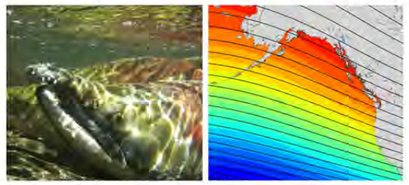

Evidence for Geomagnetic Imprinting as a Homing Mechanism in Pacific Salmon

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Problem

In the final phase of their spawning migration Pacific salmon use chemical cues to identify their home river, but how they navigate across the open ocean is unknown.

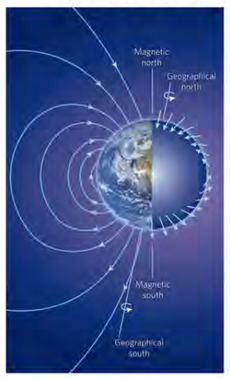
Hypothesis

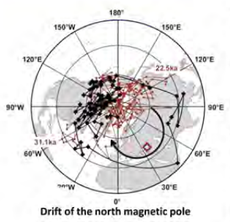
Salmon imprint on the magnetic field that exists where they first enter the sea and later seek the same field upon return.

Summary of Findings

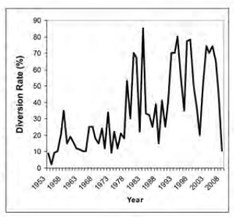
Analysis of a 56-year fisheries dataset on Fraser River sockeye salmon, which must detour around Vancouver Island to approach the river through either a northern or southern passageway revealed that the proportion of salmon using each route was predicted by geomagnetic field drift. The more the field at a passage entrance diverged from the field at the river mouth, the fewer fish used the passage. Additionally, more fish used the northern passage in years with warmer sea surface temperature (presumably because fish were constrained to more northern latitudes). Field drift accounted for 16% of the variation in migratory route used, temperature 22%, and the interaction between these variables 28%. This is the first empirical evidence of geomagnetic imprinting in any species and implies that salmon guide their homing migration using geomagnetic cues.

1. Testing the navigational mechanism used for long-distance natal homing

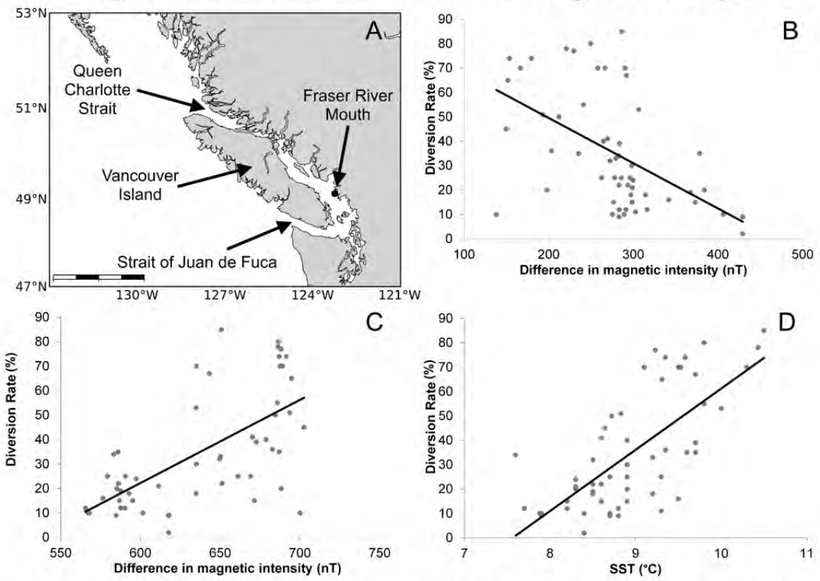




If a species uses magnetic cues for homing, then variation in its migratory routes might be correlated with the gradual drift of Earth's magnetic field. We tested whether "diversion rate" (the percentage of sockeye salmon returning through Queen Charlotte Strait to reach the Fraser River, B.C.) between 1952 and 2008 was related to field drift quantified by the International Geomagnetic Reference Field (IGRF-11).

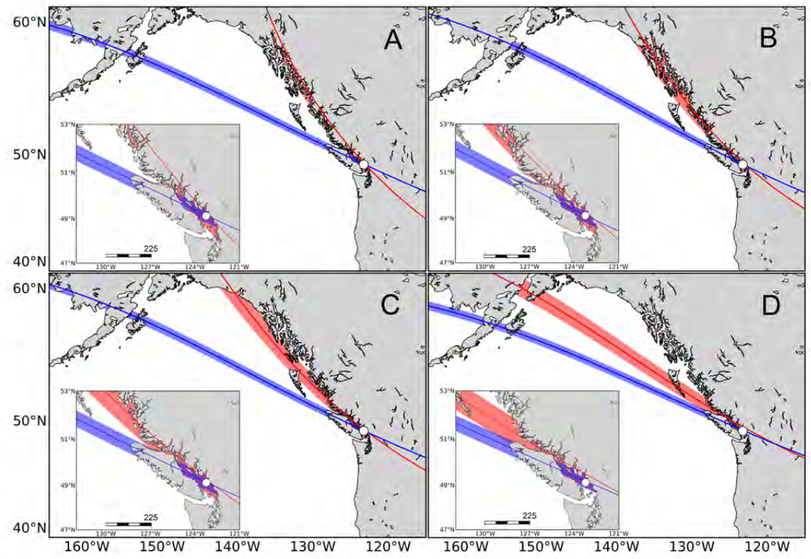


2. Geomagnetic drift predicts the migration route of homing sockeye



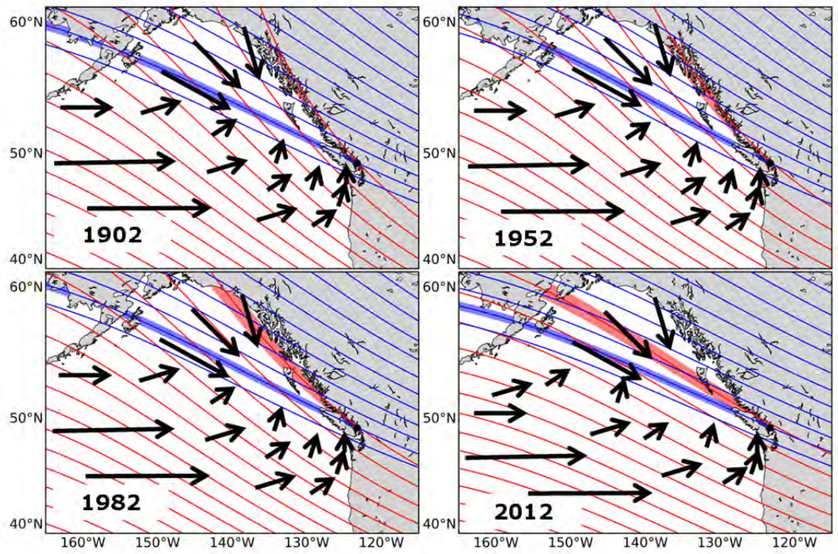
(A) Map of study area (scale bar 225 km) and graphs of the relationship between diversion rate and the difference in magnetic intensity between the mouth of the Fraser River and (B) Queen Charlotte Strait; (C) the Strait of Juan de Fuca. (D) Diversion rate vs. April SST off NW Vancouver Island.

3. Drift of geomagnetic coordinates



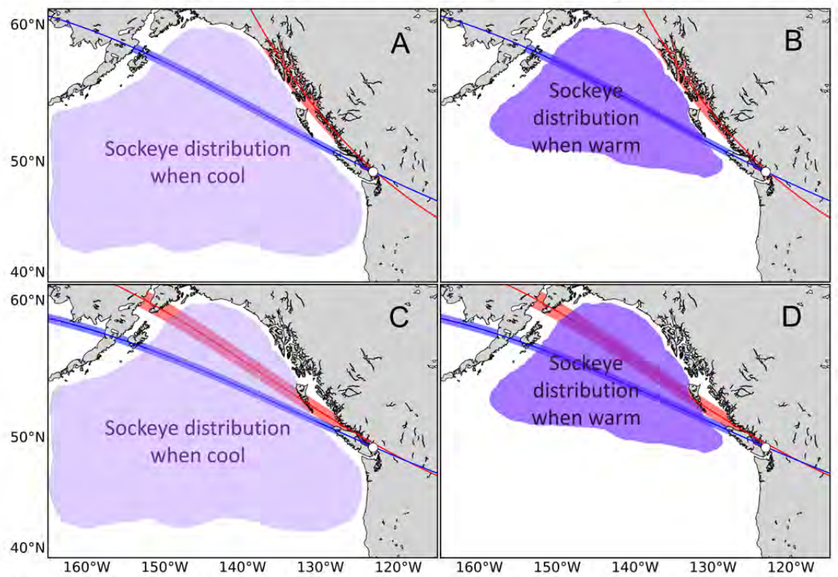
Magnetic intensity (red) and inclination angle (blue) at the Fraser River mouth in (A) 1900, (B)1951, (C)1976, and (D) 2008 that salmon would have encountered when migrating to sea plotted 2 years later, when they return to spawn.

4. Possible homing strategy



A hypothetical navigation strategy whereby sockeye salmon relocate the mouth of their natal river using magnetic intensity and inclination angle. This strategy is robust with respect to geomagnetic drift observed this past century.

5. Influence of ocean temperature



Ocean temperature influences salmon distribution. If sockeye that encounter the "home" magnetic intensity follow it southward, an interaction between temperature and field drift would cause diversion rate to be (A) low, (B, C) moderate and (D) high.

Putman NF, Lohmann KJ, Putman EM, Klimley AP, Quinn TP, & Noakes DLG (2013) Evidence for geomagnetic imprinting as a homing mechanism in Pacific salmon. *Current Biology*, 23:312-316.

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