San Francisco Estuary Institute

7770 Pardee Lane, 2nd Floor • Oakland, CA 94621-1424
Office (510) 746-SFEI (7334) • Fax (510) 746-7300

Nutrient Strategy Session to Outline a Bay Monitoring Program
June 30th, 2011
SFEI First Floor Conference Room
7770 Pardee Lane, Oakland, CA
9:00 AM to 4:30 PM
DRAFT Meeting Summary

List of Attendees

Walter Boynton, Chesapeake Biological Laboratory
Jim Cloern, USGS
Maureen Downing-Kunz, USGS
Tom Gallagher, HDR/ Hydroqual
Kathy Hieb, CDFG
Wim Kimmerer, Romberg Tiburon Center
Raphe Kudela, UC Santa Cruz
Jim Kuwabara, USGS
Anke Mueller-Solger, IEP/DSC
Alex Parker, Romberg Tiburon Center
Dave Schoellhamer, USGS
Tara Schraga, USGS
Martha Sutula, SCCWRP
Jan Thompson, USGS

Amy Chastain, BACWA
Mike Connor, EBDA
Naomi Feger, SFBRQWCB
Arleen Feng, ACCWP /BASMAA
Terry Fleming, USEPA
Chris Foe, CVRWQCB
Tom Hall, EOA/ South Bay Dischargers
Karen Taberski, SFBRWQCB

Rachel Allen, SFEI
Jay Davis, SFEI
Thomas Jabusch, SFEI
Lester McKee, SFEI
Meg Sedlak, SFEI
Don Yee, SFEI

Via Telephone

Dick Dugdale, Romberg Tiburon Center
Chris Francis, Stanford
Stephanie Fong, CVRWQCB
Trish Mulvey, SFEI Board
David Senn, ETH Switzerland soon to be SFEI
Frances Wilkerson, Romberg Tiburon Center

1. Introduction and Goals

Jay Davis introduced the goal of the meeting as "high-powered brainstorming," focused on developing a strategy for monitoring nutrients in the Bay, but recognizing that the overall end product is a long-term, collaborative workplan for nutrient science, including both a sequence of steps and a budget. He emphasized the need to be specific as to what needs to be completed by when (in 2012, 2013, 2015, etc.). He also indicated that a considerable effort is being undertaken to develop Numeric Nutrient Endpoints (NNE) for San Francisco Bay and the two groups should try to work closely to avoid duplication of efforts.

One of the objectives for the day's meeting was to develop an RMP plan for nutrients for 2012 and beyond and to discuss additional partners/ sources of revenue to address this issue. The RMP has tentatively set aside funds for future years: 2012 ($100K), 2013 ($200K), and 2014 ($300K); however, a good plan will be needed to justify these expenditures.

The primary purpose of the end product will be to serve as a science strategy. The second purpose of the strategy will be to serve as a fundraising plan. To be successful in both, the nutrients strategy team will need to build a program that addresses multiple stakeholder groups. Jay also indicated that given the uncertainties of funding, the group will develop different levels of plans. He compared these plans with different types of cars: a minimal program - "Pinto"; a medium sized program – "Civic"; and a detailed deluxe version – "Tesla."

Naomi Feger identified the overarching question, as related to the assessment of beneficial uses: "Are beneficial uses impaired or is there a threat of impairment?" To answer this question, we need a good assessment framework and monitoring program.

2. Numeric Nutrient Endpoints and Information Needs

Martha Sutula focused her presentation on two key questions: 1) What is it that we need to assess nutrient impacts (eutrophication) in San Francisco Bay? and 2) How will a plan be developed? The starting point is assessing eutrophication versus other effects. Key to the NNE approach is to focus on loads rather than on concentrations per se.

In discussing how the San Francisco Bay effort is organized, she explained that the technical team is led by SFEI, with SCCWRP participating to ensure technical consistency.

Martha provided a brief overview of the San Francisco Bay framework, including habitat types considered and candidate indicators. Although there is an overarching framework for NNEs in California, there are specific candidate indicators for San Francisco Bay, such as ammonia and urea. Martha also discussed the indicator evaluation and evaluation criteria, and presented recommended indicators for each habitat type.

Martha described her expected outcome of the meeting as agreement on: the next steps, who will be involved, and how to fund the continuing effort. She emphasized the strong nexus to the Delta, but that the San Francisco Bay NNE's focus is the Bay. One of the main challenges ahead will be to establish thresholds.

In terms of next steps, Martha concluded that 1) work involved in developing the assessment framework depends on the indicators selected, and 2) the projected timeframe for the assessment framework and workplan is about 2-3 years, dependent on future funding.

Walter Boynton noted that in the Chesapeake Bay Program, there is a disconnect between criteria and monitoring. It results from the fact that monitoring was established before criteria were developed. Martha then discussed important elements for the development of the assessment framework. An important consideration is the required temporal and spatial density of data to inform monitoring decisions.

With regards to modeling needs, Martha provided the following recommendations. Models can be as simple or complex as precision requires: 1) loading model(s) (riverine inputs, nonpoint source, groundwater, atmospheric, oceanic exchange) and 2) estuary model(s) (hydrodynamic, sediment transport, eutrophication). Core monitoring needs to include special studies to validate these models.

Next steps for moving towards a workplan for NNE development in San Francisco Bay include 1) prioritizing recommendations from the completed literature review and data gaps analysis (*there are approximately 30 recommendations for multiple habitat types*), 2) assembling the priorities into a coherent strategy and identifying next steps, 3) identifying cooperating institutions (what are their roles and what expertise is required?), and 4) investigating potential sources of funding.

To illustrate what is meant by assessment framework, Martha also presented the Macroalgal Assessment Framework from the European Union's Water Framework Directive. Martha emphasized the need to discuss the NNE with stakeholders and the San Francisco Bay Nutrients Strategy Workgroup.

Arleen Feng asked whether the choice of monitoring activities by the RMP nutrient strategy is one-time or would possibly involve later iterations to refine NNE Assessment Framework. Martha said she was not sure. Arleen clarified that the RMP nutrient strategy should be nested in the NNE Assessment Framework, but cannot be leading or replicating NNE. Martha responded that San Francisco Bay NNE provides a management context for the emerging RMP nutrient monitoring program.

In response to a comment concerning indicator selection, Martha reiterated the need for all four of the indicator evaluation criteria to be met. Arleen commented on the value of NNE as a regulatory framework and to establish regulatory milestones. The Water Board likes to take a position of taking "no regret" actions. Martha considered this a challenge due to the possibility of

the long response time of indicators to eutrophication. Chris Foe pointed to the need for assessing connections between the "spine" and peripheral elements ("branches", sloughs, etc.) of the Bay.

Martha agreed and provided a scenario applying to algal toxin concentrations. For example, if a Harmful Algal Bloom (HAB) occurs in the Delta, there is potential to find the toxins downstream in Suisun Bay, but not in the rest of the Bay. Terry Fleming suggested that the discussion focus on the development of indicators and then address the specifics of where and when to monitor. Mike Connor stated that it does not make sense to monitor cyanobacteria or other HAB toxins downstream of the Delta, because any signs seen in the Bay would be insignificant compared to effects in the Delta, and would not influence management actions upstream at the source. Naomi Feger stated that we should in fact influence management actions upstream, that the indicators established for the Bay should also be ones that can apply upstream to the Delta and that we are concerned about downstream impacts due to cyanobacteria toxin.

3. Chesapeake Bay Nutrient Monitoring

Walter Boynton focused his presentation on how lessons learned from Chesapeake Bay would apply to San Francisco Bay. He pointed out that when the Chesapeake Bay community got serious about thinking about criteria for restoration, Chesapeake Bay was already exhibiting many of the classic indicators of eutrophication, unlike the current conditions of today's San Francisco Bay. Walter pointed out the importance of resolving tough scientific problems early, such as the ammonia-nitrate-phytoplankton controversy in the San Francisco Estuary. Here are some of the lessons he shared:

Beware of models/modelers. In Chesapeake Bay, for example, decision-makers asked modelers whether the monitoring program should measure dissolved organic carbon? How about silica? Modelers responded: "no, we don't need these". As a result, the Chesapeake Bay Monitoring Program does not measure these important indicators anymore.

Beware of financial erosion. Boynton advised planners to be careful and thoughtful before eliminating monitoring activities that may be key to understanding the system. The financial outlook for Chesapeake Bay Program is not good. Walter indicated that because of the elimination of funding, the program no longer monitors plankton and physical-chemical properties of the water column. In addition, the benthic monitoring has been reduced substantially.

Challenges in measuring and controlling loads. Walter noted that the ratio drainage area versus water surface is much larger in San Francisco Bay compared to Chesapeake Bay, meaning that there is a much bigger challenge characterizing and controlling loads in San Francisco Bay than in Chesapeake Bay. Also, in the Chesapeake Bay Monitoring Program, the sampling design did not make adjustments based on tides. With the big spring/neap tide difference here in San Francisco Bay, tidal adjustments need to be considered in the sampling design, to avoid blurring

signals. He also suggested thinking about the diversity of the San Francisco Bay system. For example, appendages such as tidal sloughs may have pretty interesting, variable rates.

Use language that decision makers can understand. Walter pointed out that using analogies works, for example explaining "resiliency" as akin to a person sweating and shivering. He also emphasized that it is important for managers and politicians to know that eutrophication is "complicated stuff".

Non-point sources. In Chesapeake Bay, agriculture is the "big gorilla". In addition, nitrogen is "falling from the sky".

Success. Maryland established a "flush tax" in a period with a conservative republican government, to control loads from POTWs. This was passed only with substantial senior political support.

TMDL. The TMDL that is coming to Chesapeake Bay is based on the 303(d) list released in 2008. Bay Program participants brief politicians before policies get released.

Monitoring and Research. The monitoring and research communities need to work together. They need to grow with each other. Agency people are really smart but get pulled in too many different directions to be able to give these issues a lot of substantial thought. .

Take home messages. Walter recommended thinking broadly regarding measurement variables; ecology is complicated. There is a need to ensure that data are of high quality (QA/QC is important) and readily accessible to all interested parties. Measurements should be made available as quickly as possible. Walter also advised getting the loads right: nitrogen, phosphorus, and sediments in the case of Chesapeake Bay. He pointed to the importance of diversity in designing the monitoring and the need for strategizing, because one monitoring system will not be sufficient for all time and space scales. Monitoring needs to be long-term; long-term commitments are needed. He warned against the probability of flat-line funding. Walter further suggested the need for spending sufficient amounts of money, and not just on research. He warned against allocating substantial resources to collection and too little for analysis. He suggested taking advantage of research efforts coupled to monitoring: monitoring tells us about "what is" (status and trends) and research answers the "why" questions, and both are critical. He also recommended including some central rate processes in the monitoring program. These processes underlie the concentrations that are typically measured and increase "explainability". He further advised against putting all the eggs in one analysis basket and making models more complicated than needed, and not solely depending on complex models for analysis and forecasting but instead using parallel analysis approaches. Walter also advised that the San Francisco Bay program would need to put information, such as the monitoring data from wastewater treatment plants, on compelling websites. He urged building support from all interested parties, since local effects are important and it is good to have some local heroes. He also affirmed that the regional view is critical. Federal presence was essential in Chesapeake Bay.

4. Overview of San Francisco Bay Monitoring

The following researchers gave brief descriptions of ongoing monitoring programs in the San Francisco Bay Region and suggestions for monitoring needs.

a. USGS Water Quality Program (Jim Cloern)

Jim Cloern provided a brief overview of the USGS Water Quality Program (http://sfbay.wr.usgs.gov/access/wqdata/).

b. CeNCOOS (Raphael Kudela)

Raphael Kudela suggested that biophysical modeling could provide information on oceanic boundary conditions for San Francisco Bay. He provided a brief overview of the Central & Northern California Ocean Observing System (CeNCOOS) and potential remote sensing applications in San Francisco Bay. One of the objectives for San Francisco Bay is to improve primary productivity estimates, specifically to get different (spatially resolved) data for North and South San Francisco Bay and inform models.

c. Interagency Ecological Program (Anke Mueller-Solger)

Anke provided a short overview of where and what the IEP monitors. She noted that zooplankton monitoring is missing in San Francisco Bay. IEP is monitoring zooplankton in San Pablo Bay, but funders never saw a need for doing that in other parts of the Bay. Mike Connor asked whether USGS and IEP are measuring the same things in San Pablo Bay and if the two programs are seeing different information. Jim Cloern affirmed that the two groups monitor within days of each other and data show good agreement. This may be an area where resources could be redirected to address new needs. Anke explained that IEP's mission is to conduct mandated monitoring in the Bay-Delta, including the Stockton Deep Water Ship Channel. The good thing is that there is monitoring. The bad thing is that there is no flexibility; the monitoring is hard to change. For example, IEP is doing only deep-water sampling, but that's not all there is. IEP does not monitor contaminants, the Delta RMP is supposed to fix this. Eutrophication is a good issue to connect the Bay and Delta.

d. California Department of Fish and Game (CDFG): Bay Studies (Kathy Hieb)

Kathy Hieb provided a brief overview of CDFG's routine biological monitoring of the Bay. She stated that CDFG has a good boat with an equipped deck, which is mostly used in the Delta but could be used in San Francisco Bay. Currently, there is a big push to make CDFG's CDT (conductivity, temperature, depth) data more available. Chris Foe noted that it is important to measure biological and chemical data combined, as done by DFG. Kathy characterized CDFG's monitoring as providing a snapshot view of conditions. She also noted that CDFG could monitor zooplankton but that processing of the data would be very expensive. Anke Mueller-Solger noted that is an important consideration to sample physical, chemical, and biological features such that

the data can be used in integrated analyses. Kathy pointed out that there are issues with retrieving data from the IEP database, because of the way the data are organized. Anke noted that the problem is more the web interface than the database. Kathy commented that her program's priority is to get the samples collected.

e. California Ocean Sensing (Wim Kimmerer)

Wim Kimmerer reviewed several ocean sensing stations in the Bay that are used to collect basic water quality indices and used to monitor sea surface current. One of the stations is located at the Romberg Tiburon Center, which is a particularly good spot since the water off the pier is relatively deep, 30 ft, and the site is readily accessible.

f. USGS Suspended Sediment Monitoring Program (Dave Shoellhamer)

Dave Schoellhamer provided an overview of continuous monitoring stations in the Bay maintained by the USGS. This network does a good job in terms of temporal resolution, and a bad job in terms of spatial resolution. One of the main differences between USGS sensors and the continuous sensing stations maintained by Romberg Tiburon Center is that the USGS sensors are active year-round versus the RTC program which is only deployed in summer months. Dave presented new dissolved oxygen measurements from the Dumbarton Bridge station suggesting that tidal variability is important. Four components explain 89% of the variance in DO: 1) tidal variability, 2) diurnal cycles, 3) mixing, and 4) tidal advection. Many processes affect DO, and the margins of the Bay are different from the main channel in this regard. Anke noted that IEP also has YSI sensors but that it has not been a priority to review this data. For example, IEP measures monthly horizontal and vertical profiles, including in the Stockton Deep Water Ship Channel and San Pablo Bay, but the data are completely underutilized. Chris Foe confirmed that the IEP had a wealth of good information (pH, etc.).

g. Regional Monitoring Program (Meg Sedlak)

Meg Sedlak provided a brief overview of the long-term status and trends monitoring of the RMP. She also noted that it would be interesting to know concentrations of key constituents in the margins of the Bay. Although the sites are distributed throughout the Bay based on a randomized design, they are sampled using a boat which limits the access to regions with more than approximately 4 feet of water at high tide. Jim Cloern asked whether the RMP samples benthic macroinvertebrates and whether there is anything the emerging nutrient program can use. Meg responded that benthic macroinvertebrates are sampled once a year. Anke added that IEP samples benthos twice a year, in the fall and in the spring. Sampling by the RMP and IEP in San Pablo Bay and Suisun Bay are somewhat complimentary.

h. Zooplankton and Macrobenthos (Wim Kimmerer/Jen Thompson)

Wim Kimmerer stated that there are lots of things that get measured in San Francisco Bay, that don't get measured in Chesapeake Bay, for example zooplankton. Others get measured in

Chesapeake Bay that don't get measured in San Francisco Bay. Wim clarified that there is no zooplankton sampling in Central and South Bay and only one station in San Pablo Bay. He stated that there has never been a microzooplankton program and suggested that this as well as bacteria be included. Also, the cycling of carbon and carbon budgets are not considered but should be. For example, when production is high, respiration is high, and when production is low, respiration is low.

Jan Thompson discussed the monitoring of Macrobenthos in the Bay, focusing her brief overview on what is known about suspension feeders other than invasive clams. Bivalve numbers are known, otherwise nothing is known; for example, there is no monitoring in South Bay. Walter Boynton commented that the bivalve biomass in San Francisco Bay is large compared to Chesapeake Bay.

i. Monitoring Seagrass and Macroalgae in the Bay (Presentation from Kathy Boyer, presented by Martha Sutula)

Martha discussed interactions of seagrass (eelgrass in the Bay) with epiphyton and macroalgae as a result of nutrient enrichment. There have been a few surveys of the extent of the eelgrass beds in the Bay since the early 2000s– the last CalTrans funded survey is being conducted this year. The largest bed is north of Pt. Richmond. Surveys of seagrass beds observed low levels of epiphyton, which don't seem to cause a problem. A macroalgae bloom was observed at Crown Beach in 2006. Macroalgae is more likely to be observed in sloughs or diked salt ponds because of the longer hydraulic retention times. The recommendation of the NNE technical review was to focus on macroalgae.

Post meeting notes from Kathy Boyer, SFSU:
The low levels of epiphyton typically seen on eelgrass in the Bay are unlikely to have negative impacts, but occasional larger blooms may be detrimental. Macroalgae are also generally low in biomass in eelgrass beds, however, we have measured biomass at times in the range that has been shown to impair eelgrass beds elsewhere in central/northern California (~2000-4000 g wet wet per m^2; Boyer and Huntington 2008 for Gracilariopsis sp. in Tomales Bay, Olyarnik 2008 for Ulva sp. in Bodega Bay). Macroalgal and epiphyte abundance data will be available in a forthcoming masters thesis (Gwen Santos, winter 2011). We do not know the thresholds for impacts to eelgrass beds in San Francisco Bay, nor did the studies cited above evaluate thresholds adequately. Further, increasing light penetration may shift these thresholds and increase the relative abundance of algae and their effects in seagrass beds.

j. Romberg Tiburon Center Monitoring (Dick Dugdale/Alex Parker)

Dick Dugdale provided an overview of measurements taken by RTC's San Francisco Bay Environmental Assessment and Monitoring Station. The rapid sampling off the RTC seawall shows that nutrient and phytoplankton monitoring will have to be based on fixed, automated sampling systems due to the short time scales of physical events and physiological responses. Ways in which this can be accomplished include: 1) automated nutrient analyzers, and 2)

automated phytoplankton coverage. For the latter, flow cytometry is a potentially powerful tool that gets at the size fraction of algae based on fluorescent characteristics. Dick provided the flowing recommendations: in addition to regular shipboard sampling, monitoring in support of model development and management will require automated data acquisition at fixed locations. Methods development will be required, especially for ammonium. A powerful combination for monitoring would be CTD, automated nutrient analysis, and flow cytometry at key locations in the Sacramento River, Suisun Bay (and San Pablo Bay), Central Bay, and South Bay. Possible locations include Hood, Rio Vista, Mallard Island, the RTC Pier, and a South Bay location. Data acquisition is the easier part, but there is also a need to budget realistically for analysis, especially for phytoplankton community data. Lester McKee asked why there is no recommendation for a station outside of the Golden Gate. Dick responded that Point Reyes would be really good for an offshore site. He indicated his group is ready for offshore work and putting the resulting data in the SUNTANS model, if they can combine funding with other sources. He affirmed this would be an important thing to do with the nutrient strategy in mind.

Summary of Selected Monitoring Programs in the San Francisco Bay and Delta

Program	Point Person	Lead Agency	Objectives	Description	Duration	Funding Level
Water Quality Program	Jim Cloern	USGS	Following and understanding changes in the water quality of SF Bay	Monthly cruises of the Bay	1969 - present	
CeNCOOS	Raphael Kudela	NOAA				
Interagency Ecological Program	Anke Mueller-Solger	IEP/DSC	Gauging the environmental health of the estuary	IEP projects fall into three large program categories: IEP Core Program, IEP Pelagic Organism Decline (POD) Program, and IEP Coordinated Studies Program	1970 -present	$39.1M
Bay Studies	Kathy Hieb	CDFG	Routine biological monitoring of the Bay	Biological (midwater trawl, otter trawl) and water quality (SBE CTDs)	1980 - present	
California Ocean Sensing	Wim Kimmerer	Romberg Tiburon Center	Implement CeNCOOS in Bay	There are several ocean sensing stations in the Bay that are used to collect basic water quality indices and used to monitor sea surface current		
Suspended Sediment Monitoring Program	Dave Schoellhamer	USGS	Making time series data of salinity, temperature, water level, and SSC in San Francisco Bay available to scientists, resource managers, educators, and the general public.	The USGS maintains a number of fixed monitoring stations in the Bay that monitor for SSC and DO among other parameters.	1989 - present	

Program	Point Person	Lead Agency	Objectives	Description	Duration	Funding Level
Regional Monitoring Program	Meg Sedlak	SFEI	Collect data and communicate information about water quality in the San Francisco Estuary to support management decisions	The RMP conducts annual water cruises in the summer. In addition to organics and inorganic parameters, basic water quality data is collected.	1993 - present	$3M
San Francisco Bay Environmental Assessment and Monitoring Station	Dick Dugdale	Romberg Tiburon Center	SF-BEAMS is part of a larger distributed observatory that monitors marine environments along the entire coast of California.	The station continuously monitors San Francisco Bay water quality, weather conditions, and surface currents in the deep water channel that lies a few hundred meters north of the Tiburon Peninsula.	2002 - present	unfunded

5. Brainstorming Session

Mike Connor facilitated the brainstorming session on important components of a nutrients monitoring program for the Bay. He asked a few questions of the group to initiate brainstorming:

1) Does the Bay currently have a eutrophication problem?
2) What signs would we need to see to determine that there is a eutrophication problem?
3) What signs would indicate change?

Anke Mueller-Solger indicated that whether the Bay is eutrophic depends on the definition of eutrophication.

Jim Cloern noted that the political setting for this issue is unusual because of the unprecedented interest in nutrients, resulting in a higher probability of identifying new sources of funding for this work. Over the last 20 years, there have been clear signals of change in the Bay, although the Bay does not seem to be currently impaired by nutrients. However, the future trajectory is unclear – we could be headed towards hypoxia. In making the case for continued monitoring of the Bay, we should not risk "crying wolf", but rather highlight the known concerns: that the Bay is enriched in nutrients, and an informed evaluation of the condition and projected trajectory for how nutrients are converted into biomass in the Bay relies on all of the monitored parameters.

Mike Connor focused on the second question, asking for specific indicators of eutrophication.

Jim Cloern, building on one of the key points from Walt Boynton's presentation, indicated that multiple indicators would be necessary to conclude that the Bay is impaired. The group put forth a number of indicators that might serve as signs of impairment:

- increasing frequency of DO concentrations below 5 mg/L
- algal toxins at concentrations that affect the health of humans or biota
- proliferation of macroalgae
- increased movement of contaminants in foodwebs (e.g., as a result of uptake in phytoplankton or increased organic matter)
- fish kills
- phytoplankton biomass greater than 30.
- ecologically disruptive algal blooms, such as brown tides
- impacts of plumes of ammonia on the Farallones, or other ecosystems downstream of the Bay
- depletion of silica
- increased productivity
- food web changes (e.g.,fish and zooplankton getting smaller, increase in jellyfish)
- decrease in seagrass
- increases to some threshold for
    - microphytobenthos (benthic algae).
    - sediment nutrients (TOC/TON)
    - macroalgae

Existing signs of impairment and further notes on indicators
During the discussion, it was discovered that a number of these signs have already occurred, at least in part. Naomi Feger pointed out that there is some evidence of microcystis blooms in Suisun Bay. Anke Mueller-Solger noted that fish kills have occurred in Suisun Marsh, and algal toxins have been detected in Antioch as well as upstream. She also indicated that fish have been getting smaller across all trophic levels. Phytoplankton biomass greater than 30 has been observed in the South Bay.

Mike Connor noted that in fact most of what was put forward are indicators that are captured by the NNE project.

In response to the suggestion of evaluating impacts at the Farallones, Martha Sutula suggested eventually expanding the NNE exercise to the ocean.

Jim Cloern pointed out that nutrient enrichment has been strongly tied to jellyfish accretion, such as in Tokyo Bay. It was acknowledged that the life cycle of jellyfish are not well understood but that a strong link between nutrients and jellyfish has been observed in Denmark. Jellyfish were not selected as an NNE indicator as they didn't meet all the selection criteria. They are relatively easy to sample. Anke Mueller-Solger noted that Suisun Marsh has strong data sets on jellyfish.

Regarding macroalgae, Anke Mueller-Solger added that the cooling water intakes at Potrero used to screen out fish; it now screens out macroalgae. Jan Thompson added that macroalgae has been frequently detected in the shallows near Alameda.

Martha Sutula indicated that the NNE effort ultimately decided not to include microphytobenthos as an indicator because it is hard to measure and interpret. Martha Sutula also suggested that sediment TOC should be normalized relative to sediment grain size, and used as a supporting rather than a primary indicator. Jan Thompson noted that while sediment TOC is low, a complete removal of sediment grazers would cause it to increase.

Dave Schoellhamer pointed out that these are management triggers, that is, signs that could indicate to managers that things are wrong ("red flags").

Chris Foe noted that "eutrophication" has not been clearly defined, even with regards to its spatial extent. The indicators put forth so far are primarily focused on the spine of the Bay. Naomi Feger noted that low DO has been reported in marshes in Suisun associated with management of the Duck Clubs. However, in the South Bay, the managed ponds result in low DO within the ponds, rather than low DO discharges. Tom Hall advised the group that the Board has required a number of low DO studies in the Lower South Bay, some of which are currently ongoing.

Further discussion
Given the general agreement on the types of indicators needed, Mike Connor posed a follow up question: how do we design a monitoring program to detect changes in these indicators?

Martha Sutula noted that these indicators are not the only monitoring that will be performed, but that a number of other parameters, such as nutrients in the water, will need to be monitored to provide context for interpretation of the data.

Amy Chastain asked what management actions are available, and what sort of impact they could have on the system. The potential for future management actions should partly inform the design of the monitoring program.

Walt Boynton noted that macrobenthos have been important in the Chesapeake Bay, and that a paper by Herman describes a worldwide relationship between nutrients, food supply, and infauna in estuaries. Jan Thompson pointed out that this paper included a point from South San Francisco Bay. She indicated that the physical energy of San Francisco Bay does not distinguish San Francisco Bay from the Chesapeake as much as their benthos associates them, and that were San Francisco Bay to abruptly lose its bivalves, the response of the Bay would likely parallel what has been seen in the Chesapeake.

Jay Davis informed the group that the RMP has tentatively allocated $100,000 for nutrients special studies in 2012, contingent upon a promising plan for using the funds that is consistent with the developing nutrients strategy. He is looking for ideas for this money from the group.

Jim Cloern noted that Chris Francis from Stanford was listening in on the discussion, and that he should be included in the next phases of monitoring development, as he brings expertise in denitrification processes in the Bay. He will share a paper on denitrification (Mosier and Francis, 2010) with the group.

6) Strawman monitoring for SF Bay system

Jim Cloern presented a strawman proposal for monitoring, highlighting specific questions that will need to be asked and answered in more detail: What to sample? Where to sample? and When to sample? His preliminary proposal only addresses these questions for open water, and was intended more as an exercise than a definitive plan. He also put forth an incomplete list of on-going or proposed pilot studies, and asked for further input from the group. However, the final monitoring program will not be designed immediately or definitively. The program will need to develop and carry out a number of pilot and special studies before settling on a long-term monitoring program.

Martha Sutula noted that there had been minor changes to the NNE from the version that Jim used to mock up the strawman.

What should be included in a monitoring program?
Consistent with Walt Boynton's presentation, Anke Mueller-Solger suggested that the monitoring program emphasize data management and analysis to accompany data collection.

Jim Cloern suggested using part of the RMP's $100,000 to support Dave Schoelhamer's continuous monitoring at fixed stations with additional instrument packages, such as DO and fluorescence sensors, and funding for analysis of the data. Walter Boynton indicated that there is

a real need to do more short term/continuous monitoring of DO as the DO levels can fluctuate substantially. Raphe Kudela indicated that he could provide these fixed stations with SPATT sensors (Solid Phase Adsorption Toxin Tracking) for monitoring of phycotoxins and that his group could conduct the analyses for toxins. Terry Fleming asked that this funding include data synthesis, so that those designing the nutrients strategy will be up to date on DO findings and perspective. Jim indicated that he has funding for 2012 to conduct nutrient and phytoplankton composition monitoring but that this funding has been discontinued and there will be a future need.

What to monitor?
Building off the list of primary and supporting indicators proposed by Jim Cloern, Alex Parker suggested including DOC/ DON and POC/PON in the suite of nutrients, and adding nitrogen rates to C13 productivity monitoring. He indicated that depth integrated productivity is also important to include. Mike Connor asked if production, including denitrification, should be monitored. Jim Kuwabara indicated that it will also be important to understand the flux of particulates/nutrients from sediments.

Jim Cloern noted that the parameters generally fall in three categories, designed to support:
1) Evaluation of impairment
2) Understanding of processes
3) Model building and verification

Martha Sutula clarified that primary indicators will be used to make status assessments and management decisions, while co-factors and supporting indicators provide context and information needed to interpret the data.

Where to monitor?
Jim Cloern suggested that monitoring may need to include managed ponds and coastal ocean, as well as the traditional locations in the Bay. Anke Mueller-Solger and Kathy Hieb suggested that the sloughs and tidal marshes are important locations within the Bay, which may behave differently from surrounding areas.

Walt Boynton noted that most modeling will require more spatial than temporal resolution to feed into models. As an example, he stated that in the Chesapeake, they have observed that far greater differences of the rates of nitrification/denitrification occur spatially than temporally.

The group discussed potential locations of sampling sites – transects vs. sampling from moored sensors. It was noted that the temporal variability observed in DO would have likely been missed if the monitoring occurred only at transects, and spatial variability is lost if sampling only occurs at moored sensor stations. Although the USGS monitoring occurs along the spine of the Bay, Alex Parker noted that the data set from the Polaris cruises is a unique and venerable record, and worth continuing in whatever monitoring program is ultimately adopted.

Jim Cloern suggested performing a spatially dense survey once a year during the end of the dry season during a neap tide (to minimize the effects of variable freshwater dilution and intense

tides) as a pilot study. This effort will be used to determine the appropriate balance of spatial and temporal intensity.

When to monitor?
Walt Boynton noted that much of the extant monitoring is bi-weekly or monthly, and that data on a shorter timescale will reflect the vacillations of many parameters closely linked to in-bay physics. He added that San Francisco Bay, like the Chesapeake Bay, has a propensity for low DO, and that if the strong physics at work in the bay did not destratify the water, fish kills would be more common.

Wim Kimmerer and Jim Cloern noted that tidal cycles are very important in temporal variability, and in fact much of the temporal fluctuations may in fact be due to passing water masses. Anke Mueller-Solger suggested filling in temporal knowledge with a network of flux stations, designed to measure water bodies travelling by.

Pilot Studies
In addition to the pilot studies outlined by Jim Cloern, Wim Kimmerer proposed developing a conceptual model for nutrients in the Bay, in order to bring the various researchers onto the same page. While the NNE assessment framework could provide the basis for a conceptual model, the NNE is driven by information that is known, while the conceptual model should be driven by questions regarding unknown processes.

Chris Foe noted that detailed monitoring in back sloughs will be important for a monitoring program and would be an interesting pilot study, although Mike Connor indicated that the healthy part of the Bay, in the middle, is where we will make and enact management decisions. Jim Cloern agreed that a spatially intense sampling effort would be a useful special study in 2012. Arleen Feng suggested that this special study work would be helpful in towards establishing a link between local areas and the Bay as a whole, and stated that it also would be essential as a basis and rationale for any further RMP monitoring/special study efforts, although complete monitoring around the edges of the Bay may be too large an effort for the RMP.

The list of pilot studies, as proposed by Jim Cloern and the group, is given below, along with notes on their current status and related work.

- Conceptual Model
    - A conceptual model should be developed to provide a common ground for discussions of nutrient processes in the Bay and to be the foundation for the design of the monitoring program.
    - The conceptual model proposal will be written up by Martha Sutula and Dave Senn for September TRC meeting, requesting some of the $100,000 from the RMP for this project.
    - Jim Cloern and Wim Kimmerer will also provide help on the proposal, perhaps in the context of a brainstorming session like this meeting specifically for the conceptual model.
    - Martha will also look at the interaction between the conceptual model, the NNE assessment framework and the nutrients strategy. She noted that the context for

the conceptual model still needs to be developed, as a conceptual model for the deep Bay would be different from one for shallow waters.
    - Anke Mueller-Solger noted that the conceptual model should link the Bay with the Delta. All agreed that this was important.
- Diagnostic pigments (CHEMTAX)
    - Raphe Kudela is pursuing an alternative method to microscopy for measuring phytoplankton composition, HPLC with CHEMTAX, which uses pigment ratios to determine the main taxonomic groups present.
    - This study will begin to answer the question of whether this method can be used in San Francisco Bay for monitoring the phytoplankton composition. It is much less expensive than microscopy and will allow more samples to be collected throughout the system. At this time the extent of phytoplankton composition sampling is limited by funds.
    - Alex Parker is also gearing up to test a flow cytometer and fluoroprobe (belonging to Anke).
    - A pilot study for 2012 is underway, under Tara Schraga's lead to fund Raphe Kudela's HPLC/CHEMTAX analysis and compare it to years of the microscopic counts USGS has funded a taxonomist to complete. Alex Parker will be adding the flow cytometer and fluoroprobe to this year long study to test their viability for accurate determination of phytoplankton groups. USGS will also fund Raphe analyzing some HPLC/CHEMTAX samples for Alex from other stations in the North Bay not on the Polaris track. This project will bring together these efforts and include a summary analysis at the end.
- Urea
    - A pilot study measuring urea in the Bay, led by Tara Schraga and Jim Cloern, is scheduled for monthly sampling (5 stations) for one year (2012).
    - Parker and Dugdale also have five stations that they are sampling annually.
- Algal Toxins
    - In 2012 the USGS is conducting a pilot study collecting samples for phycotoxin analysis throughout the Bay on 1 cruise each month. Raphe Kudela will analyze the samples. Jim Cloern indicated that he needed assistance filtering on the USGS monthly cruises since they are adding this analysis and the CHEMTAX samples .
    - Raphe proposed deploying SPATT collectors at various sites throughout the Bay as a pilot study. The bags integrate the toxins they are exposed to over the period of time deployed.
- Moored sensors
    - Dave Schoellhamer noted that there may be funding from USGS to add sensors at the 6 moored stations, including DO, chlorophyll, fluorescence, and telemetery.
    - The pilot study still needs additional funding for data analysis, so Dave Schoellhamer will put together a proposal for this funding from the RMP, including an inventory of the existing locations and advantages and drawbacks to putting sensors in other locations.
- Productivity method
    - Tara Schraga proposed performing in-water productivity measurements and comparing it to output from a productivity sensor. If there is agreement, the in-

water instrument can collect productivity samples. If the methods are comparable, the in-water method would increase the temporal resolution and be less expensive (both in cost of samples and labor, and in time needed). The Cloern project uses the DO productivity measurement method while Alex Parker prefers C13/N15 labeling.
    - This pilot study is not currently planned for 2012 due to lack of trained staff and funds for staff or instrument.
- Stratification of sampling
    - Jim Cloern noted that a separate meeting should be held to discuss spatial and temporal stratification of sampling, which should follow the development of the Conceptual Model.
    - Naomi Feger and Karen Taberski noted that the estuary portal and the California Water Quality monitoring council are looking at how to integrate data from multiple sampling efforts in the Delta/Estuary and make it available to the public. The IEP is developing an inventory of studies/monitoring efforts with input from the Boards, the RMP, DWR, DFG etc.
    - Naomi Feger will take the lead on developing an inventory of monitoring stations in the Bay Delta.
    - *Post meeting note – Region 5 of the Water Board with SFEI has developed an atlas of current monitoring for the Delta. Naomi Feger will have SFEI GIS staff scope out the level of effort to integrate this information with sampling station information from the Bay based on RMP, USGS and DWR monitoring.*

Nutrients Strategy

Martha Sutula and Arleen Feng noted that the stakeholders are also interested in seeing a clear strategy outlined. Martha offered to help develop the strategy. Arleen Feng asked how the relationship of RMP nutrients strategy team with NNE group would be established. It was suggested that strategy team become the administrative support team for the NNE group, to maximize on existing work and strengths. Jay Davis proposed a meeting in the early September (once Dave Senn has arrived) to discuss the conceptual model proposal, and that the monitoring design discussions recommence after the conceptual model is developed. Mike Connor suggested that this meeting also serve as the next meeting for the nutrients strategy team, and that a number of the scientists currently present will not need to attend this meeting.

Action Items

Jim Cloern reviewed the action items from the meeting

1) Collect side by side samples and compare approaches for assessing phytoplankton communities (Alex Parker)
2) Participate in monthly USGS Polaris cruises with Jim Cloern and Tara Schraga (Karen Taberski, RMP staff, Alex Parker, *a student volunteer was identified following the meeting*)
3) Identify sensors and funding for purchasing them to add to existing mooring stations (Dave Schoellhamer and Tara Schraga)
    - Measurements to potentially include: Dissolved Oxygen, fluorescence, DON, DOC, etc.
    - Contingent on funding, Raphe Kudula to provide SPATTs for fixed moorings.
4) Develop proposals for using the $100,000 from the RMP in 2012 to submit to the RMP Technical Review Committee (meeting in September) and Steering Committee (meeting in October)
    - Proposal 1) Develop a conceptual model of nutrient cycling in the Bay and Delta (Dave Senn)
        - Martha Sutula to work with Dave Senn to write up proposal for September TRC meeting.
        - Martha will also look at the interaction between the conceptual model, the NNE assessment framework and the nutrients strategy.
    - Proposal 2) Support analysis of continuous dissolved oxygen, fluorescence, etc. data from moored stations around the Bay (Dave Schoellhamer)
5) Develop a georeferenced spatial monitoring layer that will show all of the monitoring types and locations in SF Bay and the Delta (Naomi Feger, Anke Mueller-Solger)

Tom Hall added one further item:

6) Develop a schedule and outline for the RMP nutrients strategy (Jay Davis, Meg Sedlak, Naomi Feger, and Martha Sutula)