Native and Non-Native Species Richness in the Sacramento and San Joaquin River Delta

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Introduction

Non-native fish play an important ecological role in many aquatic habitats and have the potential to out-compete native species in their native habitats, particularly in habitats that have been highly altered by human activity. Long term success (integration) of invading species is much more likely in an aquatic system permanently altered by human activity than in a lightly disturbed system (Moyle 1996). Non-native fishes enter the waterways through intentional and unintentional introductions. Ballast water from ships, government agency stockings and other stockings are among the factors that have contributed to the large number of non-natives. Further, the region has a mild climate that enables non-natives to establish themselves more easily than in other regions. The San Francisco Estuary is now recognized as the most invaded aquatic ecosystem in North America (Cohen and Carlton 1995).

The purpose of this study was to investigate long term dynamics in species richness of native versus non-native fish species in near shore habitat of the Sacramento and San Joaquin Rivers and Delta. We use data collected by the Delta Juvenile Fish Monitoring Program (DJFMP), which has conducted beach seine sampling in the Sacramento and San Joaquin Rivers and the Delta to monitor long term trends in fish assemblages since 1976.

Methods

The DJFMP uses beach seines to monitor fish species in nearshore communities of the Sacramento and San Joaquin Rivers and Delta. There are 43 beach seine sample locations: Region 1, Lower Sacramento has 7 sites, Region 2, North Delta, contains 10 sites, Region 3, Central Delta has 9 sites, Region 4, South Delta contains 9 sites and Region 5, San Joaquin River has 8 sites. During fall, two additional sites are sampled in the North Delta region to help detect other races of salmon. Because beach seining sites and regions have changed through time, only data with consistent year round sampling were included here. Species richness, calculated as the total number of species, was determined in each region by year for native and non-native species separately. Further, the difference in richness between native and non-native fish was calculated in each region by year to assess their concurrent change in richness through time.

Results

Overall, in Regions 1, 2, and 4, the number of non-natives increased while the number of natives decreased (Figs.1A, 2A, and 4A). In region 3, non-native richness increased, but the number of natives remained the same (fig.3A). In Region 5, the number of non-natives and natives both increased (Fig.5A).

In Region 1 (Fig. 1B), the concurrent change between non-native and native increased significantly through time (Region 1: R^2 = .423, p = 0.016). In Region 2 and 4, the differential increased through time (Region 2: R^2 = .453, p = 0.064) and (Region 4: R^2 =.360, p = 0.067), although the relationship was only imperceptibly significant (Fig. 2B, 4B). In Region 5, there was absolutely no relationship in the concurrent change of native and non-native species (Fig. 5B).

Discussion

Although trends in individual native and non-native species richness (Fig. 1A-5A) are not statistically significant, the differential between native and non-native fish species (Fig. 1B,2B, and 4B) indicates that there is a concurrent increase in non-natives and decrease in natives through time in multiple regions. These patterns suggest that non-native fish species have the ability to reduce populations of native fish species through either competition for shared resources (i.e., food or habitat) or predation. Most of the deliberate introductions into California were meant to improve sport and commercial fishing and to provide cheap food for the people of the state (Moyle 2002).

Surprisingly, the strongest relationships between native and non-native fish were in the highest regions (most upstream) on the Sacramento River. This is interesting due to the fact that the highest reaches of our sampling are the least favorable for non-native species. Also, the Sacramento River is the least altered by human activity in the entire system.

Although many of the trajectories in native and non-native richness are not statistically significant, the trends are fairly consistent among regions despite the relatively short period of time. In the future, looking at seasonal specific changes in species richness would allow us to utilize more of our long term data. Certainly, more data in the future will also assist in determining whether these trajectories in native and non-native species richness are real. Further, determining species-specific predator-prey or competitive interactions driving these patterns may be useful to understand or even reverse these trends in the future.

Acknowledgements

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References

Cohen, A, Carlton J. 1995. Non-indigenous Aquatic Species In A United States Estuary: A Case Study Of The Biological Invasions Of The San Francisco Bay and Delta. A Report for the USFWS. Washington D.C. p.210.

Moyle P, Light T, 1996. Biological Invasions of Fresh Water: Empirical Rules and Assembly Theory. Biological Conservation 78: 149-191.

Moyle P. 2002. Inland Fishes of California. London: University of California Press. p. 61

Region 1: Lower Sacramento River

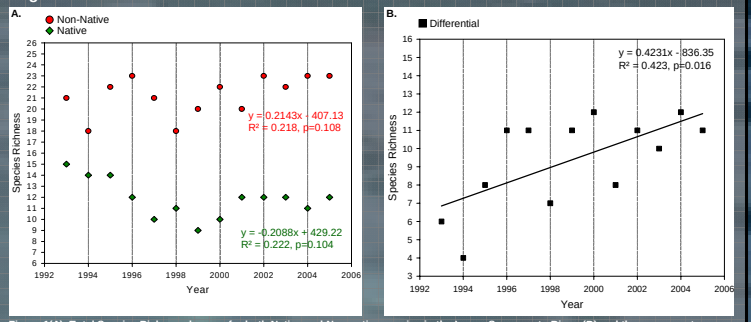


Figure 1(A): Total Species Richness by year for both Native and Non-native species in the Lower Sacramento River, (B) and the concurrent change between native and non-native species richness by year.

Region 2: North Delta

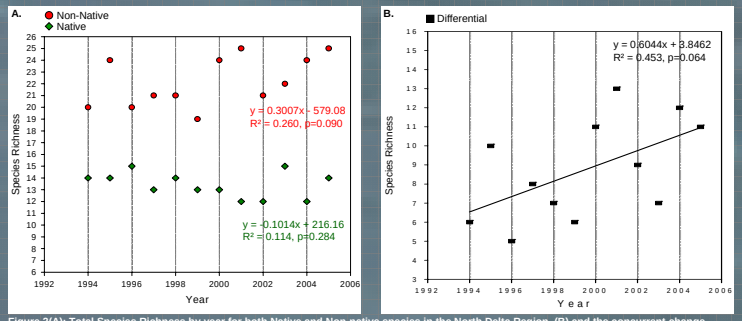
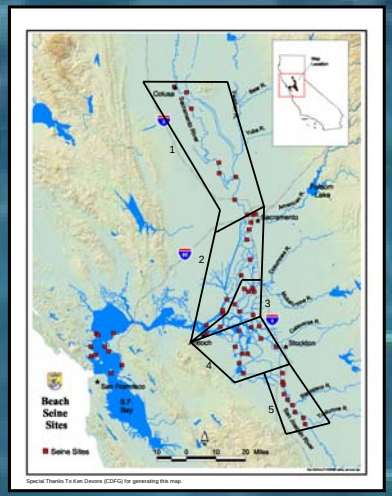


Figure 2(A): Total Species Richness by year for both Native and Non-native species in the North Delta Region, (B) and the concurrent change between native and non-native species richness by year.



Region 4: South Delta

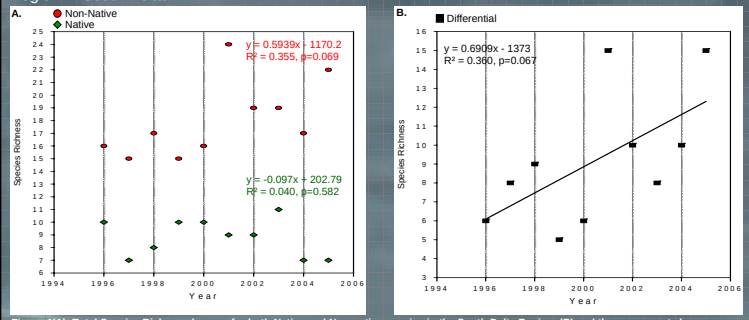


Figure 4(A): Total Species Richness by year for both Native and Non-native species in the South Delta Region, (B) and the concurrent change between native and non-native species richness by year.

Region 3: Central Delta

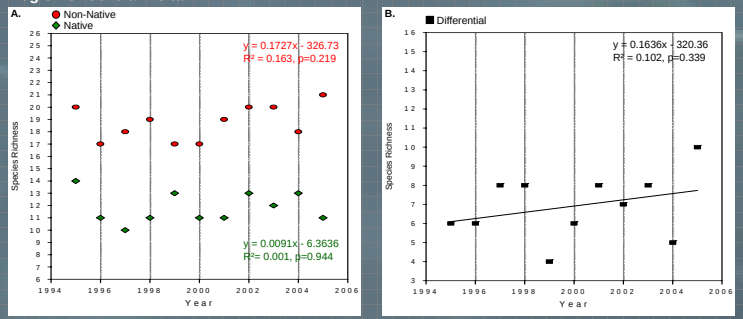


Figure 3(A): Total Species Richness by year for both Native and Non-native species in the Central Delta Region, (B) and the concurrent change between native and non-native species richness by year.

Region 5: San Joaquin River

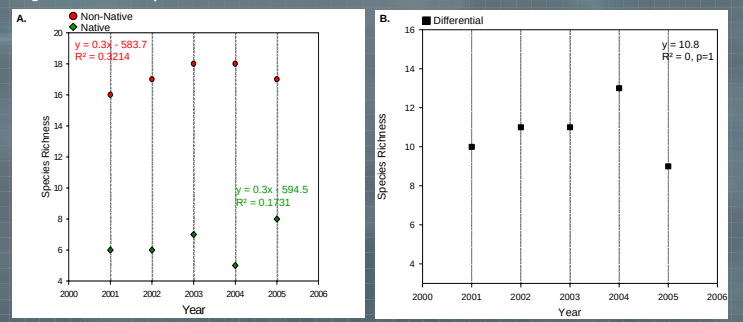


Figure 5(A): Total Species Richness by year for both Native and Non-native species in the San Joaquin River, (B) and the concurrent change between native and non-native species richness by year.