

2007 versus 2008 Genomics Contrast Study

	Low Survivorship	High Survivorship
	2007	2008
Fraser FW	10	10
Fraser SW	10	10
WCVI SW	10	5

Liver – diet and disease

Brain – hormonal control of feeding/migration/other

White muscle – growth

Ho: 2007 Fraser fish may be more conditionally compromised due to poor ocean productivity, resulting in reduced prey abundance and quality (poor feeding—liver) leading to poor growth (muscle).

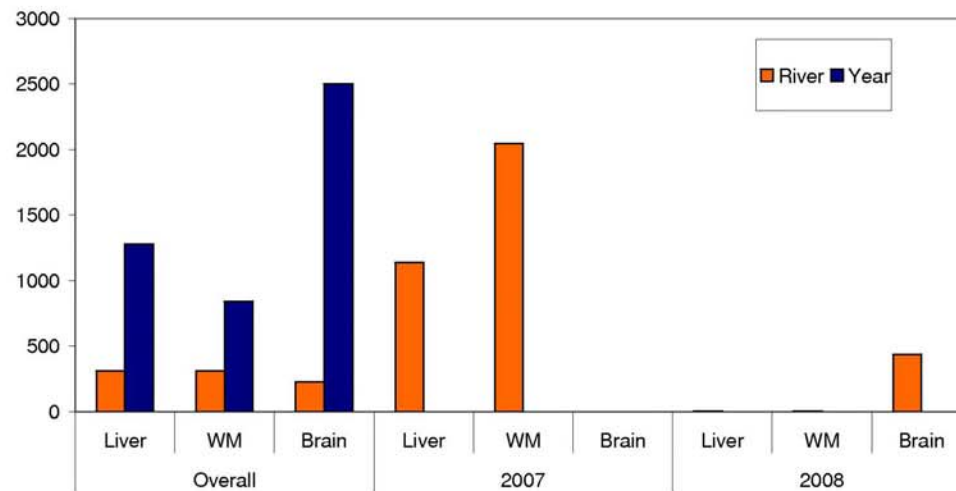
Ho: that 2007 WCVI – that did not migrate through the Strait of Georgia and survived well – were in better condition than Fraser fish, but that differences may not have existed in 2008.

4x44K Agilent Array

Miller et al. in prep

2007 versus 2008 Contrast Study: SW

Number of genes significant ($q < 0.05$) in T-tests between years and river systems



Year is more significant than River-system (Fraser vs WCVI) overall
River-system significant in liver and white muscle in 2008 but not 2008

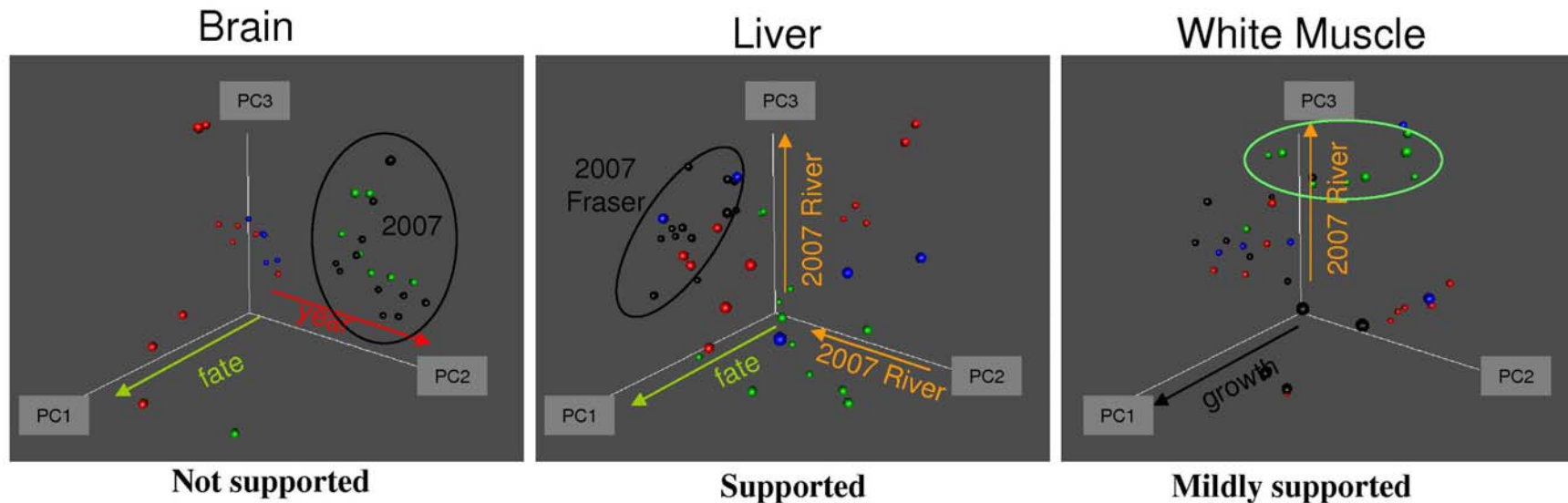
4x44K Agilent Array

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SW Date: River System (Fraser versus WCVI) x Year

Ho: Fraser will be more distinct from WCVI in 2007 than in 2008 (as survival was similar in 2008, but not 2007)

Higher distinction Black vs. Green than Red vs Blue



Fraser	2007	Stock x Year (SW)
Fraser	2008	
WCVI	2007	
WCVI	2008	

4x44K Agilent Array

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Functional Liver Signatures Reveal Immunosuppression and Stress in 2007 Fraser salmon smolts

- **Mortality-related signature** (PC1)

- 90% of Fraser 2007 fish contained the MRS vs. <50% in 2008

- MRS also observed in WCVI salmon, but lower prevalence in 2007 than 2008

- **Immunosuppression** (PC3 SW, PC1 2007 SW, t-tests)

- Signatures differentiating Fraser 2007 vs 2008 and 2007 Fraser vs WCVI indicate Immunosuppression in Fraser 2007 fish

- Innate and humoral immunity most strongly affected

- **Stress** (PC2 SW)

- Numerous stress pathways also stimulated in 2007 Fraser fish

- Oxidative stress (main contributor to tissue damage under starvation)

- DNA damage response

- Cellular response to stress

- Xenobiotic metabolism

While food deprivation could explain the immunosuppression and stress, metabolic elements associated with prolonged starvation are relatively weak

Note: hypoxia and metabolic shifts potentially associated with starvation were stronger when the MRS was removed by contrasting only MRS fish in both years

Miller et al. in prep

“DFO summer surveys of Queen Charlotte Sound in 2007 had the smallest mean size since sampling began in the late 1990’s”

PC1 of White Muscle—Potentially a Growth-Related Profile

Up 2007 end of PC1

DNA metabolism/replication/protein-DNA complex/kinetocore
 regulation of mitotic cell cycle/cell cycle/cell proliferation
 carbohydrate metabolism
 nucleosome organization
 microtubule cytoskeleton
 glycoprotein biosynthesis
 protein AA glycosylation
 vesicle-mediated transport
 melanosome
 ER/protein folding
 cellular response to DNA damage stimulus
 alcohol catabolism

Rapid Slow

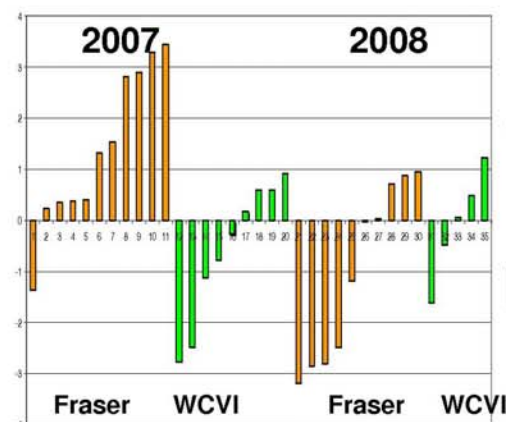
x
x

Up 2008 end of PC1

protein AA phosphorylation/AA transport
 structural constituent of muscle/contractile fiber/myofibril
 ubiquitin ligase
 insulin receptor signaling pathway
 cellular carbohydrate biosynthetic process
 transcription
 T-cell activation/JNK
 apoptosis,
 microtubule assembly
 regulation of homeostasis

x
x
x
x
x
x
x

White Muscle PC1 – Growth-related profiles?



Slow Growth

Rapid Growth

Functional analysis of genes highly loaded in PC1 shows a strong signal related to growth, with numerous pathways stimulated under rapid growth turned in the negative end of the PC1 distribution

Most 2007 Fraser fish are at the extreme PC1 positive end—the slow growth end; higher variability existed in 2008 and for 2007 WCVI

Genomic data are consistent with the purported slower growth of Fraser sockeye post-smolts in the ocean, relative to 2008 post-smolts

Miller et al. in prep

Environment (FW/SW) x Year
Fraser River Stocks Only

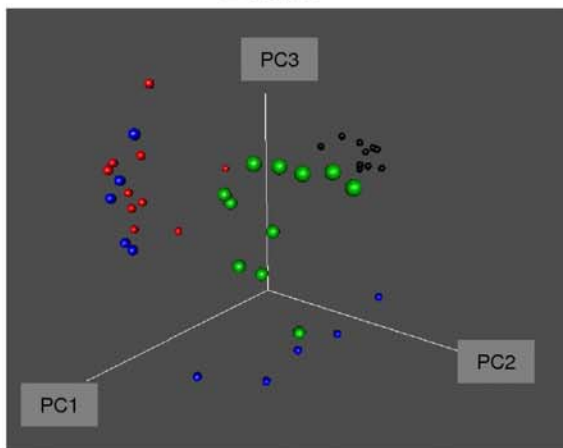
NEW DATA

Ho: If ocean productivity is *the* key factor, 2007 Fraser will be more distinct from 2008 in SW than FW

Ocean **Green** vs. **Blue**

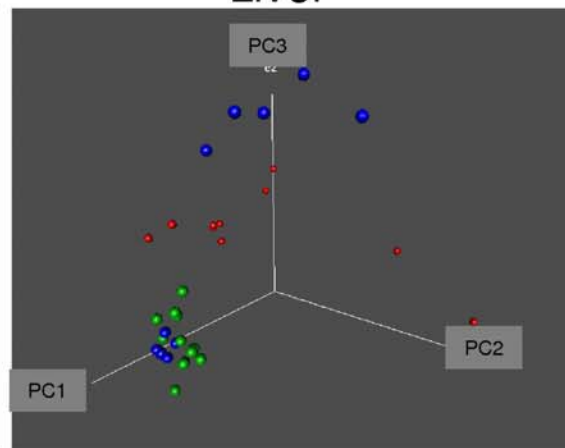
FW **Black** vs. **Red**

Brain



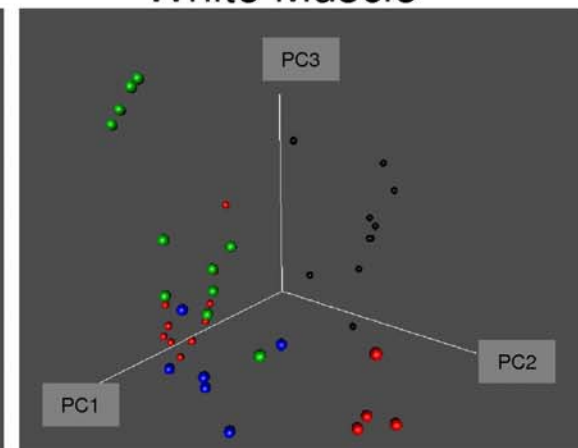
Ocean and FW distinct between years

Liver



Some 2008 SW distinct
No FW 2007 data

White Muscle



Ocean and FW distinct between years

It appears that while there are SW differences in physiology between years, the SW environment alone does not explain all physiological variation in the data

FW	2007
FW	2008
SW	2007
SW	2008

4x44K Agilent Array

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Genomic Summary of 2007 Fraser Sockeye

- High prevalence of Mortality-related signature (MRS) in brain and liver hypothesized to result from a novel viral disease
Fish with the MRS signature in brain in FW quickly disappear in the ocean
- 2007 Fraser sockeye were highly stressed in the marine environment (liver)
some indication of hypoxia, possibly from heterosigma blooms
- Immunosuppression in the marine environment (liver), may relate, in part, to stronger MRS
- Ho: reduced feeding (but not outright starvation) may be a factor (liver)
- A high proportion of 2007 Fraser sockeye carried a low-growth type signature in the ocean, whereas fewer 2008 fish and WCVI fish carried this signature
- However, the marine environment may not explain all of the variance in physiology and fate of 2007 sockeye salmon, as the brain and muscle tissues from 2007 and 2008 Fraser sockeye salmon were highly divergent even in the FW environment

