From Research to Management:
Can bloom models predict shellfish toxicity?

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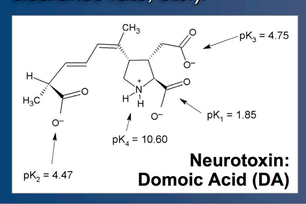
Management Issue:
Domoic Acid (DA) toxicity in shellfish

Pseudo-nitzschia is a diatom genus commonly found along the California coastline. Toxigenic species of *Pseudo-nitzschia* produce the neurotoxin domoic acid (DA); when toxigenic *Pseudo-nitzschia* proliferate ('bloom'), this toxin can accumulate in shellfish to significant levels. The statewide Marine Biotoxin Monitoring Program (a division of the California Department of Public Health) protects public health from the threat of shellfish biotoxicity by monitoring sentinel shellfish maintained at numerous coastal locations throughout California. While this program has been successful in its mission of public health and safety, it relies upon the institution of an annual sport harvest quarantine for 6 months of the year (May 1 through October 31) and year-round sentinel shellfish monitoring. As such, the program is constrained spatially (sentinel shellfish can only be deployed where they can grow), analytically (biotoxin analysis in shellfish is expensive and analysis of a biological matrix can be problematic) and according to our incomplete understanding of toxin dynamics in shellfish (e.g. uptake rate, clearance rate, etc.).



Objective:
Evaluate model utility according to management needs

Now, two years after their development, we have an opportunity to apply the models towards new observational data from a shared (UCSC and CDPH) monitoring station in northern Monterey Bay (Santa Cruz Municipal Wharf, SCMW). This application exercise allows us to answer the following questions:

Questions:

1. Do the models predict *Pseudo-nitzschia* blooms at SCMW?
2. How do predictions from regional models time with bloom observations at SCMW, a single monitoring site within the model domain?
3. Are the models useful for management purposes, namely (a) the prediction of DA toxicity in SCMW sentinel shellfish, or (b) DA detection by Solid Phase Adsorption Toxin Tracking (SPATT; a passive sampling technology designed for deployment as a 'man-made' sentinel shellfish)?

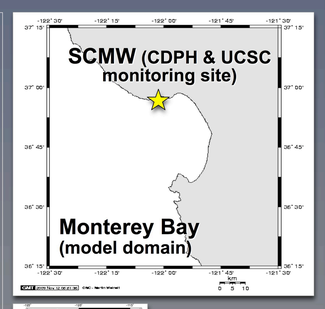


Figure 1: Maps of study location.

Research Tool:
Predictive models of toxigenic blooms

A recent publication in *Marine Ecology Progress Series* describes models which were developed for the prediction of toxigenic *Pseudo-nitzschia* blooms in Monterey Bay, California (Lane et al., 2009). Model validation against 'unknown' (future) blooms demonstrated a predictive success rate of greater than 75% for their regional application. The question we commit to here is: *Although these models were developed for the prediction of regional Pseudo-nitzschia blooms, can they be useful tools when applied towards a related, 'real-world' management purpose, i.e. the anticipation of localized shellfish toxicity at a pier-based sentinel shellfish monitoring site?* Through their employment for this unintended purpose, can the models inform or predict within this context, imparting an advantage to managers which is not otherwise available?

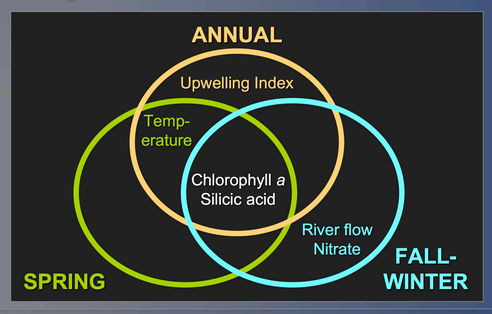


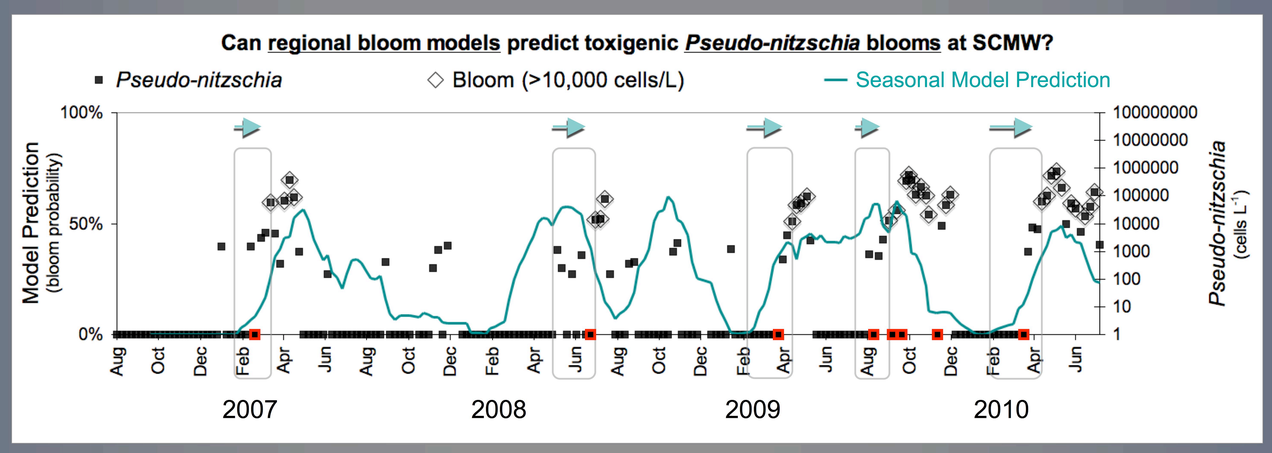
Figure 2: The 3 models and their variables (i.e. 'bloom factors').

Annual: Year-round
Spring: Feb 14 - June 30
Fall-Winter: July 1- Feb 13

1. Do the models predict *Pseudo-nitzschia* blooms at SCMW?

Predictive value at SCMW

	Annual model	Spring model	Fall-Winter model
Do the models improve our ability to anticipate blooms at SCMW?	Yes	Yes	Yes
By how much? i.e. How much better is model prediction vs. 'playing the odds'?	28%	61%	18%

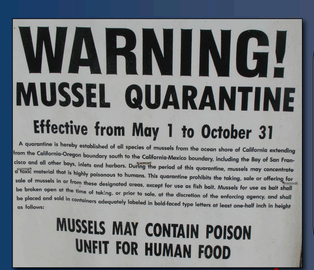


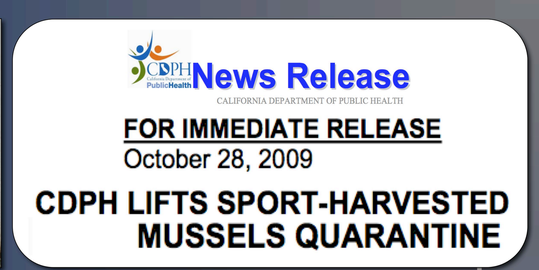
2. How do predictions from regional bloom models time with bloom observations at SCMW?

- Bloom predictions precede bloom 'arrival'.
  Models begin signaling favorable bloom conditions prior to the observation of increasing toxigenic cells.
- Cell counts can remain low (or at zero) up to the week before bloom 'arrival', thereby providing no advance warning of a bloom event.

3a. Are the models useful to managers for the prediction of shellfish toxicity at SCMW?

Yes (e.g. 2009)


WARNING!
MUSSEL QUARANTINE
Effective from May 1 to October 31
A quarantine is hereby established of all species of mussels from the ocean shore of California extending from the California-Oregon boundary south to the California-Mexico boundary, including the Bay of San Francisco and all other bays, inlets and harbors. During the period of this quarantine, mussels may concentrate a toxic material that is highly poisonous to humans. This quarantine prohibits the taking, sale or offering for sale of mussels in or from these designated areas, except for use as fish bait. Mussels for use as bait shall be broken open at the time of taking, or prior to sale, at the discretion of the enforcing agency, and shall be placed and sold in containers adequately labeled in bold-faced type letters at least one-half inch in height as follows:
MUSSELS MAY CONTAIN POISON
UNFIT FOR HUMAN FOOD


News Release
CALIFORNIA DEPARTMENT OF PUBLIC HEALTH
FOR IMMEDIATE RELEASE
October 28, 2009
CDPH LIFTS SPORT-HARVESTED MUSSELS QUARANTINE

2009 →

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Oct 19 - Dec 22
Toxic shellfish!

Fall 2009 toxicity event

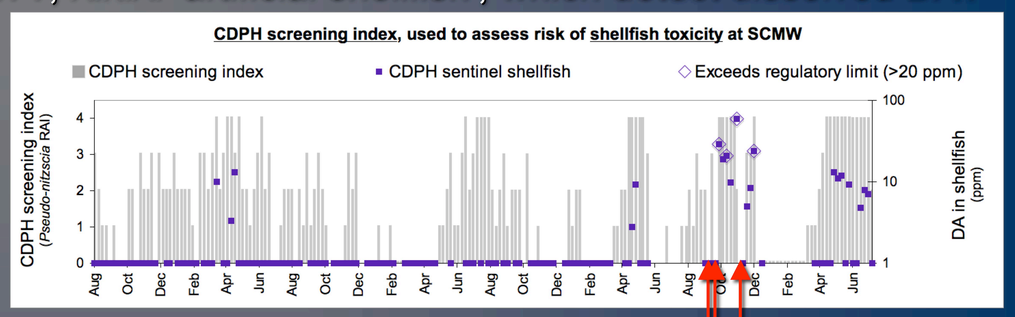
- Fall-Winter model predictions increased in Sept/Oct, preceding mussel toxicity.
  - The model predicted blooms through December, predicting mussel toxicity during the quarantine 'off-season'.

Sept 15 . 23%
Sept 23 . 60%
Sept 29 . 88%
Oct 5 . 99%
Fall-Winter model

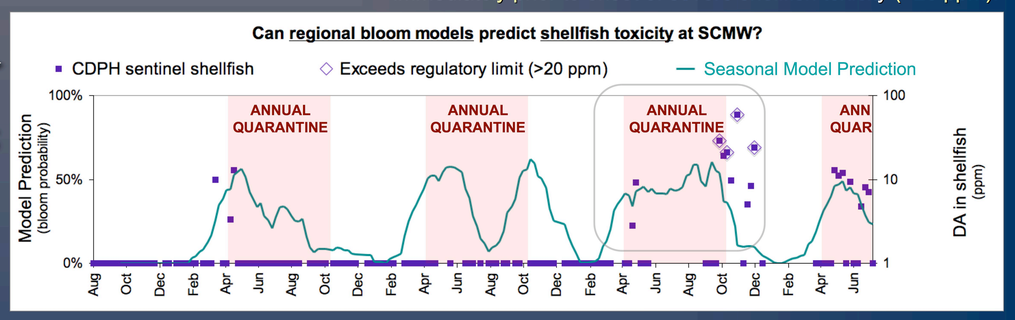
News Release
CALIFORNIA DEPARTMENT OF PUBLIC HEALTH
FOR IMMEDIATE RELEASE
November 13, 2009
CDPH WARNS CONSUMERS NOT TO EAT SANTA CRUZ COUNTY SPORT-HARVESTED SHELLFISH

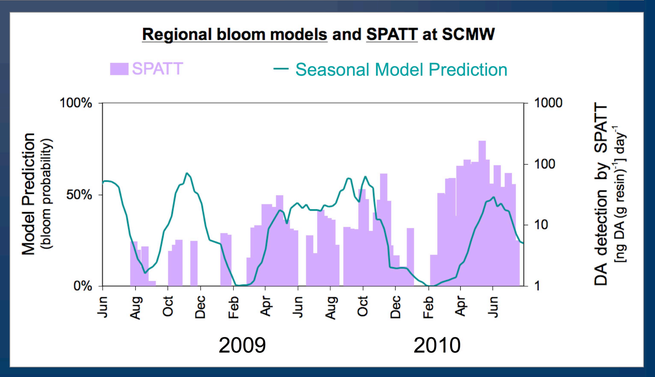
3b. How do the models compare with the CDPH risk assessment strategy? And with SPATT, A.K.A. 'artificial shellfish', which detect dissolved DA?

- The current screening index (RAI) describes risk for the discrete time and place of sample collection.
- RAI is conservative, but still failed as an indicator of impending toxicity.
- Shellfish at SCMW exceeded regulatory levels once (Fall 2009); regional models anticipated this toxicity event.
- Unlike RAI (resolves a discrete sample), the models resolve broad spatial dynamics (regional, environmental). As an integrative sampler, SPATT monitors DA through time (across a week, as deployed at SCMW).
- Model predictions and SPATT data match very closely; the two technologies simultaneously signal bloom conditions (models) and toxin incidence (SPATT) which are otherwise unrecognized and/or unanticipated by RAI, cell counts, etc.



Red arrows indicate RAI = 0 ('zero risk') assessments, recorded immediately prior to onset of severe shellfish toxicity (>20 ppm).





References
Lane JQ, Raimondi PT, and Kudela RM (2009). Development of a logistic regression model for the prediction of toxigenic *Pseudo-nitzschia* blooms in Monterey Bay, California, Marine Ecology Progress Series, 383, 37–51.
Lane JQ, Roddam CM, Langlois GW, and Kudela RM. Application of Solid Phase Adsorption Toxin Tracking (SPATT) for field detection of the hydrophilic phycotoxins domoic acid and saxitoxin in coastal California. Limnology and Oceanography: Methods. In press.

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