INFLUENCE OF HARMFUL ALGAL BLOOMS ON THE FORAGING BEHAVIOR OF SHOREBIRDS IN CENTRAL CALIFORNIA

Carrie Bretz, Kate Thomas, Rikk Kvitek, Finnegan Barry- California State University Monterey Bay

Abstract

We tested the general hypothesis that the foraging behavior and distribution of shorebirds under natural conditions are mediated by benthic prey toxicity due to harmful algal blooms (HAB's). In California, observed changes in shorebird (mainly Oystercatchers, Willets, Godwits and Whimbrels) feeding behavior was correlated with seasonal changes in paralytic shellfish poisoning toxins in their primary prey, sea mussels (*Mytilus californianus*) and mole crabs (*Emerita analoga*). In rocky habitats where mussel toxicity exceeded 150µgSTX/ 100g, Oystercatchers significantly increased their consumption of limpets as well as their discard rate of mussel tissue. In sandy beach habitats where *Emerita* toxicity exceeded 150µgSTX/ 100g, shorebird abundance decreased significantly, while their rejection rate of *Emerita* prey increased significantly.

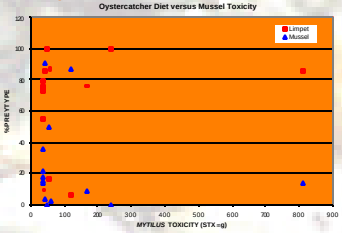
Approach

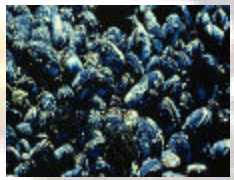
Shorebirds and seasonally toxic prey in California

Our general approach was to document and correlate changes in the foraging behavior of free-ranging avian predators with seasonal changes (spatial and temporal) in harmful algal bloom (HAB) related toxicity of their invertebrate prey in two different habitat and community types. Habitats included: 1) Rocky shores where Black Oystercatchers (*Haematopus bachmani*) forage primarily on sea mussels (*Mytilus californianus*), and, 2) Exposed sandy beaches where a diversity of shorebirds forage on extremely abundant mole crabs (*Emerita analoga*). Each of these prey species are known to accumulate PSPT during HAB events. These two systems provided ideal study sites for determining the ecological role of phytotoxins in benthic communities. Pairing each sandy site with a rocky site separated by only a few hundred meters not only minimized field effort, but enabled comparisons of prey toxicity and predator behavior in different habitat types exposed to very similar bloom conditions. Although shellfish at the proposed study sites generally exceed the state quarantine level for PSPT toxicity every year (80µg STX/100g - STX is saxitoxin, the most potent compound in the PSPT toxin profile), it is also true that more intense toxic phytoplankton blooms occur at random locations along the California coast nearly every year.

The sites (north to south): Limantour Beach, Pescadero Beach, Pebble Beach, Pfeiffer State Beach have historically exhibited a latitudinal gradation in toxicity from the north to the south. Therefore, Limantour and Pescadero beaches were considered "toxic" sites, while Pebble Beach and Pfeiffer were considered control areas.

Hypothesis 1 results- Birds switch to alternate prey at high prey toxicity

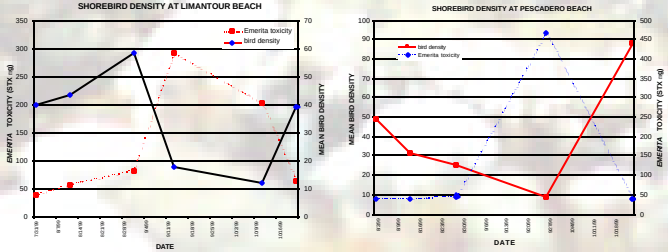




Mussels (*Mytilus* spp.) have very fast uptake and depuration times for PSPT. They are one of the first species to become toxic during a bloom, often attaining very high levels within hours of exposure, but are generally back below detectable toxin levels within a few weeks following the bloom.

Oystercatcher diet changed significantly with an increase in the toxicity of *Mytilus californianus*. Oystercatchers ate significantly more limpets when mussel toxicity exceeded 150 µg STX/100g. At toxin levels below this value there was no significant difference in the number of mussels and limpets eaten by Oystercatchers.

Hypothesis 2 results- Birds densities are locally reduced during periods of high prey toxicity



Shorebird abundance on sandy beaches declined significantly when *Emerita* prey toxicity exceeded 150 µg STX/100g at Limantour and Pescadero ("toxic sites"). Non-toxic control sites (not shown) showed no decline in bird abundance during the same time period.

Hypotheses

How does the seasonal increase in prey toxicity due to PSPT producing HAB's influence the foraging behavior of avian predators?

- H_1: Avian predators switch to alternate prey at a predictable toxicity threshold.
- H_2: Avian predators leave the area at a predictable toxicity threshold.
- H_3: Avian predators reject prey containing concentrations of toxins above a threshold level.

Conclusions

Shorebirds reduce their exposure to PSP toxins during HAB events by,

- changing their diet
- discarding toxic prey
- avoiding effected areas

These behavioral responses may account for the rarity of shorebird mortality due to HAB's.

Methods

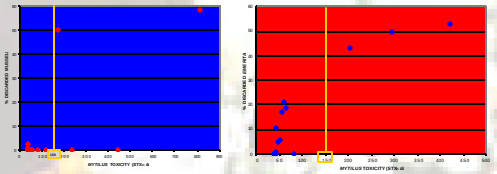
Field Data

Observations of foraging birds were made every two weeks during the lowest tides of the month at pre-selected rocky and sandy beach sites from April through October. Foraging data was collected using a "continuous focal sample" method. Type and duration of the bird's activities were recorded to the nearest second, as well as habitat used, and weather and surf conditions. Major activity categories included: searching, prey handling, inactive periods of foraging due to wave interruption, resting, interacting with other birds (especially kleptoparasitism), and out-of-view. All prey captured during a focal sample was identified and recorded. Rejection and partial consumption of prey was also noted.

Toxin analysis

Representative samples of prey (sea mussels and mole crabs), were collected during each sampling period for PSPT analysis. These samples were handled and processed according to California State Department of Health Services (CDHS) shellfish monitoring protocols, and analyzed for PSPT by CDHS using the standard mouse bioassay.

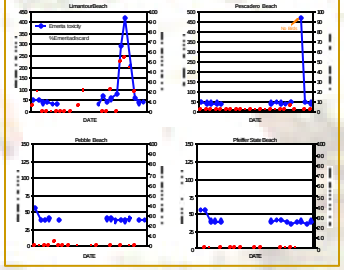
Hypothesis 3 results- Birds discard a significantly greater percentage of captured prey at higher toxicity



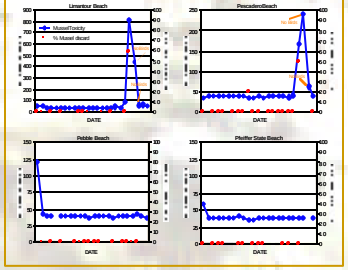
At higher toxicity (levels 150mg STX/100g) both Oystercatchers and shorebirds discarded captured prey at significantly higher rates. Figures show results pooled for all sites and dates.

Little attention has been paid to the fact that mole crabs (*Emerita analoga*), one of the most important and abundant bird prey resources along Pacific beaches, accumulate PSPT as rapidly as do mussels.

Sandy Beach Shorebird /*Emerita*discards



Oystercatcher /*Mytilus* discards



Prey discard patterns for individual sites are shown above. Discard rates generally increase as prey becomes toxic and decrease as prey toxicity is reduced. During periods of highest prey toxicity birds were often absent at Limantour and Pescadero sites.

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