State of Bay-Delta Science 2022

Information Sheet

Delta Science Program

DELTA STEWARDSHIP COUNCIL

- The State of Bay-Delta Science is an ongoing synthesis and communication effort that summarizes the "state of the science" for topics relevant to Bay-Delta management.
- The theme of the 2022 edition is "ecosystem services and disservices of Bay-Delta plants and algae."
- Seven articles explore how plants and algae affect ecosystems and respond to management of the estuary and its watershed.

Background

The State of Bay-Delta Science (sometimes referred to as SBDS) is an ongoing synthesis and communication project coordinated by the Delta Science Program. Editions contain collections of articles that summarize the scientific understanding, or "state of the science," of various topics relevant to management of the Bay-Delta system. The intent of the effort is to distill key advances in our understanding and highlight remaining knowledge gaps for science and policy audiences. While previous State of Bay-Delta Science editions covered a broad set of topics, forthcoming editions will be released approximately every two years and take a more focused, themed approach. This change allows SBDS article development and publication to occur on a shorter production time cycle so that editions are timelier and more relevant to current priorities for management and science.

January 2023

Each edition is developed under the direction and guidance of an interdisciplinary editorial board that includes the Delta lead scientist, Delta Science Program staff, and distinguished scientists. The editorial board identifies the theme and topics for each edition based on their knowledge of current management priorities and areas of recent scientific focus.

State of Bay-Delta Science 2022: Ecosystem services and disservices of plants and algae

Scientific, management, and public interest in issues connected to plants and algae (referred to as "primary producers") in the Delta has risen sharply in recent years. While most often recognized for their position in the food web, plants and algae contribute to many more ecosystem services and disservices of critical management interest in the Bay-Delta. While the multitude of benefits that ecosystems provide to humans are broadly recognized (so-called "ecosystem services"), ecosystems can also inflict harm or other negative effects on humans, and these effects are increasingly recognized as ecosystem disservices.

In the Delta and worldwide, harmful algal blooms are becoming more common and intense, are apparently resilient to dynamic climatic conditions in the Delta and are increasingly impacting people through effects on food sources, recreation, and health. Invasive aquatic vegetation, which disrupts recreation and alters habitat conditions, is on the rise and has been the subject of a recent scientific studies encompassing the ecology of novel vegetation, their effects as ecosystem engineers, the efficacy and effects of current control measures, and critical needs for controlling these invasive species in wetland restoration areas. New technologies and data-processing tools such as remote sensing (e.g., satellite imagery) and eDNA have vastly improved our toolkit for studying aquatic and terrestrial organisms in these communities but have not yet been incorporated into routine Bay-Delta monitoring programs. Lastly, carbon sequestration through wetland plant growth is increasingly recognized for its importance in mitigating climate change and is the subject of increasing scientific, management, and economic interest. Carbon sequestration is intrinsically tied to another Bay-Delta issue – subsidence – since the same processes that capture carbon raise land elevations and can work to reverse this critical threat to Delta safety and infrastructure.

Topics

The 2022 edition of the State of Bay-Delta Science contains the following chapters:

1. **Introduction: Ecosystem Services and Disservices of Primary Producers in the Delta**

   Authors: Laurel Larsen, Sam Bashevkin, Maggie Christman, Louise Conrad, Cliff Dahm, Janet Thompson

   Plants and algae form the basis of food webs by functioning as 'primary producers' transferring light energy into food for 'consumers' of this energy (e.g., fish and other wildlife). In the Sacramento-San Joaquin Delta, primary producers perform numerous ecosystem services—which ultimately benefit humans—as well as ecosystem disservices, which have negative effects on human communities. For example, primary producers generate energy for food webs, provide habitat to fish and wildlife, influence carbon and sediment cycles with local, regional, and global implications, and influence human health, recreation, and livelihoods. Depending on the socioecological context, these services may be perceived as positive benefits (e.g., services) or negative impacts (e.g., disservices), and these effects may be simultaneous. This chapter introduces the topics explored in the following six topical chapters comprising SBDS 2022.

2. **Landscape change and variation in invader abundance drive primary production of aquatic vegetation in the Sacramento-San Joaquin Delta**

   Authors: Katharyn Boyer, Samuel Safran, Shruti Khanna, Melissa Patten

   Expanding on a multi-year working group effort led by Jim Cloern and San Francisco Estuary Institute published in 2021, this chapter explores changes in carbon and energy production of submerged and floating aquatic vegetation from the historic to modern Delta. Scenarios of potential change in terms of vegetation control, alterations of conditions supporting these vegetation types, and active restoration of native plant species are explored to see how overall Delta productivity could change in the future given different management actions.

3. **Ecology and ecosystem impacts of aquatic vegetation in the Sacramento-San Joaquin Delta**

   Authors: Maggie Christman, Shruti Khanna, Judith Drexler, Matthew Young

Dramatic increases in aquatic vegetation have occurred over the last two decades, largely due to explosive growth of a handful of invasive submerged, floating, and emergent plant species. These species act as ecosystem engineers creating conditions that favor further growth and expansion into additional habitats. This chapter explores the state of the science of our understanding of the biology and ecology of aquatic macrophyte communities with an emphasis on how submerged and floating aquatic vegetation is affected by environmental conditions and the impacts these communities have in turn on the ecosystem.

4. **Management of invasive aquatic vegetation in the Sacramento-San Joaquin Delta and Suisun Marsh: the history and science of control efforts and recommendations for the path forward**

Authors: J. Louise Conrad, Madison Thomas, Karen Jetter, John Madsen, Paul Pratt, Patrick Moran, John Takekawa, Gina Skurka Darin, Lydia Kenison

While there is a long history of vegetation control efforts in the Delta, scientific studies that directly address effectiveness of various chemical, mechanical, or biological control methods have only occurred relatively recently. This chapter explores the history of aquatic vegetation control efforts in the Delta and the science underlying investigations of effectiveness for various approaches.

5. **Remote sensing of primary producers in the Delta**

Authors: Erin Hestir & Iryna Dronova

Remote sensing methods are being used to study a growing number of Delta issues, from detecting pigments and other water constituents to assess the presence of algae or other primary producers, creating historical records of aquatic weed expansion across the Delta through space and time, and monitoring of levee subsidence. The number of methods being used has likewise expanded to include everything from boat-mounted sensors, human-operated low-flying planes, aerial drones, to freely accessible satellite imagery. This chapter explores the emerging technologies and applications of various methods for studying primary producers with an emphasis on remote sensing as well as emerging or developing technologies for tracing origins and expansions of invasions.

6. **Status, trends, and drivers of harmful algal blooms along the freshwater to marine gradient in the San Francisco Bay-Delta system**

   Authors: Raphael Kudela, Meredith Howard, Stephen Monismith, Hans Paerl

   Harmful algal blooms (HABs) are on the rise worldwide, including the Bay-Delta where climate change is expected to increase their prevalence into the future. Due to the global nature of this problem, this chapter draws from what we have learned about HABs from other systems to synthesize the main drivers, impacts, and management responses to HABs, with a particular focus on relevance to the Bay-Delta. Human dimensions and environmental justice issues related to HABs in the Bay-Delta are also addressed.

7. **Carbon sequestration and subsidence reversal in the Sacramento-San Joaquin Delta: management opportunities for climate mitigation and adaptation**

   Authors: Lisamarie Windham-Myers, Patty Oikawa, Steve Deverel, Dylan Chapple, Judith Drexler, Dylan Stern

   Numerous studies conducted over the last two decades have investigated what conditions are most favorable for carbon sequestration, the magnitude of carbon that can be sequestered, and vegetation types with the highest carbon sequestration and subsidence reversal potential. As a growing number of restoration projects are implemented, researchers are now looking toward how restoration, flooded agriculture and other types of land-use change impact carbon sequestration and subsidence reversal, quantifying the comparative value of various land uses, and how these practices are best managed for maximum benefit. This chapter describes the main environmental drivers of carbon sequestration and subsidence reversal as well as various considerations necessary for managing these processes.

Where can I find more information?

Learn more and access the reports at http://sbds.deltacouncil.ca.gov/. All SBDS 2022 articles are peer-reviewed and available online as Volume 20, Issue 4 of the open-access San Francisco Estuary and Watershed Science journal.