Chapter 4: Analysis of Aquatic/Terrestrial Linkages

Linking Aquatic and Terrestrial Systems

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Preface of study task intent

The overall goal of Task 3 is to understand how the flood cycle influences the controls of primary and secondary production and how and to what degree this aquatic production supports consumers in riparian habitats. [(Please also see the summary document of insect and bat trophic interactions.)](http://baydelta.ucdavis.edu/reports/final/files/crg/reports/AquaticInsectBat_Raineyetal2006.pdf)

General background on study system

Primary production on inundated floodplains includes phytoplankton (free-floating algae), periphyton (attached algae), and macrophytes. In river and lake systems, both phytoplankton and attached algae, more edible, fast growing taxa predominate early in succession for both phytoplankton and attached algae and are replaced over time by less edible taxa. Algal succession toward less edible taxa may be accelerated in more productive environments with higher nutrient fluxes or irradiation. Based on observations in other systems, we predict that high nutrients and long residence times of floodplain water will promote phytoplankton or floating macrophytes. Long residence times with lower nutrient inputs will favor rooted macrophytes. Shorter residence times will favor attached algae as chief sources of local primary productivity.

Aquatic herbivore-detritivore grazers are essential links in food webs that govern the amount of algal production that is converted to terrestrial consumers. In floodplain ecosystems, we expect these assemblages to be dominated by rapidly colonizing, fast growing populations of insects and zooplankton. It is not obvious which group should dominate at various times after spillover, or under regimes with short water residence on floodplains. Because grazer abundances may be strongly affected by predation, floodplain features (rooted or floating vegetation) that provide refuges for invertebrates can have major effects on their dynamics. During a spring 2000 flood observed on the Cosumnes, chironomids initially colonized following spillover, but within weeks were replaced, first by cladocerans then copepods, whose densities then fell as larval fish increased.

Operational hypotheses

1. Detrital inputs, rates of primary and secondary production and predation in aquatic food webs vary among different riparian and floodplain habitat types.
2. Timing and duration of inundation influence algal community development
3. Algal assemblages shift from edible to less edible over the course of succession
4. Floodplain and riparian forest vegetative structure influence residence time, light, nutrient availability, and corresponding algal edibility
5. Timing and duration of inundation, floodplain and riparian forest geomorphology and vegetative structure, and season and temperature regimes influence secondary production
6. Aquatic insects and crustacean zooplankton both contribute significantly to secondary production
7. Zooplankton and benthic insects differentially support native and non-native fish

Brief methods

We collected, quantified, and identified taxa in samples of zooplankton, benthic insects, periphyton, phytoplankton, and macrophytes in various sites that varied in residence time at key points in the flood cycle. We also measured stable isotopes, essential fatty acids and elemental nutrient ratios in phytoplankton, periphyton, macrophyte, and plant detritus samples as indicators of their food quality for consumers following published methods. We will experimentally measured grazing impacts and investigate zooplankton and insect growth on algae diets to infer edibility. We also conducted feeding trials to detect differences in growth and reproduction rates of invertebrates on various diets.

Key findings

Based on our preliminary data, small algal cells (especially cyanobacteria and small flagellates) dominate the phytoplankton community in the Cosumnes floodplain during flood events. During the drain period, the community tends to shift to a greater proportion of larger cells (especially diatoms). Large diatoms and cryptophytes often make up most of the phytoplankton biomass in sites with higher residence times (HRT), while smaller-celled chrysophytes often contribute a large amount of biomass at sites with shorter residence times (SRT). Ciliated protozoa are also often numerous at SRT sites.

Algal community development and “edibility” is driven both by abiotic factors such as flood phase and water residence time and by biotic factors such as trophic cascades. For example, nutritionally less valuable cyanobacteria and other very small algal cells often dominate during the initial phases of a flood event, but are soon replaced by slower growing, more edible algae, which provide food for and are eventually suppressed by rapidly expanding invertebrate populations. During the drain period, sites with lower residence time and better connectivity may be more favorable to fish which suppress the invertebrate community and allow algae of greater edibility such as smaller-celled diatoms, cryptophytes, and chrysophytes as well as many protists such as ciliates to persist. In contrast, sites with higher residence time and less connectivity may have fewer fish and more invertebrates, giving rise to a phytoplankton community dominated by larger and less edible algae such as large pennate diatoms.

Zooplankton biomass was always higher at HRT sites relative to LRT sites on the floodplain or river sites. Densities typically declined with dilution following flood events. Zooplankton biomass generally reached a maximum between 2 and 3 weeks after onset of ponding. This pattern was maintained throughout the year despite the increasing presence of fish predators from April until early June. Residence time has a significant influence on zooplankton biomass with greater initial biomass in areas of HRT. There were higher abundances of cyclopoid copepods at LRT sites and higher abundances of larger species such as Daphnia as well as a higher abundance of calanoid copepods. Fish predators were less abundant in HRT sites. Fatty acid analysis showed Daphnia has highest ALA and EPA, calanoids has high EPA and cyclopoids had high DPA. This suggests cyclopoids may be more dependent on microbial prey. Benthic insects become relatively more diverse and more abundant beginning in late February. Benthic insects were more abundant in HRT sites, and recovered more quickly at these sites with the onset of ponding.

Recommendations for management and monitoring

1. Maintain diversity of floodplain habitats including open floodplain areas without large woody vegetation, forested floodplain and pond habitats (that become seasonally dry)
2. Manage floodplains to ensure that multiple, repeated inundation events occur with a 2-3 period from at least early January through early May
3. Monitoring of benthic insects and macrozooplankton should occur weekly at multiple sites on floodplain and in adjacent river channel
4. This should also include monitoring of phytoplankton, microbial populations and microzooplankton (rotifers, ciliates) on a daily period immediately following floods and then twice weekly through the flood cycle at multiple sites on floodplain and in adjacent river channel
5. Avoid creation of extensive HRT without periodic flood connection

Documents

* [Temporal and spatial variation in aquatic insect emergence and bat activity in a restored floodplain wetland (William E. Rainey, Mary E. Power, and Sandra M. Clinton)](http://baydelta.ucdavis.edu/files/crg/reports/AquaticInsectBat_Raineyetal2006.pdf)
* [The Influence of Flood Cycle and Fish Predation on Invertebrate Production on a Restored California Floodplain, Grosholz, E., Gallo, E. (*Hydrobiologia*, 2006 In Press).](http://baydelta.ucdavis.edu/files/crg/reports/pubs/GrosholzGalloHydrobiologia2006.pdf)
* [Examination of nitrate cycling and retention mechanisms in a semi-arid floodplain, Gallo, Dahlgren, & Grosholz (In Submission)](http://baydelta.ucdavis.edu/files/crg/reports/Gallo_etal_NitrateMS.pdf)
* [Biogeochemistry of a California Floodplain as revealed by high resolution temporal sampling, Gallo, Dahlgren, & Grosholz (*Freshwater Biology*, In Review)](http://baydelta.ucdavis.edu/files/crg/reports/Gallo_etal_FreshwaterBiology.pdf)