Effects of Low Oxygen on Pacific Staghorn Sculpins and Olympia Oysters

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Introduction

- Elkhorn Slough is an estuary in central California located in a productive agricultural watershed
- The estuary hosts rich plant and animal communities, but monitoring has revealed that **water quality** at some sites is very **impaired**
- Sites at Elkhorn Slough exceed limits for nutrient concentrations, algal cover, chlorophyll a, and dissolved oxygen (Hughes et. al)
- A common **ecosystem response** from low dissolved oxygen is **mortality** of benthic organisms (Diaz and Rosenberg 2008)
- For surviving organisms, they experience sublethal stressors including **impacts on growth** and reproduction (Vaguer-Sunyer and Duarte 2008)
- No previous data has been collected linking water quality with estuarine species survival at Elkhorn Slough
- We examined the effects of low dissolved oxygen on two common estuarine species

Objectives

1. Characterize variation in dissolved oxygen conditions across different sites within the estuary
2. Determine whether low dissolved oxygen causes mortality in sculpins or oysters, and growth rate of oysters

Study Site

Six sites were selected with varying water quality. Eutrophication expression was scored based on indicators including algal cover and dissolved oxygen (Hughes et al. 2011). (Figure 1). Sites with a high expression are indicated in red, low in green.

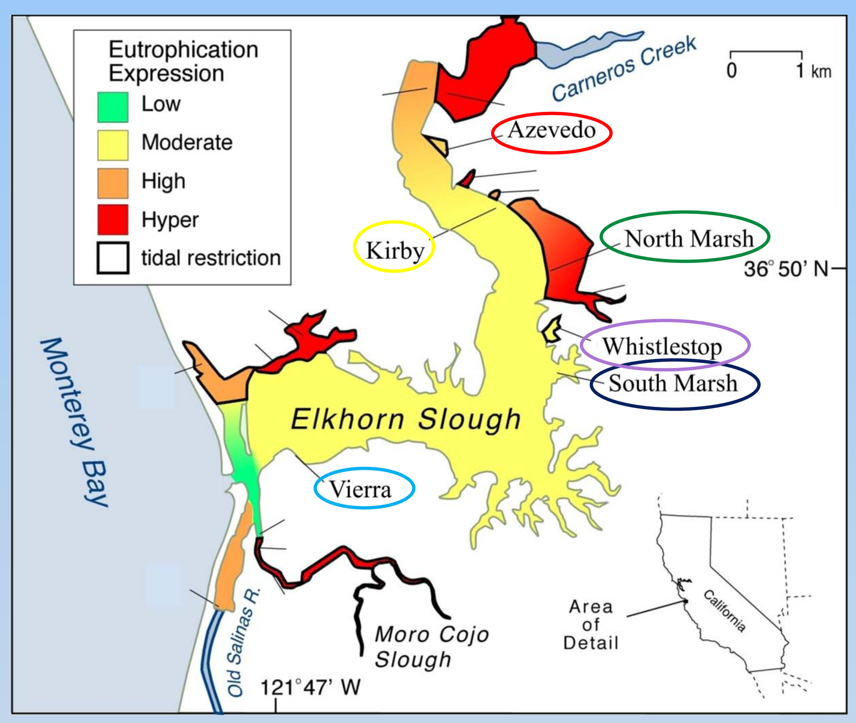

Figure 1: Study sites located along Elkhorn Slough. Site names are colored according to the same scheme as is used in the results.

Study Species

Two contrasting taxa, a fish, and invertebrate were selected as indicators of estuarine community response to oxygen conditions.

Pacific Staghorn Sculpin

- Benthic fish common at Elkhorn Slough
- Known to **tolerate variable temperature and salinity conditions**

Olympia Oysters

- Important bivalve found on rocky substrate at Elkhorn Slough
- **Broad temperature and salinity tolerances reported**

Methods

Each Site Contained

- A multiparameter sonde
- 2 closed minnow traps containing 2 sculpin were attached with nylon rope to a PVC stake
- 5 oysters placed in a mesh suet bag attached to the rope

Procedures

- Fish were given algae once a week for food
- Fish checked every other day
- Oysters checked once a week
- Oysters were measured before and after the experiment
- Dates of sculpin experiment: 7/20-8/19
- Dates of oyster experiment: 7/20-10/10

Results: Dissolved Oxygen Conditions and Survival

Survivorship of Indicator Species Was High

- Most sculpins and oysters survived despite variation in dissolved oxygen (Table 1)
- **All four fish died at Azevedo**, the site with the longest duration of hypoxia, only 3 days after start of experiment

Table 1: Survival of sculpin and oysters

	Sculpin		Oysters	
Site	Days Survived	Number Survived	Days Survived	Number Survived
Azevedo	3	0	83	5
Kirby	24	4	83	5
North Marsh	24	4	83	5
South Marsh	24	4	83	5
Vierra	24	4	83	5
Whistlestop	24	4	83	2*

*3 oysters were eaten

Hypoxia Duration Varied Among Sites

- Azevedo had by far the longest average hypoxia (<1mg/L oxygen) duration (Figure 2)
- Sculpin apparently **cannot survive extended hypoxia events**, but can survive short events

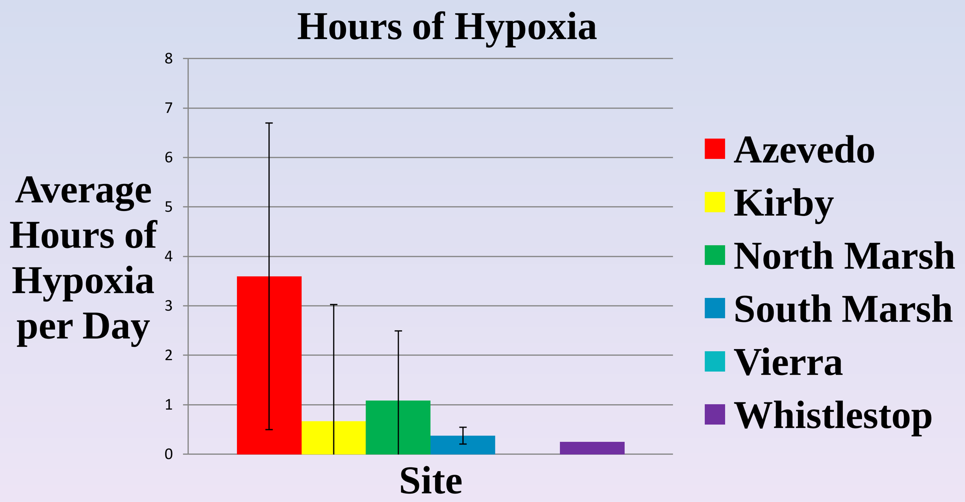

Figure 2: Average duration of hypoxia events during July 20th – August 3rd.

Diurnal Fluctuation Varied by Site

- Dissolved oxygen is much more **variable at Azevedo** than at Vierra (Figure 3)
- Hypoxic conditions occur every night at Azevedo

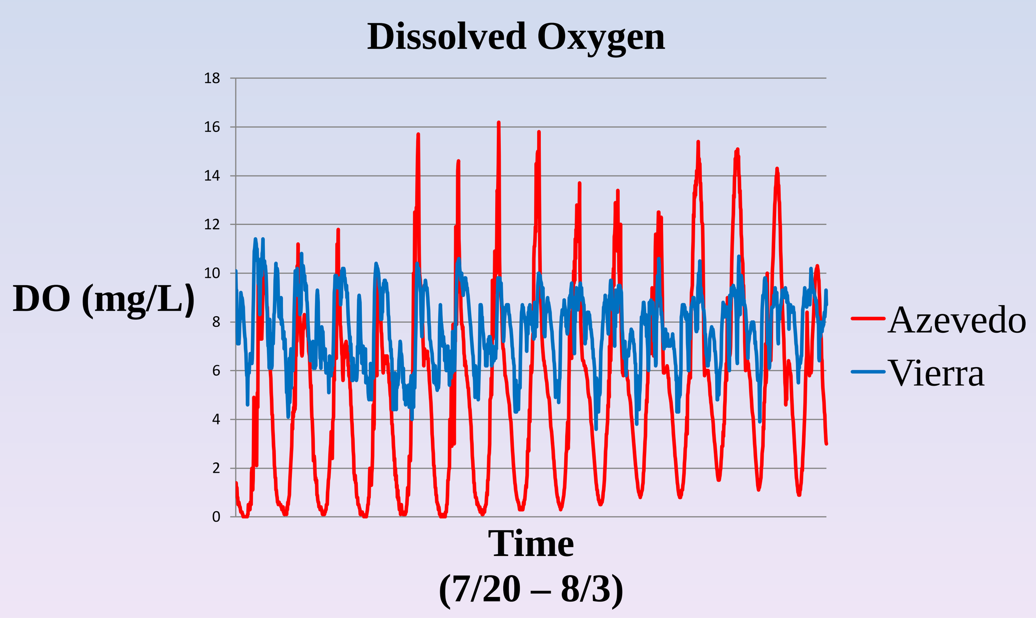

Figure 3: A comparison between Azevedo and Vierra over about two weeks (each hypoxic event at Azevedo represents one night).

Results: Growth

Growth Rates Among Sites:

- Oysters **grew the least at Azevedo**, the same site where the sculpins died. Growth at this site was close to zero, perhaps because oysters had closed shells and could not feed during hypoxic periods
- Oyster growth was variable at the other sites, and did not correspond closely to hypoxia duration

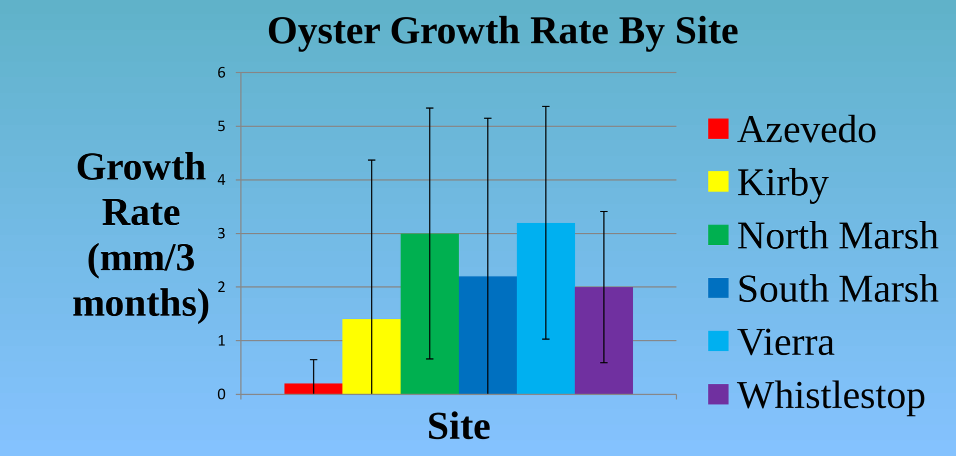

Figure 4: Average growth rates of oysters per site

Conclusion

- Water quality is very degraded at some sites at Elkhorn Slough, which have nightly hypoxia events
- Staghorn sculpins and oysters **can withstand low oxygen** conditions, including periods below 1 mg/L dissolved oxygen
- Despite generally high tolerance, staghorn sculpins were shown to be **vulnerable to periods of >3 hrs of hypoxia**
- While Olympia oysters survived low oxygen, their growth rate slowed to near zero at the site with most extended low oxygen
- Therefore, **eutrophication can negatively affect even tolerant estuarine species,** with lethal effects on sculpin and sublethal effects on oysters

Future Research

- Exact hypoxia tolerances of sculpins could be determined with laboratory experiments
- Longer term field experiments with sculpins could be used to examine sublethal effects of low oxygen, such as decreased growth or fecundity
- Other parameters besides dissolved oxygen should be correlated with oyster growth. For instance, the variable growth rates obtained among sites may be related to temperature or chlorophyll

References

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- Vaquer-Sunyer R, Duarte CM. 2008. Thresholds of hypoxia for marine biodiversity. PNAS 105(40): 15452-15457.