Diel Migrations of Salmon Smolts in the Sacramento River, Delta, and San Francisco Bay Estuary.

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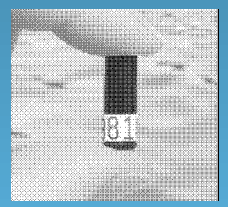
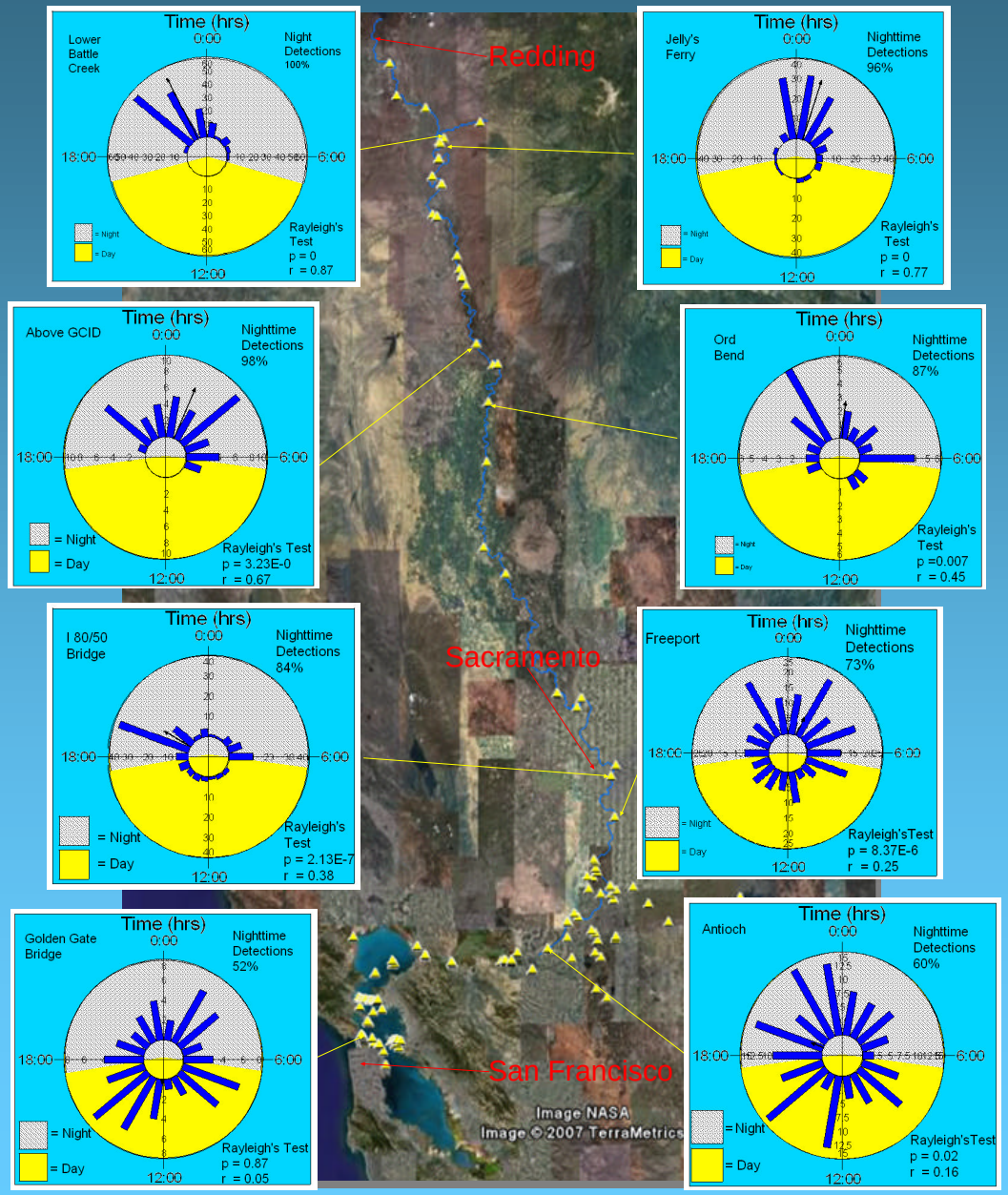
Introduction

Late fall run Chinook smolts migrate down the Sacramento River and through the San Francisco estuary. We analyzed times that the smolts, carrying coded transmitters, were detected at monitors (see yellow triangles on map to right) located along the length of the river. The risk of exposure to predation may be high in the clear river waters during daytime causing smolts to migrate during nighttime to avoid being eaten.



Methods

We placed individually coded beacons on 200 individuals and plotted their detection times on 24 hour "clock diagrams", illustrated with blue bars extending outward from center. Midnight is at the top of the graph, noon is at the bottom. Nighttime is indicated by stippling and daytime by yellow fill. The precision of the timing is described using the length of the mean vector (r). If all detections occurred within one hour then r would be one. In other words, the closer r is to one, the more the detections are occurring around the same time of the day. If r is zero the detections were distributed uniformly over every hour of the day. The *Rayleigh Test* considers the null hypothesis: **Detections are uniformly distributed throughout the entire day**. If the null hypothesis is rejected ($p<0.05$) then the fish are **not** detected equally throughout the day.



Results

Chinook exhibit a diel pattern of migration in the upper river. They travel more at night than in the lower reaches of the river and bay. The Battle Creek monitor (top left graph) detected 100% of fish during nighttime with an r value of 0.865. The Golden Gate Bridge monitors detected 52% of fish at night and have an r value of 0.045. The percentage of nighttime detections decreased with each successive monitor downriver as well as decreasing r values. There was no abrupt change from nighttime to daytime detections at any point along the path of migration rather a gradual shift towards uniformity.

Discussion

This gradual shift towards uniformity may be because there is no abrupt change in turbidity. The river simply gets more and more turbid the closer to the ocean it gets. In the future we plan to look at turbidity more closely to determine if this is in fact the case. The smolts traveling at night in the upper reaches of the river may be holding during the day in order to avoid predation by the many birds, fish and mammals in the upper river. Higher turbidity in the lower river and bay, as well as deeper water, may give smolts more protection from predators. Further inquiry needs to be made into the influence of the tides on the migrations of chinook smolts.

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