Protocol for Fish Passage Determination of Closed Bottom Structures

- Ministry of Environment
- Ministry of Forests
- Integrated Land Management Bureau
- Department of Fisheries and Oceans
- Council of Forest Industries

May, 2008

Why did the fish cross the Road?

Because it couldn't pass through the culvert!

Agenda: Day 1

"Protocol for Fish Passage Determination of Closed Bottom Structures"

Morning

1. Introduction and Background
2. Planning Phase

Afternoon

3. Data Collection Phase
4. Data Analysis Phase
5. Restoration Phase
6. Reporting Phase

"Field Assessment for Fish Passage Determination of Closed Bottomed Structures"

7. Basic fish biology as related to stream crossings
8. Culvert basics

Agenda: Day 2

"Field Assessment for Fish Passage Determination of Closed Bottomed Structures"

Morning (till 10:30)

1. Field Assessments: Methodology and Important Considerations

Field Trip

logistics

Overall Process

Introduction

1. Introduction and Background

Overall Process

Introduction

Relevant Legislation

- *Forest Practices Code:* Section 13 (2) of the *Forest Road Regulation*
- *Forest and Range Planning Act:* Section 56 of the *Forest Planning and Practices Regulation*
- *Fisheries Act:* Section 20, 22, 26, 32, 35, 36, 37

Overall Process

Introduction

Why is this important?

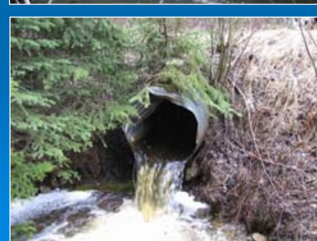
- Fish Passage issues have found to be a dominant problem in fish habitat and population factors in several studies (Beechie, 1994 Washington, USA Skagit basin)
- Many studies have shown that approximately 60 – 90% of stream road crossings with closed bottom culverts do not pass fish (Conroy 1997, Washington, USA)
- Recent monitoring efforts in BC (since 2005) have demonstrated similar problems with closed bottom culverts

Overall Process

Introduction

–1977 report to a Federal Provincial committee on Fishways and stream crossings.

- "Poor culvert design and location can be ranked among the most devastating fish constraints to be found in the Province."
- "Until adequate corrective measures are taken, fish populations will continue to be detrimentally affected, and the province will be burdened with the difficult task of replacing dwindling numbers of fish stocks."



Overall Process

Introduction

Brian Dane, DFO, 1978

"A Review and Resolution of Fish Passage Problems at Culverted Sites in BC"

"..culvert should be installed so that the bottom of the structure is at least 0.31 m below the natural gradeline of the stream"

Overall Process

Introduction

BC

Through GIS analysis, the Fish Passage Working Group estimates there are approximately:

- 550,000 km of resource roads with approx. 370,000 stream crossings (0.7 crossings/km.)
- Data from other projects shown 56% of these are closed bottomed structures
- Of these 38% are on fish streams
- Results in approx. 76,000 culverts on fish streams
- **Potential fish barriers: 30,000 to 70,000**

Overall Process

Introduction

Washington State

State	8% - 2,700 culvert barriers
Private	64% - 21,460 culvert barriers
Federal	14% - 4,600 culverts barriers
County, Municipal	14% - 4,600 culverts barriers
TOTAL	**33,000 culvert barriers (plus 6,000 dams)**

WDFW, 2001

Overall Process

Introduction

Issue also important for other freshwater species

- freshwater mussels, amphibians etc.

Crayfish

Tailed frog

Pacific giant salamander

Overall Process

Introduction

GOAL

Maintain channel continuity through the crossing

- Streambed diversity and material are similar to natural channel
- Water velocities and depths, cover and resting areas are similar to natural channel
- Crossing is transparent to aquatic species

Overall Process

Introduction

What is this protocol for?

Determining whether fish are capable of passing through a closed bottom structure (CBS)

CBS = Culvert

Round, elliptical

metal or plastic

Overall Process

Introduction

“Fish Passage Protocol for Culvert Sites”

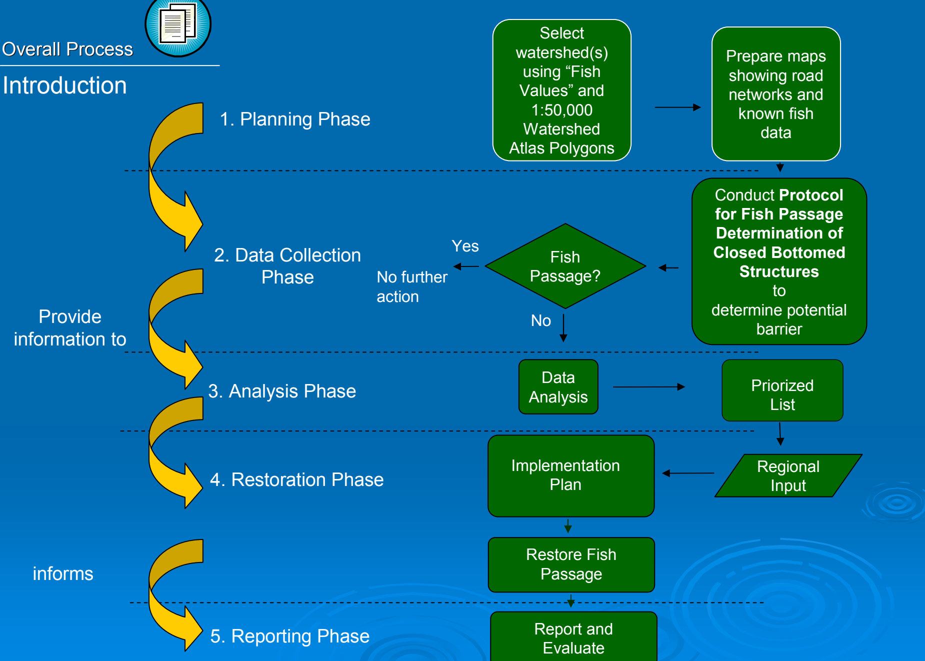
Systematic watershed-based approach

Involves 5 steps

1. **Planning Phase**
2. **Data Collection Phase**
3. **Analysis Phase**
4. **Restoration Phase**
5. **Reporting Phase**

Overall Process

Introduction

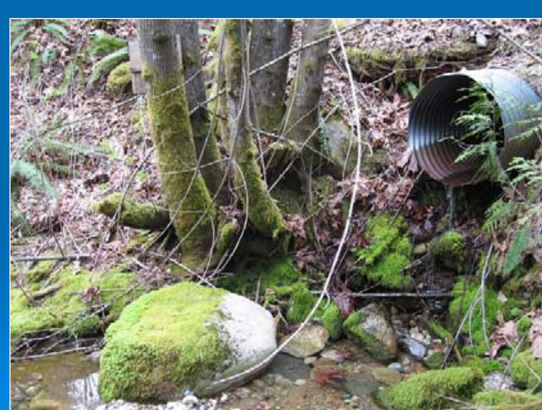


Overall Process

Introduction

Overall Process

2. Planning Phase



Overall Process

Planning Phase

2 steps

1. Establish priority areas
2. Prepare working maps

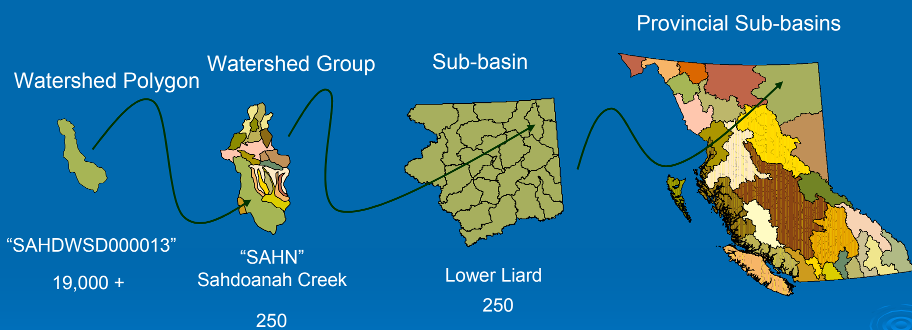
Overall Process

Planning Phase

1. Establish priority areas using 1:50,000 BC Watershed Atlas polygons and "Fisheries Value"

Overall Process

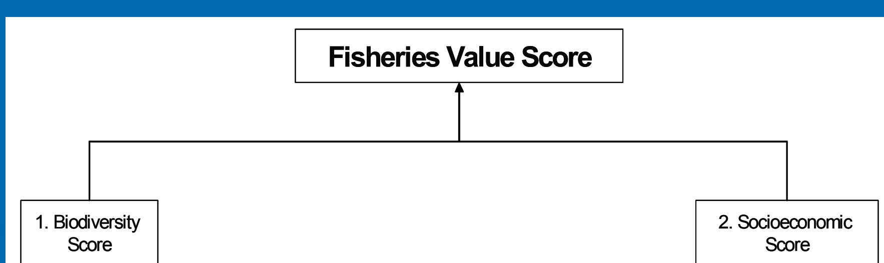
Planning Phase



Watershed Atlas polygons

Overall Process

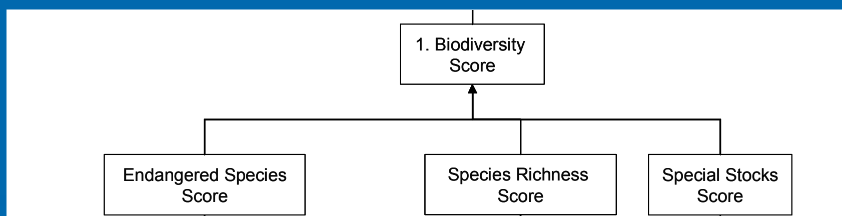
Planning Phase



Fisheries Value

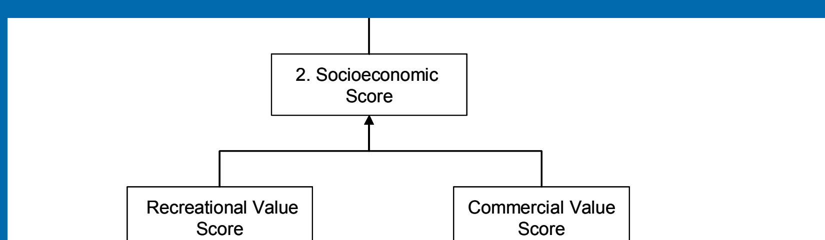
Overall Process

Planning Phase



Overall Process

Planning Phase



Overall Process

Planning Phase

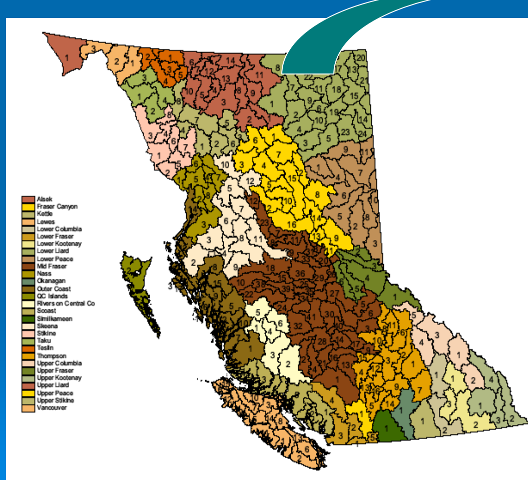
1. **Establish priority areas using 1:50,000 BC Watershed Atlas polygons Watershed Atlas polygons and "Fisheries Value"**

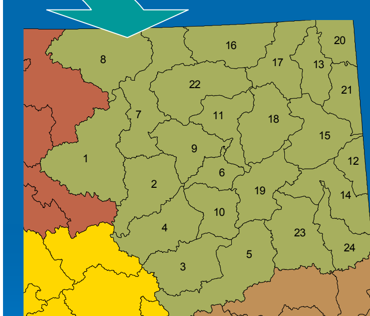
- **Average "Fisheries Value" polygon score for each Watershed Group Watershed Groups were ranked within each Sub-basin**

Overall Process

Planning Phase

Ranking of watershed groups within sub-basins

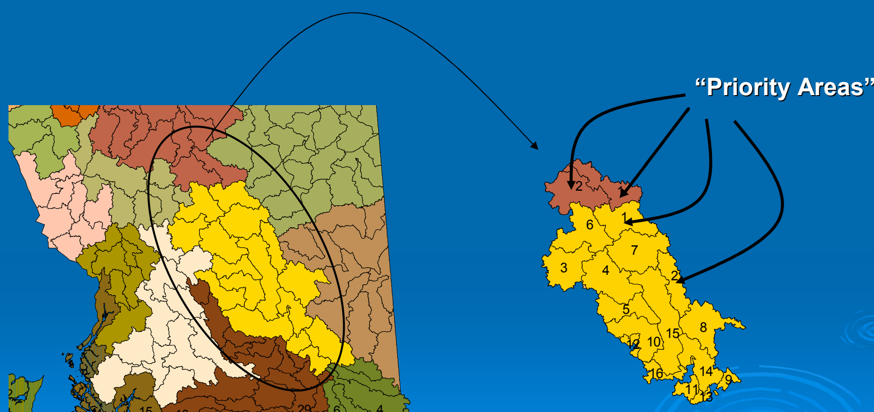




Overall Process

Planning Phase

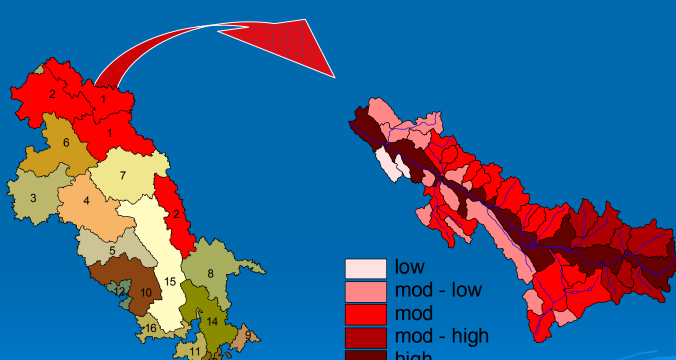
1. **Establish priority areas using 1:50,000 BC Watershed Atlas polygons Watershed Atlas polygons and "Fisheries Value"**



Overall Process

Planning Phase

1. **Establish priority areas using 1:50,000 BC Watershed Atlas polygons Watershed Atlas polygons and "Fisheries Value"**

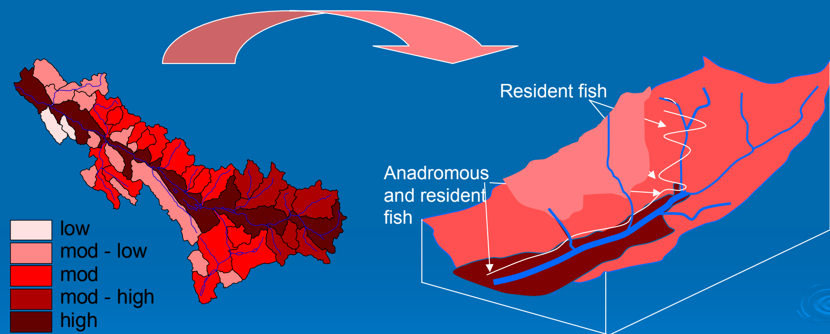


Focus on higher value polygons within higher ranked watershed groups

Overall Process

Planning Phase

1. **Establish priority areas using 1:50,000 BC Watershed Atlas polygons Watershed Atlas polygons and "Fisheries Value"**

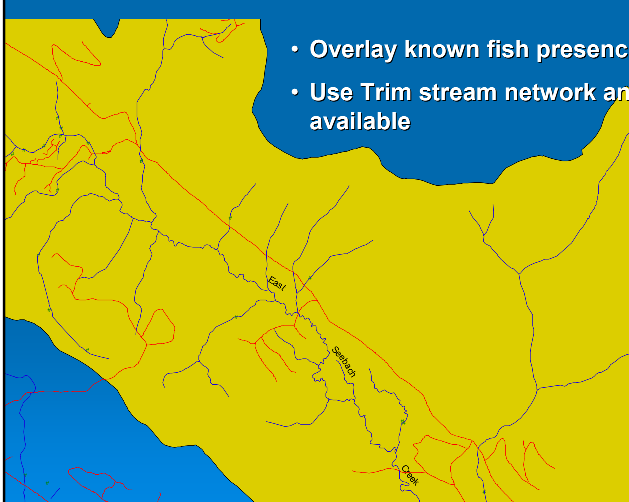


Focus on higher value polygons within higher ranked watershed groups

Overall Process

Planning Phase

2. Prepare working maps



- **Overlay known fish presence with road networks**
- **Use Trim stream network and best road information available**
- **Check FISS, EcoCat, etc.**

Overall Process

Planning Phase

Overall Process

3. Data Collection Phase

Data Collection Phase

Outlined in detail in document entitled

"Fish Passage Protocol for Culverted Sites"

Methods have evolved over the years based on development by E. George Robison in Oregon and BC and by others in jurisdictions throughout the Pacific Northwest

Data Collection Phase

Four Main ways to evaluate fish passage:

- **Experiments/surveys observing actual fish passage success**
- **Velocity measurements**
- **Hydraulic analysis**
- **Measurement of surrogates indicative of hydraulic conditions**

Overall Process

Data Collection Phase

Field Assessment designed to quickly answer question "Does this stream crossing likely provide safe fish passage"

- **Cumulative scoring approach using hydraulic surrogates**
- **Takes about 10 – 20 minutes to complete for each crossing**

Overall Process

Data Collection Phase

Data Collection has 2 steps

1. **Collection of field information**
2. **Determination of barrier category**

Overall Process

Data Collection Phase

Field Information

Information collected can be placed into three categories

- Location and survey data (i.e. date, UTM, crossing type, etc.)
- Fish passage criteria (i.e. outlet drop, slope, channel width, etc.)
- Site information to assist in identifying potential remedy and assist in priorization (i.e. depth of fill, valley fill, habitat value, etc.)

Overall Process

Data Collection Phase

Barrier Determination

Risk	Embedded*	value	Outlet drop	value	Slope	value	SWR	value	Length	value
low	> 30 cm. or > 20% of Diameter and continuous	0[1]	< 15	0	< 1	0	< 1.0	0	< 15	0
mod	< 30 cm. or 20% of Diameter but continuous	5[2]	15 - 30	5	1 - 3	5	1.0 - 1.3	3	15 – 30	3
high	No embeddment or discontinuous	10	> 30	10	> 3	10	> 1.3	6	> 30	6

[1] Properly embedded culverts are considered passable as per natural stream channel. No further consideration of other surrogates is required.
[2] A culvert that is embedded less than 30 cm or 20% of the culvert diameter is at greater risk of being a barrier to fish passage

Overall Process

Data Collection Phase

Barrier Determination

Cumulative Score	Result
0 - 14	passable
15 - 19	potential barrier
20 or greater	barrier

Overall Process

Data Collection Phase

Overall Process

4. Analysis Phase

Overall Process

Analysis Phase

Involves 3 steps

1. Check fish presence based on known information
2. Calculate Habitat Gained Index
3. Prepare preliminary cost/benefit estimate

Overall Process

Analysis Phase

Step 1: Check fish presence based on known information

- Binary decision - Yes or No
- Designed to focus on restoration where fish presence is known.
- Better fish distribution data - additional restoration candidates can be added

Overall Process

Analysis Phase

Step 1: Check fish presence based on known information

Criteria as follows

1. Fish presence upstream or within one stream order downstream of the stream crossing (1:50,000 scale).
2. No downstream barriers (as either revealed from the Provincial FISS dataset or local knowledge) that would preclude fish access (viewable through iMap or downloadable through the LRDW with an IDIR account).
3. Stream gradients upstream and downstream (to point of known fish presence) less than 20% (30% for bull trout systems).

Overall Process

Analysis Phase

Step 2: Determine the Habitat Gained Index

Simply the length of accessible habitat upstream of the subject cros

- **Length of stream upstream of crossing with a gradient less than 20% (greater than 30% for BT).**
- **Done from contour mapping and obstruction information using TRIM data.**

Note: MOE currently working on GIS model to assist with this calculation - should be available in summer of 2008 and will be posted on FIA fish passage website

Overall Process

Analysis Phase

Step 3: Cost Benefit Analysis

Calculate a cost benefit for establishing fish passage at a given location based on an examination of potential solutions, HGI and local knowledge

- **Not a absolute value but rather a rough estimate used to establish preliminary ranking of site.**
- **Detailed cost estimates can be prepared after restoration plans are finalized.**

Overall Process

Analysis Phase

Step 3: Cost Benefit Analysis

Develop possible restoration options

1. Removal of the structure and deactivation of the road
2. Replacing the culvert with a bridge or other open bottom structure.
3. Replacing the structure with a streambed simulation design culvert.
4. Adding substrate material to the culvert and a downstream weir to reduce overall velocity and turbulence and provide low velocity areas.
5. Backwatering the structure to reduce velocity and turbulence.
6. Combination of 4. and 5.

Overall Process

Analysis Phase

Step 3: Cost Benefit Analysis

- Rough estimates for the first two solutions (bridge and streambed simulation) can be derived by estimating costs based on measurements taken during the Field Protocol (i.e. depth of fill, downstream width, valley fill, culvert fix).
- Discuss cost factors with local authorities to obtain reasonable estimates.
- Structure removal can only be considered solution at Implementation Phase (need regional input)
- More than one solution is possible.

Overall Process

Analysis Phase

Step 3: Cost Benefit Analysis

Site No	HGI	Proposed Solution 1	Span (m)	Cost Estimate 1 ($K)	Proposed Solution 2	Cost Estimate 2 ($K)	Cost Benefit 1	Cost Benefit 2
18	32	BW	19	15			2.13	
9	13.4	EM	21	10			1.34	
4	45	SB	36	250			0.18	
17	16	SB	18	120	2000 x 22 SS	65	0.13	0.25
1	16.8	SB	21	140	3000 x 25 SS	85	0.12	0.20
7	2.1	CB	12	80	1600 x 25 SS	70	0.03	0.03
6	2.7	SB	24	135	2000 x 25 SS	75	0.02	0.04
5	1.7	SB	21	120	3200 x 20 SS	80	0.01	0.02

BW backwatering
EM embeddment
SB steel bridge
CB concrete bridge
SS streambed simulation

Overall Process

Analysis Phase

Overall Process

5. Restoration Phase

Overall Process

Restoration Phase

Involves:

1. **Developing an Implementation Plan for restoration and,**
2. **Developing detailed costing for individual project implementation**

Overall Process

Restoration Phase

Implementation Plan

- Uses information from the Analysis Phase
- Makes decisions about which structures to fix and a proposed schedule to fix them
- Takes place at regional or sub-regional level and involve all affected parties that have an interest in maintaining and using the road.
- Discussion about structure removal can take place.
- Important to use local expertise in fisheries/habitat biology and engineering to develop plans that ensure greatest restoration of fish habitat for $$$ spent.
- Proposals involving backwatering involve some additional data collection
- Reviewed annually

Overall Process

Restoration Phase

Implementation Plan

May be influenced by:

- Budget considerations
- Cost/benefit
- Habitat value
- Fish life cycles
- Acceptability of embedded culverts
- Availability of personnel and equipment
- Scheduled structure replacement date
- Life of structure
- Longevity of road
- Active hauling
- Access

Overall Process

Restoration Phase

Detailed Costing

- Detailed cost estimates, supported by appropriate design and engineering should be prepared for the structures identified in the Implementation Plan.
- For FIA eligible projects: see FIA submission standard http://www.for.gov.bc.ca/hcp/fia/landbase/fia_activity_standards_fish_passage.pdf
- For other projects: follow standard MOF procedures

Overall Process

Restoration Phase

Overall Process

5. Report and Evaluation Phase

Overall Process

Reporting Phase

Reporting (Interim to common database filed via web applet)

Assessments: two requirements

1. Data submission- soon to be posted data entry sheet (excel spreadsheet) http://www.for.gov.bc.ca/hcp/fia/landbase/fishpassage.htm
2. Project summary submission

Overall Process

Restoration Phase

Evaluation

- Recommended practice – currently no standard
- Government plans to:
  - Check some field assessments
  - Restoration Projects

Overall Process

Restoration Phase

Additional Information

BC

FIA fish Passage Website

- Information related to FIA eligible fish passage projects http://www.for.gov.bc.ca/hcp/fia/landbase/fishpassage.htm
- General Information related to fish passage in BC http://www.for.gov.bc.ca/hfp/fish/FishPassage.html

US Forest Service

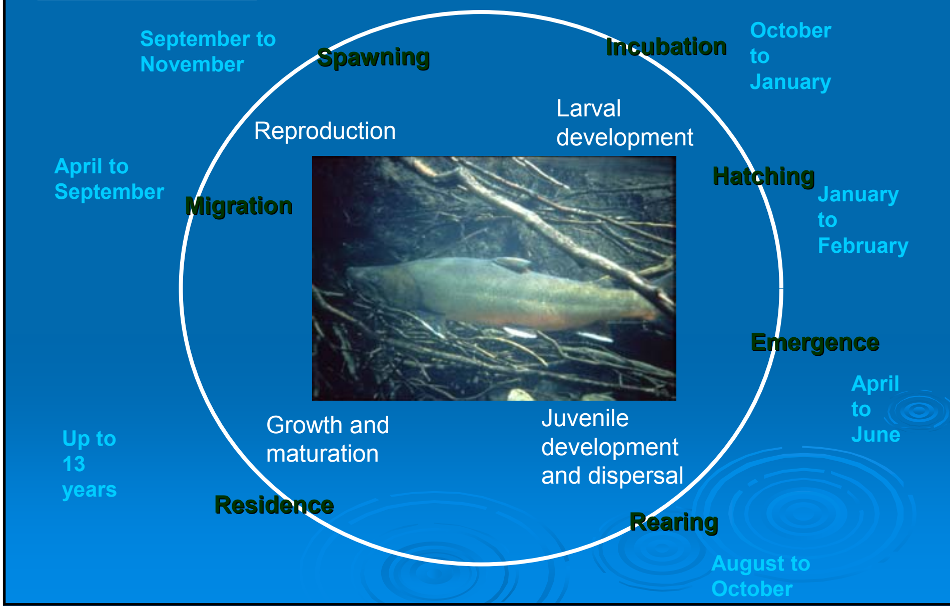
Fish Xing

- Great source of information about fish passage issues http://www.stream.fs.fed.us/fishxing/

6. Basic Fish Biology as it Relates to Stream Crossings

Bull trout life history

Field Methods



Field Methods

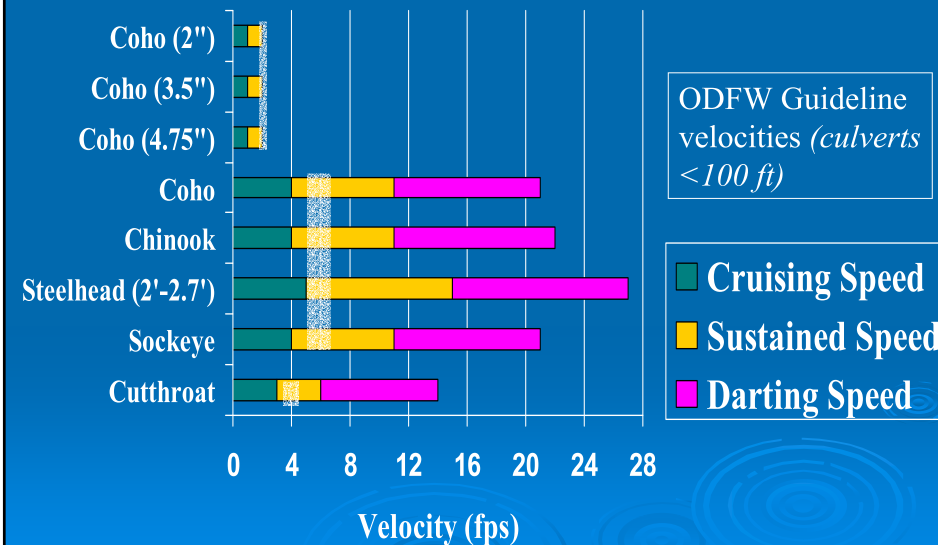
Biology

Freshwater Residence Period by Species and Life Stage (Siletz River, Oregon)

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Chum	Adult										■	■	■
Salmon	Young			■	■	■	■						
	Eggs	■	■	■								■	■
Coho	Adult	■							■	■	■	■	■
Salmon	Young	■	■	■	■	■	■	■	■	■	■	■	■
	Eggs	■	■	■	■						■	■	■
Spring	Adult					■	■	■	■	■	■		
Chinook	Young		■	■	■	■	■	■	■	■			
	Eggs	■	■							■	■	■	■
Fall	Adult	■							■	■	■	■	■
Chinook	Young		■	■	■	■	■	■	■	■			
	Eggs	■	■	■							■	■	■
Searun	Adult	■	■	■	■	■	■	■	■	■	■	■	■
Cutthroat	Young	■	■	■	■	■	■	■	■	■	■	■	■
	Eggs	■	■	■	■	■						■	■

Adapted from From 2000 Training on Fish Passage in Oregon: Marganne Allen

Relative Swimming Speeds by Species and Fork Length (Bell 1986)



Adapted from Allen,2000 from Fish Passage Training

Field Methods

Biology

Fish Swimming Ability

- Level of exertion
- Fish size
- Relative capabilities of different species
- Swimming length without rest
- Other: distance already traveled, turbidity, temperature, oxygen levels, water depth, disease, water velocity

Field Methods

Biology

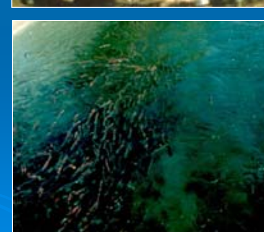
Fish habitat requirements

- Adult migration corridors
- Suitable spawning habitat
- Egg incubation and emergence
- Juvenile rearing and feeding
- High water refuge and overwintering habitat
- Juvenile out-migration

Field Methods

Biology

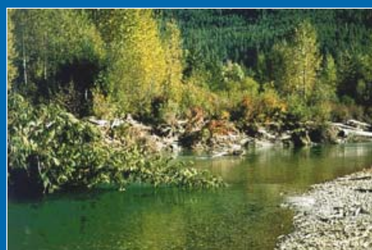
Adult migration corridors



Field Methods

Biology

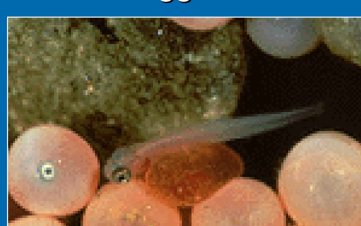
Access to suitable spawning habitat

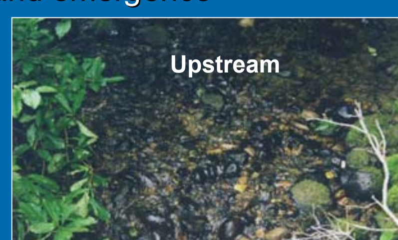


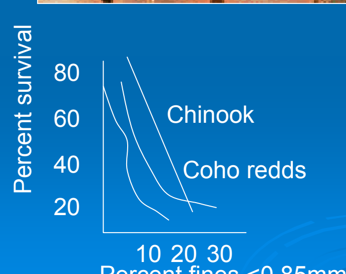
Field Methods

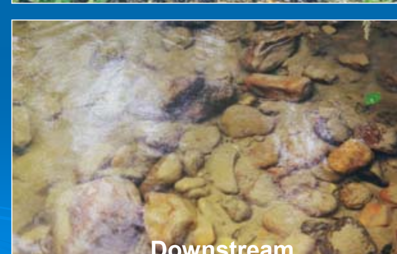
Biology

Egg incubation and emergence









Field Methods

Biology

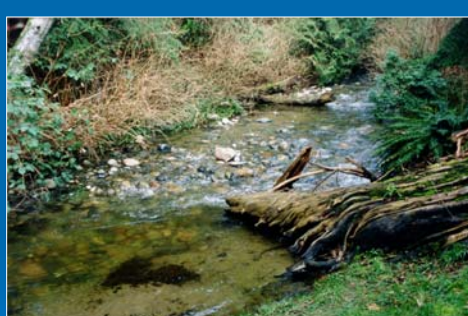
Egg incubation and emergence

- Located at or adjacent to good quality groundwater sources
- Eggs must remain in flowing, oxygen-rich water during the winter period
- Sediment can lead to smothering of eggs and de-oxygenation of water

Field Methods

Biology

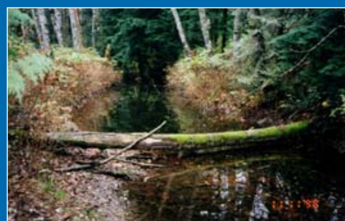
Access to juvenile rearing and feeding

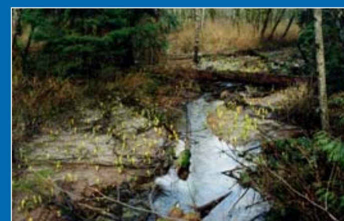


Field Methods

Biology

High water refuge and overwintering habitat

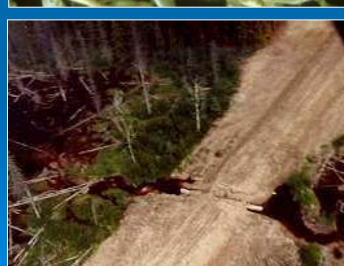




Field Methods

Biology

Juvenile out-migration



Field Methods

Biology

Field Methods

3. Culvert Basics

Field Methods

Culvert Basics

Overall GOAL

Maintain channel continuity through the crossing

- Streambed diversity and material are similar to natural channel
- Water velocities and depths, cover and resting areas are similar to natural channel
- Crossing is transparent to aquatic species

Field Methods

Culvert Basics

Culverts without a suitable substrate bottom generally do not pass fish

unless:

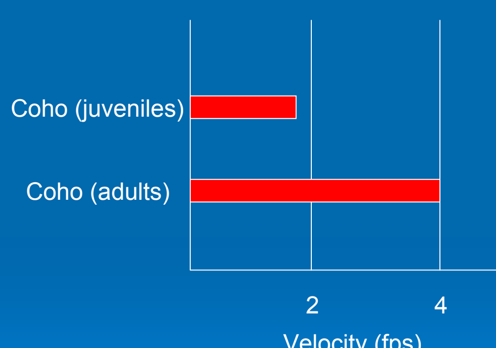
Very low gradient less (than 1%) relative large size (compared to stream channel > 0.8x) and are backwatered.

Field Methods
Culvert Basics

Fish Swimming Ability

- Level of exertion
- Fish size
- Relative capabilities of different species
- Swimming length without rest
- Other: distance already traveled, turbidity, temperature, oxygen levels, water depth, disease, water velocity

Field Methods
Culvert Basics



Fish stream crossings should:

1. Retain the pre-installation stream conditions.
2. Maintain the channel cross-sectional area and stream gradient.
3. Retain or replicate the streambed characteristics.

Poor historical record in providing fish passage due to:

High velocities and turbulence

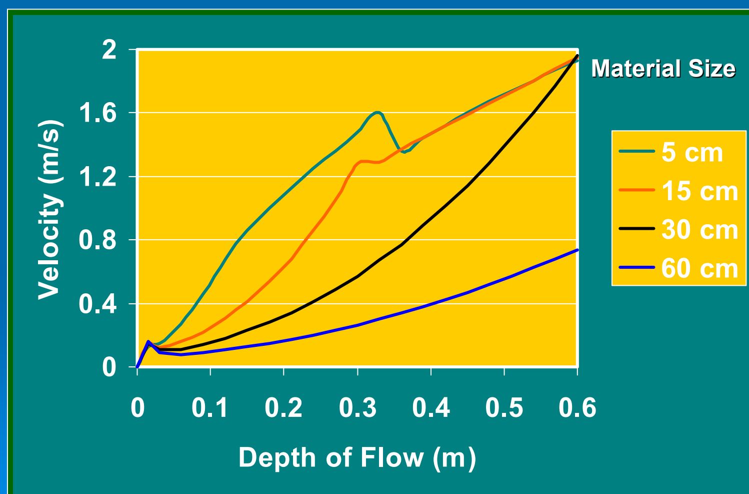
No streambed substrate

Perched culverts

Field Methods

Culvert Basics

Material Size Influence on Velocity



Field Methods

Culvert Basics

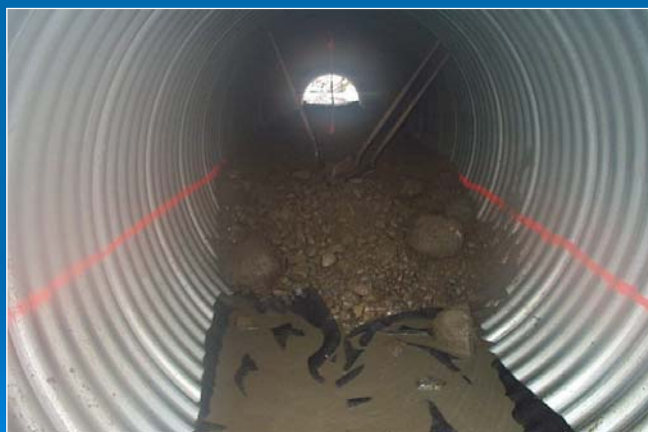
Velocity Refuge (Shadows)

Roughness reduces velocity and creates shadows

Field Methods

Culvert Basics

Closed Bottom Structures



- **Creativity required for substrate placement**

Substrate Installation

Field Methods

Culvert Basics

Substrate Installation

Wheel barrow

Small excavator

Conveyor

Substrate Installation

- Substrate material must be well mixed and contain enough fines to fill voids to keep water on the surface

Field Methods
Culvert Basics

Substrate Installation

- Fines should be "washed-in" to ensure a good seal

Field Methods

Culvert Basics