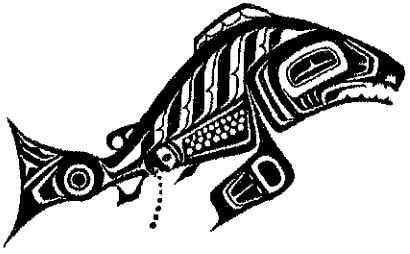
Habitat and Enhancement
Facts and Figures

Third Edition

Habitat and Enhancement Branch

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada



Habitat and Enhancement Facts and Figures

Third Edition, 2003

DEDICATION

This book is dedicated to the vision and energy of the volunteers who have made the Community Involvement Program a success.

CONTENTS

Animal Identification

FIELD IDENTIFICATION GUIDE FOR JUVENILE PACIFIC SALMON

Introduction

There are problems of identification that arise from the remarkable range of visual and physical variations of young salmon. The purpose of this section is to help identify the difference between each species by using general characteristics.

Page 4, "Identification Features of Juvenile Salmonids," can be used to help identification through simple visual differences, while later pages provide a more thorough "key" to assist in identification. This is done with successive statements regarding external and sometimes internal features. The key also includes the identification of other species that are sometimes mistaken for salmon.

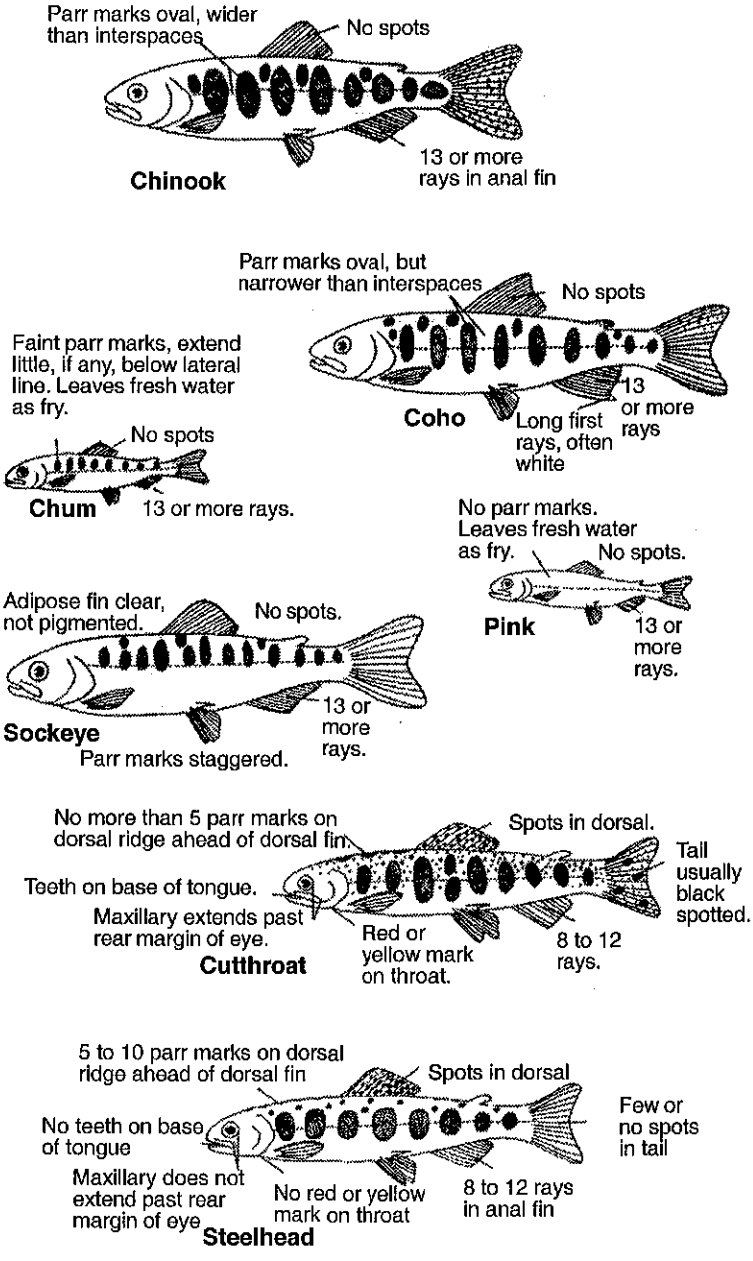
A glossary of terms frequently used in fish identification is included to aid you in using either section.

Glossary of Terms Commonly Used to Identify Fish Species

Adipose fin:	a small, fleshy fin on the back between the dorsal fin and the caudal fin
Anal fin:	the fin behind the anus
Anterior:	in front of, the head end
Caudal fin:	the tail fin
Dorsal fin:	the main fin, mid-line on the back
Fleshy appendage:	a small "finger" of flesh attached at the base of the pelvic fin (ventral fin)
Gill arch:	the bony support to which the gill filaments and the gill rakers are attached
Gill rakers:	spine-like structures attached to the gill arch, serving to strain food
Hyoid:	bony plate at the back of the mouth
Lateral line:	a series of pores forming a line along the side of a fish's body
Maxillary:	the bony plate forming the upper jaw
Palatines:	a pair of bones on the roof of the mouth, extending outward and backward from the head of the vomer, sometimes bearing small teeth
Parr marks:	dark vertical bands on the sides of young fish, usually roundish to long-oval in shape
Pectoral fins:	paired fins attached to the pelvic girdle
Pigmented:	not clear or translucent, but coloured, usually dark
Posterior:	behind
Pyloric caecum:	the spaghetti-like fingers attached to the stomach where it leaves the intestine
Ray (of a fin):	the bony support of a fin
Ventral fin:	the same as a pelvic fin
Vomer:	a bone on the roof of the mouth towards the front

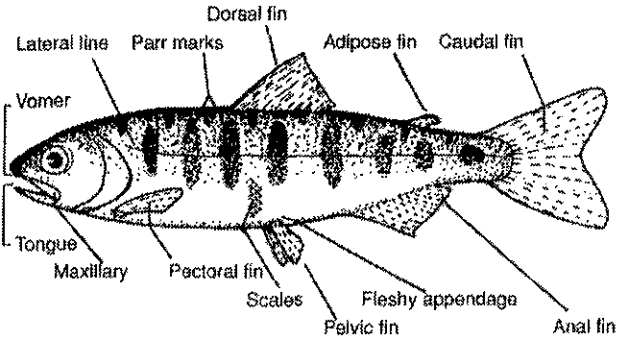
Identification Features of Juvenile Salmonids

Drawings show approximate relative sizes at migration.



External Characteristics

A hypothetical salmonid showing external characteristics:



Detailed Identification Key:

Read the first statement; if it correctly describes your fish, go to the next statement and so on to successive statements until the specimen is identified. If, however, before you reach a positive identification (shown in italics) you come to a statement that does not describe your specimen, you must go to the alternative statement (number in brackets). Continue with this until your fish is identified. For example, if statements 1 through 11 are correct, it is a cutthroat. If 8 is not correct, move to statement 12 and continue from there until you have identified the fish.

Some external features offer positive identification of various species; for your convenience, each is marked with an asterisk. Internal features that offer positive identification are marked with a double asterisk. Of course, to check the internal features you will have to sacrifice the fish.

If some terms are unfamiliar, refer to the Glossary.

Key

1 (47) Adipose fin and scales present

2 (48) Fleshy appendage at base of pelvic fins present

3 (49) Mouth large, reaching at least to centre of eye. ***Family Salmonidae.***

4 (17) Anal fin higher than long, with 8 to 12 developed rays (Fig. 1A)

5 (52) *Teeth on head and shaft of vomer (Fig. 2A)

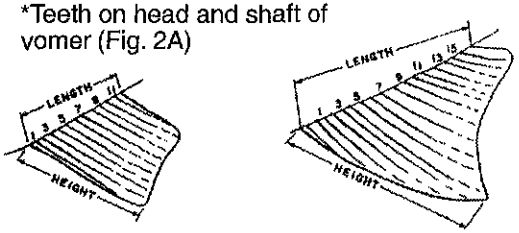


Fig. 1: A. Cutthroat, steelhead B. Sockeye, chum, coho, pink, chinook

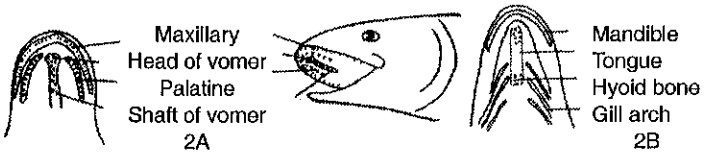
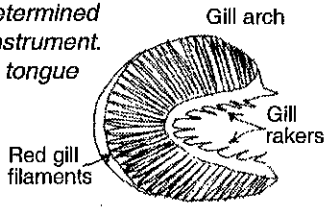


Fig. 2: Location of dentition in (2A) the roof and (2B) the floor of the mouth of salmonid fishes. (Presence or absence of teeth on the vomer or tongue may be determined by the use of the little finger or a blunt instrument. The small hyoid teeth at the base of the tongue are located between the gill arches of the lower jaw and are difficult to find.

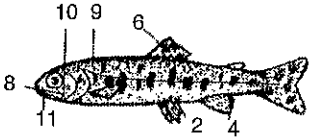


6 (18) Dorsal fin with large dark spots.
Steelhead or cutthroat.

7 (53) Adipose fin not orange; no row of pale round spots along lateral line

8 (12) *Small hyoid teeth at base of tongue

9 (13) Not more than five parr marks on mid-dorsal ahead of dorsal fin



10 (14) Maxillary reaching past posterior margin of eye

11 (15) Red or yellowish hyoid mark under lower jaw. Tail usually black spotted.
Cutthroat (O. clarki)

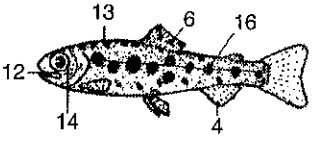
12 (8) *No teeth at base of tongue

13 (9) Five to ten parr marks along mid-dorsal ridge ahead of dorsal fin

14 (10) Maxillary short, not reaching past posterior margin of eye

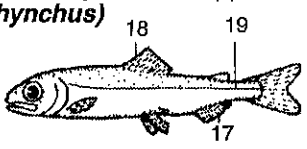
15 (11) No hyoid mark under lower jaw. Few or no spots on tail.

16 (20) Parr marks almost round.
Rainbow (Salmo gairdneri or Steelhead (O. mykiss)



17 (4) Anal fin longer than deep, with 13 or more developed rays (Fig.1B)

18 (6) Dorsal fins without large dark spots, may be black tipped
Pacific salmon (Genus Oncorhynchus)



19 (20) No parr marks. Fry leave fresh water while small – approximately 1.75 inches (45mm) long.
Pink salmon (O. gorbuscha)

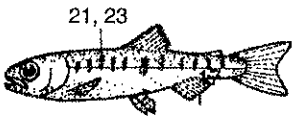
20 (16) Parr marks present as vertical bars or oval spots.

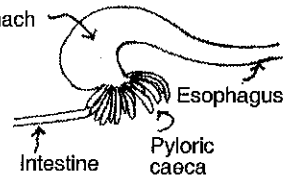
21 (30) Parr marks short, extending little, if any, below lateral line.

22 (25) Gill rakers on first arch, 19 to 26.
**Pyloric caeca, 140 to 186

23 (26) Parr marks faint. Sides below lateral line iridescent green.

24 (27) Small when migrating from fresh water, approximately 1.5 inches (40mm long)
Chum salmon (O. keta)





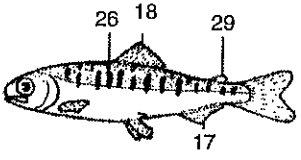
25 (22) Gill rakers on first arch, 30 to 40.
**Pyloric caeca 60 to 115.

26 (23) Parr marks usually sharply defined. Sides below lateral line silvery, not iridescent green.

27 (24) Relatively large when migrating from fresh water, approximately 3 to 5 inches (80 to 126 mm long).

28 (31) Gill rakers long and slender, more than 29 on first arch.

29 (32) Adipose fin clear, not pigmented.
Sockeye salmon (O. nerka)



30 (21) Parr marks large, vertical bars centred on lateral line.

31 (28) **Gill rakers short and thick, fewer than 29 on first arch.

32 (29) Adipose fin at least partially pigmented.

33 (40) **Pyloric caeca more than 90.

34 (41) Parr marks broader than interspaces.

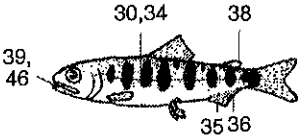
35 (42) Anterior rays of anal fin not distinctly longer than rest, not white edged.

36 (43) Anal fins not pigmented

37 (44) Black spots, when present, are on both lobes of caudal fin.

38 (45) Adipose fin not completely mottled, clear area at anterior base of fin.

39 (46) Black gums along base of lower teeth.
Chinook salmon (O. tshawytscha)



40 (33) **Pyloric caeca less than 80.

41 (34) Parr marks narrower than interspaces.

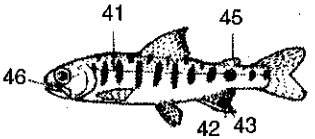
42 (35) Anterior rays of anal fin elongated; when depressed they extend to base of last ray.

43 (36) Anal fin pigmented between rays, resulting in black banding.

44 (37) Black spots, when present, on upper lobe of caudal.

45 (38) Adipose fin completely pigmented.

46 (36) Mouth gray to white
Coho salmon (O. kisutch)



47 (1) Adipose fin not present; scales present or lacking.
Not salmonidae

Note: *Some salmonids have had adipose fin clipped for identification as hatchery produced fish.*

48 (2) No fleshy appendage at base of pelvic fin.

49 (3) Mouth small, not reaching centre of eye; teeth weak or absent

50 (51) Depressed dorsal fin, shorter than head
Whitefishes; Genus (Coregonus)

51 (50) Depressed dorsal fin, longer than head.
Arctic grayling (Thymallus arcticus)

52 (5) **Teeth on head of vomer only
Chars; Genus (Salvelinus); Dolly Varden (S. malma)

58 (7) Adipose fin orange; row of distinct pale round spots along lateral line.
Brown trout (Salmo trutta)

ATLANTIC SALMON WATCH PROGRAM

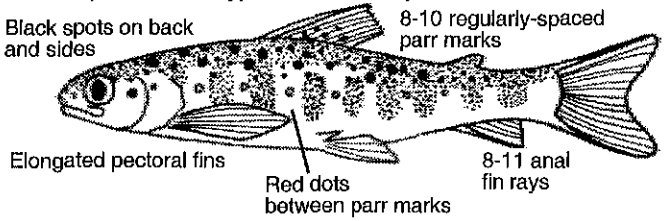
The Atlantic Salmon Watch Program (ASWP) is a cooperative research program operated by Fisheries and Oceans Canada with funding from the BC Ministry of Agriculture Food and Fisheries. The purpose of the program is to study the abundance, distribution and biology of Atlantic salmon in British Columbia and its adjacent waters. The ASWP monitors commercial and sport catches and observations of Atlantic salmon throughout British Columbia, Alaska and Washington in co-operation with the BC Ministry of Water Land and Air Protection, the Alaska Department of Fish and Game and the Washington Department of Fish and Wildlife. Hatchery volunteers have consistently played a very important role in the study of Atlantic salmon in BC, providing valuable sighting information and capturing samples.

All encounters of Atlantic salmon, in any life-stage, should be reported to the ASWP (1-800-811-6010) immediately. If feasible, positively identified Atlantic salmon specimens should removed from the system, and frozen or put on ice as soon as possible. The ASWP will arrange transport of the specimen to the Pacific Biological Station. If there are significant numbers of adult Atlantic salmon encountered or any juvenile Atlantic salmon, then further surveys will be attempted by the ASWP.

Identification of Atlantic salmon.

Most Atlantic salmon that are encountered in freshwater are immature (silver) adults. The primary identification key is 2-5 large black spots on the gill cover of the fish (operculum). Other identifying features include, 8-11 anal fin rays, very large scales relative to body size, large black spots on the back, and occasionally worn fins resulting from net-pen containment.

As Atlantic salmon mature, their coloration changes to a distinctive copper hue. The number of spots on the gill cover increases and the males develop a hook or kype on the lower jaw.



Since 1996, small numbers of juvenile Atlantic salmon have been found in BC streams, and lakes. Atlantic salmon juveniles can be identified by elongated pectoral fins, black spots on the back and sides, and 8-10 regularly spaced parr marks with a single red dot between.

Colour identification cards and posters are available free of charge by contacting the ASWP.

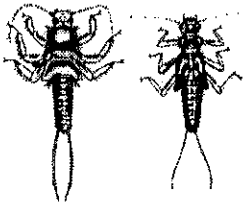
Contacts:

Andy Thomson Tel: 1-800-811-6010 FAX: 250-756-7053
ASWP@pac.dfo-mpo.gc.ca
Website: http://www-sci.pac.dfo-mpo.gc.ca/AQUA/PAGES ATLSALM.HTM

AQUATIC INSECT LARVAE

Examples from principal orders vital to stream-rearing salmonids. From *Stream Enhancement Guide,* March 1980.

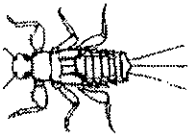
Plecoptera (Stonefly) Nymphs



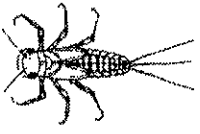
Pteronarcidae Family (Pteronarcys) Length to 50 mm. Grazers. Inhabit aquatic vegetation and leaf masses. Sometimes found under rocks in quiet riffles.

Perlodidae Family (Isogenus) Length to 25 mm. Predators. Found under rocks in quiet riffles or free-ranging on the bottom in quiet waters.

Ephemeroptera (Mayfly) Nymphs



Ephemerellidae Family (Ephermerella doddsa) 8-18 mm long. Grazers. Inhabit silted areas, leaf masses and aquatic vegetation. Sometimes found under rocks in quiet riffles. One species (E. doddsi) adapted to cling to under surfaces of rocks in fast waters.

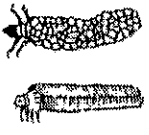


Heptageniidae Family (Rhithrogena) 8-18 mm long. Grazers. Gill structure is limpet-like, enabling nymphs to cling to undersurfaces of rocks in fast water.

Baetidae Family (Baetis) 4-15 mm long. Primarily grazers. Streamlined nymphs, many with heavily-fringed caudal appendages. Either free-ranging in backwaters or found clinging to the undersurfaces of rocks in riffles.

Trichoptera (Caddisfly) Larvae

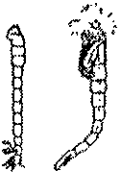
Hydropsychidae Family (Hydropsyche) Length to 15 mm. Net weavers. Found in riffles tending to their funnel-shaped nets in which food is collected.



Limnephilidae Family (Limnephlus) Build cases to 50 mm. Vegetarians. Found free-ranging on bottom. Cases are constructed of stone, sand, twigs, leaf fragments—almost any suitable material common to the particular habitat in which they dwell.

Brachycentridae Family (Brachycentrus) Build characteristic cases of twigs, square in cross-section; case to 12 mm long. Vegetarians. Found under rocks in riffles.

Chironomidae (Midge) Larvae and Pupae



(Chironomus) Larvae to 15 mm. Grazers. Build tubes from secreted material in silted or muddy bottoms.

(Chironomus) Pupa to 20 mm. Rises from bottom to emerge at surface. Adult is mosquito-like; males have noticeably-plumed antennae.

Salmon Culture

EGG DISINFECTION USING AN IODOPHOR (IODINE)

From *Summary of Water Quality Criteria for Salmonid Hatcheries* by Sigma Environmental Consultants Ltd., 1983.

It is common practise in many facilities to disinfect eggs after fertilisation, both to protect those same eggs from harmful bacteria that may be on the egg surface or in the ovarian fluid of the female and to protect organisms (including fish) downstream.

The standard treatment for egg disinfection in B.C. is a static water bath containing iodine at a level of 100 ppm (100 parts iodine to 1 million parts water or 1 ml iodine to 10 litres water) for a period of 10 minutes. Usually eggs are rinsed after fertilisation then placed in a tray with the right solution of iodophor and water and left for 10 minutes. When the bath is finished, the flow is turned back on or the tray is pushed all the way back in the stack where water is running.

Most of the "iodophors" or disinfectants with iodine as the active ingredient are at a strength of 1%, however, be sure to check on the label before measuring the dosage.

If your iodophor is 1% active iodine you have to use 100ml of solution to get 1ml active ingredient - so for 20 litres water measure out 200ml of solution. It takes 7-10 litres solution per Heath type tray.

MINIMUM AND MAXIMUM TEMPERATURE LIMITS FOR INCUBATION

Species	Minimum ILL[1]	Temp. C SAFE[2]	Maximum ILL[1]	Temp. C SAFE[2]
sockeye	2.7	5.0	17.5	12
pink	3.8	5.0	15.6	12
chum	3.7	5.0	15.8	14
chinook	2.75	4.5	15.8	14
steelhead	2.25	3.0	14.6	11
coho	1.6	3.0	13.0	10

Notes:

[1] Incipient lethal level, 50% mortality, fertilization to hatch.

[2] Suggested level that will not cause excessive mortality (near 10%) in the absence of other deleterious conditions (i.e. low D.O., toxic substances, fungal infections, etc.). The upper or lower limits may not be optimal for growth and health of developing embryos and larvae.

* There are stocks of salmon that are acclimated to colder or warmer incubation temperatures so the above is a general guide only.

TREATMENT FOR PARASITES ON FISH AND FUNGUS ON EGGS

NOTE: Be sure to follow safe handling instructions for any chemical or theraputant and check with your Community Advisor and fish health specialists at the Pacific Biological Station if you have not used a treatment before. Improper handling, dosage and application can result in serious injury to personnel and significant fish mortality.

If you have access to the Internet, Syndel Labs has a site with drug applications, dosages, and WHMIS safety data: www.syndel.com.

The most common treatment for parasites is ParasiteS (a formaldehyde-based chemical). Extreme caution must be exercised. Eyes and skin must be protected and proper ventilation maintained. If water temperatures are 15 degrees centigrade or above, you should not proceed without contacting fish health specialists at the Pacific Biological Station: 250-756-7057.

The treatment can be a static bath or a "flush" type, depending on the size of container, water temperature, fish densities etc. Check with a specialist before increasing frequency from that listed.

Static Bath for Parasites on Fish
(167ppm or 1ml ParasiteS to 6000 ml water for 1 hour)

The static bath treatment is straightforward. The concentration is 167ppm active ingredient and the length of time is 1 hour. 167ppm = 1:6000

Depending on the number of fish in the container and water temperature you may want to set up an oxygenation system for the duration of the treatment. If densities and water temperatures permit, you may be able to reduce the water in the container for the length of the treatment and therefore, greatly reduce the amount of chemical to use. NOTE: must consider how easily chemical can be added to give an even distribution and additional stress to fish by the movement of people around the container and mixing process.

Normally, the chemical is mixed in one or more buckets of water (depending on the size of rearing container) and then distributed throughout the rearing container and mixed as well as possible.

To calculate the amount of chemical to use, you must first calculate how much water is in the container and you do this by obtaining the volume of water in m^3 and multiplying that by 1000 to get litres of water - then by another 1000 to get millilitres of water.

Example: A 3m diameter circular tub with 1m depth = 7.1m^3 volume and 7,100,000ml water.

If the target strength of chemical is 1ml to 6000ml water then the amount of chemical to use = 7,100,000/6000 = 1183ml.

Long Flush Treatment for Parasites on Fish
(25ppm or 1ml ParasiteS to 40,000ml water for 8 hours for 2-3 days)

Note that this treatment is more complicated than a static bath and math should be checked by an experienced fish culture technician. Treatment time depends on the type of container and water exchange rate. The 8 hours above refers to a large concrete raceway pond.

A flow-through treatment is commonly used for larger ponds where effective mixing of the chemical is not possible by hand. In this treatment the chemical is mixed with water and metered into the container at a fixed rate for a period of time so the required level of effective ingredient is met and maintained.

To use this method you need a special metering pump, a custom bucket with a hose and metering clamp or an IV bag with metering system. You set up the system to supply a desired flow into the head box of the container. For this exercise we will set the flow at 100 ml/minute (some pumps cannot do less very well). You also need to know the flow of water in litres/minute going into the rearing container. Let's use 1000 lpm in the example.

To calculate the amount of chemical to use for each minute of flow into the pond you take the inflow of water in ml and divide by 40,000 (1,000,000/40,000 = 25ml chemical/minute).

You then multiply the number of ml per minute times the total time you are treating to get the total amount of chemical needed. (25ml/minute x 60 min/hr x 8 hrs.) = 12,000ml chemical or 12 litres.

If your metering system is delivering 100ml/minute the total solution (called stock solution) needed is 100ml/min x 60min/hr x 8 hrs = 48,000ml or 48 litres. If you take 48 litres minus the 12 litres chemical you get the amount of water to use in the stock solution = 36 litres.

So, the total "stock solution" needed for an 8 hr. treatment is 12 litres chemical and 36 litres water.

You may have to mix the stock solution up in several buckets and add these to the metering bucket as needed.

Here is another example to use if rearing containers are Capilano type rearing troughs and you want to apply the flow-through method. The treatment is for 4 hours. Flow to trough = 25gpm (100lpm) and metered stock solution flow = 100ml/minute.

Flow to trough = 100,000ml/min. The chemical required is 100,000/40,000 or 2.5ml/min x 60min/hr x 4 hrs = 600ml. Total stock solution = 100ml/min x 60 x 4 = 24,000 ml or 24 litres. Stock solution needed for 4 hour treatment = 600ml ParasiteS and 23.4 litres of water.

Rapid Flush Treatment for Parasites on Fish
(167ppm or 1ml ParasiteS to 6000ml water for 1 hour, one to two days)

FISH: Use the same formula as for the longer treatment using new concentration and time.

Low Dosage Treatment for Fungus on Eggs

(167ppm or 1ml ParasiteS to 6000 ml water for 1 hour one or two days per week from 24 hours post fertilisation to 1 week prior to eyed).

This can be applied as a flush or a bath, depending on type of incubator and water temperature. Be aware that bath treatments might be too dangerous in heavily loaded incubators where water temperatures are over 10 degrees, oxygen levels are not at 100% saturation and during the last week to 10 days prior to eyeing when oxygen demand is increasing.

Flush Treatment: Remember that you want the last tray or cell in the line to have 1 hour exposure so you may have to add a few minutes to the overall treatment. An example using a Heath type vertical drip incubator with 8 trays is:

Water flow to incubator = 16 lpm, so with 8 trays that hold approximately 10 litres/tray, the time it takes for the bottom tray to start treatment is about 5 minutes (8 trays x 10 litres/tray = 80 litres and 80 litres divided by 16 lpm flow = about 5 minutes). Overall treatment time to ensure the bottom tray has full concentration of the chemical for 1 hour is 1 hour and 5 minutes.

With a dilution factor of 1ml ParasiteS to 6000ml water, for 16lpm flow (16,000 ml) you would need 16,000/6000 or 2.7ml parasiteS each minute. Over a 65 minute period you would require 65x2.7 or 176ml ParasiteS.

If your metering pump flow is 100ml/minute a total of 100x65 or 6500ml of treatment solution is needed. The treatment solution will be 176ml ParasiteS and 6.324 litres water.

Bath treatment:

Mix up enough treatment solution to completely replace the water in the incubator and have some spill over, turn off the water flow, drain as much of the water from the container as is safely possible, add the solution and start a timer. After an hour the flow to the incubator would be turned on. A static bath for a Heath type incubator with 8 trays would require about 100 litres of 1:6000 solution to completely fill all the trays at the right concentration with some extra. You mix the solution in buckets and slowly pour it from the back of the top tray or use a siphon or small water pump to transfer it at a rate that does not cause rolling in the eggs. If you had a 100 litre bucket then the calculations for amount of parasiteS and water would be 100,000ml (100 litres)/6000 or 17ml ParasiteS and 99.983 litres of water.

Rapid Flush Treatment for Fungus on Eggs

(1670ppm or 1:600 concentration (1ml ParasiteS to 600ml water) for 15 minutes. Frequency = 1x/wk from 24 hr. Post fertilisation to eyed. For general procedure see Flush treatment for parasites on fish. For this exercise we will treat an 8-tray Heath stack incubator. NOTE: make sure there is good ventilation in incubation area during treatment.

Water flow to incubator = 16lpm or 16,000ml/minute. To get 15 minutes of full strength treatment mix enough solution for 20 minutes. 27ml/min x 20min = 540ml ParasiteS needed.

If the meter pump flow is 100ml/minute a total of 100ml/min x 20 min = 2000ml treatment solution is needed. The treatment solution will be 540ml ParasiteS and 1460ml water.

Treatment for Bacterial Gill Disease Using Chloramine T: Use rapid flush treatment of 8.5ppm (1g Chloramine T to 117,547 ml water) for one hour on two consecutive days.

Example using Capilano type trough with flow of 25gpm (100 lpm) and meter flow of 100 ml/min. Trough flow @100 lpm = 100,000 ml. 100,000/ 117,647 = .85g Chloramine T per minute. If treatment is for one hour then .85 x 60 = 51g per hour.

If meter flow is 100 ml/min. then the total amount of stock solution needed is 100 x 60 or 6 litres. If you take 6 litres (kg) and subtract total chloramine T needed at 51g (ml) then the amount of water in the stock solution is 5.95 litres.

The total stock solution then is 5.95 litres of water with 51 grams of Chloramine T.

ESTIMATING PERCENT FERTILIZATION

The process of egg collection is the key to a successful fish culture facility. Low fertilization among groups of egg and sperm collected can indicate a serious problem in the particular method used. Use Carnoy's or Stockard's Solution. (Note: if you cannot determine fertilisation success wait until eggs are at 100 ATU's before clearing. The embryo should be easily visible with the naked eye.)

Stockard's Solution:

This solution can be bought ready-made from Syndel or other suppliers. Stockard's solution clears and preserves eggs and the embryonic tissue can be observed through the eggshell within one or two hours. Dead eggs that have turned white can often be cleared sufficiently to reveal embryonic detail.

Formaldehyde (40 or 37%)	50 ml
Acetic acid (glacial)	40 ml
Glycerin	60 ml
Water	850 ml
	1 litre

Carnoy's Solution

Mix 75 parts of 50% ethyl alcohol and 25 parts of acetic acid. This mixture should be mixed fresh each time it is to be used.

1. 10 hours after fertilization a sample of 5 eggs is soaked for several minutes in the above solution.
2. The unfertilised germinal disk or the embryo of the fertilized egg turns opaque white and is easily distinguished.
3. Look for a white spot on the outer periphery of the egg. Examine the white spot for two divided sections = two cell stage thus a fertilized egg. If divisions are not readily visible, press egg against the bottom of a Petri dish and rotate with finger until disk and division(s) are visible.
4. Once located, examine a larger sample of eggs (e.g.. 100) to determine % of fertilization.

EGG COUNTS

Egg inventories are only done at the green egg (before fertilisation) or eyed egg stage of development. The eyed stage is preferred as the embryo is well-developed and there is less risk of mortality from handling. At the green egg stage you want as little handling as possible and the focus should be on fertilisation and planting. A rough inventory can be obtained through less intense sampling or use of historic averages of eggs per female.

Regardless of when you inventory, eggs should be divided or measured in batches of from one to a few females so there is no danger of mechanical shock to eggs at the bottom of the container or nets.

It is also important to note that when doing an inventory at the green egg stage no water can be used as it will cause eggs to swell, closing off the micropyle and preventing fertilisation. Green eggs should be kept in containers for doing inventory while eyed eggs can be handled with a soft, aquarium-sized fine-meshed dipnet.

There are several methods of doing an inventory and these are divided into the egg development stage that is most appropriate. All methods employ sub-sampling and this can be done a number of ways, depending on fertilisation and disease protocols. Sub-samples can be:

- small pre-measured lots of eggs taken from a representative number of females and the results averaged and applied to a group of females
- a few eggs from all females mixed together then smaller lots measured for an average that is applied to all females
- pre-measured amount of eggs from each female with results only applied to that female

Green Pre-fertilised Eggs

Remember that no water can be used and that excessive handling will affect fertilisation success.

Volume Method – Take a 50 or 100ml sub-sample from each pail and count the number of eggs in each sample. Measure the volume of the entire lot of eggs to be inventoried (by female or egg pail), divide by the sub-sample size and multiply that by the average count for the sub-samples.

Example: There are 10 pails of eggs with one female/pail. Eggs are going to be mixed together after fertilisation but individual eggs/female numbers are wanted at plant. Three 50ml sub-samples are taken from a mix of eggs from all females. Average number of eggs per 50ml = 100 eggs.

Sub-sample eggs are placed back in the pails then volume of each pail (female) recorded. The number of eggs/pail is (vol/pail)/50 x 100.

Once the inventory is done, eggs can be fertilised, rinsed and planted.

Weight Method – This method assumes that there will be some ovarian fluid in the egg pails. If there is excessive ovarian fluid in the egg pail then some should be drained away prior to weighing. Try to ensure that sub-samples have the same level of ovarian fluid as the egg lot being inventoried. Use the same process as above except use weights; usually sub-samples are 25 or 50g. Remember to tare the weight of a dry, empty sub-sample container before adding eggs. For egg pails, simply tare a dry empty egg container on the scale before weighing each full one.

Eyed Eggs (post shocking)

Do not keep eggs out of flowing water any longer than necessary and process only the amount that can be done quickly. Ensure eggs are moist throughout the process.

Volume – Generally the same methodology is used as for green eggs except there is no concern over moisture. At this stage there will be dead eggs and live eggs. Pick all dead eggs from each group (whether it be a tray or a portion of a larger incubation unit) and put aside. If there are low numbers of dead eggs then these can be hand-counted, otherwise use sub-sample counts and apply average sub-sample count to total volume of egg group. Note that eggs will be netted from the incubation container and that sub-sample volume and total volume will be of eggs, not eggs and water or ovarian fluid.

Displacement – Count out 100 eggs and place in a graduated cylinder with a known measure of water to determine the volume of water in millilitres displaced by the eggs. Do separate measures for live and dead. Place the larger group of eggs in a container with a known measure of water (ensure there is enough water to show the full displacement and measure). To determine the total number of eggs:

Total egg displacement (including sub-samples) in ml/average 100/egg displacement measure in ml x 100 eggs. Add number of dead to number of live eggs to get total original inventory.

Weight – use same methodology as for green eggs except can drain excess water from eggs before measuring.

Modified Von Bayer Method, for Eyed Eggs

No. of Eggs in 30.5cm trough	No. of Eggs in One Litre	No. of Eggs in 30.5cm trough	No. of Eggs in One Litre
34	1623	60	8939
35	1758	61	9353
36	1927	62	9793
37	2096	63	10263
38	2266	64	10761
39	2435	65	11294
40	2648	66	11861
41	2842	67	12468
42	3057	68	12895
43	3293	69	13574
44	3515	70	14300
45	3757	71	14815
46	4022	72	15353
47	4312	73	16211
48	4577	74	16818
49	4864	75	17457
50	5172	76	18130
51	5110	77	18839
52	5801	78	19578
53	6194	79	20362
54	6536	80	21187
55	6901	81	22057
56	7296	82	22977
57	7612	83	23455
58	8063	84	24452
59	8548	85	25508

(See *An Evaluation of Methods of Egg Enumeration* by R.E. Burrows, 1951. Progressive Fish Culturist, pp. 79-85.)

GUIDELINES FOR STAGES OF EGG DEVELOPMENT BY ACCUMULATED THERMAL UNITS

Accumulated Thermal Units (ATUs) = running total water temperature

For Example:

Day 1 water temperature	8°C	8 ATUs
Day 2 water temperature	9°C	17 ATUs
Day 3 water temperature	9°C	26 ATUs

Predicted ATUs for pink, chum, chinook, coho sockeye, steelhead from IncubWin (J.Jensen), new version 2.0.

Cutthroat data from Fraser Valley Trout Hatchery
Temperatures ranging from 5 to 12 C

Pink	**ATU's**
To eyed stage	224 - 257
To hatch stage	545 - 662
To emergence	868 - 1034
Chum	
To eyed stage	217 - 250
To hatch stage	498 - 546
To emergence	845 - 1126
Chinook	
To eyed stage	242 - 258
To hatch stage	512 - 526
To emergence	825 - 1029
Coho	
To eyed stage	217 - 237
To hatch stage	448 - 475
To emergence	777 - 829
Sockeye	
To eyed stage	236 - 257
To hatch stage	614 - 694
To emergence	943 - 1088
Steelhead	
To eyed stage	159 - 180
To hatch stage	312 - 360
To emergence	601 - 663
Cutthroat (at 10°C)	
To eyed stage	185 - 200
To hatch stage	310 - 330
To emergence	550

Remember, the ATU chart is used only as a guideline. Carefully check eggs and fry before carrying out procedures such as shocking, ponding etc. At the extreme high and low temperature range, development may occur at a faster or slower rate.

FISH FOOD ORDERING CALCULATIONS AND TIPS

Basically what you want to do is estimate how much food it will take to raise fish to the target release size or sizes. Write down the species, number of fish and the target release size(s) at the top of the page. Use fish food chart to list food size and fish size ranges that would apply to that group of fish (Feed Schedules are supplied by food manufacturers on request). Start out using estimated ponding inventory and fish size. Update calculations as you revise inventory and obtain weight samples.

If you have experience with a species of fish you might have a food conversion factor to apply (i.e, it takes 1.2kg of food to get 1kg of growth at a certain water temperature and fish size. Note that food conversions will be affected by the type of food).

Example: Species is Chinook, estimated ponding # = 500,000 and average ponding size estimated at .45g. Target release numbers and sizes = 1/2 of inventory as fed fry at 2.5g and 1/2 smolt releases at 5g.

Food type: Ewos Dry Formula – temperature range 5-6 degrees

CALCULATIONS: (Cr = crumble)

Food size	Range for Your fish	Wt gain In grams	Est.# Fish	Biomass Gain - grams	Est.Food Conversion	Total Est. Food Required		
						Grams	Kgs	20kg bags
#1 Cr.	.45-1.5g	1.05	500,000	525,000	1.2	630,000	630	31
#2 Cr.	1.5-2.5g	1.00	500,000	500,000	1.2	600,000	600	30
#3 Cr.	2.5-5.0g	2.50	250,000	625,000	1.0	625,000	625	31

Tips:

Order all of smallest food size and 25% of next food size because fish are on the small stuff for such a short period. Order a small amount of the next largest size of food throughout program so can respond to rapid growth or ranges of fish sizes in rearing area.

Consider:

- water temperature and fish growth rate when determining how much of any food size order to get at once.
- food production times, delivery opportunities (barges, trucks etc. may not run regularly) and anticipated fish growth (use growth formula).
- type of food (storage requirements and amount of storage space). Adjust calculations as fish inventory changes.

Food Conversion

The ratio of food fed to achieve a biomass gain (combined weight of all fish in the container or group).

Example: In a two week period your fish grew from 1.0 to 1.2g in average size. #fish= 100,000

Biomass gain = 100,000 x (1.2g - 1.0g) = 100,000 x .2 or 20,000g (20kg).

If you fed 25 kg of food in that period then your food conversion would be 25kg food/20kg weight gain or 1.25 kilograms of food to get one kilogram of growth, a conversion ratio of 1.25:1

Food conversion can be one of the tools to indicate whether too much, too little or wrong size or quality of food is being fed. It will also be affected by the type of food fed re: moist or dry.

USEFUL FORMULAS

Instantaneous growth formula - Daily growth in % body weight gain/day

Growth = ln (average end weight) – ln (average start weight)
÷ Number of days

ln = natural log or naperian logarithm

You can express the growth in % body weight gain/day. Just make sure you remember that when you go to use it to project a weight in the future. e.g., if growth = .045, that is 4.5%.

Fish Condition Estimation (weight to length ratio)

This is another tool that can be used to track general fish health and calculate feed & growth rates.

The "normal" condition may vary slightly depending on species (chum might be @ 1.0 and coho @ 1.1)

Use average wt. in grams and average length in mm -
100,000 x wt/(LxLxL)

Calculating Volume of Circular Rearing Containers

3.14 x radius^2 in metres x depth in metres (radius is 1/2 of diameter)

	Diameter	Depth	Formula	Volume
Imperial	10ft	3ft	3.14 x (5'x5') x 3	235.5
Metric	3.05m	.914m	3.14 x (1.74mx1.74m) x .914	8.69

Modified Peterson Formula for Population Estimation Using Mark/ Recapture

Pop. = (#fish marked + 1) x (total fish recaptured + 1) ÷ (number marked fish recaptured + 1)

Sturdies Formula for Estimating Adult Fish Weight

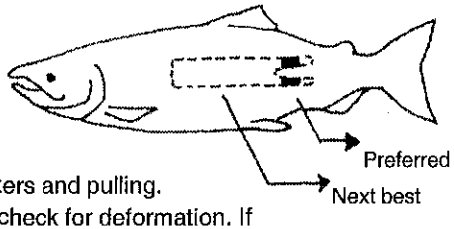
Multiply four thirds of the fish's length by the square of its girth and divide the final figure by 1000, where length and girth are measured in inches and girth is measured at front of dorsal and length is nose to fork.

HOW TO TAKE SCALE SAMPLES

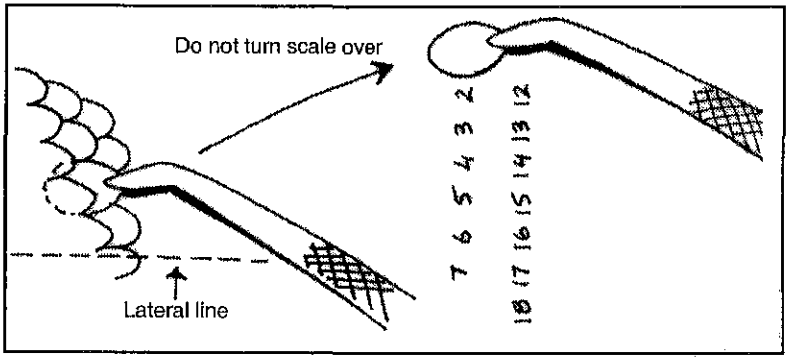
Scale samples are taken from both sides of each fish; the number of scales required varies by species.

Scales from each side are arranged in individual squares in scale books. Always complete sampling first side of fish before starting second. In an emergency, a piece of brown paper butcher's tape will do nicely for a scale book substitute. Stick scales to the gluey side.

1. Place fish on its side.
2. Wipe the preferred area (see diagram) clear of water and slime.
3. Remove scale from preferred area by grasping its exposed edge with tweezers and pulling.



4. Hold scale up to the light to check for deformation. If scale is deformed or abnormal, discard and select another.
5. Centre the scale on the numbered square on the scale book so that the side that faced up on the fish remains facing up on the book. To check if the correct side is facing up, scrape the surface of the scale with tip of tweezers. It should be rough with ridges.
6. Be sure the scale is sticking firmly to the scale book. Use no additional water to adhere the scale, just the moisture already present.
7. Turn the fish on its other side and repeat the procedure.



WATER QUALITY CRITERIA FOR SALMON CULTURE

Parameter	Best	Toxic
Temp	>2-3C	<18-25C
pH	6.5-8.5	<5;>9
D. Oxygen	>6-8 ppm	
Gas pressure – total	<103%	110%
– N2+Ar	<100%	
Alkalinity – total	20-300	
Ammonia – total (incubation)	<0.002	0.08
– total (rearing)	<0.005	0.08
CO_2 (free total)	2-5	20+
Clorid (Cl)	<170	400
Clorine	<0.002	0.006
Total Cl residuals	<0.003	
Colour	<15 TCU	
Conductivity (mhos/cm)	150-2000	
Cyanide	<0.005	
Fluoride (F)	<1.5	2.3-7.5
Hardness As $CaCO_3$	20-400	
H_2S	<0.002	>0.004
Nitrogen (N)	<100%	
Nitrite (NO_2)	<0.012	0.2
Nitrate (NO_3)	0.12	
$NO_2 + NO_3$	<0.13	
Pest/ Herbicides	0	
Phosphate (Tot)	<0.05	
Residue – filterable (TDS)	<2.000	
– nonfilterable	<3 incubation <25 rearing	
Residue – total	<2,000	
Silica (SiO_2)	<10-60	
Sulfate (SO_4)	<90	
Sulphide	<0.002	
Taste/odour	odour free Inoffensive taste	
TDS – (mineral content)	500-1,000	
Turbidity (FTU & JTU)	1-60 JTU	1,000

Metals	Symbol	Best* *(mg/L)
Aluminum	Al	<0.1
Arsenic	As	<0.05
Barium	Ba	1.0
Calcium	Ca	1.0-5.0
Cadmium (Soft water)	Cd	<0.0003
(Hard water)		<0.007
Chromium	Cr	<0.01
Copper (Soft Water)	Cu	<0.002
(Hard Water)		<0.06
Iron	Fe	<0.3
Mercury	Hg	<0.0002
Potassium	K	0.1-5
Magnesium	Mg	0.3-14
Manganese	Mn	0.1
Sodium	Na	0.3-20
Nickel (Soft water)	Ni	0.045
(Hard water		0.25
Leas (Soft Water)	Pb	<0.004
(Hard Water)		<0.05
Selenium	Se	0.05
Silicon	Si	10-60
Silver	Ag	<0.0001
Zinc (Soft Water)	Zn	0.015
(Hard Water)		0.12

LOADING CRITERIA

Loadings are expressed in two measurements: weight per given volume and weight per given water flow. When calculating how much to load in a particular container, one of these ratings will suggest a lower number of fish than the other depending on the container, its flow characteristics, and the species and size of fish involved. *Always* load the *lower* suggested number of fish. For help in calculating volumes, visit www.abl.msstate.edu/tools/tools.index.html.

ADULT LOADING
Long Term (weeks)

CHUM	Flow	1.2kg adults/LPM	10lb./U.S. GPM
	Density	32kg/m^3	2 lb./$ft.^3$
CHINOOK	Flow	1.2kg/LPM	10lb./U.S. GPM
	Density	32kg/m^3	2 lb./$ft.^3$
COHO	Flow	1.2kg/LPM	10lb./U.S. GPM
	Density	32kg/m^3	2lb./$ft.^3$

Short Term (Days)

Loadings can be double for short periods. Chum salmon in particular can tolerate loading up to 4lb./$ft.^3$

INCUBATION
Heath Trays

Flow 11 – 15 LPM/8 tray stack 3-4 U.S. GPM/8 tray stack
Density 5,000-11,000 eggs/tray

	Eggs/tray	kg/tray	litres/tray
COHO	8,000	2.1	1.7
CHINOOK	5,000	2.1	2.4
CHUM	5,000	2.1	2.2
PINK	11,500	2.1	–

Comment: If trays are not loaded to capacity, use the lower flow to prevent boiling. If capacity loaded, use lower flow until advanced eyed, then increase flow to upper range until ponding. If a two-stack arrangement is used, then flows should be set at a maximum of 5 U.S. GPM or 19 LPM and the lower stack trays loaded at 75% of suggested loadings.

Upwelling Gravel Boxes

This category includes Pallant boxes, bulk boxes, mini-bulk incubators, and in-stream substrate incubators. Variations for species, design, and technique require expert advice from a fish culture technician.

REARING

Suggested Loadings

Capilano Troughs

Flow	0.5kg/LPM – 1.0kg/LPM 4.5 – 6.0lb./U.S. GPM
Density	32.35kg/m^3 2 – 3 lb./$ft.^3$

Comments: Most facilities have Capilano troughs arranged in tandem. Flows should be 120 LPM at ponding and be increased to 240 LPM as fish approach 2 grams. Five grams is the preferred maximum size fish to be raised in these containers. Chinook are the least tolerant of higher loading densities of all the species.

Flow	120 LPM – Ponding to 1g 240 LPM – 1g to 5g

Note: New models of Capilano troughs may have different volumes, but generally they are about 2.2m^3/trough.

Circular tubs

CHINOOK	Flow	0.5 – 1.0kg/LPM	4.2 – 8.3lb./U.S. GPM
	Density	10.0kg/m^3	0.623lb./$ft.^3$
COHO	Flow	0.5 – 1.15kg/LPM	4.2 – 9.6lb./U.S. GPM
	Density	10.0kg/m^3	0.623lb./$ft.^3$

Comments: Circular tubs seem useful in raising larger fish.

Conservative loading & flow calculations:

Tub diameter		Tub depth		Tub volume		Tub capacity		Flow required	
ft	m	ft	m	ft^3	m^3	lbs fish	kg fish	USG	LPM
4	1.22	3	0.91	37.68	1.07	23.47	10.67	6	21
5	1.52	3	0.91	58.88	1.67	36.68	16.67	9	33
6	1.83	3	0.91	84.78	2.40	52.82	24.01	13	48
8	2.44	3	0.91	150.72	4.27	93.90	42.68	23	85
10	3.05	3	0.91	235.50	6.67	146.72	66.69	35	133

Capacity of tubs in number of fish for several size ranges:

Tub diameter (ft)	2 – 5g	5 – 7g	7 – 10g	10 – 20g
4	2134	1524	1067	534
5	3335	2382	1667	834
6	4802	3430	2401	1201
8	8537	6098	4268	2134
10	13339	9528	6669	3335

Earthen or Semi-natural Rearing Channels

CHINOOK	Flow	0.5 – 1.1kg/LPM	4.2 – 9.2 lb./U.S. GPM
	Density	10 kg/m^3	.623 lb./$ft.^3$
COHO	Flow	0.5 – 1.8kg/LPM	4.2 – 15 lb./U.S. GPM
	Density	10 kg/m^3	.623 lb./$ft.^3$
CHUM	Flow	0.5 – 1.2kg/LPM	4.2 – 10 lb./U.S. GPM
	Density	10 kg/m^3	.623lb./$ft.^3$

Comments: Calculations for chinook were based on a size of 2 grams at initial loading and a release at 5 grams. Coho have an initial loading at 2 grams and a release size of 20 grams. Chum were assumed to have a release weight of not more than 2 grams.

TRANSPORT LOADING

Comment: Temperature not to exceed 20C. Assume 100% oxygen saturation.

Type of Aeration	Loading Rate		Safe Transport Time
	Kg/litre	Lbs/U.S.G.	
Oxygen	0.1	0.8	2 – 3 hrs.
Compressed air	0.1	0.8	2 – 3 hrs.
None	0.013	0.1	1 hr.

With no aeration, multiply loading by saturation of water supply (i.e. 70% saturation). Acceptable: Trans. Load = (.7) x (0.13)kg/litre = .009kg/litre.

NETPEN LOADING RATES

The standard initial loading rate recommended for netpens used in juvenile rearing is 12kg/m^2 (2.5lb./$ft.^2$), a density per area calculation. Final densities at release size should not exceed a density per volume level of 5kg/m^3 (0.3lb./ft^3).

Factors to consider are: duration of time in the netpens, water quality, water "flow" or movement through the netpen, mesh size, water temperature, size and species of fish and amount of food being fed.

Be sure to consider maximum size to which fish are expected to grow and plan to have maximum loading coincide with maximum size. If this is not possible you should plan to add more rearing pens and reduce densities periodically during the rearing period.

CHEMICAL REPLACEMENTS

As all chemicals are now banned in fish culture (unless authorized by appropriate agencies in specific situations); new methods for anaesthetizing fish and treating fungus have been developed. Several follow:

ANAESTHETICS

Carbon dioxide gas: CO_2 gas added to a static bath can be an efficient method to anaesthetize adult and juvenile fish. It is recommended to add baking soda to the bath as a buffer to maintain the original pH of the water. Dissolved oxygen should also be added and a level of at least 6ppm should be maintained.

The following is a recommended formula:

CO_2 – 200 to 400mg/l

DO – 6mg/l to saturation

pH – 6.0 minimum

Note: If the CO_2 levels are too high or the solution too acidic, fish may react by haemorrhaging at the gills. The most important key to anaesthetizing fish successfully is to monitor them carefully until a method is determined that works for your situation. Volume of water used, as well as temperature and hardness, will make a difference to how much CO_2 is required. CO_2 should not be used in enclosed areas as elevated levels in the air (>10%) can cause loss of consciousness in humans.

Alka Seltzer: 1 tablet per litre of water. It is especially useful in field situations.

Note: Alka Seltzer also contains citric acid and aspirin

Club soda: 250 – 300ml to 4 litres of water.

Clove oil: Works fairly well on adults, however, it may not acceptable to fish handlers because of strong odours. The "natural" clove oil seems to work best. Target concentration is less than 60ppm. Some individuals find clove oil irritating to the skin and eyes so wear gloves and use in a well-ventilated area.

FUNGUS CONTROL

Salt can be used for control of fungus on eggs and adults:

20ppt (parts per thousand) salinity for one hour for eggs. 2 to 3 times per week from 24 hours post-fertilization to eyed stage.

25ppt for 1 hour for adults.

Salt Treatment Example:

21g/l = 21ppt NaCl and $CaCl_2$ (Buffer)

21g x 26/27 = 20.22g/l NaCl

21g x 1/27 = 0.78g/l $CaCl_2$

140 l of stock solution for an eight tray stack

140 l x 20.22g NaCl = 2831g NaCl

140 l x 0.78g $CaCl_2$ = 109g $CaCl_2$

This is the amount of salt used for one bath.

Procedure:

1. Mix up stock solution
2. Turn off fresh water flow to stack
3. Introduce stock solution into top tray
4. Monitor salinity at outflow of bottom tray. When salinity reaches stock concentration, shut off flow.
5. Static bath for one hour
6. Turn on fresh flow to stack

Once you have determined how much stock solution you need to displace the fresh water in the stack, it is no longer necessary to monitor concentration.

IMPORTANT:

When salt (NaCl) is ordered, it must be specified that it DOES NOT contain the anti-caking additive YPS as this contains cyanide.

Transport:

10 ppt salt in transport tanks and marking basins is helpful to prevent electrolytes from being lost during stress and handling. This also has disinfectant properties on the marking wound.

CHEMICAL DILUTION

Active ingredient in ml or g		Amount of active ingredient required for various quantities of water			
Concentration in ppm	Dilution ratio	5 litres 1.3 USG	10 litres 2.64 USG	20 litres 5.28 USG	25 litres 7.9 USG
8.5	1:117,647	0.043	0.085	0.170	0.213
25	1:40,000	0.125	0.250	0.500	0.625
100	1:10,000	0.500	1.000	2.000	2.500
167	1:6,000	0.833	1.667	3.333	4.167
1670	1:600	8.333	16.667	33.333	41.667

ppm = parts per million so 1ppm = 1 part chemical to 1,000,000 parts water. This translates to 1 ml or 1 g active ingredient (specific chemical) per 10 litres water. If you are using Imperial measures, multiply the USG by .833.

DISSOLVED OXYGEN SATURATION (ppm)

Distilled water exposed to atmosphere (20.9% oxygen gas) at pressures and temperatures indicated*

Temp F	Temp C	Altitude in Feet: Sea Level	1,000	2,000
32	0	14.6	14.1	13.5
33	0.6	14.4	13.9	13.3
34	1.1	14.2	13.7	13.1
35	1.7	14.0	13.5	12.9
36	2.2	13.8	13.3	12.7
37	2.8	13.6	13.1	12.6
38	3.3	13.4	12.9	12.4
39	3.9	13.2	12.7	12.2
40	4.4	13.0	12.5	12.1
41	5.0	12.8	12.3	11.9
42	5.6	12.6	12.2	11.7
43	6.1	12.5	12.0	11.5
44	6.7	12.3	11.8	11.4
45	7.2	12.1	11.7	11.2
46	7.8	11.9	11.5	11.1
47	8.3	11.8	11.3	10.9
48	8.9	11.6	11.2	10.8
49	9.4	11.5	11.1	10.6
50	10.0	11.3	10.9	10.5
51	10.6	11.2	10.8	10.4
52	11.1	11.0	10.6	10.2
53	11.7	10.9	10.5	10.1
54	12.2	10.8	10.4	10.0
55	12.8	10.6	10.3	9.9
56	13.3	10.5	10.1	9.7
57	13.9	10.4	10.0	9.6
58	14.4	10.3	9.9	9.5
59	15	10.2	9.8	9.4
60	15.6	10.0	9.7	9.3
61	16.1	9.9	9.6	9.2
62	16.7	9.8	9.5	9.1
63	17.2	9.7	9.3	9.0
64	17.8	9.6	9.2	8.9
65	18.3	9.5	9.1	8.8
66	18.9	9.4	9.0	8.7
67	19.4	9.3	8.9	8.6
68	20	9.2	8.8	8.5
69	20.6	9.1	8.7	8.4
70	21.1	9.0	8.6	8.3
75	23.9	8.6	8.3	7.9

*Saturation in stream water is usually 0.2-0.5ppm lower than those listed in table due to dissolved minerals, etc.

Adapted from *Diseases of Pacific Salmon - Their Prevention and Treatment,* by James Wood, 1979.

BIOSTANDARDS - SALMON SURVIVAL
Total % Survival - Catch Plus Escapement

The table below gives some indication of overall survivals from release to catch or escapement to spawning grounds (expressed as a percentage) which can be expected from hatchery releases.

Species	Smolt	Fed Fry	Unfed Fry
Sockeye			0.5 - 3.0%
Coho	0.7% - 7.0%	0.35 - 3.5%	0.105 - 1.05%
Chinook	0.1% - 5.0%	0.05 - 2.5%	0.02 - 1%
Chum		0.5% - 2.5%	0.2 - 1%
Pink		0.5% - 5.0%	0.375 - 3.75%
Steelhead	1 - 2 %	0.1 - 0.2%	NA
Cutthroat	0.5 - 7.0%	NA	NA

For example:

From a **smolt** release of 10,000 coho
You may expect adult production ranging from 70 to 700 fish.

From a **fed fry** release of 10,000 coho
You may expect adult production ranging from 35 to 350 fish.

From an **unfed fry** release of 10,000 coho
You may expect adult production ranging from 1 to 53 fish.

Habitat

TRANSPORT VELOCITIES FOR VARIOUS CLASSES OF STREAMBED MATERIALS

Material	Diameter	Velocity
Silt	0.005-0.05mm	15-20cm/sec
Fine – coarse sand	0.25-2.5mm	30-65cm/sec
Fine – coarse stone	25-75mm	80-120cm/sec
Cobbles	100-200mm	270-390cm/sec

Tractive Force (a measurement to indicate what size of rock material will remain in place).

Tractive force = 1000 x average bankfull depth of flow in metres x slope of the water surface.

Example: the average bankfull depth is .5m and the slope is 4%.
1000 x .5 x .04 = 20kg/m^2

A tractive force of 20kg/m^2 indicates that material of less than 20cm could be unstable.

NATIVE PLANTS FOR SHORELINE, BANK AND UPLAND

Trees (E = Erosion control or bank stabilization value)			
Name	**Sun or Shade, Soil and Moisture**	**Height**	**Method of Propogation**
Big-leaf or Broadleaf Maple (Acer macrophyllum)	sun - shade moist, rich	to 30m	seed, transplant
	fast-growing		
Black Cottonwood or Balsam Poplar (Populus balsamifera) ***E***	sun moist, wet	30 - 65m	cutting, seed, transplant
	very fast-growing, fragrant leaves, hardy, shallow-rooted, short-lived. low to mid elevation, trees will resprout when cut, valuable in restoring flooded lands or other wet habitat, tolerates flooding		
Cascara (Rhamnus purshiana)	sun - shade dry - wet	10 -12m	cutting, seed, transplant
	low to mid elevation, good for soil-binding, grows well on disturbed sites		
Douglas Fir (Pseudotsuga menziesii) ***E***	sun - part shade well-drained, dry	to 75m	seed, transplant
	rapid growing, good soil binding roots, low to mid- elevation, good for stream-side or buffer zone plantings		
Douglas Maple (Acer glabrum) ***E***	sun - shade moist, well-drained	to 10m	seed, transplant
	showy autumn colour		
Grand Fir (Abies grandis)	sun - part shade moist - dry, well-drained	to 60m	seed
	best conifer for soil binding roots, adapted to broad range of habitats, drought tolerant		

Lodgepole or Shore Pine (Pinus contorta)	sun moist - dry	9 - 30m 5 -15 m coastal	seed
	excellent above ground cover, adaptable to many sites, salt tolerant, fast growing		
Pacific Crabapple (Malus diversifolia)	sun - part shade moist - wet	2 - 12m	seed
	good in woods, swamps and edges of standing or flowing water, and on shoreline - Coastal		
Paper or White Birch (Betula papyrifera)	sun moist - dry	to 30m	seed transplant
	fast-growing, yellow fall leaves, white peeling bark		
Red Alder (Alnus rubra)	sun - part shade moist	to 25m	seed, cutting, sucker
	fast-growing, hardy, nitrogen fixing		
Sitka Mountain Ash (Sorbus sitchensis)	sun - part shade moist - dry	1 - 4m	seed and rooted stock
	white flower clusters, showy red fruit, red fall colour		
Sitka Spruce (Picea sitchensis) ***E***	sun - shade moist - wet	to 70m	seed, transplant
	tolerates flooding but is shallow rooted, often found in wet forests or bogs - coastal		
Trembling Aspen (Populus tremuloides)	sun moist - dry	20 - 30m	cutting seed, sucker, root cuttings
	fast-growing, yellow fall leaves, low elevation, forms dense groves by suckering, likes sandy or gravelly soils		
Vine Maple (Acer circinatum) ***E***	sun - shade mesic	to 10m	seed, transplant
	showy autumn colour, sprouts from roots, forms tree in open, more shrubby in shade, shade tolerant - coastal		
Water or Black Birch (Betula occidentalis)	Sun - shade wet	to 10 m	seed, transplant

Western Hemlock (Tsuga heterophylla)	sun - shade moist - wet	to 60m	transplant, seed
	low elevation, long-lived, suitable for wetland edges and buffer zones		
Western Red Cedar (Thuja plicata)	sun - shade moist - wet	to 60m	transplant, seed
	rapid-growing, moisture loving, can be hedged, low elevation, tolerates seasonal flooding, excellent choice for wetland and riparian sites		
Shrubs and Shrubby Trees			
Beaked Hazelnut (Corylus cornuta)	sun - shade moist - dry, well-drained	1 - 4m	seed, suckers
	yellow autumn colour, edible nuts, low elevation, good stream side plant, intolerant of saturated soil		
Bitter Cherry (Prunus emarginata)	sun - part shade dry - moist	2 - 15m	seed, transplant
	attractive white flowers, red fruits, likes loamy, sandy or gravelly soils		
Black Raspberry (Rubus leucodermis)	sun mesic	to 2m	seed, root cuttings, and dividing clumps
	thorns, red-black berries, excellent erosion control by dense above-ground portion		
Black Gooseberry (Ribes lacustre)	part shade - shade moist - medium soils	.5 - 2m	seed, cutting, layer
	erect to spreading, prickles and spikes on branches, low to high elevation, DO NOT plant within 900 ft of 5 needle pines (secondary host of white pine blister rust), good for shady, damp areas or drier forested slopes		
Black Twinberry (Lonicera involucrata) *E*	shade wet - moist	.5 - 3m	cutting, seeds
	low to mid elevation, fast-growing erect shrub, likes moist forest, clearings, stream sides, swamps		

Black hawthorn (Crataegus doublasii) ***E***	sun moist - wet	to 10m	seed, transplant, root cuttings
	thorns, white flowers, good autumn colour, moist sites along streams and ponds at low to mid elevations		
Blue Elderberry (Sambucus cerulea) ***E***	sun- part shade mesic - dry mesic moist - wet moist - dry	to 6m	seed and cuttings
	needs good drainage, good for dry, open sites, grows fast once established, edible berries		
Choke Cherry (Prunus virginiana)	sun mesic - dry	to 10m	rooted stock
	white flowers, edible red fruit, rich moist soil preferred but adapts to dry, exposed sites.		
Evergreen huckleberry (Vaccinium ovatum)	part shade - shade moist to slightly dry	to 2m	cuttings, seed or layering
	glossy evergreen, white flowers, edible black fruit, tolerant to salt spray		
Hardhack (Spirea douglasii)	sun - shade well drained moist - wet	1 - 2m	sucker, cutting, seed
	showy pink flowers, no pests, dense thickets, suckers profusely adaptable, tolerates moist soil to seasonal flooding, can be invasive in level wet areas with shallow water		
Highbush cranberry (Viburnum edule)	sun - part shade well-drained, moist	to 6m	cuttings, seed, rhizome cuttings and stem cuttings
	white flower, edible orange-red fruit, red fall colour		
Indian Plum (Oemleria cerasiformis)	Sun - part shade, moist - dry	1.5 - 5m	transplant, seed, cutting
	low to mid elevation, good for edges of stream banks, rivers and wetlands, very early flowering - coastal		

Low Oregon Grape (Berberis nervosa) - Groundcover	sun - shade well-drained, dry	to 4 ft	cuttings, layers
	slow-growing, thicket-forming, evergreen, good easy-care ground cover		
Mock Orange (Philadelphus lewisia)	sun - part shade moist - dry	to 3m	cutting, layer
	spreading, fast growing, early fragrant white flowers, good for dry, open sites, good land reclamation plant, no pests, low to high elevation		
Mountain Alder (Alnus tenuifolia)	sun moist - wet		seed, transplant
	inland		
Ocean Spray (Holodiscus discolour) ***E***	sun - part shade mesic-dry	to 4m	seed
	showy white flowers, drought tolerant, good with other ground covers, good on dry, steep slopes or disturbed sites, resprouts readily when cut or grazed, prefers rocky gravelly hillsides		
Pacific ninebark (Physocarpus capitatus) ***E***	sun - part shade moist - dry	to 4m	cutting seed and rooted stock
	low to mid elevation, likes wet , open places like edges of lakes and streams - coastal		
Pin Cherry (Prunus pensylvanica)	part shade moist	to 5 m	
	low elevations		
Red Twinberry (Lonicera utahensis)	shade moist		cutting, seed
	inland		
Red Elderberry (Sambucus racemosa) ***E***	sun - shade moist - wet	to 6m	cutting, seed
	white flower clusters, showy red fruit, aggressive once established, berries edible when cooked - coastal		

Red Huckleberry (Vaccinium parvifolium)	part shade - shade dry - slightly moist or on rotting wood		seed, cutting, sucker, layering
	edible red fruit, attracts hummingbirds and deer, good for upland, wooded areas		
Red Raspberry (Rubus idaeus)	sun mesic	to 2m	seed, root cuttings, and dividing clumps
	thorn, red edible berries, rapid growing, suckering, excellent erosion control by dense above-ground portion		
Red-Flowering Currant (Ribes sanguineum)	sun - part shade moist	1 - 3m	seed, cuttings
	showy red flowers, blooms early, attracts hummingbirds, good for dry sites		
Red-Osier Dogwood (Cornus stolonifera or sericea) ***E***	sun - shade well-drained moist,	1 - 6m	cutting, (seed), layer
	showy red twigs, white flowers, fast-growing, hardy, holds soil well, good in open sites and disturbed areas and along shorelines and seepage areas		
ROSE: Prickly Rose (Rosa acicularis)	sun - part shade moist	to 1.2m	stem cutting, root cutting, layers
	thorns, pink flowers, red hips, hardy, fast-growing, suckering, low to mid elevation, poor erosion control through roots		
ROSE: Prairie Rose (Rosa woodsii)	sun - part shade dry - moist	to 2m	stem or root cutting, layers
	low to mid elevation, poor erosion control through roots, needs water for establishment at low elevations		
ROSE: Nootka rose (Rosa nutkana) ***E***	sun - part shade mesic	to 3m	sucker, seed stem or root cutting, layers
	thorns, pink flowers, red hips, hardy, fast growing, spreading low to mid elevation, poor erosion control through roots, often found near water in open woodlands, tolerates saturated soils, can grow near salt water		

ROSE: Clustered Wild Rose (Rosa pisocarpa)	sun - part shade moist - wet	to 2.5m	stem or root cutting, layers
	wetland margin plant, hardy, tolerates flooding, fast-growing, suckering, also tolerant of dry conditions and infertile soils.		
ROSE: Baldhip Rose (Rosa gymnocarpa)	sun - shade mesic	to 1.2m	stem cutting, root cutting, layers
	thorns, pink flowers, red hips, hardy fast-growing, spreading by suckering low to mid elevation, poor erosion ,control through roots, very drought tolerant		
Salal (Gaultheria shallon) ***E***	sun - shade	to 5m	transplant, seed, stem cuttings
	good slope stabilizer, prefers some shade, tolerant of poor soils - coastal		
Salmonberry (Rubus spectabilis) ***E***	sun - shade moist - wet	to 4m	stem and root cutting, transplant, seed, and dividing clumps
	excellent erosion control by dense thickets, spreads rapidly by underground stem system, good for eroded or disturbed sites - coastal		
Saskatoon , Serviceberry (Amelanchier alnifolia) ***E***	sun - part shade well-drained, moist - dry	1 - 5m shrub to 30 ft	sucker, seed
	showy white flowers, edible fruit, upright. spreading, low to high elevation, good for dry sites		
Shrubby Cinquefoil (Potentilla fruticosa)	sun mesic - dry	to 1m	
	showy yellow flowers, good for ground layer on dry open sites		
Sitka or Slide Alder (Alnus sinuata or sitchensis)	sun - part shade moist	1 - 5 m	seed, cutting, sucker
	low to high elevation, roots fix nitrogen, good for poor soils, disturbed sites, bare areas, high flood and snow resistance		
Snowberry (Symphoricarpos albus) ***E***	sun - part shade dry - wet	to 1m	suckers, cutting, transplant, seed
	dense thickets, sucker readily, mid to high elevations		

Snowbrush (Ceanothus velutinus)	sun up	60 cm - 1 m	cutting transplant
	mat-forming evergreen , white flowers, fragrant foliage, fixes nitrogen, drought tolerant - inland		
Tall Oregon Grape (Mahonia or Berberis aquifolium)	sun - part shade mesic - dry well-drained	to 2m to 1 m	cutting, layer seed
	tough prickly leaves, evergreen, can be spindly in shade, drought tolerant, slow-growing, will grow in dry shade or full sun		
Thimbleberry (Rubus parviflorus) ***E***	sun - part shade mesic - moist	.5 - 3 m	transplant, seed and root cuttinngs and dividing clumps
	thornless, spreads by underground stems, good soil-binder for steep, drier slopes or on open sites, or exposed stream areas		
Western or Pacific Crabapple (Malus fusca)	sun moist - well drained	to 10m	seed
	thorns, fragrant pink-white flowers, small edible fruits, low elevation, forms dense thickets, does well near salt water, sloughs and estuaries.		
WILLOW: Pacific willow (Salix lasiandra or lucida) ***E***	sun - part shade moist - wet	9 - 12m	cuttings
	fast growing, new growth is showy yellow, tolerates flooding		
WILLOW: Scouler's willow (Salix scouleriana) ***E***	sun - part shade moist - wet	2 - 12 m	cuttings
	fast-growing, tolerates flooding, drought-tolerant		
WILLOW: Sitka willow (Salix sitchensis) ***E***	sun - part shade moist - wet	1 - 8m	cuttings
	dense, fast growing, tolerates flooding		

Ground Covers and Herbaceous Perennials				
CLEMATIS (Clematis spp.) Columbia clematis (Clematis columbiana) Western or White clematis (Clematis ligusticifolia) Blue clematis (Clematis occidentalis)	sun - part shade moist			
	spreading or climbing vines, white or blue flowers, good for groundcovers			
Common juniper (Juniperus communis)	sun moist - dry			
	drought-tolerant, low evergreen , bluish berries			
Devil's Club (Oplopanax horridus)	part shade - shade moist - wet	1 - 3 m		
	large leaves, very spiny stems, attractive red berries			
Kinnikinnick (Arctostaphyl os uva-ursi) ***E***	sun moist - dry	to 20 cm	seeds or cuttings	
	trailing evergreen groundcover, drought tolerant, good for dry sites and banks, bright red berries			
Orange honeysuckle (Lonicera Ciliosa)	part shade moist	to 6m		
	vine with orange flowers and berries, low to mid elevations, attracts hummingbirds			
Trailing or Wild Blackberry (Rubus ursinus) ***E***	sun - shade moist - dry		seeds, stem cuttings or division	
	creeping, trailing plant, very spiny, edible berries, aggressive growth makes good groundcover and erosion control			

Western Mugwort (Artemisia ludoviciana) ***E***	sun medium - dry	30 - 90cm	
	silvery foliage, spreads underground in silty soil		
Western trumpet honeysuckle (Lonicera ciliosa)			
Yarrow (Achillea millefolium) ***E***	sun medium - dry	50 cm	
	white or pink flowers, fragrant foliage, very adaptable and drought-tolerant, good ground cover, invasive with irrigation		
Yellow Mountain Avens (Dryas drummondii)			

SOURCES:

Streamkeepers Manual: Native Species Suited for Riparian Revegetation Projects

Access Near Aquatic Areas: A Guide to Sensitive Planning, Design and Management (The Stewardship Series). Suggested Live Barrier Species for Coastal BC (Native Plants)

The Roles and Uses of Native Vegetation in Riparian Areas (Guidelines for Bank Stabilization Projects in the Riverine Environments of King County)

Naturescape BC, Native Plant and Animal Booklet, Southern Interior

Streambanks Restoration Manual by David Polster

Grow Your Own Native Landscape, Michael Leigh (Native Plant Salvage Project)

Devil's Club Streamside Native Plants, Barbara and Richard Porter

WILLOW CUTTINGS

Cutting - Take donor stock from close by and of similar habitat. Take when plant is dormant (leaves are off). Best cuttings are 2 ft. long and diameter of your finger. Cut bottoms diagonally and tops square as reminder which end goes up; or colour one end.

Storing - Minimize or eliminate storage time altogether. Freezer will tend to dry out cuttings. Best stored under snow bank during winter.

Site Selection - Scarify ground to prepare site. Plant in wet site, ensuring bottom of cutting reaches wet soil.

Planting - Poke hole with planting tool such as rebar rod. Bury 75% to 80% of cutting with at last 2 buds above ground. Tamp down soil around hole. Water in summer or if soil is dry. Place vole guard around stem if required.

Conversion Tables

CONVERSION TABLES

To Convert	Into	Multiply By
	A	
Acre	square chain (Gunters)	10
Acre	rods	160
Acre	square links (Gunters)	1×10^5
Acre	hectare or sq. hectometer	.4047
Acres	square feet	43.560.0
Acres	square metres	4.047
Acres	square miles	1.562×10^{-3}
Acres	square yards	4.840
Acre-feet	cubic feet	43.560.0
Acre-feet	gallons	3.259×10^5
Atmospheres	cm of mercury	76.0
Atmospheres	feet of water (at 4C)	33.90
Atmospheres	inches of mercury (at 0C)	29.92
	C	
Centigrade	Fahrenheit	(C degree x 9/5)+32
Centimetres	feet	3.281×10^{-2}
Centimetres	inches	0.3937
Centimetres	kilometres	10^{-5}
Centimetres	metres	0.01
Centimetres	millimetres	10.0
Centimetres	mils	393.7
Centimetres	yards	1.094×10^{-2}
Chains (surveyors or Gunter's)	yards	22.00
Cubic centimetres	cubic feet	3.531×10^{-5}
Cubic centimetres	cubic inches	0.06102
Cubic centimetres	cubic metres	10^{-6}
Cubic centimetres	cubic yards	1.308×10^{-6}
Cubic centimetres	gallons (U.S. liquid)	2.642×10^{-4}
Cubic centimetres	litres	0.001
Cubic centimetres	pints (U.S. liquid)	2.113×10^{-3}
Cubic centimetres	quarts (U.S. liquid)	1.057×10^{-3}
Cubic feet	cubic inches	1.728.0
Cubic feet	cubic metres	0.02832
Cubic feet	cubic yards	0.03704
Cubic feet	gallons (U.S. liquid)	2.642×10^{-4}
Cubic feet	litres	28.32
Cubic feet	pints (U.S. liquid)	59.84
Cubic feet	quarts (U.S. liquid)	29.92
Cubic feet/minute	cubic cm/second	472.0

Cubic feet/minute	litres/second	0.4720
Cubic feet/minute	pounds of water/minute	62.43
Cubic feet/second	million gallons/day	0.646317
Cubic feet/second	gallons/minute	448.831
Cubic inches	cubic centimetres	16.39
Cubic inches	cubic feet	5.787×10^{-4}
Cubic inches	cubic metres	1.639×10^{-5}
Cubic inches	cubic yards	2.143×10^{-5}
Cubic inches	gallons	4.329×10^{-3}
Cubic inches	litres	0.01639
Cubic inches	mil-feet	1.061×10^{5}
Cubic inches	pints (U.S. liquid)	0.03463
Cubic inches	quarts (U.S. liquid)	0.01732
Cubic metres	bushels (dry)	28.38
Cubic metres	cubic centimetres	10^{6}
Cubic metres	cubic feet	35.31
Cubic metres	cubic inches	61.023.0
Cubic metres	cubic yards	1.308
Cubic metres	gallons (U.S. liquid)	264.20
Cubic metres	litres	1,000.0
Cubic metres	pints (U.S. liquid)	2,113.0
Cubic metres	quarts (U.S. liquid)	1,057
Cubic yards	cubic centimetres	7.646×10^{5}
Cubic yards	cubic feet	27.0
Cubic yards	cubic inches	46,656.0
Cubic yards	cubic metres	0.7646
Cubic yards	gallons (U.S. liquid)	202.0
Cubic yards	litres	764.6
Cubic yards	pints (U.S. liquid)	1,615.9
Cubic yards	quarts (U.S. liquid)	807.9
Cubic yards/minute	cubic feet/second	0.45
Cubic yards/minute	gallons/second	3.367
Cubic yards/minute	litres/second	12.74

D

Days	seconds	86,400.0

F

Fathoms	metres	1.828804
Fathoms	feet	6.0
Feet	centimetres	30.48
Feet	kilometres	3.048×10^{-4}
Feet	metres	0.3048
Feet	miles (nautical)	1.645×10^{-4}
Feet	miles (statute)	1.894×10^{-4}
Feet	millimetres	304.8
Feet	mils	1.2×10^{4}

Feet of water	atmospheres	0.02950
Feet of water	inches of mercury	0.8826
Feet of water	kg/square centimetre	0.03048
Feet of water	kg/square metre	304.8
Feet of water	pounds/square feet	62.43
Feet of water	pounds/square inches	0.4335
Feet/100 feet	per cent grade	1.0

G

Gallons imperial	cubic centimetres	4546.09
Gallons imperial	cubic feet	0.160543653
Gallons imperial	cubic inches	277.4194327
Gallons imperial	cubic metres	0.004546090
Gallons imperial	cubic yards	0.005946061
Gallons imperial	litres	4.54609
Gallons(liq. Br. Imp)	gallons (U.S. liquid)	1.20095
Gallons (U.S.)	gallons (Imperial)	0.83267
Gallons imp. of water	pounds of water(at 15.8C)	10.01097718
Gallons imp. of water	pounds of water(at 17C)	10.00920061
Gallons imp. of water	pounds of water(at 4C)	10.02181145
Gallons imp./minute	cubic feet/second	0.00268
Gallons imp./minute	litres/second	0.0758
Gallons imp./minute	cubic feet/hour	9.633
Grams	kilograms	0.001
Grams	ounces (avdp)	0.03527
Grams	pounds	2.205×10^{-3}
Grams/litre	parts/million	1,000.0

H

Hectare	square metres	10,000
Horsepower	kilowatts	0.7457
Horsepower	watts	745.7

K

Kilograms	pounds	2.205
Kilograms	tons (long)	9.842×10^{-4}
Kilograms	tons (short)	1.102×10^{-3}
Kilometres	centimetres	10^5
Kilometres	feet	3.281
Kilometres	inches	3.937×10^4
Kilometres	metres	1,000.0
Kilometres	miles	0.6214
Kilometres	millimetres	10^6
Kilometres	yards	1,094
Kilometres/hour	centimetres/second	27.78
Kilometres/hour	feet/minute	54.68
Kilometres/hour	feet/second	0.9113
Kilometres/hour	knots	0.5396

Knots	kilometres/hour	1.8532
Knots	nautical miles/hour	1.0
Knots	statute miles/hour	1.151
Knots	yards/hour	2.027
Knots	feet/second	1.689

L

Litres	cubic centimetres	1,000.0
Litres	cubic feet	0.03531
Litres	cubic inches	61.02
Litres	cubic metres	0.001
Litres	cubic yards	1.308×10^{-3}
Litres	gallons imperial	0.2199969
Litres	gallons (U.S. liquid)	0.2642
Litres	pints (U.S. liquid)	2.113
Litres	quarts (U.S. liquid)	1.057
Litres/minute	cubic feet/second	5.886×10^{-4}
Litres/minute	gallons/second	4.403×10^{-3}

M

Metres	centimetres	100.0
Metres	feet	3.281
Metres	inches	39.37
Metres	kilometres	0.001
Metres	miles (nautical)	5.396×10^{-4}
Metres	miles (statute)	6.214×10^{-4}
Metres	millimetres	1,000.00
Metres	yards	1.094
Miles (nautical)	feet	6,080.27
Miles (nautical)	kilometres	1.853
Miles (nautical)	metres	1,853
Miles (nautical)	miles (statute)	1.1516
Miles (nautical)	yards	2.027
Miles (statute)	centimetres	1.609×10^{5}
Miles (statute)	feet	5,280
Miles (statute)	inches	6.336×10^{4}
Miles (statute)	kilometres	1.609
Miles (statute)	metres	1,609
Miles (statute)	miles (nautical)	0.8684
Miles (statute)	yards	1,760
Milligrams	grams	0.001
Milligrams/litre	parts/million	1.0
Millilitres	litres	0.001
Millilitres	centimetres	0.1
Millimetres	feet	3.281×10^{-3}
Millimetres	inches	0.03937
Millimetres	kilometres	10^{-6}

Millimetres	metres	0.001
Millimetres	miles	6.214×10^{-7}
Millimetres	yards	1.094×10^{-3}
Millions gallons/day	cubic feet/second	1.54723

O

Ounces	grams	28.349527
Ounces	pounds	0.0625
Ounces	ounces (troy)	0.9115
Ounces	toxns (long)	2.790×10^{-5}
Ounces	tons (metric)	2.835×10^{-5}
Ounces (fluid)	cubic inches	1.805
Ounces (fluid)	litres	0.02957

P

Parts/million	grains/U.S. gallon	0.0584
Parts/million	grains/Imperial gallon	0.07016
Parts/million	pounds/million galllons	8.345
Pints (liquid)	cubic centimetres	473.2
Pints (liquid)	cubic feet	0.01671
Pints (liquid)	cubic inches	28.87
Pints (liquid)	cubic metres	4.732×10^{-4}
Pints (liquid)	cubic yards	6.189×10^{-4}
Pints (liquid)	gallons	0.125
Pints (liquid)	litres	0.4732
Pints (liquid)	quarts (liquid)	0.5
Pounds	grains	7.000
Pounds	grams	453.5924
Pounds	joules/centimetre	0.04448
Pounds	joules/metre (newtons)	4.448
Pounds	kilograms	0.4536
Pounds	ounces	16.0
Pounds	ounces (troy)	14.5833
Pounds	poundals	32.17
Pounds	pounds (troy)	1.21528
Pounds	tons (short)	0.0005
Pounds of water	cubic feet	0.01602
Pounds of water	cubic inches	27.68
Pounds of water	gallons	0.1198
Pounds of water/min	cubic feet/second	2.670×10^{-4}
Pounds/cubic foot	kg/square metre	16
Pounds/square foot	kg/square metre	4.882
Pounds/square foot	pounds/square inch	6.944×10^{-3}
Pounds/square inch	pounds square foot	144.0

Q

Quarts (liquid)U.S.	cubic feet	0.03342
Quarts (liquid)U.S,	cubic inches	57.75

Quarts (liquid)U.S.	cubic yards	1.238×10^{-3}
Quarts (liquid)U.S.	gallons	0.25
Quarts (liquid)U.S.	litres	0.9463

S

Square centimetres	square feet	1.076×10^{-3}
Square centimetres	square inches	0.1550
Square centimetres	square metres	0.0001
Square centimetres	square miles	3.861×10^{-11}
Square centimetres	square millimetres	100.0
Square centimetres	square yards	1.196×10^{-4}
Square feet	acres	2.296×10^{-5}
Square feet	square inches	144.0
Square feet	square metres	0.09290
Square feet	square miles	3.587×10^{-8}
Square feet	square millimetres	9.290×10^{4}
Square feet	square yards	0.1111
Square inches	square centimetres	6.452
Square inches	square feet	6.944×10^{-3}
Square inches	square millimetres	645.2
Square inches	square mils	10(6)
Square inches	square yards	7.716×10^{-4}
Square kilometres	acres	247.1
Square kilometres	square centimetres	10(10)
Square kilometres	square feet	10.76×10^{6}
Square kilometres	square inches	1.550×10^{9}
Square kilometres	square metres	10^{6}
Square kilometres	square miles	0.3861
Square kilometres	square yards	1.196×10^{6}
Square metres	acres	2.471×10^{-4}
Square metres	square centimetres	10^{4}
Square metres	square feet	10.76
Square metres	square inches	1.550
Square metres	square miles	3.861×10^{-7}
Square metres	square millimetres	10^{6}
Square metres	square yards	1.196
Square miles	acres	640.0
Square miles	square feet	27.88×10^{4}
Square miles	square kilometres	2.590
Square miles	square metres	2.590×10^{6}
Square miles	square yards	3.098×10^{6}
Square millimetres	square centimetres	0.01
Square millimetres	square feet	1.076×10^{-5}
Square millimetres	square inches	1.550×10^{-3}
Square yards	acres	2.066×10^{-4}
Square yards	square centimetres	8,361

Square yards	square feet	9.0
Square yards	square inches	1,296
Square yards	square metres	0.8361
Square yards	square miles	3.228×10^{-7}
Square yards	square millimetres	8.361×10^{5}

T

Tons (long)	kilograms	1,016
Tons (long)	pounds	2,240
Tons (long)	tons (short)	1,120
Tons (metric)	kilograms	1,000
Tons (metric)	pounds	2,205
Tons (short)	kilograms	907.1848
Tons of water/24 hours	pounds of water/hour	83.333
Tons of water/24 hours	gallons/minute	0.16643
Tons of water/24 hours	cubic feet/hour	1.3349

W

Watts	horsepower	1.341×10^{-3}
Watts	horsepower (metric)	1.360×10^{-3}
Watts	kilowatts	0.001

Y

Yards	centimetres	91.44
Yards	kilometres	9.144×10^{-4}
Yards	metres	0.9144
Yards	miles (nautical)	$4.934\ 10^{-4}$
Yards	miles (statute)	5.682×10^{-4}
Yards	millimetres	914.4

Approximate weights of various materials

Material	Pounds per cubic feet	Cubic feet per ton
Sand	95	23.5
Clay	120	18.5
Earth	112	20.0
Gravel	112	20.0
Coal	56	40.0
Coke	32	70.0
Ashes	40	56.0
Chalk	140	16.0
Limestone	120	18.5
Asphalt	150	15.0
Cement	90	23.0
Concrete	130	17.0
Mortar	112	20.0
Quicklime	53	42.0

Contacts

OBSERVE RECORD REPORT
Fish and Wildlife Violations

Help Maintain our Natural Resources

The unethical angler is a threat to our fisheries resource and outdoor recreation. Violations of these regulations damage the resource and reduce fishing opportunity for all anglers. You can help to prevent offences by participating in the Observe, Record, and Report program.

Do not confront a suspected violator. You cannot make a "citizen's arrest" or seize evidence. Only a Conservation Officer or Constable is legally authorized to seize property. Instead, familiarize yourself with current regulations so that you may recognize an offence.

Observe: If you observe a violation of these regulations such as:

- angling in closed areas
- exceeding catch quotas
- taking protected species or undersized fish
- using illegal fishing gear
- transporting live fish or using fish for bait
- selling fish taken by sport fishing
- damaging fish habitat

Record: Your observations in note form promptly and take photographs if possible. Notes should include:

- date, time, location and weather conditions
- identity of violator(s) and companions or an accurate description of them
- boat or vehicle licence and description
- evidence at the scene, and
- action of violator(s)

Report: Your observation as soon as possible.

Contact the nearest Conservation Officer, RCMP, Department of Fisheries and Oceans, or call 1-800-465-4336 (toll free, 24 hours a day, 7 days a week). Your complaint will be registered and directed to the right action centre.

Wallet sized cards listing information to be reported are available at Fish and Wildlife offices throughout the province.

Fisheries and Oceans Canada Community Involvement

www.pac.dfo-mpo.gc.ca

Joanne Day, Information Coordinator
DFO, 200 - 401 Burrard Street, Vancouver, V6C 3S4
Tel: 604-666-6614 Fax: 604-666-0417 Email: dayj@pac.dfo-mpo.gc.ca
Information on Community Involvement, activities like Storm Drain Marking and Salmonids in the Classroom, and Habitat publications.

Fisheries and Oceans Canada Community Advisors

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Pacific Streamkeepers Federation

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Order the Streamkeeper's manual from Zo Ann Morten.
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Website: http://www-heb.pac.dfo-mpo.gc.ca/pskf/home.htm