The 25th Anniversary of the RMP

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HIGHLIGHTS

- Stewardship of San Francisco Bay is supported by the Regional Monitoring Program, one of the best water quality monitoring programs in the world, now in its 25th year
- This article provides a chronology of major milestones in the history of the RMP that highlights the features that have allowed the Program to continue to flourish after a quarter century
- The key ingredients of a successful long-term water quality monitoring program include: sustained funding; sound science supported by thorough peer review; collaboration and partnership; thoughtful planning; effective communication of information; and adaptation in response to changes in the ecosystem, the regulatory framework, and scientific understanding
- The participants have seen the benefits of decision-making that is based on solid information, and remain committed to providing the funds to sustain the Program
- The RMP is well-poised for the future and the major changes in store for the Bay that will be driven by population growth, climate change, changes in water management, habitat restoration, and continuing efforts of water quality managers to protect this treasured ecosystem

A RMP workgroup meeting. Photograph by Jay Davis.

San Francisco Bay is the defining feature of our region, a big part of what makes the Bay Area a wonderful place to live and a world-renowned tourist destination. The Bay is also known as a world-class ecosystem. As the largest estuary on the west coast of the Americas, it provides habitat for vibrant populations of fish and wildlife that make their home in the midst of an urban area supporting seven million people. One indication of its global ecological significance is its recognition as a Site of Hemispheric Importance for migratory shorebirds.

Less well-known is the fact that stewardship of San Francisco Bay is supported by one of the best water quality monitoring programs in the world. The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) originated from an innovative idea, conceived in the mid-1980s, that reached fruition in 1993 with the inception of a systematic and multi-faceted monitoring program. In 2017, the RMP is now in its 25th year of monitoring and is stronger than ever.

This article provides a chronological account of the most momentous milestones in the history of the RMP. The stories behind these milestones highlight the features that have made the Program successful and allow it to continue to flourish after a quarter of a century.

RMP MILESTONES 1986-2017

The RMP has been made possible by the contributions of scores of people over the years. This timeline highlights people mentioned in the text and those who are still active in the Program and have been active for 10 years or more, with photos indicating each person's first year of RMP activity.

1986

Water Board adopts Basin Plan with toxic pollutant standards

1988

Steve Ritchie becomes Executive Officer of the Water Board

1989

Mike Carlin and Tom Mumley oversee pilot metals monitoring

Monitoring methods development by Russ Flegal at UC Santa Cruz begins with funding from the Water Board

1986: Conception

In 1985, Roger James, the Executive Officer at the San Francisco Bay Regional Water Quality Control Board (Water Board), told his staff member Steve Ritchie that they would be adding toxic pollutant standards for metals in water to the Basin Plan. In early 1986, Ritchie and his colleagues realized that there were some unpublished data by Dr. Jim Kuwabara of the US Geological Survey (USGS) on toxic metals in Bay water, and that was about the extent of available data. The idea of establishing a toxics monitoring program for the Bay was born. Adopting the standards proved to be a contentious endeavor due to the lack of information on Bay water quality and whether it was getting better or worse after substantial investments (over $3 billion) had been made in wastewater treatment systems. Nevertheless, Basin Plan standards for toxic pollutants were indeed adopted in late 1986.

In 1988 Steve Ritchie became the Executive Officer. Addressing the lack of information on Bay water quality was one of his top priorities. He considered using the Water Board's authority to immediately require the discharge permit holders to monitor toxic pollutants in the open Bay, but he and his staff decided to wait due to a lack of established methods.

RMP Historical Documents

A collection of documents on the history of the RMP are available on a special archives page of the RMP website:

sfei.org/rmp/rmp-history

The collection includes an excellent overview written for the 20th anniversary of the Program, an article from the RMP newsletter with Steve Ritchie's remarks on the 10th anniversary, and other historical and foundational documents.

1990

Decision to have SFEI (then the Aquatic Habitat Institute) administer the program

Karen Taberski is hired to lead the Pilot RMP, beginning a 27 year period of leadership in the Program

Water Board begins meeting with dischargers

1991

Pilot RMP (1991-1992) initiated

Brian Anderson

1992

Resolution 92-043 of the Regional Board initiates the RMP

RMP Manager: Bruce Thompson

TRC Chair: Jim Salerno

Program participants agree on cost allocation and fund the program

1989: Laying a Solid Foundation

It is essential to the success of a monitoring program that all stakeholders with an interest in the ecosystem accept the data and information generated as unbiased, high quality science. An important way in which the RMP has maintained a high standard of scientific quality is through inclusion of leading scientists as RMP investigators. Many RMP investigators are recognized nationally or internationally as leaders in their fields.

In 1989, the Water Board took an important first step down the path toward high quality science when it set up a contract with Dr. Russ Flegal at UC Santa Cruz to monitor metals in the Bay using state-of-the-art ultra-clean techniques (Flegal et al. 1991). Funding for this initial work in 1989 and 1990 was provided by the Water Board. At that time Dr. Flegal was already established as one of the pioneers in measuring miniscule concentrations of metals in ocean waters, and he successfully adapted those techniques for monitoring the Bay.

The methods developed for the Bay by Dr. Flegal ultimately informed the development of US Environmental Protection Agency methods at the national level for sampling ambient water for trace metals at levels low enough to allow comparison to water quality criteria. Funding from the Bay Protection and Toxic Cleanup Program (BPTCP), which was established by the state in 1989 as a rider on a state bill to bail out the state Superfund program, made it possible to conduct further metals monitoring, along with monitoring of trace organic contaminants and toxicity, in 1991 and 1992 in the precursor of the RMP - the Pilot RMP (Taberski et al. 1992). The BPTCP funding also made it possible for the Water Board to bring Karen Taberski on staff to lead the Pilot RMP. Karen Taberski continued to play a major role in the RMP until her retirement in 2016. In addition to water monitoring, the Pilot RMP included monitoring of sediment (metals, organics, and toxicity) and bioaccumulation in mussels (metals and organics).

Investigators like Dr. Flegal have made the Bay a laboratory for advancing understanding of water quality in coastal ecosystems. Thanks to the work of Dr. Flegal and his students and post-docs at this early stage of the RMP, and over the first decade of the Program, we obtained a reliable and complete dataset of metals concentrations throughout the Bay to compare to water quality objectives. With the inception of the RMP, San Francisco Bay quickly became one of the best-monitored estuaries in the world.

Applied Marine Sciences, with a team led by Andy Gunther, is awarded the contract for conducting initial RMP monitoring

1992

Progress Report on the Pilot RMP (Taberski et al.)

The Aquatic Habitat Institute is transformed into the San Francisco Estuary Institute for the express purpose of administering the RMP

1993

Jim Cloern

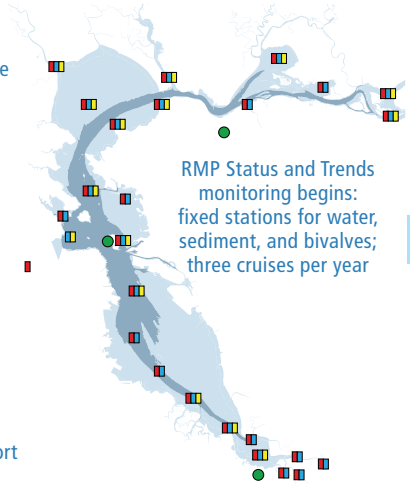
Dave Schoellhamer

Bridgette DeShields

Bryn Phillips

Steering Committee and Technical Review Committee begin regular meetings

RMP begins long-term support of monitoring by USGS of 1) hydrography and phytoplankton and 2) suspended sediment

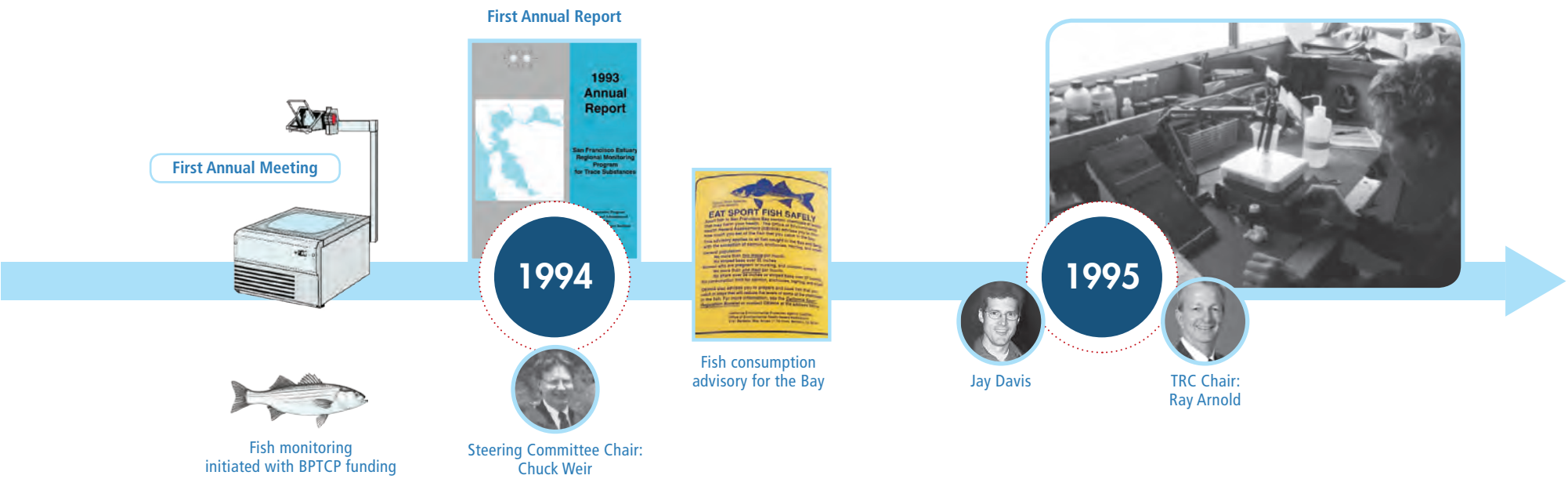


RMP Status and Trends monitoring begins: fixed stations for water, sediment, and bivalves; three cruises per year

1992: A Key Ingredient - Funding

While the Pilot RMP was demonstrating the feasibility of toxics monitoring in the Bay, the Water Board enacted Resolution 92-043 endorsing the Regional Monitoring Program, authorizing the Executive Officer to select dischargers to participate, requiring annual reports on the program, and stating the intention to include requirements for RMP participation in NPDES permits. Representatives of 48 publicly owned treatment works (POTWs), industries, local stormwater management agencies, the US Army Corps of Engineers, and Pacific Gas and Electric met with Steve Ritchie at the offices of SFEI (known as the Aquatic Habitat Institute at that time). The group collectively agreed to carry out the program in a collaborative fashion by asking SFEI to act as a coordinator and fiscal agent. Between July and December of 1992, Program participants agreed upon a cost allocation scheme and funded the Program, and SFEI, working with the Water Board and technical staff of participants, designed the Program and selected a prime contractor (Applied Marine Sciences [AMS]) to implement the monitoring. Dr. Andy Gunther of AMS led a team that included Dr. Flegal, Dr. Bob Risebrough (a pioneer in trace analysis of organic contaminants), and many others to conduct the sampling and analysis for the initial years of the Program.

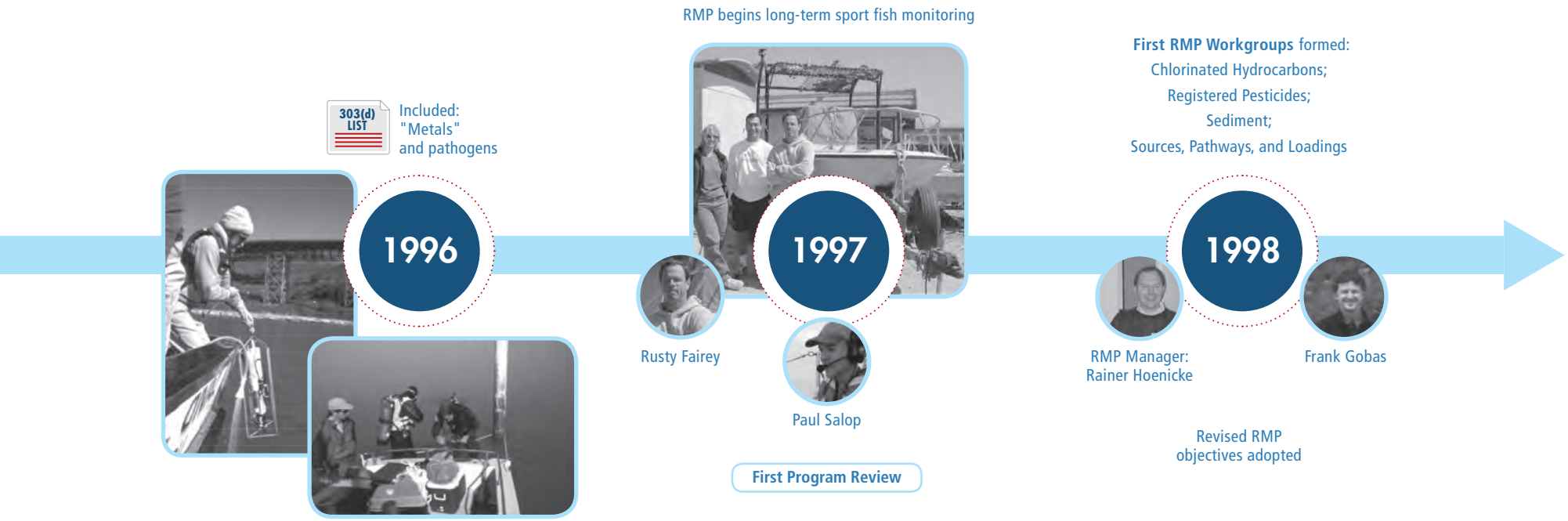
A key ingredient of successful monitoring - sufficient and stable funding - was now in place. The cost allocation scheme and these institutional arrangements have stood the test of time and remain in place today. Funding for the Program has been steady and gradually increased over the years, from $1.2 million in 1993 to $3.5 million in 2017. Over the past 20 years, however, RMP funding has not quite kept up with inflation. In 2016, new funding streams - from permit violation penalties and modifications of effluent monitoring requirements - began to substantially augment the core budget. The participants have seen the benefits of decision-making that is based on solid information and long-term planning, and remain committed to providing the funds to sustain the Program.



1993: The Era of Joint Fact-finding Begins

At the 2003 Annual Meeting celebrating the 10th anniversary of the RMP, Steve Ritchie noted the importance of collaboration and partnership to the success of the Program: "We have to force scientists and managers to meet at the table and stay at the table together and work at getting relevant information and using relevant information. That is the real key to the RMP and will continue to be the key over time." In 1993, the basic governance structure of the RMP was established, with a Steering Committee and a Technical Review Committee (TRC) that have each been meeting on a quarterly basis ever since. The Steering Committee consists of management representatives from the Water Board and each of five categories of discharger (wastewater, industrial, stormwater, dredger, and cooling water). The Steering Committee determines the overall budget and allocation of funds, tracks progress, and provides direction from a manager's perspective. The first chair of the Steering Committee was Chuck Weir. The TRC consists of technical representatives from the Water Board, discharger groups, USEPA (Region IX) staff, and a non-governmental organization, and provides oversight of the technical content and quality of the RMP. The first TRC chair was Jim Salerno.

These committees, along with later additions to the governance structure, have provided a forum for an innovative and highly valued collaboration among regulators, the regulated, scientists, and other interested stakeholders. The strong spirit of cooperation and joint fact-finding that emanates from the RMP has contributed greatly to a lack of combat science and legal battles over Bay water quality. The success of the collaboration in the RMP has led to other major cooperative efforts in the region: the process for developing site-specific objectives for copper and nickel, the Clean Estuary Partnership (2001-2006), and the Nutrient Management Strategy (2014-present) (pages 22-33). The governance structure of the RMP is also serving as a model for regional monitoring programs in the Delta, the Russian River, and other places.



1993: Let the Time Series Begin

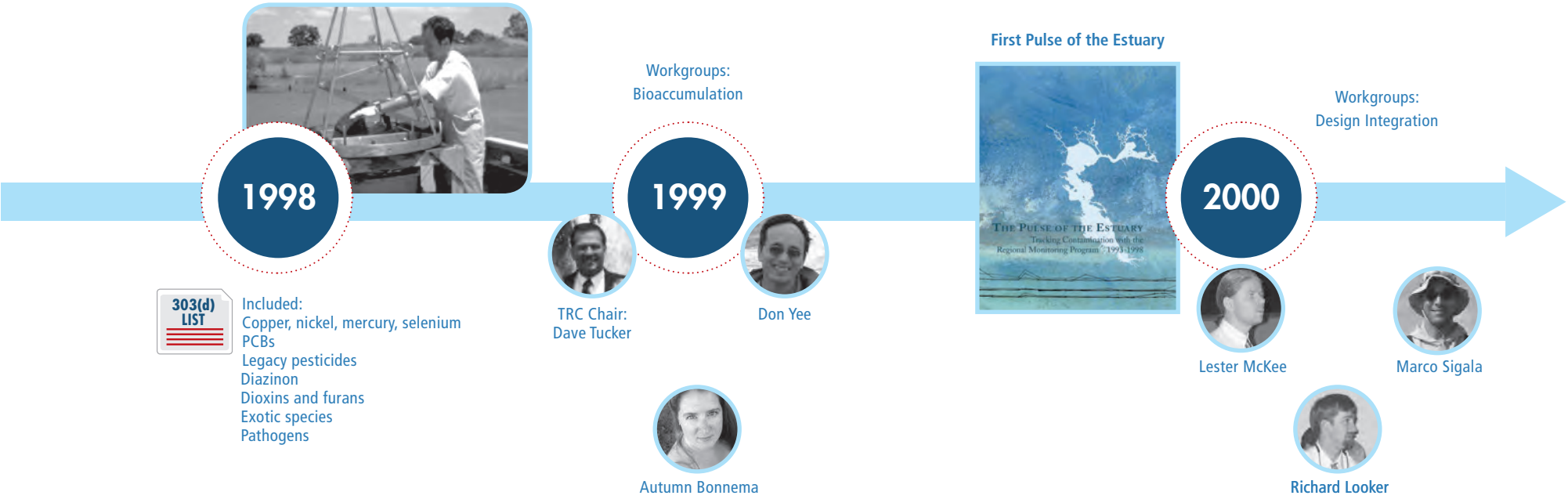
With the groundwork laid, the Program officially began in 1993 under the leadership of the first RMP manager: Dr. Bruce Thompson. From the beginning the Program included two categories of monitoring: 1) status and trends (S&T) monitoring; and 2) pilot and special studies. S&T monitoring in 1993 included sampling of water, sediment, and bivalves at fixed stations along the main channel of the Bay.

Two important pilot studies that were initiated in 1993 were later incorporated into S&T: monitoring of chlorophyll and other basic water quality parameters by Dr. Jim Cloern of USGS; and monitoring of suspended sediment by Dr. Dave Schoellhamer of USGS. These datasets provide excellent examples of the value of sustained long-term monitoring. Both datasets have been valuable in many ways, but detections of unexpected changes have been of particular interest. For suspended sediment, a sudden decrease of 36% was observed in 1999, leading to a new conceptual model for this important parameter. Possibly influenced by the decrease in suspended sediment, phytoplankton abundance (as indicated by chlorophyll concentrations) also began a period of change in the late 1990s. In particular, late summer chlorophyll in the South Bay increased from roughly 1995 to 2005, but then leveled off. This increase triggered concern that the Bay's historic resistance to its high nutrient loads might be weakening - a concern that has led to increased monitoring of nutrients under the Nutrient Management Strategy.

1994: First Annual Report and First Annual Meeting

The goal of the RMP is to "collect data and communicate information about water quality in San Francisco Bay in support of management decisions." Communication is central to the mission of the Program. Two communication platforms - the annual report and the Annual Meeting - that were established in 1994 have served the Program well over the past quarter century.

The format of the annual report has evolved considerably. The first annual reports provided thorough documentation of the monitoring methods and data, and were aimed at a technical audience. By the late 1990s the desire for a more accessible report led to a shift toward publication of an annual summary with a focus on



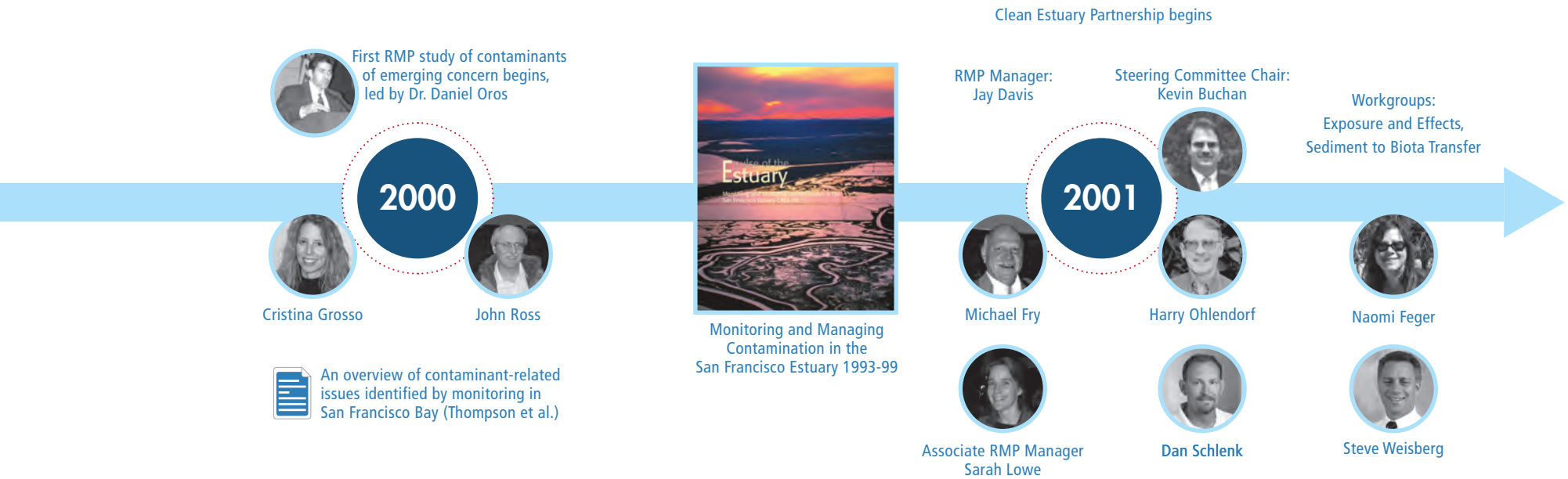
conveying information (interpretations of data to answer management questions): "The Pulse of the Estuary." The Pulse itself then began a process of evolution, with progressive improvements in the use of visual communication elements and the focus on a theme of current importance. At present, the Pulse is published every other year, and in the alternate years the RMP Update provides a concise overview to RMP stakeholders of recent activities and findings, and a look ahead to significant products anticipated in the next two years.

Annual Meetings have been held each year since 1994, and continue to be a communication forum that is highly valued by stakeholders. The nearly 200 attendees appreciate a day full of presentations and discussions on the latest developments in Bay water quality science and management.

1994: A Turning Point in Water Quality Regulation

After completing the Pilot RMP, Karen Taberski led the first Bay-wide survey of contaminant accumulation in fish, also using BPTCP funds. The sampling was conducted in 1994, and the release of the resulting report led the California Office of Environmental Health Hazard Assessment to issue a fish consumption advisory for the Bay at the end of that year. The advisory was intended to protect the public from exposure to harmful concentrations of mercury, PCBs, chlorinated pesticides and dioxins. The fish data ultimately led to the inclusion of these contaminants on the 303(d) List, and the development of TMDL control plans for mercury and PCBs. The water quality objectives established in these TMDLs were not for concentrations of these contaminants in water, as had been the case for Bay contaminants up to that point, but for concentrations in fish tissue, marking a major shift in the regulation of water quality.

The development and adoption of the TMDLs had a far-reaching and enduring impact on the activities of the RMP. Long-term monitoring of contaminants in sport fish was added to the Program in 1997 (the latest report on the fish monitoring was just released in June 2017). Monitoring of mercury, PCBs, and other contaminants that accumulate in fish tissue has been a major emphasis in both the Status and Trends and special studies elements of the Program. Sport fish-related work even included a major special study, conducted in collaboration with the California Department of Public Health, to determine consumption rates for different ethnic groups (SFEI 2000). The RMP fish monitoring effort has served as a model for similar efforts that were later conducted in the Delta region and throughout the state.



1998: Sharpening the Focus

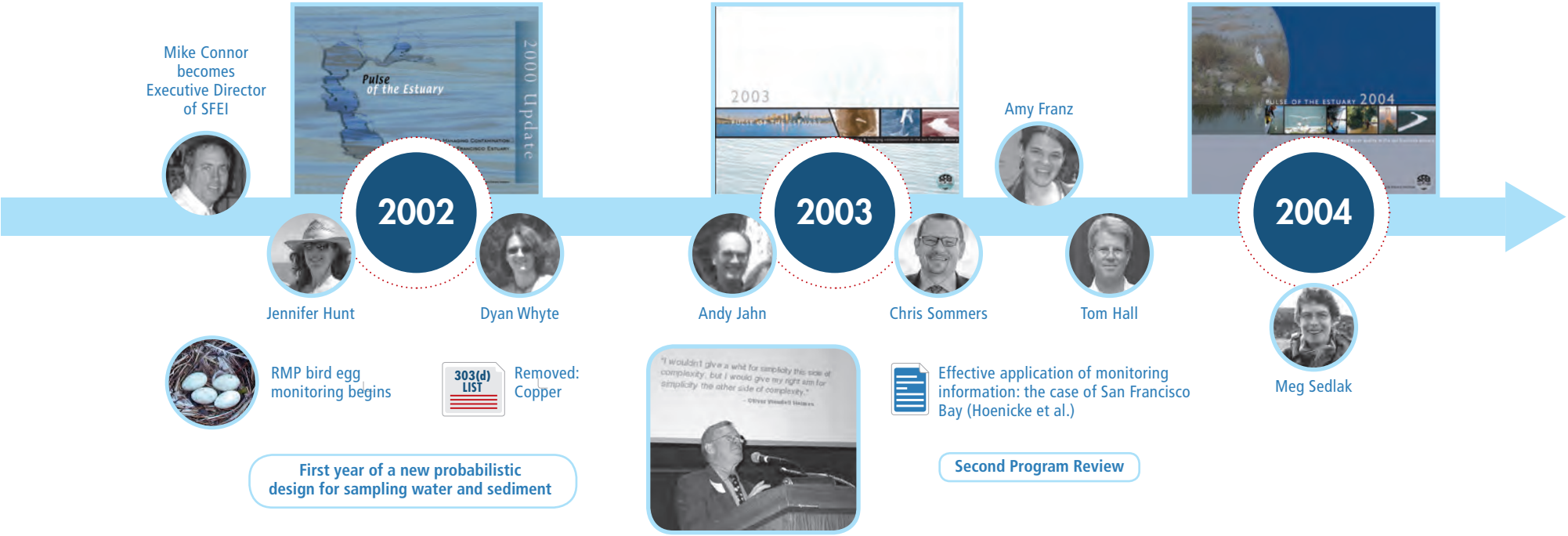
Careful articulation of a monitoring program's objectives and the questions it is intended to answer is essential to obtaining the information needed to support decision-making. The original objectives of the RMP were somewhat imprecise and were not adequately articulated. A review of the Program in 1997 by a team of high caliber scientists, led by Dr. Brock Bernstein and Dr. Joe O'Connor, recommended that the objectives be re-evaluated and supported by a framework of management questions to provide a more precise focus for the Program. Revised objectives were established in 1998.

The 1998 objectives broadened the scope of the Program to include subject areas that had not been part of the original design: sources, pathways and loadings; effects; and synthesis. The RMP is presently guided by a framework of management questions developed after the 1997 Review, revised in 2004, and revised again in 2008. Management questions to be answered and decisions to be informed are carefully considered for each element included in the RMP.

1998: The Best Form of Peer Review

Changes to the activities of the RMP stemmed from the new objectives adopted in 1998. Subcommittees ("workgroups") were formed to develop study plans for several priority topics identified in the Review process: Chlorinated Hydrocarbons; Registered Pesticides; Sediment; and Sources, Pathways, and Loadings. The Sources, Pathways, and Loadings Workgroup remains active to this day.

The Chlorinated Hydrocarbon Workgroup established a novel formula for developing the data needed for the PCB TMDL. This formula has served the Program extremely well. For this workgroup, two of the world's experts on chlorinated hydrocarbon fate and transport (Dr. Frank Gobas and Dr. Steve Eisenreich) were invited to join RMP stakeholders and local scientists and to advise the entire process of planning, implementing, and reporting on chlorinated hydrocarbon studies. With their guidance, a simple PCB mass budget was developed that ultimately served as the foundation for the PCBs Total Maximum Daily Load (TMDL).



This experience demonstrated that the best time to receive guidance from experts is in the planning stages of studies, to make sure the work sets off on a productive path to begin with. Peer review more commonly occurs in the reporting phase of a project, when it is too late to do anything about a potentially flawed study plan.

The RMP now has six workgroups that follow this formula, and many eminent scientists have served as science advisors. Dr. Gobas continues to advise the Program to this day as a member of the PCB and Dioxin workgroups. Having leading external scientists, scientists with local knowledge of the Bay, and stakeholders together at the table has proven to be a powerful approach to achieving the goal of the RMP: asking the right questions and efficiently answering them.

2000: A Shift to Forward-Looking Monitoring

RMP monitoring in the 1990s was highly focused on addressing the serious information gaps on legacy contaminants such as mercury, PCBs, and organochlorine pesticides, or on contaminants like copper that had long been recognized as a concern. The 1995 Annual Report included a chapter by Dr. Bob Risebrough, one of the global pioneers in measuring PCBs and DDT in the environment, titled "Polychlorinated Biphenyls in the San Francisco Bay Ecosystem: A Preliminary Report on Changes Over Three Decades." The chapter provided an entertaining summary of PCB data spanning from Dr. Risebrough's first measurements of shiner surfperch from the Bay in 1965 to the latest RMP data from 1994.

2005

Adam Olivieri

Linda Wanczyk begins as art director for the RMP

Added: Beach pathogens

Removed: Diazinon

2006

Karin North

Luisa Valiela

Emerging Contaminant Workgroup

Barbara Mahler

Alicia Gilbreath

Derek Muir

The chapter concluded with a section titled "Are There 'New PCBs' Out There?" Dr. Risebrough pointed out that there were hundreds of peaks in the chromatograms of RMP samples that were not identified, and that the concept of surveillance monitoring was being ignored. He wrote: "… the list of reported contaminants is a very imperfect description of the real world. A survey of potentially beneficial plants in a rainforest using a guidebook that identifies only bananas, the coconut palm, and five species of orchids would be equally incomplete."

In 2000, Dr. Daniel Oros began a RMP-funded study to identify some of those unidentified peaks in Dr. Risebrough's chromatograms. This study was a first foray into what has become one of the biggest focus areas of the RMP: monitoring for contaminants of emerging concern (CECs) (pages 34-43). The RMP is now a world-leader in monitoring for CECs, with the goal of early detection of problematic chemicals to support management intervention before they become "new PCBs."

2002: A Major Remodel for Status and Trends

Core elements of a monitoring program must remain constant in order to effectively track long-term trends in contamination. However, a purely static monitoring program would become less and less relevant over time as management priorities shift, as understanding increases, as technology advances, and as the ecosystem changes. The RMP strives to become more and more relevant and cost-effective, and has established several mechanisms that make adaptation a hallmark of the Program, most notably 1) continual review by stakeholders and science advisors, and 2) exploration of new approaches through pilot and special studies.

A prime example of this adaptation is the evolution of the Status and Trends (S&T) element. As mentioned above, S&T monitoring began in 1993 with sampling of water, sediment, and bivalves at fixed stations primarily along the main channel of the Bay, with three cruises per year for water and two cruises for sediment and bivalves.

In 2002, in response to the 1997 Program Review, a pivotal revision to S&T was implemented after a significant amount of committee work led by Dr. Rainer Hoenicke, the RMP Manager at the time, and Dr. Bruce Thompson. A spatially randomized (or "probabilistic") sampling design was developed under the guidance of Dr. Don Stevens (one of the nation's leading experts on this topic), with the goal of generating data that are representative of the entire Bay and that allow the Water Board to better evaluate whether water and sediment quality in the Estuary is impaired.

In order to afford this more spatially intensive sampling design within a fixed budget, the number of sampling events was reduced to one per year, during the dry season, since this is the least variable time period. Some of the original fixed stations were also retained to allow continued tracking of long-term trends. This design is still in place, but the frequencies of sampling have been further reduced, with water sampling occurring once every two years, and sediment sampling occurring once every four years. Reductions in S&T monitoring have allowed a larger proportion of the annual budget to go to a diverse array of special studies addressing higher priority information needs.

2007: A Shift to Forward-Looking Planning

In 2007, mercury was a hot topic in the Bay. The TMDL control plan had been developed by the Water Board and was on its way to approval by USEPA. The TMDL development process had identified some technical information gaps. Meanwhile, the Estuary (the Bay and Delta) had become a national focal point for mercury science due primarily to millions of dollars in funding from the CalFed Program. The RMP was also fielding many proposals for mercury studies.

Dr. Tom Mumley of the Water Board, a Steering Committee member and future Committee chair, had the idea of taking a more proactive approach to the planning process for RMP mercury studies. He requested the development of a specific multi-year strategy for mercury studies to ensure that the RMP would provide the information most urgently needed to manage this top priority pollutant.

The RMP approach to tackling such tasks is to organize a collaborative team effort. Consequently, a Mercury Strategy Team comprised of several RMP

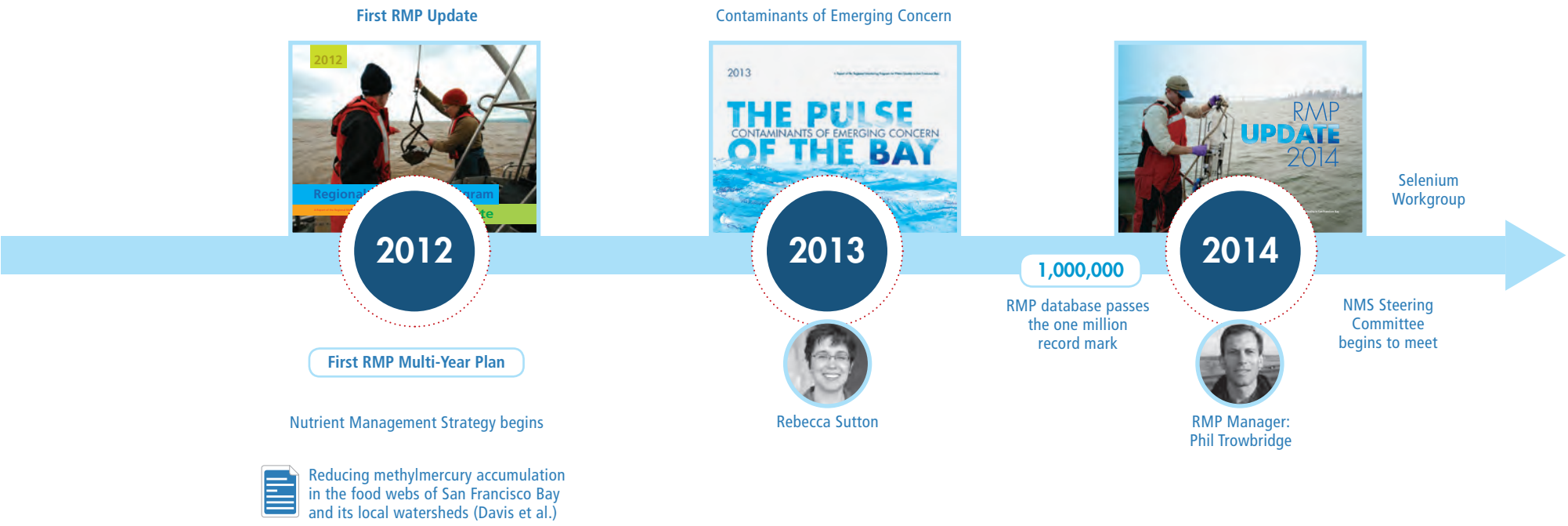
stakeholders was formed in the summer of 2007. The Team formulated a series of management questions to attempt to identify actions that would reduce mercury uptake in the Bay food web in a relatively short timeframe. The management questions and a five-year funding plan were articulated in the form of a RMP Mercury Strategy. The Strategy formed the basis of a request for proposals that was issued at the end of 2007. Over the next four years, the RMP invested $900,000 in mercury special studies to implement the Strategy, culminating in a synthesis paper in 2012 that largely answered the management questions.

Inspired by the Mercury Strategy, other RMP Workgroups also began developing five-year plans, identifying the highest priority management questions for their topics and planning series of studies to answer them. Beginning in 2012, all of these plans were bundled, along with other key Program information, into a Multi-Year Plan for the RMP as a whole. The forward-looking planning that has now become a hallmark of the RMP traces back to that turning point in 2007.

2014: The Rise and Fall of PBDEs - RMP Documents a Success Story

Thanks to all of the strong work on governance highlighted above, the RMP has monitored the Bay long enough to document significant changes in Bay water quality. Monitoring for polybrominated diphenyl ethers (PBDEs) provides an example of the Program documenting the full arc of a water quality management success story. PBDEs are a class of bromine-containing flame retardants that was widely used starting in the 1970s, but rarely studied until the 1990s. In response to observations in the 1990s of rapidly increasing concentrations in humans and wildlife, including Bay studies that reported some of the highest values in the world, the California Legislature banned two types of PBDE mixtures in 2006; the last mixture ("deca") was phased out in 2013.

A decade of PBDE monitoring by the RMP resulted in a dataset covering periods during and after PBDE use, and consisting of hundreds of measurements of water, sediment, and aquatic organisms. By 2014, PBDE levels in bird eggs



and bivalves declined by 74-95%, and levels in Bay sport fish (shiner surf-perch) declined by nearly half. In sediment, concentrations of penta component BDE-47 also dropped, but the dominant sediment-bound PBDE compound, deca component BDE-209, has shown no sign of decline yet.

In 2017, due to the declines and resolved uncertainties about risks to humans and wildlife, PBDEs were reclassified by the RMP from a moderate concern to a low concern for the Bay. RMP data were critical to demonstrating the success of these management actions. This well-documented success story was published in *Environmental Science and Technology*, a leading environmental science journal (Sutton et al. 2015).

Looking Forward

With sustained commitment and funding over the past 25 years, the RMP has matured into a Program that is well-poised for the future. The RMP has proven that it can readily adapt to maintain its sharp focus on providing the science that is most urgently needed to protect Bay water quality. Continued financial support and a capacity for adaptation will be crucial to continued success in the next 25 years, with major changes in store for this ecosystem - driven by population growth, climate change, changes in water management, habitat restoration, and other forces - that will add to the challenge of tracking progress in managing the wide array of threats to Bay water quality. ●

> "We have a tremendous resource in the Bay, and I don't think we appreciate it as much as we should. We owe it to ourselves and to society, to understand it, manage it, and nourish it. That is a collective responsibility of all of us as managers and scientists: to make the Bay the best that it can be, and the RMP is a critical component of that."
>
> — STEVE RITCHIE

The State of Bay Water Quality: 2015 and 2065

Microplastic Workgroup

2015

The Regional Monitoring Program for Water Quality in San Francisco Bay: Science in support of managing water quality (Trowbridge et al.)

Declines in Polybrominated Diphenyl Ether Contamination of San Francisco Bay following Production Phase-Outs and Bans (Sutton et al.)

Municipal Regional Stormwater Permit re-issued

Sediment sampling in the Central Bay margins

2016

Selenium: North Bay TMDL approved

The 25th Anniversary of the RMP

2017

Microplastic Strategy

Beaches Bacteria TMDL approved