Legacy Pesticides: Continuing Effects

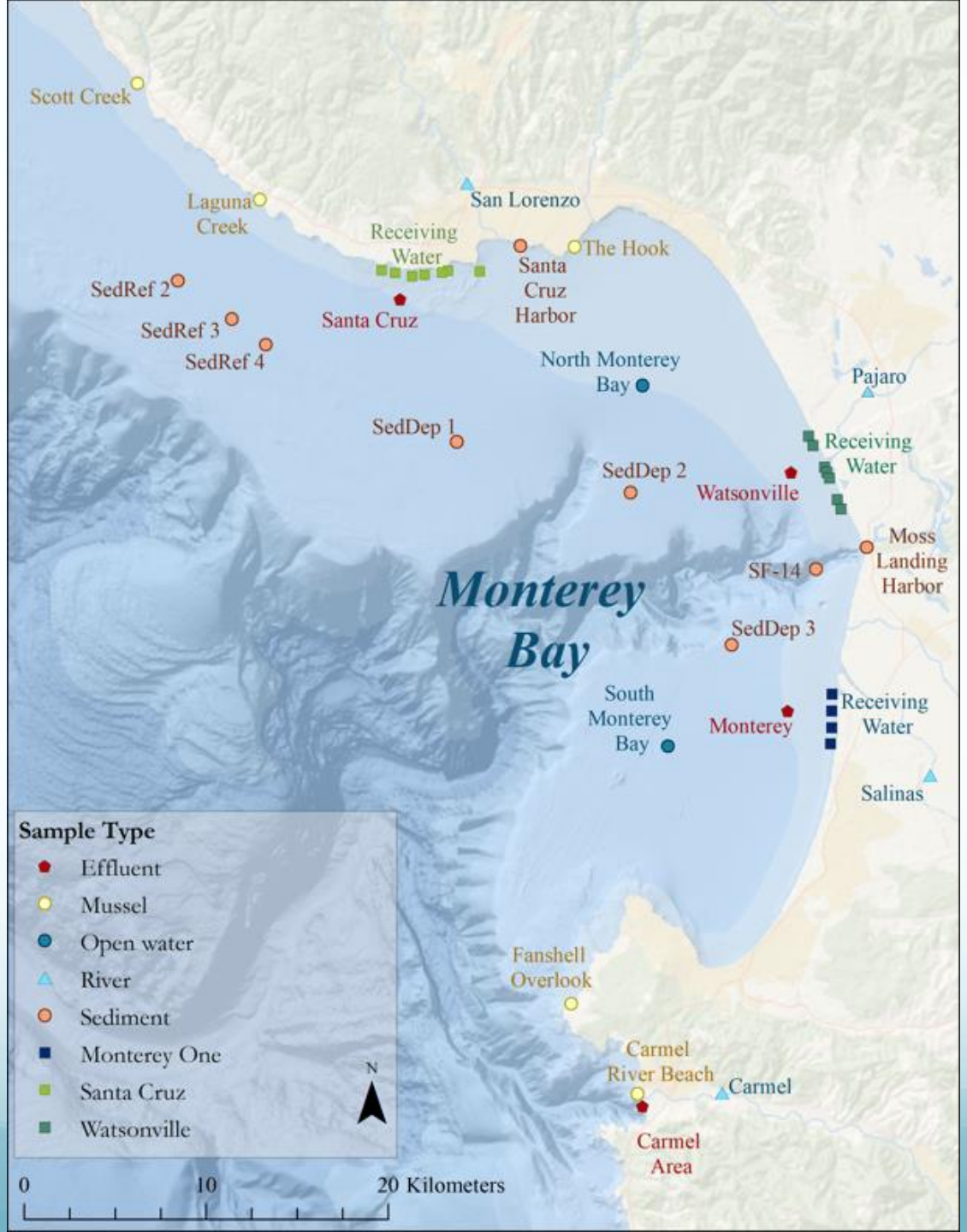
The Importance of Long-term Regional Monitoring

CCLEAN

November 9, 2017

CCLEAN

- Since 2001
- Sources and Loads of Persistent Organic Pollutants (POPs) into Monterey Bay
- Status and Trends of Beneficial Uses
- High-volume *in situ* solid-phase extraction
  - 200+ liters extracted = very low reporting limits
  - 30-day sampling periods in wet season and dry season
  - Effluent (4), rivers (4 > 2 > 1), ocean water (2)
- Resident mussels (5) annually in wet season
- Analyzed for chlorinated pesticides, PCBs, PBDEs, PAHs, pyrethroids, and fipronils (and neonicotinoids)


Scott Creek
Laguna Creek
San Lorenzo
Receiving Water
The Hook
Santa Cruz Harbor
SedRef 2
SedRef 3
SedRef 4
Santa Cruz
North Monterey Bay
Pajaro
SedDep 1
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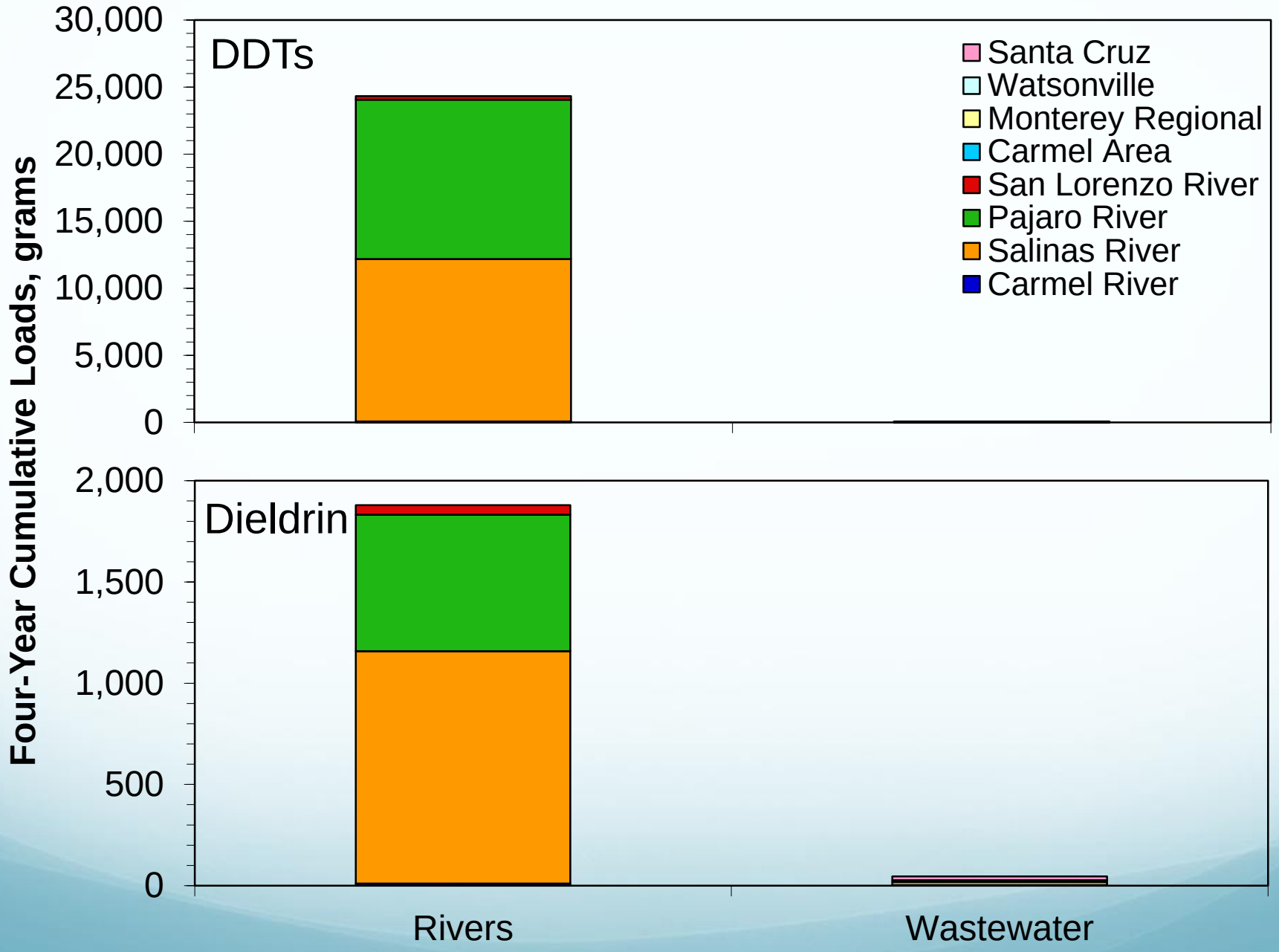
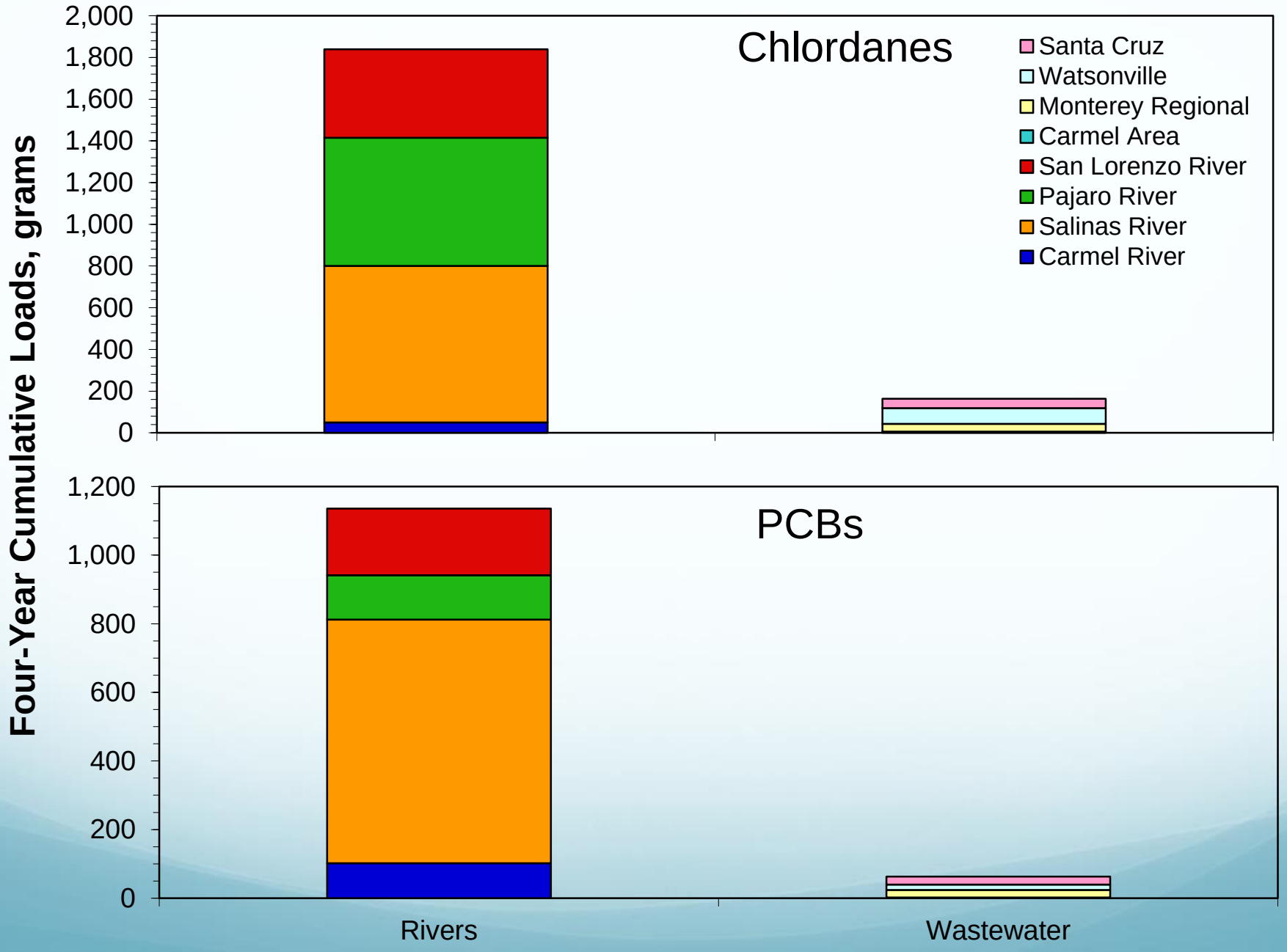
Salinas
Fanshell Overlook
Carmel River Beach
Carmel
Carmel Area
Sample Type
Effluent
Mussel
Open water
River
Sediment
Monterey One
Santa Cruz
Watsonville
N
0
10
20 Kilometers

Rivers

- 2002 – 2007
  - San Lorenzo, Pajaro, Salinas, and Carmel
    - Highest loads of measured constituents came from rivers
- 2008 – 2017
  - San Lorenzo, Pajaro
- Currently
  - San Lorenzo River

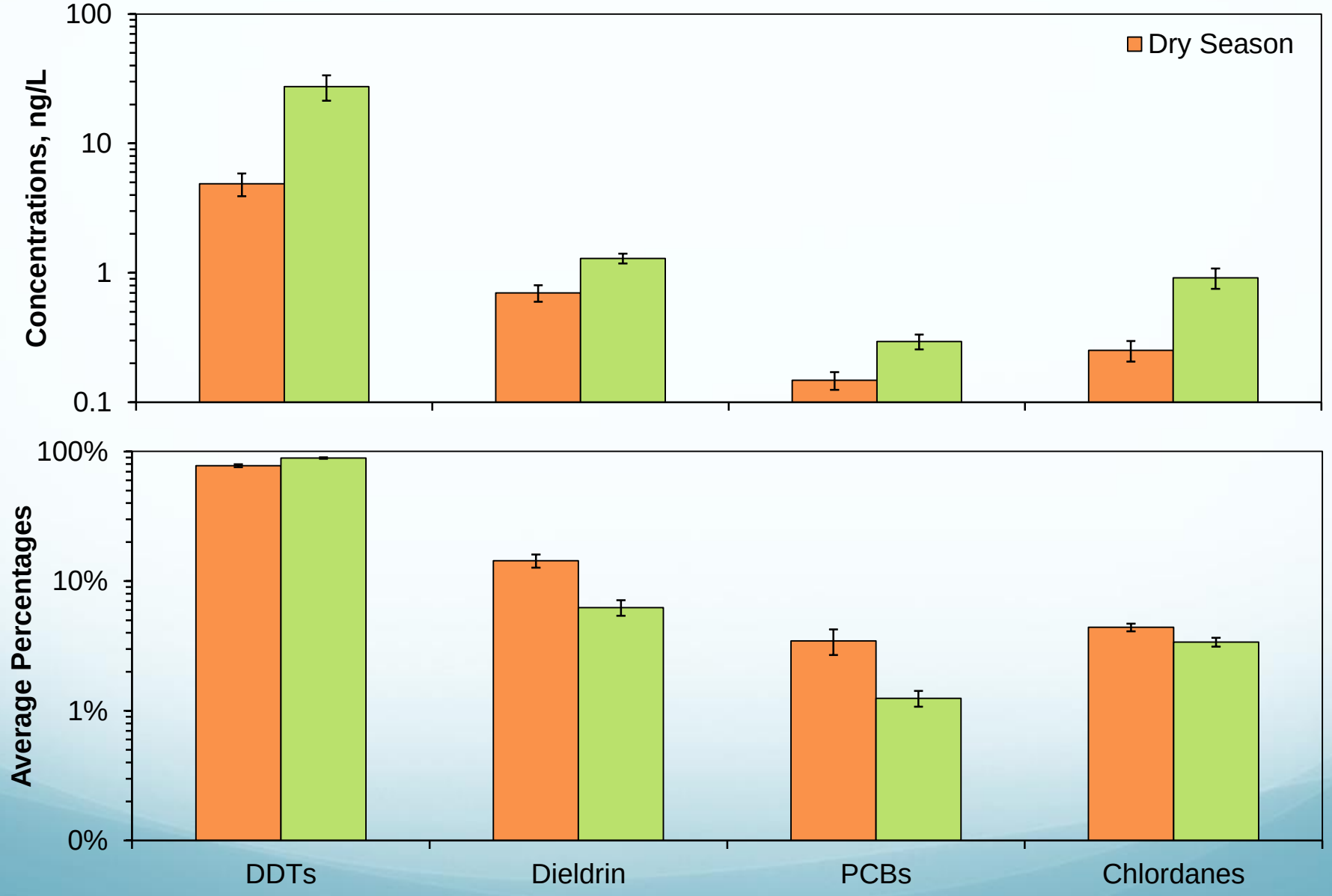

DDTs
Dieldrin
Four-Year Cumulative Loads, grams
30,000
25,000
20,000
15,000
10,000
5,000
0
2,000
1,500
1,000
500
0
Santa Cruz
Watsonville
Monterey Regional
Carmel Area
San Lorenzo River
Pajaro River
Salinas River
Carmel River
Rivers
Wastewater


Four-Year Cumulative Loads, grams
Chlordanes
Santa Cruz
Watsonville
Monterey Regional
Carmel Area
San Lorenzo River
Pajaro River
Salinas River
Carmel River
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
PCBs
1,200
1,000
800
600
400
200
0
Rivers
Wastewater

Pajaro River Impairments
California Toxics Rule Criteria

POP	% Samples Exceeding	Average % Exceedance	Max % Exceedance
p,p' DDD	70%	159.9%	1089%
p,p' DDE	93.3%	1153%	4832%
p,p' DDT	70%	515%	4257%
Dieldrin	96.7%	733%	1671%
Chlordane	20%	54.7%	171%
PCBs	50%	162%	323%

Pajaro POP Seasonality



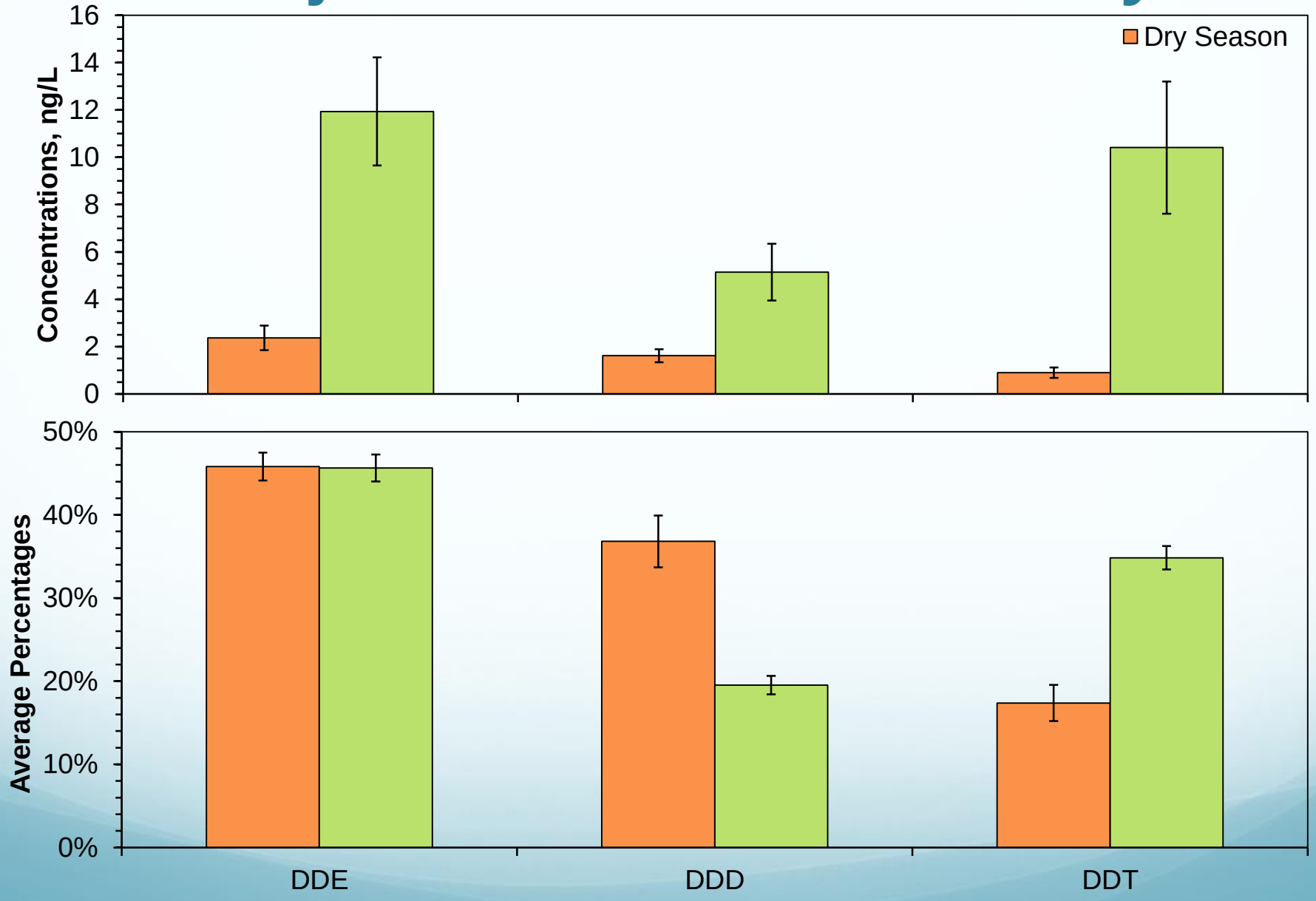
DDT Facts

- There are 3 DDT compounds: DDT, DDE, DDD
- In the environment, microbes break down DDT:

  Aerobic (plenty of oxygen): DDT → DDE

  Anaerobic (no oxygen): DDT → DDD

Pajaro DDT Seasonality



Pajaro River Results

- Pajaro River routinely fails water quality criteria

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- Proportionally higher amounts of DDT in wet-season than in dry-season DDTs

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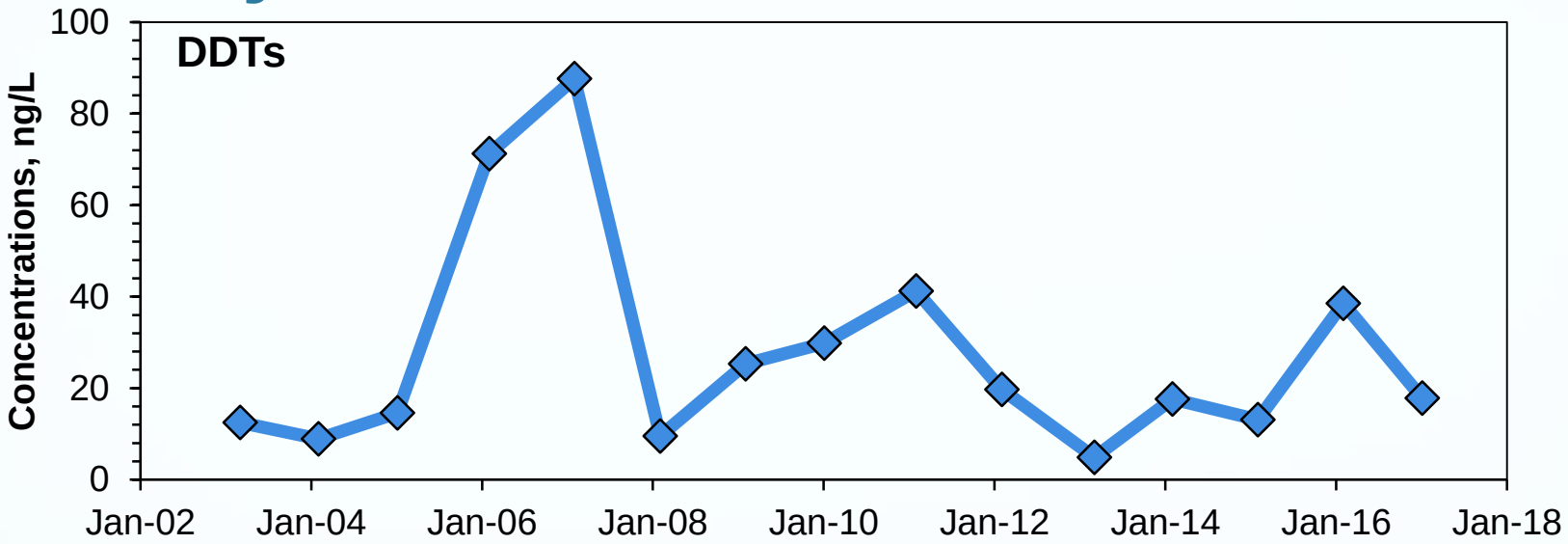
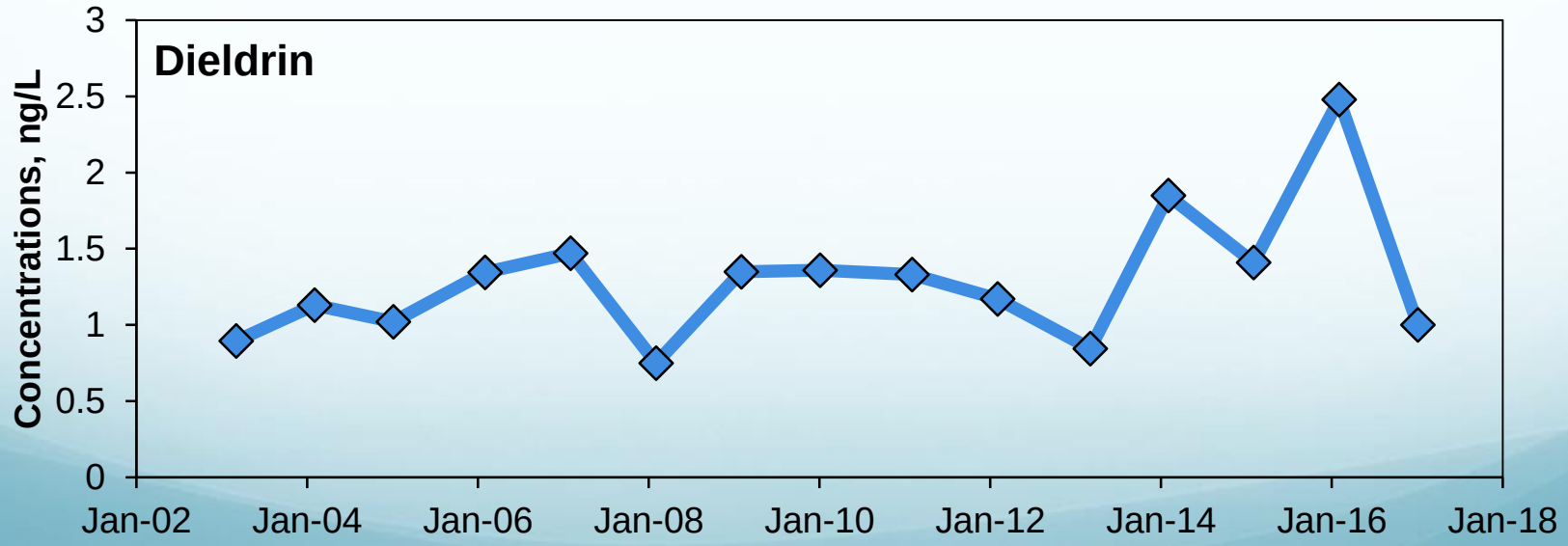
  - High wet-season DDTs and Dieldrin are due to runoff from land
- Proportionally higher amounts of DDT in wet-season than in dry-season DDTs
  - Wet-season sources of DDTs are less degraded than dry-season sources

Pajaro POP Concentrations





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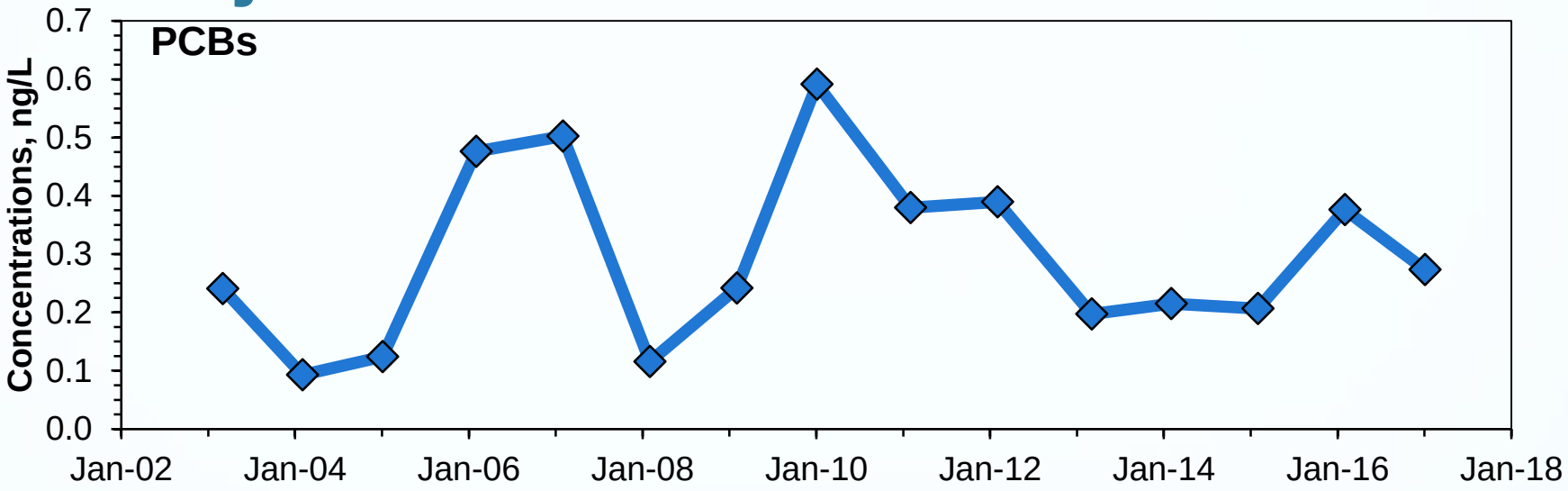
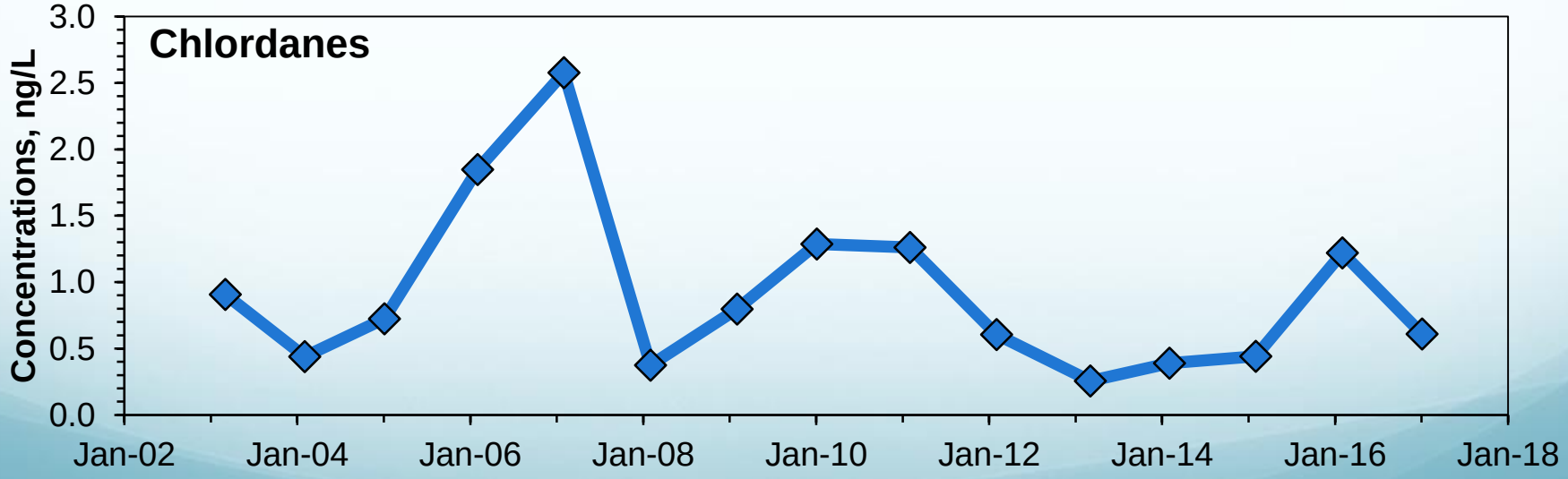
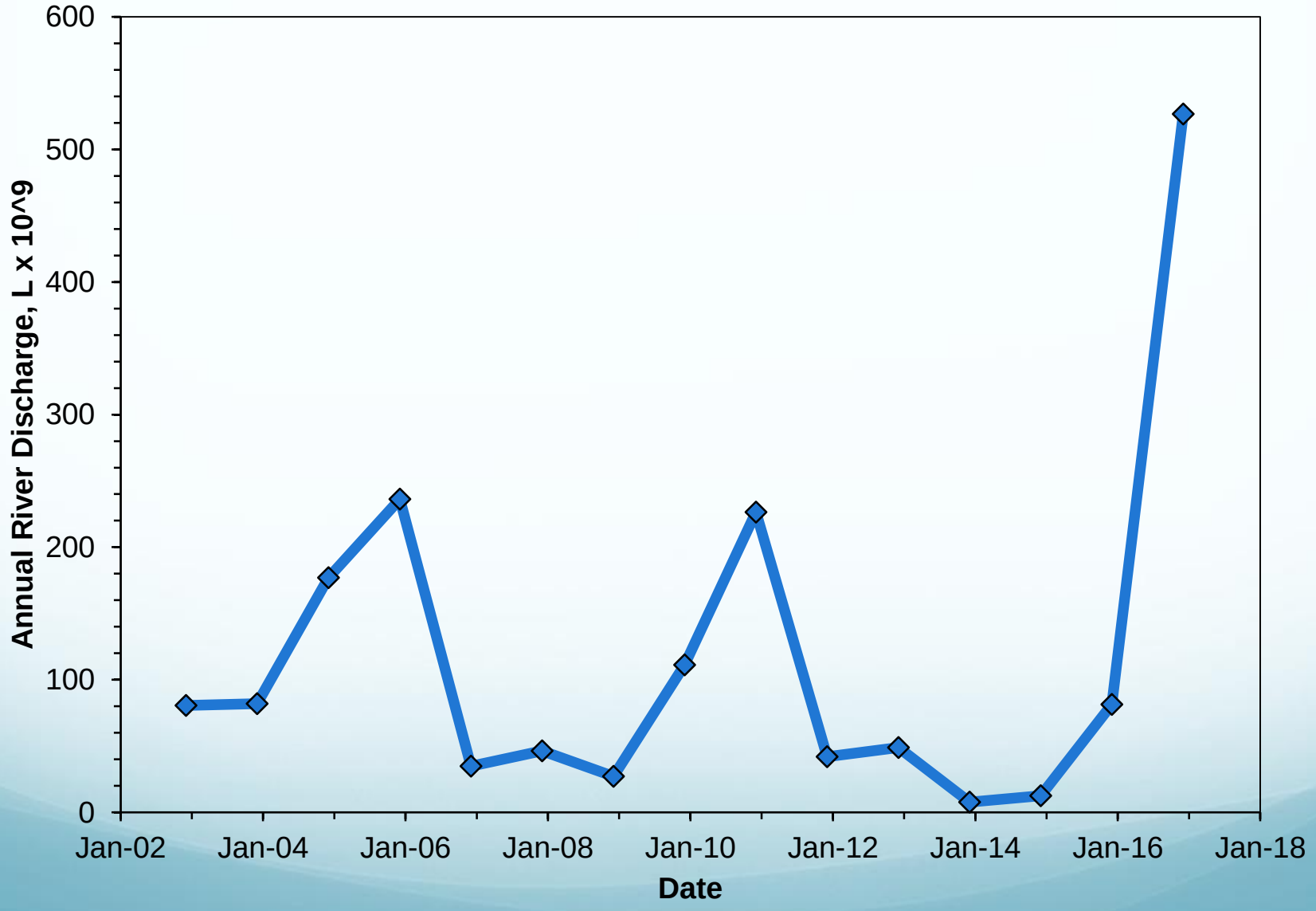
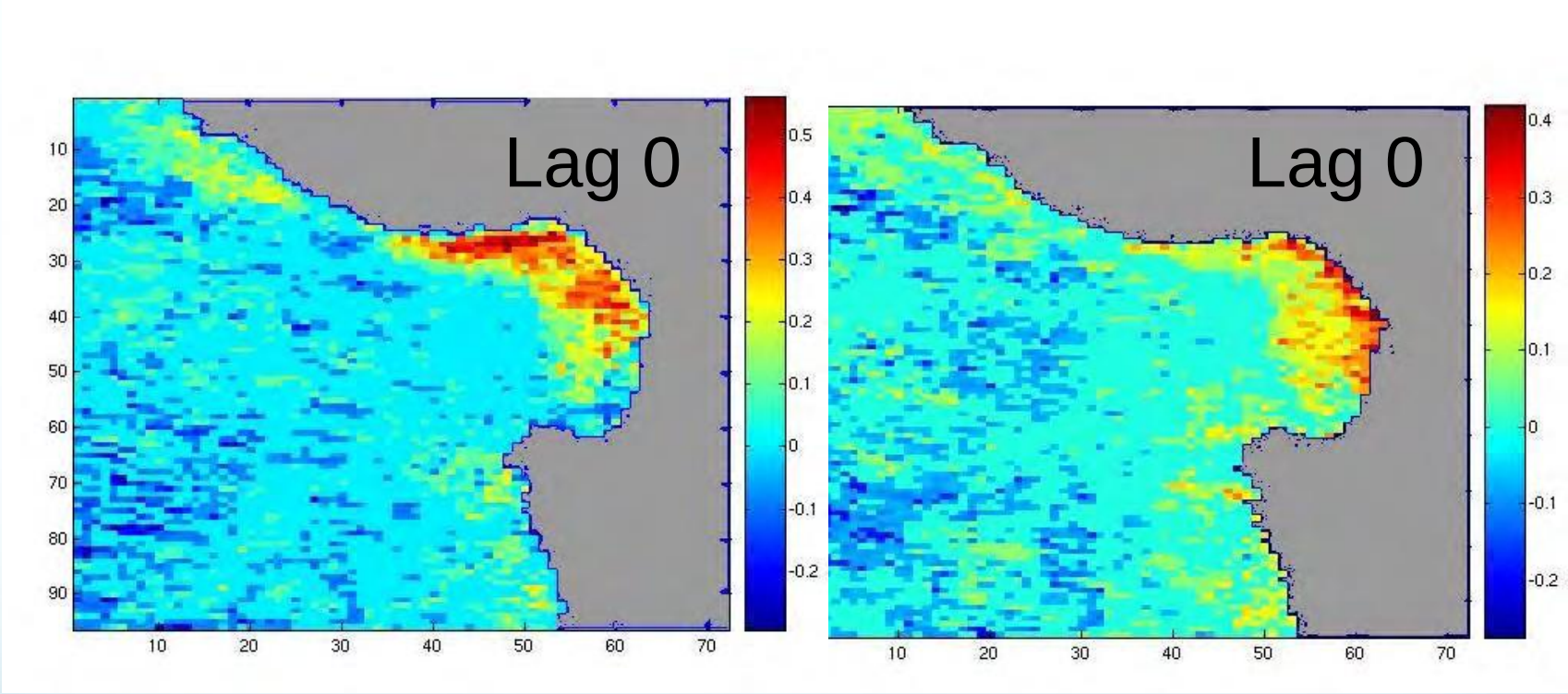




Pajaro Discharge Volume

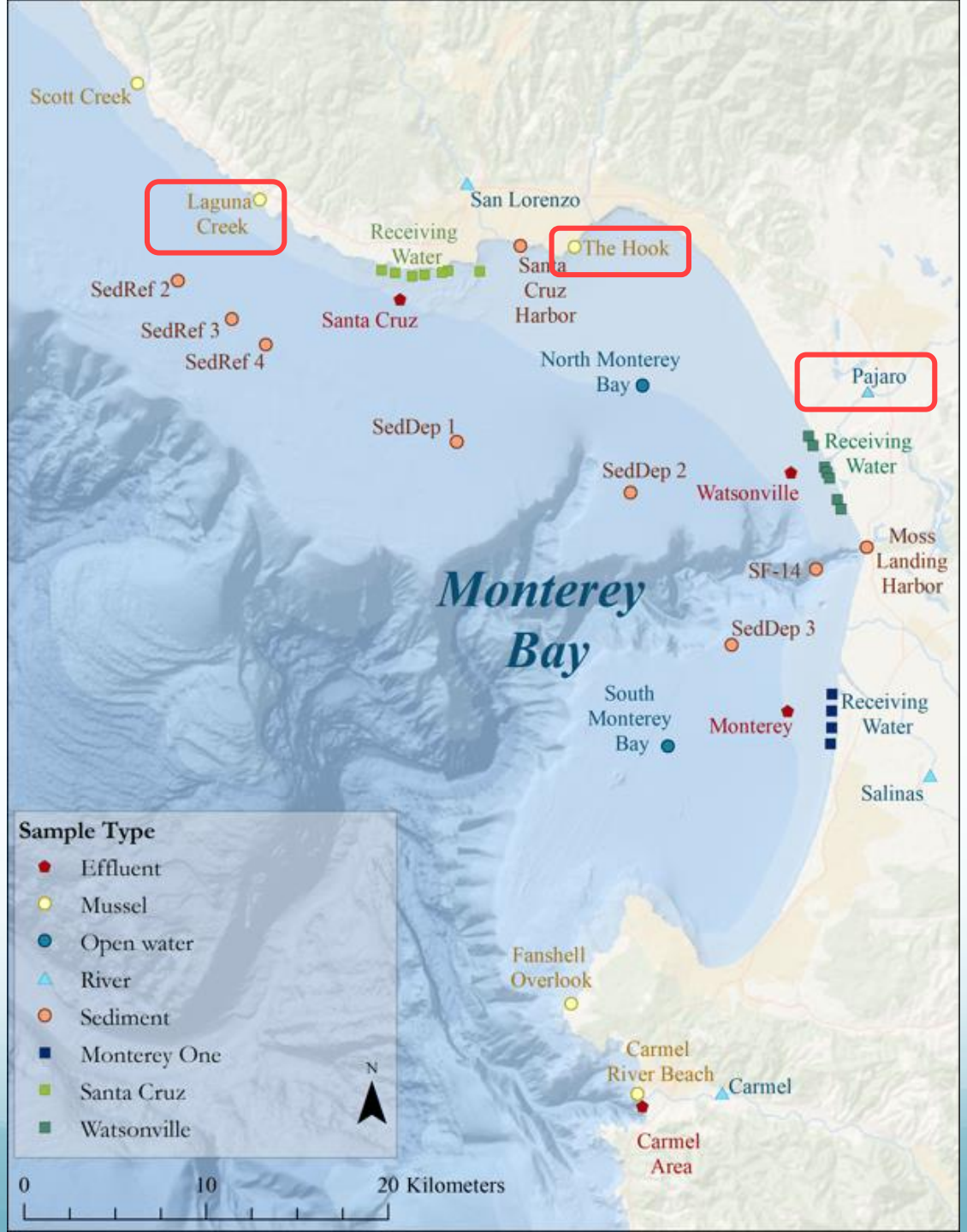


Where Do River Loads Go?



Pajaro River

Salinas River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Sample Type
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Open water
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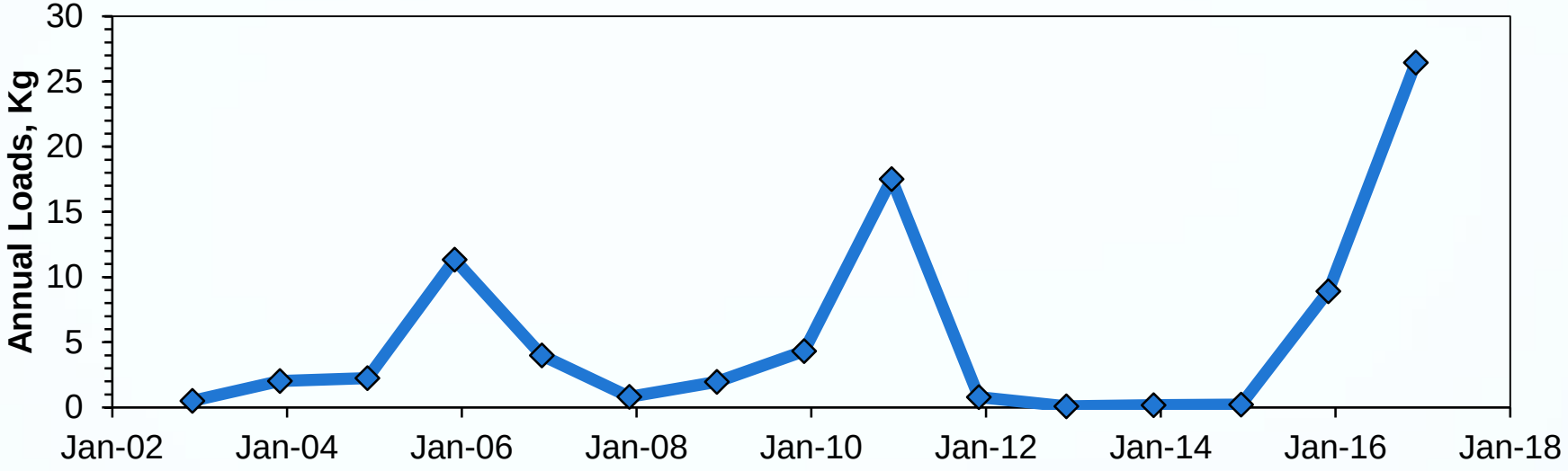
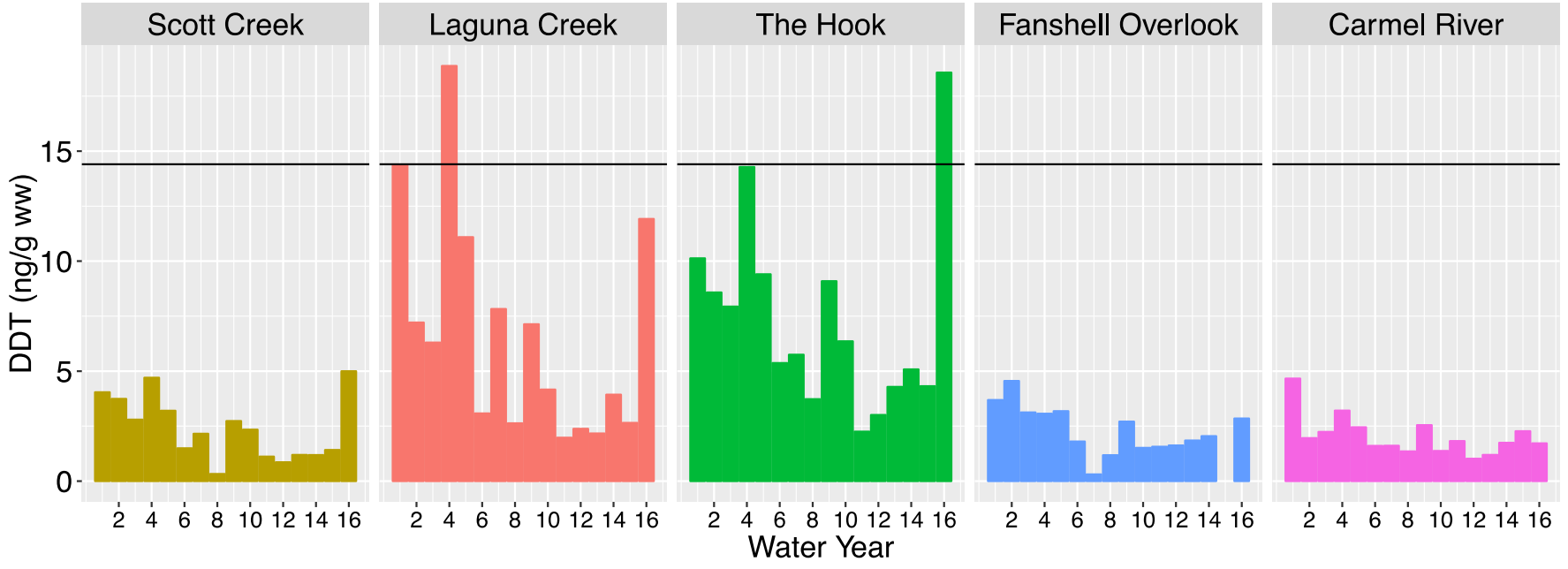
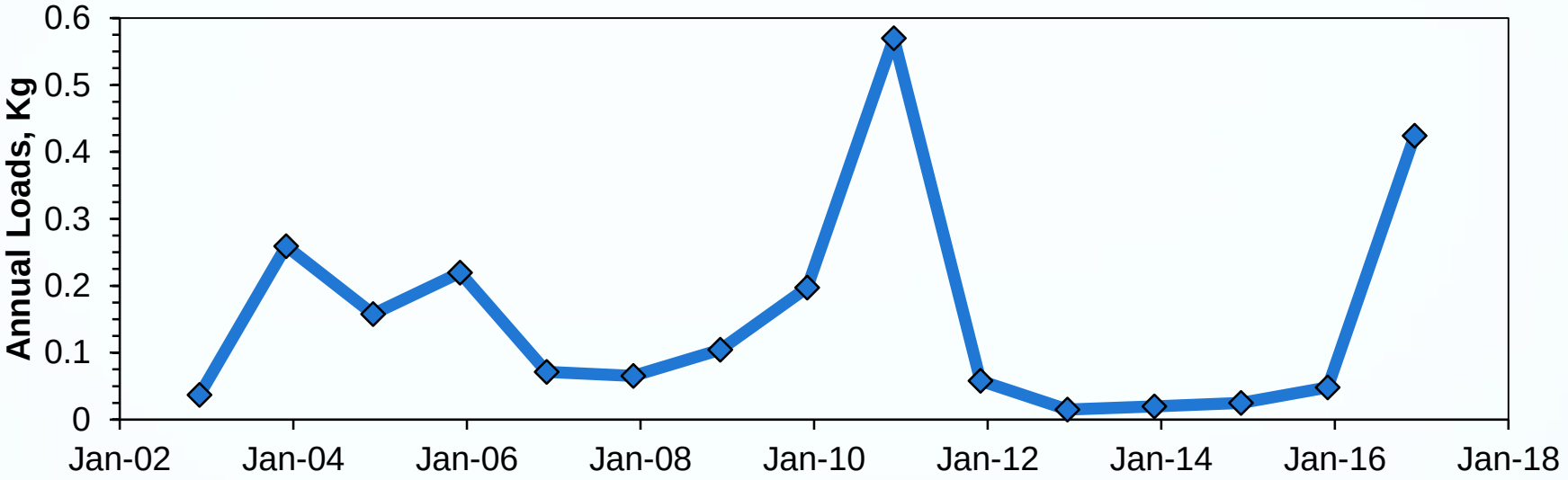
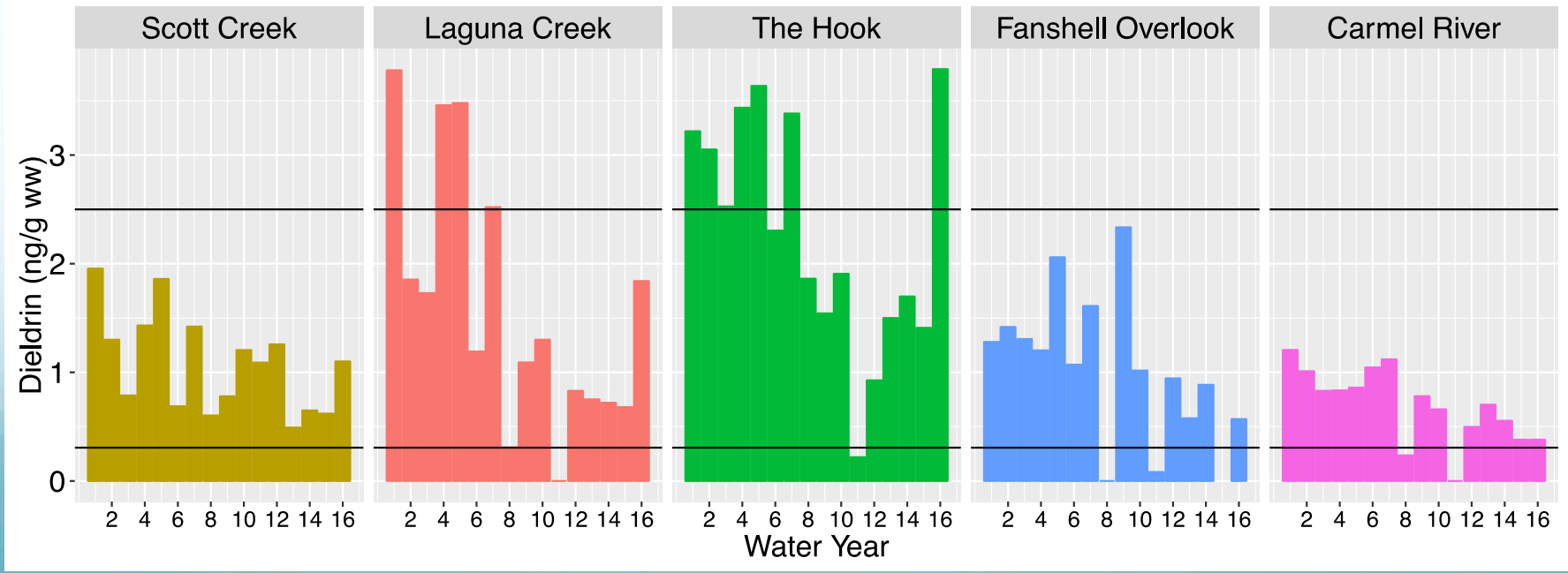
DDT Loads


Annual Loads, Kg
30
25
20
15
10
5
0
Jan-02
Jan-04
Jan-06
Jan-08
Jan-10
Jan-12
Jan-14
Jan-16
Jan-18

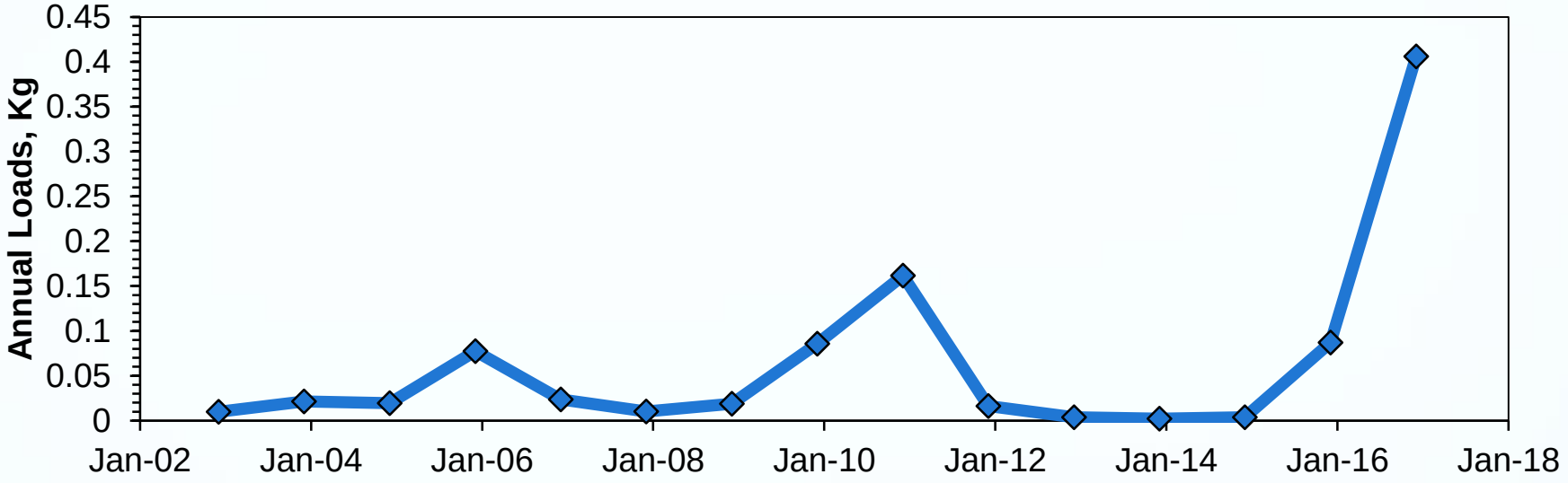

Scott Creek
Laguna Creek
The Hook
Fanshell Overlook
Carmel River
DDT (ng/g ww)
15
10
5
0
2 4 6 8 10 12 14 16
Water Year

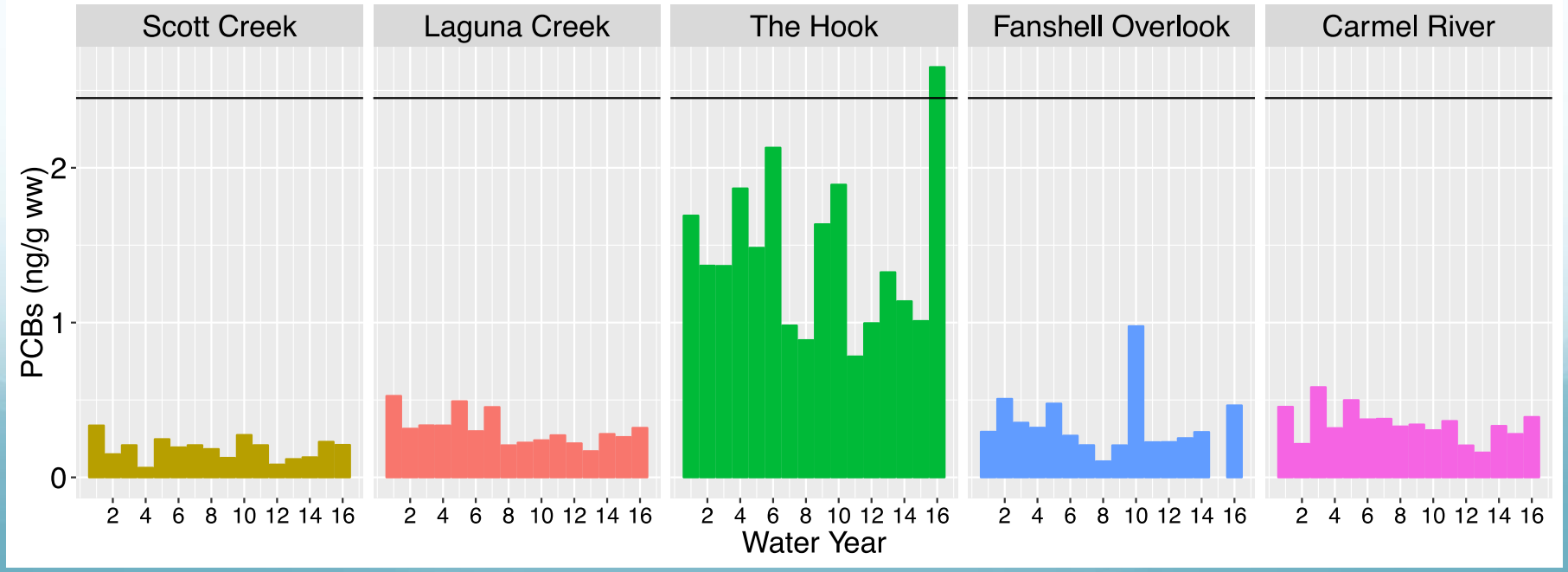
Dieldrin Loads



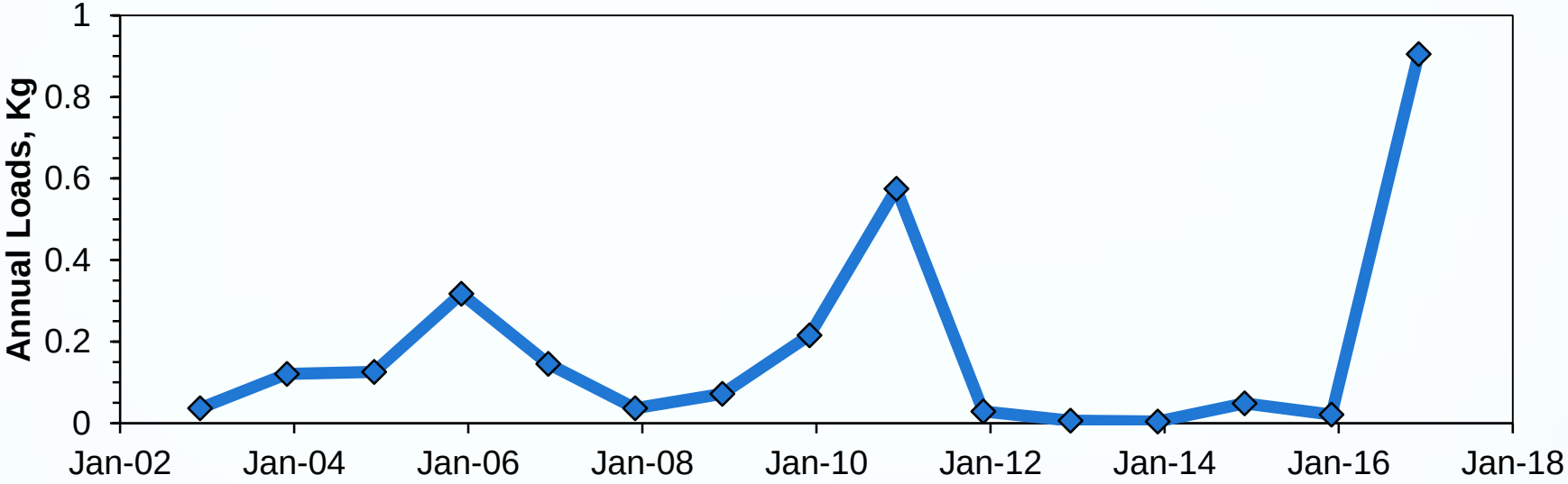


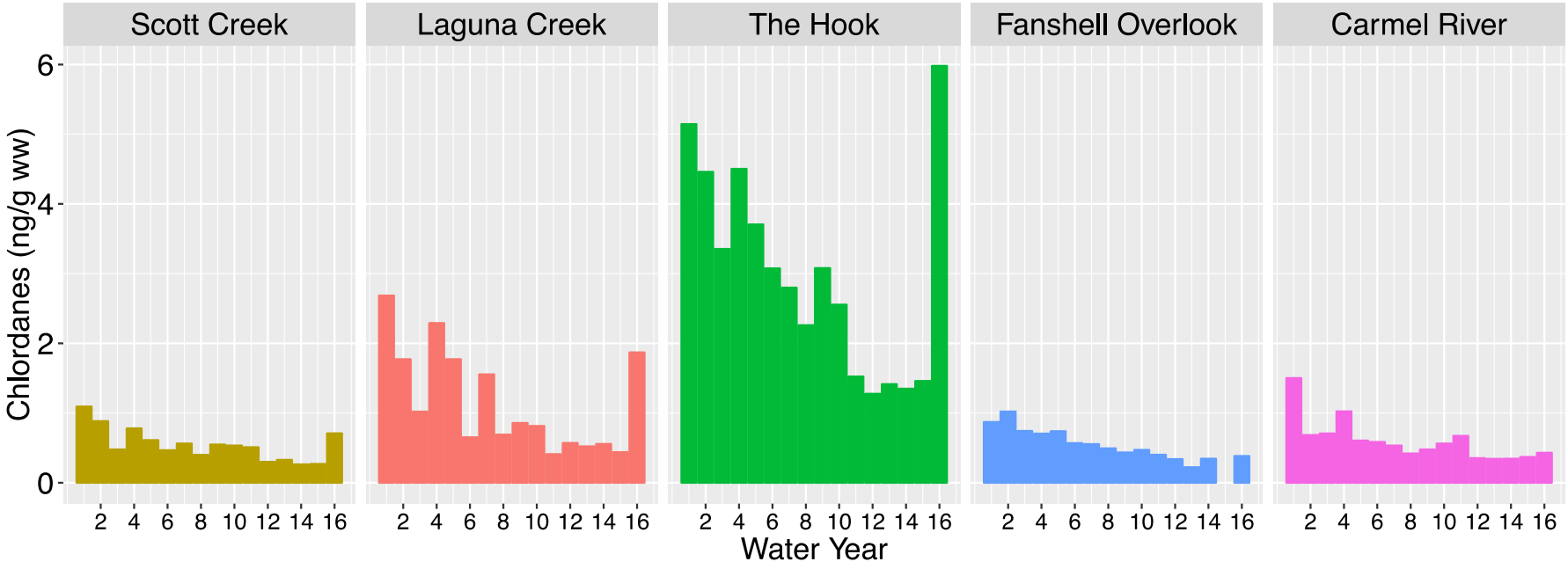
PCB Loads


Annual Loads, Kg
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan-02
Jan-04
Jan-06
Jan-08
Jan-10
Jan-12
Jan-14
Jan-16
Jan-18


Scott Creek
Laguna Creek
The Hook
Fanshell Overlook
Carmel River
PCBs (ng/g ww)
2
1
0
2 4 6 8 10 12 14 16
Water Year

Chlordane Loads





Why Should We Care?

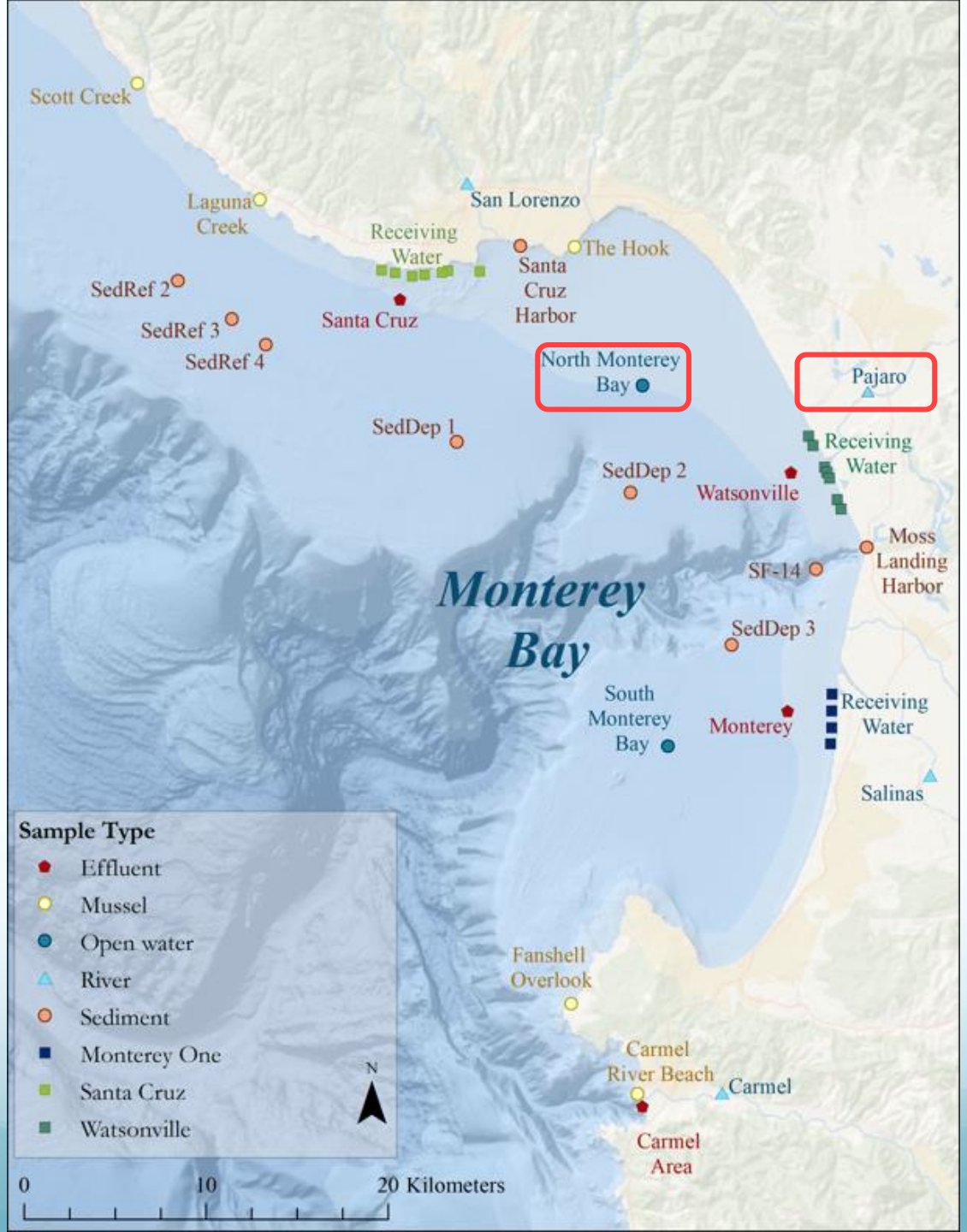
- High concentrations of some chlordanes and PCBs in **sea otters** were significant risk factors for the animals having various infectious diseases
- Endangered Southern Resident **killer whales** exceed toxic thresholds for PCBs and have very high DDT concentrations (“California signature”)
- **Top smelt** and **shiner surf perch** in Elkhorn Slough exceed USEPA DDT human health alert levels for subsistence fishers

What Can We Do?

- Keep contaminated sediments on the land
- Support continued sampling of river discharges into Monterey Bay

Do River DDTs = Ocean DDTs?

- Fingerprinting: Using relative differences in compound concentrations to infer sources:
  - “Did the oil on this beach come from that ship?”
  - Did the contaminants in this ocean come from this river?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Carmel Area
Sample Type
Effluent
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Open water
River
Sediment
Monterey One
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Watsonville
N
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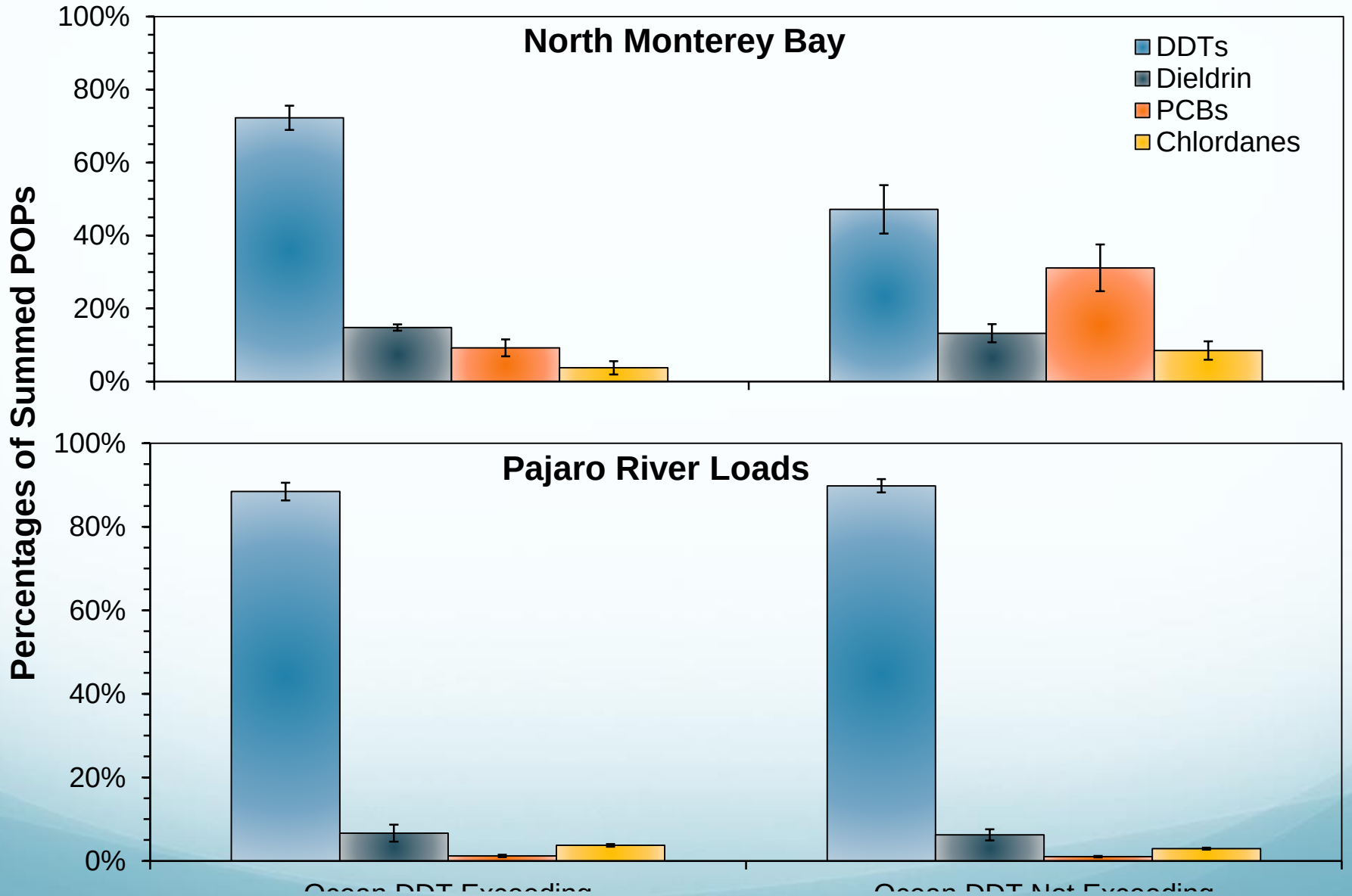
River Loads vs. Ocean Impairments



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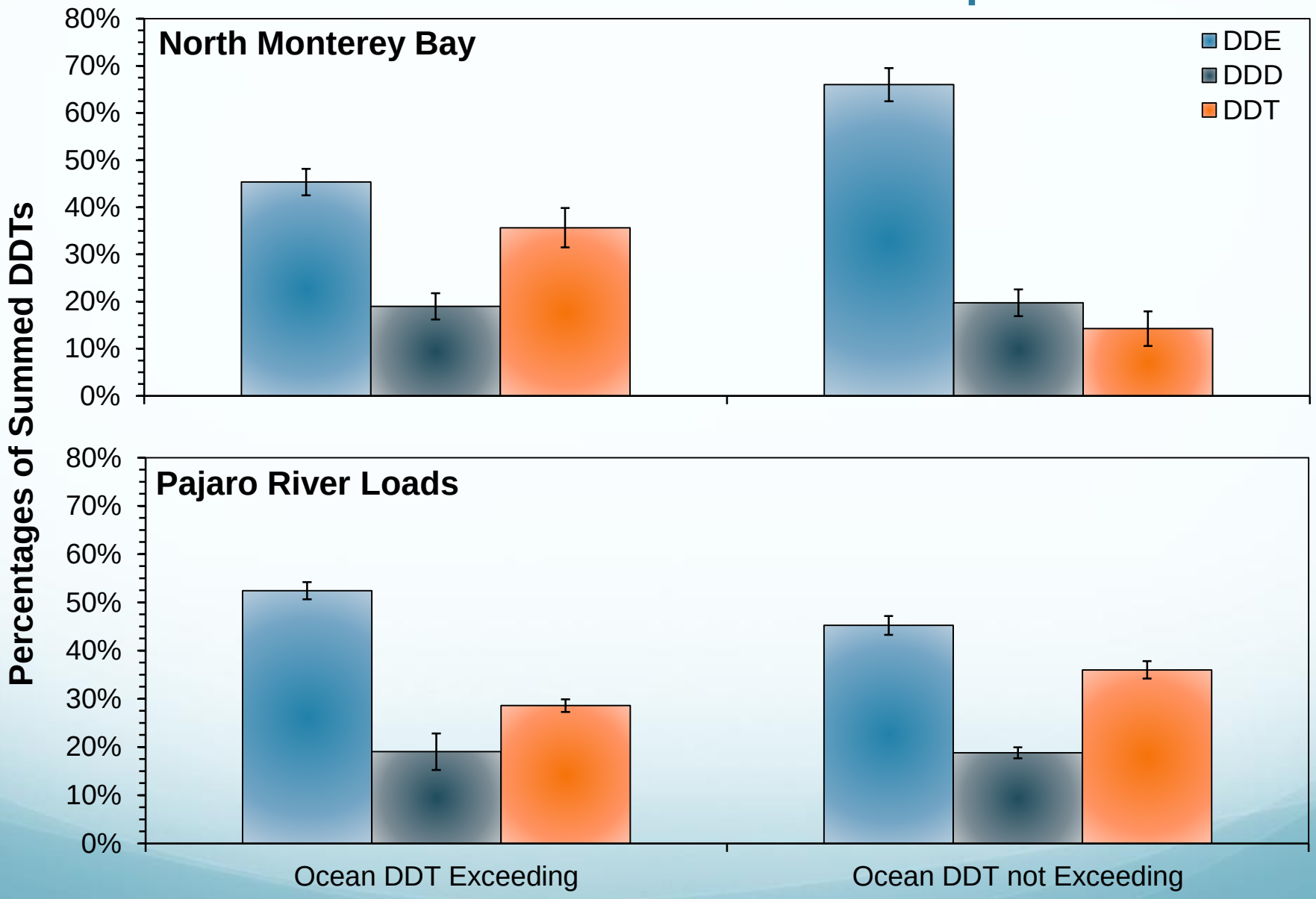
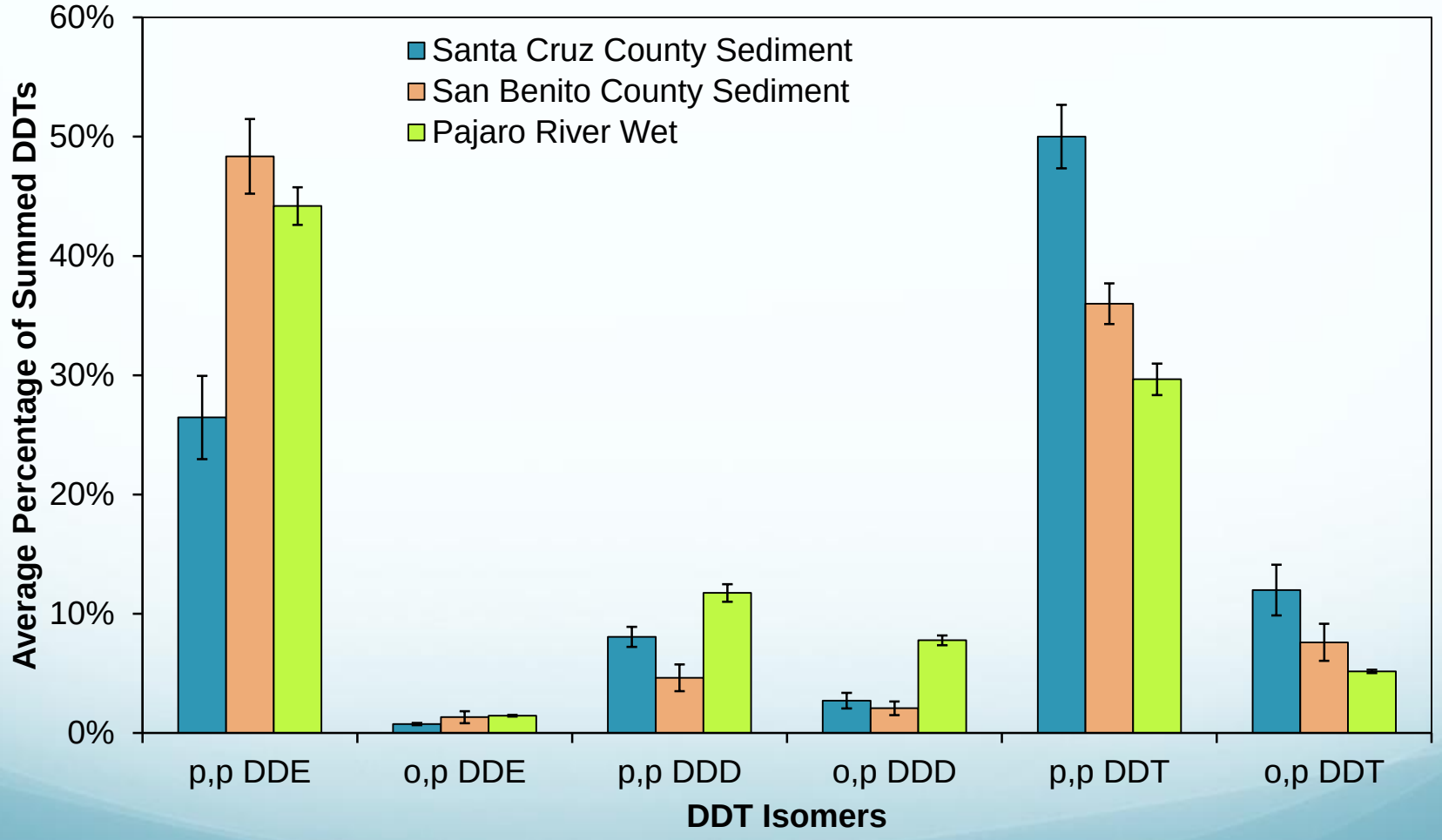


1985 DF&A Study

- Investigation of sources for continued DDT residues in food
- 99 samples from 32 counties
  - 4 sites in each of Santa Cruz and San Benito counties

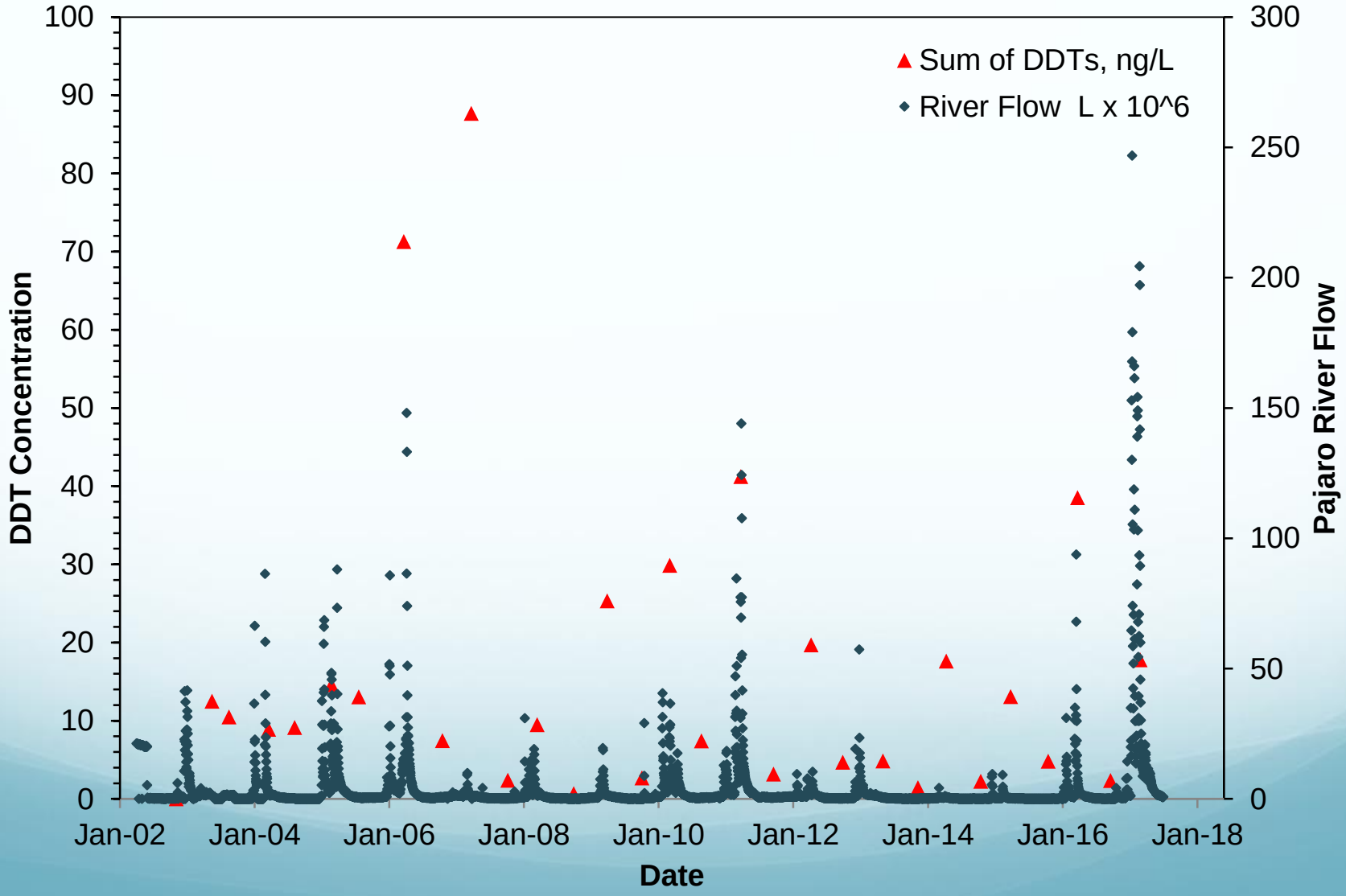
1985 Sediment vs Pajaro



DDT Conclusions

- Effects of rainfall on DDT concentrations and DDT's affinity for sediment particles suggests erosion is the primary cause of elevated wet-season DDTs in the Pajaro River
- Discharges of DDTs from the Pajaro River are associated with high concentrations in ocean water and shellfish
- Pajaro River wet-season average proportions of DDTs are significantly similar to agricultural sediments from 1985, suggesting continuing erosion of agricultural soils
- Downward trends in Pajaro River DDT concentrations over time are not significant

DDT and River Flow



DDT and Rainfall