Freshwater Fisheries Society of BC

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Development of All-Female Sterile Kokanee for recreational fisheries in British Columbia

Outline

- Background
- Potential effort response to stocking new lakes with kokanee (AF3n)
- Progress in the development of all-female sterile (AF3n) kokanee

Background

- By 2000 the province cultured about 8 million fish of 7 species / 50 stocks annually
- Stock roughly 800 lakes annually
- Angling effort has declined by 30% over 15 years
- 50% of all freshwater fishing occurs on stocked lakes
- 51% of stocked lakes in the province now receive sterile or all-female sterile fish

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Development of Special Stocks in BC

- rainbow trout
  (wild, domestic, 3n, AF, AF3n)
- steelhead
  (3n)
- cutthroat trout
  (3n)
- eastern brook trout
  (AF3n only)
- kokanee
  (3n, AF3n)

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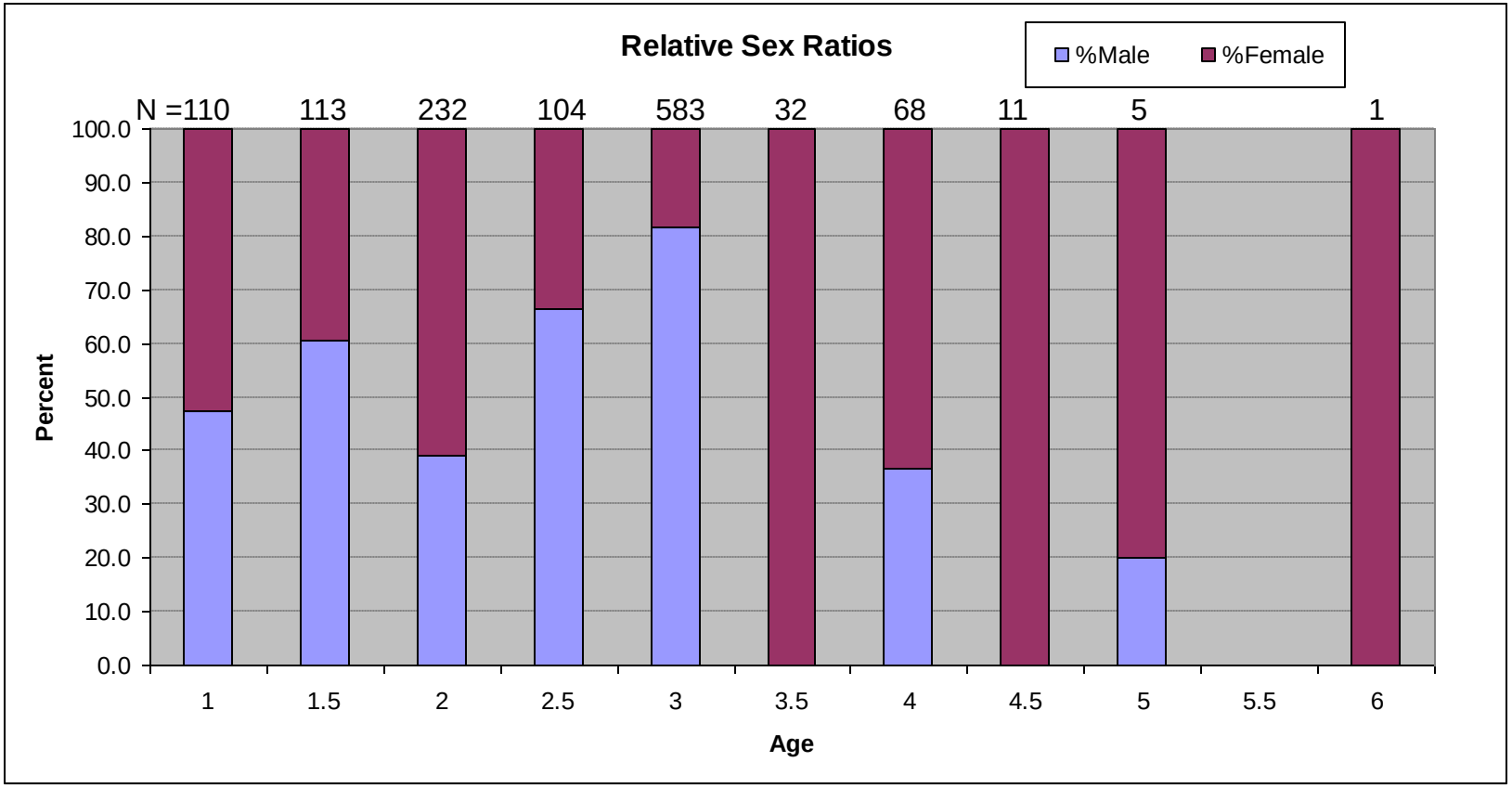
Post-stocking performance of 3n kokanee

- Sterility rates are not 100% (95 – 100%) so we are limited where we can stock them.
- Have been testing them in lakes for 8 years now (5 lakes not previously stocked with kokanee)
- Survival of sterile kokanee in the 1st season in "harsh" conditions is generally lower than non-sterile counterparts but no different when conditions are normal.
- Growth of sterile kokanee is similar to 2n kokanee, at least in less stressful environments.
- 3n males still "mature" and die off (especially in productive lakes). Females seem to live longer and stay bright but some do mature at ~age 5. >80% of fish older than age 3 are bright sterile females.


Relative Sex Ratios
%Male
%Female
N =110
113
232
104
583
32
68
11
5
1
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percent
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Age

Advantages of AF3n kokanee for fisheries management

- Addresses the loss to the fishery due to 2n and 3n male drop out and poor flesh quality
- Takes advantage of potential longevity and flesh quality of non-maturing females (provides more large bright fish for all angler types)
- Creates a functionally non-reproductive population
- Provides a diversity of fishing opportunity
- Provides a fishery at times when new/lapsed anglers are able to fish (summer/winter)

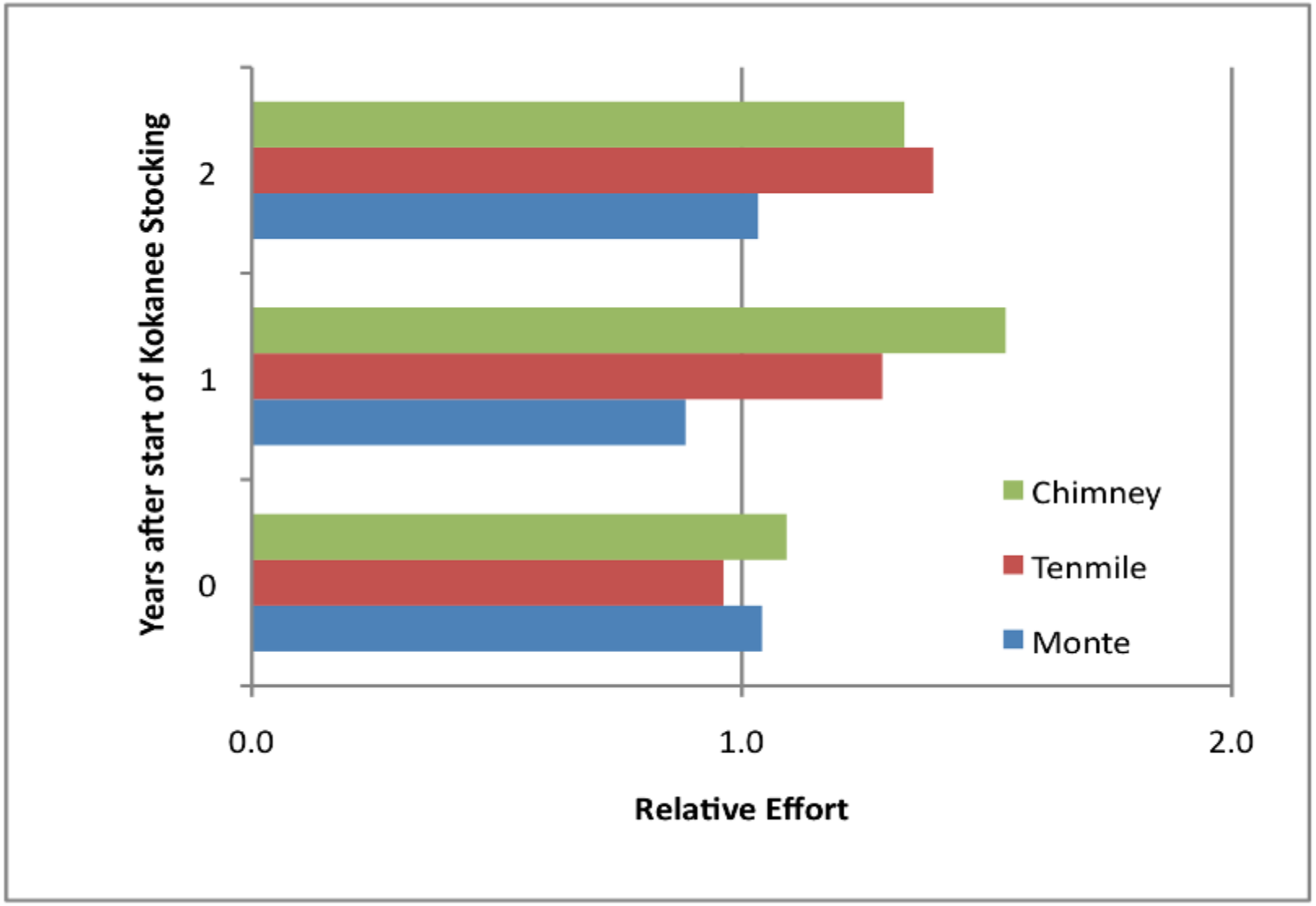


Figure 1. Relative summer effort 0, 1, and 2 years after kokanee introduction on three lakes (adjusted for weather and daytime effects).

Effort measurements

- Camera counts


07/31/2009 09:00

Angler effort before and after 3n kokanee introduction (AD)

LAKE	Prior to 3n kokanee stocking			2 years after stocking			% AD increase after KO stocking
	Winter	Summer	Total	Winter	Summer	Total	
Monte	0	3512	3512	7112	2944	10056	186%
Dutch	100	1000	1100	2000	2000	2000	82%
Ten Mile	low	3258	3258	4400	5224	9624	195%
Alleyne	125	1000	1125	365	1000	1365	21%

Potential of added Angler Days (AD)

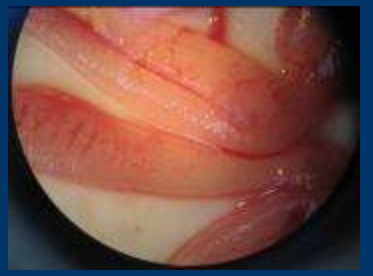
Increase in AD / ha when adding kokanee		Total Increase in AD if 8000 ha are stocked with kokanee	If 1 AD = $25, and 20% are new anglers	If 1 AD = $100, and 20% are new anglers
If add 4 AD/ha	4	16,000	$160,000	$640,000
If add 15 AD/ha	15	60,000	$600,000	$2,400,000
If add 30 AD/ha	30	120,000	$1,200,000	$4,800,000

Steps in producing AF3n stocks

1. Change females into males to produce XX males
2. Cross XX males with females (XX) to produce all-female (AF) progeny
3. Pressure shock AF progeny (eggs) shortly after initial fertilization to produce sterile all-female fish (AF3n)
4. MT treat some AF progeny to maintain XX male brood fish

XX Male Kokanee Development

- We've developed an immersion protocol to sex reverse female kokanee
- At 75% hatch, immerse the mixed sex eggs/alevins in MT baths for 2 hours, repeat 1 week later
- Rear them until you are able to sex them. If you are successful at converting females to males, sex ratios will be greater than 1:1 (>50% Males).



Kokanee – 2005 Brood

MT Immersion Treatment ($\mu g \cdot l^{-1}$)	% Males		
	Rep 1	Rep 2	Rep 3
0 (Control)	48.8	50.0	59.4
200	100	100	100
400	100	100	100
800	100	100	100
200 @ 100% hatch	100	--	--
400 @ 100% hatch	100	--	--
200, 3 immersions	100	--	--
400, 3 immersions	100	--	--

Kokanee – 2008 Brood

MT Immersion Treatment ($\mu g \cdot l^{-1}$)	% Males		
	Rep 1	Rep 2	Rep 3
0 (Control)	62.2	57.5	64.8
25	100	100	100
50	100	100	100
100	100	100	100
150	100	100	100
175	100	100	100
200	100	100	100**
400	100	100	100
800	100	100	100

Kokanee – 2009 Brood

MT Immersion Treatment ($\mu g \cdot l^{-1}$)	% Males		
	Rep 1	Rep 2	Rep 3
0 (Control)	50%	50%	67%
0.1	66%	64%	
1	94%	92%	
5	100%	100%	
10	100%	100%	
25	98%	100%	100%
25*	94%	100%	
50	100%	100%	100%
100	100%	100%	100%
150	100%	100%	100%
175	100%	100%	100%
200	100%	100%	100%
200*	100%	100%	100%

XX Male Kokanee Development

- We've developed an immersion protocol to sex reverse female kokanee
- At 75% hatch, immerse the eggs/alevins in MT baths for 2 hours, repeat 1 week later
- Tested MT concentrations between 0.1 and 800 ug•l^{-1}
- We successfully convert females to males using doses as low as 1 ug•l^{-1} (92-94%) and 50 ug•l^{-1} (100%) = 0.00005 g•l^{-1}

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(XX)

x

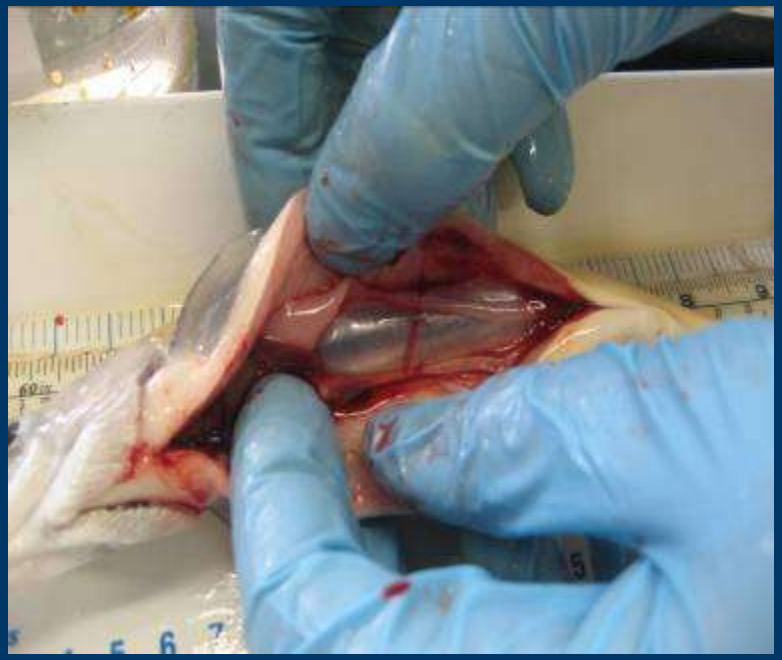
(XX)

Pressure Shock after fertilization

Immerse in MT at 75% Hatch

AF3n

100% XX ♂ (brood)

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If you started with mixed sex eggs…..

1 X 1 cross

X

(XY)

½ ♀ & ½ ♂ progeny

&

(all XX)

1 X 1 cross

X

(XX)

All ♀ progeny

*Development of 100% XX males from mixed sex eggs (groups from 1*1 crosses)*

Potential brood – MT treat all families at hatch

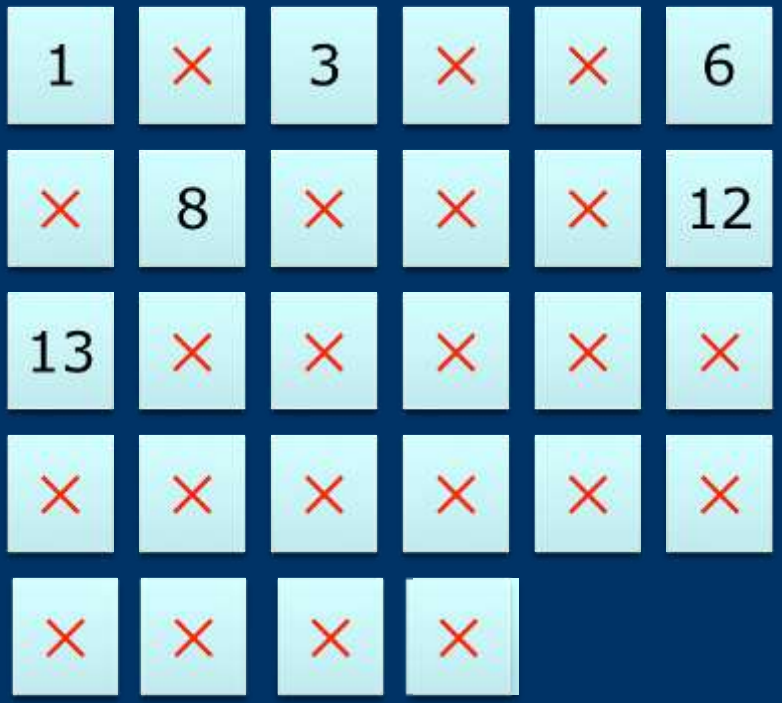
1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28		

Control groups for all MT treated families – No MT treatment

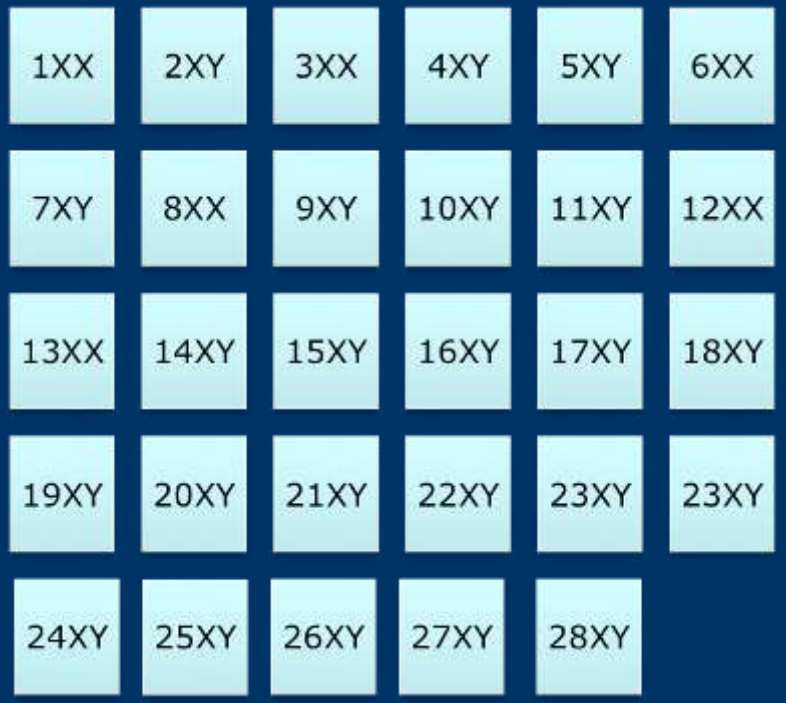
1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28		

*Development of 100% XX males from mixed sex eggs (groups from 1*1 crosses)*

Potential brood – MT treat all families at hatch



Control groups for all MT treated families – No MT treatment



Biostandards for XX male brood

- Survival from ge to fry ranges from 0 to 83%
- Maturation rates at age two – 48 to 85%
- Maturation rates at age three – 100%
- XX male kokanee have functional gonaducts making the spawning of production numbers very easy

Time Line for Brood Development

- Fall 2012 – Our first brood of 100% XX males (63 fish) will be mature.
  - Brood propagation crosses (MT treat family groups at hatch)
  - AF3n production (cross XX males with groups of pooled eggs and then pressure shock soon after fertilization)
- Spring 2013 – First stocking of production numbers of AF3n kokanee if all goes well
- Fall 2013 to Fall 2015 – Monitor the in-lake performance and fishing effort changes

Huge Thank-You to all the Clearwater Hatchery Staff !!

Questions?

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