

# Willamette Fisheries Science Review 2018

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# ***The Secret Life of Salmon***





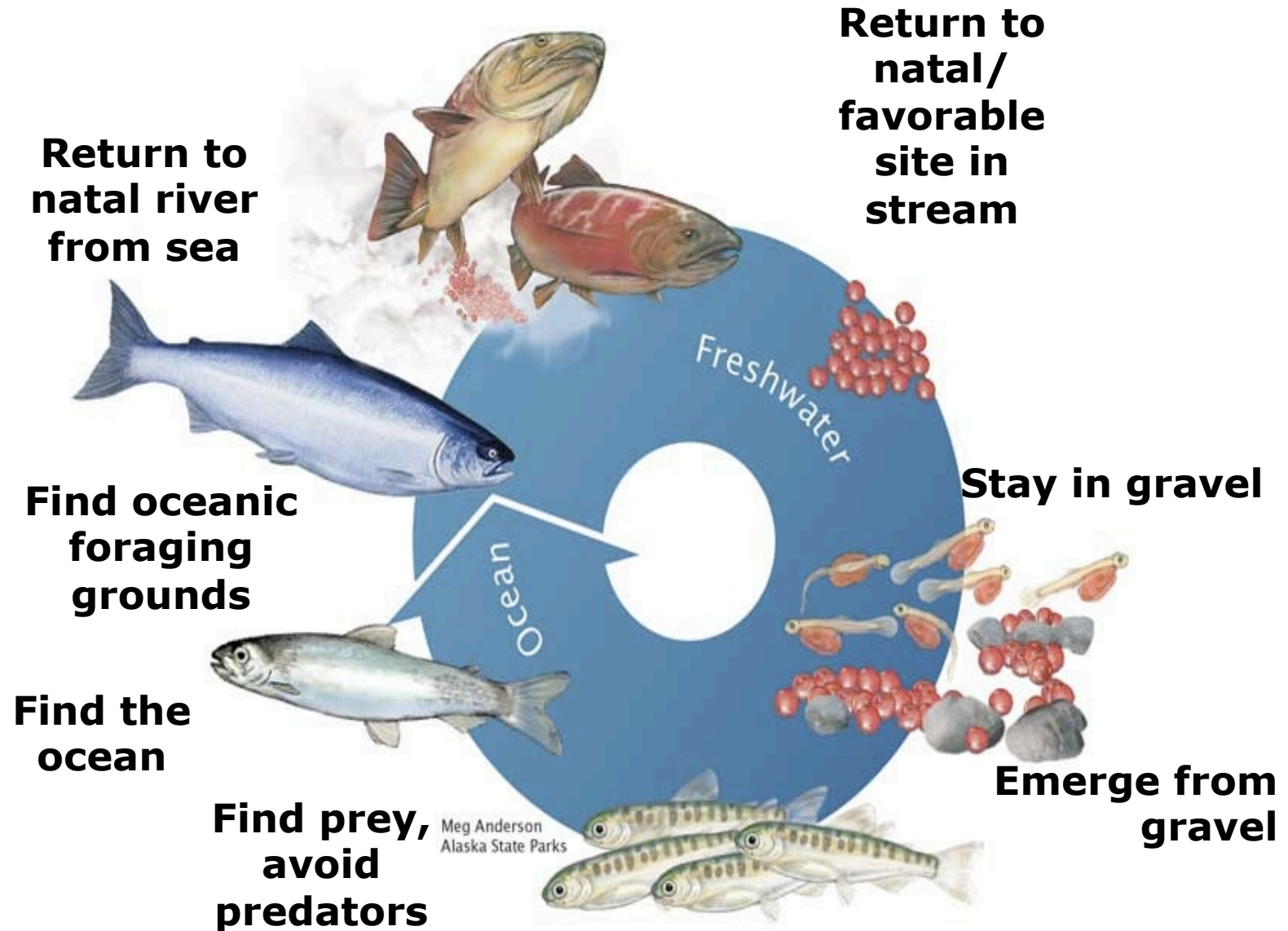


OSU





# Some current research - different life-stages





# Life History

- STRATEGY

- “A rule that specifies how the organism deals with every possible circumstance.”
- “A rule for action.” (algorithm)
- “A pre-programmed rule that an animal obeys.”

- TACTIC

- “Individual actions or responses, comprising a strategy.” (moves)

# **Conditional Life History (Hypothesis = Model)**

**It Depends ...**

Ontogeny (individual development)

Epigenetics (gene & environment interactions)

Study TACTICS



# “Reverse Engineering”

- Factors contributing to the expression of life history tactics
- Study selected points (intervals) during development
- Predict behavior
- Observe – compare to predictions
- Test hypothesis (model)



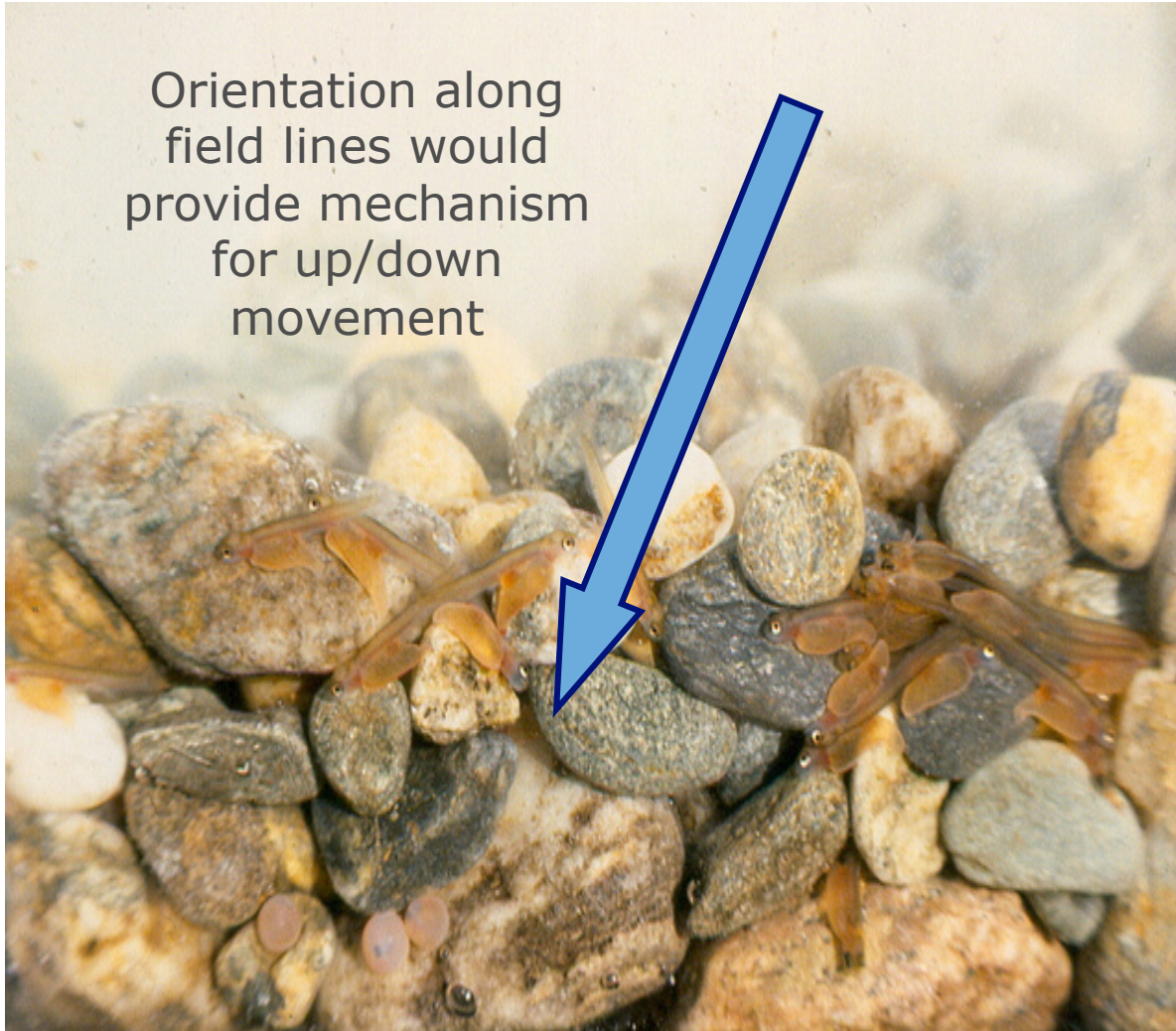


Emerging: Which way is up?



# Which way is up? Northern Hemisphere

Orientation along  
field lines would  
provide mechanism  
for up/down  
movement





# Which way is up? Southern Hemisphere

Orientation along  
field lines would  
provide mechanism  
for up/down  
movement

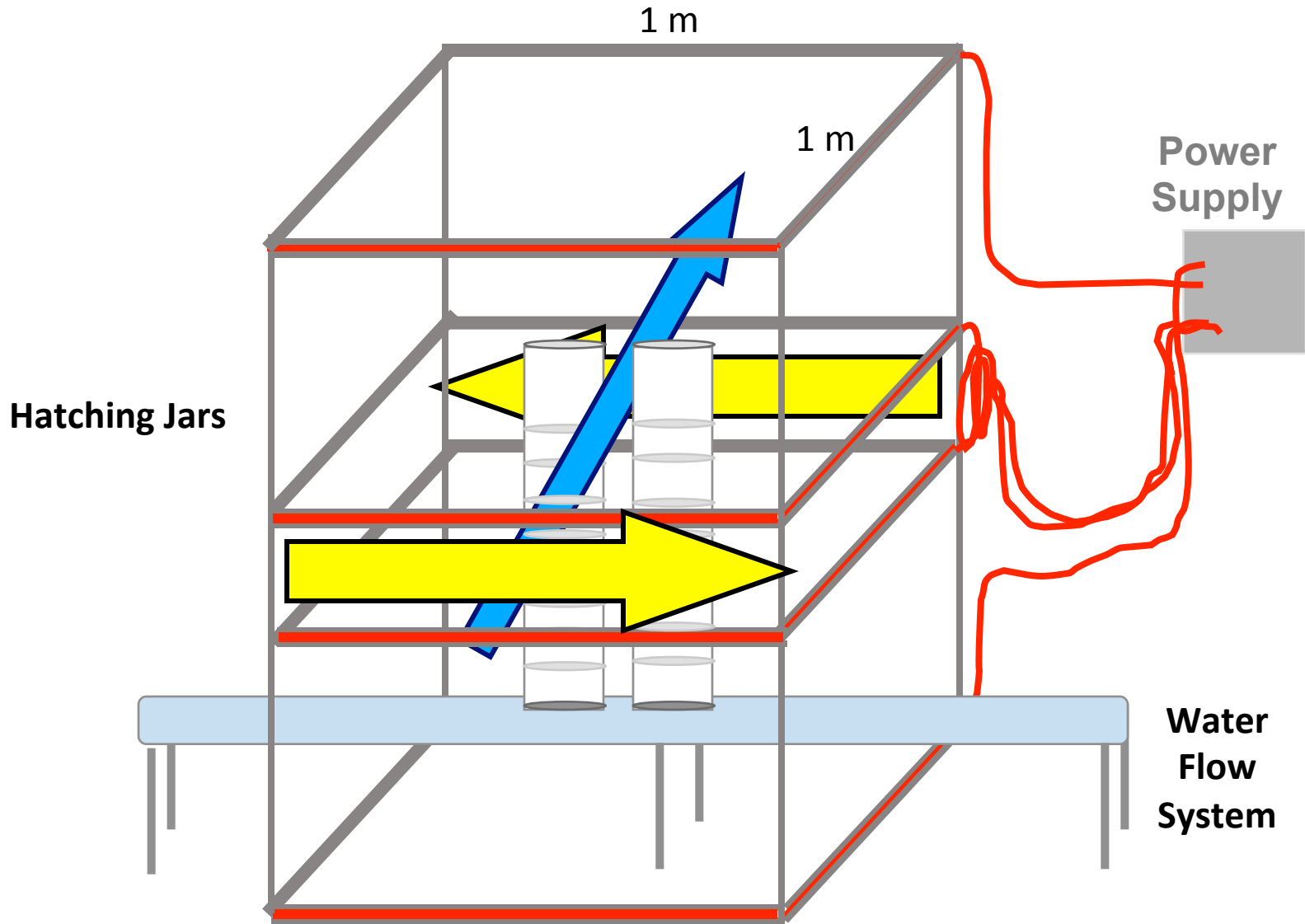


# Emergence





# Magnetic Test Coil



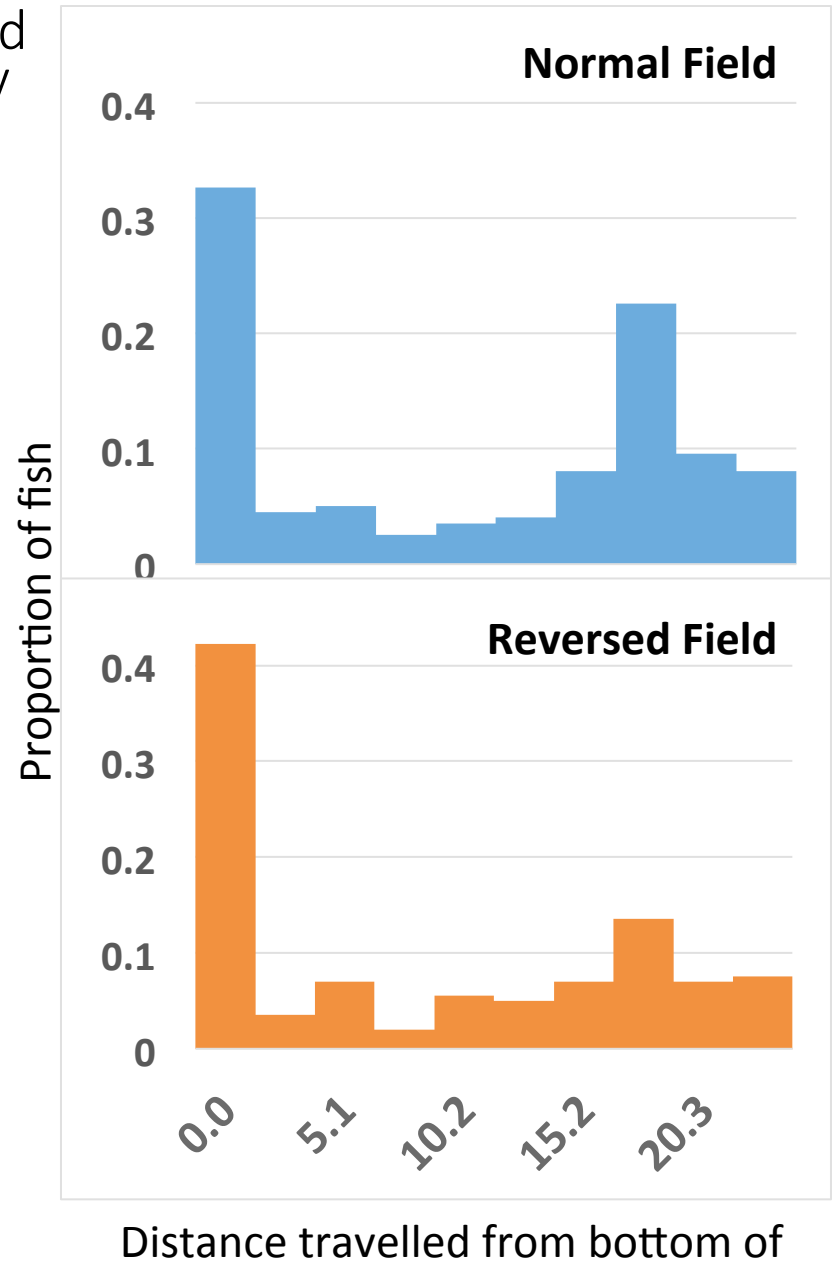
Swim-up behavior significantly influenced by polarity of vertical magnetic intensity

Normal mean: 10.4  
cm

Reversed mean: 8.4  
cm

Mann-Whitney U-  
Test

$p = 0.025$ ,  $n = 200$

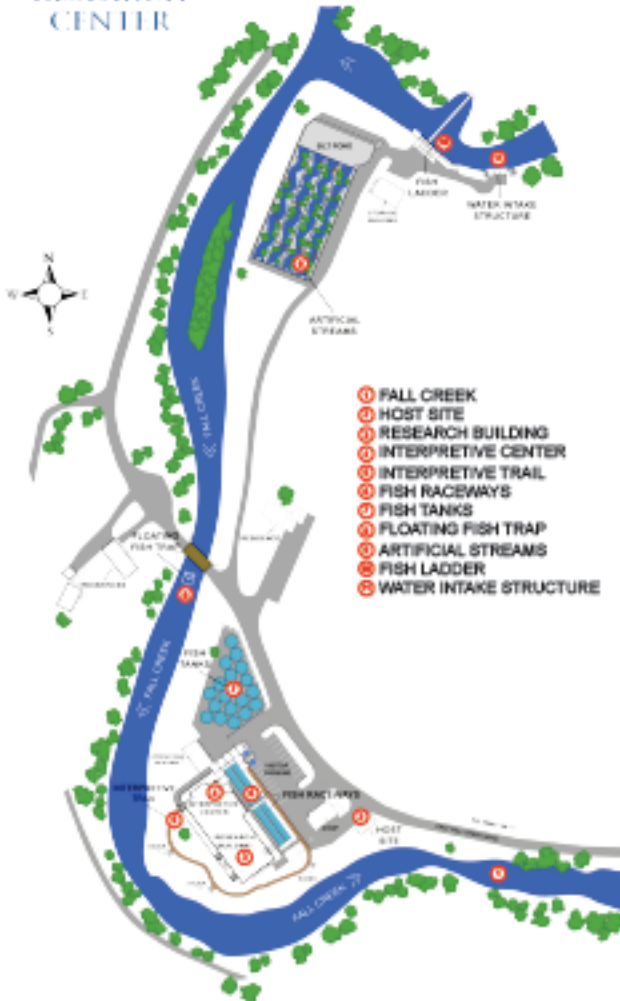




# Can salmon embryos learn incubation water?



OREGON  
HATCHERY  
RESEARCH  
CENTER



Clackamas Spring Chinook



Fall Creek

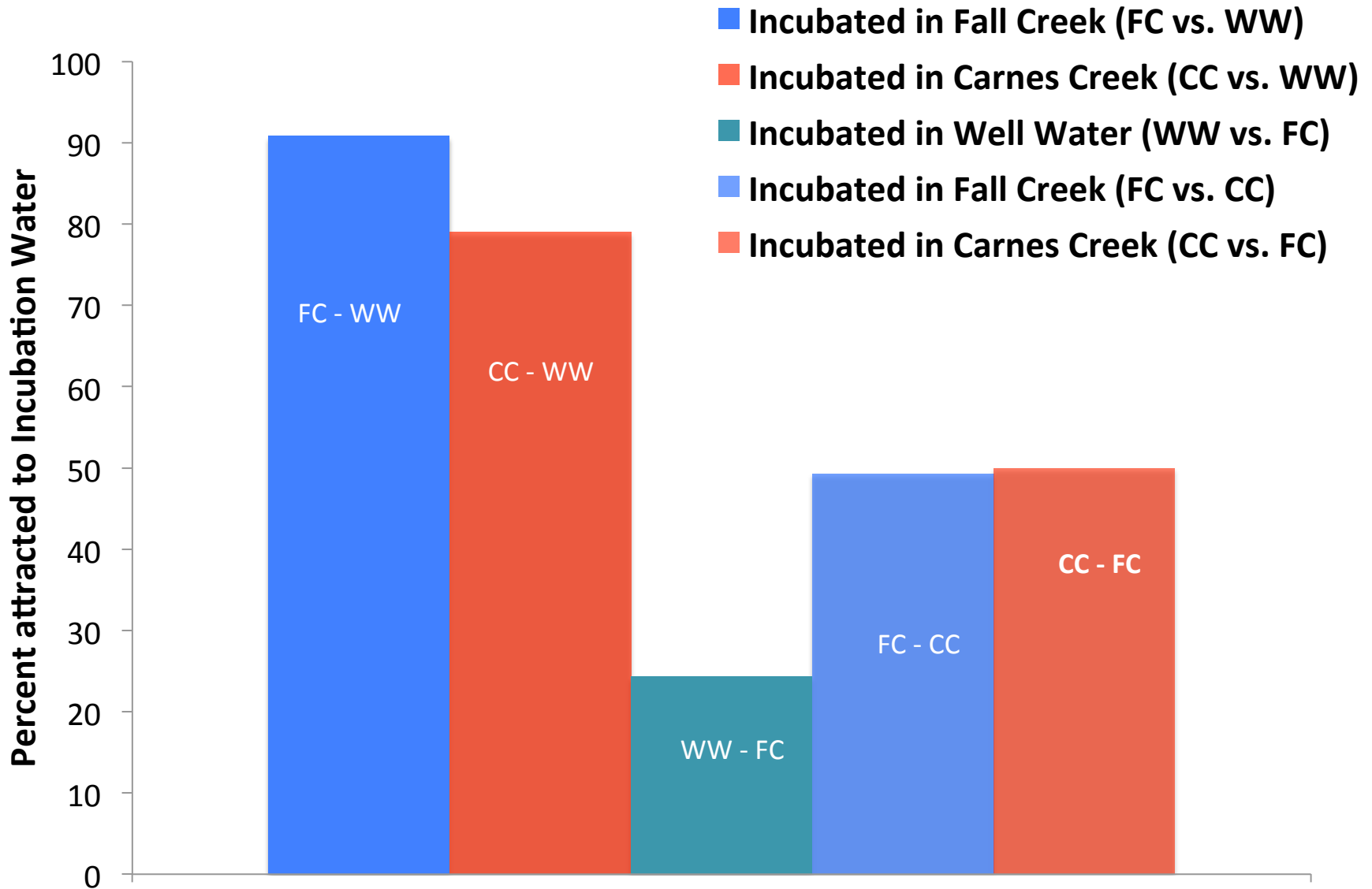
Well water

Carnes Creek

Y-maze testing  
of emergent fish



# Chinook embryonic learning





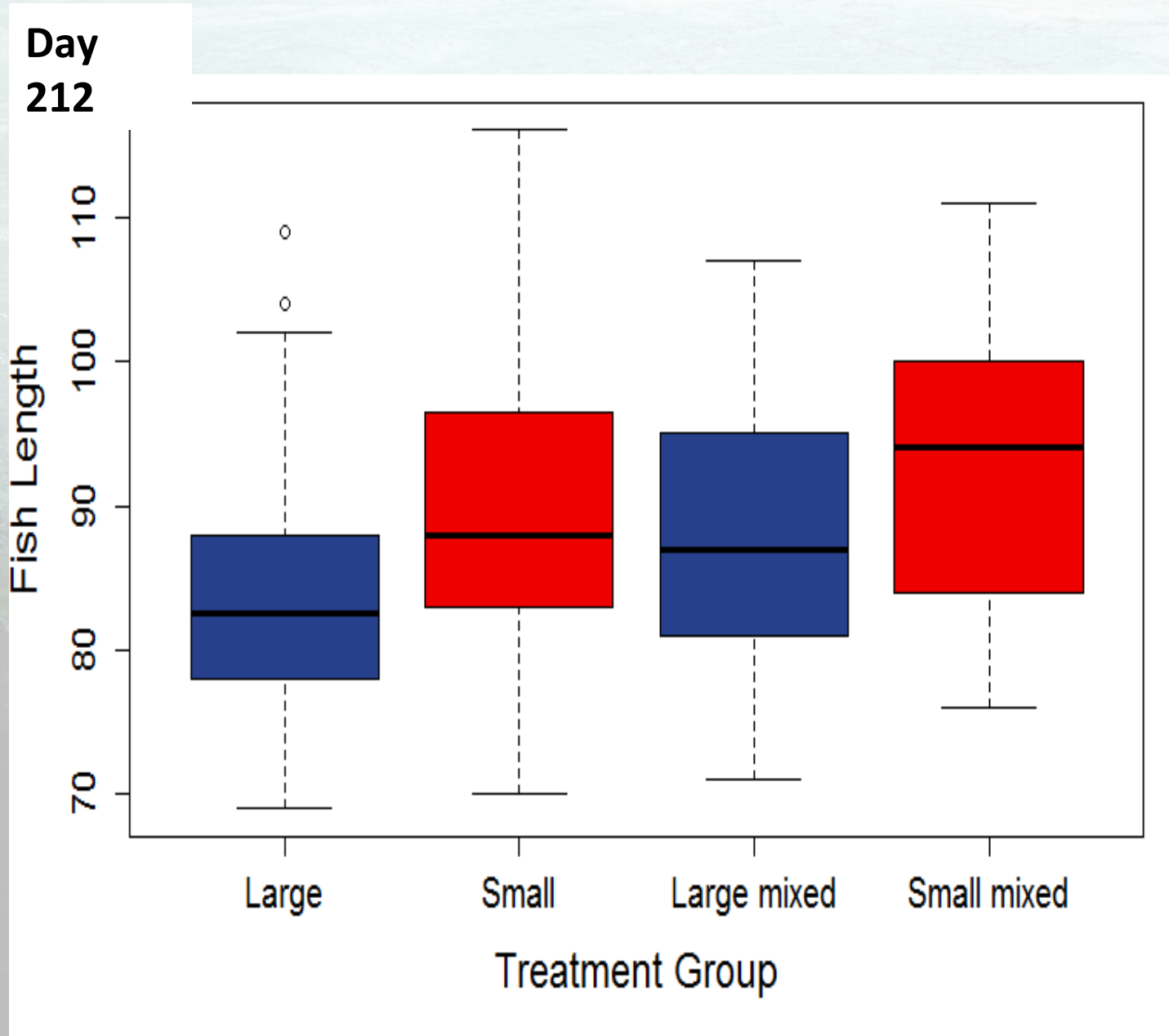
# Smolting

**For individual juvenile salmon – smolting is a**

- **Conditional Strategy**
  - **Physiological state of fish, age, size, environmental cues**
- **Tactics**
  - **Migrate (smolt)**
  - **Resident (residual freshwater)**







Background

Fin Quality

Movement

Egg Size

Wrap-up

# Study design

- Two basins
- Acoustic telemetry
- 70 fish by basin
- Time series
- V7 implanted throughout the run





# Methods

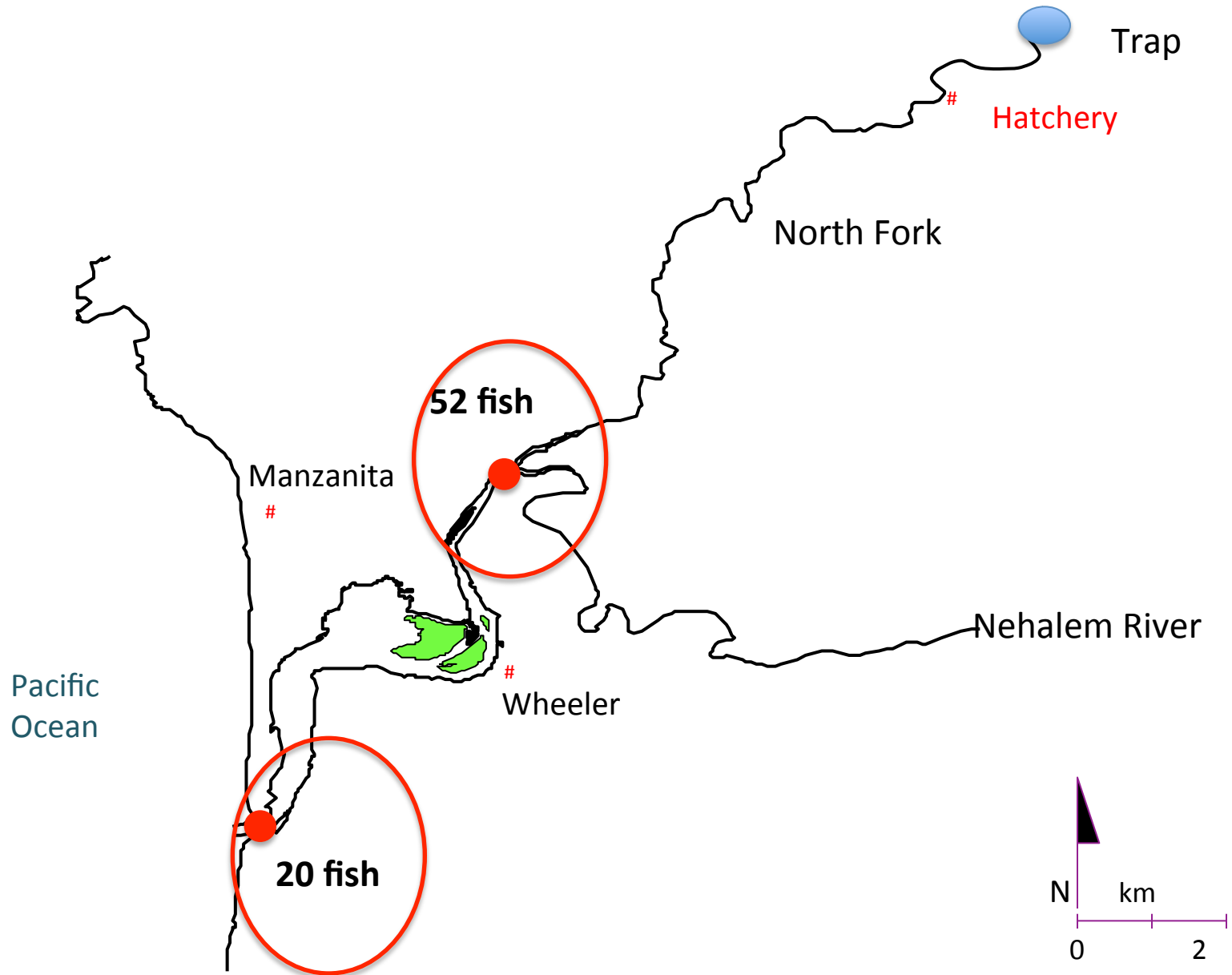
- Screw trapping
- Surgical implants of Vemco tag
- Deployment of acoustic array
- Physiology: Gill ATPase, blood
- Parasite: sample fish at the trap, above and below the trap
- Genetic pedigree of every fish
- Digital photo of every fish



# Alesea Estuary



# Nehalem Bay





# How do marine animals orient their movements on the scale of an ocean basin?

**An animal needs to know:**

- 1) Where it is
- 2) Where it wants to go
- 3) How to set a course to get there
- 4) How to correct for errors



Do salmon know where they are, where they are supposed to be, and how to get there?

Yes, yes, yes!



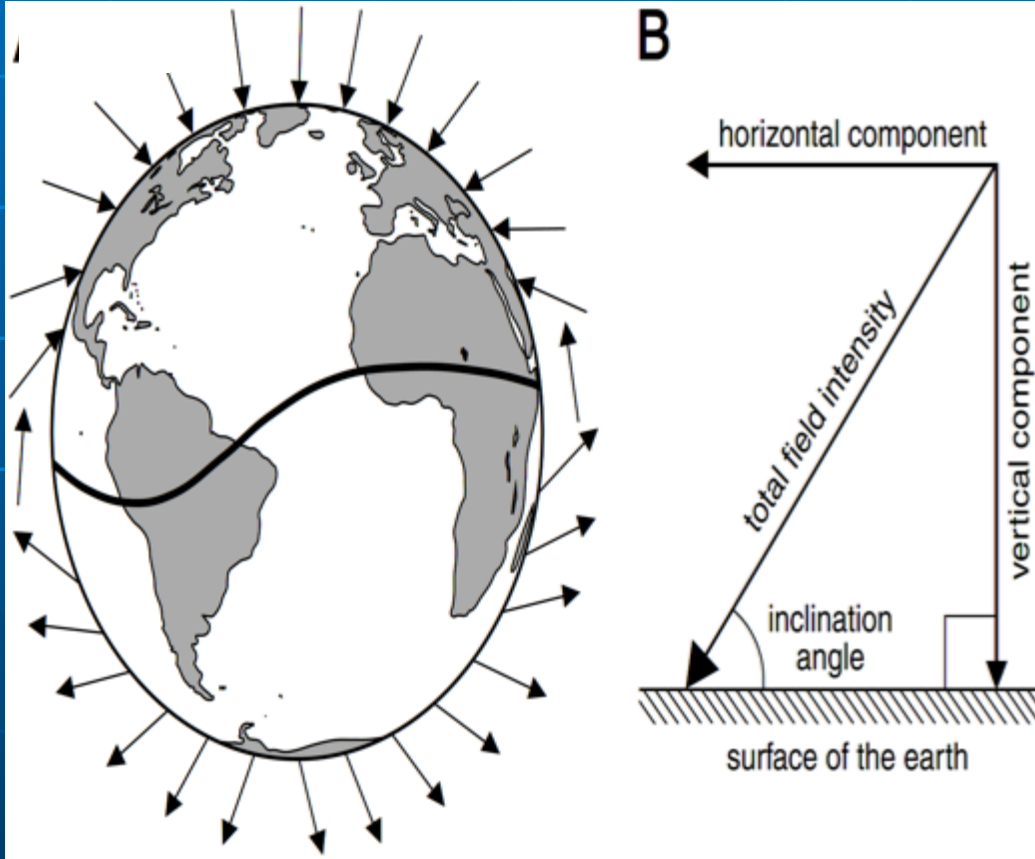
# Navigation – requires *MAP* and *COMPASS*



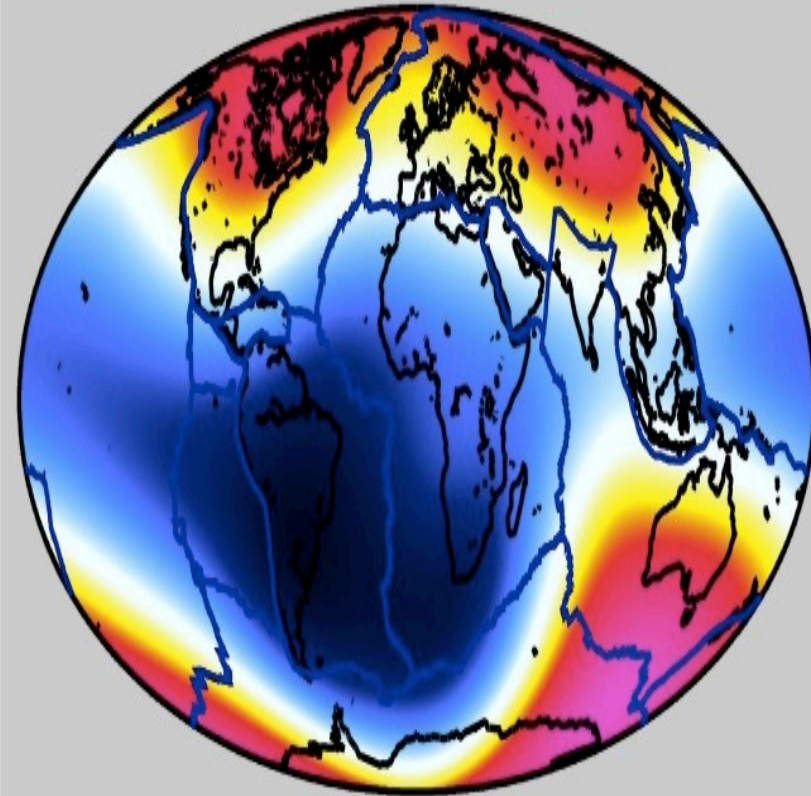


# Map information

## Inclination Angle



## Intensity



Lohmann et al. 2007

Stefan Maus 2006

# Evidence for a magnetic map

Northern field

**215°**

Rayleigh  $r = 0.135$

Rayleigh  $p = 0.014$

$n = 233$

Ambient field

Rayleigh  $r = 0.048$

Rayleigh  $p = 0.582$

$n = 240$

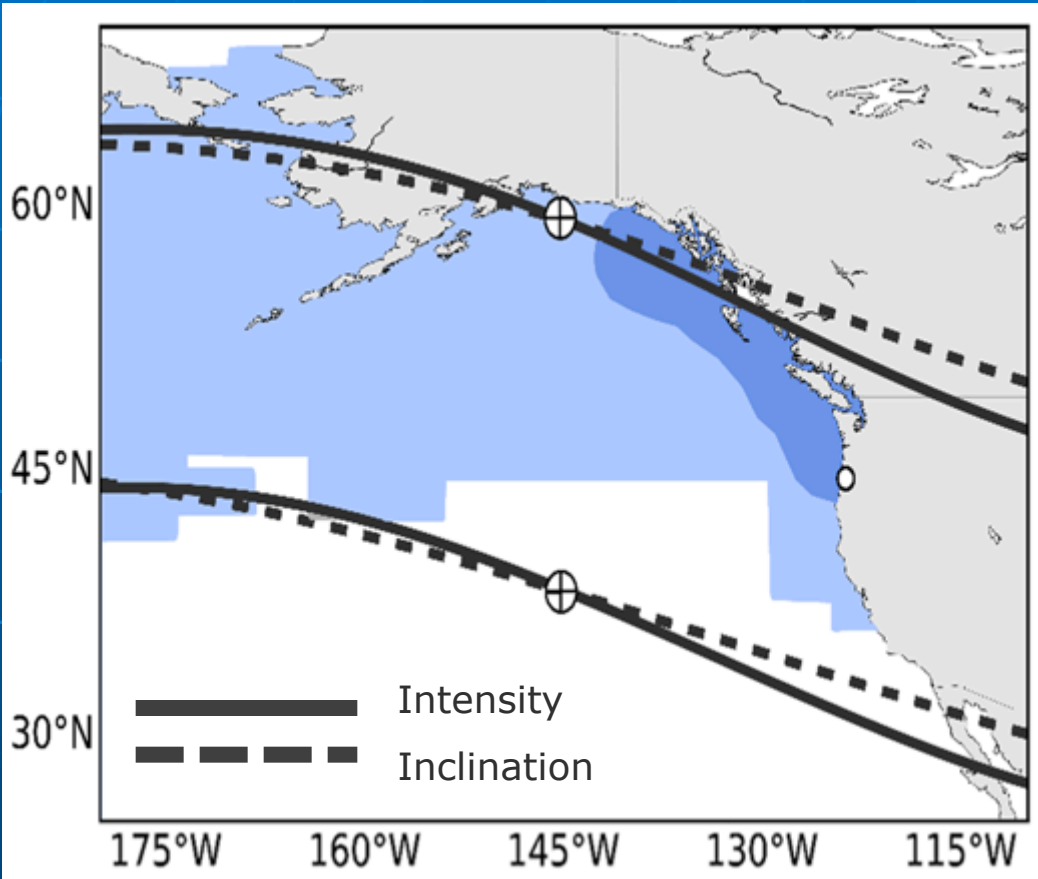
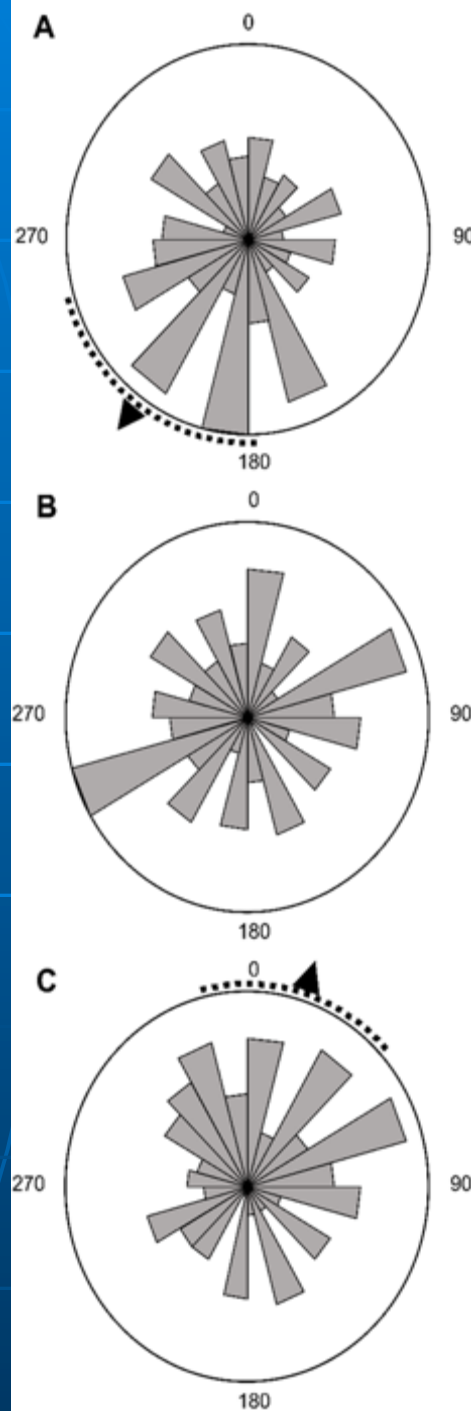
Southern field

**17°**

Rayleigh  $r = 0.163$

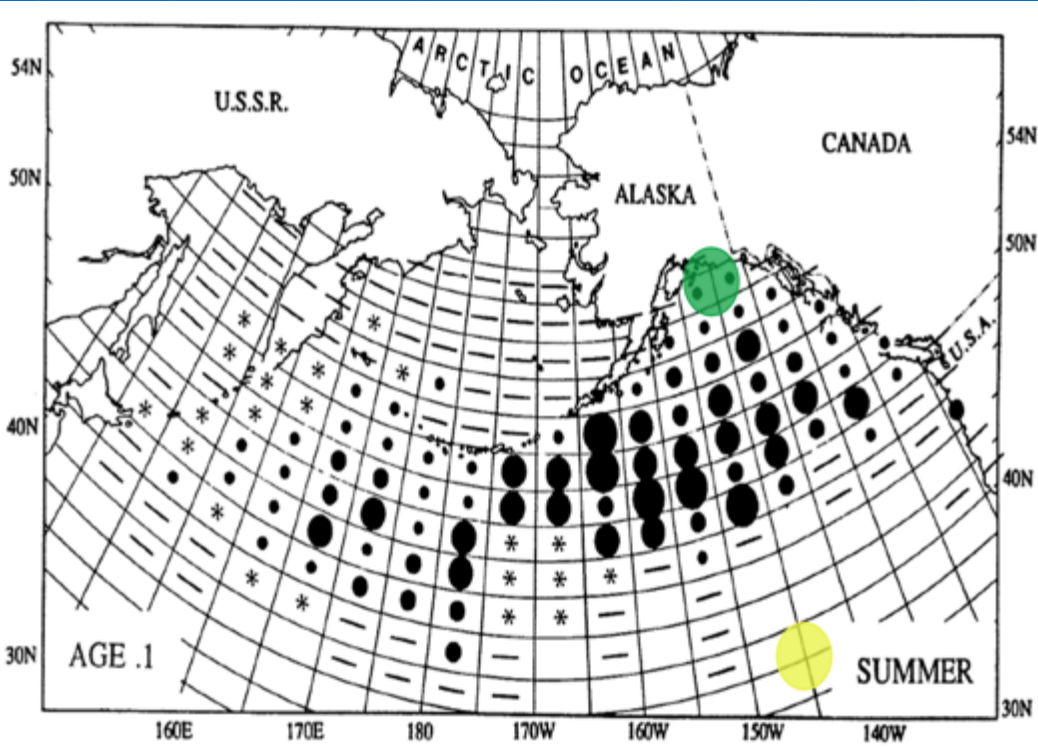
Rayleigh  $p = 0.002$

$n = 234$



Putman et al. 2014  
*Current Biology*

# Steelhead trout in the Pacific Ocean

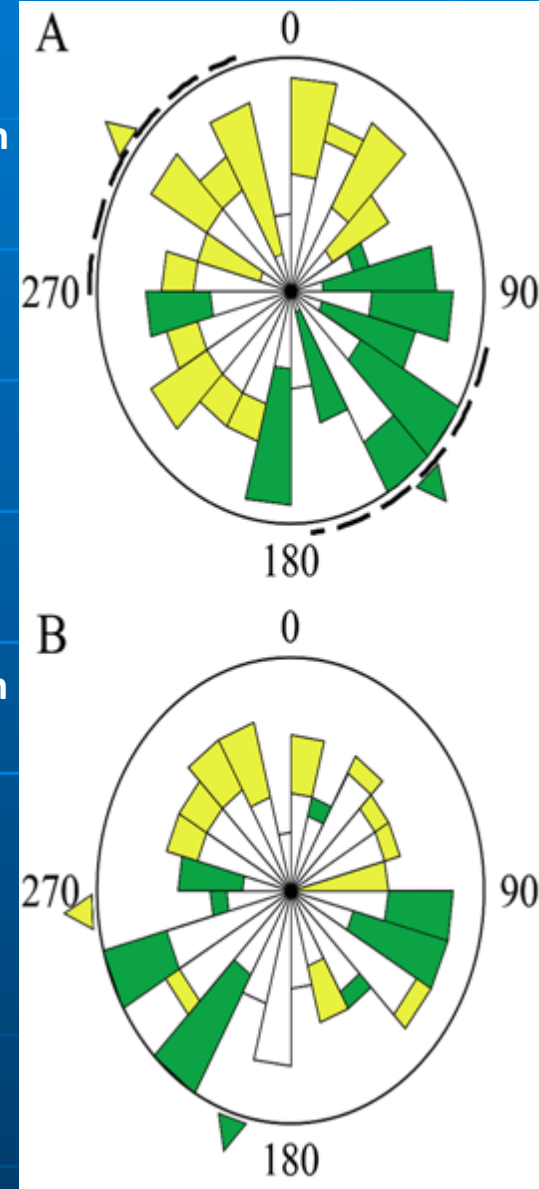


(A) Fish reared in "normal" field

Mardia-Watson-Wheeler Test  
 $P = 0.00016$   
 $n = 160$

(B) Fish reared in "distorted" field

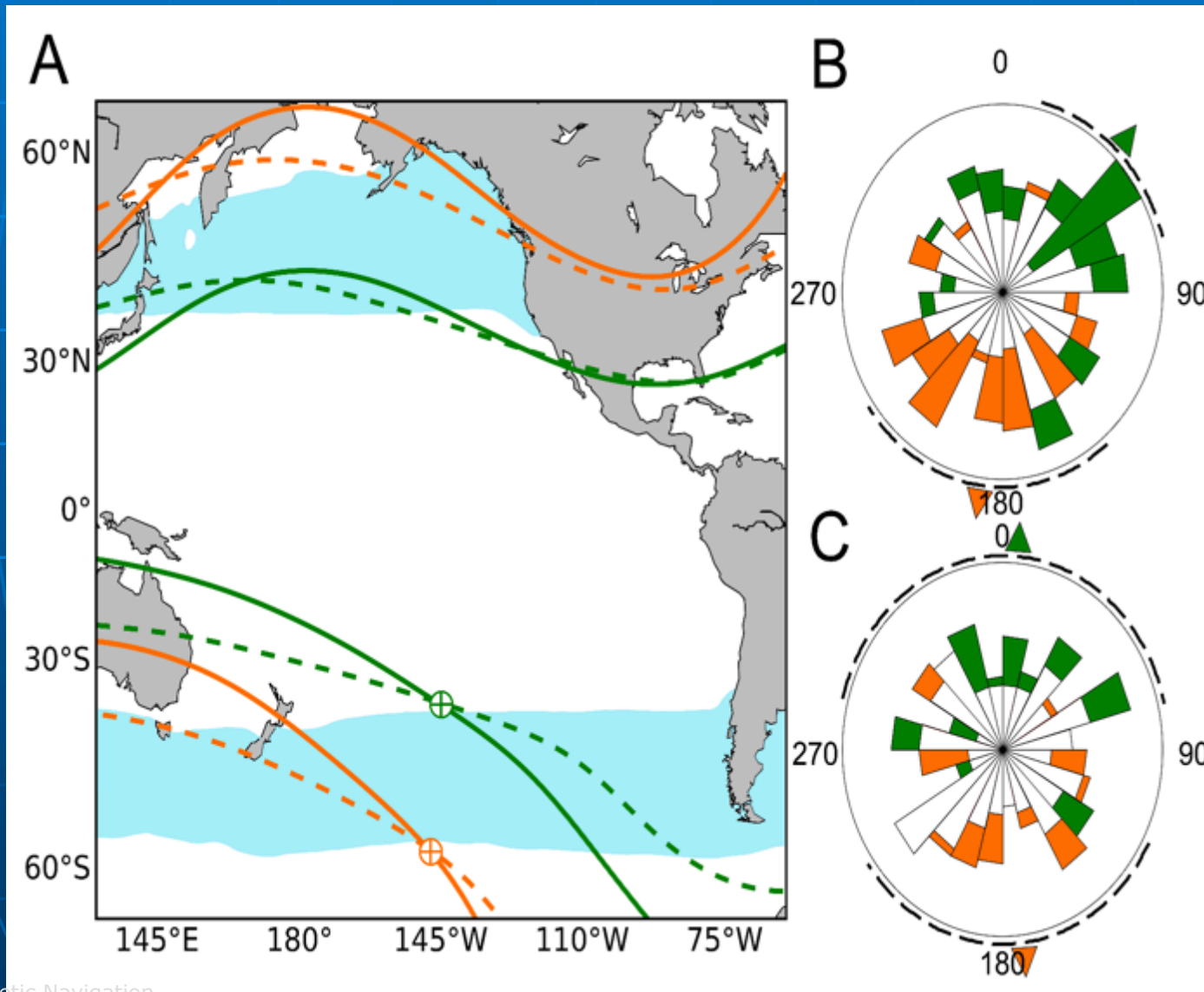
Mardia-Watson-Wheeler Test  
 $P = 0.387$   
 $n = 159$



Putman et al. (2014)  
*Biology Letters*



# Salmon go the wrong way in simulated Southern Hemisphere magnetic fields.







# Chinook mate choice









Questions?



Photo courtesy of Tom Quinn and Richard Bell