

Solving the Mystery of Red Tides in Santa Cruz:
Dinoflagellates, Oceanography, Wildlife and Human Health

MBARI
December 17, 2007
10am – 12:30pm

Attendees:

Dave Jessup, CA DFG; OSPR
Jeff Paduan, NPS and COCMP
Steve Peters, SC County of Environmental Health
Elizabeth Phillips, CA DFG and BeachCombers
Heather Kerkering, CeNCOOS
Raphael Kudela, UCSC and CIMT
Melissa Miller, CA DFG; OSPR
Steve Ramp, CeNCOOS and MBARI
Rondi Robison, CIMT
John Ryan, MBARI
Tom Wadsworth, CeNCOOS

A group of representatives from various organizations in the Monterey Bay area met to discuss data collected during a recent and strong red tide which occurred in the northern section of Monterey Bay throughout much of November. Each participant provided different data sets in an attempt to discover any correlations during the red tide event between oceanographic processes and conditions with wildlife and human health.

Following introductions, Dave Jessup led the discussion with a powerpoint presentation which provided a time reference of the major recent oceanographic events in Monterey Bay and surrounding areas and the dates of seabird and marine wildlife stranding peaks. Much discussion ensued and each researcher had an opportunity to share their data and provide input into solving the ‘mystery.’

Overall agreement and decisions:

- Stranded birds were coated with a ‘mystery’ substance associated with the foam produced during the recent red tide events. The coating was not a result of an oil spill.
- *Akashiwo* is the dinoflagellate associated with the recent red tide. The red tide was not toxic although it may have provided the ‘wetting agent.’
- This is a very unique event. Very little historical data exists from a similar event October 27-28, 1997. Steve Peters acknowledged a similar red tide event (and associated human health issues) from the early 1980s – possibly *Akashiwo*.
- It is worth further investigating the chemical components of the red tide and the Light Brown Apple Moth (LBAM) spray, Checkmate.

- Need to determine the protein in the coating substance, the red tide and associated foam, and the LBAM spray. Is there a specific amino acid, MAA, or protein responsible?
- Oceanic trends suggest later and stronger upwelling conditions and red tide events in Monterey Bay since 2000. The northeast corner of Monterey Bay is susceptible to red tide events. Although there are known hotspots, the appearance and characteristics of red tides can change daily. The movement and flow of red tide in the Bay is influenced by a number of ocean and atmospheric processes including variability in wind relaxation and rain events. Physical processes within the bay can concentrate blooms.

FOAM: contains a protein not normally found in seabirds; MAA found in foam but not in water samples from the SC wharf.

LBAM: loaded with triphosphates and surfactants; low urea levels (please see additional attached document).

Action Items:

- Questions to answer: What is the protein and molecular structure? What is the product or by-product of *Ashikawo*? Is MAA a potential cause? Is Monterey Bay predisposed to events? What can we gather from past events?
- Dave, Raphe and Melissa will try to obtain an additional sample of the LBAM spray from the County or possibly the Regional Water Quality Control Board (Karen Worcester). Additionally, we will try to determine the amount and concentration of the spray as well as the area covered using connections to the County and the Department of Agriculture.
- Raphe will try to determine if there is a relationship between the sprayings and phosphate levels in the ocean. LBAM is loaded with triphosphate and surfactants. The levels of urea are too low to have a large impact.
- Raphe will try to determine if other labs are available to do an analysis and will talk with Scripps about previous analysis on red tide “foam”.
- Beth and Hannah (Beth volunteered you) will search for specimens from the 1997 event for testing (bacterial polysaccharide? protein? carbohydrate?) and comparison to the coating associated with this event.
- Rondi Robison will gather CIMT ship survey data regarding species distribution
- Melissa Miller will ask UCSC researchers about additional LBAM spray analysis
- We will all share our findings and information.
- CeNCOOS will continue to coordinate the response effort and include everyone involved.
- We will not reveal any other information to the public or scientific journal until the protein is identified.

Information we have/can collect to aid in the investigation:

- MERIS and additional satellite imagery demonstrating areas of increased productivity and actual bloom events.
- Surface current velocities and overall ocean/tidal flow

- BeachComber data on historical trends in bird strandings and peaks.
- Ship survey including species distribution
- Checkmate (LBAM) sample for analysis (one lab analysis showed that the product has no water soluble components).
- Many coated bird feathers and stranding data
- Phytoplankton surveys by the SC Environmental Health Department.
- Historical oceanographic data showing occurrence and patterns of red tides in Monterey Bay.
- MBARI and LOBO mooring data and wind conditions in the Monterey Bay area

Pattern of events (Dave has a great powerpoint. I haven't captured the events as well, so I will distribute the powerpoint when I get a hold of it).

November 3rd: Offshore bloom detected in northern Monterey Bay

November 5: The “mystery spill” was first spotted in southern Monterey Bay off Pajaro Dunes by a group of scientists conducting a sea otter aerial count.

November 6: Cosco Busan oil spill in San Francisco Bay

November 7-13: Seabird strandings along Sunset and Manresa beaches (~50) involving mostly near shore diving ducks such as surf and white-winged scooters).

November 11-12: rain pulse; nutrient pulse in the Slough

November 14th: Red tide in northern Monterey Bay

November 19th: Active bloom detected

November 20-21st: Fulmar stranding peak on the beaches around Marina. Mostly YOY birds (135 live birds and over 50 dead). Many beach cast sardines appeared on these beaches the same days.

November 26-29th: 3rd Seabird beaching peak in Moss Landing/Santa Cruz/Capitola (more northern sections of the bay) areas which included a diversity of seabird species (150 grebes, scooters, loons and pelican).

Seabird Health

Total live stranded birds: 550

In general, most of the birds were suffering from prolonged starvation. Starvation occurred due to the product coating the feathers, as blood values in the birds were normal.

All of the birds had lost waterproofing (generally a result of an oil spill) but the product at first seemed somewhat stickier, oilier and smelled of fish. It also left a yellow/green stain. As the event progressed, these characteristics seemed to decline. The product

washed off very easily and seemed to be more water soluble than any oil experienced in the past (even the oil in the 1997 Monterey Bay 'mystery spill').

Recovery of the stranded seabirds fell in the range of 60-70%. This range is much higher than the percentage of recovery with oiled birds.

Beth Phillips provided additional information regarding the migration, health and feeding habits of the stranded birds. This information is useful when looking at the location of red tide foam lines both near shore and offshore and for assessing the normal condition of birds during this time of year.

Corresponding ocean physical properties and circulation:

Raphe Kudela provided satellite imagery (fluorescence line height data), SST and HF radar surface current vectors for the dates Dave highlighted (Nov. 3, 12, 14, 22). The data indicates that the general patterns were moderately cool water on Nov 3 with weak circulation. The blooms were northern bay, away from the shore. By Nov 12, there was a strong recirculation in the Bay, with a very distinct front. This would be consistent with birds washing up on the more northern beaches, and also with the red tide moving around Pacific Grove to Carmel. Nov 14, the circulation pattern was similar, but the south bay was clearing while the north bay (Manresa, Santa Cruz, etc) had strong onshore propagation of the red tide (and probably birds). By Nov 22, the bloom had dissipated but is still forming a "bathtub ring". From our SC Wharf sampling, there's still plenty of biomass but not red tide.

Raphe provided his bottom line interpretation: that the circulation patterns probably kept the red tide in a recirculation pattern within the bay, with generally nearshore northward transport.

Using the satellite imagery and model, Dave was able to predict the 3rd bird beachings event.

John Ryan also provided MERIS remote sensing data which indicates when a bloom is actually active. He found the largest peak on November 19th. The bird stranding peak on the 20-21st corresponds perfectly with this event as there is a usual 2-3 day lag time between when birds are affected and when they wash ashore. John also noted that satellite imagery cannot always pick up variability. Using MBARI mooring data, John noted a strong wind relaxation event followed by a warming event. These physical processes can influence tidal patterns and exchange.

Jeff Paduan provided surface current patterns within the bay during the past month. There is a distinct circulation pattern in the Bay, moving waters from the southern region to the northern region, with a stalled eddy in the northeastern corner of the bay. It is fairly common that water flowing from the Elkhorn Slough area moves northward and remains in a circulation holding pattern in the northeaster section of the bay. Currents within the bay can transport to this regional 'incubator.'

Additional information of interest:

- Oceanic trends suggest later and stronger upwelling conditions and red tide events in Monterey Bay since 2000. Red tides are occurring much later in the year than normally and have occurred every fall since 2004. Red tide events occurred in August (2004) and have occurred later each year (2007 – November/December).
- 8-9 sea otter deaths
- Record number of surfers and ocean-goers reporting illnesses to the SC Department of Environmental Health (sinus infections; eye irritation; skin rashes)
- Anchovy/Sardine beach castings during one event. It is difficult to link this to the tide and no boils were recorded near the piers.
- In a recent investigation by OSPR, fish-oiled pelicans were discovered near Moss Landing fish handling facilities.
- *Akishiwo*: reported to produce hydrogen peroxide and cause respiratory and skin conditions. When distributed by heavy wave action, it can exacerbate the situation and increase amounts.
- Almost impossible to associate agricultural runoff with blooms.
- A uncommonly high number of jellies were present during the red tide.

As I explain in the ppt, we use a "threshold level" - long-term mean
> plus 2* SD to determine an event a significant event. In this case,
> there were significant events in spring and fall of 2007 and for some
> species this may have been related to algal blooms.

There was more than one event in the Fall-Winter of 1997. In very late October a "mystery spill" (clear fishy smelling grasy product) like event centered on Manressa and Sunset beaches occurred involving around 500 grebes, scoters and loons. It may or may not have had a red tide connection or preceding event. It was over by about November 10, except for lost of birds still in care and being released. Interestingly enough it all ended about when a very big western Pacific storm came in just after Halloween.

Starting in mid to late November of 1997 we had a series of black oiled marine birds predominately common murre. This went on in several waves into January and this was eventually found to be due to the leaking sunken tanker Luckenbach which leaked oil when rocked and rolled by Pacific winter storms until 3-4 years ago when it was all figured and the Luckenbach was cleaned out.

Hi all,

I recently obtained data from MERIS, a European satellite sensor that is particularly well suited for identifying "extreme blooms". Thanks to Stephanie King and Jim Gower of IOS for production and use of this data, which spurs an update. Steph & Jim, we are investigating possible relationships between a very strong red tide bloom and seabird deaths that occurred last fall.

Attached is a MERIS time series from October - November 2007. Please do not distribute this, as the data belongs to Jim Gower and Stephanie King. According to Jim's published studies, values we see in red in these images correspond with extremely high surface chlorophyll concentrations. Notes:

1) October 2 was the first indication in 2007 MERIS data of an "extreme bloom".

2) Extreme bloom conditions were initially "anchored" to the coast near the Elkhorn Slough / Salinas & Pajaro River connections to Monterey Bay (October 2, 8 images). This followed shortly after the first rainy period of the year and an associated nutrient pulse (see other attached images). Following this rain, during 9/21 through 9/26, there was a period of elevated nitrate concentrations (25-70 uM) measured in the lower Slough, near where Elkhorn Slough / Salinas River waters enter Monterey Bay. The 70 uM pulse was the largest observed during September - November 2007. Perhaps nutrient flushing from agricultural land is strongest during the first significant rain event of the season? We are getting Pajaro River nutrient data for this period to see if a pulse from that source was resolved.

3) As we know, but MERIS describes very nicely, extreme bloom conditions persisted and expanded greatly during October and November.

Our drifter studies indicate that these coastal plumes (Elkhorn/Salinas & Pajaro) tend to be retained nearshore. A working hypothesis is that nutrients delivered by these coastal plumes can introduce perturbations to the nearshore phytoplankton community, for example pumping up a red tide bloom with nutrients. Such perturbations can propagate into coastal oceanographic dynamics that can cause bloom growth/spreading or decay/dispersion.