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## Background

*S. neurona* is a protozoan parasite that can infect a wide range of terrestrial and aquatic mammals. Sarcocystosis often manifests as encephalopathy; however, in California sea lions (*Zalophus californianus*), *S. neurona* has been found to manifest as polyphasic rhabdomyositis. Studies of sea otters suggest that marine mammals may be exposed to *S. neurona* through land-to-sea transmission of sporocysts shed by the definitive host, the Virginia Opossum (*Didelphis virginiana*).

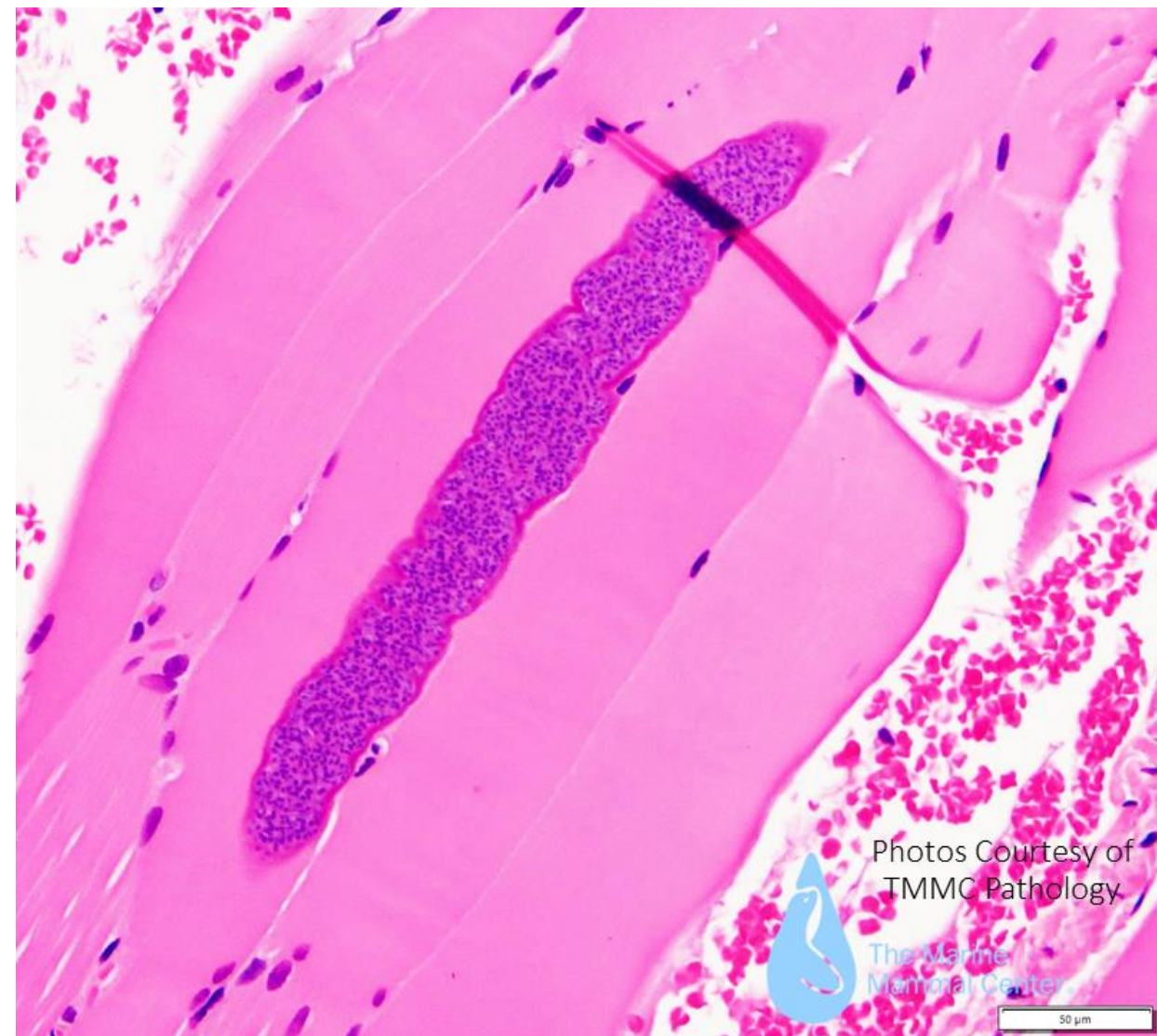


Figure 1: Histological image of a sarcocyst in a CSL myocyte



Figure 2: Gross necropsy image of megaesophagus in a CSL with sarcocystosis

## Rationale and Objectives



Seroprevalence study (1998-2009) found overall seroprevalence of 0.5% for juvenile CSLs



TMMC observations: increased CSL strandings and sarcocystosis

This study aimed to investigate whether California sea lion (CSL) exposure to *Sarcocystis neurona* has increased during the past decade and to evaluate potential risk factors associated with *S. neurona* infection.

## Methods

Archived serum samples from CSLs that stranded to The Marine Mammal Center (TMMC) from 2012-2017 were stratified by age-sex class and tested for antibodies to *S. neurona* using indirect fluorescent antibody testing (IFAT). 20 samples were randomly selected per age-sex class (pups: 0-1 years, yearlings: 1-2 years) per year (n=454).

Statistical analysis of risk factor association was performed using chi square and logistic regression. Environmental and demographic risk factors included total yearly rainfall, average yearly streamflow, average yearly sea surface temperature, age, sex, and stranding location.

## Results

### Serosurvey

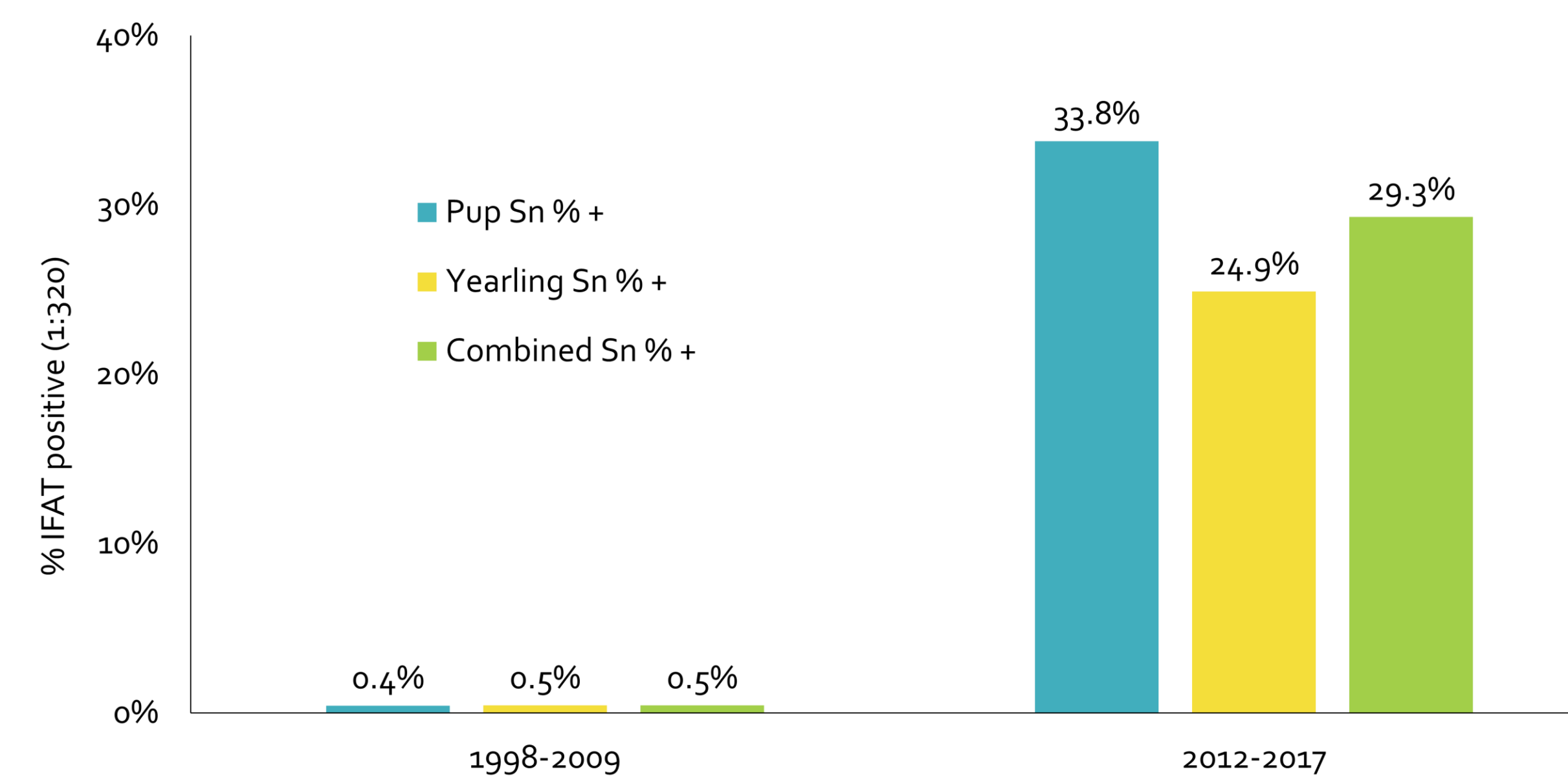


Figure 3: Seroprevalence of *S. neurona* in CSLs in a previous study (1998-2009) and our current project period (2012-2017).

Seroprevalence significantly ( $P < 0.001$ ) increased in 2012-2017 compared to the previous study period (1998-2009).

### Environmental and Demographic Risk Factors

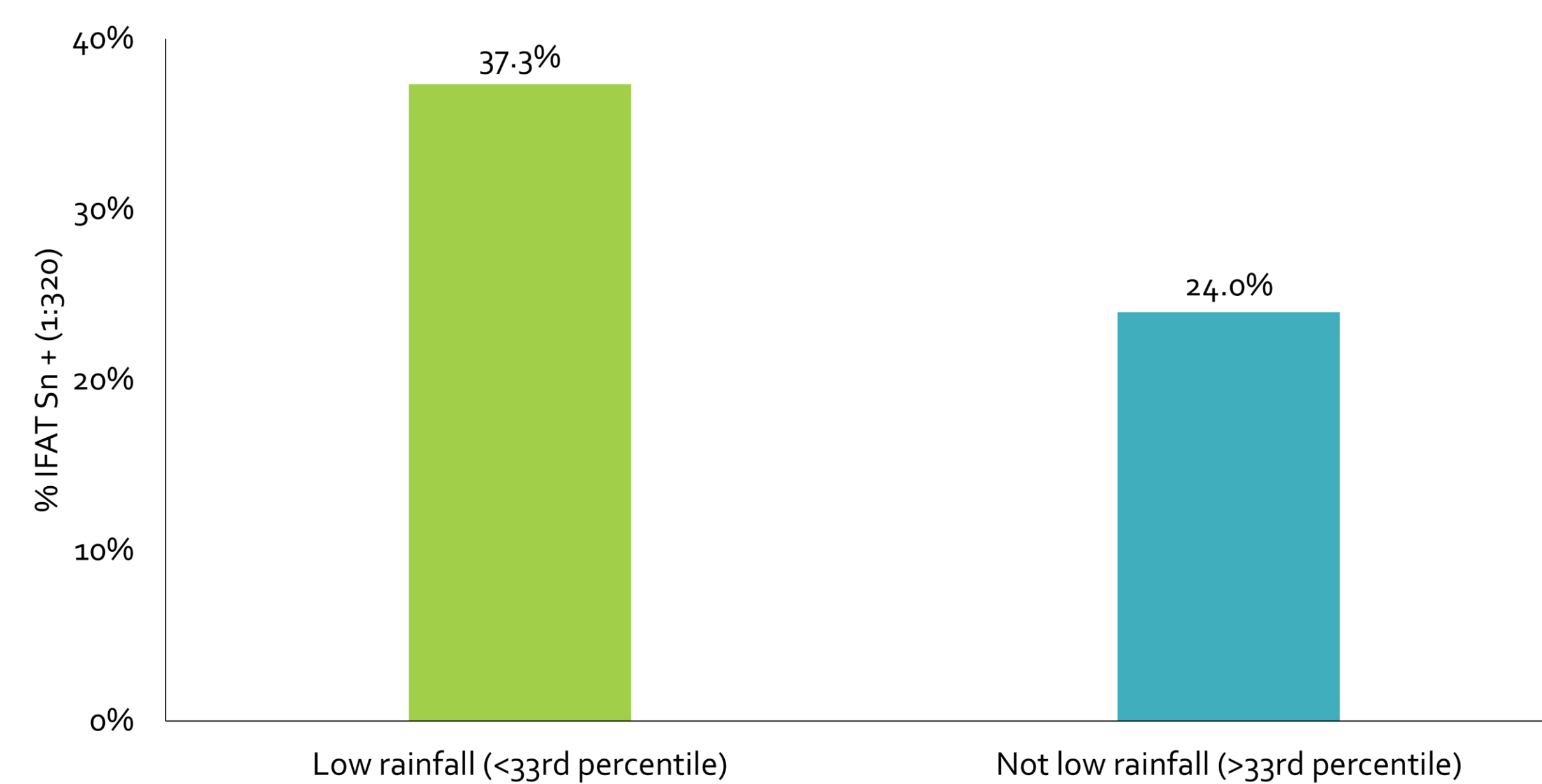


Figure 4: Seroprevalence of *S. neurona* in CSLs during years of low rainfall (<33rd percentile total rainfall (mm) per year) and years when rainfall was not categorized as low (> 33rd percentile).

Seropositivity was significantly higher ( $p=0.003$ ) in years with less rainfall (<33rd percentile of total yearly rainfall in the study period)

Table 1: Environmental and demographic risk factor analysis

| Risk variable         | Reference       | P Value      | OR (95% CI)                  |
|-----------------------|-----------------|--------------|------------------------------|
| <b>Age (pup)</b>      | <b>yearling</b> | <b>0.038</b> | <b>1.50 (1.004-2.360)</b>    |
| Sex (female)          | male            | 0.407        | 1.19 (0.792-1.778)           |
| <b>Rainfall (low)</b> | <b>not low</b>  | <b>0.003</b> | <b>1.90 (1.233 to 2.899)</b> |
| Streamflow (low)      | not low         | 0.072        | 1.47 (0.965 to 2.226)        |
| SST (not high)        | high            | 0.428        | 1.20 (0.760 to 1.907)        |

## Discussion

### Key Findings

- Seroexposure to *S. neurona* in juvenile CSLs increased significantly in 2012-2017 compared to the previous study period (1998-2009)
- Pups had significantly higher seropositivity than yearlings
- Decreased rainfall was associated with increased seroprevalence

### Discussion

Increased seroexposure could be due to:

- Shift in prey availability
  - Abnormal warm water event led to decreased prey availability and CSL Unusual Mortality Event (2013-2016)
- S. neurona* definitive host population dynamics
  - Varied environmental conditions may lead to increased opossum populations and parasite shedding

### Limitations

- Time constraints: limited study period/population
- CSLs are migratory (difficult to determine location of exposure)
- Serologic exposure does not equal disease
- Rehabilitation population does not reflect wild populations

### Future Directions

- Expand study period (2010-2019, all age classes)
- Other environmental risk factors: harmful algal blooms, fires
- Risk factor association with clinical disease/death due to *S. neurona*

## Acknowledgements

Financial support was provided by the Students Training in Advanced Research (STAR) Program through a UC Davis School of Veterinary Medicine Endowment Fund

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Miller, M.A., et al., 2002. Evaluation of an indirect fluorescent antibody test (IFAT) for demonstration of antibodies to *Toxoplasma gondii* in the sea otter (*Enhydra lutris*). *Journal of Parasitology*, 88(3), pp. 594-599.

