PERFORMANCE, HYDROLOGICAL & BIODIVERSITY ASPECTS OF FLOATING PHOTOVOLTAIC SOLAR ENERGY

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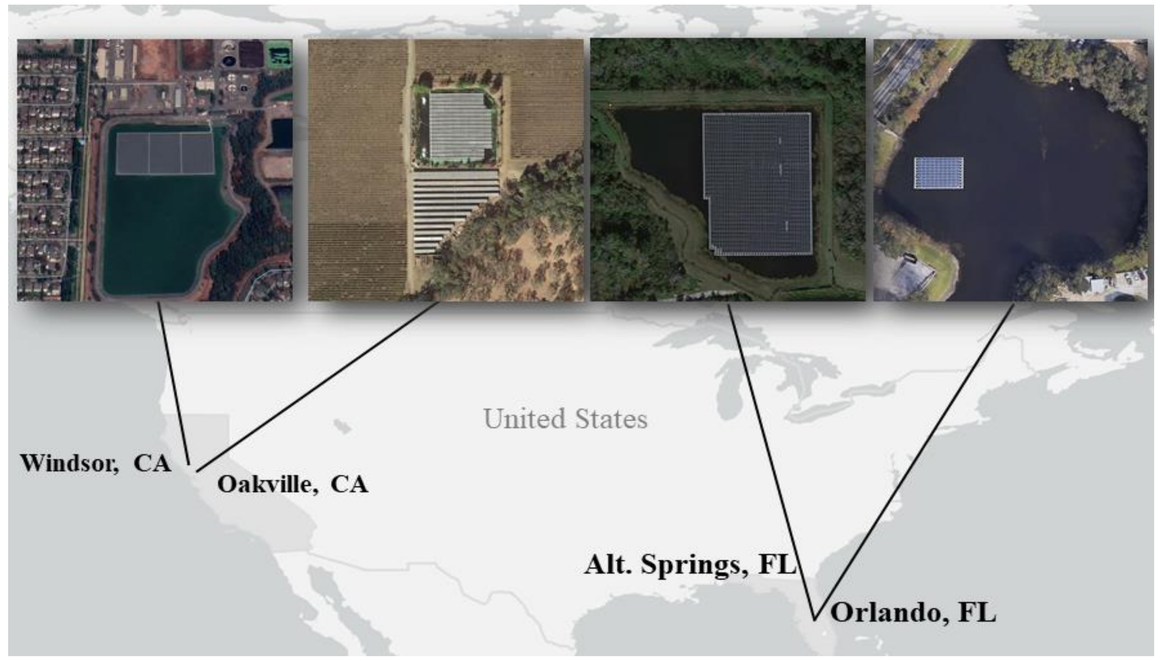
EXECUTIVE SUMMARY

Floating photovoltaics (FPV) has emerged as a viable and deployable renewable energy technology in many places around the world. Declining panel prices and land scarcity, along with claims of improved system performance, are among the reasons for FPV popularity. However, documented research on the water quality and thermodynamics of the host water body, along with the impacts on biodiversity and panel performance, is limited. While the performance of land-based PV systems (LPV) can be effectively predicted, little work has been done on how, or if, these same evaluation methodologies translate to FPV. Additionally, studies evaluating the durability of FPV and its ecological impacts on water quality and biodiversity are scarce. Through detailed instrumentation of four existing FPV systems and four LPV systems that will serve as control sites, this project undertakes a first-of-its-kind systematic and comprehensive collection of FPV-related techno-ecological data in North America. These data will be used to examine FPV performance, assess potential environmental risks and benefits, and provide data that can aid in the development of research protocols to understand the impacts of FPV more fully. This multi-year study will incorporate seasonal field-based survey efforts across a two-year period at four FPV installations of various installed power capacities, percent coverage of the host water bodies, and climatic regimes. The results of this study will inform future research directives that may better allow for the accurate modeling and prediction of FPV environmental impacts and system performance by FPV developers and associated stakeholders.



HYPOTHESES AND GOALS

1. Shading of the water body with PV panels will impact water thermodynamics of the hosting water body

2. Major water quality parameters, such as dissolved oxygen, pH, and algal concentrations will be altered due to FPV installations.

3. FPV installations will reduce irradiation to water surface, decreasing aquatic vegetation growth

4. Avian species will interact with FPV in a novel manner for feeding and roosting behavior

5. Invertebrate concentrations may increase on FPV compared to open water area

6. Operating solar panel temperature may be lower due to evaporative cooling of the water body

METHODS

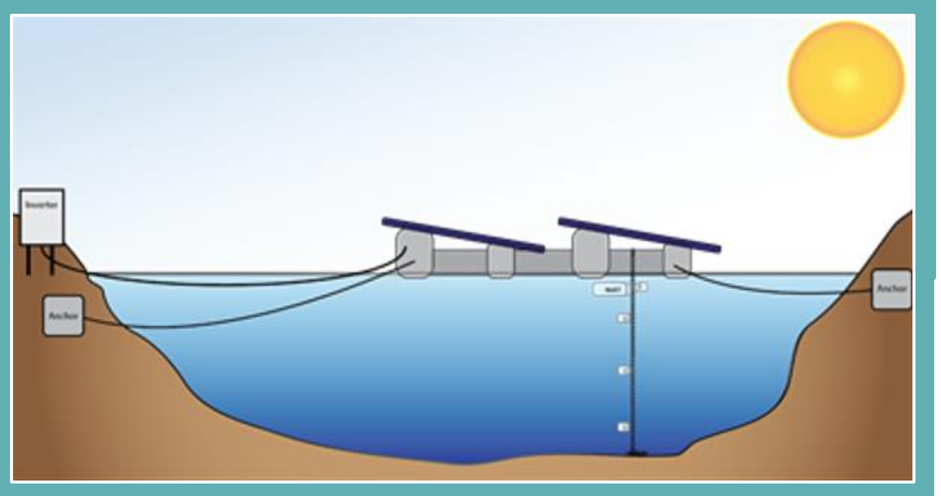
Seasonal Water Quality Sampling

•Major water quality parameters are measured at each site for four consecutive days with a YSI ProDSS multiparameter sonde.
- Parameters: pH, dissolved oxygen, conductivity, turbidity, chlorophyll-a, phycocyanin, water temperature

•Measurements averaged across 0.2m intervals over each water column profile
•Sample profile columns are taken at four randomized locations beneath the FPV installation, one profile column at each cardinal edge of the FPV installation, and three open water locations.

Long-term water quality sampling

Water temperature measurements are taken every half hour below the FPV installation and in the open water of the hosting water body. At each location, water temperature is taken at four depths; near-surface, near-benthos, and two equidistant locations between the surface and benthic locations.

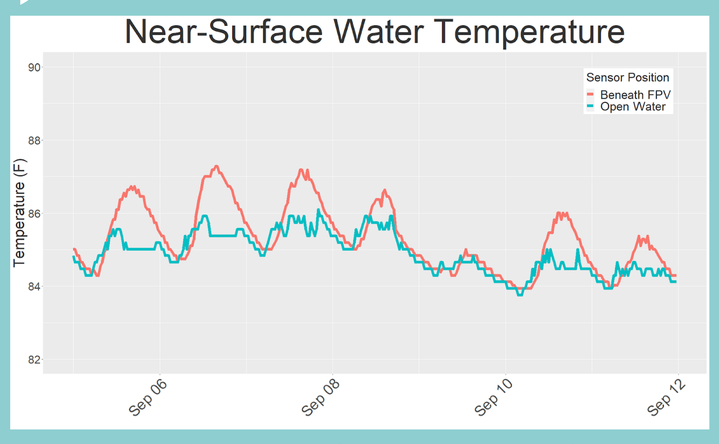


Biodiversity Sampling

Seasonal field studies are conducted four test locations. A field study for consists of a four consecutive day analysis with morning, midday, and afternoon avian point-count and behavioral surveys.
Seasonal avian surveys performed three times daily to track the presence, absence, and interactions of various avian species with FPV installations
- Quantitative point counts
- Qualitative spatial/behavioral surveys: Observers track movements of birds in the study area to gain in-depth understanding of how individuals are interacting with the environment and where/when birds interact with FPV

Seasonal invertebrate sampling also occurs both beneath FPV installation, in the open water, and on the shoreline of FPV-hosting water bodies.
- Analyzed for differences in species type and overall abundance

EARLY RESULTS



1. Shading of water body

Result: FPV installations may raise the daily maximum surface water temperature beneath the array, compared to the open water body (figure 1). FPV installations may also increase the diel temperature range of near-surface water temperatures beneath FPV installation.
Impact: Preliminary results indicate possible fluctuation in surface water temperatures that may impact stratification patterns of the water body, impacting nutrient distribution, algal and flora growth, and other factors. Further research is needed to validate these trends over time.

2. Water Quality Parameters

Results: Preliminary observations show a general reduction in average near-surface dissolved oxygen levels beneath FPV
Impact: Reduced dissolved oxygen levels may limit photosynthesis and aquatic fauna activity in water body

3. Aquatic Vegetation and Algae growth

Results: Additional cross-seasonal testing is necessary for trend analysis of vegetation and algal growth impacts of FPV, however preliminary findings demonstrate invasive aquatic vegetation growth may be limited beneath FPV

4. Avian and Ecological Interactions with FPV

Results: Water birds, specifically herons, cormorants, and anhingas, use FPV as a feeding space, and hunting ground. Mammals, such as river otter, use FPV as resting area.
Impact: FPV may alter trophic interactions of local food webs and provide novel habitat for local ecology.

5. Invertebrate Impacts of FPV

Results: General higher concentration of invertebrates on FPV than in similar open water body surface waters
Impacts: FPV may create novel habitat for invertebrate species, altering local food web dynamics

FUTURE RESEARCH OBJECTIVES

1. Investigation of heavy metal leachate owing to FPV panels
2. Underwater fauna interaction with FPV installations
3. Impacts of FPV soiling owing to avian species on array performance
4. Multi-year trends of water temperature and near-surface dissolved oxygen beneath FPV installations
5. Multi-year seasonal trends in algal indicator presence, pH, and conductivity beneath FPV installations