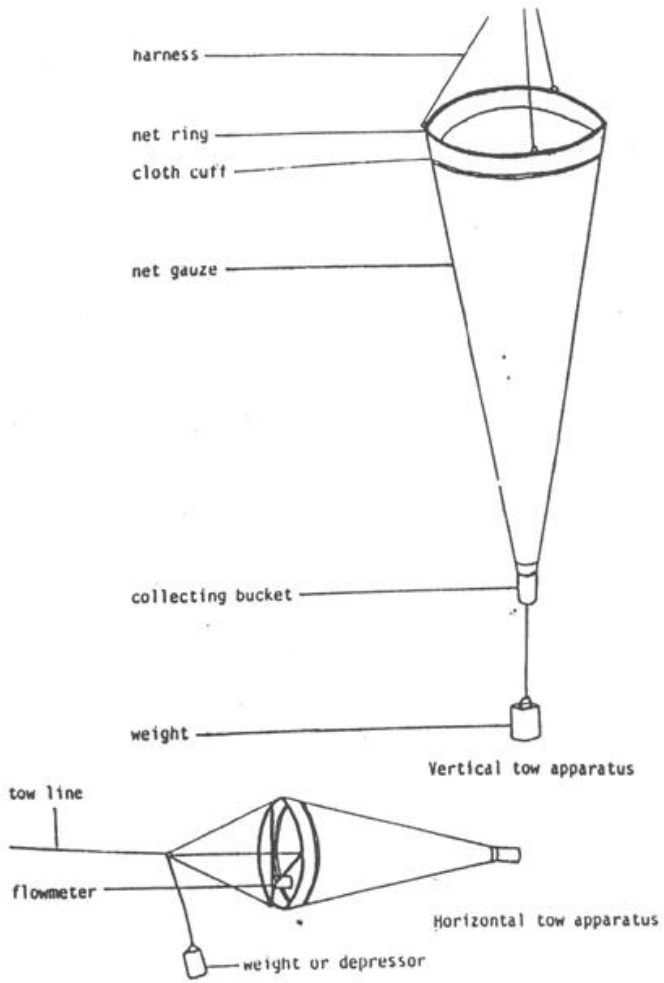


Figure 2. Conical plankton net and towing apparatus.

TABLE 1. 1987 TYEE SPIT PLANKTON SAMPLING
% COMPOSITION AND RELATIVE DENSITY.

DATE	VOLUME FILTERED m3	SETTLED VOLUME mls.	RELATIVE DENSITY ml/m3	%COMPOSITION phyto	zoo
April 2	4.242	100	23.57	90	10
April 7	4.242	150	35.36	97	3
April 14	4.242	125	29.47	85	15
April 16	4.242	20	4.7	75	25
April 21	4.242	50	11.8	40	60
April 24	4.242	10	2.4	10	90
April 27	4.242	10	2.4	0	100
May 4	4.242	5	1.18	60	40
May 8	4.242	3	.71	10	90
M .2	4.242	5	1.18	10	90
may 15	4.242	2	.47	10	90
May 21	4.242	1	.24	0	100
May 26	4.242	125	29.5	100	0
June 1	4.242	15	3.54	80	20

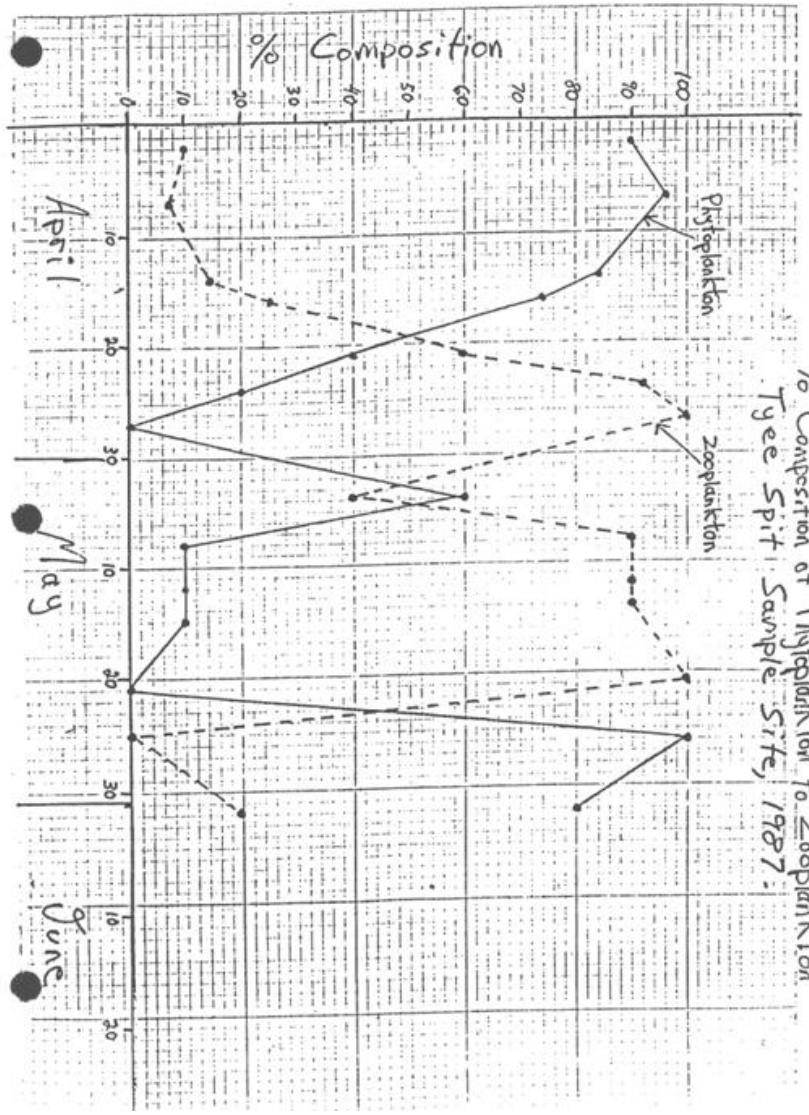


Figure 2

% Composition of Phytoplankton to Zooplankton
Tyee Spit Sample Site, 1987.

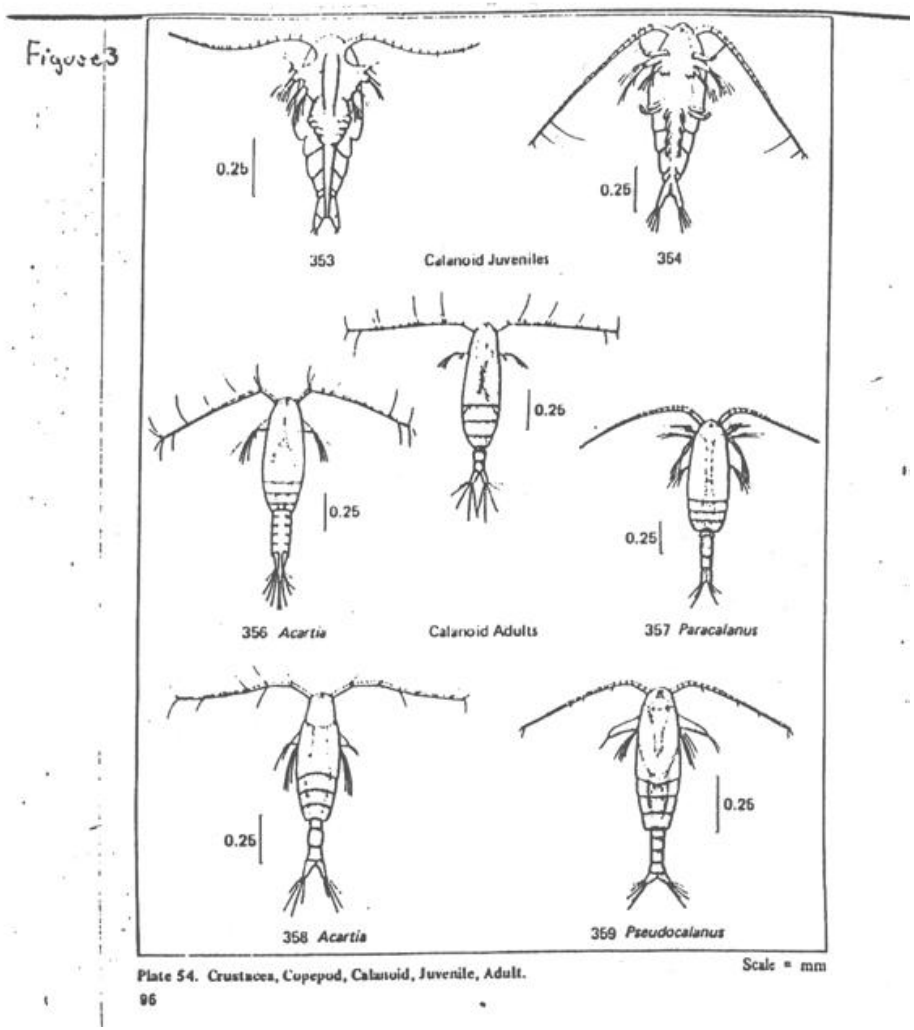


Plate 54. Crustacea, Copepod, Calanoid, Juvenile, Adult.

96

Records

What type? What info? Who needs it?

Rough Data or field notes are the most common type used for incubation and rearing records. These may be set up as ducks back (waterproof paper) or clipboard format. Preferably your

choice is one that suits the needs of the program and is easy enough for new workers or other people to read and use. Notes left on cigarette wrappers etc. are not considered a good choice for keeping track of field observations, but will work in a pinch.

The info collected should be transferred to permanent binder or onto computer format with back up disc either daily weekly or as each field page becomes full. It is important to keep this info in a safe place, as God knows someday, someone will want to look at it. Your data requirements should be reviewed by a scientific authority (CA, Biologist etc.) for validity and usefulness. The more info the merrier to a certain extent.

It might be a good idea to set up a calendar system for updating data and fry sampling, this way you can schedule manpower for these tasks and continuity.

Regular daily data might include:

- Temperatures min. max and mean (air and water)
- Oxygen levels, each container (inlet and outlet ppm)
- Flow readings (litres per min, gph, cfs etc.)
- Pump info like well level pressure readings.
- Weather conditions etc.

Important! Incubation and Rearing data should include;

- All containers should be id as well as labelled for species, #'s of fish, stock name etc.
- # of mortalities per individual container (per day will give you fish health trends) CWT's
- Balance of live fish (someone will want to know #'s)
- Average length & weights of individual fry or bulk weight of fry and date sampled.
- Total Bio-mass of pond or container Total Bio-mass = (avg. wt. Gms* # of fish)/1000=kg.
- Bio. Flow Rate = Kg/lpm 100 kg/ 200 1pm = .5 kg fish per 1.01pm (stay within limits <. 85) too much flow becomes velocity challenge and too low flow oxygen depletion.
- Density levels = kg/M3 again stay within limits <12 kg per M3
- Transfers in and out, should be recorded by date and number offish.
- Type and amount of food fed per day Accumulative total fed for growth conversions
- Growth Conversion = total amount fed to produce total growth of fish (.7% for dry feeds)
- Growth Conversion example: 7kg of food fed = Biomass growth of 10 kg. This will help for growth predictions and feed orders.
- Start with 100,000 fry at .30 grams = 30 kg. At 1.5 grams they will have grown 120 kg of Bio-mass this should equate to 84 kg of #l Ewos starter at .7% growth rate. So you will need approximately 3.8-4 bags of starter. Next step is from 1.5 gm to 2.5 gm. #2 starter etc.
- Daily Comments column should be included for adding any particular or peculiar notes.

Fry Sampling

How to and how often?

Newly ponded fry should be sampled for a start point, you may use fry examined for ponding for this sample to eliminate stress. Some of these will have varying stages of yolk absorption and might skew your sample. Some hatcheries use a historical start size and rely on a sample after fry are up and feeding well (usually about 2 weeks). 0nce fish are up and feeding well a sampling schedule should be incorporated.

Juvenile Sampling

Fish size and temperature determine the physiological capacity for fish to grow. In order to give them enough food to meet this growth, accurate data on temperature and fish size is needed. Instead of measuring each fish every two weeks, a sample of the population is sufficient. Don't guess fish weight or length.

How you take the sample is very important. **Random sample**

A sample must represent accurately the size distribution in the rearing container. A good sample contains the same proportion of large, small, and average size fish as are in the whole population. If a sample does this, it is said to be representative. To get a representative sample, you must sample the population randomly —that is that every fish has the same chance of being captured as any other fish. There should be no selection for large, small, sick, or dead fish.

How to get a random sample:

- Sample fish before they are fed if possible, to reduce the stress of sampling; Early morning works best for us and try not to muck around too much as stress from this can outweigh the objective of a sample.
- Lower water depth but keep water flow going — this makes it easier to catch the fish — they have less room to swim; (Optional this may not be suitable or practical for some containers)

- Sample a few fish from many parts of the pond to get a total of fifty fish. If fish are concentrated at one area than take more samples from that area than the less populated. Try dip-netting fish into one bucket and then take a scoop of+50 into another bucket. Whatever system or methods you use keep it standardized so that a consistency is achieved.
- For releases, take three independent samples of fifty to make sure that you know just how big your fish are. Some larger groups may require 3 independent samples of 100 fish.

Sample size

The sample size must be at least fifty fish. Smaller samples have been found to be not very accurate because it takes only one large one or one small one to give a false estimate of mean length or weight. Larger sample sizes are fine, but usually the extra time means that it doesn't get done. Sampling must be done on a regular basis. It's just a matter of setting up a schedule.

Sample Techniques for weights and lengths

Standardize system to keep sampling techniques consistent. Using a balance or digital scale that is accurate to +/-. 01 of a gram is best for individual weights. Fry measuring boards can be made or bought for fry to adult size.
When anaesthetic is used for sampling length and weights make sure to consult scientific authority for proper procedures, especially when using MS-222. Carbon dioxide in compressed gas or Alka-Seltzer tablets is usually safe and easy to use. Buffering with Sodium Bicarbonate is recommended to keep pH level safe. If you are just doing weights then fish can be handled usually without anaesthetic.

Sample frequency

When fish are growing rapidly, their growth must be monitored to adjust feed rates frequently. It causes more harm to fish to be underfed as stress, cannibalism and disease problems will occur. The best sample frequency is one that keeps the fish culturist aware of how big his/her fish are and is not so frequent that the stress of sampling causes reductions in growth.

One common sample frequency is once every two weeks. This may have to be reduced if temperatures become high enough to cause stress or ponds are crowded, etc. Use your judgment. In between weight and length samples, the satiation method of feeding will enable you to keep up to your fish's food requirements.

***** I added this in case you are using MS 222 (Buffering anaesthetic)**

One anaesthetic commonly used is MS 222. This compound is fairly safe and the compounds do not cause damage to fish if used in the proper concentrations. It is a strong acid, however, and the low pH can cause damage to gill tissues. The anaesthetic bath must be buffered to pH 7.0 with sodium bicarbonate (NaHC03. baking soda).

The usual method of measuring out MS 222 is to dissolve the 100-gram bottle that it is usually supplied in, in a litre of water. This stock solution is kept cool and. away from light, usually stored in a light proof well labelled bottle (H&S). When it is time to make up an anaesthetic bath, the stock solution is measured out and added to water, usually about 10 L. The

recommended amount of sodium bicarbonate to add is 2 mg/L for every 1 mg/L of MS 222.
After adding sodium bicarbonate, recheck pH to see if it is near 7.2. Try the solution with a few fish and time their recovery. If it takes more than 3 minutes in fresh water to recover, too much bicarbonate may have been added, causing high C02 concentrations. Or anaesthetic concentration level is to high so you may dilute (H20) to achieve a better recovery time 1-2 min.

Procedure to follow for anaesthetizing fish

- Mix up stock solution (100 g of MS 222 plus water to make l L of stock solution);

- Try anaesthetic bath on a few fish using a small amount of MS 222 stock solution in 10 L (2 Imp, gal.) of water. Recovery time should be 1 to 2 minutes in fresh water if fish are removed as soon as they knock out and handled.

Carbon Dioxide as an Anaesthetic

At Puntledge Hatchery we commonly use C02 as an anaesthetic for performing length and weight sampling. It is safe and easy so why change?? The only initial cost is for a small C02 cylinder, regulator plus flow meter and hose. Once purchased this will allow you to perform many samples without recharging the bottle. A full bottle might last a year or two. It also can be used on adults by increasing the flow and air stone size.

For juvenile sampling we fill a small basin with ambient water add C02 through an air stone for 5-10 min. and buffer with 1 tablespoon Sodium Bicarbonate. Check pH level if needed to try and return it to start point ~7
You should always try these procedures with a few fish to see if they go out within a minute and return to swimming by 3-5 min.
Once fry are knocked out you can place fry on measuring board and read length from nose to inside curve of the fork-tail. Read measurement in millimetres and correlate with weight for KC value. Try not to drip water with sample fish, as this will certainly skew each sample. Readings of 1.0 are normal anything above or below by. 10-. 30 should be questioned.

After fish are up and swimming you may return them to respective containers.

Dos and Don'ts

- Do a representative sample and don't disturb them too much
- Do samples quickly as water temperature in buckets can warm
- Don't knock out too many fish at once, as longer drug contact time is fatal.
- Use air bubblers to keep fry in holding buckets oxygenated
- Keep methods and techniques the same for consistency
- Don't use too much anaesthetic it can be fatal and stressful on fish
- Try to use growth profiles to reduce sampling
  - Alternate length/weight sampling so you do weights one week and weights & lengths 2 weeks after.

stock:	Big Q	TOTAL LIVE=	647012		ponded #	650363
cont.:	R.W.2 A to F	was2-c	c.w.t.code	18-38-27	# marked	21340
					to sea pen-	100000

DATE	MORTS unmark	ACCUM. MORTS unmarked	Morts marked	Morts Accum. marks	#Live marks	# LIVE unmark	WGT.gm.	TOTAL WGT.kg.	FOOD FED kg.	ACCUM. FED	M3 AREA	LOAD DENS. kg/m3	WATER FLOW lpm	BIO.FLOW RATE kg/lpm	COMMENTS
Feb.05/99	0	0				650363	0.4	260.15	0.4	0.4	50	5.20	500	0.52	ponded
Feb.19/99	796	796				649567	0.6	389.74	50	50.4	50	7.79	500	0.78	wgt.sam.
Mar.02/99	189	985				649378	0.73	474.05	60	110.4	105	4.51	1700	0.28	wgt.sam.
Mar.18/99	288	1273				649090	1	649.09	125	235.4	105	6.18	3300	0.20	wgt.sam.
Mar.30/99	418	1691				648672	1.34	869.22	250	485.4	105	8.28	3300	0.26	wgt.sam.
APR.13/99	372	2063				648300	1.89	1225.29	374	859.4	200	6.13	5000	0.25	
May 03/99	453	2516				547847	3.1	1698.33	300	1159.4	200	8.49	5000	0.34	move 100k to seapen
May13/99	428	2944	10	10	21330	526079	4.1	2156.92	300	1459.4	250	8.63	5000	0.43	marked may7-11
May 26/99	344	3288	53	63	21277	525735	5.54	2912.57	400	1859.4	250	11.65	5000	0.58	release pull screens
		3288		63	21277	525735		0.00		1859.4	250	0.00	5000	0.00	length=80.0
		3288		63	21277	525735		0.00		1859.4		#DIV/0!	5000	0.00	kc=1.1
		3288		63	21277	525735		0.00		1859.4		#DIV/0!	5000	0.00	Ewos fed
		3288		63	21277	525735		0.00		1859.4		#DIV/0!	5000	0.00	conversion .7kg food= 1 kg. Of fish growth

Sheet2

stock:	summer	chinook						
.:	today 2002							
Pond id	RaceW 2a							
FISH#	LN (mm)	WT (g)	KC					
1	56	1.8	1.02		26	61	2.57	1.13
2	65	3.01	1.10		27	63	2.64	1.06
3	56	1.97	1.12		28	62	2.5	1.05
4	63	2.5	1.00		29	66	3.1	1.08
5	67	3.2	1.06		30	63	2.75	1.10
6	62	2.5	1.05		31	56	1.91	1.09
7	64	3	1.14		32	61	2.4	1.06
8	64	3	1.14		33	54	1.72	1.09
9	61	2.44	1.07		34	67	3.37	1.12
10	65	3	1.09		35	67	2.94	0.98
11	63	2.8	1.12		36	63	2.7	1.08
12	57	2.1	1.13		37	64	2.77	1.06
13	60	2.33	1.08		38	61	2.5	1.10
14	54	1.61	1.02		39	67	3.2	1.06
15	59	2.12	1.03		40	64	2.52	0.96
16	56	1.77	1.01		41	53	1.61	1.08
17	57	1.8	0.97		42	62	2.6	1.09
18	60	2.3	1.06		43	65	3.1	1.13
19	60	2.3	1.06		44	62	2.4	1.01
20	58	2	1.03		45	62	2.5	1.05
21	54	1.7	1.08		46	61	2.4	1.06
22	60	2.2	1.02		47	61	2.3	1.01
23	61	2.31	1.02		48	64	3	1.14
24	63	2.6	1.04		49	57	2	1.08
25	59	2.2	1.07		50	59	2.1	1.02
					Ave.	61.0	2.4	1.1
					SD.	3.711	0.461	0.046
KC=	(Wgt.gm *	10^5) / (Ln	* ^3)					
put this formula in KC cell			(D*10^5)/(C^3)					

Coho	2001B.Y.		100	TOTAL	Live	DEAD	Allev.	Live	Accum.	COMMENT
E.T. DATE	1ST PICK	TRAY ID.	Eggs wgt.	WGT. EGGS	Eggs 1stpic	2&3 PICKS	Dead Pick	Pond #	Live Fry	
Nov.13/01	Dec.12	E-1	24.15	2000	8282	200	62	8020	8020	start cell#1
"	"	2	24.32	2000	8224	195	57	7972	15991	
"	"	3	24.2	2000	8264	219	50	7995	23987	
"	"	4	24.25	2000	8247	198	36	8013	32000	
"	"	5	24.53	2000	8153	175	32	7946	39946	
"	"	6	24.3	2000	8230	220	60	7950	47897	
"	"	7	24.18	2000	8271	175	55	8041	55938	
"	"	8	24.2	2000	8264	197	50	8017	63956	
"	"	9	24.25	2000	8247	203	37	8007	71963	
"	"	10	24.8	2000	8065	194	45	7826	79789	
"	"	11	24.7	2000	8097	200	44	7853	87642	
"	"	12	24.93	2000	8022	167	70	7785	95427	
"	"	13	24.67	2000	8107	190	46	7871	103298	
"	"	14	25.1	2000	7968	208	37	7723	111021	
"	"	15	25.23	2000	7927	174	83	7670	118691	
"	"	16	24.85	2000	8048	155	70	7823	126515	
"	"	17	25.35	2000	7890	210	70	7610	134124	
"	"	18	24.3	2000	8230	190	74	7966	142091	151871
"	"	19	24.54	2468	10057	192	85	9780	151871	end cell #1
"	Dec.15/01	20	24.8	2000	8065	124	40	7901	159771	start cell#2
"	"	21	24.61	2000	8127	102	35	7990	167761	
"	"	22	25.28	2000	7911	104	41	7766	175527	
"	"	23	25.27	2000	7915	108	35	7772	183299	
"	"	24	25.08	2000	7974	114	34	7826	191125	
"	"	25	25.32	2000	7899	105	33	7761	198886	
"	"	26	23.73	2000	8428	131	34	8263	207149	
"	"	27	24.98	2000	8006	124	35	7847	214997	
"	"	28	25	2000	8000	104	39	7857	222854	
"	"	29	24.53	2000	8153	92	48	8013	230867	
"	"	30	24.93	2000	8022	94	42	7886	238754	
"	"	31	25.05	2000	7984	105	60	7819	246573	

Coho	2001B.Y.		100	TOTAL	Live	DEAD	Allev.	Live	Accum.	COMMENT
E.T. DATE	1ST PICK	TRAY ID.	Eggs wgt.	WGT. EGGS	Eggs 1stpic	2&3 PICKS	Dead Pick	Pond #	Live Fry	
Nov.13/01	Dec.12	E-1	24.15	2000	8282	200	62	8020	8020	start cell#1
"	"	2	24.32	2000	8224	195	57	7972	15991	
"	"	3	24.2	2000	8264	219	50	7995	23987	
"	"	4	24.25	2000	8247	198	36	8013	32000	
"	"	5	24.53	2000	8153	175	32	7946	39946	
"	"	6	24.3	2000	8230	220	60	7950	47897	
"	"	7	24.18	2000	8271	175	55	8041	55938	
"	"	8	24.2	2000	8264	197	50	8017	63956	
"	"	9	24.25	2000	8247	203	37	8007	71963	
"	"	10	24.8	2000	8065	194	45	7826	79789	
"	"	11	24.7	2000	8097	200	44	7853	87642	
"	"	12	24.93	2000	8022	167	70	7785	95427	
"	"	13	24.67	2000	8107	190	46	7871	103298	
"	"	14	25.1	2000	7968	208	37	7723	111021	
"	"	15	25.23	2000	7927	174	83	7670	118691	
"	"	16	24.85	2000	8048	155	70	7823	126515	
"	"	17	25.35	2000	7890	210	70	7610	134124	
"	"	18	24.3	2000	8230	190	74	7966	142091	151871
"	"	19	24.54	2468	10057	192	85	9780	151871	end cell #1
"	Dec.15/01	20	24.8	2000	8065	124	40	7901	159771	start cell#2
"	"	21	24.61	2000	8127	102	35	7990	167761	
"	"	22	25.28	2000	7911	104	41	7766	175527	
"	"	23	25.27	2000	7915	108	35	7772	183299	
"	"	24	25.08	2000	7974	114	34	7826	191125	
"	"	25	25.32	2000	7899	105	33	7761	198886	
"	"	26	23.73	2000	8428	131	34	8263	207149	
"	"	27	24.98	2000	8006	124	35	7847	214997	
"	"	28	25	2000	8000	104	39	7857	222854	
"	"	29	24.53	2000	8153	92	48	8013	230867	
"	"	30	24.93	2000	8022	94	42	7886	238754	
"	"	31	25.05	2000	7984	105	60	7819	246573	

EWOS - 2000 BROOD FOOD REQUIREMENT/ORDERING

Summer Chinook

Fish Size	#	gain/fish	biomass gain	conv.	food req.-Kg.	food size	$/Kg	cost $
.45 - 1.5	420K	1.0	420.0	0.7	294	# 1	2.95	867.3
1.5 - 2.5	410K	1.0	410.0	0.7	287	# 2	2.95	846.65
2.5 - 5.0	400K	2.5	1000	0.7	700	1.2 mm	2.45	1715
5.0 - 7.0	400K	2.0	800.0	0.7	560	1.5 short	2.20	1232
			2630.0	1.12	1841.0			4660.95

Fall Chinook - Production

Fish Size	#	gain/fish	biomass gain	conv.	food req.-Kg.	food size	$/Kg	cost $
.45 - 1.5	550	1.0	550.0	0.9	495	# 1	2.95	1460.25
1.5 - 2.5	545	1.0	545.0	0.9	490.5	# 2	2.95	1446.975
2.5 - 5.0	540	2.5	1350.0	0.9	1215	1.2 mm	2.45	2976.75
5.0 - 7.0	536	2.0	1072.0	0.8	857.6	1.5 short	2.20	1886.72
			3517.0	1.12	3058.1			7770.695

Production - COHO

Fish Size	#	gain/fish	biomass gain	conv.	food req.-Kg.	food size	$/Kg	cost
.23 - .3	400	0.07	28	0.9	25	# 0	3.05	76.25
.3 - 1.5	396	1.2	475.2	0.9	425	# 1	2.95	1253.75
1.5 - 2.5	392	1	392	0.9	350	# 2	2.95	1032.50
2.5 - 5.0	390	2.5	975	0.8	775	1.2 mm	2.45	1898.75
5.0 - 12	385	7.0	2695	0.8	2150	1.5 short	2.20	4730.00
12.0 - 20.0	380	8.0	3040	0.8	2425	1.5 mm	2.20	5335.00
			7577.2	0.81	6125.0			14326.25

Colonization - COHO

Fish Size	#	gain/fish	biomass gain	conv.	food req.-Kg.	food size	$/Kg	cost
.23 - 0.3	500	0.07	35	0.9	50	# 0	3.05	152.50
.03 - 1.5	496	1.2	595.2	0.9	550	# 1	2.95	1622.50
1.5 - 2.0	492	0.5	246	0.9	225	# 2	2.95	663.75
			876.2	0.94	825.0			2438.75

Production - CHUM

Fish Size	#	gain/fish	biomass gain	conv.	food req.-Kg.	food size	$/Kg	cost
.33 - 1.0	2000	0.67	1340	1.0	1350	# 1	3.05	4117.50
			1340	1.0	1350			4087.00

stock: Big Q | TOTAL LIVE= 547012 | ponded # 660363
cont.: R.W.2 A to F was2-c | c.w.t.code 18-38-27 | # marked 21340
to sea pen- 100000

DATE	MORTS unmark	ACCUM. MORTS unmarked	Morts marked	Morts Accum. marks	#Live marks	# LIVE unmark	WGT.gm.	TOTAL WGT.kg.	FOOD FED kg.	ACCUM. FED	M3 AREA	LOAD DENS. kg/m3	WATER FLOW lpm	BIO.FLOW RATE kg/lpm	COMMENTS
Feb.05/99	0	0				660363	0.4	260.15	0.4	0.4	50	5.20	500	0.52	ponded
Feb.19/99	796	796				649567	0.6	389.74	50	50.4	50	7.79	500	0.78	wgt.sam.
Mar.02/99	189	985				649378	0.73	474.05	60	110.4	105	4.51	1700	0.28	wgt.sam.
Mar.18/99	288	1273				649090	1	649.09	125	235.4	105	6.18	3300	0.20	wgt.sam.
Mar.30/99	418	1691				648672	1.34	869.22	250	485.4	105	8.28	3300	0.26	wgt.sam.
APR.13/99	372	2063				648300	1.89	1225.29	374	859.4	200	6.13	5000	0.25	
May 03/99	453	2516				547847	3.1	1698.33	300	1159.4	200	8.49	5000	0.34	move 100k to seapen
May13/99	428	2944	10	10	21330	526079	4.1	2156.92	300	1459.4	250	8.63	5000	0.43	marked may7-11
May 26/99	344	3288	53	63	21277	525735	5.54	2912.57	400	1859.4	250	11.65	5000	0.58	release pull screens
		3288		63	21277	525735		0.00		1859.4	250	0.00	5000	0.00	length=80.0
		3288		63	21277	525735		0.00		1859.4		#DIV/0!	5000	0.00	kc=1.1
		3288		63	21277	525735		0.00		1859.4		#DIV/0!	5000	0.00	Ewos fed
		3288		63	21277	525735		0.00		1859.4		#DIV/0!	5000	0.00	conversion .7kg food=
															1 kg. Of fish growth

Tagging Workshop topics

1) What do I need before I start?

2) Condition offish.

3) Prepare the fish.

4) Tag positioning.

5) Adipose fin clipping.

6) Anaesthetic Mis-use mortality.

WHAT DO I NEED BEFORE I START?

1. PERSONNEL

Fish tagging is performed using an assembly-line system, including one, two or three tagging machines and a crew complement of taggers, fin clippers and supervisors. The operation should be continuous throughout the day and proceed consistently for days or weeks until all the fish are marked. In personnel terms, it is important to ensure that the team is appropriately organized, that everyone is well trained and directed, and that sufficient supervision is provided to ensure adequate quality control and operational efficiency.

Team Organization

Each site potentially has a different team organization based on different methods of hiring workers and assigning responsibilities. Where a contractor is retained, a tagging supervisor from the hatchery should be in charge since the tagging crew does not report to the hatchery manager. It is critical that the tagging supervisor closely communicate with the hatchery management, not only to ensure that the marking quality and numbers are achieved, but also to coordinate the tagging rate with strategies for starving and holding the fish to be marked. In this way, the tagging and hatchery components can be coordinated to ensure a smoothly run operation. For coded-wire tagging, the ratio of clippers to taggers should be 2:1, or two clippers for every tagger. Therefore, if three tagging machines are used, six clippers are required. The importance of a 2:1 ratio is based on the efficient use of the taggers' time and also ensures that the clippers have sufficient time to maintain quality clips. If the ratio is 1:1, the clipper cannot maintain pace with the tagger. Either the clipper must speed up, in which case fin clip quality suffers, or the tagger must slow down. At one hatchery where a 1:1 strategy was used, an incidence of 75% poor clips and a marking rate of only 12,000-13,000 fish/day was reported for a two-machine set-up, which is at least 4-5,000 below the average rate obtained with a 2:1 clipper/tagger ratio using a similar set-up. Personnel requirements for fin clipping operations do not differ greatly from those required for coded-wire tagging, except that fin clipping operations are more loosely organized since no need exists to coordinate with machine speeds. It is important, however, that all new personnel be trained properly, and that each clipper be taught the proper technique. It will be expected that during the first few days of training, the clipping speed will be below average, but it will increase with time. Clipping quality can be controlled with good supervision so that the only variable between crews should be clipping speed as related to previous clipping experience.

Job Descriptions

Taggers: Taggers should be experienced. They must be able to handle fish properly, and recognize correct machine operation and correct tag placement. When training new taggers, higher tag loss and higher mortalities should be expected.

Clippers: Clippers must be able to handle fish carefully, clip the fin properly and size-sort the clipped fish. It is not mandatory that fin clippers be experienced at the start of the operation. They can be trained in one hour to make a quality clip. Those unable to do so, probably lack sufficient manual dexterity and should be replaced at the end of the day. Speed should not be encouraged until high quality clips are regularly obtained. Once this occurs, speed will increase naturally, usually without a loss in clip quality.

Supervisor: The supervisor must ensure that 1) the tagging operation is properly planned and organized, 2) the equipment and fish are ready for tagging, 3) the personnel are adequately trained and monitored, 4) the quality control standards are effectively and consistently in place, and 5) the data are collected in an orderly manner.

2. CONDITION OF FISH

The most important aspect of preparing fish for coded-wire tagging is establishing the seasonal timing of the tagging activities. Tagging usually takes place from late February to early July, with the exception of over wintered Coho, which may be tagged in, mid-winter. Preparing fish for fin clipping is similar to preparing them for coded-wire tagging, except that much smaller fish can be fin clipped.

The primary factors to consider are water temperature and fish size. Since each hatchery has its own temperature regime and subsequent growth curves, the following weights and temperatures are provided to assist in estimating appropriate site-specific timing for tagging operations.

Species	Minimum Weight (g)	Maximum Temperature (C)
Chinook	1.0	14
Coho	1.0	15
Chum	0.8	14

In general, even if the fish size criteria are met, marking should not be undertaken if 1) water temperature is above the determined critical level for the hatchery in question, 2) fish are being treated for disease, or 3) fish are smelting. Each of these major concerns, as well as fish size, is discussed below.

Water Temperature

Maximum water temperatures during tagging can vary among sites and stocks. For example, Hartley Bay fish were tagged at water temperatures ranging from 20°C to 25^0 with approximately 10 mortalities reported each year (100,000 Coho tagged in each of 3 years). Normally, tagging at these temperatures at other locations would kill the fish. However, the Hartley Bay fish are hatched and reared at high water temperatures and are released into a warm-water lake. In contrast, Chinook at Quesnel Hatchery are reared in cold water and have a maximum tagging temperature of only approximately 12C. At more southerly hatcheries it may be possible to tag Chinook safely at 15^C or 16C. Therefore, each hatchery should conduct

its own experiments to determine the critical temperature for tagging under site-specific conditions (Table 1).
When determining the critical temperature for each site and species, it is important to assess the past history of tagging operations to determine the actual temperatures at marking, the mortalities at that time, and whether or not differences in the daily mortalities coincided with even a slight change in temperature.

If it becomes necessary to tag fish at water temperatures higher than the considered maximum, it is especially important not to clip too deep, as this will guarantee fungus growth on the fish. Furthermore, the hatchery management should consider increasing the numbers of fish tagged in order to compensate for expected higher than normal mortalities. In locations and at times of the year when warm water temperatures may create handling and tagging problems, variation in the daily timing of tagging may help avoid working in the heat of the day. For example, tagging shifts from 5:00 am to 11:00 am and from 6:00 pm to 8:00 pm daily, or from 6:00 am to 2:00 pm could take advantage of cooler daily air and water temperatures. The primary problem with this scheduling is that government hatchery crews work from 8:00 am to 4:00 pm so that a special effort would be required to coordinate the different shifts of hatchery and marking crews. Often a 6:00 am to 2:00 pm shift works well; the tagging crew gets a 2-hour head start on the regular hatchery activities, and when they leave for the day, the hatchery crew has a few hours to inspect the tagged fish and move untagged fish into containers prior to the next day's marking

HOW DO I DO IT?

1. PREPARE THE FISH

Preparing the fish for tagging involves proper fish starving and containing procedures.

Starving Fish

Prior to tagging, the fish should be starved for at least 24 hours and preferably 48 hours. Starvation will allow stomach evacuation in the first day resulting in reduced output of ammonia and excretory by-products associated with stressful fish handling and tagging. Also, it is noted that the fish will "firm up" with starvation. Fish that are not starved before tagging have a noticeably softer nose cartilage, resulting in increased tag loss. For extended tagging operations (e.g. Quesnel Hatchery: 850,000 Chinook coded-wire tagged over a 20-day period), low-ration feeding and starvation routines must be carefully planned in order to avoid increased tag loss in the fish that are tagged first and undue stress in the fish that are tagged last.

Containing Fish

In organizing hatchery space and activities in preparation for marking, two major concerns stand out: 1) minimizing fish handling before tagging begins, and 2) providing suitable holding and recovery containers during tagging of multiple groups of fish while supplying cool, clean water at all times. These concerns are discussed below.
Fish that are not being marked immediately should be kept as comfortable as possible prior to tagging. Minimizing fish handling before tagging begins can be done by avoiding disturbing the entire large raceway in order to obtain one dip net of fish. This factor is important given the large numbers of fish tagged each year at a given hatchery. Fish Size

For scheduling purposes, a 2.5 g average size is considered optimal for tagging, as the fish are relatively uniform and at a convenient size for handling and grading. At this size, two tagging machines can be set up to obtain optimal tag placement, one machine covering the 1.8 2.5 g size range, and the other the 2.5 4.0 g size range. Note that fish tagged at a larger size (e.g. 6 g average) will show a larger size variation (1-12 g) and consequently will require more grading and nose-mold adjustments. This will make it more difficult to obtain good tag placement. Tagging scheduling should include getting the fish to an optimum tagging size of 2.5 g in such a way as to coincide with natural migration and any other timing factors that the hatchery is considering.
Fish size is an important factor that influences primarily tagging speed and efficiency. Fish that are smaller than the optimum 2.5 g size are often harder to hold and handle by the clippers and taggers, thereby slowing down the operation. Also, fish that encompass a relatively wide size range or are unsorted, result in inefficient use of the tagging machines. That is, if one machine is set up to accommodate 60% of the fish and another to accommodate 40%, then one tagger remains idle more frequently than the other. Optimally, when using more than one tagging machine, the size range should overlap so that the middle range can be handled by either machine, thus maintaining a steady pace throughout. For this reason, a two-machine system with an overlapping size range is considered to be very efficient.

It is important to tag a random sample of the hatchery fish regardless of their size so that a representative size range of the overall hatchery production is marked. If the fish are graded prior

to marking so that all small and large individuals are excluded and only the medium-sized fish are tagged, a non-representative group of hatchery fish will be traced through the CWT returns in the recovery system. This defeats the purpose of tagging. For example, in some observed cases, fish were sorted prior to tagging so that large and small fish were set aside, and only the mid-sized fish were retained for marking. This approach allowed more accurate tag placement and better overall tagging success. However, the statistics generated from these tag returns did not reflect the majority of the hatchery population, most of which consisted of either larger or smaller fish which may have experienced different survival rates from the mid-sized fish.

Tag Positioning

Tag positioning should be checked by slicing open the fish head longitudinally with a scalpel. The nose tag should be positioned squarely in the centre of the nose cartilage (Fig. 3). One fish should be sacrificed hourly for each tagging machine to avoid missing a gradual change in fish size, which can easily go unnoticed by the crew. Frequent tag positioning checks will also monitor whether the taggers are getting "ahead" of their machines.

Of all, the hatchery sites visited by the author, not one tagging operation was using the correct head mold size for the size offish being tagged, or getting the correct tag placement. Typically, the small fish were tagged too deep and the large fish not deep enough. Yet the questionnaire returns indicated that all the hatcheries knew what the correct tag placement was. Two possible reasons may explain this problem: 1) not knowing what the correct tag placement looks like when examining the freshly killed fish at the tagging site, and 2) not sorting the fish for size prior to tagging. It is the author's opinion that not sorting the fish properly for size was the primary reason for poor tag placement. This omission is best illustrated by an example. At one hatchery, a special tagging area was designed and constructed that included a tagging table with allowance for fish transfer troughs to lead to each of the two or three tagging machines. Although it would have been a simple task for the clippers to place large, medium and small sized fish into different troughs in order to size-grade the fish for each machine, this was not done. Consequently, fish of all sizes were passed to all the machines. This resulted in small fish being tagged too deep and larger fish tagged not deep enough, as determined by random checks for tag placement at each machine. Similarly, at another hatchery, fish were sorted prior to tagging so that very small fish were graded out. The remaining population (90%) ranged from 1.5 g to 4.5 g. When the tagging operation commenced, no further size grading was conducted by the clippers so that the same problem of incorrect tag placement occurred despite two machines operating. Random tag placement checks showed that although medium-sized fish were tagged correctly, they represented only 50% of the population. In fact, a 48-hour examination showed a 6% tag loss in the overall group. In both the above examples, the fish were healthy and of an appropriate size for tagging, so that no tag losses need have occurred.

It is imperative for the fin clippers to sort the fish for size during the tagging operation, to ensure that fish sizes and head molds are closely matched. Failure to do this will result in poor tag placement and increased tag loss rate.

We recommend the following measures to correct tag placement:

1. If the nose tag is not placed squarely in the centre of the nose cartilage but rather is too high or too low, change the head mold. A placement that is too high usually indicates too big a mold, while a placement that is too low usually indicates too small a mold.

2. If the tag is centered but placed too deep, pull out the head mold accordingly.

3. If the tag is placed too shallow, push the mold in. Mark the position on the mold with a pencil to know where you started from.

4. If unsure which head mold is best for a group of fish, anaesthetize a random sample of fish and test all the head molds on all the fish sizes. Try and fit the fish to the mold sizes available.

The manufacturer provides nose molds that come with each machine. For the majority of CWTed fish, the following molds are appropriate:

Fish Size			Head Mold
0.7	1.0	g	700/lb
2.0	3.0	g	200/lb
3.0	4.5	g	120/lb
10.0	20.0	g	30/lb

Note that head mold size is stamped in base of mold, and that colour of mold may change.

3. ADIPOSE FIN CLIPPING

Clip Checking

Both the supervisor and the taggers should check adipose clips constantly and alert the clippers immediately of any problems. The tagging supervisor should check the adipose clips visually by taking fish out of the taggers' basins prior to coded-wire tagging, or if possible, from the sorting troughs so that individual clippers can be identified. Adipose fins are best inspected by placing an anaesthetized clipped fish in a water-filled vial, holding it up to a light source and viewing with a naked eye or through a magnifier. The taggers can check for poor clips during the tagging process. Although deep clips are usually not apparent to the taggers, peaks or bumps of adipose fins will often be noticed when glancing at the anaesthetized fish in the basin prior to tagging.

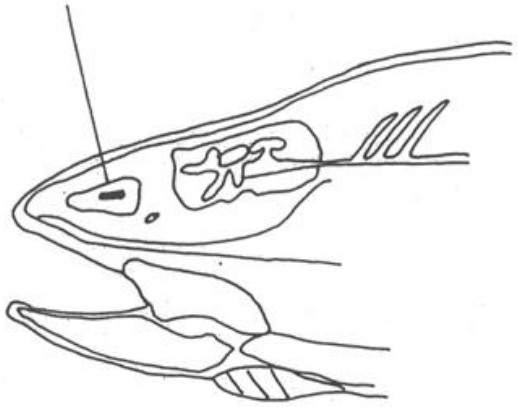
Determination of Good and Poor Adipose Clips

A good adipose clip is one which is cut neither too deep nor too shallow, and where no evidence exists that the fin was ever present when viewed under a dissecting microscope or through a magnifier.

The two most commonly encountered problems in adipose fin clipping are clips that are too deep or too shallow. Too deep a clip will be visible as a white spot in the clipped area indicating that some skin was taken off (Fig. 5). Since any scalping of the back of the fry may result in fish mortality, such clipping should be discontinued. A proper clipping technique will not eliminate deep cuts completely, but will reduce their incidence to perhaps 10 to 20 fish per day, instead of 15-20% of the total group or, in one documented case, over 50% of the fish tagged.

Too shallow a clip will appear as a peak or a bump of an adipose fin left on the clipped fish and will be visible when the fish is turned sideways.
The most common problem is to leave a tip at the anterior part of the adipose fin. Such an incomplete clip, especially on small fish, will likely result in regeneration.

(A) Proper Tag Placement Within Cartilege



(B) Improper Tag Placements

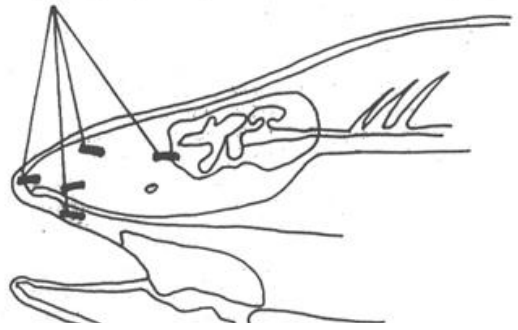


Figure 3. Proper (A) and improper (B) coded-wire tag placement.

5. MORTALIY

Acceptable Mortality Level

An acceptable tagging mortality level is 100-200 mortalities for every 100,000 fish tagged, or 0.1-0.2% of the tagged population. At the surveyed hatcheries, acceptable tagging mortality levels ranged from 0% to <2.0% (Table6). In fact, it is possible for only 10 or 20 fish in a group of 100,000 to succumb during a tagging operation. Normal rates should be about 5 mortalities per day and if this increases to about 40 per day, both the tagging supervisor and the hatchery manager should begin looking for specific problems. The marking procedure itself does not result in marking mortalities. However, fish handling during tagging may be incorrect, or the fish may be smelting, or not fully recovered from a recent disease treatment, or unhealthy as indicated by increased mortalities prior to tagging. Specific fish handling concerns that should be checked when mortalities occur include anaesthetic mis-use, deep clips and poor water quality. These and other mortality factors are discussed individually below.

Anaesthetic Mis-use

Anaesthetic mis-use is the primary cause offish handling mortalities. The length of time the fish are left in the anaesthetic bath and the concentration of anaesthetic are the primary concerns. Note that:

1. Leaving the fish in an anaesthetic bath too long will result in fish kill.
2. Not changing the anaesthetic frequently enough will result in oxygen depletion and increase in the bath temperature, both factors leading to fish stress and possible mortality. It is the author's experience that the anaesthetic bath temperature can rise 2^0C within just over half an hour. This increase is sufficient to shock the fish but this state is not apparent when they are immobilized.

Assuming correct anaesthetic concentration, the following precautions are recommended to minimize tagging mortality from anaesthetic mis-use:

1. Carefully monitor the length of time that the fish are immersed in the anaesthetic bath.
2. Change the anaesthetic bath every half hour, and provide constant aeration and temperature monitoring to assure adequate oxygen levels and an even ambient temperature in the anaesthetic bath.

WHAT SHOULD I BE LOOKING FOR?

1. QUALITY CONTROL CHECKS - GENERAL

Always conduct quality control checks. It is human nature that better tagging performance will be obtained with frequent quality control checks. Check frequently tag positioning, tag retention, fin clip quality, mortality *levels* and marking speed.

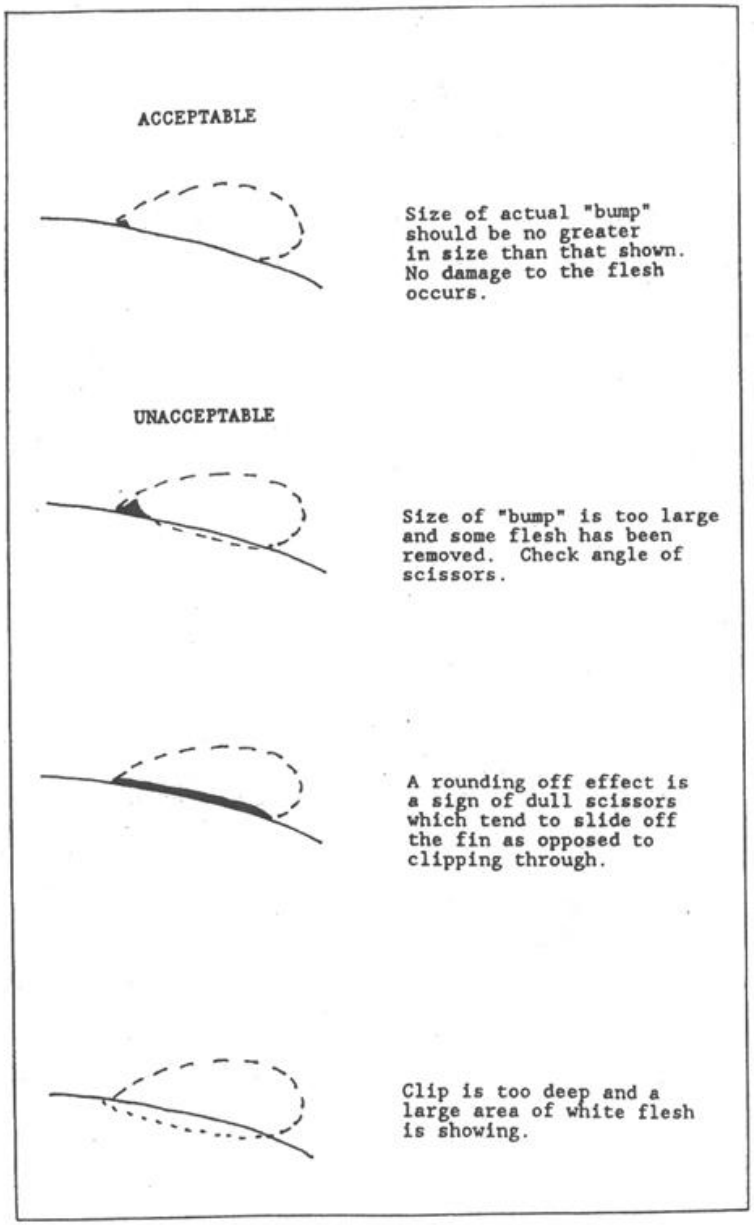
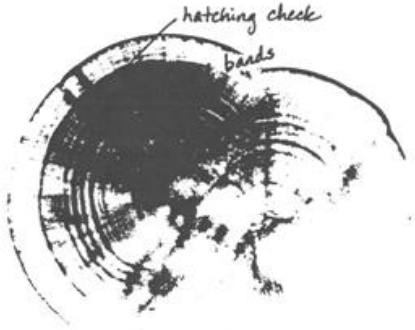


Figure 5. Acceptable and unacceptable adipose fin clips.

Photos taken: Dec. 16, 1992.

Photos of Thermal Marked Chinook
from Robertson Ck. Hatchery, Dec. 1992

~~Pg. 1~~ 7

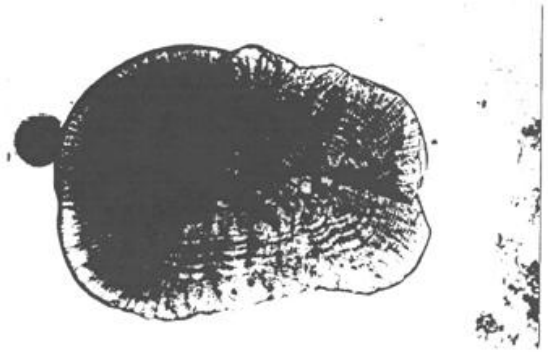


Otolith Surface
TM92-001
fish #1 Left

- 4 bands of thermal mark are indicated.

Magnification = 200 X 3.3 FK.
(unless otherwise indicated)

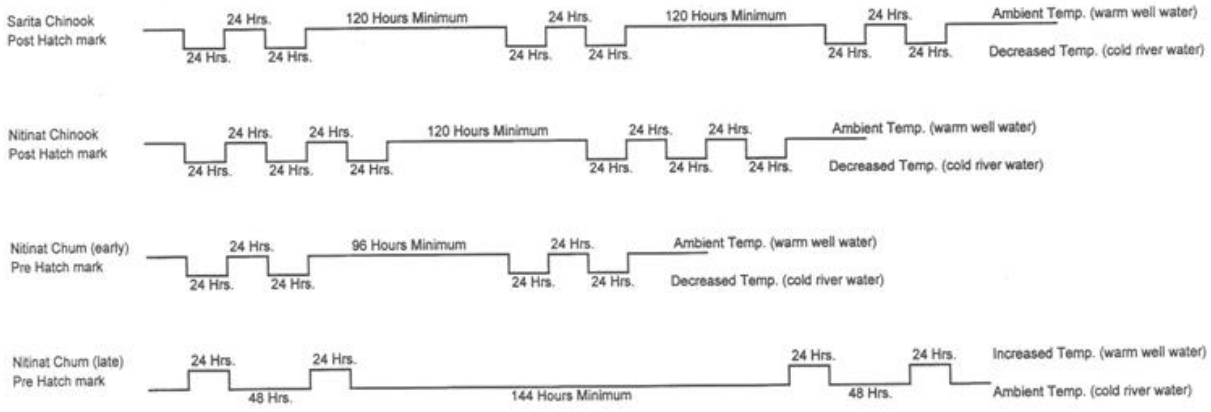
HT #1



TM92-002
fish #1 Right

HT #1 4 hr. expt

Otolith Marking, 1994 Brood Nitinat Hatchery



Puntledge River Hatchery - Coded Wire Tag Program

DATE	ANAESTHETIC
SPECIES	CONCENTRATION ML LT
GROUP	TAG CODE

SUMMARY OF NUMBERS TAGGED

MACHINE #1	MACHINE #2	SESSION TOTALS
Session Finish:	Session Finish:	
Rejects:	Rejects:	
Total:	Total:	
Retentions: %	Retentions: %	
Start Temp °C:	Start Temp °C:	
Session Finish:	Session Finish:	
Rejects:	Rejects:	
Total:	Total:	
Retentions: %	Retentions: %	
Start Temp °C:	Start Temp °C:	
Session Finish:	Session Finish:	
Rejects:	Rejects:	
Total:	Total:	
Retentions: %	Retentions: %	
Start Temp °C:	Start Temp °C:	
COMMENTS:		DAILY GRAND TOTAL

27/8/97

TAGMARK.XLS, tm-03

TRANSPORT Part I

PREPARATION

As Westers (1981) pointed out, fish transport often is the final activity undertaken in the hatchery program and, without meticulous planning, it is possible to destroy a significant portion of the year's hatchery production in this one operation.
Prior to starting any preparations, a fish transport permit must be applied for both freshwater and saltwater destinations two months before the date of the proposed transplant. Blank forms can be obtained from Ms. D. Kieser, Transplant Committee, Pacific Biological Station, Nanaimo, B.C. V9R 5K6.

Vehicles and all associated transport equipment should be serviced and tested in advance of transport, and the route should be carefully planned and test driven to ensure access to the release site and minimize stress on the fish. Routes involving travel on ferries can require a special letter of permission to allow the aeration system to remain running during the ferry ride.

The transport system and all support items which make contact with the water (eg. aerators, release hoses, dip nets, boots, etc.) must be thoroughly disinfected before use.
The water temperatures at both the hatchery and the release site should be monitored. Temperature differences of 2-3°C are tolerable, but greater differences are likely to stress the fish. If the difference is greater than 23 C, thought should be given to altering the release date or, where possible, acclimating the fish at the hatchery to the release site's temperature over a period of several days. The use of lower temperatures during transfers of normal duration will not affect acclimation (Kennedy 1978).

LOADING

Except where cannibalism or eye picking problems occur, juvenile fish should be starved for two days before loading to avoid having the water fouled by feces and reduce ammonia build-up during transport (approach this practice with caution). In the past, it has been suggested that fish be crowded by screens into a small part of their raceways to accustom them to being crowded. The benefits of this procedure now are in doubt. The fish should be in good health, and should not be smolting. The latter requirement is somewhat impractical, in that this is when most juveniles are moved in the federal hatchery system. However where it is possible to move fish earlier, do so.
Fish are transferred into the transport container in various ways. The most common method with small numbers of fish is to crowd the fish using screens or nets into a small section of the holding or rearing container, then to dip net the fish into the tank. With large numbers of juveniles (ie. over 100,000), commercially available fish pumps are recommended; use of dip nets and buckets results in long loading times and heavy stressing of the juveniles prior to transport. A fish pump in good order can load 500,000—600,000 fry in 30—45 minutes with little mechanical injury.
It is important to reduce stress during loading. The loading operation should not be hurried. Loading excites the fish and they use much more oxygen than usual immediately after loading. For this reason, aeration is especially important during loading and for

about an hour after. If feasible, water should run into the tank and overflow for a time after loading if there is no control of oxygen level. When compressed oxygen is used, it is normal procedure to charge the transport tank with oxygen to the 135% saturation level at loading. As the fish calm down after loading, the amount of pure oxygen required is reduced and the delivery rate can be adjusted to maintain 80%.
The number of fish that can be carried in a given tank depends on several factors. The higher the temperature, the smaller the fish, and the longer the trip, the less the weight of fish that can be moved successfully. Hatchery personnel can modify loading rates as they gain experience.

During Conuma Hatchery operations (B. Anderson) it was observed that chum salmon fry loaded at > 0.2 kg/litre were disoriented upon release into quiet water; some swam into the current, while others dove to the bottom or swam into shore. It took about 15 minutes to establish schooling and downstream migration behaviour at these higher densities,' whereas these schooling and migration behaviours were immediate at densities < 0.2 kg/litre.

At Puntledge Hatchery a loading rate of**, 10** kg / litre of water. For example: For every 1000 litres of water we add 100 kg of fry. Total tank volume is 1100 litres or kilograms.
In order to load tank efficiently we fill transport tank to a pre set mark at 1000 litres. Then we added 100 litres of water (fish) and put another mark on tank wall. Next procedure is to sample an accurate individual weight of fish and calculate the number of fish to fill 100kg of tank space.

$$\text{Loading density (kg/litre)} = \frac{\text{Kg of Fish}}{\text{tank capacity (Litres)} - \text{water displaced by fish (Litres)}}$$

Juvenile fish preferably should be weighed, as they are loaded. This can be cumbersome as you weigh large buckets of fish and lift into transport tank. An alternative method is to note the amount of water that they displace when loaded into the transportation tank. This method greatly reduces handling of the fish and allows use of a fish pump. All you need to do is measure the total volume of your transport tank. Near the highest water level you can affix a centimetre ruler to calibrate displacement. Add and measure in litres enough water to reach 10 cm

below the highest mark on ruler. Now add as many litres of water to add up to standard loading density, (ie add 100 litres = 100 kg = 5 cm rise on tank). After you add fish to desired density fill remaining space with water.

If the sides of the tank are not perpendicular, the amount needed to fill the tank to a given level can be found by filling it with a known quantity of water. Depths corresponding to specific volumes of water can be marked on the tank or on a measuring stick.

Adding common salt (no YSI sodium chloride) to the transport water to make a 0.5% solution seems to lessen moralities through reduction of osmosis regulatory demand. The process of aerating water in which fish are being transported causes copious foaming at the water surface. Sometimes anti-foaming agents are used to control foaming. Use ofMS-222 for sedation of salmonids during loading or transport is not advised (Piper et al 1982) nor necessary. After about an hour, carbon dioxide levels reach 20-30 ppm and appear to sedate the fish.

TRANSPORT

The fish should be examined at least hourly during the trip. At each stop, dissolved oxygen and water temperature levels are checked, usually by meter. Compressed air and oxygen supplies and aeration lines also must be checked carefully. Where possible, the gauges on the air and oxygen bottles should be visible from inside the truck cab. It is also helpful if the set-up allows continuous reading of dissolved oxygen and water temperature from the truck cab. The rate at which air or oxygen is delivered should be regulated to keep the water 80-100% saturated with dissolved oxygen. Using an 1125 litre transport tank, a 0.25 kg/litre loading density and at water temperatures of 4-8 **C,** initial air and oxygen delivery rates should be about 10 and 5 1pm respectively. As the fish calm down, the oxygen delivery rates can be reduced to 2 1pm or less. Water temperature should not rise more than a few degrees over the duration of the trip.

If fish show signs of stress during an inspection, it is probably because of insufficient oxygen in the water. Unless oxygen is monitored and known to be acceptable, aeration should be improved if fish show distress. In an emergency, water should be replaced if possible, or pumped up and sprayed back by some Improvised arrangement. Failing that, water can be aerated by repeatedly dipping out a pail-full and pouring it back into the tank with maximum splashing and agitation. If water temperature is too warm, some means of cooling it should be found. As commercially available ice blocks or cubes are normally made using chlorinated water, the ice should not be added directly to the tank. Place the ice in a plastic bag or other type of leak-proof container before putting it in the tank.

In the hatchery, a continual flow of water carries away the carbon dioxide and ammonia that the fish produce in metabolism. However, these metabolites accumulate during transportation without water renewal. Aeration drives off enough of the carbon dioxide, such that dangerous amounts do not accumulate as long as the water remains well— aerated and cool. However, ammonia will continue to build up throughout the trip. Most of the ammonia ionizes, and only the un-ionized remainder is harmful to fish. Fortunately the lower the pH, the greater the proportion of ammonia that ionizes. Carbon dioxide, when dissolved in water, forms carbonic acid, which lowers pH. Thus the carbon dioxide that fish produce while being transported helps keep the level of un-ionized ammonia low enough that salmonids can tolerate it, except on lengthy trips. If a long trip is contemplated, planning should include establishment of water exchange sites and procedures. Tank water should not be dumped en route where there is any change of it entering a stream course, unless it is disinfected and neutralized first.

RELEASE

Most salmonids that are transported are taken to a place where they are to be released into the natural environment. Transportation stresses salmonids and their chances of survival after release may be improved by keeping them in a net pen at the release site for some days before release. This may also help to imprint them so that they will return to that area as adults. However, it has been found that fry transported at 0.25 kg/litre with air and oxygen aeration are capable of maintaining position in velocities of 10-15 cm/sec for 24 hrs. Therefore, direct release into slow moving areas may be equally successful.

Before unloading at a release site or at another hatchery, it was usual in the past to "temper" the tank water with water from the new environment over 20-30min. The need for this is questionable. For some recent releases on Vancouver Island, tank oxygen levels have been matched to stream levels. This seems to reduce the jumping and erratic behaviour of release fish.

Fresh Water to Salt Water Release

If the transfer is from fresh to salt water, some additional precautions are necessary. If juveniles are placed into saltwater too early, they will fail to grow, if not die (Kennedy 1978). The size at which successful transfer can occur varies with the species and with the degree of freshwater influence. Pink and chum salmon can be safely transferred to salinities of 10-30 ppl when they are fully buttoned-up (approximately a week after emergence). The three remaining salmon species can tolerate transfer to salt water that is less than 20 ppl at 1.5-2.0 g, but optimum size for full strength seawater is 5 g for Chinook, 8 g for yearling Coho, and 35 9 for yearling steelhead. (Clarke 1982.) (Optimum size considerations, however, will be overridden by the seasonal 'window', when fish are physiologically prepared to smolt). Although fish have often been transferred abruptly from fresh to salt water without obvious detrimental impact, it is advisable to alter salinity gradually over about five days, if the capability exists to do so.
After each trip, the tank and all equipment used to handle the fish should be thoroughly cleaned and disinfected as outlined In the Preparation section.

These documents have been altered from original material to be used for the Puntledge Training Workshop. My apologies for streamlining this manual for our use. (Doc. no. 1946 Published Aug. 1987 -Fish transport techniques in common use at Salmon Enhancement Facilities in B.C. By B.G. Shepherd and G.F.Berezay

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Salmon Transport Methods Part II

Parameters involved in transporting salmonids at any life stage are extremely variable;
therefore it is advisable to use the following information as a guideline only.

Densities given have been, and are used very successfully, but many factors, both
Physical and/or physiological will affect safe loading rates. With this in mind, one can ? ok at what salmonid eggs, fry/smolts and adults require in the way of proper, transport and release techniques. Equipment is also an important factor in all transfers and should be a key aspect of the transport "plan".

FACTORS INVOLVED IN TRANSPORTING (Physiological Factors) Eggs

1. Require oxygen and a constant cool temperature while in transport.
2. Green eggs (unfertilized) must be cool and free from water and direct sunlight.
3. Keep sperm in a watertight container with air/02 space. Also keep free from water and direct sunlight. (Whirl bags)
4. Water hardened eggs: transfer in containers with clean cool water. Do not shock or bump container.

Fry & Adults

1. Require a constant oxygen level (8-12 ppm) along with cool water temperatures not exceeding 20.0 C*
2. Metabolic wastes such as ammonia, carbon dioxide and nitrogen should also be limited.
3. **STRESS** is a major limiting factor to the loading capacity of the transport system. Stress can be derived from a number of areas: water quality and temperature, fish health, metabolism and environmental conditions are but a few variables. During the transport operation, stresses will be caused by crowding, dip netting and water quality deterioration within the tank. Upon release, the fish is stressed not only by the physical release, but also by its new environment. Stress can hinder growth and smoltification, or it can trigger disease outbreaks.

4. Stress taxes a fish's energy, which one would preferably have used in other
physiological processes. If stress is minimized, then metabolic wastes will be less and fish health will be better, thus providing a better chance for survival. This is one area where good practical fish culture and planning can be beneficial.

Practical Factors:

1. ** **Have the Necessary Transplant Approvals Been Obtained?**
2. When considering any transport one must ask the following questions:
3. Number of eggs/fish and available time to transfer
4. Costs associated with project
5. Equipment availability/practicality and condition
6. Accessibility to transfer locations
7. Prior knowledge of operation & information available
8. Implications of transfer-logistics

Egg Transport:

Green Eggs

1. Can transfer gametes separately in a cooler or bucket or small buckets in cooler
2. Ensure temperature is kept cool and eggs/sperm away from direct sunlight and rain
3. If fertilization is more than 4 hours away then if possible, add oxygen to sperm bags
4. Acclimatize gametes at incubation site by placing in buckets floating in facility water (fertilize in water less than 16.0 C)
5. Fertilize using standard hatchery practices
6. Record procedures & temperatures for future reference
7. Disinfecting at receiving facility if necessary

Off-Site Fertilization

1. Fertilize eggs and rinse in stream water
2. Fill egg container with water
3. Place in a location away from direct rays of sun and in the shade or in the running stream
4. If possible wait 2 hours until eggs are water-hardened before transferring to incubation site
5. Record procedures for future reference

Eyed Eggs

1. Transfer eyed eggs preferably after picking moralities
2. Ensure a means of keeping eggs cool, **ie:** ice in bottom of tray of transport box or in cooler '"important. - Do not allow the eggs to be in direct contact with ice.
3. Moisten towels with clean, cool non-chlorinated water and wrap around eggs in tray, bucket, cooler, etc.
4. Maintain temperature monitoring of eggs while transferring
5. May re-moisten towels with cool water if necessary?
6. Disinfect at receiving facility at 100~ppm available iodine for 10 minutes
7. Place eggs in new incubator
8. Disinfect transfer containers (250-ppm recommended)
9. Adjust records accordingly

Fry/Smolt Transport;

Logistics of the Move

1. Where are the fish to be transferred to? Release sites.
2. Ensure access to release sites and suitable environment for fish, ie: water temp, sheltered areas, predators and land access approval
3. "Scout out" potential release locations BEFORE actually transferring fry
4. Check that all transport equipment is available and is functioning properly
5. Review plan with crew involved
6. Have alternate plan of action if problems arise - more than one back-up plan has been put into effect with past smolt/fry transfers
7. Record important information
8. Do a dry run to see if plan works!

Equipment

1. Ensure all of the equipment to be used is in good condition and is functioning properly
2. What is the back-up system? Second oxygen system, water pump system to flush tank, buckets to exchange water?
3. Make sure all of equipment has been disinfected if pertinent
4. A "dry-run" of procedures may be helpful before actually moving fish (if deemed necessary) assess abilities of both equipment and crew

Fish

1. A successful transplant starts with healthy fish
2. Ensure fish are in good condition before transfer
3. Avoid handling fish for at least 7 days before
4. Starve fish from 48-72 hours prior to transport
5. Fish transport best when their stomachs are empty
6. Lower metabolism as food digested, therefore can maintain a higher quality of transport tank water
7. May want to sample fish - best before day of release

8. Reduce fish stress - careful handling and proper procedures

Loading Densities

LOAD RATES will depend on a number of different criteria:

Temperature

-Cooler water contains more oxygen than warm water and fish also metabolize less in cooler water than warmer water therefore loading densities can be greater in cool water

Fish size

-The larger fry have a lower metabolic rate than smaller fish, therefore more larger fish can be transferred per trip (weight wise) than smaller fish

Water quality

-Some transport systems maintain water quality better than others depending on set-up.
-Maintain oxygen level at 6-12 ppm throughout trip

Transit time

-if trips are in excess of 2 hours then loads should be lowered accordingly

Additives

-Salts (non YSI) added to the tank water can help maintain both water and fish quality. Anti foaming agents might be used also.
-Use marine grade salts at 3-12 ppm
-Anaesthetics have been used but are not often recommended for various reasons such as: difficulty in measuring and control, (smolt impeding, residual effects, etc)

***Costs .**

1. If time and dollars available then reduce loading densities
2. Helicopter transfers are expensive and densities will be maximized
3. One group uses the Coast Guard for helicopter service.

** **SAFE** loading densities for juvenile salmonids is 150-gms/litre or 0.15 to 0.17 kg/litre (greater if fish healthy, water quality good and short duration.) At Puntledge we use this for heli. transports and 0.10 for transport tanks with a longer transit time.
** **Remember** in your calculations that fish displace water; thereby the full capacity of the tank is not available if you fill it up to capacity before loading fish.

Loading without aeration

If no aeration than load at 0.013 kg/litre and at 70% saturation ie: *(0.7)*(OA3)* kg/litre = 0.009 kg/litre

Loading Transport Unit

The fish have been starved and are healthy. The crew is aware of procedures and all equipment is ready end functioning properly. Calibrate all oxygen meters!!!

1. Minimize stress by careful yet swift handling of the fish
2. Ensure crew are ready to begin
3. Crowd fish if necessary
4. Charge tank with oxygen at 3-6 1pm (lower if using ceramic stones)
5. Dip fish from rearing unit and drain most of water from net (be discrete with time to drain net)
6. If using a scale: Pour fish from net into large bucket on scale w/ water. (Record wt.)
7. If using displacement: Pour fish into transport tank with water to start up level. (Use a ruler in cm and fill to appropriate # of centimetre rise)
8. Check and record displacement of fish in tank
9. Continue this until loading density in tank is obtained
10. Do 1 kg sub-sample offish (# fish/kg) and record
11. Lower oxygen flow to 2-41pm as this will ensure sufficient oxygen for fish but will not supersaturate water (* lower flow rate if using ceramic stone to: 1/2 -1&1/2 1pm)
12. Observe fish and ensure they are OK Check oxygen levels and record
13. Secure lid (spill-proof)
14. Head for release location via quickest route

Transport

1. Use an oxygen meter if available and practical to monitor and/or change the oxygen level in the tank. We usually keep probe in tank during transport for real time reading.
2. Stop and observe fish every 20-60 minutes or as necessary (longer if using probe)
3. Fish when checked should usually head to the bottom of the tank when lid is opened
4. If fish look sluggish and ride high, or have their heads out of water then more oxygen may be needed
5. If fish are skittish on top, then the water may be supersaturated with oxygen (lower oxygen flow)

THERE IS A FINE LINE BETWEEN ENOUGH OXYGEN AND SUPERSATURATION

1. When water becomes supersaturated then the oxygen level is too high. This can damage the fish.
2. Knowing the best level is knowing fish and their behaviour - practice is the best educator.
3. If problems arise with either equipment or fish - you may wish to use the "back-up plan" and/or radio for help

Release

1. If scatter-planting fish, then buckets or backpacks etc can be used. Ensure water quality is adequate for the duration the fish are in the container (portable aerators).
2. Although acclimatization may seem necessary at this time, it is now proven not pertinent as adjustment time is not adequate to benefit fish (acclimatize fish at hatchery from 2-3 *days* prior to transfer) if possible and necessary
3. When releasing with a hose make sure outlet is smooth and free from any
obstructions, which may harm fish as they pass. A calm area is best as it allows the fish to reorient themselves and swim away on their own
4. Ensure release hoses are flushed
5. Watch fish: for reactions to transfer and new environment
6. Record pertinent information
7. Shut off oxygen systems (*ENSURE this is done) and gather equipment

Post-Release

1. Review operation and evaluate all aspects

2. Record event and pertinent information for future reference
3. Make improvements if necessary
4. Clean, repair and maintain equipment used
5. Compare weight figures to book balance
6. Document release summary including all pertinent information on release group

Adult Transport

1. Loading densities depend on the condition of the adult and water quality parameters such as temperature, etc
2. Some species of adult salmonids seem more tolerant of stress than others. Generally Chinook tend to be the most difficult to transfer in heavier densities whereas chum can often be loaded quite heavily
3. Evaluate the condition of the adults before transport and load accordingly
4. Adult-loading densities can generally be greater than in fry/smolt transport

Health and Safety

1. Air stones should never be removed from water when compressed gas is flowing. Air stones have been known to explode under excessive pressure.
2. Never leave air stones in tank when empty as they may break on bumps.
3. Protect stones from freezing, as water trapped in stone will expand.
4. Always use a regulator with flow meter not exceeding 20-30 psi
5. Carry a first aid kit during transports. Also spare hoses, couplers & tool kit.

Juvenile Transport Guidelines

Species	Density Kg/lts	Tank Cap.lts	Size of Fish gm	Total #fish	Time duration
Coho	0.21	220	6.0	7700	20 min.
Chinook	0.15	1000	7.0	21500	2.5 hrs
Chum	0.10	1800	0.90	200000	1.0 hrs
Pink	0.06	1800	0.23	450000	1.0 hrs

Adult Transport Guidelines

Species	Density Kg/lts	Tank Cap.lts	Size of Fish gm	Total #fish	Time duration
Coho	0.26	1000	3000	88	2.0 hrs
Chinook	0.15	1000	9000	17	4.0 hrs
Chum	0.32	1000	4000	80	1 hr.
Pinks	0.22	1000	1500	150	2.0 hrs

PREVENTION OF INFECTIOUS DISEASES

The best way to control disease is to **prevent it.**

Infectious disease occurs as the result of interactions among: a fish; a pathogen; and the environment. Fish are much more at the mercy of their environment than we humans. For instance, even if unclothed, a person's internal temperature remains virtually unchanged over a wide range of air temperatures, and the only consequence is discomfort. By contrast, a fish's internal temperature is always essentially the same as that of the water in which it swims, and a sudden change in water temperature requires immediate and often drastic changes in the fish's physiology. Our comparative independence from external temperature is only one of many ways in which we are much less at the mercy of our environment than is a fish. Unlike us, when the fish's environment changes even slightly, it must adjust physiologically. If it cannot adjust sufficiently and fast enough, it dies. If it can adjust, it survives, but the physiological "effort" may cause stress. When a fish is under stress and pathogens are present, disease may result. Apart from environmental fluctuations, such as sudden changes in water temperature, stress in hatchery fish can be caused by overcrowding or by activities such as handling, sorting, counting, sampling, and trough cleaning. An important factor in these activities is fright. Fright stresses fish greatly; fish can literally be scared to death. Among many ways of avoiding stress, a fish pump, properly used, appears to be good for moving fish from one tank to another. Water requirements are discussed in Water Quality, including oxygen needs and the degree of crowding that causes stress. Water Quality also indicates the concentrations at which some toxic substances cause stress. Salmonids are also stressed by continual exposure to water temperatures above 18 C or to pH values outside the range 6 — 9. Another approach to disease prevention is to minimize the chances of hatchery fish being exposed to disease causing pathogens. The first consideration is preventing such pathogens from becoming established in the hatchery area. Disease-causing agents or pathogens can be brought into a hatchery by people who have just visited another fish hatchery or, particularly, who have just handled salmonid carcasses. To decrease risks of disease from this source, such people should wash their hands with soap and hot water and disinfect or change footwear. It is less urgent, but still advisable, to change outer clothing as well. Many hatcheries rear salmonids in surface water from some part of a river system. There are generally wild fish in the river system, some of which carry pathogens. Infected fish in the water supply are a continuing potential source of disease to hatchery fish. The use of water from deep wells would virtually eliminate this problem and the elimination of salmonids from that part of the river system above the hatchery water—intake would greatly reduce the risk. Because of other considerations, it is unlikely that either alternative will be feasible at any established salmonid hatchery. However, hatchery personnel should at least be aware of the danger and of alternatives. Serious thought should be given to ways of killing pathogens in the water supply prior to use, such as: ozone treatment; irradiation; or chlorination followed by dechlorination. Wild fish in the water supply can be particularly unfortunate if they can move easily from waters below the hatchery water discharge to waters above the hatchery water intake. When they are in hatchery discharge water, they are exposed to diluted medicines used to treat hatchery diseases. Such exposure can cause the development of a

strain of fish disease pathogen resistant to one or more of the medicines used. When the wild fish then move above the hatchery intake, any resistant pathogens that they shed are carried into the hatchery. As a result, the usual treatment may become ineffective. In most salmonid hatcheries, eggs are taken from wild fish and some of the parents used carry infectious diseases. Eggs taken from diseased parents are a potential source of disease in the hatchery. However, at most salmonid hatcheries, the eggs are treated with a disinfectant, which kills pathogens on the egg surface. This procedure is designed to prevent parent-to-egg transfer of pathogens, and appears to be effective in preventing disease from entering hatcheries by this route. Except during early feeding, hatchery salmonids are fed pellets in which fishmeal is a major ingredient. The methods now used to prepare fish diets should ensure that any diseases of the fish used for fishmeal are not transmitted to hatchery fish. However, at an earlier time, hatchery diseases were often the result of using feed made from infected fish. Hatchery personnel should realize that feed is a potential source of disease and ensure that the feed used has been prepared by a method that kills pathogens. While it is obviously desirable to keep pathogens out of the hatchery, no precautions will keep them out entirely. A third approach to disease prevention is to minimize the concentrations of pathogens within the hatchery. People can move pathogens within the hatchery area on hands, feet, and to a lesser extent, outer clothing. Frequent hand—washing with soap and hot water and the use of disinfectant foot baths (waterproof footwear is assumed) will reduce the risk. In most salmonid hatcheries, the spread of disease is minimized by thoroughly disinfecting brushes, dip nets, etc. before and after use, and between using them for one lot of fish and using them for another. Ponds are either cleaned and disinfected or thoroughly sun-dried after use before a new lot of fish is put into them. Several disinfectants whose active ingredient is chlorine have been used successfully for many years. More recently developed disinfectants that are regularly used include: wescodyne, betadine, and ovidine, whose active ingredient is
iodine; and roccal, whose active ingredient is ammonia. All should be used according to the manufacturer's directions. For disinfecting equipment, wescodine, betadine and ovidine should be diluted t~ 400 PPM of active ingredient, and roccal and hyamine to 600 PPM of active ingredient. Chlorine **is** the cheapest. However, unless the equipment is properly flushed after use, some chlorine is deposited on it. It re-dissolves when the equipment is next used, to the detriment offish. General cleanliness in the hatchery area is essential. The mixture offish feces and uneaten feed that accumulates on the bottoms of ponds is a potential source of disease and should be removed at least daily where feasible. The design of some ponds makes removal difficult. In such
cases, great skill is needed to remove the sludge without unduly stressing the fish. It is important that the carcasses offish that die in hatchery ponds be recovered and buried, incinerated or otherwise disposed of in a way that eliminates them as a potential source of disease within the
hatchery. This also removes an attractant to predators.

Definition of stress

Stress has been defined in many different ways. A general definition of stress in human medicine was initially proposed by Selye *(1950),* as "the sum of all the physiological responses by which an animal tries to maintain or re-establish a normal metabolism in the face of a physical or chemical force." More specifically, stress in fish results from environmental or other factors that extend the animal's physiological processes beyond the normal range.

Sources of stress

Stress in intensive fish culture is almost unavoidable. Fish are subjected to numerous environmental conditions and husbandry procedures that are stressful. Some of the major sources of stress in fish culture include vaccination, handling, sorting, grading, crowding and transport. Stress induced by such practices may result in decreased growth and increased susceptibility to disease, and in cases where the stress is severe enough, death may result.

Physiology of stress in fish

In response to a stressor such as handling or crowding, a fish will undergo a series of biochemical and physiological changes in an attempt to compensate for the challenge imposed upon it. These changes are collectively known as the "generalized stress response" and have been termed the General Adaptation Syndrome (GAS) by Selye *(1950),* in which the stress response involves three stages:

1) *An Alarm Reaction.* Recognition of the stressful event by the fish activates neuro-endocrine responses, and "stress" hormones, notably adrenaline and cortisol, are released into the bloodstream.

2) *Resistance Stage.* A series of physiological processes occur that enable the fish to acclimate, or adapt, to the stress.

3) *Exhaustion Stage.* If the duration or severity of the stress exceeds the tolerance limits of the fish, then adverse physiological effects occur.

Biological stress indicators

For fish, a useful framework for considering the stress response in terms of primary, secondary and tertiary levels of organization has been developed (seeWedemeyer et al. 1990).

Primary response. During the alarm reaction stage, the endocrine system releases adrenocorticotrophic hormone (ACTH) from the pituitary gland. This hormone enters the blood stream and stimulates the interrenal cells of the head kidney tissue to produce cortisol. Chromaffin cells, found in the same general area, release adrenaline. These hormones are often referred to as the "stress hormones

Secondary response. The stress hormones activate a number of metabolic pathways that result in alterations in blood chemistry and hematology. These effects include increases in blood concentrations of glucose and lactate, and decreases in chloride ion concentration and white blood cell numbers.

Tertiary response. If the fish is unable to acclimate or adapt to the stress, whole animal changes may occur, such as decreases in growth, disease resistance, reproductive success, smoking, swimming performance, etc. At a population level, decreased recruitment and productivity may alter community species abundance and diversity.

Fish Health *(*Fish Disease)

Control of diseases in hatchery fish can be achieved best by a program of good fish management. This involves maintaining the fish in a good environment, with good nutrition and a minimum of stress. However, attempts should be made to eradicate the serious diseases from places where they occur. *Containment is* accomplished by not transferring diseased fish into areas where the disease does not already exist. *Eradication,* when feasible and beneficial, involves the removal of infected fish populations and chemical decontamination of facilities and equipment. In some cases, simply keeping additional disease agents from contaminated waters can result in effective eradication.

Disease Characteristics

Disease- Cawing Organisms

Organisms that cause diseases in fish include viruses, bacteria, fungi, protozoan, and a wide range of invertebrate animals. Generally, they can be categorized as either pathogens or parasites, although the distinction is not always clear. For our purposes, we consider sub cellular and unicellular organisms (viruses, bacteria) to be pathogens. Protozoan and multicellular organisms (invertebrate animals) are parasites, and can reside either inside the host (endoparasites) or outside it (ectoparasites). Low numbers of either pathogens or parasites do not always cause disease signs in fish. Viruses are neither plant nor animal. They have been particularly successful in infecting fish. Viruses are sub microscopic disease agents that are completely dependent upon living cells for their replication. All known viruses are considered infective agents and often have highly specific requirements for a particular host and for certain tissues within that host. Deficiencies or excesses in the major components of the diet (proteins, amino acids, fats, carbohydrates, and fibre) often are the primary cause of secondary bacterial, fungal, and parasitic diseases. Fish with a diet deficient in protein or any of the indispensable amino acids will not be healthy and will be a prime target for infectious agents. The same is true of deficiencies of fatty acids or excesses of digestible carbohydrates. Secondary disease agents may infect a fish in which biochemical functions are impaired.

Disease Recognition

Disease can be defined briefly as any deviation of the body from its normal or healthy state causing discomfort, sickness, inconvenience, or death. When parasites become numerous on a fish, they may cause changes in behaviour or produce other obvious signs. Individual diseases do not always produce a single sign or characteristic that is diagnostic in itself. Nevertheless, by observing the signs exhibited one usually can narrow down the cause of the trouble to a particular type of causative agent. Some of the obvious changes in behaviour offish suffering from a disease, parasite, or other physical affliction are

(1) loss of appetite;

(2) abnormal distribution ~fl a pond or raceway, such as swimming at the surface, along the tank sides, or in slack water, or crowding at the head or tail screens,

(3) flashing, scraping on the bottom or projecting objects, darting, whirling, or twisting, and loss of equilibrium; and

(4) weakness, loss of vitality, and loss of ability to withstand stresses during handling, grading, seining, loading, or transportation.

In addition to changes in behaviour, disease may produce physical signs and lesions, or be caused by parasites that can be seen by the unaided eye. Signs observed may be external, internal, or both. For microscopic examination, **it** may be necessary to call in a fish pathologist. Gross external signs of disease include discoloured areas on the body; eroded areas or sores on the body, head, or fins; swelling on the body or gills; popeye; hemorrhages; and cysts containing parasites or tumours. Gross internal signs of disease are colour changes of organs or tissue (pale liver or kidney or congested organs); hemorrhages in organs or tissues, swollen or boil-like lesions; changes in the texture of organs or tissues; accumulated fluid in body cavities; and cysts or tumours. If a serious disease problem is suspected, a pathologist should be contacted for assistance in isolating and identifying the causative agent. If a virus is suspected, contact a laboratory for analysis of tissues. Two other classes of disease are important to fish culturists, in addition to those caused by pathogenic organisms. One is nutritional in origin, and the other concerns environmental factors, including bad hatchery practices and poor water quality, that stress the fish.

Stress and Its Relationship *to Disease*

Stress plays a major role in the susceptibility offish to disease. The difference between health and sickness depends on a delicate balance resulting from the interactions of the disease agent, the fish, and the environment (Figure 78). For example, although bacteria such as species of *Aeromonas*, *PseudomonaS,* and *Flexibacter* are present continuously in most hatchery water supplies, disease seldom occurs unless environmental quality or the defence systems of the fish have deteriorated. Fish in intensive culture are affected continuously by environmental fluctuations and management practices such as handling, crowding, hauling, and drug treatment. All of these, together with associated fright, can impose significant stress on the limited disease defence mechanisms of most fishes. Table 36 presents a list of infectious diseases together with the stress factors known to be predisposing conditions. In addition to sophisticated physiological measurements, behavioural changes, production traits (growth, weight gain or loss, food conversion), morbidity, and mortality are factors that can be used to evaluate the severity of stresses.

figure 78. (A) Frequently, a fish population (l) must interact with a pathogen (2)in an unfavourable environment (3) for an epizootic (l—!—3) to occur. (B) Interaction of more than three factors may be required. In carp hemorrhagic septicemia, a chronic virus infection (1) of the common carp (2), followed by exposure to *Aeromonas liquefaciens* (3) in a stressful environment (4), may be prerequisites to an epizootic (1—2—3—4). (Source: Snieszko 1973.)

Whereas some pathogens of fish are highly virulent and cause disease as soon as they invade a fish, most diseases are stress-related. Prevention of these diseases best can be done through good hatchery management. Environmental stresses and associated disease problems are minimized by high water quality standards, optimum rearing densities, and adequate nutrition. Management stresses such as handling, stocking, drug treatments, hauling, or rapid temperature fluctuations of more than 5 F frequently are associated with the onset of several physiological diseases. Table 37 gives a partial listing of these fish cultural practices, their associated disease problems, and stress mitigation procedures if known.

Some diseases occur at certain hatcheries at regular intervals. When fish culturists are aware of this, there often is sufficient forewarning to treat the fish before the disease reaches a serious stage.

Symptoms

When organisms become numerous on a fish, they may cause changes in its behaviour or produce other obvious symptoms. Unfortunately, each disease or parasite does not always

produce a single symptom or syndrome characteristic in itself. Nevertheless, by observing the symptoms one can usually narrow down the cause of the trouble. Some of the obvious changes in behaviour of fish suffering from a disease, parasite, or other physical affliction are:
(1) loss of appetite,
(2) abnormal distribution in pond, such as riding the surface, gathering at the pond sides or in slack water, and crowding the head or tail screens,
(3) flashing, scraping on bottom or projecting objects, darting, whirling, or twisting, and loss of equilibrium, and
(4) loss of vitality, weakness, and loss of ability to stand handling during grading, seining, loading, or transportation.

In addition to changes in behaviour, disease may produce physical symptoms, or the parasite may be seen by the unaided eye. For microscopic examination, it is necessary to call in a fish disease expert. Symptoms observed may be external or internal, or a combination of both.

Gross external symptoms are:
(1) discoloured areas on the body,
(2) eroded areas or sores on the surface of the body, head, and fins,
(3) swelling on the body or gills,
(4) popeye,
(5) hemorrhages,
(6) cysts containing parasites.

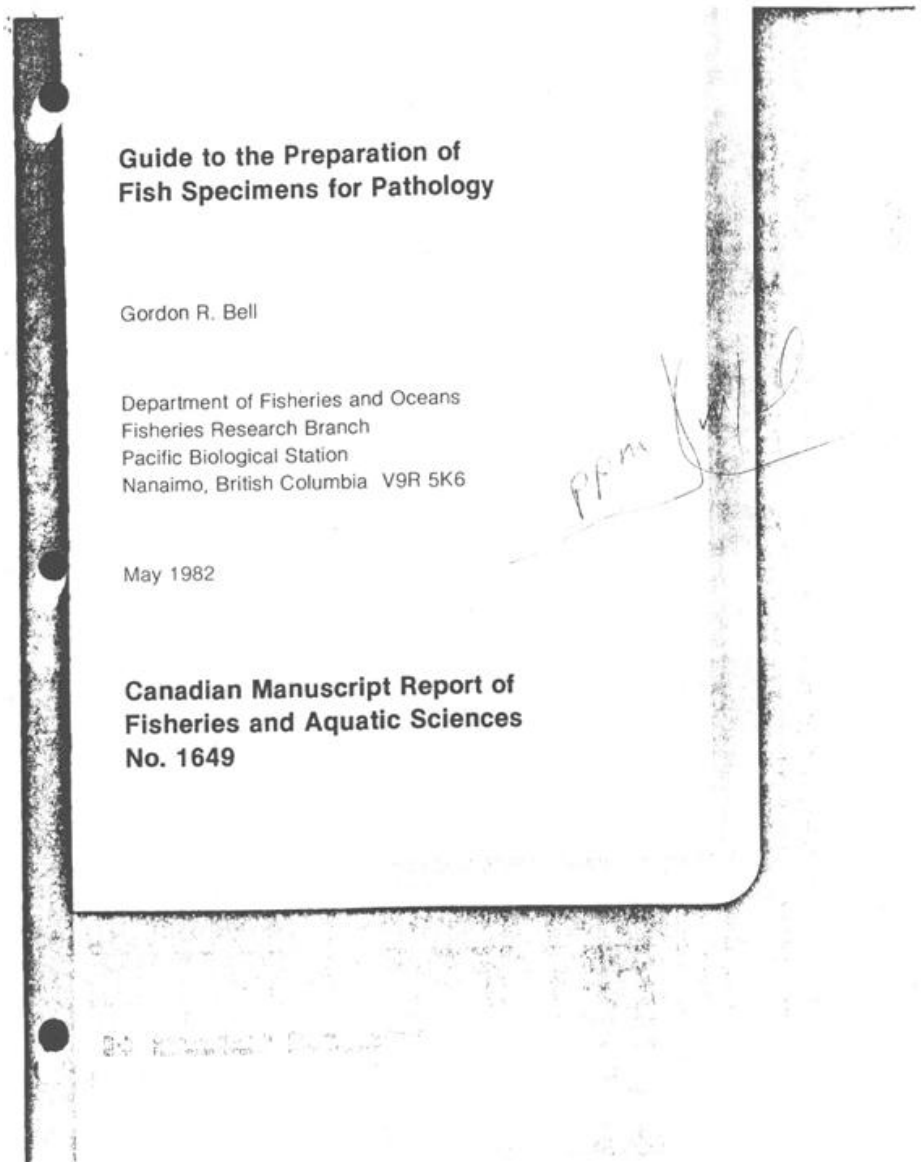
Gross internal symptoms are:
(1) colour changes of organs or tissue (pale liver or kidney or congested organs),
(2) hemorrhages in organs or other tissues,
(3) swollen or boil-like lesions,
(4) change in texture of organs or tissues,
(5) accumulated fluid in body cavities, and
(6) cysts containing parasites.

Diseases and Parasites

Before taking up specific diseases, it will be best to describe briefly a general classification of disease-causing organisms among fish. The majority of such organisms may be placed in two groups. One is the plant kingdom. Bacteria and fungi belong to this group. The other is the animal kingdom. Forms belonging to this group vary from the relatively simple, single celled animals (Protozoa) to the complex, multicelled organisms (Metazoa) such as worms, copepods, and mussels. In addition, mere are two other classes of diseases important to fish culturists. One is nutritional in nature; the other is caused by virus. As previously mentioned, diseases or parasites may be found externally or internally, or both in some cases.

ress factors in the aquatic environment which are debilitating to warm and cold water fish and increase susceptibility to the indicated diseases.

Disease	Environmental stress factors predisposing to disease
Furunculosis *(Aeromonas salmonicida)*	Low oxygen (4 ppm); crowding; handling in the presence of *A. salmonicida*; handling for up to a month prior to an expected epizootic.
Bacterial gill disease *(Myxobacteria sp.)*	Crowding; unfavorable environmental conditions such as chronic low oxygen (4 ppm) and elevated ammonia (1 ppm NH_3-N); particulate matter in water.
Columnaris *(Flexibactor columnaris)*	Crowding or handling during warm (15 C) water periods if carrier fish are present in the water supply; temperature increase to about 30 C, if the pathogen is present, even if not crowded or handled.
Kidney disease *(Corynebacteria salmoninus)*	Water hardness less than about 100 ppm (as $CaCO_3$); diets containing corn gluten or less than about 30% moisture.
Hemorrhagic septicemia *(Aeromonas & Pseudomonas sp)*	Pre-existing protozoan infections such as *Costia* or *Trichodina*; inadequate cleaning leading to increased bacterial load in water; particulate matter in water; handling; crowding; low oxygen; chronic sublethal exposure to heavy metals, pesticides or polychlorinated biphenyls (PCB's); for carp, handling after overwintering.
Enteric Redmouth Disease *(Yersinia ruckeri)*	Water temperatures above 13 C; crowding; handling and grading; high organic content of water.
Vibriosis *(Vibrio anguillarum)*	Handling; dissolved oxygen lower than about 6 ppm, especially at water temperatures of 10-15 C; brackish water.
arasite infestations *(Costia, Trichodina, Hexamita)*	Overcrowding of fry and fingerlings; low oxygen; excessive size variation among fish in ponds.
Spring viremia of carp	Handling after overwintering at low temperatures.
Fin and tail rot	Crowding; improper temperatures; nutritional imbalances; chronic sublethal exposure to PCB's; suspended solids, 200-300 ppm chronically.
Coagulated yolk (white spot) disease of eggs and fry	Rough handling; malachite green containing more than 0.08% zinc, gas supersaturation of 103% or more, mineral deficiency in incubation water.
"Hauling loss" (delayed mortality)	Hauling, stocking, handling, in soft water (less than 100 ppm total hardness); mineral additions not used, CO_2 above 20 ppm.
Blue sac disease of eggs	Crowding; accumulation of nitrogenous metabolic wastes due to inadequate flow patterns.



Guide to the Preparation of Fish Specimens for Pathology

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May 1982

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1649

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Rapport manuscript Canadian des sciences halieutiques et aquatiques

Ces rapports contiennent des renseignements scientifiques et techniques qui constituent une contribution importante aux connaissances actuelles mais qui, pour une raison ou pour une autre, ne semblent pas appropries pour la publication dans un journal scientifique. Us se distinguent des Rapports techniques par la portee du sujet et Ie lecteur vise; en effet, ils s'attachent principalement a des problemes d'ordre national ou regional et la distribution en est generalement limitce aux organismes et aux personnes de regions particulieres du Canada. II n'y a aucune restriction quant au sujet; de fait, la serie reflete la vaste gamine des intercts et des politiques du Ministere des Peches et des Oceans, notamment gestion des peches; techniques et developpe-ment, sciences oceaniques et environnements aquatiques, au Canada. Les Manuscrits peuvent ctre consid6r6s comme des publications completes. Le litre exact parait au haul du resume de chaque rapport, qui sera public dans la revue *Aquatic Sciences and Fisheries Abstracts* et qui figuera dans 1'index annuel des publi-cations scientifiques et techniques du Ministere. Les num6ros de 1 a 900 de cette scrie ont 6t6 publics a titrc de manuscrits (Serie biologique) de 1'Office de biologic du Canada, et aprcs le changement de la designation de cet organisme par decret du Parlement, en 1937, ont 6te classes en tant que manus-crits (Scrie biologique) de 1'Office des recherches sur les pccheries du Canada. Les num6ros allant de 901 a 1425 ont 6te publi6s a titre de manuscrits de 1'Office des recherches sur les pecheries du Canada. Les num6ros 1426 a 1550 ont 6t6 publi6s a titre de Rapport manuscrits du Service des peches et de la mer, Ministere des Peches et de ITEnvironnement. Le nom de la s6rie a 6t6 chang6 a partir du rapport num6ro 1551. La page couverture porte le nom de l'6tablissement auteur ou 1'on peut se procurer les rapports sous couverture cartonn6e.

Canadian Manuscript Report of Fisheries and Aquatic Sciences
No. 1649

May 1982

GUIDE TO THE PREPARATION OF FISH SPECIMENS FOR PATHOLOGY

by
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PREFACE

This somewhat regionally oriented document is a revision and update of an earlier one that has long been out of print. It is primarily intended for use by those responsible for investigating incidents involving dead or dying fish in the wild. However, fish culturists may find useful in particular the sections on preserving and shipping samples for pathologic examination and on the systematic examination of fish.

It was intended that the original document become part of a field handbook for fisheries workers but this goal has been at least partly achieved by the publication of separate components of the handbook dealing with the anatomy and physiology of salmon, the investigation of fish kills, and by the present document. Reference to these publications can be obtained by consulting the bibliography.

A glossary of terms commonly used in fish health work is included to assist the layperson.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Bell, (i. R. 1982. Guide to the preparation of fish specimens for pathology. Can. MS Rep. Fish. Aquat. Sci. 1649: iv + 16 p.

Selection of preservation methods suitable for pathologic examination of fish specimen’s is discussed along with details of the methods themselves. A guide to the systematic examination of salmonid fishes and a glossary of terms used in fish pathology are also included.

The document is intended for fisheries workers primarily in British Columbia and the Yukon but most of the information is of broader applicability.

Key words; Fish pathology, sampling (biological), pathogens, histology.

RESUME

Bell, G. R. 1982. Guide to the preparation of fish specimens for pathology. Can. MS Rep. Fish. Aquat. Sci. 1649: iv + 16 p.

Ce manuel presente un choix de methodes detaillees de preservation convenant a 1'etude pathologique des specimens de poissons. Sont aussi inclus un guide d'examen systematique des salmonides et un glossal re des termes utilises en ichthyopathologie.

Ce document est destine principalement aux chercheurs des peches de la Colombie-Britannique et du Yukon, mais la plus grande partie de 1'information est d'une applicabilite plus vaste.

Mots-cles: ichthyopathologie, echantiilonnage (biologique), microbes pathogenes, histologie

INTRODUCTION

Fish can be killed or made sick (become "moribund") by a variety of, causes, man-made or natural. Man-made causes include poisons (agricultural or industrial wastes), decomposable wastes that rob the water of oxygen, thermal pollution, silt, fibres, grits, explosions, gas super-saturation, and capture, release or disposal from fishing activities. Natural causes include infectious diseases; high temperatures; toxic or physically damaging algal blooms; rotting blooms that deplete the water of oxygen, alter the pH and possibly produce toxic hydrogen sulphide; and "turnover" of lakes (end result much like from rotting blooms). Some causes can be either man-made or natural.

Although the Diagnostic Service at the Pacific Biological Station deals principally with infectious diseases (caused by living agents) and is not equipped to do chemical analyses, personnel can offer useful advice on the selection and routing of samples for analysis. Further, within the service, histopathology or the study of abnormal tissue structure can be used to detect the action of certain types of chemicals.

There are several methods for preserving dead or dying fish depending upon the kind of examination that will be conducted in the laboratory. The ideal specimens for examination are moribund fish because dead fish undergo so many changes due to autolysis (self-digestion) and microbial invasion that the diagnostic features can be masked or obliterated. (These processes are accelerated by increasing temperature.) However, since it is not always possible to obtain or submit such specimens, several methods of preservation will be discussed. Selection of a preservation method usually depends upon assessment of the probable type of cause of the incident and this assessment (Table 1) may depend in part upon the results of a systematic examination of the specimen(s) as outlined in Table 2 and more briefly in Fig. 1 and 2. Some guidance for assessing the type of cause is given in Table 1, along with recommendations for the appropriate preservation method.

METHODS OF PRESERVATION AND FIXATION

The objective of the various methods of preservation and fixation is to retard, or "fix" the degenerative processes in the tissues but in such a way that the cause(s) of the event can be discovered. Fixatives should preserve tissues in as lifelike a way as possible, i.e. without causing artifacts that might mask critical features, or be misleading.

Freshly dead, iced fish are almost as useful as moribund specimens but frozen specimens are nearly useless for histopathology because the tissue structure is destroyed. On the other hand, formalin and alcohol-based fixatives cannot be used if diagnosis will involve the culturing of live microorganisms because these substances usually sterilize the specimen.

Fixed tissue can, however, be useful if the invading microorganism has a characteristic morphology. Metazoan (multicelled animals) and many protozoa (single-celled animals) are identified by microscopic features but bacteria cannot be identified by morphology alone. Helminths (worms) and some other metazoans are distorted and may be extremely difficult, perhaps impossible, to identify if they are fixed in cool formalin. They should be killed quickly in 70-80*C water and then placed in fixative, or killed directly in a hot fixative.

If possible, include several apparently healthy specimens of the same species, sex and size for comparison. This request is, however, more feasible for hatchery situations than for fieldwork.

Whatever method is chosen for preservation or fixation, be sure to label the specimens clearly and indelibly to avoid confusion at the laboratory.

A. PRESERVATION OF LIVE FISH

Method A: Shipment in water. Live fry or fingerlings can be transported or shipped over many hours in a polyethylene bag (minimum of 0.1 mm thickness) partly filled with ice-cold water. As a rough rule of thumb, put 10-12 fry and 4-6 fingerlings per half gallon of water. Flush the water with pure oxygen (preferably) or air, and seal the bag (several knots in the plastic will do) leaving 3-5 times as much gas volume as water. Seal this bag inside another and place the double bag in an insulated container, such as a styrofoam ice chest, packed with pieces of ice. Seal and ship immediately.

B. PRESERVATION OF DEAD FISH, TISSUES OR PARASITES

Method B: Iced specimens. Moribund fish or ones that have been dead for 1 or 2 h can be effectively shipped on ice in insulated containers (e.g. styrofoam coolers) if they are received within 24 h at the laboratory. Fish that have been dead for several hours at 15 *C or greater are usually poor specimens because of tissue decomposition and secondary invasions. Ice in individual, closed polyethylene bags (domestic thickness would do), or at least separate any healthy from diseased specimens.

Method C: Frozen specimens. Frozen specimens shipped in well-insulated containers (e.g. styrofoam coolers), especially those packed with dry ice (solid carbon dioxide) rather than "wet" ice, can travel satisfactorily for 1-2 days. Freeze rapidly in individual, closed polyethylene bags (domestic thickness would do), or at least separate and distinguish healthy from diseased specimens.

If dry ice is used, provide adequate venting so that gas pressure does not build up in the shipping container. (Consult airline-shipping regulations about requirements for special labelling of the package.) Freeze

3 -

the specimens and seal, individually if possible, in gas-tight glass or metal containers to prevent the high concentrations of acid-generating carbon dioxide from killing micro organisms which might be cultured for diagnosis. Most fish viruses survive for various periods especially in tissues held at -20 *C or lower.

Method D: Fixation in formalin. (Formalin is a 37% solution of formaldehyde in methanol and water. It is obtainable from scientific supply houses, pharmacies or morticians. Store at room temperature away from children. It is an irritant, so avoid contact with sensitive tissues.) Place the moribund or just dead specimens in a glass or plastic container (metal containers often rust undesirably) and add 10-20 times the volume of IOX formalin (i.e. one volume of commercial formalin plus nine volumes of water) to the volume of specimen. Most of the unaffected musculature can be filleted if it is necessary to reduce the volume of specimen. Fixation is improved if the final solution contains 0.9-1.OX table salt (sodium chloride), i.e. 0.9-1.0-g/100 cc of 10X formalin. Further improvement may be obtained by adding an excess of calcium carbonate (chalk or marble chips) to the fixative. However, neither of these additions is essential.

Fry can be preserved intact but larger fish should be carefully slit along at least two-thirds the length of the abdomen, and through the brain case to facilitate the penetration of fixative. Also slit tissues or tumours that are more than 1 cm thick. (Until the slow-penetrating formalin contacts the tissue, degenerative changes will continue.)

It is unnecessary to submit the whole fish if, for example, a large fish has strictly localized abnormalities. Affected parts can be cut out and fixed, but please identify the locations of the excised tissue photographically if possible.

The fixed specimen can be shipped immediately as it is, in the full volume of formalin, or after at least 4 days in fixative it may be removed and wrapped in fixative-soaked material and shipped in sealed plastic bags suitably protected.

If formalin cannot be obtained, 70X solutions of rubbing alcohol, or methyl (methyl hydrate), ethyl, or propyi alcohols in water can be used.

INFORMATION TO BE SUPPLIED WITH THE SAMPLE

A. REQUIRED

1. Date and location of the incident or sampling.

2. Numbers and species affected.

3. Sex, length, weight, and scale sample of fish from which specimen **taken.** (If fish is whole, this information is unnecessary.)

4. A description of the behaviour and appearance of the fish at time of sampling. Note in particular any abnormalities and whether specimen was dead or alive.

5. Water conditions - such as temperature, salinity (sea water, brackish, fresh water), oxygen, colour, turbidity, pH and smell (rotten egg -hydrogen sulphide).

6. Any peculiar or unique weather conditions.

7. Activities in the area, e.g., boats, spraying, construction, heavy algal blooms.

8. Location of incident in relation to any nearby industrial effluent or outfall.

9. Any other observations, which you think, are relevant to the incident.

10. Your name, mailing address, and phone number.

B. SUPPLEMENTARY

Only if considerable numbers of fish are involved in the incident, would it be helpful to the diagnostician if any common signs of disease as outlined in Table 2 were noted. Following this table also serves as a guide for the systematic and critical examination of specimens, an examination that might also give on-site clues as to the cause, and help in the selection of typical specimens for laboratory examination. Reference to Pig. 1 and 2 only may be adequate for rapid, routine examination and reporting.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY

Bell, G. R. 1978. Investigation of mortalities in the wild. p. 255-273 Jn Methods for the assessment of fish production in fresh waters. 3rd Edition. Ed. T. B. Bagenal. International Biological Program Handbook No. 3, Blackwell Scientific Publications Ltd., Oxford.

Smith, L. S., and G. R. Bell. 1976. A practical guide to the anatomy and
physiology of Pacific salmon. Fisheries and Marine Service, Misc. Spec. Publ. No. 27, Ottawa.

SHIPPING INSTRUCTIONS

1. Phone Gary Hoskins (Head, Diagnostic Service) or his assistant, Dorothea Kieser, particularly if you are planning Co send iced samples, to expedite shipping routes and carriers. This applies also to samples for T. Shortt (Fish and Wildlife Branch) who works in association with the Diagnostic Service and deals with problems involving trout and other freshwater fishes apart from salmon.

2. Send samples to: Diagnostic Service
   Department of Fisheries and Oceans Resource Services Branch Pacific Biological Station Nanaimo, British Columbia V9R 5K6
   Phone: (604) 758-5202

3. Please don't send live or iced specimens toward the end of the week
   because they might not reach the laboratory by Friday. However, if you have an urgent problem you can contact G. Bell or G. Hoskins at our home phones, 754-6114 or 758-7833, respectively.

Table 1. Guide to assessing the type of cause of fish mortalities or illness.

Field observation	Probable cause	Method of preservation*
1. Death or illness often within hours: many species involved: no gross signs of disease.	1. Severe reduction of water quality; environmental stress.	A,B,C
2. Death or debilitation occuring over several days or weeks, usually of single species and age class. May or may not be associated with discoloured areas on gills, skin and scales; fluid in body cavity and discoloured areas on internal organs.	2. Microbial invasions (i.e. bacteria, viruses, protozoa, fungi).	A,C,B,D
3. High loads of visible parasites such as "lice", leeches, worms, etc. Usually one species or group (i.e. salmonids) affected.	3. Parasite infections ("infestations").	A,B,D,C
4. Growths (tumours) on body. Usually only a few individuals affected. Rare.	4. Cancers (neoplasms).	A,D

*Methods, discussed in the text, are given in order of decreasing preference, i.e. A is ideal, others less so.

Covers open more than normally ☐ Engorged ☐ Covered with mucus, food and dirt particles ☐ Patches: white ☐ brown ☐ yellow ☐ gray ☐

(EXAMINED UNDER MICROSCOPE OR HAND LENS)

Filaments and lamellae: swollen ☐ fused ☐ club-shaped ☐ ballooned ☐ Cottony tufts present ☐

Small grayish-white objects: on filaments ☐ on lamellae ☐ between filaments ☐ between lamellae ☐

Colour of gills: deep red ☐ pale red ☐ white ☐ haemorrhagic spots ☐

5. MUSCULATURE

Sores ☐ or boils ☐ filled with red pus ☐ small red spots ☐

Well defined sores ☐ or cysts ☐ filled with creamy ☐ or cheesy ☐ contents

Hard cysts like sand grains: small ☐ large ☐ black ☐ or yellow ☐

6. EYES

Normal ☐ Opaque ☐ White: lens ☐ or center ☐ Tiny spots in lens ☐

Red spot in cornea ☐ Popeye ☐ One eye missing ☐ Both eyes missing ☐

7. BODY CAVITY

Appears normal ☐ Excessive fluid present ☐ /Fluid: colourless ☐ Opaque ☐ Bloody ☐

Present on wall: spots ☐ or haemorrhages ☐ /Worms: tape-like ☐ or round ☐ /Small Cysts ☐

8. INTESTINAL TRACT

Normal ☐ Empty ☐ Filled with food ☐ /Filled with mucus: colourless ☐ Yellow ☐ Reddish ☐

Hind gut bloody ☐ Blood in vent ☐ Stomach opened ☐ Round worms present ☐ Flatworms present ☐

Table 2 (cont'd)

9. LIVER

Normal ☐ Red ☐ Yellow ☐ Brown ☐ Pale ☐ Colour of coffee with cream ☐ Marbled ☐

Spotty ☐ /Cysts: Small ☐ or large ☐ White ☐ Yellow ☐ Watery clear ☐

10. SPLEEN

Red ☐ Black-red ☐ Pale ☐ Spotty ☐ Shrivelled ☐ Lumpy ☐ Grossly enlarged ☐

11. PYLORIC CAECA

Normal ☐ Fused together ☐ Worms inside ☐ Bloodshot ☐

12. KIDNEY

Normal ☐ /Pinpoint spots: gray ☐ or white ☐

Gray pustules: how many: Where located:

Small ☐ Large ☐ Creamy consistency ☐ Cheesy consistency ☐ Hard and gritty ☐

[a]Adapted from an anonymously authored, discontinued U.S. Fish and Wildlife publication.

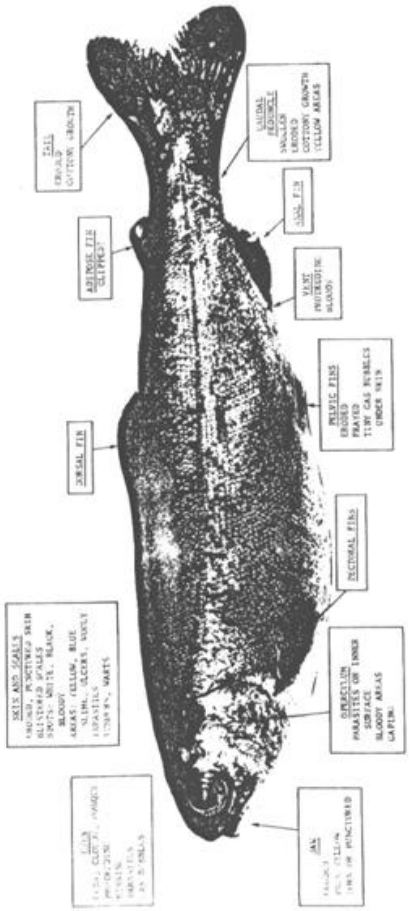

FIG. 1. GENERAL GUIDE TO EXTERNAL EXAMINATION.
IT IS MOST USEFUL TO BEGIN EXAMINATION AT GAT, THE HEAD (ANTERIOR) AND MOVE SYSTEMATICALLY TO THE TAIL (POSTERIOR).

APPENDIX I

GLOSSARY OF TERMS USED IN FISH PATHOLOGY

Aetiology (Etiology) - study of the causes of a disease: aetiologic agent of a disease is the causative agent of a disease.

Bacteria - unicellular micro organisms of the class Schizomycetes (fission fungi). Bacteria causing fish diseases are not photosynthetic and for the most part grow readily on common laboratory media composed of extracts and digests of natural substances. Bacteria cannot be identified under the microscope by their shape alone but by the use of special culture techniques and other diagnostic methods.

Carrier - a fish (host) harbouring a disease-producing organism (pathogen), without evidence of overt disease in the host. Such carriers placed among susceptible fish can cause an epizootic.

Contagious (communicable) disease - a disease which is transmissible from one individual Co another by direct or indirect contact with infected material.

Control or check - a sample or specimen (e.g. fluid, tissue, whole fish) which affords a standard for comparison with the abnormal or diseased material submitted. In the case of tumours, control tissue can be included by cutting widely around the diseased area (lesion) or by submitting the whole, diseased organ. In experiments, a control is a standard against which observations may be evaluated as a result of using a procedure identical in all respects to the experimental procedure, except for the omission of the one factor being studied.

Debilitated - weakened and usually made more susceptible to disease.

Diagnosis - determination of the cause of a disease.

Disease - health and disease are relative concepts and difficult to define but disease should be regarded as any (dynamic) process which reduces the capacity of the organism or part thereof to deal with its environment. Many diseases are not contagious e.g., broken bones, some neoplasms, vitamin deficiencies, and physiological disorders.

Enzootic disease - a disease that is constantly present at a low level in a population. Occasionally an enzootic disease can flare up and become epizootic.

Epizootic disease - an epidemic among non-human animals, an outbreak of disease involving a high proportion of the population.

Excise - to remove by cutting.

Fixative - an agent, usually formalin based, which stops further changes in the tissue and preserves it suitably for histology.

Formalin (Formol; Morbicid) - a 37X aqueous solution of formaldehyde containing 10-15X added roethanol and some spontaneously formed formic acid. Solutions tend to accumulate white sediments of paraformaldehyde but this polymer does not materially reduce the effectiveness of the formalin. Another white precipitate or cloudines, which can also be ignored, occurs if the formalin is stored at near freezing temperatures. (Store at moderate temperatures.) Formalin is an irritant, which is best, handled with gloves and should not be allowed to contact the eye or mucous membranes. Remove externally by flushing with water and internally by administering emetics such as warm salt water. Follow emetic with milk and raw eggs. Summon medical attention if more than a teaspoon or so is swallowed.

Fungi - mushrooms, rusts, yeasts and, most important in fish pathology, moulds (molds). Moulds are simply organized, non-photosynthetic plants, which produce microscopic, cellular filaments (hyphae). These appear to the eye as fuzzy masses. Reproductive "spores" are produced in vast numbers from special structures. Moulds are commonly regarded as secondary invaders, not primary pathogens of fish, but this is probably an unwarranted assumption. Several genera, not just Saprolegnia, are often involved in fish diseases.

Haematology - the study of blood and blood-forming tissues.

Health - like the term "disease" health is a relative concept and difficult to define. A healthy organism should have its maximum ability to deal with change in its environment. In human medicine there are certain standardized ranges for many body constituents, structures, and functions within which most healthy (by definition) individuals must fall. Such ranges are only now being determined for fishes.

Helminths - the principal helminth parasites of fishes are the Crematodes
(flukes), the cestodes (tapeworms), the nematodes (round worms), and the acanthocephalans (spiny-headed worms).

Histology - microscopic study of the form and structure of tissues. The study usually involves fixation of the tissue, embedding it in paraffin, cutting paper-thin sections, removing the paraffin, and finally staining the section.

Histopathology - a study of abnormal microscopic changes in tissue structure. It is noteworthy that ice crystals formed during freezing of the specimen usually destroy the tissue structures, but sometimes diagnostically useful features remain.

Host - a fish or any other organism that harbours or provides sustenance for another organism.

Infection - there are many kinds of infections but generally the word refers to the introduction or entry of a pathogenic microorganism into a susceptible host whether or not this causes overt disease.

Invasion - penetration of a microorganism into the tissues and cells of a host.

Malignant - progressing in virulence (invasive) in contrast to "benign" which does not so progress. Usually refers to types of tumours.

Microorganism - any living organism of microscopic or ultramicroscopic size:
in common usage refers to bacteria, viruses, protozoa, and moulds.

Moribund - in a dying state.

Mycosis - a disease caused by the presence of moulds (fungi).

Necropsy - examination of a body after death.

Neoplasm - an abnormal, persistent mass of tissue, the growth of which is uncoordinated with normal tissue maintenance and development. Cancer refers to any type of malignant neoplasm.

Normal - ideally, refers to some characteristic(s), which falls within an objectively defined range around the mean or average: see "health". Too often "normal" is a uselessly subjective tenn.

Parasite - an organism (usually multicellular except protozoa) that spends at least part of its life cycle in or on another organism, the host from which it draws support without killing its unwilling benefactor, e.g. fish worms, copepods.

Pathogen - a microorganism capable of producing disease in a healthy fish:
the distinction between a pathogen and a non-pathogen is often difficult to make because it is a matter of degree and circumstance.

Pathology - study of the cause, nature, process and effect of disease.

Population - a group of individuals of the same species set in the same framework of time and space.

Predisposing factors - factors that render an organism more susceptible to disease (see stressor).

Protozoa - microscopic, unicellular organisms in the lowest division of the animal kingdom, e.g. Myxosoma cerebralis, the causative agent of whirling disease; costia, trichodinids on the skin of trout. Traditionally these organisms are regarded as "parasites" when they invade a living host.

Secondary infection - an infection occurring in a fish already infected by a different pathogen.

16

Sign of a disease - any manifestation or evidence of disease as seen by an
observer. "Symptom" is only appropriate for human medicine because it includes the patient's feelings about his disease.

Stressor - factor or factors that reduce the capacity of an animal to meet
the demands of its environment. Stressors such as high temperature, low oxygen, chemicals, and extreme exercise can kill directly or predispose the animal to infectious disease.

Tumour - see neoplasm.

Toxin - a poison produced 6y living cells, e.g. endotoxins produced by the rupture of the furunculosis-causing bacterium Aeromonas salmonicida;
neurotoxins (nerve toxins) from the microorganism causing red tide (paralytic shellfish poisoning or PSP). PSP can kill certain species of fish.

Trauma - injury caused directly by violent contact of external objects with the body of the animal. Some soft "tumours" on salmon appear to be the result of trauma.

Vector - a carrier, usually an animal that transfers an infectious agent -usually a pathogen - from one host to another, e.g. snails and leeches. Inanimate vectors are "fomites".

Virus - a group of infectious agents that can multiply only within living host cells and which with rare exceptions can only. be seen under the electron microscope, e.g. infectious pancreatic necrosis, viral haetoorrhagic septicaemia (not reported in North America) and infectious haematopbietic necrosis (in the Pacific Northwest). Usually preserved by freezing.

Virulence - the ability of a microorganism to invade and injure the tissues of if host: disease-producing power.

Zoonosis - any disease in man acquired from diseased, so-called lower
animals, e.g., certain helminth conditions. Microbial xoonoses from fish are, fortunately, extremely rare.

CONUMA HATCHERY COHO PROGRAM OPERATIONS AND TECHNIQUES

Hatchery Coho Program

Overview

The Coho program can be divided into 4 parts, adult capture incubation, rearing and release. Each part has it's own tools and procedures.
The eggs collected during the fall are usually split into 2 groups out plant and smolt, depending on how much of the egg target has been met. Usually 150k are reared as smolts, and released from the hatchery as one year olds, between 20 and 24 grams. The remainder are reared about two and a half months, as out plants, and then transferred by truck to the upper watershed, between 3 and 4 grams.

ADULT CAPTURE:

Adults can be collected from either the river or as swim-ins from the concrete ponds; each location requires its own equipment and methods.

Objective: To capture and spawn the number of adults required to fulfil the egg targets determined preseason.

Equipment:

River:

- Boat
- ⇒ Jet boat (fuel, paddles, crash helmets, anchor and line, tools; wrenches etc.)
- ⇒ Outboard jet boat (fuel, paddles, anchor and line)
- ⇒ Aluminium and Styrofoam boat (fuel)
- Hand held radio
- Seine net
- Extra rope
- Safety gear (Swift water life jackets, Throw bag, First aid kit)
- Egg buckets
- Sample bags (spunk bags)
- Garbage bags (small kitchen bags)
- Zak knifes
- Record sheets etc. (pencils, water proof paper)
- Portable shelter

- Fish clubs (aluminium tire checkers)
- Waders
- Appropriate foot wear (felt soled wading boots)

Onsite:

- Fish screw
- Hydraulic pump
- Crouders (pond, end channel)
- Sorting tables
- 12-inch aluminium pipe (elbows, etc.)
- Shelter
- Fish clubs (aluminium tire checkers)
- Egg buckets
- Sample bags (spunk bags)
- Garbage bags (small kitchen bags)
- Zak knifes
- Record sheets etc. (pencils, water proof paper)
- Spawning chairs
- Fish clubs (aluminium tire checkers)

Procedures:

River:

- Ensure all gear is ready and in working order

⇒ Appropriate fuel tanks filled
⇒ Boat plugs are in place
⇒ Appropriate net is loaded on boat

Onsite:

- Assemble sorting tables and aluminium pipes

INCUBATION:

Incubation takes place in 2 stages; stage 1, from fertilisation to hatch, stage 2, from hatch (alevin) to ponding. Each stage has a number of procedures to obtain the desired objective.

Coho are incubated in Heath Trays through both stages of incubation.

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Objective: To provide conditions for the survival of the Coho Salmon from the egg to the rearing stage, by providing, the optimum flows, temperatures, and densities.

Equipment:

Procedures:

- Temperatures are recorded twice daily.
- Daily checks at all stages to ensure optimum conditions for survival

⇒ Flows are maintained at 12 lpm from fertilisation through to eyed.

⇒ Flows are maintained at 16 lpm from eye to ponding.

Salt Treatment:

- The eggs are salt treated 2 to 3 times per week for fungus

⇒ Treatments are done for 1 hour at 20 ppt

Dead pick:

- When the eggs have eyed dead are removed. This is done at no less than 250 ATU's.
- The dead pick can be done 3 ways, by hand (using a large pair of tweezers and a picking table), by machine (not recommended because the machine tends to damage eggs), and using salt to float the dead out.

⇒ The salt method is done using a 95 ppt (95gms salt /L) salt solution, and a flat dip net. The eggs are placed into the solution and allowed to float, if the solution is right the live eggs will shortly (about 30 to 45 seconds) begin to sink, leaving the dead floating for a very short while (another 30 to 45 seconds) before they too begin to sink. While the dead eggs are floating the dip net is used to skim them from the surface. The live eggs are removed immediately after the dead eggs have been removed.

REARING:

Objective: To provide conditions for optimum growth, and health of Coho salmon.

Smolt:
Out plant:

RELEASE:

Smolt Release:
Out plant Release:

Under direction of the assistant manager (GT03), it is the responsibility of the fish Culturist to ensure that the following requirements are carried out either by delegation and/or, participation, therefore giving the assistant manager more time to fulfill their administrative, planning and other office management duties. At present, a casual worker carries out some of the administrative duties.

The organization and planning of rearing, adult, and incubation strategies is done in conjunction with the assistant manager. Therefore giving the Culturist direction as to the, coordination, delegation and execution of the required tasks.

Through out the year, as the workload of the Culturist increases, casual employees are hired to assist the Culturist in most of the non-technical tasks. Usually, depending on the program, the Culturist is assigned as supervisor of a team of two or more casual workers, allowing the Culturist to focus on the planning, technical and data management aspects of their assigned program. As the workload dictates, the Culturist assists in the performance of daily hatchery duties.

The environmental conditions in which the fish Culturist works can at times be extreme, ranging from hot, dry and dusty in the summer, to cold, wet and windy in the fall and spring, to below freezing, and damp in the winter. In some cases, the duties must be done regardless of the weather conditions, or the fish and ultimately the economic factors will suffer.

Environmental and safety hazards the fish Culturist must be aware of are numerous. (I.e. slippery pond and river bottoms, high and white water, bears, sudden weather changes, electricity and water, working alone, etc.) It is the responsibility of the Culturist (team supervisor) to be aware of all safety factors and to communicate them to the team members, through training and example. In all cases safety comes first.

It must be noted that the following is a general physical description of the many tasks of the fish Culturist (GT02, General technician) and that there are many technical and supervisory aspects to the position as well.

1. Rearing Program

Pond Preparation

-Gather equipment necessary to do the job
i.e. pumps, pressure washer, fuel, hose brooms, etc.
-Using a broom or fire hoses, removes lose debris and other lose foreign matter from the pond.
-Using the power washer removes stains and other matter not moved by previous methods.
-Place, caulk, and wedge screens, then place and wedge stop logs.
-Place and caulk transition chute or pipes.
-Set flows
-Return equipment to its proper location.

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Ponding

-Gather equipment necessary to do the job
I.e. hammer, crowbar, flashlight etc.
-Place appropriate stop logs, or plug drains to the drain system.
-Ensure all chutes and stop logs in pond and transition channels are fry tight.
-Remove wedges from keeper channel screens and stop logs, remove screen and then slowly remove stop logs, releasing fry to the pond outside.
-Once release has started, the water to the keeper is shut off until, the water level has dropped to almost nothing and then turned on again. This procedure is repeated until all the fry are flushed from the channel.
-When ponding is complete; equipment and channel gear is placed in its appropriate storage place.

Sampling

Individual sample

-Collect and set up all necessary materials and equipment.
I.e. computer, anaesthetic tub, scales, measuring stick dip nets, air pumps, fry seine, buckets, etc.
- Using the fry seine the fry are crowded to an accessible location along the pond,
-The sample bucket is partially filled with water, and a small sample of fry is placed there in. The samples are then brought to the weigh station, for sampling.
-When at the weigh station, the anaesthetic is tested for strength, by placing one or two fish into the anaesthetic basin.
-If their reaction is favourable, the sampling begins by placing enough fish into the anaesthetic, so that the persons sampling can quickly, measure and weigh the fish, then place them into the recovery tank, without any undo stress.
-All data is entered on to the computer as the sample is read.
-Once the sample has recovered, it is returned to its original pond. The procedure is then repeated until all assigned groups are sampled.
-The sampling gear is then cleaned and returned to its storage compartment.
-This procedure is repeated four or more times through out the rearing season.
(Bulk sample)
-The capture and set up are the same as the individual sampling.
-A sample group of 100 or more is placed into the anaesthetic, and allowed to calm.
-Once calm, the fish are scooped up using a small dip net, drained of water, and placed into a beaker of water on top of the scale, the weight is recorded and the sample is counted back into its bucket and allowed to recover.
-The fish are returned to their ponds, and the weigh station is returned to its starting condition
-This procedure is done on a weekly basis.

Feeding

-Using the data collected during sampling a feed ration is determined and posted at the weigh station.
-If the food is frozen; it is removed from the freezer, the previous day, and allowed to defrost.

Feeding cont.

-Feed bags are typically 22 to 25 kg.
-At the beginning of the day, a half day ration is distributed to individual feed containers at the weigh station. If the ration is more than a bag, then the whole bag and the difference is distributed to feed stations located around the site.
-From the feed station the food is rationed out over the half day, to the prescribed number of feedings and food sizes.
-To feed the pond (fish), the food rationed is, mixed into a 10 or 20 litre bucket, and flung by hand and scoop to the hungry fish.
-This procedure is then repeated for the afternoon feedings.
-After all the feed has been fed, all feed buckets and scoops should be returned to the weigh station, cleaned and dried.
-Ensure all data is recorded to its appropriate location.

Rearing Container Maintenance (in use)

Rearing ponds

-Pumps hoses, vacuum head, handles, and other materials and equipment is gathered.
-Pump fueled and the oil checked.
-Appropriate hoses etc. are attached
-The pump is primed and started
-The ponds are cleaned by passing the head of the vacuum from one of the pond to the other, while the pump sucks the lose debris from the pond bottom.
-As the pond is cleaned, the operator is counting the morts sucked up by the vacuum.
-Once the pond is complete, the equipment is moved to begin on the next pond.
-The morts are recorded to their appropriate locations.

Capilano troughs

-morts are removed, and the debris is flushed by removing the drain plug, and

brushing the debris toward the drain. The plug is replaced at a safe water level.
- the morts are recorded to their appropriate locations

Fry Transport

Truck

-all necessary equipment is collected and checked. i.e. seine nets, dip nets, O_2 bottles, and regulators, transport tank, air stones, pumps and hoses, and trucks are fueled etc.
-load and secure O_2 bottles, then transport tank, and discharge hose, fire pump and hoses on to truck.
-fill tank with water once the gear has been loaded and secured, then proceed to the dumpsite.
-once at the dumpsite the pump is fueled the oil checked, the fire and discharge hoses are laid out.
-when the dumpsite has been set up the discharge hose is connected to the tank and the water is released, to check the discharge for leaks and low spots.
-after the set up is complete, the driver returns to the hatchery.
-upon return the tank is refilled to the predetermined water fill mark, and the truck is located at a convenient location along the pond side.
-the fry are crowded to a location near the truck.
-at this point two methods of transfer from pond to truck can be used. In the past the fry were crowded to the pond side, and then transferred by dip net, from pond to bucket, then truck. This was done either by weight or a predetermined fry fill mark on the inside of the tank. Presently a fish screw has been developed to remove the fish directly to the tank, eliminating the bucket and dip net method. A sight glass has also been added to the tank to speed up the process.
-when the fry have been loaded the driver returns to the dump site, the pump is primed and started, the discharge is connected to the tank, the lid and the release gate is lifted, releasing the fry to the river.
-when the tank has emptied, it may be necessary to flush any remaining fry from the tank by using the fire hose.
-the discharge hose is disconnected the fire hose is inserted into the top end of the discharge hose and left running to flush any fry remaining in the discharge hose.
-the driver then returns to the hatchery to repeat the process.
-this procedure is usually done with two trucks staggered, so that no one is waiting while the other is loading.

Fry Transport cont.

Helicopter

-all pumps, hoses, dip nets, transport buckets with O_2 bottles and regulators attached, seine nets, crowders, wrenches, etc., are placed near the pond to be transported.
-the pump is fueled and the oil checked.
-the pump is primed and started, and the tanks are filled to the watermark

-the fry are crowded to a location near the transport buckets.
-if not already started the helicopter is signalled to begin, as the helicopter warms up for the first load, the fry are dipped into the transport tank until the fry mark is reached.
-at this point the helicopter is hovering over the loading site the loaded tank is hooked to the lanyard suspended beneath the helicopter, the helicopter is then signalled on its way.
-as the helicopter is dumping its load, the crew at the hatchery is moving the next bucket into place and preparing to send out the next trip.
-this is repeated until the pond is emptied.
-once the pond is empty the crew either moves on to the next pond, or cleans and stores the equipment for the next use.
-all data is recorded.

Vaccination

-gather and set up all gear. (i.e. holding tanks, fry seine dip nets, vaccine, pumps, hoses, vaccine tank, O_2 bottles and regulators, stopwatch, and fish screw, etc.)
-once set up is complete, the vaccine is mixed to the appropriate dilution.
-the fry are seined to the bottom end of the screw.
-the screw picks up the fish and transfers them to the holding tank.
-as the fry are moving through the screw the vaccine is pumped to a chamber near the lower end of the screw, allowing the fry to absorb the vaccine as they travel up the screw, to the holding tank.
-when the tank is full the fry are released to the next pond.
-as the process nears completion, and the screw can no longer pick up enough fry, the pond is seined to gather up the last few fish, which are, crowded to the pond side and dipped from the pond to a mesh container in the vaccine tank. The fry are held in the vaccine for a specified amount of time and then dumped into the holding tank.
-once the process is complete the gear is returned to its storage location and all data is recorded.

Marking

-to begin the marking area is cleaned, the necessary equipment is assembled, cleaned and set up.
-fry are seined into a small area, a predetermined number of fry is weighed into buckets and transferred into holding tanks.
-to begin the marking process the anaesthetic tank is filled and distributed to the individual holding containers.
-fry are removed from the outside holding tanks and distributed to tanks within reach of the marking crew.
-the fry are anaesthetized and the clipping or tagging begins.
-during the marking process it is necessary to monitor the progress and quality of

the ongoing program. As well it is necessary to monitor the health, and behaviour of the fry being marked. If the fry are being tagged it will be necessary to monitor the tagging machine performance as well.
-fry are moved to the tagging area as needed.
-data is recorded on a daily basis, to monitor progress
-once the marking is complete all fry are returned to their rearing containers.
-this program continues on for several weeks during the rearing season.
-once complete all gear is cleaned and stored.

2. Program Preparation

-at this point all data collected from the previous brood year should be, completed and summarized
-since the rest of the year is taken up by program operations, the summer is the best time to prepare for the continuation of the cycle.
-program planning and strategies.

Fall

-inventory is taken on all equipment to determine the state of repair. (i.e. seine nets, dip nets, holding nets, pen floats, sorting tables, brailers, boats and motors, bleeding racks, kill floats, etc.)
-all adult handling gear is repaired or replaced as needed.
-once the gear has been repaired and the fall program approaches, the gear that needs assembling is assembled. i.e. kill float, adult holding pens, incubation room, boats, etc.
-data books are assembled, along with all the sampling gear.
-trails, and access sites are cleared for safe access.
- ponds are cleaned and set up for adult holding and attraction.
-fences and weirs are set up, if to be used.

Spring

-once the fry have been released, keepers are hosed out of debris, disinfected with bleach and reset for egg planting.
-keeper screens are cleaned and repaired.
-all rearing gear is inventoried, repaired or replaced, then stored.

Grounds Maintenance

-alder and weed control.
-lawn cutting and maintenance
-general clean up.

3. Fall Program

Incubation

-after the initial setup, (i.e. inc. boxes cleaned and set up, flows set, and planning), the equipment and materials for fertilization is setup for egg takes. (i.e. scales, data books, garbage buckets, buckets, egg sampling equipment, etc.)
-as the eggs and sperm are delivered to the incubation, it is the supervisor's responsibility to ensure the groups are kept separate.
-the buckets are counted and the availability of sperm is determined
-the egg buckets and sperm are placed in a convenient location near the weigh station.
-the weigh pan is place on the scale and tarred. A bag of eggs is removed from the bucket, a corner is cut and the contents are poured into the weigh pan, and the weight is recorded
-a small sample of eggs is removed to determine the average weight of the eggs. This procedure is repeated approximately , every five buckets.
-once the eggs have been weighed, and weight recorded, three separate measures of sperm are added to the eggs and mixed. The eggs and sperm are then poured into a 10-liter bucket partially filled with water, mixed for a few seconds, to distribute the sperm through out the eggs. The bucket and contents are then dunked into a tank of water, the excess water, sperm, egg shells and blood are poured off, this is done a minimal amount of times, as the eggs become very sensitive to mechanical shock very shortly after contact with water.
-the fertilized eggs are then gently poured into their respective cells.
-there can be upwards of 90+ buckets to process at any given time.
-once all the buckets are processed the weigh station is cleaned prepared for further use.
-as time allows all data is recorded.

River Operations

-before the operation begins, the location of the operation is determined, according to the availability of fish, river conditions, and weather.
-the availability of fish is determined by a river swim, inspecting visually from the riverside, or considered from the previous day's operations.
-once planning is completed, all gear is checked and loaded securely onto the transport vehicle. (i.e. buckets, tarps, boats, motors, fuel, dry suits, nets, sampling gear, etc.)
-once at the access point the gear is off loaded, and carried to the work site and made ready. (i.e. net loaded to boat, tarps and bleeding racks setup etc.)
-when at the site the supervisor determines the plan of action, as to how and where.

-to begin, the net tender hands the top end of the net to a person on shore, the boat tender then proceeds onto the river, with the net unravelling behind, to where the fish are most likely to be.
-once the seine net has been deployed, the bottom end of the net is passed to another person on shore. At this point the persons on the boat quickly dismount, quickly secure the boat and continue on to assist in physically retrieving the net and captured fish from the river.
-when the set has been closed the fish are sorted from the net according to species, ripeness, and sex. The ripe males and females are bought to the beach and killed, the females are bled and hung, the inapplicable fish are released.
-as the fish accumulate, it may be necessary to, delegate two people to strip the eggs from the females, while the rest of the crew caries on with the sorting. This is done with one person presenting the fish belly first, and the person with the Zak knife slits the belly, to remove the eggs into a plastic bag lined bucket.
-at some point it will be necessary to stop the sorting, and have the rest of the crew milk the males into sterile sample bags. This is done on either dead or live fish depending on the availability of males.
-sperm collection is done by firmly gripping the tail, on larger fish a tailer can be used, holding the fish across your lap, and using your free hand, firmly squeeze below the pectoral fins and run your hand down the belly expressing the sperm into a sterile sample bag. The bag is tied off and placed into a cooler.
-once the egg take is complete, the gear is either made ready for another set or carried back to the truck, reloaded and returned to the hatchery.
-upon return to the hatchery the egg buckets and sperm are offloaded and placed to cool in the incubation room. The rest of the gear is unloaded replenished, and stored until needed again.
-all data is recorded.

Onsite Operations

-ponds, attraction channel, and equipment is set up. (i.e. ponds cleaned, proper stop logs placed, crowders sorting tables, transfer chutes, anaesthetic tank, CO_2 and O_2 bottles and regulators, shelter, and fish screw, etc.)
-once set up is complete, the adult salmon are crowded toward the screw, where they are picked up and either, depending on the species, deposited into an anaesthetic tank, or directly onto the sorting table.
-larger and more delicate fish such as large male Chinook or large ripe female Chinook should be handled gently by hand.
- the fish are then sorted according to sex, ripeness and species.
-at this point the operation continues on similarly to the river operation. With the exception of the incubation room being closer, so each lot of eggs can be brought as they are completed.
- as carcasses accumulate they are loaded into a truck and disposed of
-when the operation is done the gear, and area is cleaned, and materials

replenished for the next use.
-all data is recorded to its respective locations.

Seapen operations

-all set up is completed (i.e. CO_2 and O_2 bottles and regulators, tarps, sorting table and chutes, generator checked, power block, and brailer. Other materials pertinent to the operation are gathered, i.e. sample bags, garbage bags, Zak knifes, pencils, and paper, etc.)
-the operations are begun by observing the estuaries for numbers and species, as well as location and accessibility.
- when this criteria has been determined, the seine boat operator seines the fish into a group and transfers them to a pen, that has been towed to a location of easy access, or the group is towed to the pen site and then transferred to holding pens.
-a sample of fish is removed to determine their state of readiness.
-the processing begins when the egg take crew arrives at the pen site.
-the egg take proceeds by first off loading the necessary materials from the boat, and setting up for an egg take. (i.e. chutes, power dip net connected, generator fueled, oil checked and started, the pen to be sorted is tied securely to the front of the anaesthetic tank, walkways are placed.)
-the anaesthetic tank is set to charge, and the brailer net is placed into the tank.
-the concrete net anchors, are pulled up, and the holding net is pulled up, so as to crowd the fish toward the anaesthetic tank .
-once the walkway is in place, and the dip net attached to the power block, the

dip net operator stands on the walkway with the dip net, and proceeds to dip the fish from the holding pen to the tank lined with the brailer.

-when the tank is full the power block is disconnected from the dip net and reattached to the brailer net. The brailer is then lifted, using the power block, to the sorting table.

-at the sorting table the fish are sorted according to species, sex, and ripeness. depending on availability the males are released, as are species other than chum.

-if males are scarce in the river, it may be necessary to take or hold males at the pen site.

-as the table is being sorted, the brailer, and dip net are reset; the anaesthetic tank is recharged with CO_2, and reloaded with fish.

-if there is more than one pen it may be necessary, once the first pen is empty to untie and replace
it with another.

- as the buckets accumulate they are shipped back to the hatchery, usually in lots up to 60 buckets.

-once the job is complete for the day all gear is cleaned, the deck is cleaned and all gear that is to remain is secured to the deck of the float.

-the full egg buckets are loaded into the boat, along with the rest of the gear, and crew, everything is rechecked for security.

-once at the dock, all the egg buckets and gear is transferred to the truck and then to the hatchery, where it is off loaded.

-at the hatchery, the supplies used over the day are replenished for the next days use.

-data is recorded; samples are placed in their appropriate locations.

Adult sampling

-all data sheets, and sampling gear is accumulated prior to the spawning season. (i.e. Scale books, measuring sticks, head knifes etc

-generally adult sampling is the measuring of length, and the removal of a small amount of scales to determine the age of the fish. In the case of Coho or Chinook, with adipose fins missing, the head is also removed, to check for pins.

-it may also be necessary to collect other biological samples to determine the general health of the population, and other criteria. Other samples might include liver, eye, otilith, heart, etc.

-adult sampling is generally done at the capture or spawning site, or during a dead pitch. Sometimes, depending on available time, the samples are taken back to the hatchery, and sampled.

-the length is measured from the tail notch, to the anterior side of the eye socket. Up to five scales are removed from the preferred area, mid way between the

dorsal fin and the anal opening. The scales are removed from either side of the fish and placed rough side up on the scale book. If the adipose fin is missing the head is also removed, labelled and placed into a sample bag.
-all data including location, date, length, scale book number, scale location, entry number for heads is recorded to field books, and transferred to computer when time permits during the season or finished after the season is complete.
-all gear is cleaned and restored to its appropriate location.

Clean up

-once the brood stock collection is completed, all gear is removed from off site locations, the state of repair is noted, repaired if possible, and stored to its storage location.
-all the Sea pen operation is disassembled. Boats, floats, nets, pens and hardware is removed from the water, repaired if possible and stored.
-egg buckets are cleaned and stored.
-all field data books are collected, for computer entry.
-all samples, including scale books, and heads, are packaged and shipped to their appropriate labs, along with the data collected.

4. Incubation

1st Incubation

-after the egg take has been completed, the eggs are allowed to incubate for approximately four weeks from the date of fertilization
-during the incubation period, the cells are monitored for, temp, flow, boiling and other abnormal conditions.
-once the eggs have eyed, the dead are picked, this is done either by hand or machine, depending on species and the number of visible dead.
-to begin the eggs are shocked, using either of two methods.

1.) using a hose, the eggs are siphoned from the incubation cell into a waterless bucket, with holes to drain excess water. As the eggs are siphoned off, the stream from the outflow is directed toward the side of the bucket, thus shocking them, and turning the weak or already dead ones white, making them more visible.

2.) the eggs are shocked from the cell into a dry bucket, or dip net, and

poured from a moderate height into an empty cell, producing the results as stated previously.

-generally, because of sensitivity, and larger size, Chinook eggs are picked by hand, using either tweezers, or squeeze ball and tube.
-chum eggs, because of the volume are picked by machine into a bucket, and then placed onto the picking table where any remaining dead can be removed.
-Coho eggs are usually picked by hand because of their small numbers and small size.
- as the eggs are picked, the live are replaced to their original cells; the dead egg numbers are tabulated, using a sample weight retrieved randomly from the dead bucket.
-the dead eggs are then discarded.
-all data is then recorded to computer.

2nd incubation

-as the eggs become eyed and closer to hatch, they are transferred to keeper channels
-before the channels are loaded, the flow is set, and the channel is allowed to flush of debris and dust accumulated since setup.
-all transfer gear is collected to the weigh station, and the egg screens are laid out
-before the process begins all cells to be moved are sampled, to determine the average weight.

2nd incubation cont.

-to begin, the egg bucket is tarred on the scale, and load to a predetermined weight
-the four egg buckets are lifted onto a cart and transferred to the keeper building, where they are lifted off and carried to the channel being loaded.
-the eggs are then poured by hand onto the egg screens, into a single layer.
-this process is repeated until each channel has reached it's predetermined capacity, generally 20 to 25 screens, with up to 11kg each.
-as the numbers collected at this point are used for inventory purposes, all weights, and sample weights must be recorded accurately, and transferred to computer accurately.
-as in all hatchery operations, once the task is complete, all equipment should be cleaned and stored for future use.
-while 2nd incubation is ongoing, the channels are monitored for flow, dissolved O_2 content, and temperature, as well as alevin conditions, with respect to % hatch, crowding, and development. This information is recorded

-as the hatch completes the dead eggs and screens are removed from the channel, and dumped onto a tarp, spread out at the front of the building.
-when all the screens have been removed, the tarp is gathered and the eggs are poured into a perforated bucket and allowed to drain.
-a sample of dead is taken, and the total weight is determined, the number is recorded.
-the dead eggs are discarded, and all the gear is cleaned and stored.

5. Data Collection, Entry and Maintenance

-after the fall program is complete all data collected, if not already, is entered to its proper location on the computer.
-this data includes, swim-in, river, and Sea pen enumeration, including contractor and staff counts.
-all sample data is entered and correlated with scale book numbers, and scale location. This data is then packaged along with the scale books, and shipped to the scale lab for interpretation.
-all head collection data, is entered and correlated with entry numbers attached to the individual head.
-once the data is entered, the heads along with the data is packaged and shipped to the head lab for pin removal and interpretation.
-data with regards to incubation, 2nd incubation, and rearing is entered on an ongoing basis
-as data returns from their particular labs, it is summarized in respect to all phases of the brood year.

6. Other Tasks and Duties

- river and lake fry enumeration (i.e. incline traps, guy traps)_
-adult enumeration (river swims, stream checks, helicopter or float plane, boat)
-water quality monitoring (onsite, river, and salt water)
-monitor weather and river flows.
-onsite stand-by (site security, alarm monitoring)
-training and monitoring of contract staff.
-ensures safe work practices
-participation in public involvement programs
- in conjunction with the assistant manager, conducts, planning and strategies in regards to hatchery operations.
-monitor sport and commercial fishing activities (i.e. head collection from various locations around Nootka Sound, and observation of fishing actives)

-safe operation of river and powerboats.