Abstract

Earth system science is boundless. There are no limits to the kinds of questions, problems, mysteries, or paradoxes that motivate our research and shape its direction. So how do we decide which directions to take, which questions to answer, what problems to solve? Sometimes our research is motivated by an unanticipated event requiring a degree of stochastic interpretive crystal ball gazing. Last year we ended our careers of more than four decades as life scientists at the USGS in Menlo Park, CA. We find ourselves in a state of reflection and want to share a story about a stochastic event that brought us together as collaborators, taught us essential lessons of life as research scientists, and seeded a friendship that endures.

1. Forward Into the Past

It was 1979, and the world was very different. For any Boomer Generation “Fireheads” (aka: aging fans of the Firesign Theater), the title of this introductory section refers to that group’s anthology record album of cerebral humor which appeared that year. This was an era entirely analog in its functioning. It included turntables connected to stereos for playing the above vinyl record album at 33⅓ rpms. Computers were the size of Buicks but had less computing power than an Apple watch. Desktop computers existed only in the imaginations of Steve Wozniac and a few others. The World Wide Web was a decade away, and we submitted paper manuscripts in large packages mailed to an editor. Telephones came only with rotary dials, and operators (real live human beings) ran switchboards to connect us. It is a sobering thought to us that Lily Tomlin’s comedy routine as the annoying, intrusive telephone operator “Ernestine” would largely fall outside the realm of the humor experience of today’s emerging young scientists. There was no such thing as a word processor, so writing was initially done by hand and then finished as typewritten pages (with carbon copies and white ink to correct mistakes) composed on the most advanced and prestigious office instrument of its day, the IBM Selectric typewriter (Figure 1). This was the era of the U.S. Clean Water Acts that mandated upgrades of sewage treatment plants to return oxygen and fish to the nation’s lakes, rivers, and bays. Upgrades usually went as planned, but some had hiccups.

Television broadcasting was entirely analog, making use of electromagnetic transmission from towers that were received on antennae. Significantly, there were only three major broadcasting networks in the United States: NBC, ABC, and CBS. There was no cacophony of today’s thousands of cable or satellite stations and opinionated “news casts.” CBS had the most prestigious newsroom of the three, emerging from the towering influence of Edward R. Murrow. Murrow’s protégé was the kindly, avuncular figure of Walter Cronkite, who truly came to greatness on 22 November 1963 when, by breaking into a daytime soap opera, he reported the death of President John F. Kennedy from his desk on live black and white TV. Cronkite reacted to this horrible news for all to see: He took a moment to take off his heavy, black-framed glasses, grimace, and compose himself emotionally before carrying on. Cronkite emerged as the most trusted national figure on the American political landscape. You could have faith that what he said was true, and there was consensus that he had earned that trust (These TV events are now posted on YouTube, the links for which are given online [https://www.sfgate.com/entertainment/article/A-nation-trusted-him-And-he-has-never-betrayed-2787585.php and https://www.youtube.com/watch?v=6PXORQE5-CY]).
2. Walter, You Made a (Gasp) Error!

Our story begins one evening in September of 1979 when Walter Cronkite led the CBS evening news with the report of a massive sewage spill in San Francisco Bay (SFB), not far from our laboratory. It was claimed that that the spill would turn the waters of SFB foul and toxic to life and its fisheries for decades or longer. It also appeared in national newspapers such as the New York Times (23 September 1979) under the headline “Sewage Spill Wipes out San Francisco Bay Fish.” At the time, we were recently hired employees of the National Research Program of the Water Resources Division of the U.S. Geological Survey. The junior of us (Jim) was hired as an ecosystem modeler assigned to the (now more than five decades long) USGS study of SFB. The senior of us (Ron) was trying to convince his supervisors that basic research on anoxic biogeochemical processes (e.g., methanogenesis, sulfate reduction, and denitrification) lay within the USGS/WRD/NRP domain. A recent paper by McElroy et al. (1978) had demonstrated the utility of extracting (N2O) along the Potomac estuary to follow patterns of change in nitrogen biogeochemistry. Hence, Ron saw the SFB sewage spill as an opportunity to promote this application to a pollution issue receiving extensive national attention. After all, 1979 came only 9 years after the first celebration of “Earth Day.” And although environmental pollution takes many, complex forms, nothing was quite so obvious and revolting in the public psyche as the prospect of raw sewage flowing into the largest estuary on the west coast. Jim came from a different perspective, being in contact with many stakeholders and local agency officials. Indeed, his contacts with state officials revealed that information about the spill was entirely anecdotal, based primarily on observations by fishermen of the presence or absence of fish and shrimp in affected waters.

3. We Dip Into the Poop Soup

Motivated by our skepticism of claims that the Bay’s fishery would take years or even decades to recover, we began weekly sampling of water between the South Bay and Coyote Creek—the shallow tributary where effluent from the sewage treatment plant (STP) was discharged. Pull disclosure: Ron did not join the expeditions. Having trained as a navy diver in the sewage polluted Anacostia River 9 years before, he did not wish to repeat this experience. In his stead was his student, Charles Culbertson, accompanying Brian Cole, Andrea Alpine, and Jim Cloern, who ventured upstream to the STP with immunization shots updated. The team encountered many fecal “floaters” at the southern end of SFB (Station 30). Undaunted, we sampled for dissolved gases (O2, CH4, ΣCO2, N2O, and C2H4), dissolved inorganic nitrogen (DIN: ammonium, nitrate, and nitrite), chlorophyll-a, dissolved organic carbon (DOC), salinity, and culture counts of fecal bacteria (coliforms and streptococci). Our results (Figure 2) showed that pollution indicators were strongest near the STP where water was anoxic, had high dissolved CH4, ΣCO2, NH4+, and coliform counts, and abundant fecal matter “floaters.” But these adverse parameters declined rapidly toward the Bay as chlorophyll-a and dissolved O2 increased. Nitrous oxide behaved as an interfacial gas between regions of nitrification and denitrification. A “control” Station (30) in southernmost SFB showed no such adverse parameters. Thus, our first observations showed that the worst effects of the sewage spill were confined to the landward regions of Coyote Creek. Continued sampling over the next month showed a clear improvement in water quality as dissolved oxygen (DO) and chlorophyll-a increased, and particulate organic carbon (POC) declined along with other metabolic gases indicative of intense anoxia (CH4 and ΣCO2) or interfacial N processes (N2O). We concluded that the adverse effects of the spill were highly localized and that the ecosystem proved resilient and recovered quickly once the STP was restored to proper operation. These results stood in clear contradiction of the dire predictions of the media, fishermen, state officials, and even of the Great Man himself (aka: Walter Cronkite). It was now our turn to communicate these results and maybe, as Early Career Researchers, gain a moment in the limelight.
4. We Take it Public and Try to Gain the Limelight

The prestigious American Association for the Advancement of Science was set to hold its 1980 meeting in San Francisco. We submitted an abstract, but given the national media attention to the sewage spill, we were somewhat dismayed to learn that our paper would be presented as a poster (note: posters were a new, untested format in this era, far from the lively lightning posters of today). Nonetheless, we threw ourselves into the project and paid big bucks for a stunning satellite image of SFB to show locations of the STP and our sampling sites. We eagerly deployed ourselves next to the poster, feeling much like hosts would feel at the terminus of a wedding reception line. We waited for the hordes to line up, gather round and pepper us with questions. And we waited, and waited.

We stood by our poster for a couple of hours, during which time no one, absolutely no one came by to talk about the work. We tried to catch peoples’ eyes as they strolled the aisle, but they rapidly looked away and

Figure 2. Spatial distributions of selected chemical-biological constituents in the surface waters of between lower South SFB (Station 30) and Coyote Creek (where wastewater effluent was discharged) on 26 September 1979. Constituents included (a) total carbon dioxide ($\Sigma$CO$_2$), methane (CH$_4$), particulate organic carbon (POC), and dissolved oxygen (DO); (b) ammonium (NH$_4^+$), nitrite (NO$_2^-$), nitrous oxide (N$_2$O), and nitrate (NO$_3^-$); and (c) salinity, abundances of coliforms and streptococci, and chlorophyll-a (chl-a). From Cloern and Oremland (1983) with permission.
moved on. Maybe there was a residual unpleasant whiff from the floaters? Where were Walter Cronkite and his minions? In the back of our brains we could imagine Tammy Wynette’s plaintive, twangy voice singing these words of encouragement, especially for us ..........

Stand by your poster,
Get the folks to crowd around it.
Chat ’em up,
Tell ’em all about it.
Or you’ll wind up sad and lonely.

Stand by your poster,
It could gain you grants and glory,
As you re-tell your story,
Or you could wind up,
Just igno-ied.

Stand by your poster,
And at the session’s ending,
Just pack it up
Do not be pretending
That some great outcomes are tending ..................

We decided to drown our sorrows at the Buena Vista bar near Fisherman’s Wharf. We commiserated over drinks and perked up by plotting out our next step. We decided to strike while the iron was hot! We would write a research paper for the prestigious AAAS journal: SCIENCE.

5. On Rejections: Three Strikes, But Do Not Give Up Just Yet!

To our initial satisfaction, the editor of SCIENCE sent our submission for review—encouragement! The reviews were favorable, but the editor declined because as many others have read, “Competition for space in SCIENCE is particularly keen.” However, we were buoyed by the editor’s words that “you will not have trouble publishing it elsewhere.”

Taking the rejection in stride, we thought that the next step should be submission to a more suitable specialty journal, Environmental Science and Technology. From the editor of ES&T, we promptly received rejection Letter #2 because “There is very little new in the data or in the discussion and conclusions.” Ugh. Flummoxed and frustrated that editors and reviewers did not see the merit in our findings of ecosystem resilience as worthy of publication, we swallowed our pride and submitted to a regional journal, California Fish and Game, expecting a slam dunk acceptance. Rejection Letter #3 explained that our paper was more suitable for another journal and that “Recent publication cost increases have also forced us to reject papers that we once would have considered.” Looking back, this submission was a strategic error on our part. One reviewer commented that our reporting of “$N_2O$” must be a typographic error in placing the numeral “2” before “O” rather than after it; surely, we were referring to nitrite ($NO_2^-$). So much for the slam dunk.

By now 2 years had elapsed since we first collected the samples, and the unpublished manuscript became something of a thorn in our sides. We agreed to make one final effort and send to a journal into which our paper fit rather snugly: Estuaries. Voila! On 8 March 1982 we received a letter from the editor beginning “I am pleased to inform you ....” Therein, it was accepted and found its final resting place (Cloern & Oremland, 1983). Indeed, it was a resting place in the sense that it was rarely if ever cited. It became something of a joke between us as we would occasionally call up phrases from its text when we felt “sluggish” (a term we used to describe circulation in the South Bay) or wondered about the status of “young-of-the-year” sharks (“juvenile elasmobranchs” in the final paper, not our normal lingo).
6. Epilogue (Aka: Postmortem)

Despite our demonstration that recovery of SFB occurred within a month, a stark contrast to the dire predictions that attracted national press, this paper languished in the closet of the uncited for over a decade. Even we did not even cite it ourselves and we often tease each other about the effort, we put into publishing a dud that attracted so little interest from the scientific community. Upon reflection, the paper is rarely cited for a good reason: It reported no new scientific principles or discoveries that would guide future research directions. It did, however, have a degree of utility. We learned from a State of California attorney that the paper provided the basis for financial settlement of a lawsuit between the Bay Area Regional Water Quality Control Board and the San Jose-Santa Clara STP. The fine was originally touted to run the tune of $10,000 for each day of the sewage spill. As quoted by the New York Times, a state pollution control warden declared that “The fishery has been wiped out in an area about 4 miles long. It may take five or 10 years to recover.” We do not know the final settlement amount, but we presume it was much less than this inaccurate claim would warrant. So, unexpectedly, the paper did prove useful as quantitative documentation of the localized effect and fast recovery response to the spill, likely ameliorating the severity of the fine imposed.

Beyond this, our paper did cement a couple of things, one of which was to bolster Ron’s advocacy for USGS research on anaerobic processes. Most prominent of the benefits was that it established trust and strong friendship between our two projects and a long-lasting bond between us that endures. The short-term result of this trust was a collaborative effort on biogeochemical research on Big Soda Lake, Nevada, in the 1980s that led to further joint publications (e.g., Cloern et al., 1983). It also led to Friday afternoon martinis, which became a tradition for us to schmooze and reflect.

7. Lessons for the Early Career Scientists

We end this story with two messages for Early Career Researchers that are simple but based on our collective of more than eight decades of doing research. First, be prepared for unexpected (stochastic) events and embrace them as opportunities to take your science in directions you cannot imagine now. Many lasting and fundamental studies were launched as reactions to unanticipated events. Second, if you have not yet had a manuscript rejected by a journal, you will. So be prepared for this as well. One of the hardest challenges of the Science-biz is failure (aka: manuscript rejection). We cope with rejection in many ways, such as deep internalization (what is wrong with me?) or anger (what is wrong with them?), but we counsel against taking this too hard. It is OK to be disappointed, but do not be discouraged. Use critical reviews to strengthen your paper and submit to another journal. The comments and criticism can ultimately elevate your work. Hope it does not take four tries, like it did us. And imagine doing major revisions on a typewriter and reformatting the bibliography in accordance with the new journal’s style manual like we once did!

Good luck!!

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