Using physiological indices to estimate residualism rates in hatchery reared winter-run steelhead trout, *Oncorhynchus mykiss* in the Hood River, Oregon

Don Larsen
NOAA Fisheries
Mollie Middleton and Jon Dickey
UW, School of Aquatic and Fishery Sciences
Ryan Gerstenberger and Chris Brun
Confederated Tribes of the Warm Springs Reservation
Penny Swanson
NOAA Fisheries

Photo courtesy IDFG

Steelhead, Oncorhynchus mykiss, life history

Maturation & spawning

Embryo

Anadromous Steelhead

Parr

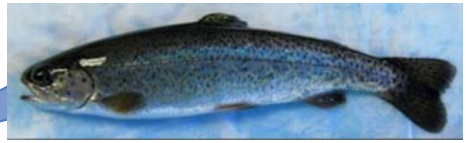
Resident Rainbow Trout

Maturation in fresh water

Ocean (1–3 years)

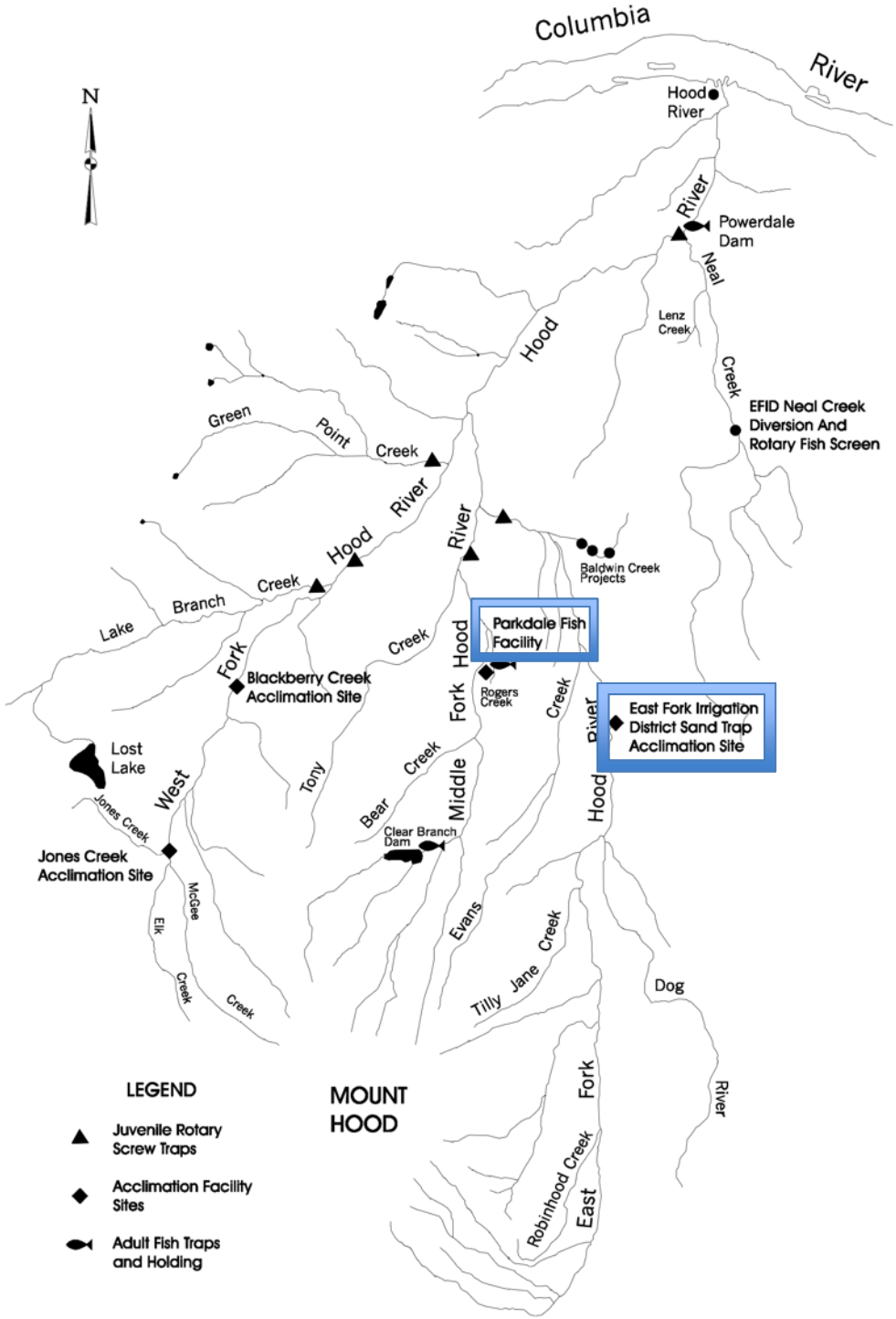
Estuary/early marine (2 weeks)

Smolt (age 1 -3)



Hood River Basin, Oregon

Co-managers from the Confederated Tribes of the Warm Springs Reservation (CTWSR) and ODFW release ~50K Hood R. winter run steelhead annually from the Parkdale Fish Facility and East Fork Sand Trap combined.



Independent Scientific Review Panel (ISRP) 2008-2010 Review of Revised Hood River Production Master Plan

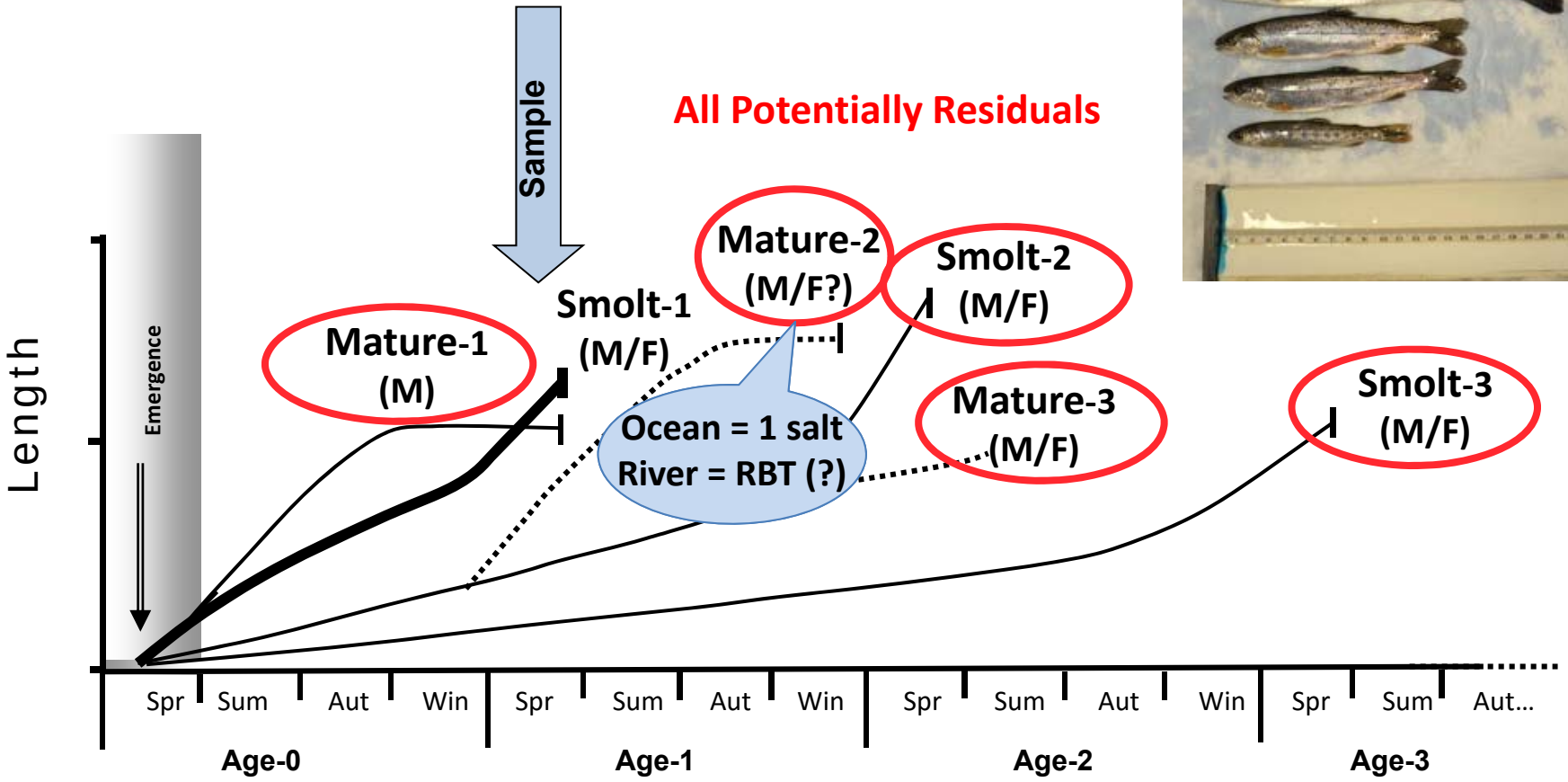
ISRP Review Summary

Residualism by Hatchery Steelhead

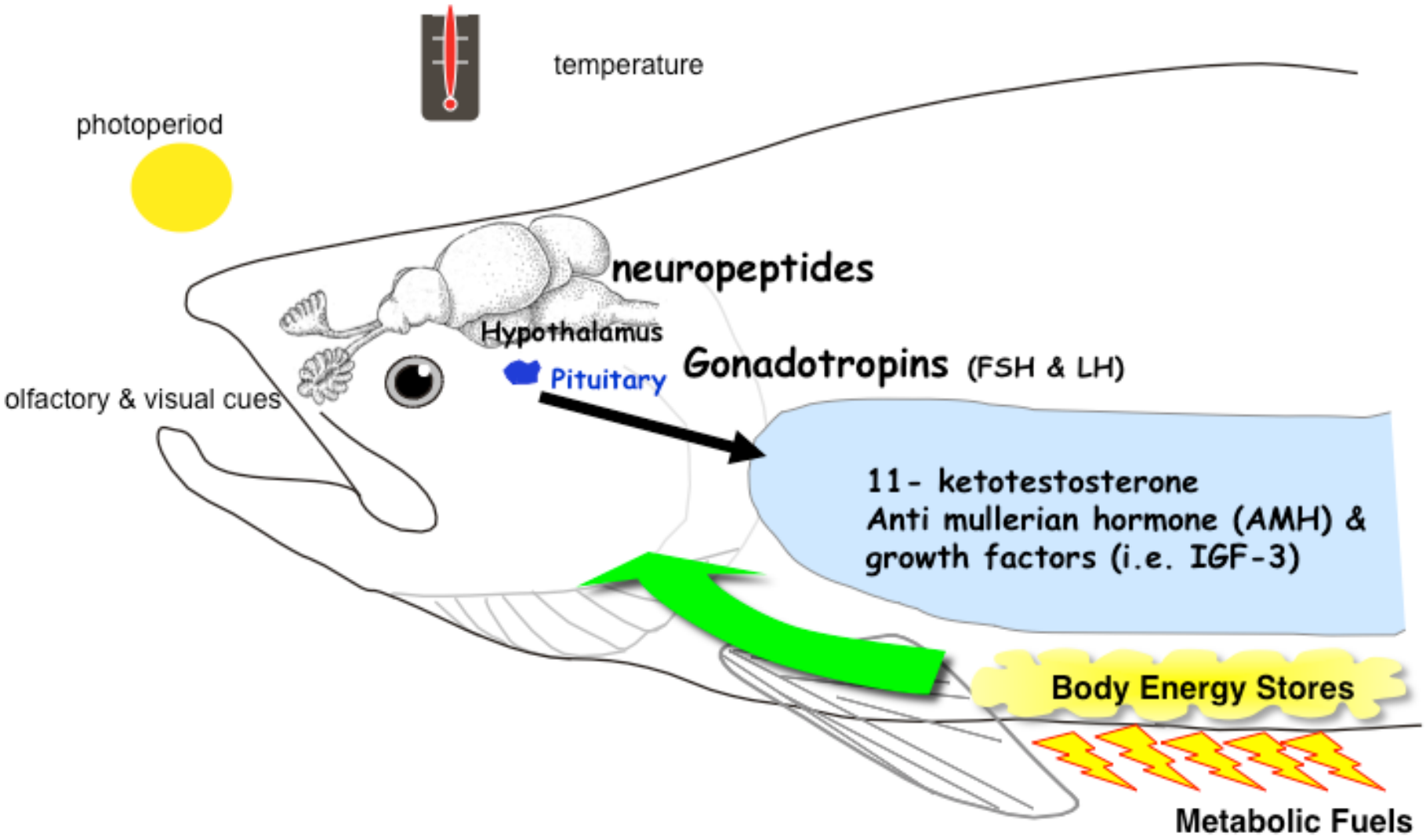
"……..reviews recommended that the project sponsors **develop M&E protocols to assess the extent to which the residualism of hatchery steelhead is resulting in the displacement of wild fish** from Hood River habitat…… These yearling residuals may compete with and displace wild underyearling parr….may contribute little or nothing to subsequent smolt yields, while a few likely mature precociously and spawn with wild fish, thus decreasing fitness of wild spawners….contributing toward hybrid swarms with cutthroat trout……..

A good starting point …….estimate the number of residuals the hatchery is producing…….or try to "forecast" life-history types.

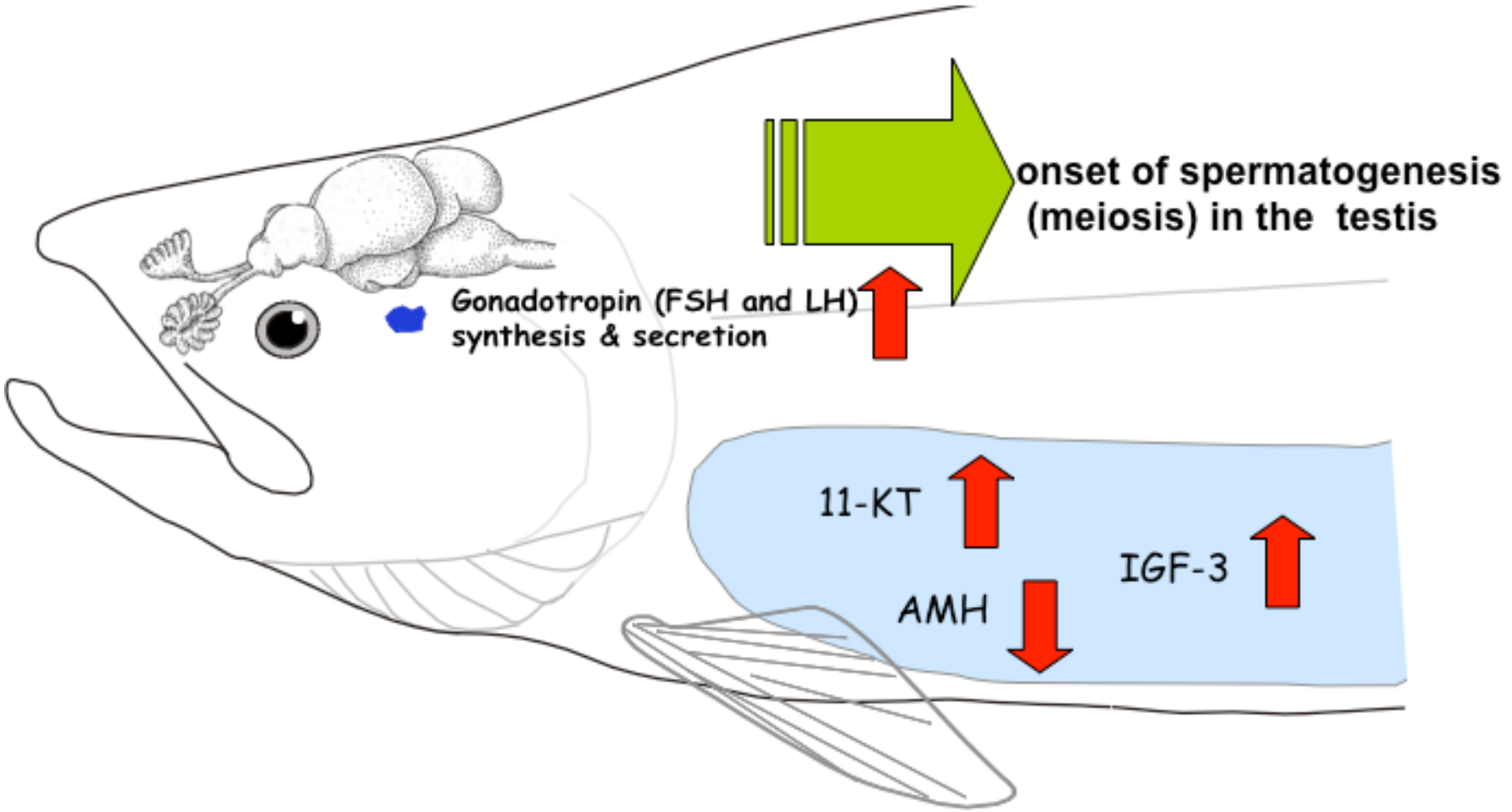
What are the possible life-history options for Hood River Winter run Steelhead?



Reproductive Endocrine Axis



Onset of Puberty in Salmon



Methods

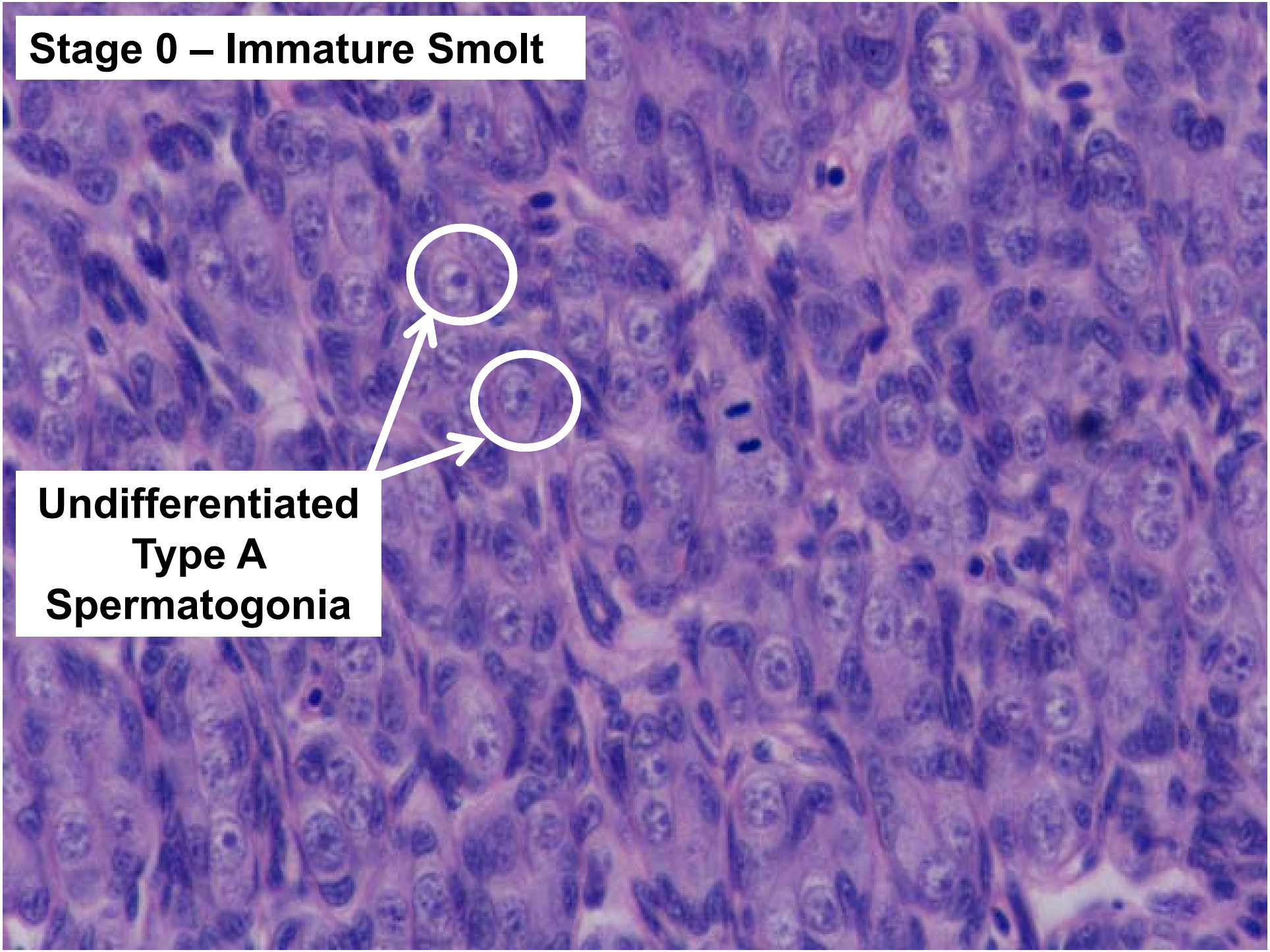
- Collect 300 Hood River Winter steelhead at Parkdale Facility in May 2012, 2013 and 2014 just prior to release
- Measure length, weight, sex, gonad weight for GSI, visual sexual development state, visual smolt state
- Collect
  - Gill tissue from males and females
  - Plasma from all males
  - Pituitary glands from all males
  - Testes from all males

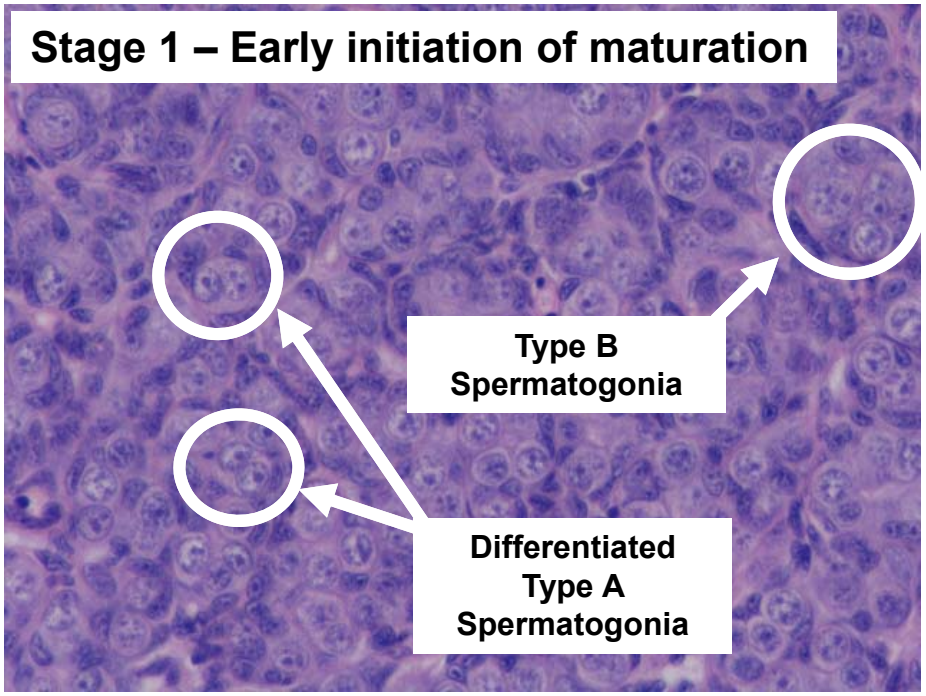
Physiological tools to determine life-history

- **Sex of the fish**
- **Testes histology – characterize cell types**
- **Male GSI**
- **Male Plasma 11-KT levels**
- **Pituitary mRNA transcript for FSH and LH in males**
- **Testes mRNA for AMH and IGF-3 (BY 2011 and 2013) in males**
- **Male and female Gill Na+/K+-ATPase levels**
- **Male and female external appearance – parr marks or silvering**
  - **1 = parr, 2 = transitional, 3 = smolt**

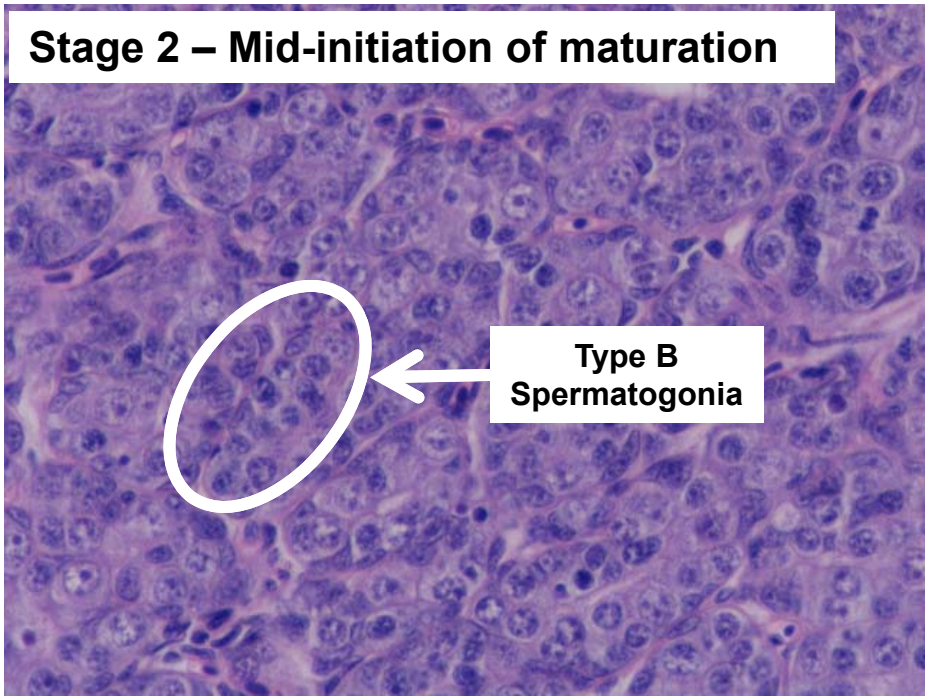
Results

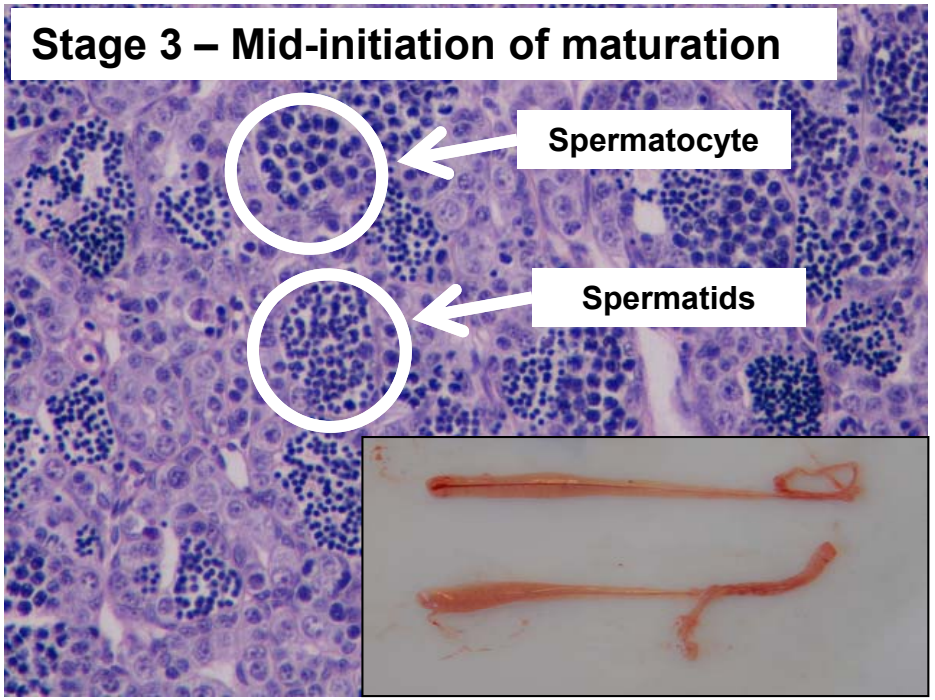
- **Sex - 154 females, 146 males (51:49) – BY 2011**
  - **165 females, 135 males (55:45) – BY 2012**
  - **149 females, 158 males (49;51) – BY 2013**
- **There were only 6 immature parr (smolt index = 1) and all were females**
- **All other females were immature smolts**
- **Smolts were the most common life-history in all years**
- **In males, maturation initiates before clear increases in GSI**
- **Using histology we recognized 6 different life-history stages (or types) in both brood years**
- **Other parameters were required to support the histological results**


Stage 0 – Immature Smolt
Undifferentiated Type A Spermatogonia



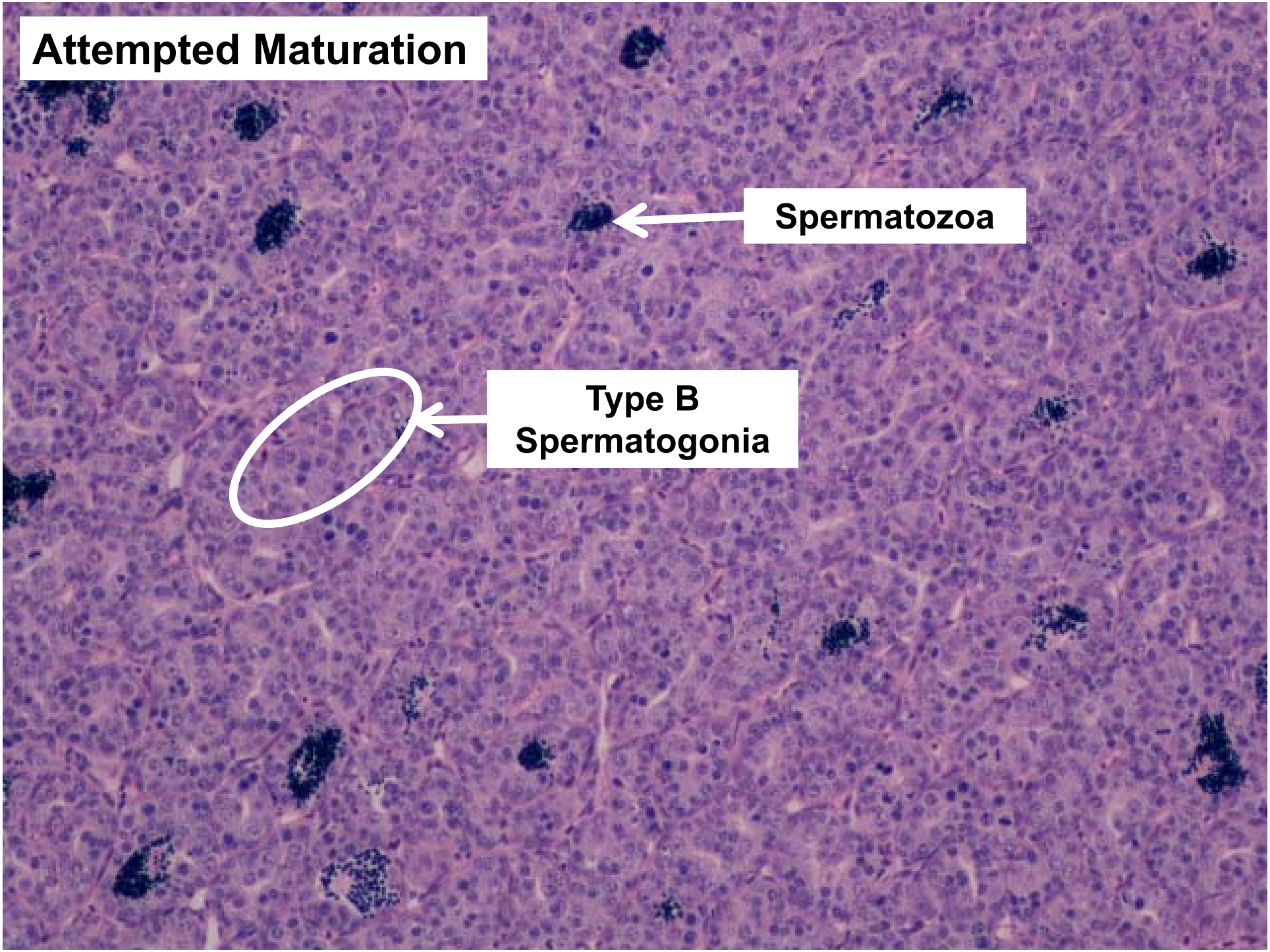
Stage-1, 2, and 3 male fish are all at varying stages of initiating maturation for next spring





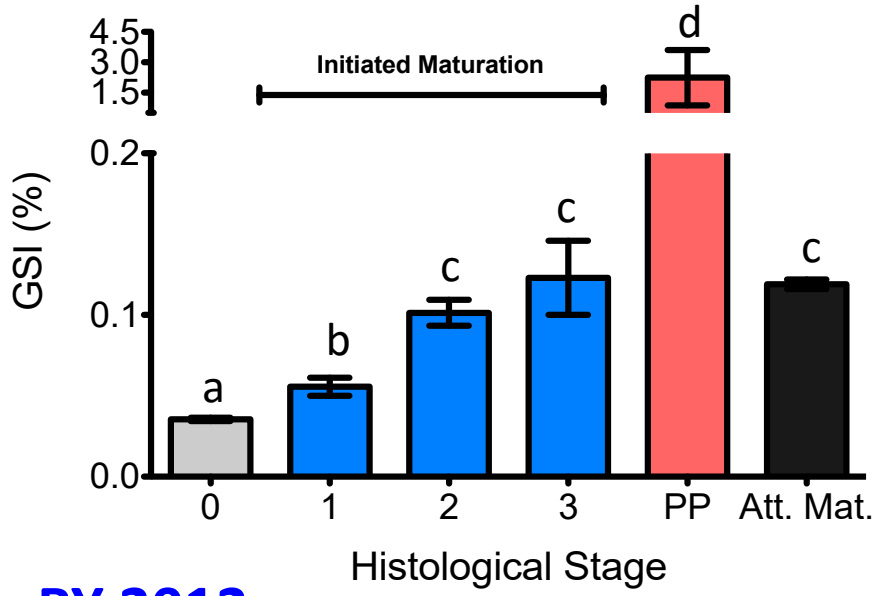
Precocious Parr

Spermatozoa

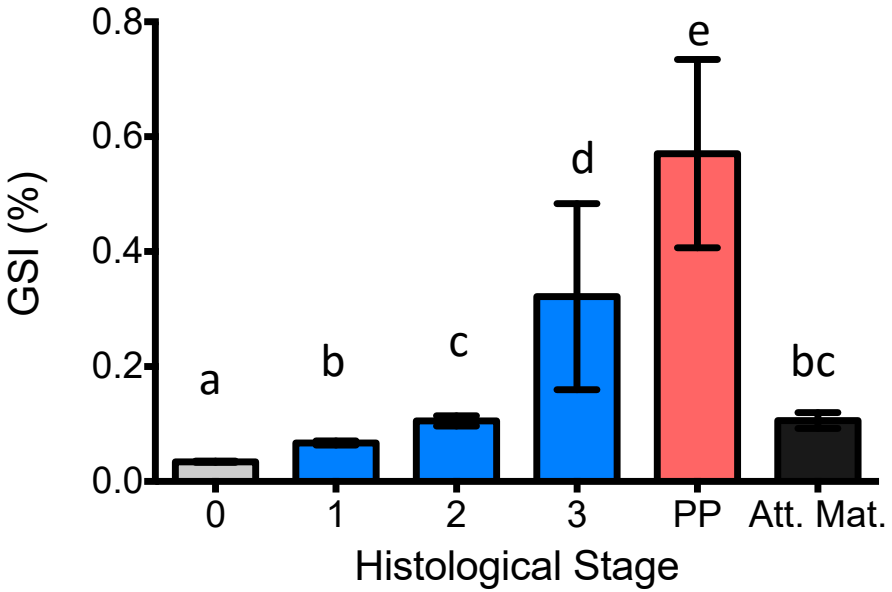

Attempted Maturation
Spermatozoa
Type B
Spermatogonia

GSI is low in smolts and increases with maturation

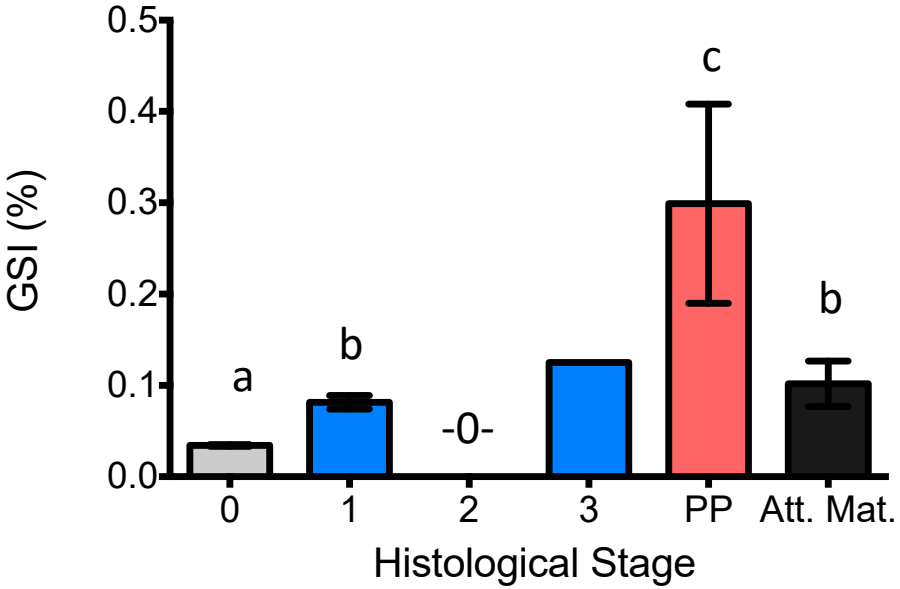
BY 2011



BY 2012

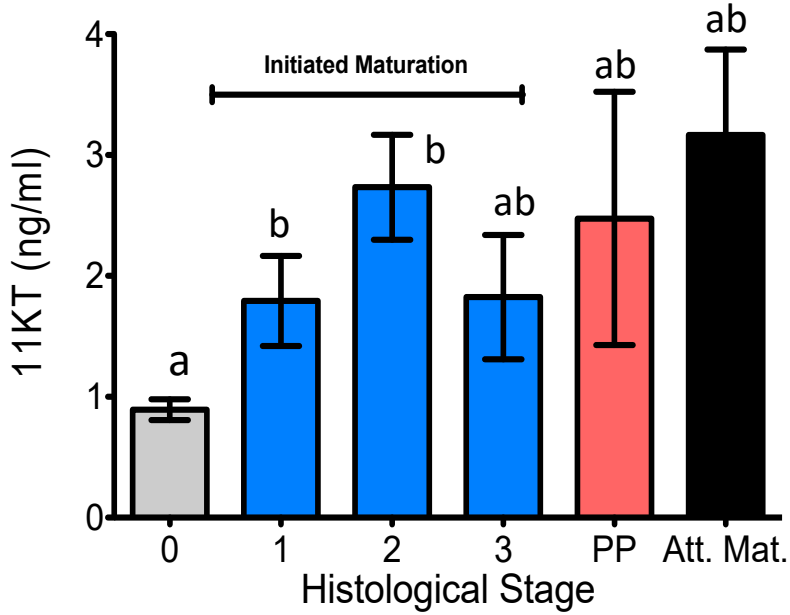


BY 2013

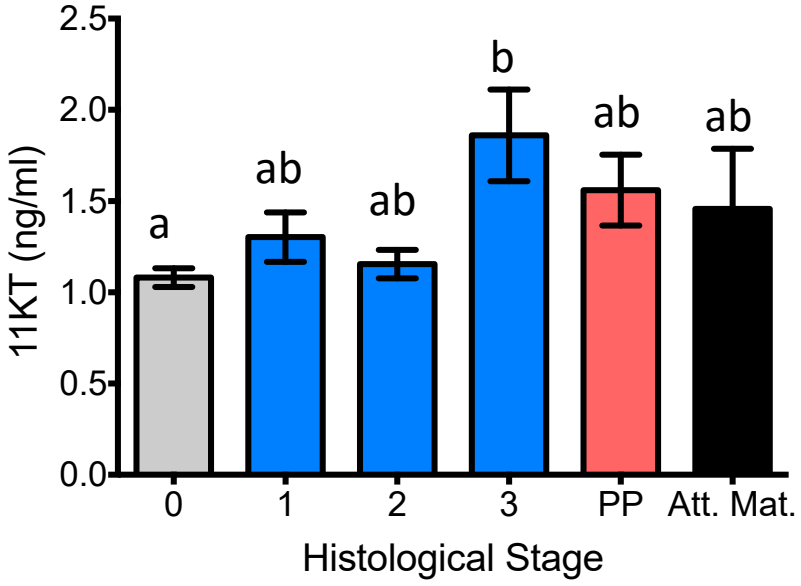


Plasma 11-KT is low in smolts and increases with maturation

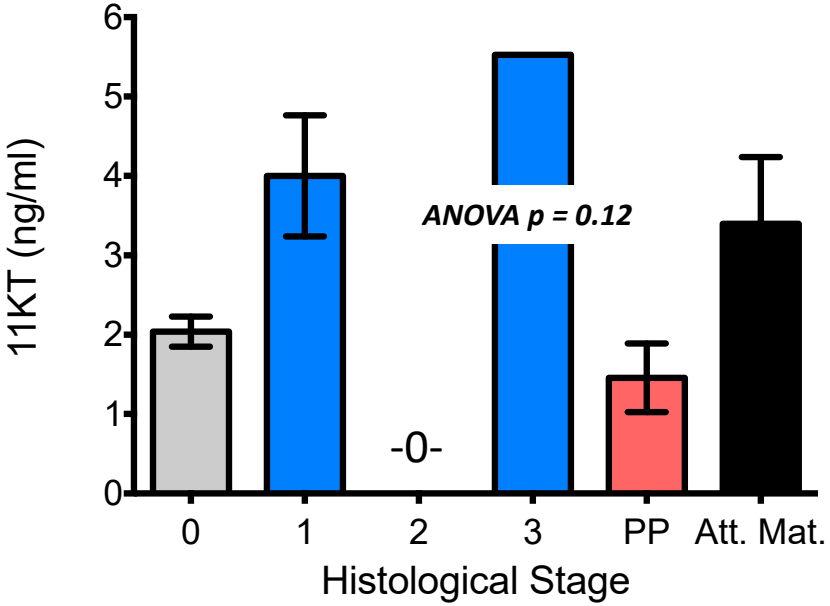
BY 2011



BY 2012

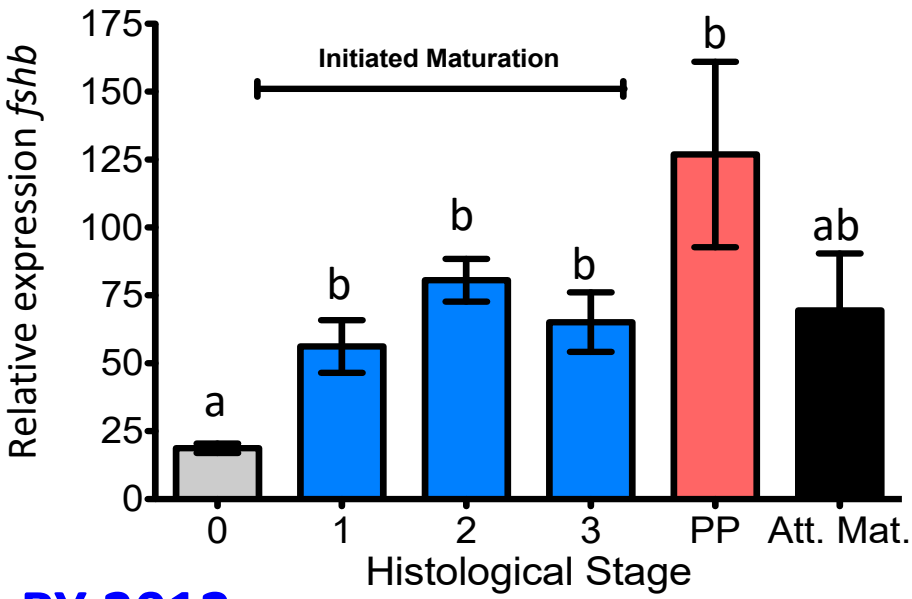


BY 2013

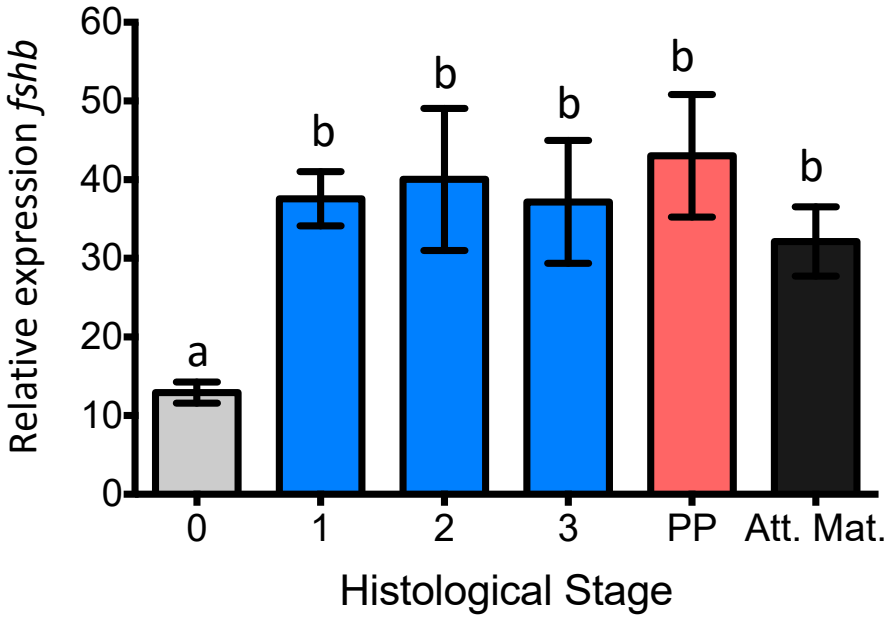


Pituitary FSH mRNA is low in smolts and increases with maturation

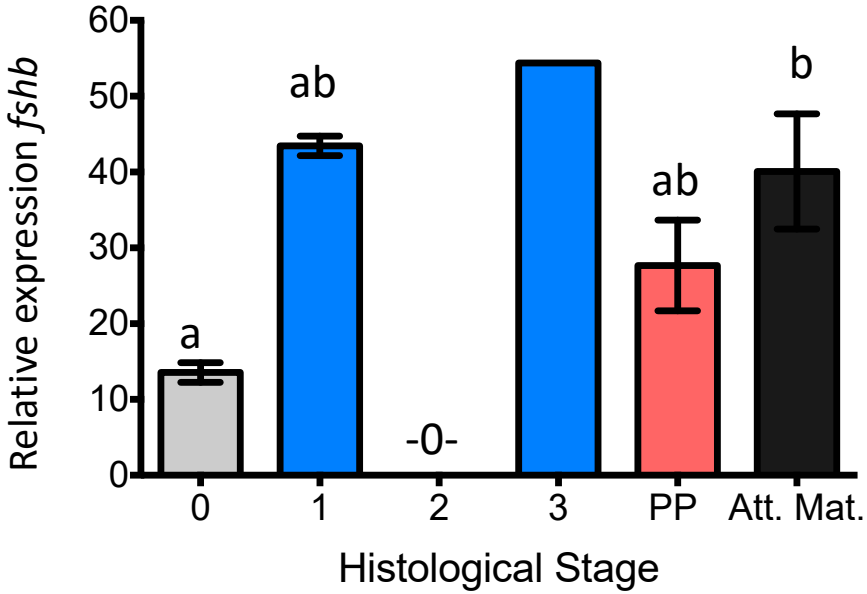
BY 2011



BY 2012

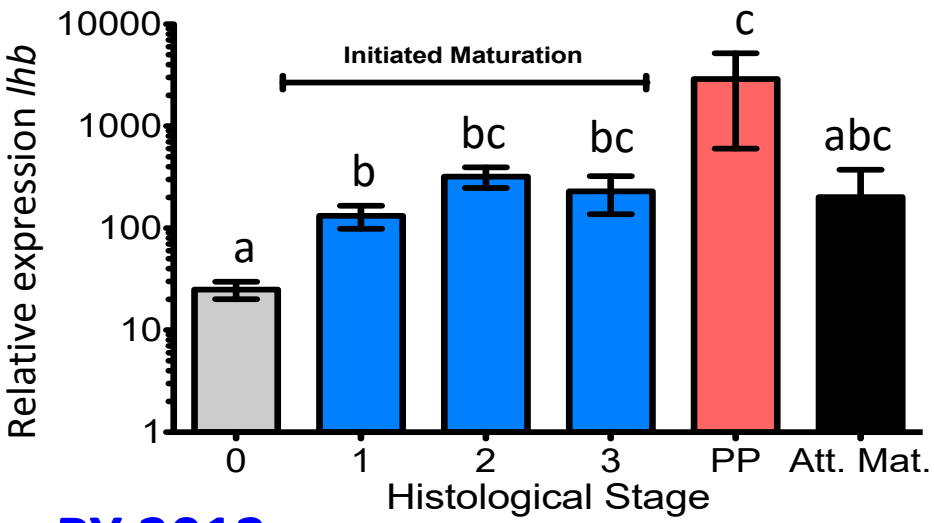


BY 2013

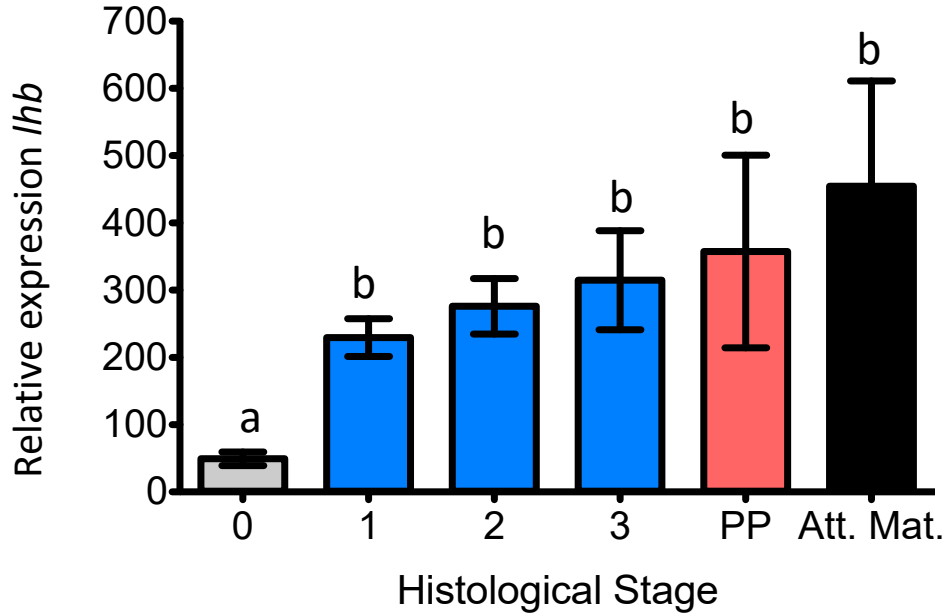


Pituitary LH mRNA is low in smolts and increases with maturation

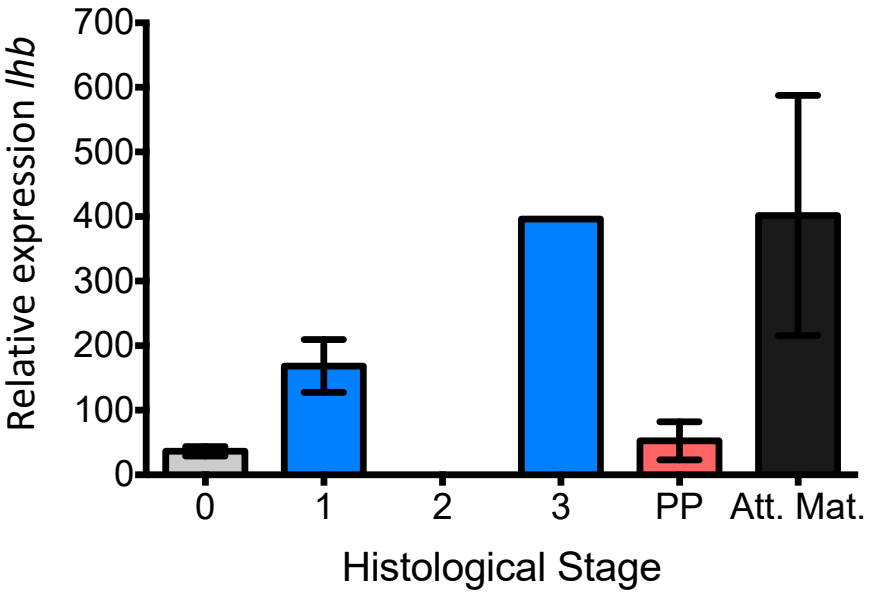
BY 2011



BY 2012

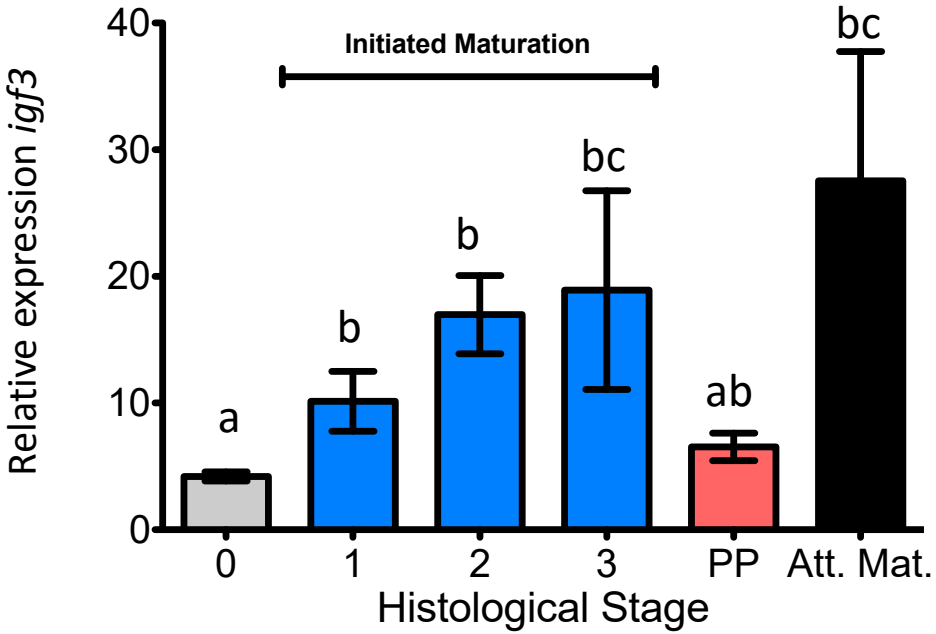


BY 2013



Testicular IGF3 mRNA is low in smolts and increases with maturation

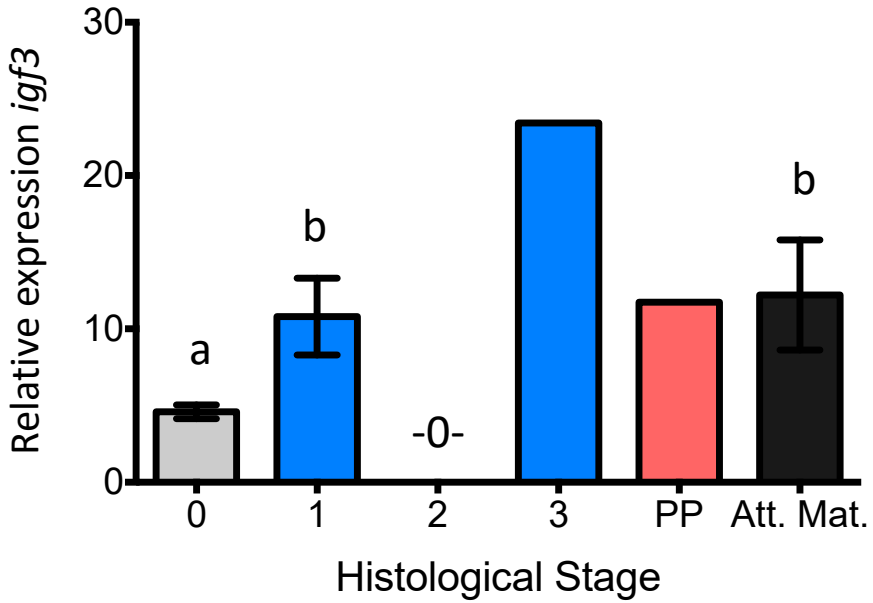
BY 2011



BY 2012

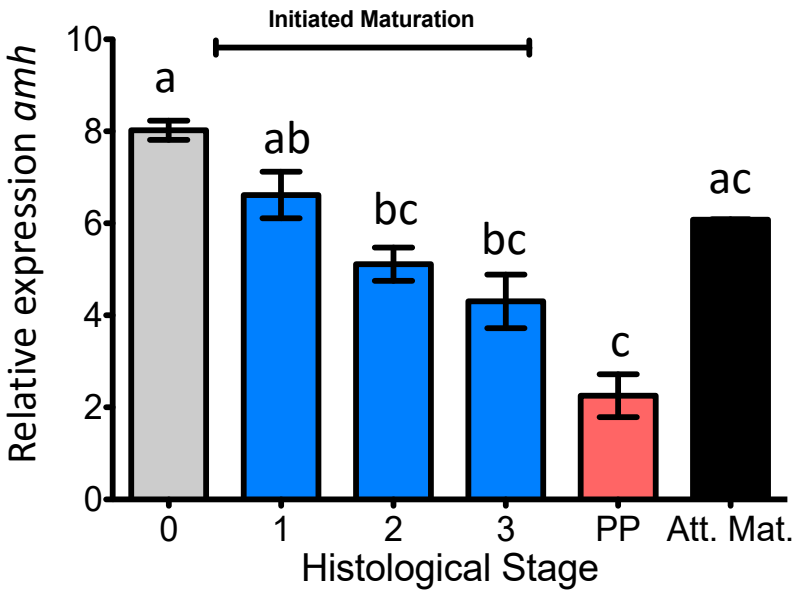
Not measured

BY 2013



Testicular AMH mRNA is high in smolts and decreases with maturation

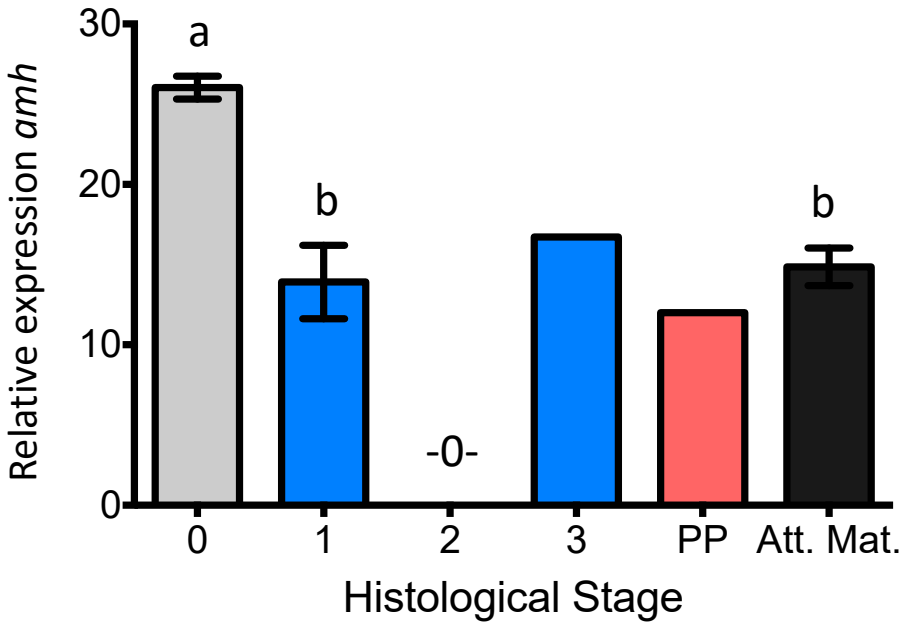
BY 2011



BY 2012

Not measured

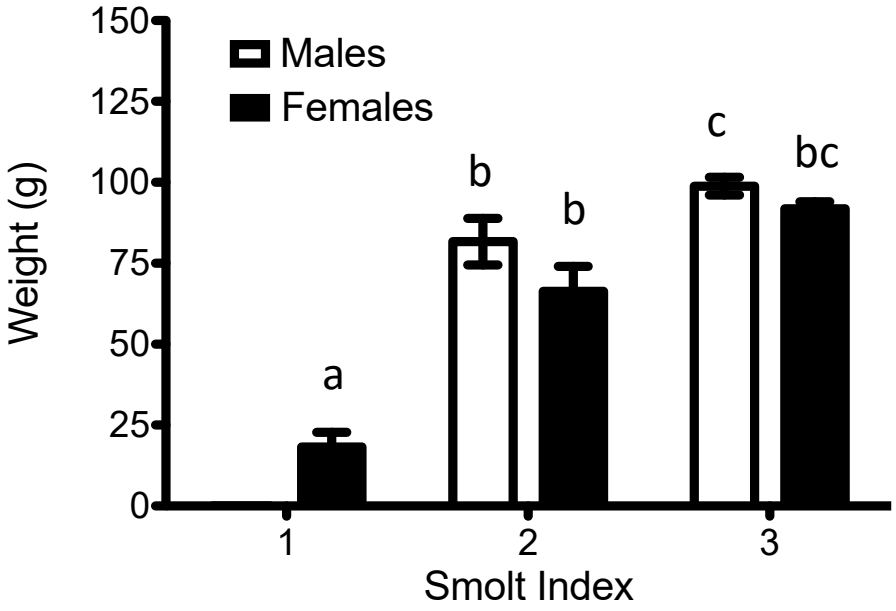
BY 2013



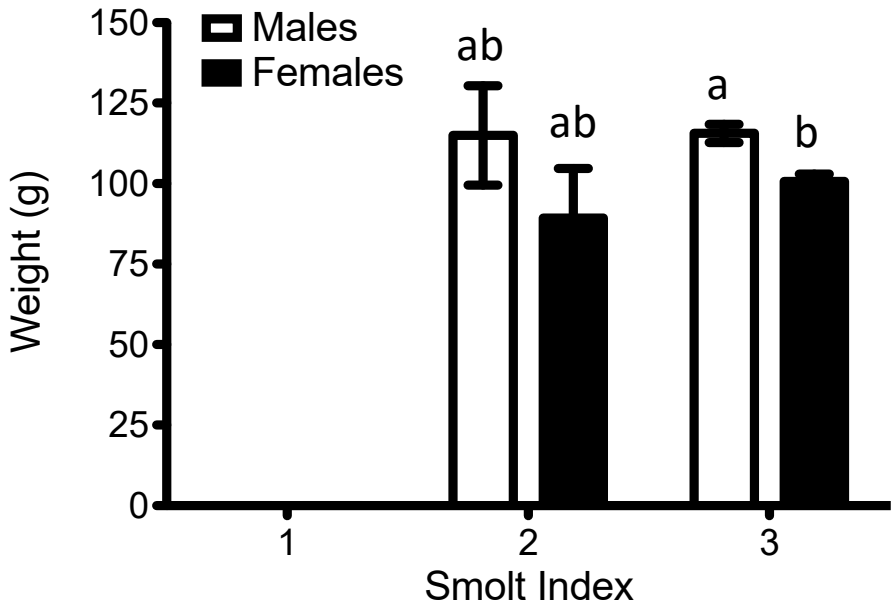
What about smolting?

Smolt Index *by* Size *by* Sex

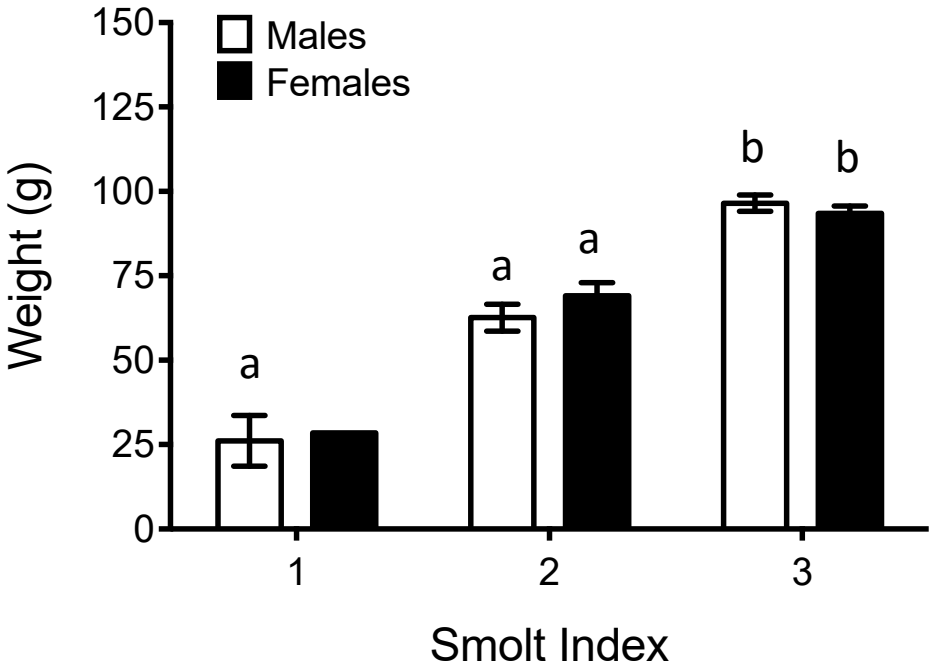
BY 2011



BY 2012

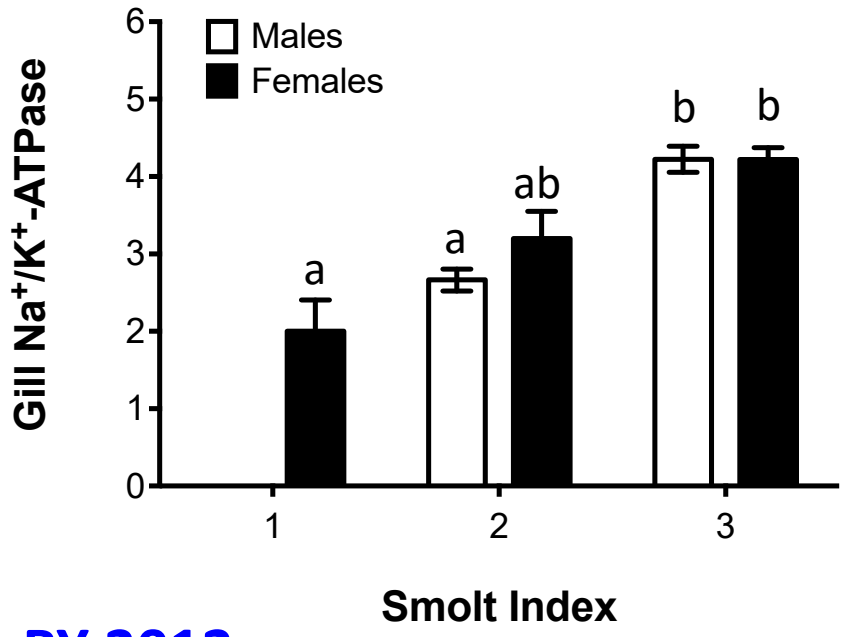


BY 2013



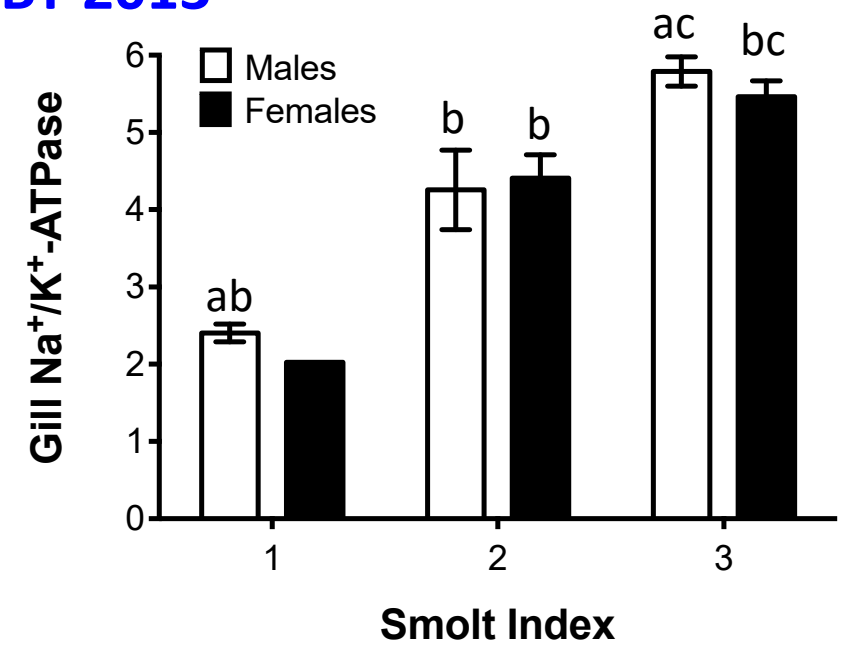
Gill ATPase increased with higher smolt index

BY 2011



BY 2012

BY 2013

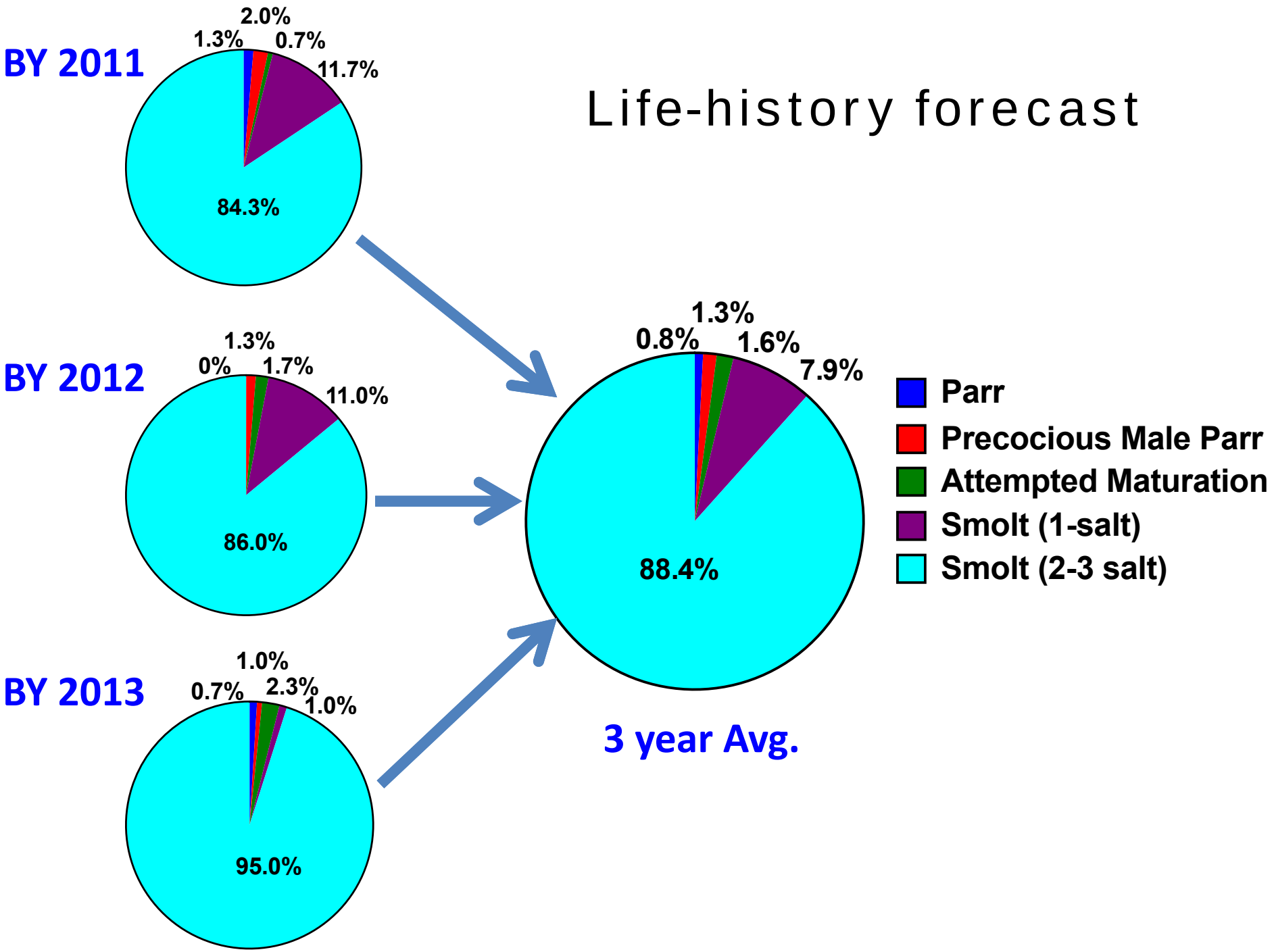


Combine all indices

size
sex
smolting
male maturation

to categorize each fish according to life-history type

Life-history forecast



Conclusions

- We have demonstrated the efficacy of using physiological indices at a single time point to forecast steelhead life-history types
- Attempted maturation appears to be a real phenotype
- Residualism estimate ~3-5% = about 1,500-2,500 per 50,000 fish
- M-2 (a.k.a. 1 Salts or “half-pounders”) ~ 8% = 5,500 per 50K.
- Challenging question – do any of the M-2’s stay in FW (RBT)?

Two more reasons to care about residuals

Maturing Testes

Yellow Jackets - Good!

Chinook eggs - Bad!

Acknowledgements

- Louisa Harding (UW), Lindsay Brewer (CTWSR) – sampling
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