Trojan Sex Chromosomes

Can Biased Sex Ratios Drive A Population To Extinction?

Chris Jeszke – Ashton Hatchery

Trojan Sex Chromosomes

Collaborative Fisheries Bureau Investigation:

- *Schill, Frew, Horton, Grunder, Heindel* – ***IDFG Fisheries Bureau***
- *Matt Campbell* – ***IDFG Eagle Genetics Lab***
- *Phil Mamer* – ***IDFG Eagle Health Lab***
- *Meyer, Koenig, Dillon* – ***IDFG Nampa Fisheries Research, Region 3***
- *Doug Engemann, Chris Jeszke, Paul Martin* – ***IDFG Ashton / Springfield Fish Hatchery***

Trojan Sex Chromosomes

<u>Exotic Introductions Problematic</u>

- Relatively few *practical* and *effective* alternatives exist to deal with non-natives
  - *Chemical*
  - *Removal/depletion*
  - *Construction of barriers*

    Logistically difficult, can be costly, may have collateral damage to non-target organisms

Trojan Sex Chromosomes

Multiple Interpretations in Literature:

Gutierrez and Teem

Cotton and Wedekind

Daughterless Technology

Daughterless Technology

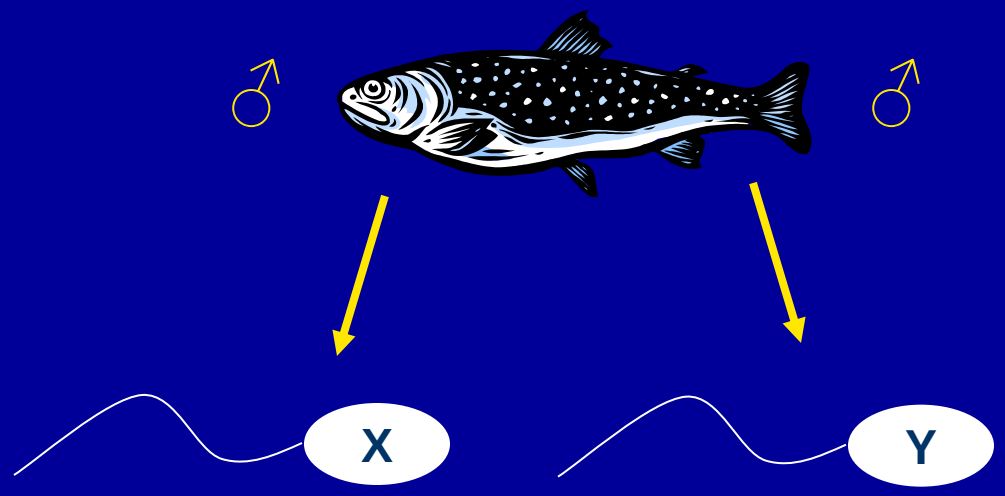
Salmonids share a common trait with most mammals in that they are

MALE HETEROGAMETIC

Male individual of a given species produces two different “kinds” of gametes with respect to sex chromosomes

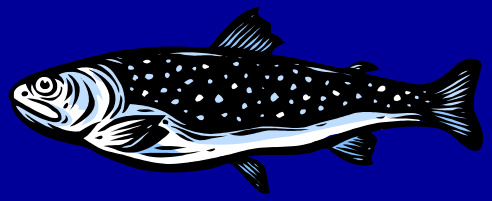
Daughterless Technology

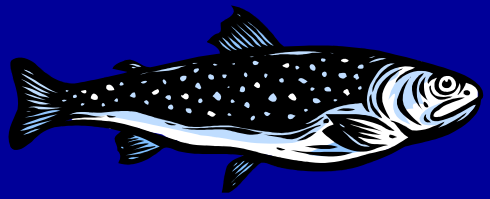
MALE HETEROGAMETIC



Either X or Y sex chromosomes

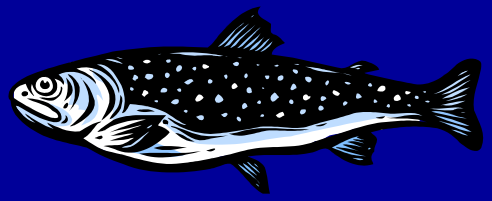
Daughterless Technology

♀ 

 ♂

	X	X
X	XX	XX
Y	XY	XY

Daughterless Technology



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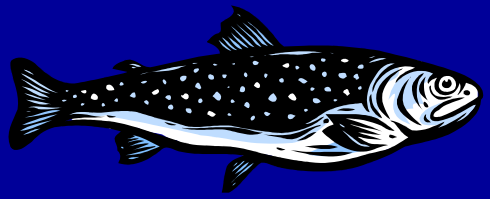

♂

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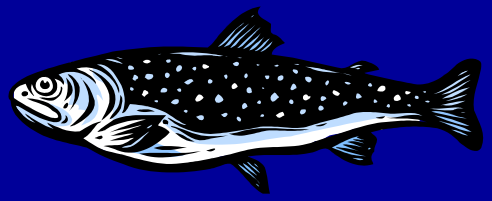
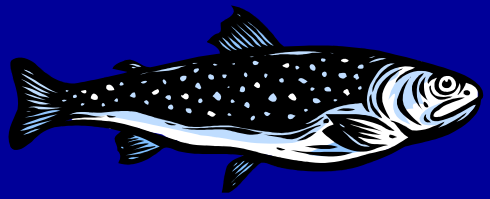
50% XX

Daughterless Technology





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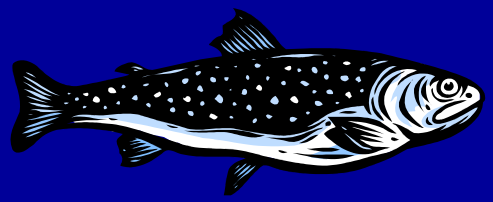
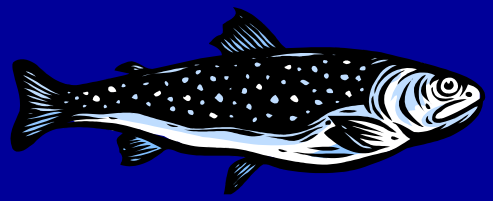
50% XY

Daughterless Technology



♀ 50% XX = Fxx

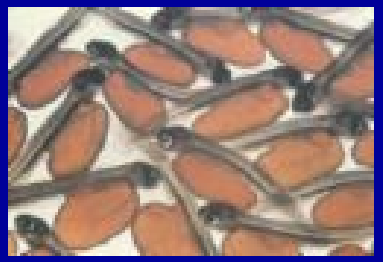


♂ 50% XY = Mxy

Fxx = phenotypic female (F), genotypic female (xx)

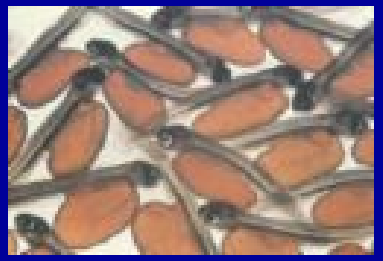
Mxy = phenotypic male (M), genotypic male (xy)

Daughterless Technology



Fxx

+ **TESTOSTERONE** = Mxx



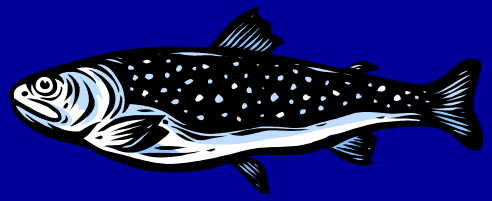
Mxy

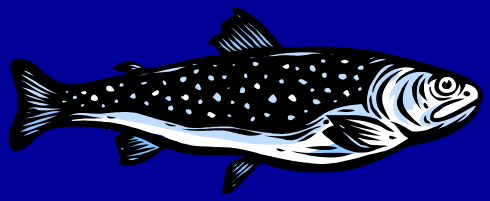
+ **ESTROGEN** = Fxy

Daughterless Technology

Why? = trout aquaculture

Fxx





Mxx

	X	X
X	XX	XX
X	XX	XX

100% XX

Daughterless Technology

Why? = tilapia aquaculture

Fxy

Generation #1

Mxy

	X	Y
X	XX	XY
Y	XY	YY

25% XX

50% XY

25% YY

Daughterless Technology

Why? = tilapia aquaculture

Fxy

Generation #1

Mxy

	X	Y
X	XX	XY
Y	XY	YY

25% XX

50% XY

25% YY

Daughterless Technology

Why?

Fyy

Generation #2

	Y	Y
Y	YY	YY
Y	YY	YY

100% YY

"supermales"

Myy

Daughterless Technology

- Gutierrez and Teem Model:

Repeated introductions of individuals that are phenotypically sex reversed from that of their genotype will provide disproportionate influx of one sex chromosome into subsequent generations, biasing sex ratio, and leading to potential population extinction

Daughterless Technology

- Assumptions:
  - Altered stocks are identical to wild with regards to *mating advantage* (no size, performance, selection differences - current research is lacking)

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  - Altered stocks are identical to wild with regards to *mating advantage* (no size, performance, selection differences - current research is lacking)
  - *Offspring viability* identical to wild
  - Model assumes iteroparity (unknown ?)
  - All individuals have same life span and mortality rates
  - No elements in system that can cause spontaneous masculinization or feminization (steroids, temperature, social environment, stocking density)

Daughterless Technology

- Rate at which Fxx eliminated relies on:
  - Rate at which Fxx eliminated through mortality

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  - Relative proportion of Fxx to Fyy in population over progressive rounds of mating

Daughterless Technology

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  - Rate at which Fxx eliminated through mortality
  - Rate at which Fxx are generated in matings
  - Relative proportion of Fxx to Fyy in population over progressive rounds of mating
  - Number of Fyy introduced and for how long (model used 3.2% introduction of Fyy in a population of several hundred individuals = extinction after a few decades)

Daughterless Technology

- Reduction in population size dependent on magnitude and frequency of Fyy = can have *mild management* of a system to *complete eradication*
- If possible, this technology is non-permanent = sex ratio returns to unity if Fyy ceases before Fxx extinct (example - unexpected and/or unwanted effects detected)

Daughterless Technology

- No (apparent) collateral ecological damage
- Only target species impacted (potential issues with hybridization?)

Daughterless Brook Trout?

Fall 2008

#1

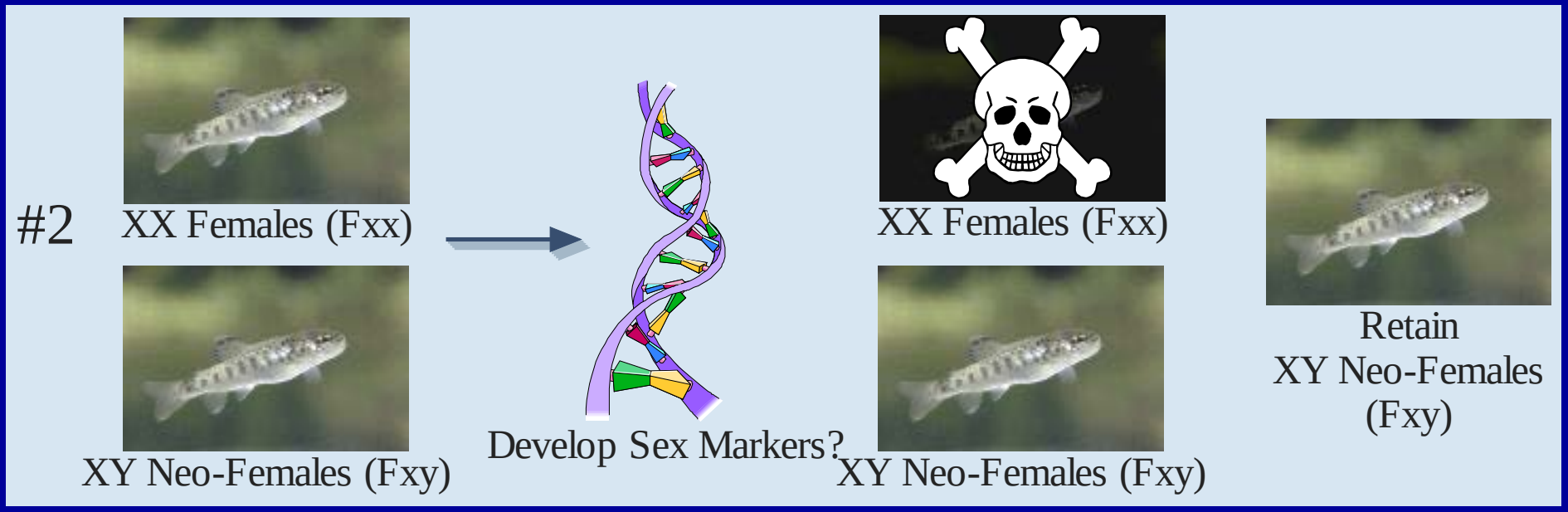
XX Female (Fxx)

XY Male (Mxy)

~50% XX, 50% XY

17 beta-estradiol
20 mg/kg diet, 60 days

Daughterless Brook Trout?



Daughterless Brook Trout?

Fall 2010

#3

XY Neo-Female (Fxy)

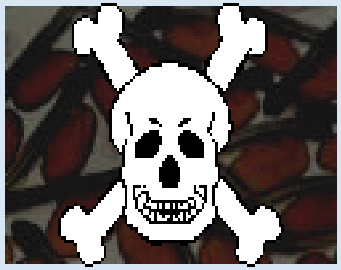
XY Standard Male (Mxy)

~25% XX, 50% XY, **25%YY**

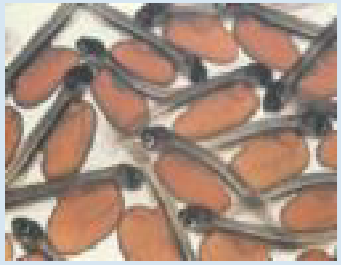
Need Sex Markers

Daughterless Brook Trout?

Fall 2010



~25% XX, 50% XY



~25% YY (Myy)

~ 1/2 of production

17 beta-estradiol
20 mg/kg diet, 60 days

YY Neo-Females? (Fyy)

Daughterless Brook Trout?

Fall 2012

#5

YY Neo-Female (Fyy)

YY "Super male" (Myy)

?

~100%YY (Myy)

Broodstock Production

What’s Happening Now?

- Need reliable genetic sex markers for Brook trout
- Ability to produce salmonid Fyy with functional gametes is unknown
- Field evaluations (triploidy’s big sister?)

What's Happening Now?

- 2011 – progeny ponded in one raceway at Ashton:

208 controls + 208 treatments; 4 unique (un-related) family types that can be crossed in 2012 – 2013 release if success.
Assume ~ 25% xx, 50% xy, 25% yy in general population

- 2012 – Sex markers have been obtained, can select Fyy's from population and determine whether or not oocytes are viable
- Spawning took place in ~ Nov 2012
- ~ 25 Myy and ~ 25 Fyy were spawned.

What’s Happening Now?

- If developing oocytes, are they viable? Spawning took place in ~ Nov 2012
- Spawning produced ~ 25 Myy and ~ 25 Fyy that were spawned.
  - 25 * 500 fecundity = 12,500 green eggs
  - 12,500 green eggs @ 70% survival to eye = 8,750 eyed
  - ~ 75% eyed to sub-yearling survival = 6,563 fish
  - ~ 6,563 sub-yearlings available for release in 2013
  - Other crosses were made with know gender control fish to confirm genetic markers

What’s Happening Now?

- Eggs are currently in incubation
- Eggs from first spawning have eyed up
- Gender ratios will be confirmed within the month
- If all offspring are Myy, sex markers are accurate, can move towards production
- Wait and see….update in Boise in 2013