5 Apr 12

Dear Ms. Jensen, State Water Board Members, and Staff,

Policies developed under California's Ocean Plan (§ 13170.2) and Enclosed Bays and Estuaries Plan (§ 13391) were specifically meant to prevent water quality degradation and protect beneficial uses of said waters for the State and its people. Current efforts to update both Plans by 2013 are commendable and extremely important. In recent years, interest in desalination as an alternative water supply for growing municipalities has rapidly gained momentum. Meanwhile, data needed to develop science-based policies specific to our State is sorely lacking. This leaves you and the Board with the difficult task of writing policies that avoids elements of assumption. While it is hoped policy amendments can balance the interests of all stakeholders, I would ask that it be precautionary in nature for now, favoring the indisputable language contained in the two Plans; specifically, that water quality degradation will be prevented and that beneficial uses will be protected. I would also ask the Board to include ways to fund the critical science necessary to fill the data gaps in order to update these two Plans in the next triennial review.

Desalination is not a cheap water supply compared to the many other alternatives of a diversified water portfolio. Energetically, the process of reverse osmosis (RO) will require significantly more electricity than diversions from local rivers or aquifers. The saltier the feedwater, the more electricity RO consumes. Since most electricity comes from fossil fuels, this leads to greenhouse gas concerns. For communities on the Central Coast or in Northern California, energy costs and CO_2 emissions for water delivery have been historically low. Only in southern California will the energy and CO_2 for desalination be comparable to current values obtained from importing water hundreds of miles overland via sophisticated networks of dams, pumps, and pipes. Board members and staff should know that each year, a quarter of the CO_2 emitted into the atmosphere is absorbed by the sea. This has been linked to the alteration of ocean water quality by the lowering of pH. Continued acidification is expected to affect plankton abundance and food webs in the future.

As a marine scientist involved in fisheries research, I consider brine discharged from desalination facilities to be the most immediate threat to marine/estuarine life. Although many have argued brine is simply salt, and the sea (or bay) is simply too big for it to have an effect, the fact is, brine is denser than its ambient source water and will therefore sink to the bottom if not properly diluted (an exception to this would be a less dense wastewater brine discharged into a saltier ocean). A density just slightly above ambient will enable a brine to sink. On the bottom, brine can roll across large areas; it can fill in depressions or accumulate in canyons and remain relatively unmixed through time. Dozens of ancient brine lakes are known to litter the seafloor around the world. These contain a limited assemblage of marine life, typically tiny crustaceans and microbes that survived the high salinities and low oxygen levels. Some brine pools are thousands of years old and may have been formed by receding seas during the last Ice Age, which then covered over once sea levels rose. With this, we know what a worse-case scenario could be if brine is not properly mitigated.

Desalination brine can contain caustic chemicals, such as those used to clean pipes and remove fouling organisms in the plant, or chlorine used to eliminate bacteria. More importantly, siting plants near any of California's "impaired" waters and drawing from them could allow pollutants present in low amounts to be concentrated to dangerous levels in the brine. If this brine is not properly diluted, it will effectively anchor a concentrated cloud of toxins to the seafloor, potentially harming benthic communities in unanticipated ways. As an example, plans to build a desalination facility on Suisun Bay (http://www.regionaldesal.com/documents.html) must anticipate the presence of pesticides, selenium, mercury, and other chemicals in the feedwater (http://www.epa.gov/region9/water/watershed/sfbay-delta/index.html#pollutant). I do not mean to specifically call this project out, but it does serve as a good case-study when considering important concerns to mitigate.

Recovery efficiencies of desalinated water projected for Suisun Bay's desalination plant range from 50% during the summer months (saltier water) up to 79% (during the wet season when water contains less salt). While the higher recovery rate greatly reduces energy cost, concentrated salts and ambient pollutants could be up to five times greater than the Bay's natural waters. It remains unknown how well native populations will tolerate an exposure of concentrated salt and pollutants, especially over the long term. During the 8 December 2011 meeting at SCCWRP, a point was made that acute brine exposure studies currently underway are not considering synergistic effects of ambient pollutants on test species. This should be addressed with research.

Brine has its greatest impact on young, developing life stages living on the seafloor. Osmoregulatory stress on rapidly growing embryos, for example, can divert energy resources away from cell growth leaving offspring weak or undeveloped. California's productive market squid fishery is one species in line of brine discharge, especially in Monterey Bay and Southern California. Squid use sandy seafloors to attach egg capsules and incubate developing embryos.

Detecting environmental impacts of brine may take many years to observe; especially if we only monitor species we have an interest in protecting. For example, Suisun Bay is home to several protected fish species. Recently, a long-term restoration project (Delta Plan) has been created to aid in their recovery. Current brine toxicity testing relies on the US EPA's approved list of species and for estuaries and that list approves the mysid shrimp, *Americamysis bahia*. Unfortunately, this species is native to the Atlantic coast and has a salinity tolerance two times higher than native mysids in Suisun Bay. Native mysids are known to be critical to the diets of young-of-year fish, including steelhead trout and green sturgeon. My concern is that thresholds of brine tolerance based on unrepresentative species could lead to the depletion of a critical food source and possibly the demise of a protected species, despite restoration efforts.
See: (http://swr.nmfs.noaa.gov/hcd/HCD_webContent/nocal/Report.pdf)

Monterey Bay and much of coastal California experience Harmful Algae Blooms (HABs or red tide) which sometimes contain powerful toxins (Caron et al. 2010. Water Research

44:385-416). I am concerned these toxins would be elevated in the brine then discharged back into the sea, especially if direct seawater intake is used. Although benthic invertebrates seem tolerant to algae toxins (at least for ambient concentrations), there remains the risk that they could make their way up the food chain, possibly contaminating seafood species and closing fisheries. Marine mammals may fall ill, as could anything else exposed to the brine. Fortunately, marine scientists are developing an HAB monitoring system in California to warn the public of blooms. Nonetheless, my concerns must be expressed here to ensure steps will be taken to prevent toxin-tainted brine from being discharged in large volumes from desalination plants.

Climate change and eutrophication of coastal waters have been linked to increasing HABS (http://www.cop.noaa.gov/stressors/extremeevents/hab/current/CC_habs.aspx). It is acknowledged that HABs are a desalination facility's Achilles heel. In the Middle East, large blooms can clog a plant and shut it down for months, sending water prices soaring. Underestimating HABs in a plant's pre-filtration design might make desalination unreliable.

Brine can restrict oxygen exchange and cause benthic communities to go hypoxic (reduced oxygen levels). Hypoxia-induced "Dead Zones" are another emerging concern for coastal oceans, especially on the west coast of North America. A continuously discharged brine spreading along the bottom could travel for miles, as has been shown in Spain with field monitoring (Fernández-Torquemada et al. 2009. Desalination and Water Treatment 5: 137–145). Benthic communities beneath this layer run the risk of hypoxia. Surprisingly, most Environmental Impact Reports (EIRs) only model brine the first few seconds after discharge. Thus these required environmental documents for permitting appear to miss the bigger picture of brine impact over time.

Along California's coast there may be areas where circulation patterns allow brine to accumulate, as has happened in some regions of the Arabian Gulf. Modeling the spread of negatively buoyant plumes on the seafloor will be complicated and complex, but multi-year simulations and analysis should be encouraged, if not mandated. Ideally, such oceanographic models could further assess site location. By having an idea of how brine behaves in receiving waters, marine biologists could then assemble a list of vulnerable species and critical habitats from which a plant designer might consider changing a particular outfall plan or relocating a pipe.

For the moment, high velocity jet discharges from pressurized pipes with a 60-90 degree upward angle is preferred in Spain and Australia. But in shallow Suisun Bay, this would not be possible. Mixing brine with wastewater was once considered a viable option. However, wastewater is 99% freshwater and its use in future recycled water projects will allow RO purification to be achieved with 1/3 the energy compared to brackish water or seawater desalting. Real-time monitoring technologies now in development promise to make wastewater a valuable, directly-potable resource in the future. Therefore wastewater dilution should probably not be considered as reliable mitigation for brine.

Finally, plant size must be scrutinized. Often EIRs base water need on past production levels averaged over years or decades when there was less incentive by the public to conserve. As water prices rise in the coming years, I suspect use per capita will drop. On the Monterey Peninsula, water use has dropped by 30% since the late 1980's despite a larger population. This is due to better conservation/efficiency attributed to WaterWise landscapes, low-flow appliances, and a response by customers to the recent, steeply tiered water rates imposed to encourage compliance under CDO-95-10 (State Order that limits water diversions from the Carmel River). In Monterey, one acre foot can serve four homes (Monterey Peninsula Water Management District, http://www.mpwmd.dst.ca.us/) while in southern California, it provides for only two. Thus I will hope that facility size, as well as the number of plants constructed in an enclosed or semi-enclosed basin (like Suisun or Monterey Bay), can be kept to a minimum until we have a better idea of how to mitigate the brine.

It has been noted several times by scientists who have published on desalination (e.g. National Academy of Sciences, 2008; Elimelech and Phillip, 2011, Science, 33:712-717) that we know little about the long term cumulative impacts of brine on the marine (or estuarine) environment. Filling gaps in the science is essential for successful desalination in the State. Fortunately, brine is easily monitored with simple instruments. Linking into California's world-class ocean observing and coastal monitoring systems will allow third party oversight as wells as the collection of missing data that could one day lead to better brine mitigation. However, funding will be required. I personally believe companies, agencies, and consumers of desalinated water must contribute to the cost of monitoring for the sake of technology advancements in the future. At the same time, incentives should be given to water agencies or industries that devise ways to better manage brine. These ways might include reuse and recovery. Brine contains valuable salts, minerals, metals, and energy (salinity gradients can be harnessed as batteries to produce electricity). Like wastewater, we might one day consider brine too valuable to simply throw away.

Sincerely,

Carol Reeb, Ph.D.

The views expressed here are not representative of Hopkins Marine Station or Stanford University.