Occurrence of Pyrethroids in Agriculturally Impacted Surface Waters of California

Scott Wagner[1] and Xin Deng[1]

[1]Surface Water Protection Program, Department of Pesticide Regulation, California Environmental Protection Agency

INTRODUCTION

The California Department of Pesticide Regulation's (DPR's) Surface Water Protection Program conducts routine monitoring of surface waters impacted by agriculture. Site selection is guided by overall pesticide use and the aquatic toxicity properties of pesticides. Pyrethroids have been detected frequently and at concentrations that exceed toxicity thresholds. The U.S. EPA Benchmarks for chronic exposure to invertebrates are in the low parts per trillion for many pyrethroids. Further, the persistence of some pyrethroids in sediment contributes to the observed detection frequencies. For example, the water-sediment half-life of bifenthrin is more than three times greater than that for permethrin. A more detailed analysis of detections, exceedances, use patterns, and commodities with common pyrethroid use can inform development of effective best management practices or other mitigation measures.

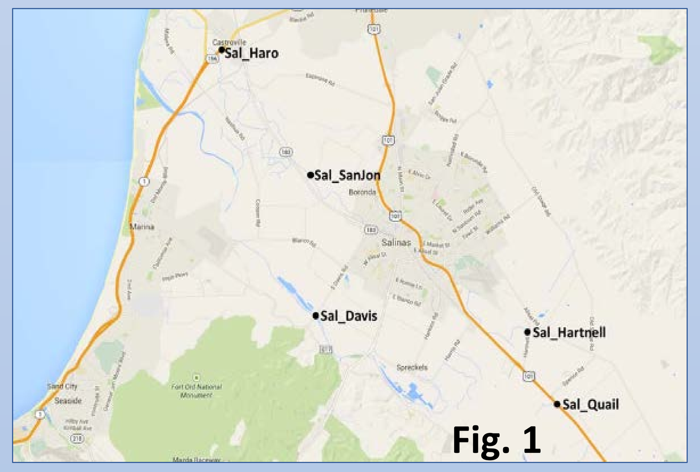
METHODS

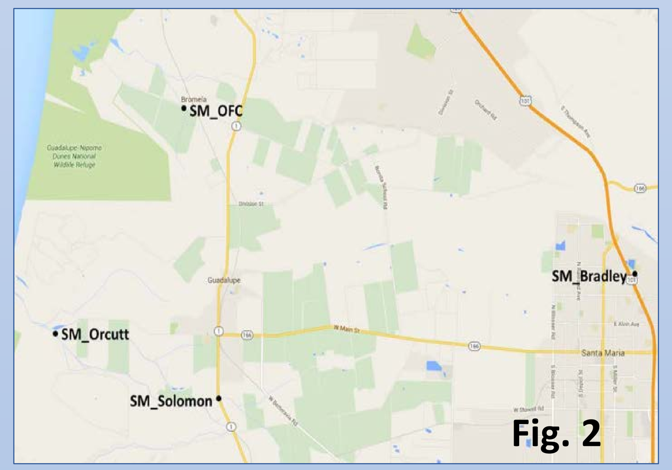
DPR sampling for pyrethroids in selected major agricultural regions of California began in 2012[1]. Grab samples are collected in 1-liter amber bottles and stored on ice or refrigerated until they are analyzed by the Center for Analytical Chemistry, California Department of Food and Agriculture. The reporting limits in the first few years of sampling ranged from 5–15 ng/L then improved to 1–5 ng/L. Six pyrethroids, bifenthrin, lambda-cyhalothrin (L-cyhalothrin), permethrin, esfenvalerate/fenvalerate, cypermethrin, and cyfluthrin, were analyzed in every sample; however, three stood out as the most frequently detected: bifenthrin, L-cyhalothrin, and permethrin.

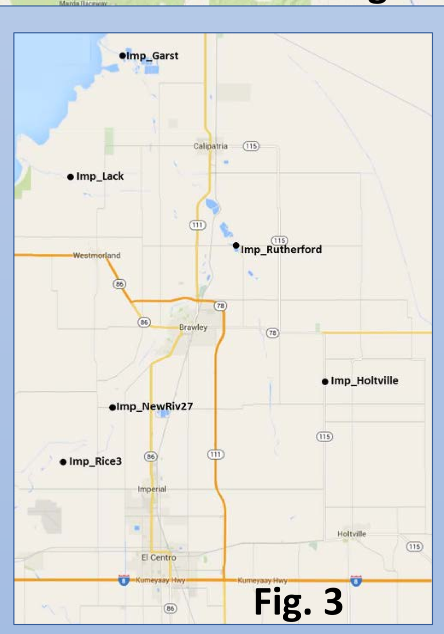
OBJECTIVES

The objectives of DPR pyrethroid monitoring are:

- Measure pyrethroid occurrences and concentrations
- Evaluate potential impacts of pyrethroid runoff on aquatic life
- Analyze spatial differences in detection rates





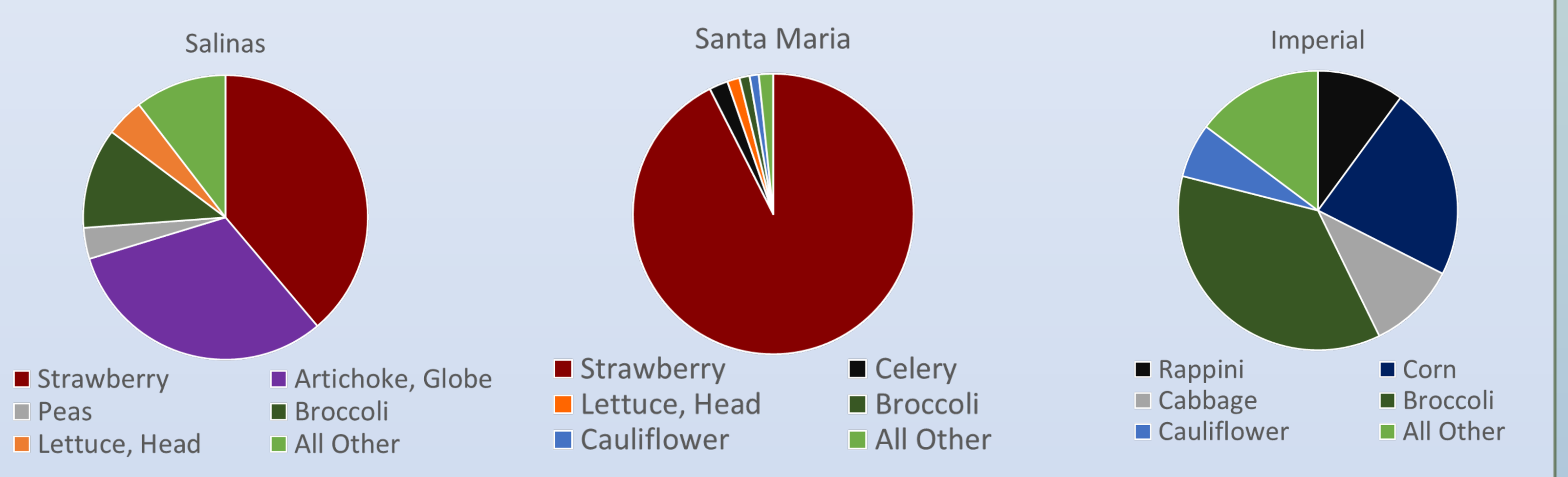


Figures 1, 2, and 3. DPR Monitoring sites in Salinas, Santa Maria, and Imperial Valleys, respectively. Figure 4. DPR monitoring sites in Salinas, Santa Maria, and Imperial at a statewide glance.

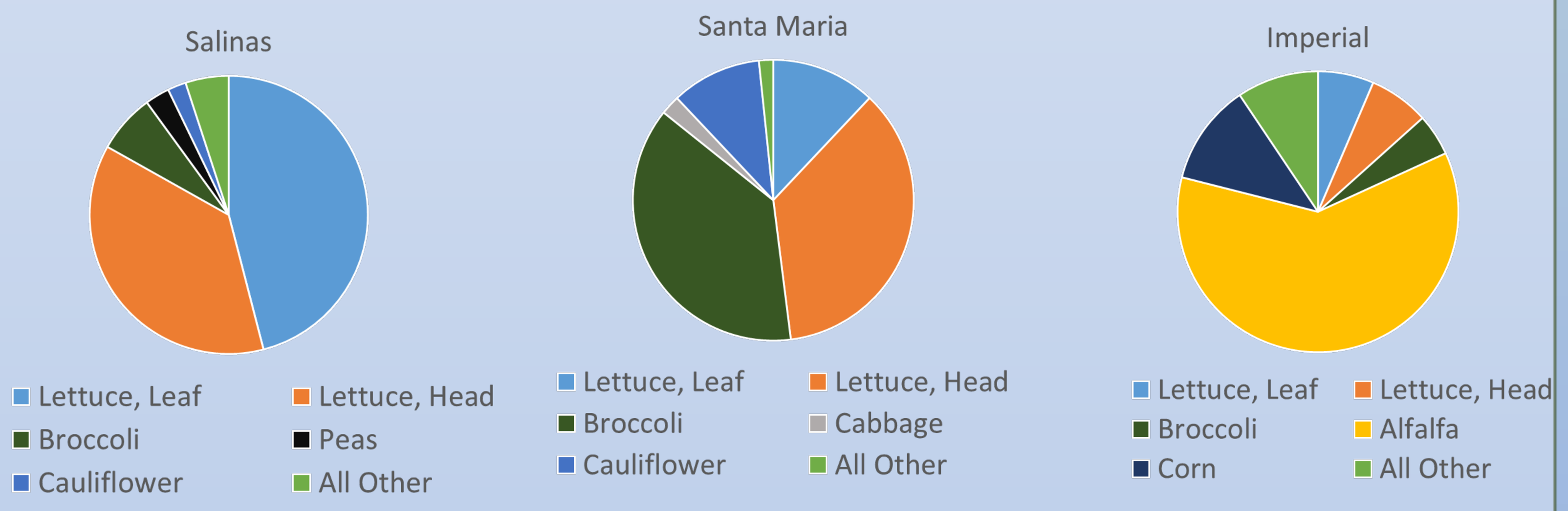
PYRETHROID USES

DPR has conducted focused monitoring in the high-impact agricultural regions of Salinas, Santa Maria, and Imperial Valley to gauge long-term trends and capture edge-of-field pesticide concentrations. A comparison of pyrethroid agricultural crop applications across these three regions can provide insight into where the pesticides are used most frequently and potential sources for loading into surface water (Table 1). Agricultural uses of bifenthrin, L-cyhalothrin, and permethrin, shown in the charts below, identify the crops that received the most treatment in 2012–2016[2]. Identifying crops with the highest pyrethroid use can be a starting point for mitigating pesticide loading to nearby surface waters.

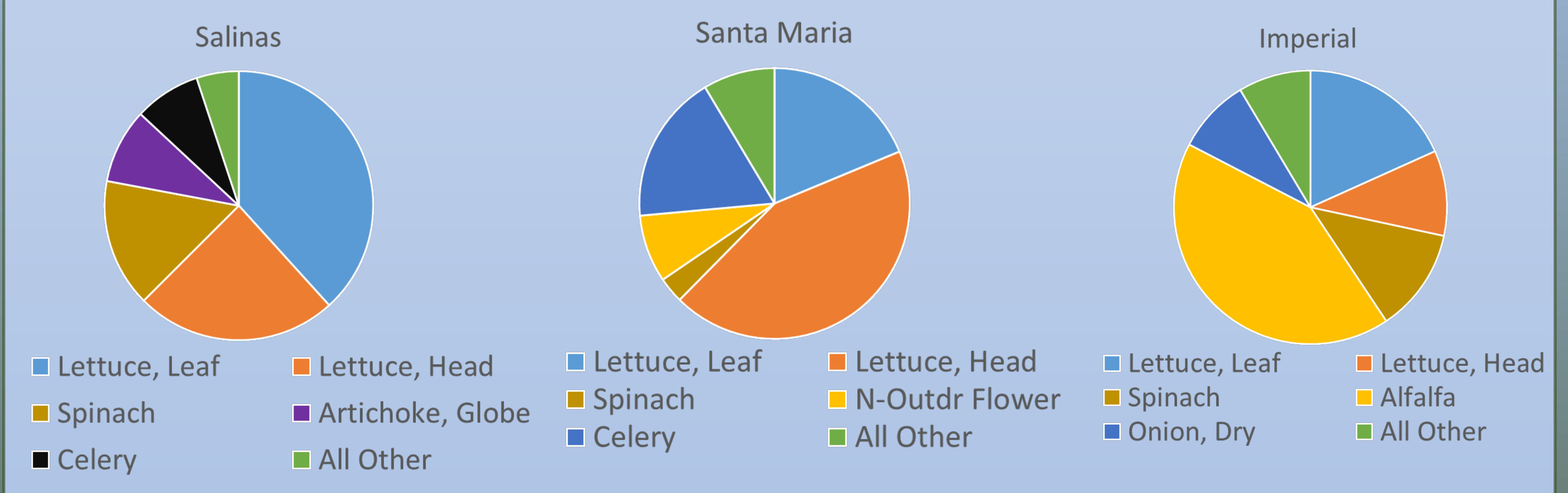
Bifenthrin



L-cyhalothrin



Permethrin



DETECTIONS

Frequent detections of bifenthrin, L-cyhalothrin, and permethrin were found with many samples also exceeding the lowest U.S. EPA Benchmark (Figures 6A, 6B, and 6C)[3]. Across the three pesticides and three regions, detections and exceedances were highest for bifenthrin in Salinas; 64% of samples showed detections while 60% of samples contained bifenthrin in concentrations that exceeded the lowest Benchmark.

DETECTIONS (continued)

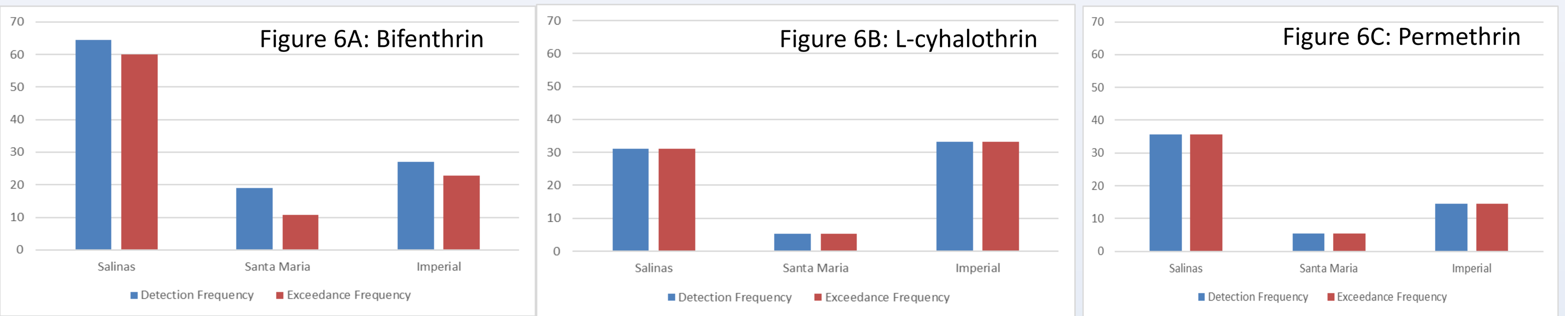


Figure 6A, 6B, and 6C. Bifenthrin, L-cyhalothrin, and permethrin detection and exceedance frequencies in Salinas, Santa Maria, and Imperial.

In the Imperial Valley, detections were highest for L-cyhalothrin, with 33% detection and exceedance frequencies. Santa Maria had the lowest detection and exceedance frequencies for the three most frequently detected pyrethroids. Among the pyrethroids in Santa Maria, bifenthrin was found to have the highest detection frequency at a rate of more than 10% of samples.

Table 1. Total agricultural use, in pounds, of the selected pyrethroids in regions of DPR monitoring, 2012–2016.

	Salinas	Santa Maria	Imperial
Bifenthrin	20,543	9,804	8,353
L-cyhalothrin	28,480	3,116	29,584
Permethrin	165,624	24,436	81,623

DISCUSSION

The detection and exceedance frequencies for bifenthrin were the highest among the three pyrethroids analyzed. However, use of bifenthrin was the lowest in Salinas and Imperial (Table 1). This dichotomy can partially be explained by the physical-chemical and degradation properties of each pyrethroid (Table 2). Bifenthrin is the least soluble and most persistent in the water-sediment environment. The detection and exceedance frequencies observed are not simply a function of use patterns; they are also a function of physical-chemical and degradation properties.

Table 2. Physical-chemical and degradation properties for bifenthrin, L-cyhalothrin, and permethrin[4,5].

	Bifenthrin	L-cyhalothrin	Permethrin
Solubility (mg/L, 20 °C)	0.001	0.005	0.2
K_{oc} (L/kg)	236,610	283,707	100,000
Water-sediment half-life (day)	161	15.1	40
U.S. EPA Chronic Benchmark (ng/L)	1.3	2.0	1.4

We identified crops with the highest use in the regions monitored to inform future pyrethroid mitigation strategies. Given the variety in crop-specific growing practices, crop-specific mitigation practices may be necessary. Identifying highest use commodities as a function of region may lead to region-specific approaches to address water quality associated with the offsite movement of pyrethroids.

References

[1] Deng, Xin. Study 304. Surface Water Monitoring for Pesticides in Agricultural Areas in the Central Coast and Southern California, 2018. California Department of Pesticide Regulation. Environmental Monitoring Branch.
[2] Department of Pesticide Regulation. Pesticide Use Reports (PUR). California Pesticide Information Portal (CalPIP).
[3] Deng, Xin. Study Report. Study 304: Surface Water Monitoring for Pesticides in Agricultural Areas of California, 2016.
[4] International Union of Pure and Applied Chemistry (IUPAC). The PPDB: Pesticide Properties Database. 2018.
[5] U.S. EPA. Aquatic Life Benchmarks and Ecological Risk Assessments for Registered Pesticides. 2018.