TRANS-LOCATED ATLANTIC SALMON (*SALMO SALAR*): USING GEOMAGNETIC ORIENTATION RESPONSES FOR INVASION RISK ASSESSMENT.
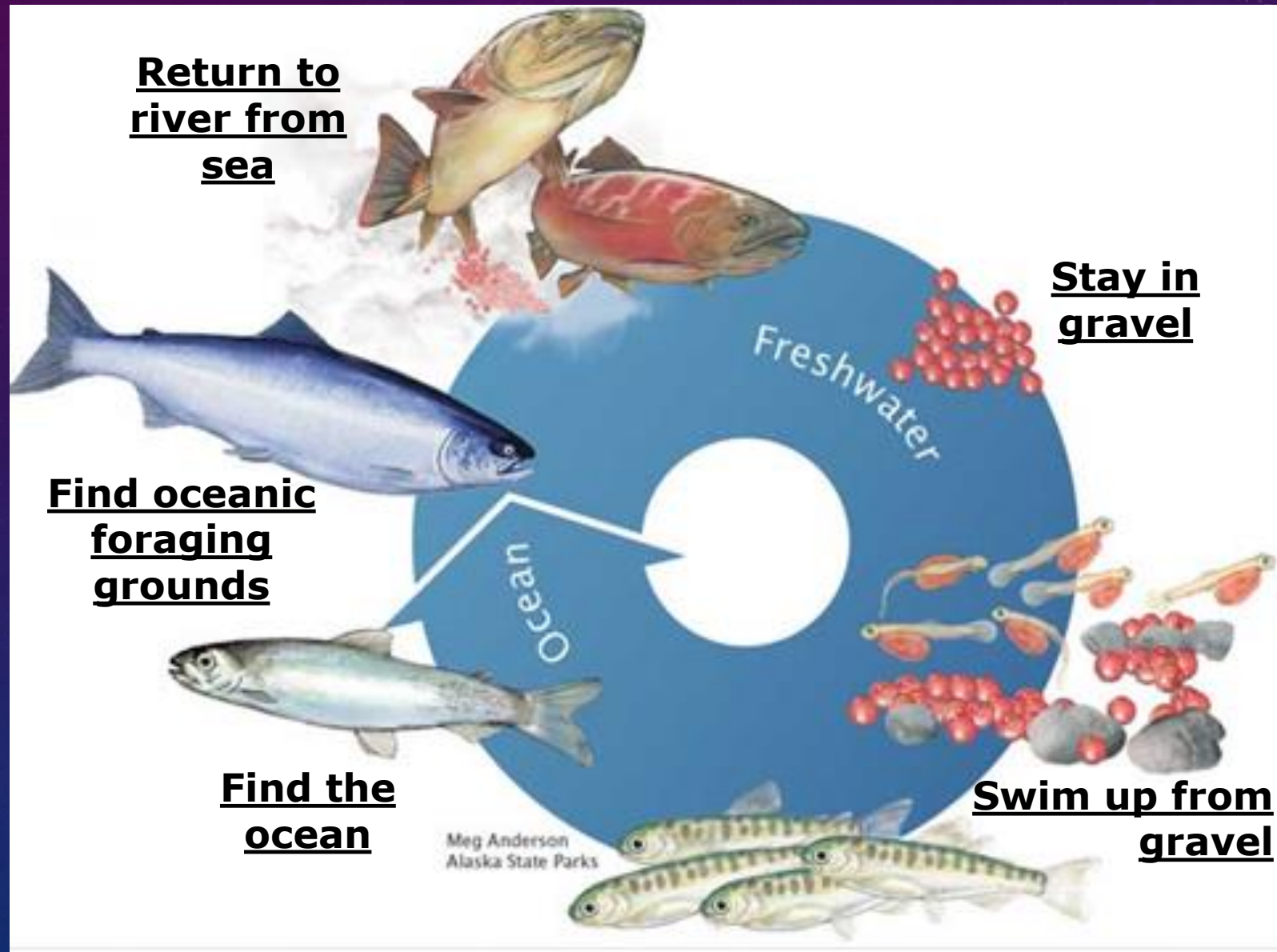
MICHELLE SCANLAN[1], AMANDA MEINKE[1], NATHAN PUTMAN[2], RYAN B. COUTURE[3], JOSEPH O'NEIL[3] AND DAVID L.G. NOAKES[1,3]

(1)OREGON STATE UNIVERSITY

(2)PROTECTED RESOURCES AND BIODIVERSITY DIVISION, SOUTHEAST FISHERIES SCIENCE CENTER NOAA, NATIONAL MARINE FISHERIES SERVICE

(3)OREGON HATCHERY RESEARCH CENTER
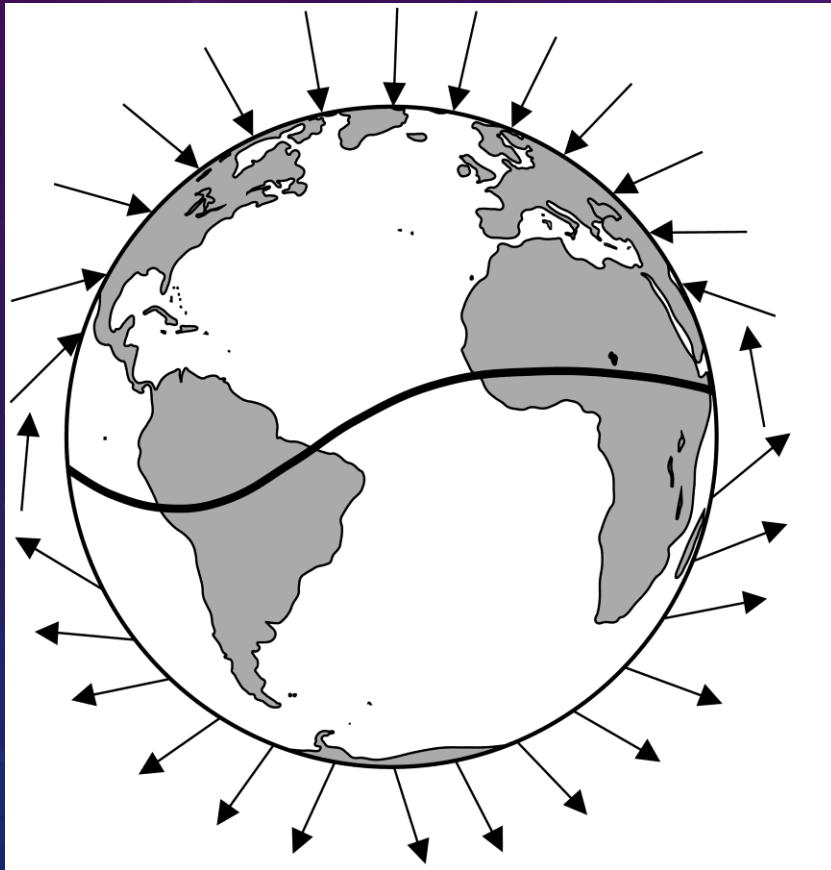
SALMON LIFE CYCLE

NAVIGATION TOOLS

- Salmon need a compass and a map.

- Early 1980s Tom Quinn showed that salmon possess a magnetic compass.

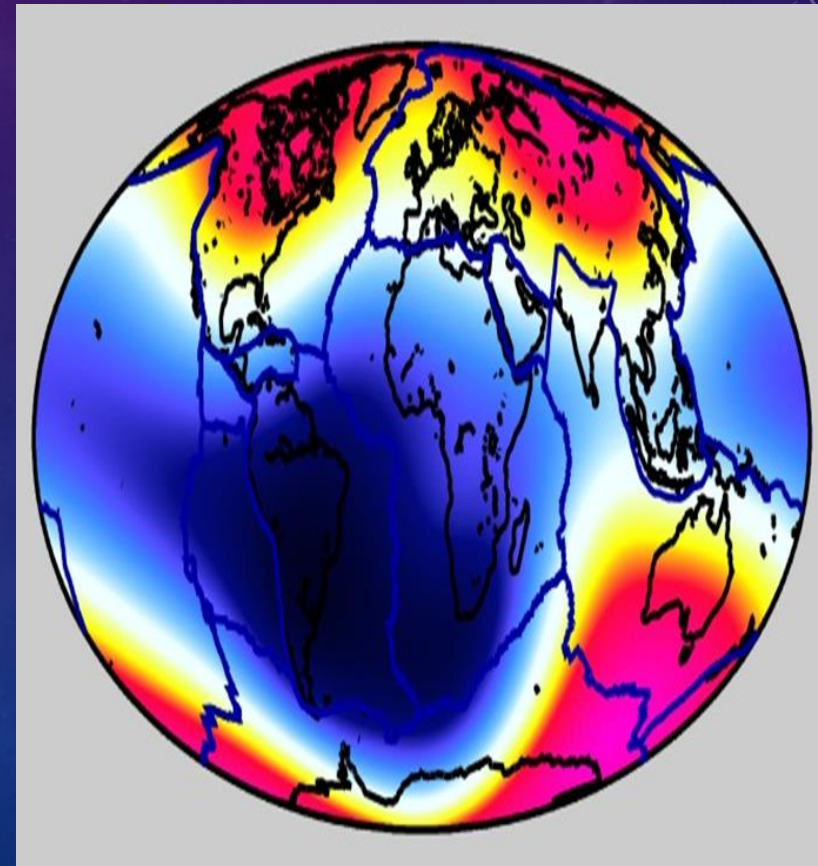- A compass alone is insufficient. Salmon need to know where they are in order to know which direction to select.

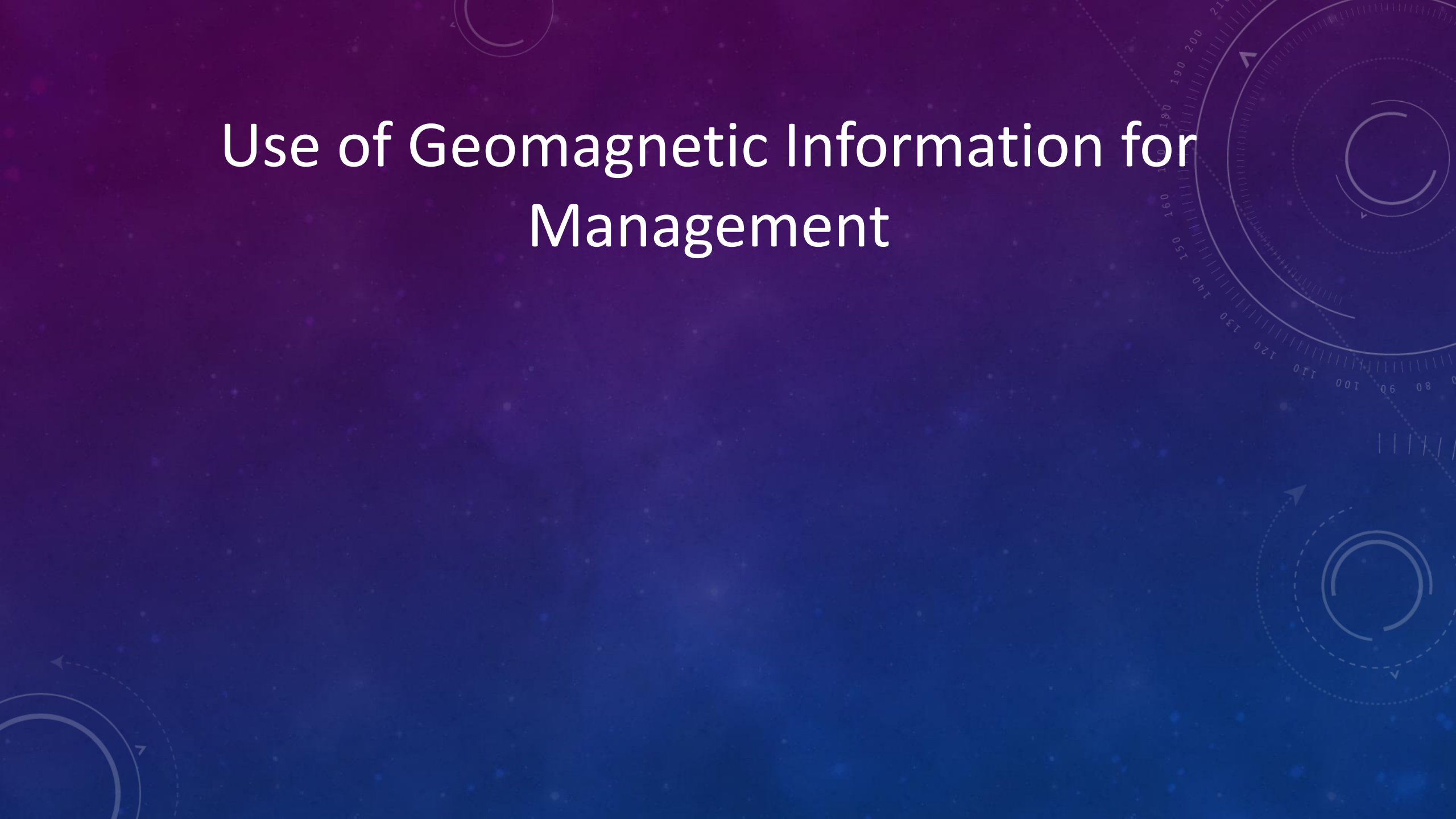# EARTH'S MAGNETIC FIELD

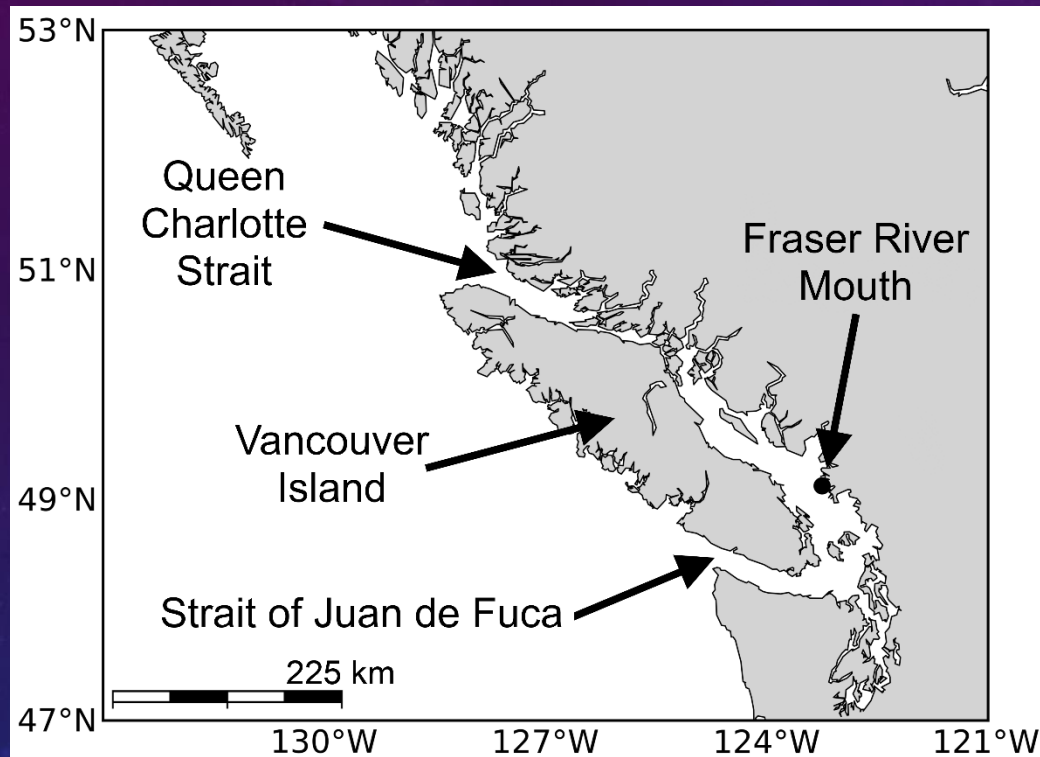## Inclination Angle

Lohmann et al. 2007

Intensity

Stefan Maus 2006

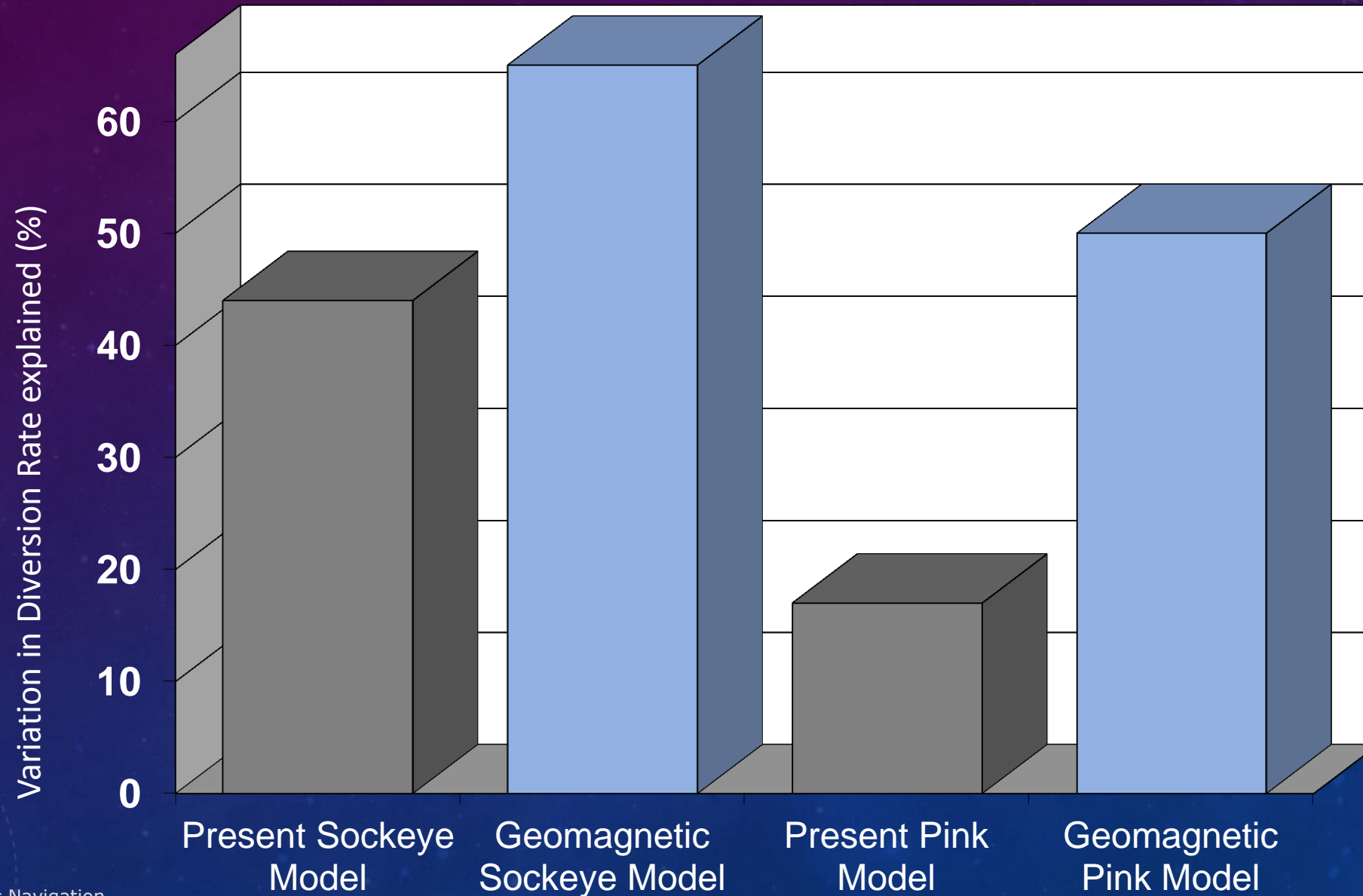# Use of Geomagnetic Information for Management

Homing of sockeye and pink salmon to Fraser River, B.C.
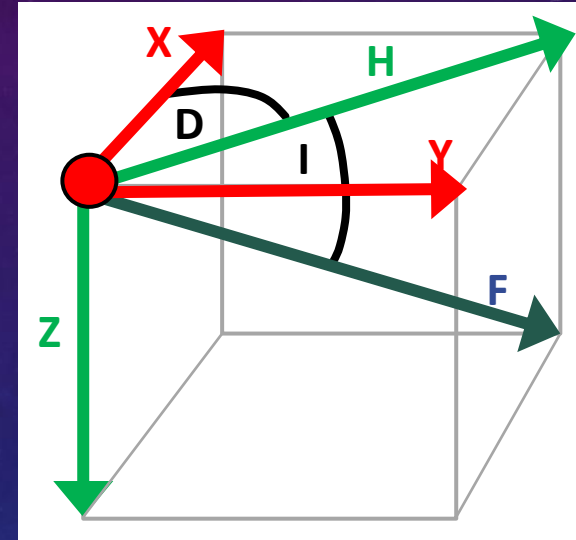

Putman et al. 2013
Current Biology

PREDICTIVE ABILITY OF PRESENT MODELS USED BY FISHERIES MANAGERS AND A MODEL BASED ON GEOMAGNETIC NAVIGATION

MAGNETIC COIL SYSTEM

Electric current
Magnetic field

X = geographic north
Y = geographic east
D = declination
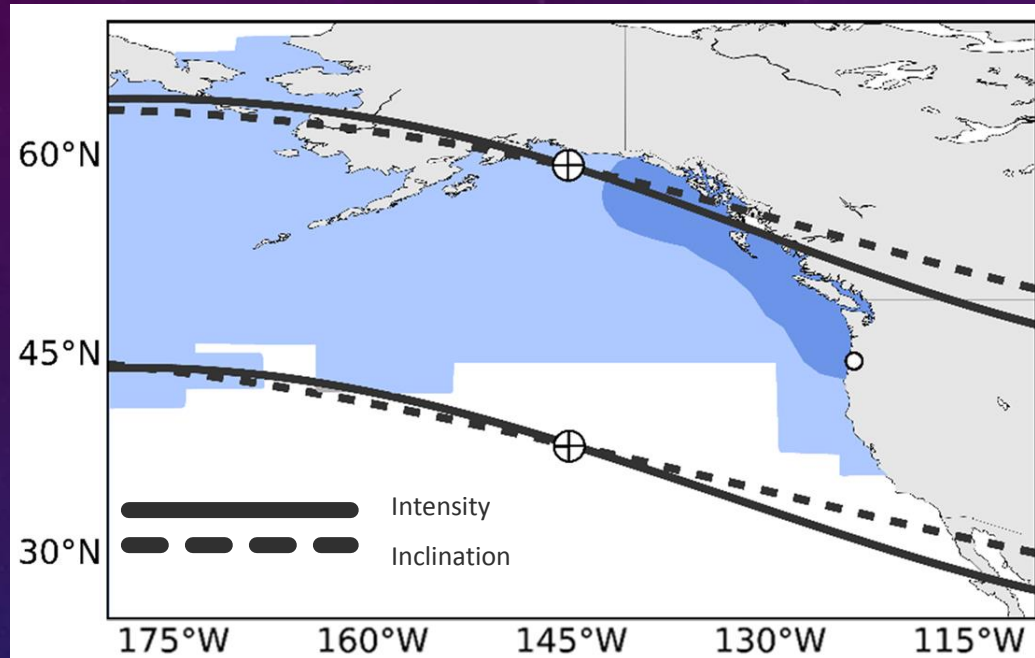I = inclination angle
F = total field intensity
H = horizontal intensity
Z = vertical intensity

Hatchery reared, navigationally naïve, parr (stream stage)

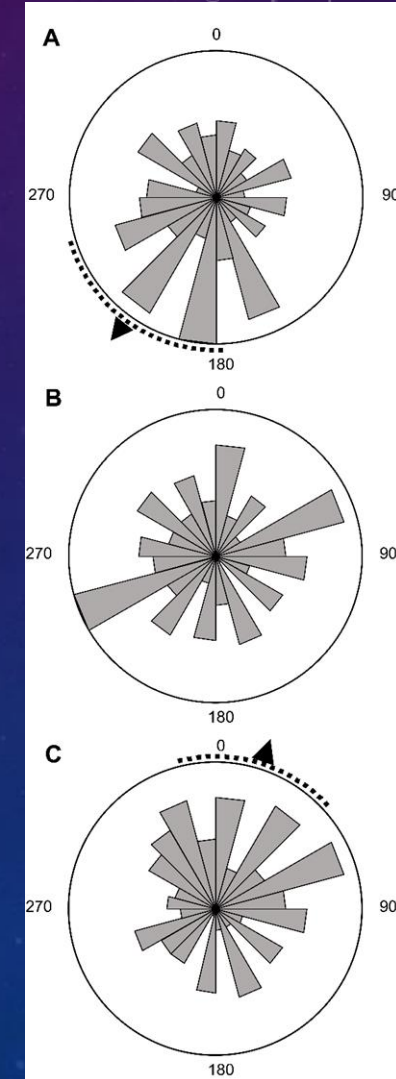# Magnetic navigation in salmon: no experience necessary!

Northern field
215°
Rayleigh r = 0.135
Rayleigh p = 0.014
n = 233

Ambient field
303°
Rayleigh r = 0.048
Rayleigh p = 0.582
n = 240

Southern field
17°
Rayleigh r = 0.163
Rayleigh p = 0.002
n = 234

Intensity
Inclination

Putman et al. 2014
Current Biology

HOW MIGHT A MAGNETIC MAP BASED ON GENETIC AND ENVIRONMENTAL FACTORS FUNCTION IN THE CONTEXT OF NON-NATIVE SPECIES INTRODUCTIONS?

Atlantic Salmon

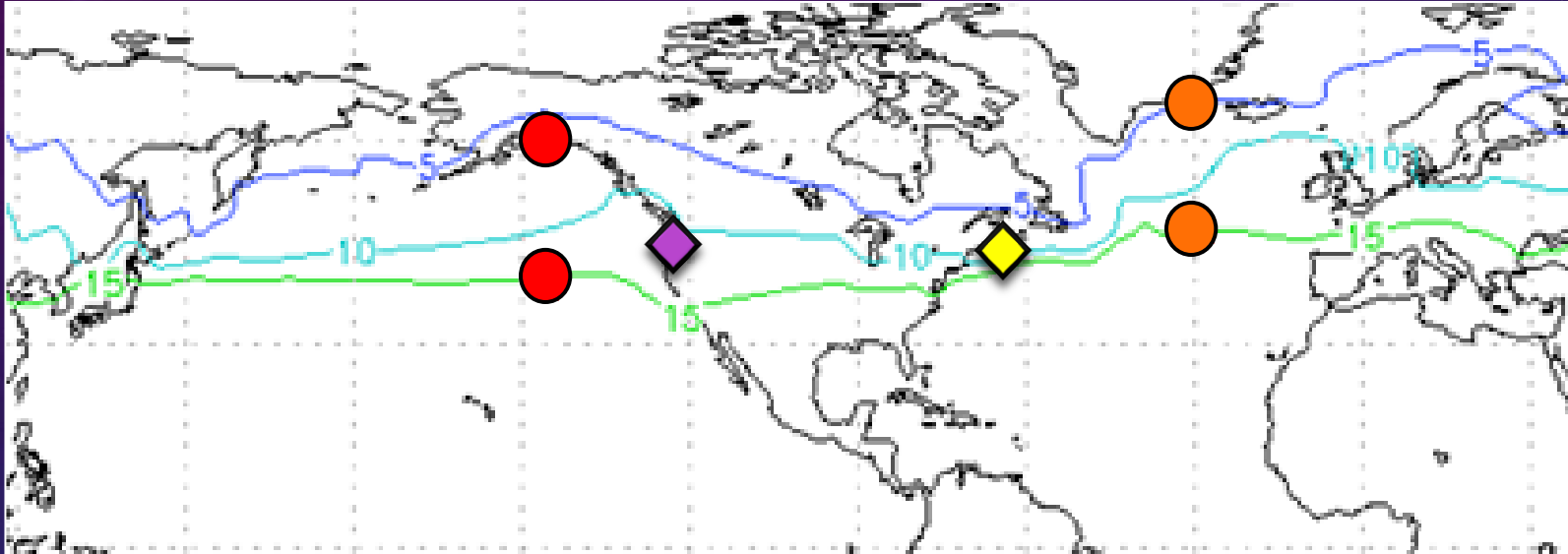http://nature.ca/notebooks/images/img/077_p_atlantic_salmon_parr_p.jpg

- Member of Family Salmonidae

- Comprised of three groups: North American, European, and Baltic.

- Spend 1-2 years in freshwater, 2-3 in marine.

- Important species for aquaculture.

Atlantic Salmon in Oregon

Atlantic salmon stocked in Hosmer Lake since 1929.
Stock provided by Wizard Falls Hatchery

Test Fields

◆ Ancestral home
Maine, USA
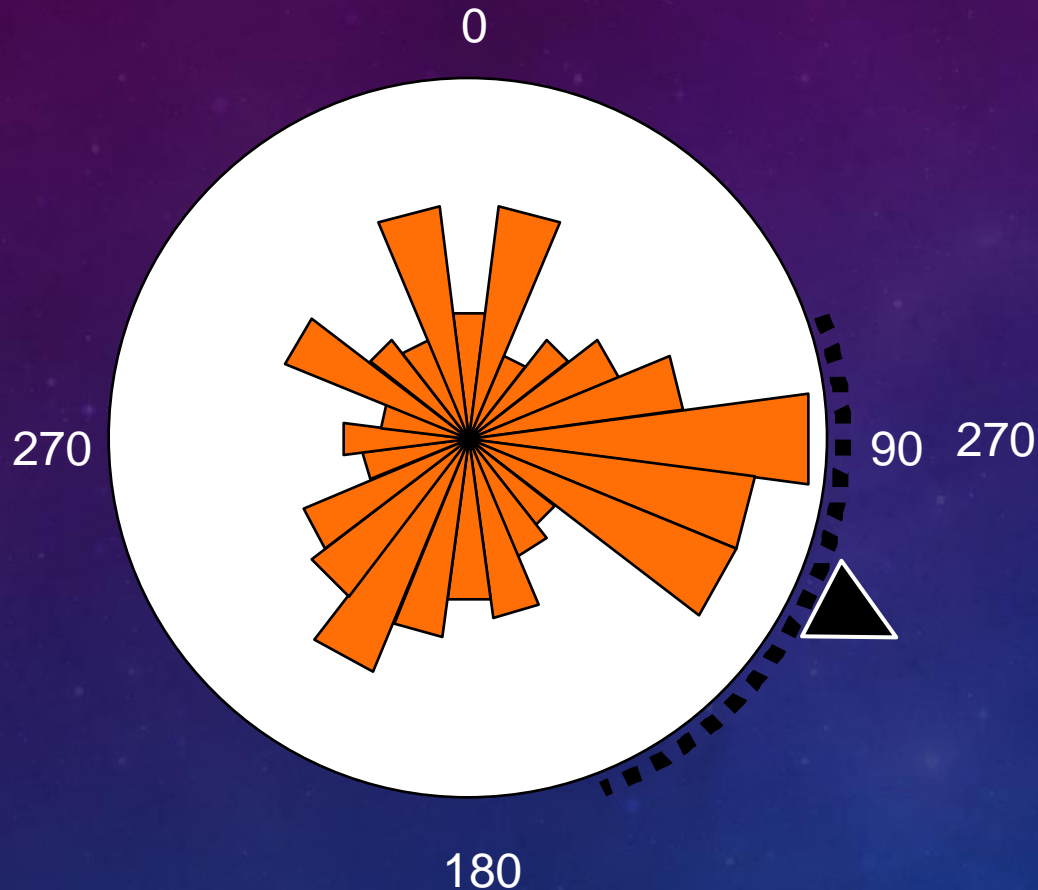
◆ Test/Rearing location Oregon, USA

● ● Simulated Test fields

Hypotheses

1. If genetic factors predominate, trans-located Atlantic salmon parr will course correct when presented with fields at the northern and southern periphery of their native oceanic range, but will be randomly oriented when exposed to fields in an introduced range.

2. If environmental factors predominate, translocated parr will not course-correct to "native oceanic fields", but will respond appropriately to fields in their introduced range.
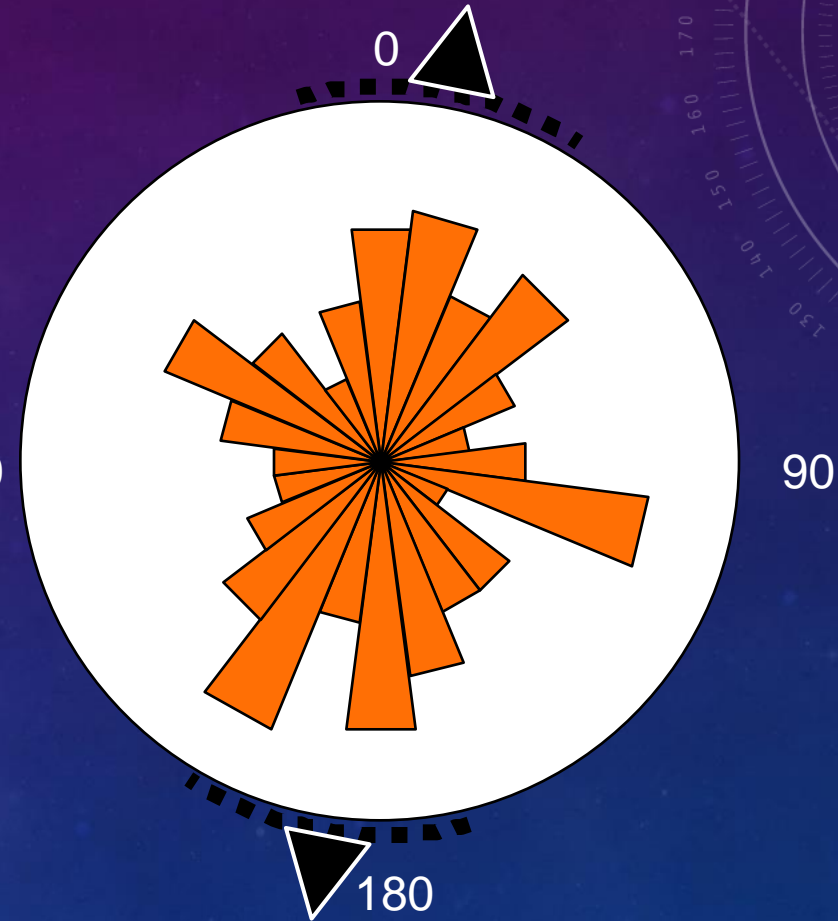
Atlantic northern field

0

270

90

180

Mean Vector: 114°
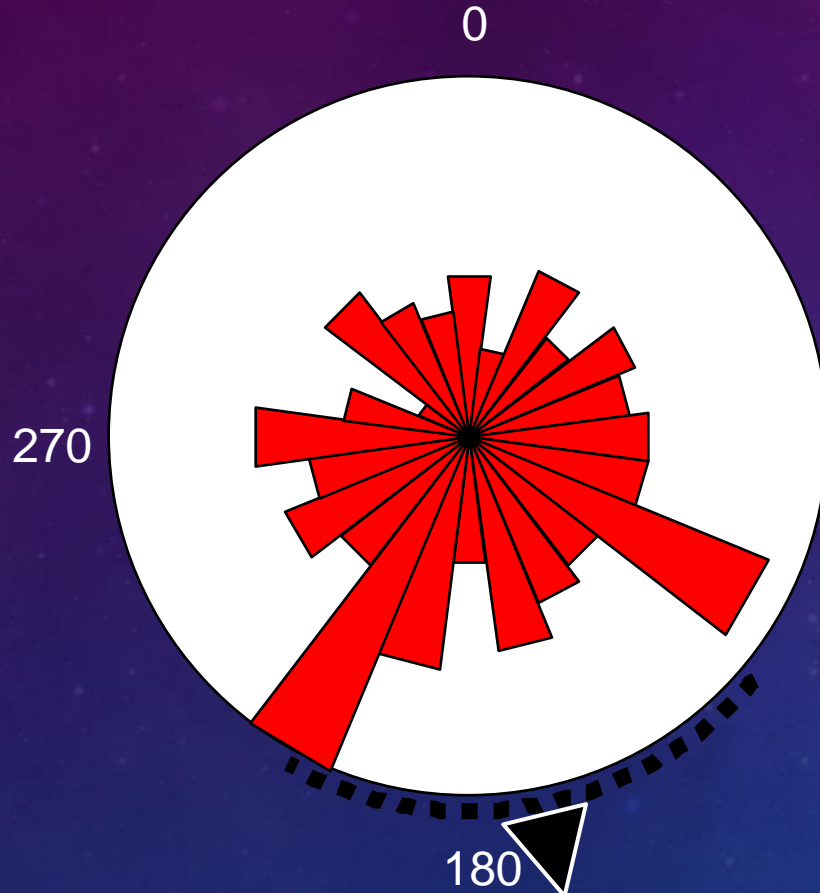p-value: 0.039
n = 236

Atlantic southern field

0

270

90

180

Mean Vector: 9°/189°
p-value: 0.043
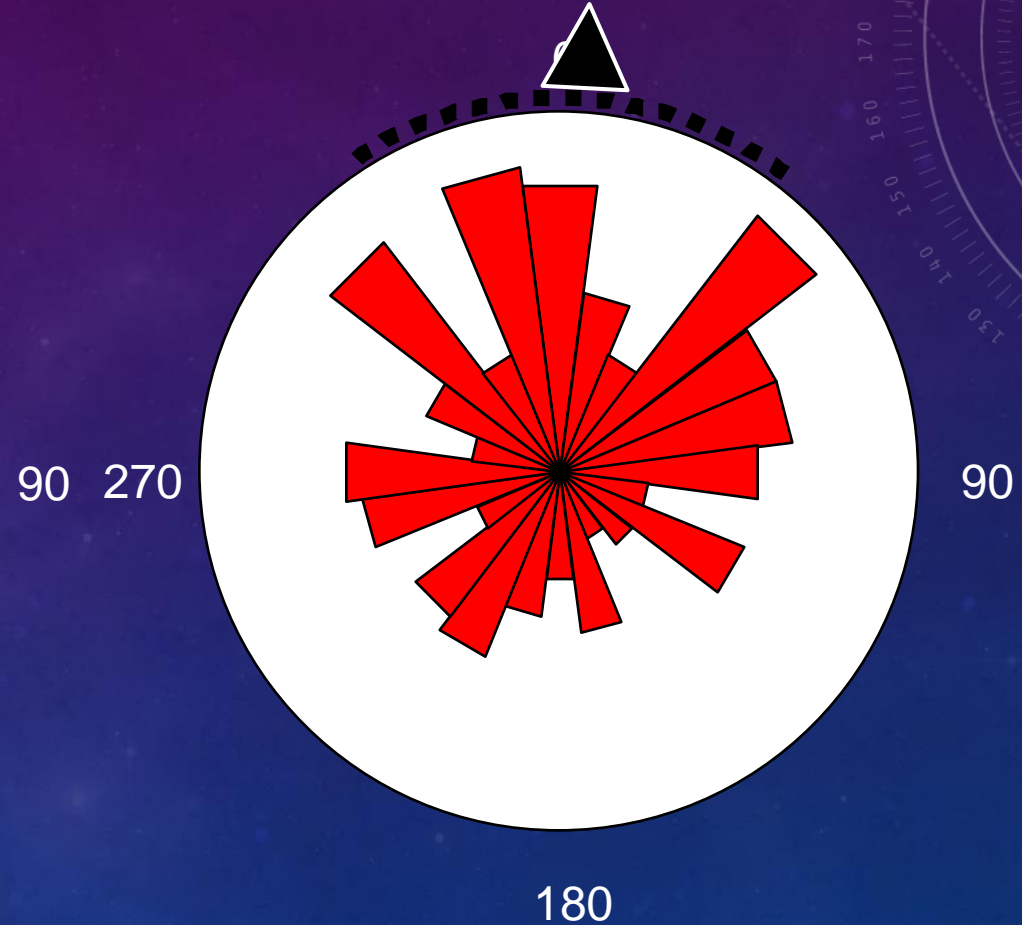n = 236

Pacific northern field

Mean Vector: 169°
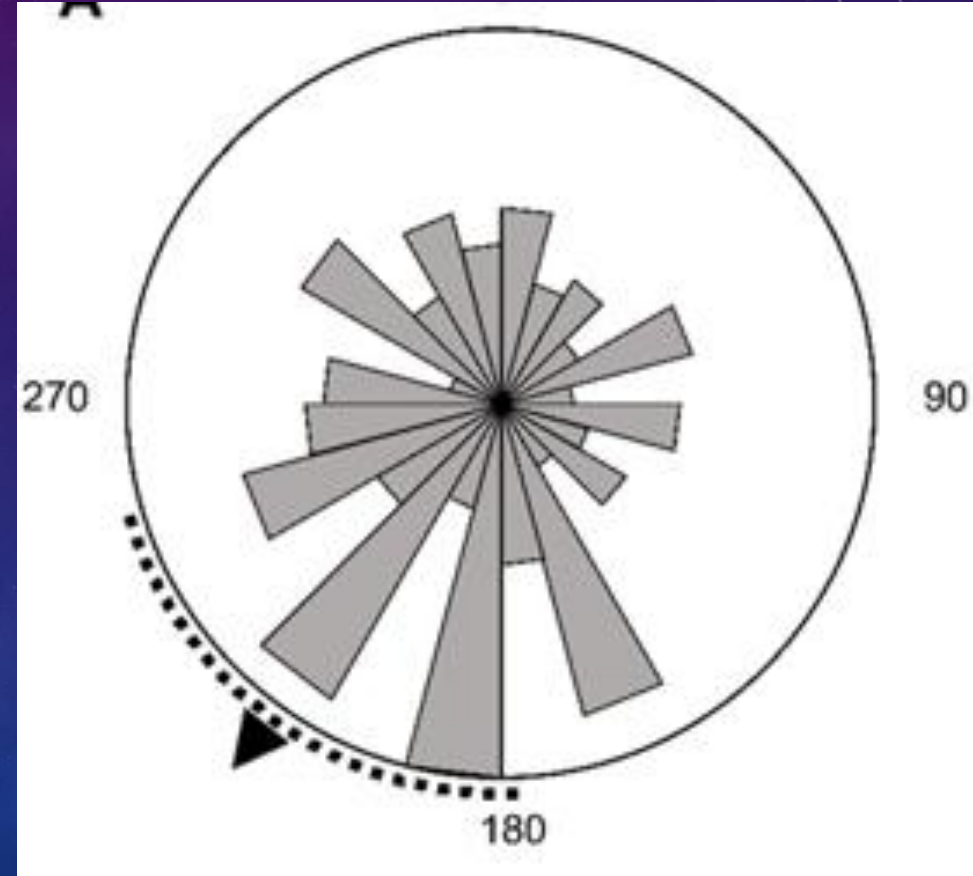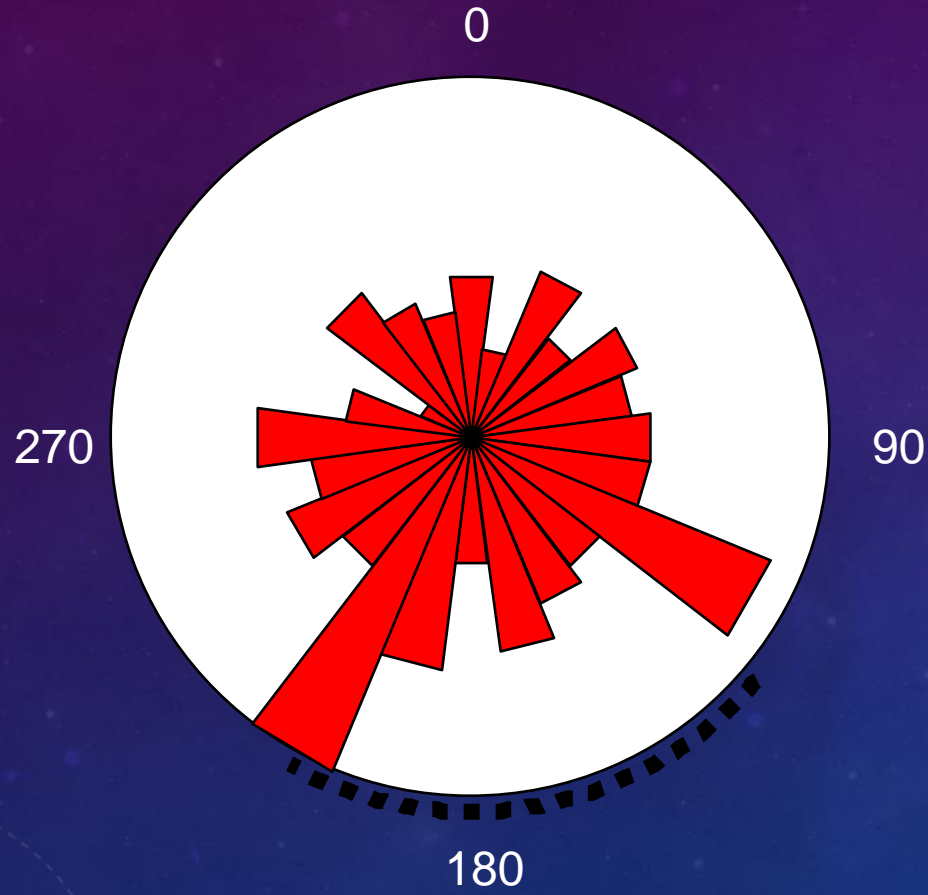p-value: 0.018
n = 234

Pacific southern field

Mean Vector: 2.6°
p-value: 0.008
n = 238

Comparison of Atlantic and Pacific Salmon Orientation Responses

Magnetic Maps and Invasion Risk Assessment

1. Magnetic maps are based on both genetic and environmental factors.

2. Suggests that Atlantic salmon reared in the Pacific NW and introduced to the North Pacific could successfully navigate to favorable ocean habitat.

3. Geomagnetic information is continuously mapped through time, and can be applied to existing fishery models.

4. Invasion risk assessments may be tested within a laboratory setting.

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