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# Nine Takeaways from a Quarter Century Working with the Interagency Ecological Program

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## INTRODUCTION

Cooperative scientific endeavors require so much more than good science. Helping to achieve a cooperative and coordinated science infrastructure in a complex socio-ecological setting such as the San Francisco Bay–Delta Estuary (estuary) has been an overarching ambition during my tenure as an agency Environmental Scientist in this field since the early 2000s and before. Enthusiasm for such a cooperative effort waxes and wanes over time with individual agencies (and budgets)— but certain lessons seem to persist.

The Interagency Ecological Program (IEP, *https://iep.ca.gov/*) is currently experiencing a reflective period, and discussions wherein individual participating agencies are reassessing how they support communal and shared responsibilities for common monitoring program as required by regulations (e.g., biological opinions, incidental take permits, water rights decisions). Historically, IEP Program Governance was codified in a commissioned review and report during 2014–2015, resulting in an agreed-upon formal structure that had been in place in an ad hoc fashion for at least a decade (GEI Consultants, Inc. 2015). This governance used a tiered approach to coordinating and directing IEP activities: from Project Work Teams to a Science Management Team for technical discussions, through a Coordinators Team for resource needs and evaluation, up to a nine-agency Directors Team for annual plan approval and conflict resolution, as needed. I thought it might be helpful and timely to reflect on conversations that support these ongoing discussions, and to enrich the conversations we have regarding monitoring science governance more generally in the estuary (see DISB 2019). The time is right to reassess how and why we do science in the IEP, and to identify where we might improve our efforts to promote good science–policy information exchange and dialog.

## NINE THINGS WE SHOULD BE DISCUSSING AS A COMMUNITY

These points are simple in concept but have proven challenging to implement—and not always achievable when supporting a scientific community that desires to be credible, relevant, and legitimate in the eyes of myriad stake-holders and decision-makers.

### 1. Constant Dialog is Fundamental

Creating useful technical information from the estuary for decision-makers must involve continuous dialog between those who make environmental observations and those who make decisions. Of the impediments to implementing good policy informed by good science over my career, the tendency to fall back on "throwing a draft or final research or project report 'over the wall'" for decision-makers to read is not necessarily effective in informing policy, no matter how cutting edge, peer-reviewed, and peer-esteemed the research might be, has been one of the most persistent. Likewise, the one-off meetings we have wherein decision-makers tell the "technical folks" what they need in order to make their decisions—expecting that one meeting to result in research program "marching orders"—is not necessarily sufficient to guide research.

Far more effective in supporting on-going science–policy dialog, in my experience, have been projects that included close communication and transmission of information—via shared in-progress documents and in-person meetings—and in learning-focused, co-produced workshops over the long-term as a requirement of implementation (recent examples include the Reorienting to Recovery salmon project or the on-going COEQWAL Climate Action Initiative project). Unfortunately, this design and extent of interaction remains the exception rather than the rule.

In any event, the science–policy conundrum we face should be seen as a human conversation and not a commodity-based transactional interaction. The more we participate in meaningful and transformative conversations, the better our science–policy interface will be. Viewing these interactions as on-going and evolving—as opposed to one-off and final—leads to better, more in-depth understanding and sharing of knowledge.

### 2. Near-Term Knowledge Requires Long-Term Context

Credible understanding of near-term change requires long-term monitoring, trend detection, and analysis (see Enright and Culberson 2009 for one example of this perspective). Using harmonic deconstruction analysis techniques, the authors of this paper explain how a 70-year data record of salinity field measurements within the estuary has distinguishable temporal features that span from minutes to days to decades in length. Only once we knew what cycles the longer-term (70-year) record contained could we discern properly the shorter-term characteristics of these data, and understand their full meaning, given tidal harmonics, and seasonal, annual, and decadal weather pattern forcings and processes. Without the proper longer-term context, we wouldn't know what we were looking at (for example, a local maximum, or a global minimum), nor would we know what direction any trend was heading (up, down, or just temporary "noise"). In

**9 Items for Community Consideration/Discussion**

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| **1** Constant dialog is fundamental | **2** Near-term knowledge requires long-term context | **3** Measures of central-tendency are inadequate for assessing ecology |
| **4** Cooperation is what leads to success of multiple agency efforts | **5** People matter | **6** IEP science should focus on ambient environmental context using a "systems" perspective |
| **7** Commoditization of science = false economy | **8** Priority setting is necessary to avoid getting lost in the details | **9** Science matters less than we think |

the words of the authors: "We underscored the value of long data records for discerning trends and variability drivers. On the one hand, ocean/atmosphere climate teleconnections explained significant decadal scale (20-year to 25-year) variability. On the other hand, slowly changing watershed runoff characteristics, northern reach bathymetry deepening, and expanding water project operations together explain long-term (greater than decadal) trends. Therefore, identifying trends and mechanisms requires data sets that are longer than the scale of the lowest frequency forcing mechanism."

In other words, keep collecting environmental data. We don't know when data collected today or tomorrow will help reveal patterns about the past. Furthermore, if the future environment departs significantly from historical patterns, we will need continuing data collection to be able to detect change and describe it in both absolute and relative terms. Of course, emerging, temporary, or urgent management needs may require adjustments to the existing data collection and environmental observation network. Changes should be made deliberately and with full understanding of how they will affect our existing observation and analysis surveys and programs.

### 3. Measures of Central Tendency are Inadequate for Assessing Ecology

Analyses using techniques based upon measures of central tendency are to be viewed with caution and skepticism when understanding and managing ecosystems in the long-term. Manufacturing processes and proscribed treatment

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and effect experimentation are appropriately studied using traditional frequentist statistical assumptions. Principal among those assumptions is that of a system under scrutiny that tends towards some average state—identifiable as, and characterized by, a system that demonstrates a "measure of central tendency." In contrast, in my view, biology and ecology do not do this—they do not tend toward the middle. Organisms and ecosystems (as DNA "enablers") reward bet-hedging, risk-taking, extreme behavior, or genetic-based variations in buffering against those conditions. Ecology and organisms require perturbation and disruption to evolve and persist—not stasis, the mean, or, say, the average streamflow condition. Biology finds opportunity in change, in metamorphosis, in maturation, in learning.

Western scientific approaches used in the San Francisco Estuary often use methods focused on quantification of some effect or outcome of interest to resources managers. A direct or simple link between cause and effect is commonly assumed, which may not be true in complicated realms such as ecosystems. We should encourage patience in accumulating understanding, satisfaction with general trend detection of indicators, indirect measures of population resilience, and assessment of the overall status and health of our ecosystems—something perhaps not best analyzed using traditional methods. Stochasticity, chance, and more robust analyses of change should form more of our research toolkits in the future.

I am increasingly disappointed in our lingering "physics envy" and its legacy in ecology vs. understanding ecosystems and organisms on their own terms. Physics is one element of ecosystem "truth," but biological understanding requires including so much more than a physical basis and underpinning. Biology and the currency of DNA are very rich in potential, and are not fully appreciated using physics or summary mathematics. Some legacy of our biological presence will persist on this planet long after mathematical models have perished; our inherent understanding of our place in this world—and our ability to exist within it—is in a recovered ability to see biology *as biology*, and not as mathematics, statistics, or engineering. We are biological beings: messy, unpredictable, chancy, emotional. We can develop a "feel" for what we are attempting to manage and discover.

### 4. Cooperation Leads to Success of Multiple-Agency Efforts

The most difficult part of trying to generate coherent, cohesive, concentric technical information about the ecology of the estuary is coordinating among the various organizations and agencies who share responsibility for affecting or monitoring effects to underlying ecosystems. This applies to funding, sample design, sample implementation, data analysis and publication, and presentation of results and their use.

We in the IEP continue to be challenged to effectively achieve this cooperation even while we have often demonstrated over the last 5 decades our skill at co-producing research products and communications that explain our evolving understanding of the science–policy interface at issue here. Notably, these include our IEP Workshops, Management Analysis and Synthesis Teams reports, Project Work Teams meetings and publications, the Science Management Team Annual Work Plan review, and the hundreds of co-produced peer-reviewed scientific publications, seminars, and trainings IEP scientists have produced over the years. Our collective governance suffers, at times, from difficulties in pursuing multiple and competing agency objectives simultaneously, reducing our overall effectiveness. Independent reviews by the Delta Independent Science Board of our Monitoring Enterprise and of IEP monitoring to support ecosystem management, for example, say this in considerable detail. Somehow, we manage to get things done in spite of ourselves, and in spite of our mostly volunteer governance agreements and Memoranda of Understanding. Generally, we have been successful because our cooperation just makes sense, particularly to those actually collecting the data and those doing the analysis and creating the information. But sometimes, as volunteers, we just can't seem to be as complete as we might like, and we often find we can't carry projects through to complete implementation, or make substantive revisions to the voluntary agreements that support our good work. We would profit from a more concerted community-supported effort at resolving our governance disagreements. It's not a shortcoming of science, in my view, it's a shortcoming of our training in organizing human beings effectively. Perhaps a stronger organizational structure—and something a little less voluntary—could help with our organizational struggles.

Coordination is a challenge because we have six federal and three state agencies trying to meld monitoring priorities from local, regional, state, and federal bureaucracies without the benefit of any central authority or any overarching designated responsibility. Many potential approaches have been discussed, and a few have been tried (see, for example, the GEI-led Business Practices Review of the IEP in 2015 submitted to the California Department of Water Resources (GEI Consultants, Inc. 2015), but none have completely worked. The release of the Delta Independent Science Board's review of our monitoring enterprise in 2022 suggests some new arrangements are possible (DISB 2022).

### 5. People Matter

The precise location of a scientist on an organization chart in a particular state, federal, or non-governmental organization plays a role in how we support and administer our science. But passionate, capable, properly trained, and effectively motivated members of our science–policy community matter much more than what position they occupy. One or two influential and effective people can change the course of a project or program.

Leadership, good ideas, and effective implementation strategies can come from anyone, anywhere. It doesn't matter who you work for, or what your rank is in your organization—if you have good ideas and are willing to work to get them implemented, we welcome you within the IEP community.

Traditional roles expected from within traditional organizational structures—with traditional oversight and command and control—have been anathema to scientific

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creativity and successful project implementation during my time with the IEP. We need to find ways to identify and support good people and good employees—and support their development and creativity—while understanding conflicting agency priorities. Useful and creative science can be done amid such bureaucracies, but it needs cultivation and encouragement from management. We need to help our managers and supervisors understand that a person's expertise and ability to work effectively in groups and across agencies is more important than whom they work for, what their job description reads at the time of hiring, or what their exact job title is. We need to find ways to cultivate identify and support successful employees, and to prolong their retention in IEP roles and activities. IEP member organizations should include additional promotional opportunities that keep scientists employed as senior specialists and deputy executives to promote the coordination of science–policy communication and information exchange.

### 6. IEP Science Should Focus on Ambient Environmental Context Using a "Systems" Perspective

Applied science must focus on implementing and assessing actions. Implementation and assessment of effectiveness is often missing from what is called "management-relevant science." We often stop short of implementing "effectiveness monitoring" as part of our management actions (using an Adaptive Management Framework, for example). Having failed to properly evaluate the effectiveness of our actions, we miss opportunities to invest in more rigorous appraisals of controversial or less-well understood issues, and frequently fail to resolve questions of management that might otherwise benefit from more careful and focused study. We need a list of implementable consequences of our esteemed monitoring science. I think this is the most difficult aspect of agency science to get right, the thing we have most struggled with, and the thing policy-makers and the public are demanding most emphatically now: we know quite a lot about certain specific segments of our system, but why aren't the species and habitats we desire performing better overall?

Environmental monitoring and understanding how ecosystems evolve and change over time is challenging. We have built a strong foundation of the physical, chemical, and biological bases in our estuary (sensu Brown et al. 2023), but our ecological systems knowledge and understanding is only just coming into focus after 50 or more years of data collection on species and how organisms interact. Ecosystems are complex and constantly changing. Managing ecosystems is hard. Discovering how humans are altering local and regional ecology must be built upon demonstrable, repeatable, peer-reviewed data collection and analysis steps.

*Maybe* turning our focus from individual species toward the integrity of the ecosystem as *a system* is a way out of this conundrum. Focusing our science on what is really important to the *system* might be a way to reframe our conversations in this regard, but we have to wade through a lot of "what I want to do," and "what we think is important" (a scientist- or discipline-specific approach) before we get to the crux of the issue, which is: what is important to the *organisms*, what is beneficial to the system? We need a more robust and fully informed picture of what our estuary is as a complete entity, and we can only do that by improving our baseline ambient-condition observation system in the Bay–Delta and its watersheds. Therefore, we might have to consider doing with less investigator-determined investigative work in return for more durable investments into system-relevant baseline environmental systems monitoring and analysis. We still don't have a great idea of what the estuary is as a system in and of itself, or how it behaves systematically. Our species-by-species approach does not seem to solve our desire to increase our knowledge of species management, because we continue to witness decreasing ecosystem performance at large. Perhaps a change to a more systems-oriented approach can provide a more productive managerial outcome in the long term.

### 7. Commoditization of Science = False Economy

To be successful as scientists and ecosystem managers, we must resist what I call the "commoditization of our science." Treating our need for scientific information as merely a transactional one undervalues the knowledge and understanding of how our natural world functions, and how we might best harmonize our behaviors with nature for long-term benefit. At the same time, we do not have unlimited resources to devote to the pursuit of understanding in and of itself. Those who fund scientific research and analysis deserve to know what they will receive for their investments. Yet the organizations that finance what we do also need to meet us where we are and understand that we value a durable natural world—and that creating a credible, effective science is, at base, a very human need and enterprise. To transcend the transactional, we need to understand what we together value as shared morals—so our acquisition of knowledge can arise within a shared system of ethics. Getting together to discuss what ignites our passions and our curiosities as people—and what values drive our management needs—is worth supporting and pursuing. Our shared interest in usable information is a defining human characteristic, and our long-term success as a species may require that we value ecosystem understanding more than we recently have.

Efficiency is a word often used in this regard, as in "we have to be more efficient with our science," but I think we all too often misuse the concept of efficiency, many times conflating "more efficient" with "cheaper." Better data and more reliable analyses commonly take more time to produce and, commensurate with higher information quality, therefore frequently cost more. Worthless data certainly can be less expensive than valuable data, and we will always need to evaluate how useful and usable our data and analyses are to our overall management information needs.

*Science is an extension of what it is to be human*: to have a brain large enough to contain abstract thought and language, creative enough to invent mythologies about our world and how it works, yet disciplined enough to know the difference between real and fake, possible and probable, likely and not worth worrying about.

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*Science is best used as a tool to promote understanding*—underpinning difficult conversations about policy choices, conservation options, the best way to model complexity, etc.— and may not be best understood as being "efficient."

*Quality data and information is the core of good science*. Communicating the essential implications of our science is really what we in the IEP are and what we do, and being clear about what we know is the point for whatever specific policy choices our policy-makers must make. We are best when we participate in knowledge generation, in whatever makes us *wiser*, not in that which ends up being cheapest or more "efficient." We need to be mindful of costs, certainly, but we also need to know how to manage our estuary with as little unanticipated impact, and as sustainably as possible.

Also, similarly, deliberately narrowing our focus to "near field" effects is not equivalent with being more "efficient." Some of what we need to know costs more than ever—granted. So maybe we need to understand that we can't have it all, and must decide what we absolutely need to know and what we will have to live without. A useful "meritocracy of science" depends upon adequate, valuable investments in data collection, analysis, and description. Our science and our understanding of what is most important to know is what's of value, and we must have conversations about what is most *valuable*, not what is less expensive, and maybe not what is more "efficient"—especially when restricted to this predominantly "commodity-based" perspective.

### 8. Priority Setting is Necessary to Avoid Getting Lost in the Details

Who chooses—and *how* do we choose—our principal object of focus? The IEP would benefit from improvements in this regard, and in exploring where best in the Program to locate these choices. Lacking a central clearing-house directorship to decide strategic matters of emphasis for the existing monitoring enterprise, and for the IEP more generally, we tend to spend our time working on the details of technical studies when it might be more useful to consider the focus and intent of our monitoring responsibilities and enterprise more generally. What is our overall and *shared* objective? The task of convening a higher-level forum within the IEP where specific options for direction-setting across our shared agency resources are considered remains elusive. We have made attempts at developing such a perspective and guidance previously (see the IEP Science Strategy 2020-2024) but this effort deserves to be enhanced. I don't currently know where this level of decision-making, agency coordination, and implementation lies for the *San Francisco Estuary and Watershed Science* (*SFEWS*—yes, this very journal) enterprise. Alternate venues for seeking such directional conversations—such as the Collaborative Science and Adaptive Management Program (CSAMP), the Delta Plan Interagency Implementation Committee (DPIIC), the Long-term Operations Group, the Delta Independent Science Board, and assorted and continuing recommendations from various periodic reviews—are all out there waiting for someone or some entity to use.

### 9. Science Matters Less Than We Think

We must be more than just scientists and understand that our science is not as important as we would like to believe. Engaging policy-makers "where they live" should become a part of every applied scientist's toolkit as we move into our shared collective ecological future. To be more effective, we must better understand how policy is made. What leads me to say this?

In a recent meeting of an advisory committee on which I serve, to help inform the organization they were advising, 17 senior scientists with something on the order of 300 combined years of professional experience in agencies, academia, national and international research, and resource management programs were asked a simple question as they reflected on their experiences to help inform the organization they were advising: *"What is the one thing you wish you would have known at the beginning of your career that would have been of value as your career unfolded?"*

Fifteen of the 17 scientists answered with some version of the following: *"science is a small part of policy-making."*

It was an important moment for me and my understanding of how science influences policy. Technical information about our ecosystem is only part of what policy-makers must consider.

Interestingly, this advisory group quickly turned their attention toward how we might better engage policy-makers, emphasizing that in addition to our hard-won technical competency and publication records we should focus more on engaging the people who chose *not* to be scientists, or analysts, or engineers—in other words, most people we deal with professionally.

So, what matters to policy-makers and program managers? We need to find out. And we need to discover how to talk with them, and respond to them, and meet their needs. Sound science needs adoption and implementation through sound policy-making. Societal engagement matters as much (or more!) than science, and scientists need to more successfully adopt communication methods that recognize this fact, and help the world outside our professional circles understand our perspectives more completely. Our science (and our ecosystem) needs more successful science–policy communication.

### Conclusion

There is a social need for our technical expertise, and for science communicators who can deliver it effectively. I think we would be more effective if we understood ourselves as resources for the state, or for the nation, or for the people—if you will—and temper our expectations and ambitions accordingly. Human beings have different propensities for science and technical information, and the excellent scientific data stream we in the IEP have provided for more than 50 years has been only *one* source of information that managers and decision-makers must keep in mind. Humbly, our interpretations are also occasionally wrong, but can

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be corrected over time as we accumulate more information, knowledge, and wisdom. We also need to fully appreciate for whom—and for what purposes— we are collecting this information. Thirty years of service in and around the IEP and the San Francisco Estuary has shown me the power of our scientific investigative mindset, but it has also instilled in me a humility before the nature we seek to understand and ultimately harmonize with, and a very great caution about the durability of human achievement in the face of—and surrounded by—the nature and the environment on *this* planet.

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