

CERF's Up!

Volume 50 • Number 3 • September 2024

Texas Starts Chapter of Society for Women in Marine Science

An Innovative Tool for Assessing Wetland Resilience

New Article Type for Understudied Coastal and Estuarine Systems



A new wave of information from the Coastal and Estuarine Research Federation



CERF's Up!

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Front and Back Covers: The fishing village of Djifer at the mouth of the Saloum River, Senegal

Photo: Curioso Photography

Call for Cover Photos for CERF's Up!

Would you like to see your favorite estuary displayed on the cover of *CERF's Up!*? If so, send high-resolution shots showing the place's natural beauty, along with a short caption and photo credit, to bulletin@cerf.science.

President's Message



Linda Blum
CERF President

Recently, the importance of the society's journal, *Estuaries and Coasts*, has been at the forefront of Governing Board work for several reasons: the need to find a new coeditor in chief, the importance of *Estuaries and Coasts* to the financial well-being of the Federation, and three new initiatives that will increase the value of *Estuaries and Coasts* to the membership and the scientific community. What follows is a brief overview of these topics along with some additional thoughts about *Estuaries and Coasts*.

By the time this letter is printed in *CERF's Up!*, the selection process for the new coeditor in chief will be complete, or nearly so. You may recall that the nominations for the coeditor position was published in the last issue of *CERF's Up!*. While Coeditor in Chief Paul Montagna and Reviews Editor Ken Heck plan to continue in their roles until the end of 2025, we are working to find a new coeditor to replace Linda Deegan who will, at the end of her fourth year, step down in December 2024. The federation owes Linda more than its deepest thanks for her service to CERF during her tenure.

The *Estuaries and Coasts* Coeditors' responsibilities are diverse and crucial. These individuals must read every newly submitted manuscript and revised submission, identify an associate editor to supervise review of the manuscript, work with the associate editors and peer reviews obtained to make final publication decisions for each manuscript, interact frequently with the publisher,

develop and implement strategies to improve the journal, and recruit associate editors. The efforts of the last few teams of journal leaders have made *Estuaries and Coasts* a top 20% aquatic sciences journal with an impact factor of 2.3!

Finding a strong coeditor in chief to replace Linda is critical. Our journal is central to the mission of the federation, not only as our intellectual voice in the scientific community, but also as an important economic factor in the operation of the society. *Estuaries and Coasts*, like most society-run journals, supports CERF with royalties: more than half of CERF's annual operating budget comes from royalties the journal generates. So, when you submit to, or review for, *Estuaries and Coasts*, you are providing financial support for CERF's operation.

Currently *Estuaries and Coasts* receives about 400 new submissions and 250 revisions every year, so each of the coeditors handles approximately 325 manuscripts each year. Another way to think of these numbers is that journal's Coeditors, Paul Montagna and Linda Deegan, must handle nearly one manuscript, either new or revised, every day of the year. Additionally, the journal receives about 16 review papers each year. These papers are generally solicited by Reviews Editor Ken Heck. While the total number of submissions is strong at this time, a way to increase *Estuaries and Coasts* support of CERF is to increase the number of papers published in *Estuaries and Coasts*, because as the number of papers published in *Estuaries and Coasts* increases, so do the royalties that make up the greatest portion of CERF's income.

Of course, increasing the number of papers published in *Estuaries*

and Coasts without decreasing the quality means increasing the number of strong manuscripts submitted. An increase in submissions means an increased workload for the editorial board and a greater need for more reviewers. One of the primary concerns the *Estuaries and Coasts* editorial board has is the enormous difficulty in obtaining useful reviews for the current number of submissions. For example, reviewer response is currently below 50%; difficulty in identifying reviewers is the main factor slowing down the publication process of *Estuaries and Coasts*. Every time you submit a paper, you create work for four people: a coeditor, an associate editor, and at least two reviewers. So, pay it forward by making an effort, when requested, to provide a good review of the manuscript you have been requested to evaluate. Indeed, if we consider our population of reviewers to be only those who submit manuscripts to *Estuaries and Coasts*, we need, in return, four reviews for every paper submitted.

One of the benefits of publishing a paper in society journals is the rigorous [peer-review process](#).¹ As the publishing business continues to evolve, competition between society journals and commercial journals has increased. Of particular concern are the rapidly increasing numbers of many seemingly honest journals adopting predatory practices that include a weak review process and the recruitment of authors to create special issues or collections. These journals then often charge a large fee to publish the article. When making the choice of where to publish your work, remember that publishing is a zero-sum game, meaning not submitting to *Estuaries and Coasts* not only devalues the journal, but hurts CERF's

1. Thomson, T.J., L. Irvine, and G. Thomas. 2024. 3 Ways to Fix Peer Review. *The Chronicle of Higher Education*. 70(21). <https://www.chronicle.com/article/3-ways-to-fix-peer-review>

bottom line as well.

Three new initiatives approved by the Governing Board make *Estuaries and Coasts* even more attractive as a place to publish. We recently announced a new type of article, Estuary and Coast Signatures articles; special collections of papers; and an early career publication award.

An Estuary and Coast Signatures article offers an opportunity to publish descriptive articles in *Estuaries and Coasts* about poorly characterized estuaries or coastal regions. Such articles will improve the understanding of the structure and functioning of estuaries and coasts by comparing the described system to those in other parts of the region or world. Publication of articles of this type recognizes that the literature is strongly biased toward Northern temperate estuaries and coasts, that all estuaries are unique, and that there is a need to publish descriptive papers from other regions that haven't been as well studied.

Another article-type change for *Estuaries and Coasts* is the move to special collections rather than special issues and special features that focus on a specific research or management topic and that has a broad appeal. Unlike special issues or features where papers accepted for publication must wait until all the articles planned for are accepted, papers accepted for a special collection will be published as they are accepted. As additional papers for the collection are approved, they will be added to the special collection. Thus, the disincentive to contribute to a special issue because of potentially long delays between paper acceptance and publication is lessened.

Another new initiative proposed by the *Estuaries and Coasts* coeditors and approved by the CERF Governing Board is the Early Career Publication Award. This award is intended to support early-career professionals and promote membership value and retention, particularly for early

career CERF members from groups underrepresented in our disciplines. The award aims to assist early-career professionals in publishing their research open access once their manuscript has been accepted for publication in *Estuaries and Coasts*. The award will also provide a one-year Early Professional CERF membership to the recipient. Two awards will be given annually. Look for an announcement later this fall for application details.

There continues to be a great deal of research on the coastal zone being conducted by CERF members and, indeed, by others throughout the world. While *Estuaries and Coasts* currently provides an outlet for many of the results of that work, we could, and should, handle more quality submissions through the journal. I encourage all our members to strongly consider submission of their work to *Estuaries and Coasts*. Doing so will showcase your work, and, at the same time, enhance the stature of both the journal and the

Upcoming Events

2024 RAE Summit

Arlington, Virginia

6–10 October 2024

<https://estuaries.org/2024-rae-summit/>

CERF 2024 October Webinar: Using the RAD (Resist-Accept-Direct) Framework for Coastal Climate Adaptation

22 October 2024

<https://bit.ly/4dKAFUs>

CERF 2024 November Webinar: Phenotypic Plasticity, Description, and Function

6 November 2024

<https://bit.ly/3MnJo20>

GERS Biennial Meeting

Fairhope, Alabama

5–7 December 2024

<https://gers.wildapricot.org/2024Meeting>

Wisconsin Wetland Association's Wetland Science Conference

La Crosse, Wisconsin

25–27 February 2025

<https://conference.wisconsinwetlands.org/>

CERF 2025 Conference

Richmond, Virginia

9–13 November 2025

<https://bit.ly/3TxmcDt>

2024 CERF Annual Business Meeting

CERF will hold its Annual Membership & Business Meeting on Friday, 15 November 2024, from 2:00–2:30 PM EST. This will be a virtual meeting held over Zoom. All members are invited and encouraged to attend. If you would like to attend, RSVP at <https://bit.ly/2024CERF-MeetingRSVP> and a zoom link will be sent prior to the meeting.

Everything is Bigger in Texas: Introducing the Texas Chapter of the Society for Women in Marine Science at the Marine Science Institute

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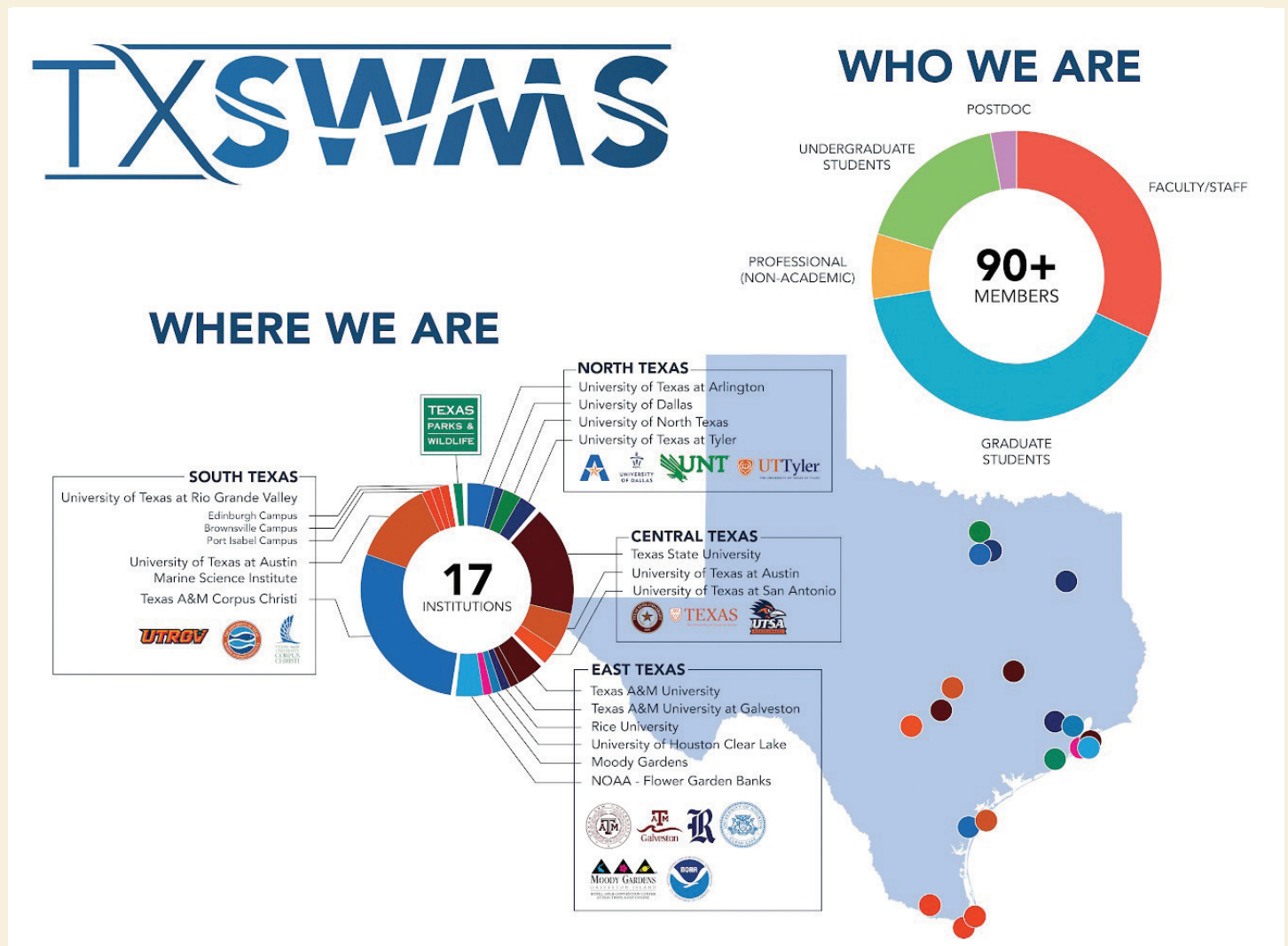
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Gender inequality is an issue that pervades many fields, including marine science. Enrollment of women in undergraduate and graduate marine science programs has continually increased over the years, yet these numbers do not translate to higher numbers of women in senior positions, an issue commonly referred to as “the leaky pipeline.” One mechanism of

increasing retention of groups within fields is through the formation of affinity groups. These groups create community and a sense of belonging within a field and have been shown to increase retention and success in fields over time. Motivated by the necessity of building this connection in the marine science field, the Society for Women in Marine Science (SWMS) was formed at the

Woods Hole Oceanographic Institute in 2014 by a group of graduate students and postdocs. In this group, gender inequality in the lab and field has been one of the main topics of discussion, in the hope of making marine science more welcoming for all women. Through chapter meetings and symposia, SWMS has had great success in building community and providing professional develop-



Organizational compositional of Texas SWMS

Image: Texas Chapter of the Society for Women in Marine Science



Bags of trash collected by Texas SWMS during World Ocean Day in Port Aransas, Texas

Photo: Texas Chapter of the Society for Women in Marine Science

ment and networking opportunities to its members.¹ Since 2014, SWMS has grown to include chapters all over the US and some international chapters.

The newest chapter of SWMS is ours, Texas SWMS. Unlike prior chapters, Texas SWMS is not located at a single institution but instead at 17 different institutions across the state, and it is still growing. Many marine scientists in Texas are not located directly on a coastline, and many of us are not at institutions that have marine science departments. In fact, some of us are students/employees at universities where we may be the only marine science representation in our departments. In order to unite scientists across the state, Texas SWMS was born in the fall of 2023 to connect and provide community, support, and networking to all of the amazing marine scientists in Texas, as well as highlight the incredible science being done here. The power of being located in more than one institution allows us to encompass individuals across all different career paths including academic, industry, and government roles. For example, we currently have members who are employees at Texas aquariums, the National Oceanic and Atmospheric Administration, Texas Parks and

Wildlife, and other non-academic institutions. Additionally, including multiple universities allows us to encompass a more diverse academic base. Of the 14 universities where our members are located, eight are minority-serving institutions including Hispanic-Serving Institutions (HSI) and Asian American Native American Pacific Islander-serving Institutions (AANAPISI). Our diverse membership, spanning various personal backgrounds, career paths, and career stages, strengthens our organization and allows us to provide support and a sense of community to all members. Our chapter was formed with five main goals. The first goal is networking, community, and collaboration. Through virtual chapter meetings

and in-person events, we aim to offer our members opportunities to connect with one another and share resources to support research across the state. Second is professional development and skill development. Our diverse membership covering different career

paths will allow us to build resources that support members in achieving success in any chosen path. We also aim to conduct workshops to help members enhance their skill sets for any career path. Third is mentorship and sponsorship. Mentors/sponsors are an essential piece of a successful career, but knowing how to find them can be difficult. We aim to build resources to help mentors grow their mentoring skills and help mentees find and identify good mentors/sponsors in their careers. Fourth, we aim to help our members explore

different career paths in marine science. Currently, our chapter website includes job boards, graduate position ads, and links for funding opportunities for undergraduate and graduate students and postdocs. Finally, our fifth goal is to participate in outreach events across the state, supporting the participation of underrepresented groups in marine science as well as spreading awareness of the research taking place across the state. As an example, Texas SWMS recently participated in University of Texas STEM Girl Day in Austin and a beach cleanup in Port Aransas for World Ocean Day, where members picked up 75 pounds of trash. This is only the beginning of our history in Texas. We look forward to connecting with and inspiring Tex-



Volunteers of TX SWMS attending and teaching K-12 students at UT Girl STEM Day in Austin, Texas

Photo: Texas Chapter of the Society for Women in Marine Science

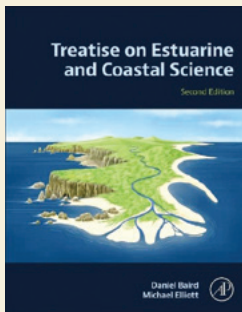
ans, even those far from the ocean, with the marine science taking place here. If you or anyone you know is interested in getting involved in the Texas SWMS chapter check out our website (<https://texasswms.wixsite.com/texas-swms>) or the general SWMS website (<https://swmsmarine-science.com>).

Reference

1. Canfield, K.N., A.R. Sterling, C.M. Hernández, et al. 2023. Building an inclusive wave in marine science: Sense of belonging and Society for Women in Marine Science symposia. *Progress in Oceanography* 218: 103110.

Treatise on Estuarine and Coastal Science, 2nd Edition

Daniel Baird and Michael Elliott, Editors in Chief



The Treatise on Estuarine and Coastal Science, a seven-volume set of books, is the most up-to-date reference work for system-based coastal and estuarine ecosystem science and management. It addresses the big issues facing the estuaries and coastal zone, in particular how to best use multi- and inter-disciplinary science to ensure the sustainability of the environment. It focusses on the need to protect and maintain the natural functioning of the estuaries and coasts worldwide while delivering the ecosystem services from which society extract goods and benefits.

Structured chapters, written by leaders in the field, include reference lists and additional reading, copious diagrams, case studies, and especially provide synthesis diagrams and conceptual models of complex issues. The treatise covers both the natural and social sciences, serving a wide audience ranging from undergraduate students to established researchers and practitioners. The work avoids autecological studies but focusses on inter-linked physical-chemical-biological-ecosystem processes and associated socio-economic issues in the coastal zone. It examines estuaries and coasts, and their interactions and feedback with humanity, from the inland catchment/river basin to the ocean shelf.

The new edition builds on and expands the previous version with significant updates and an entire new section on Climate Change and Coastal Ecosystems, covering the resistance and resilience of the estuaries, coasts, and other transitional habitats to climate change, thereby determining changes and responses needed over the coming decades.

Key Features

- Comprehensive: a unique resource in the field, *Treatise on Estuarine and Coastal Science* covers system-based coastal and estuarine science and management, linking physical, chemical, and biological ecosystem processes with associated socio-economic issues.
- Highly regarded: the previous edition was very well received by the market and widely used, with over 50,000-chapter downloads.
- Updated and forward-looking: the new edition expands the previous version with significant updates and a whole new section on Climate Change and Coastal Ecosystems, covering the resistance and resilience of the estuaries, coasts, and other transitional habitats and responses needed over the coming decades.
- Authoritative and accessible: 5,400 pages, 155 chapters, written by leaders in the field, provide synthesis and conceptual models of complex issues, ensuring that the knowledge within is easily understood by a large audience.
- Structured content: all chapters follow a common structure with set headings, making it easier for users to cross-compare and navigate the content.

Volume 1:

Coastal Ecosystem Diversity

Editors: Alan Whitfield and Michael Elliott

Volume 2:

Physical Aspects

Editors: Stephen Mitchell, Reg Uncles, and Jon French

Volume 3:

Biogeochemical Cycling

Editor: Tim Jennerjahn

Volume 4:

Structure and Function of Biological Communities and Coastal Ecosystems

Editor: Daniel Baird

Volume 5:

Modelling and Prediction

Editors: Ursula Scharler and Daniel Baird

Volume 6:

Anthropogenic Uses, Effects, and Solutions on Estuarine and Coastal Systems

Editors: Michael J. Kennish and Michael Elliott

Volume 7:

Management, Governance, and Socio-economics

Editors: Bruce Glavocic and Nicola Beaumont

<https://shop.elsevier.com/books/treatise-on-estuarine-and-coastal-science/baird/978-0-323-90798-9>

Editors' Note: This seven volume treatise was published by Elsevier in March 2024

Introducing a New Tool for Assessing Wetland Resilience

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Imagine if all the suspended sediment carried by the coastal streams and rivers of the contiguous US ended up on top of tidal wetlands. In this impossible, imaginary world, would tidal wetlands receive enough sediment to keep pace with sea level rise? Surprisingly, the answer is often “no.”

By combining tidal wetlands mapped by the US Fish and Wildlife’s National Wetland Inventory, coastal-draining river channels from the National Hydrography Dataset, and suspended sediment load modeled by the US Geological Survey’s SPARROW (SPATIally-Referenced Regression On Watershed attributes) data, we calculated a maximum height of sediment that may be added to tidal wetlands annually by rivers.¹ When compared to rates of sea level rise measured by the National Oceanic and Atmospheric Administration across the contiguous US coastlines, 72% of the 4,972 rivers we analyzed would not survive projected sea level rise, and incredibly, almost half of these tidal wetlands would require at least an order of magnitude more sediment to avert drowning due to a height deficit.

We conducted our thought experiment partly with the aim of addressing the very real question of whether management efforts to increase sediment delivery to coastal waters, such as dam removal, could potentially produce the desired outcome of increased tidal wetland resilience to sea level rise. The reality is that

dam removal often will not be sufficient to mitigate terrestrial sediment deficits, at least not for East Coast tidal wetlands.

Our results also revealed broad patterns in coastal geomorphic processes relevant to many aspects of estuarine science. First, most tidal wetlands on the East Coast and parts of the Gulf of Mexico rely heavily on sediment delivered from estuarine and near-shore deposits along with organic matter produced by the wetland itself. Second, over 90% of tidal wetlands in the US are fed by a watershed smaller than the footprint of the international airport in Houston, Texas. Small watersheds export small sediment loads, but the effect of that sediment on tidal wetlands can be large if the tidal wetland area is small, or the effect can be negligible if tidal wetland area is large.

We know the fate of tidal wetlands may not be so grim as our model predicts. That’s because our model uses the SPARROW model which predicts annual mean sediment load for each stream/river that may not have included large river floods that occur less than once every 15 years (floods that could convey large amounts of sediment). Moreover, we did not include sediment from estuarine or marine sources, nor did we account for elevation gained from wetland plants. We were not surprised to find that, when compared to actual measurements of vertical accretion, many tidal wetlands for which our model predicted a sedi-

ment deficit are in actuality keeping pace with sea level rise.

Many other questions could be tested with our modeled sediment heights or through modifications of the existing GIS model. For instance, how does altering the input parameters, such as sediment density or tidal inundation heights, affect overall sediment thicknesses? How would the addition of episodic storm discharges affect total sediment gains on tidal wetlands? Where are tidal wetlands relying more on non-fluvial sediment additions to support accretion? Are there regions where biomass production or marine sediment more important to elevation gain than fluvial sediment? How do tidal dynamics promote or prevent delivery of sediment to tidal wetlands? Are there geographic patterns within the estuary, such as distance to the main channel or distance from head of tide, where we can adjust the predicted thickness of sediment?

So we invite the CERF community to check out our hypothetical model at: <https://experience.arcgis.com/experience/8295634827d843bf8bd572189fe71484>. We hope your research will benefit from a preliminary assessment of how much your local tidal wetlands rely on riverine sediment.

Reference

1. Ensign, S.H., J.N. Halls, and E.K. Peck. 2023. Watershed sediment cannot offset sea level rise in most US tidal wetlands. *Science* 382(6675): 1191-1195.

Become a

SP²ARK Fellow



Scientists Promoting Policy, Access, Research, and Knowledge

SP²ARK is a 6-month science communication training program organized by the Consortium of Aquatic Sciences (CASS). It aims to build a diverse network of skilled science communicators among early career aquatic scientists.



Communicating
science to
inspire action

Benefits for Participants

- Gain practical skills in science communication
- Build a community and network with other early-career scientists
- Develop leadership skills
- Learn how to effectively communicate science for policy impact
- Receive training in media interactions and handling challenging conversations

Who should apply?

- Early-career aquatic scientists (senior Grad Students and Postdocs)
- Scientists passionate about improving their ability to communicate aquatic science and its applications
- Members of any of the 10 CASS societies

Application Deadline: October 15, 2024

Program Dates: November 2024 – June 2025



[**APPLY HERE**](#)



Questions? email:
spark.fellows@gmail.com



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SWS



NALMS



SCAS

Call for Nominations for 2025–2027 CERF Governing Board

Leila Hamdan, Nominations Committee Chair

leila.hamdan@usm.edu

Are you interested in giving back to CERF and shaping its future, all while learning new skills and meeting new people? Please consider running for the 2025–2027 CERF Governing Board, led by current President-Elect **Sharon Herzka** with a term beginning on 11 November 2025.

CERF is soliciting nominations for our next President-Elect, Secretary, and three Members at Large, including a Student Member at Large. Board members are responsible for the overall planning, management, and oversight of CERF activities. Serving on the Governing Board is a fantastic way to expand your network, influence CERF programs and activities to ensure they meet the needs of you and your colleagues, determine the future direction of the federation, develop leadership and other new skills, and have a lot of fun! The board generally meets four times per year (two short virtual meetings and two in-person meetings ranging from one to two days), and Board members typically serve on at least one CERF committee in addition to their role on the board. Detailed responsibilities are listed below.

No prior experience is necessary to serve on the board; any member may serve if they are dedicated to advancing our mission. The federation is committed to fostering greater diversity, equity, inclusion, justice, and accessibility (DEIJA) in all the work we do and throughout all levels of the organization, including CERF leadership. We particularly encourage nominations that reflect individual differences in social identity such as race, ethnicity, national origin, gender identity and expression, religion, sexual orientation, physical ability, and socioeconomic

background, as well as differences in discipline, career path, and life experience. We best serve our mission when our board is representative of the diversity of our membership and the coastal communities we serve.

Board service is a volunteer position, though CERF covers travel costs to attend in-person meetings not associated with the biennial conference and partial funding for board meetings held at the conference. Participating on the board also provides opportunities to receive professional training in inclusive leadership, meeting facilitation, and other skills relevant to your career.

Want to learn more about the board and whether you would be a good fit? We will be hosting a webinar to give a brief overview of the board and how it functions, as well as testimonials from board members about why they ran and what they have gotten out of their service, with plenty of time for Q&A. Details on the date, time, and registration for the webinar will be emailed to all members and we will post a recording for those who cannot attend. We also encourage you to reach out to current or past board members to get insight on these rewarding and engaging volunteer positions!

Please submit nominations through the online form (<https://bit.ly/2025CERFBoardNoms>) before the 19 December 2024 deadline. We welcome self-nominations; if you are nominating a colleague, please obtain their consent so we know all nominees are willing to serve if elected. All candidates for election will be required to attest they have upheld and will continue to uphold the CERF Code of Ethics (<https://bit.ly/CERFEthics>).

General Board Member Duties and Responsibilities:

- Carry out the affairs and purposes of the federation; maintain legal and fiduciary responsibility for the overall planning, management, and oversight of the federation
- Attend all board and business meetings
- Attend the Biennial Conference and provide visible leadership at key events, including the opening and closing receptions, student career event, and with sponsors and exhibitors
- Chair and/or participate in committees or ad hoc assignments
- Promote the goals of the federation and encourage students, friends, and colleagues to become and remain members of the federation and to participate in its activities
- Approve allocation of funds via approval of the biennial budget or by resolution
- General oversight of the journal, conference, and membership activities
- Review and approve changes to bylaws, policies, and procedures

President-Elect Duties and Responsibilities:

- Assume the duties of the President in the President's absence
- Serve as the President if the elected President is unable to complete the full term of office
- Assume other duties as assigned by the President
- Ascend to the position of President at the end of the two-year elect term (see below)

Secretary Duties and Responsibilities:

- Prepare and distribute the minutes of all board and business meetings
- Provide a list of action items and the person responsible for those

- items after each Board meeting; may bring forward unfinished action items at future meetings
- See that all notices are duly given in accordance with the Constitution and Bylaws
- May sign resolutions and official records for the federation
- Serve a two-year term

Members at Large Duties and Responsibilities:

- Represent the full spectrum of the interests of the membership
- Serve on one or more committees or perform special duties for the federation as appointed by the President
- Serve four-year staggered terms (except Student Member at Large, who serves a two-year term)
- Student Member at Large candidates must be an enrolled student at the time of their nomination

President Duties and Responsibilities:

- Chair of the Governing Board; preside at all board meetings and the Annual Business Meeting which provides an account of the state of the federation to the membership
- Supervise and provide direction to the Executive Director
- Appoint all committees, committee chairs including the Biennial Conference chairs, and committee members
- Provide oversight of and direction to all committees, and maintain dialogue between committees and the board
- Represent the federation (or designate a representative) in outreach to other organizations in support of the conference, journal, and other federation activities
- Represent the federation (or designate a representative) to affiliated

organizations (e.g., Consortium of Aquatic Science Societies) and in invitations to or discussions with other organizations for new collaborations

- Write a message to the membership in each issue of the *CERF's Up!* bulletin
- Provide remarks at the Biennial Conference and preside over key events
- Coordinate the solicitation of reports from board members and committees for submission to the board prior to each meeting
- Undertake the role of Past President upon expiration of their presidential term

Past President Duties and Responsibilities:

- Assist the President as needed
- Chair the Nominations Committee
- Provide continuity to the Governing Board

Voter Turnout and Comments Prompt Governing Board to Reconsider Wording of Revised Mission Statement

Linda Blum
CERF President

The Governing Board revised CERF's Mission Statement to align it with the priorities of members expressed in a 2022 membership survey and on which the new CERF Strategic Plan, Visions V, was based. Voting on the proposed changes to the Mission Statement and wording in the CERF Constitution closed on 18 July 2024. The changes suggested by the Governing Board were not approved due to an insufficient number of members voting. Article VIII of the CERF Constitution requires that a majority

of the eligible members cast a vote, and only 32% of the eligible members cast a vote. It is unclear if the lack of participation was because voting was a low priority due to the timing of the vote, overall member apathy, dissatisfaction with the proposed changes expressing a "No" vote by simply not voting, or for other reasons. Regardless of the reason for the low vote response, not voting helped to nullify the process. Many of the members who did vote, regardless of whether they voted

to accept or reject the proposed changes, offered clear feedback about the wording of the proposed Mission Statement and suggested that additional work was needed to align the Mission Statement with their view of CERF's mission. Consequently, the Governing Board will take up discussing the Mission Statement at their 11 September 2024 meeting and the Mission Statement will go back to the membership for a vote sometime soon after the 11 September meeting.

CERF 2024 WEBINAR SERIES

COASTAL FUTURES: THE RESILIENCE OF OUR COMMUNITIES, SCIENTIFIC ADVANCEMENT, AND OUR CHANGING WORLD

Don't miss the remaining three webinars in CERF's 2024 series on **Coastal Futures: The Resilience of Our Communities, Scientific Advancement, and Our Changing World**.

Our coastal systems encompass many communities, from the near-shore fish and mammals to estuarine marshes and the people who live and work in these diverse environments. Coastal resilience is not

only a measure of how well these natural environments are able to adapt quickly to undergoing changes but also how well the connected human communities recover after coastal hazards. Scientific advancement motivates every one of us to fulfill our curiosity, but this is only completed when we gift it to future generations. Please join us for this series of webinars looking at the advancement of scientific knowl-

edge, the different aspects of our coastal communities, the challenges they face, and how they adapt to a changing climate.

We will host one webinar a month for the rest of 2024, each tackling a variation on this theme. Visit the [CERF 2024 Webinar Series website](#)¹ for more information and to register. Registration is free for members, and \$25 for non-members.

22 October	Using the RAD (Resist-Accept-Direct) Framework for Coastal Climate Adaptation Abigail Lynch, Research Fish Biologist, USGS National Climate Adaptation Science Center
6 November	Phenotypic Plasticity, Description, and Function Françoise Daverat, Researcher, France's National Research Institute for Agriculture, Food and Environment (INRAE)
3 December	<i>Information Coming Soon, check www.cerf.science/webinars for updates</i>

The first two webinars of the series were "Successional Trajectories of Coastal Forested Floodplains Wetlands Along the River Continuum," by Elliot White Jr., Assistant Professor, Stanford University, and "Reframing Fishing Access as a Food Access Issue: Towards More Holistic Fisheries Management in the Ocean State," by Melva Treviño, Assistant Professor, University of Rhode Island. If you missed these or any past webinars, the recordings are available to members in the [Webinar Library](#);² remember to [log in](#)³ first to get access to this and other members-only benefits. And if you have ideas for the 2025 Webinar Series, please contact Webinar Committee Chair Anna Braswell (a.braswell@ufl.edu).

¹ <https://www.cerf.science/2024-webinar-series>

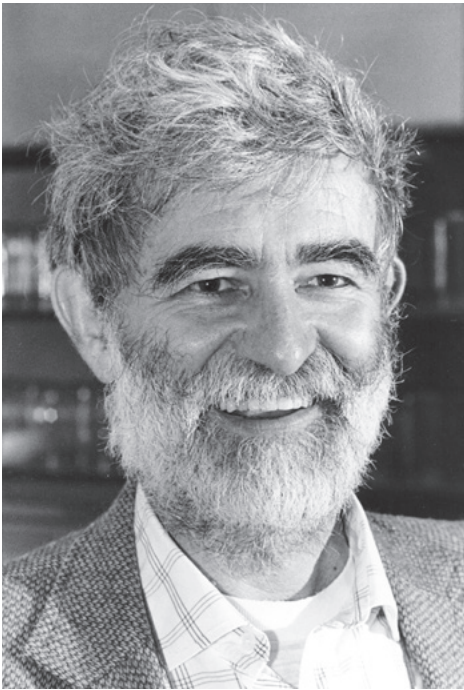
² <https://cerf.memberclicks.net/webinar-library-members>

³ <https://cerf.memberclicks.net/login#/login>



In Memoriam: John M. Teal

Robert Howarth, Cornell University, Ithaca, New York, USA and Marine Biological Laboratory, Woods Hole, Massachusetts, USA
howarth@cornell.edu



John Moline Teal

The world has lost one of the all-time great wetland ecologists: John Moline Teal passed away at his home in Rochester, Massachusetts, on 14 June 2024 after a long and full life. He was 94.

Teal was born in Nebraska in 1929. He earned a BA in 1951 and a PhD in 1955, both from Harvard University. As an undergraduate, he spent summers working in research labs in Woods Hole, Massachusetts, and ended up spending the rest of his life near the ocean, mostly in or near Woods Hole.

Teal's PhD thesis was on the community metabolism and trophic dynamics of a small spring ecosystem in Massachusetts. This work was published in *Ecological Monographs* in 1957 and together with a paper by H.T. Odum on a Florida spring published in the same year and journal, represents one of the earliest examples of a whole-ecosystem approach to understanding eco-



Ivan Valiela (left) and John Teal (right) in 1981

logical energetics. Throughout his career, Teal blended this approach to science with more detailed mechanistic studies, often on organism physiology.

From 1955 to 1959, Teal was a staff scientist at the University of Georgia's Marine Institute on Sapelo Island. The extensive salt marshes there captured his attention, and in 1962 he published a classic paper in *Ecology* on "Energy flow in the salt marsh ecosystem of Georgia" in which he compared the primary production of marsh grasses and algae with an estimate of whole-system respiration and concluded that production far exceeded respiration. He hypothesized that a large portion of primary production was exported from the marsh. This "outwelling" of

organic carbon, Teal theorized, was what led to the incredible secondary production of fish and shellfish in the coastal waters of Georgia.

Teal then spent two years at the newly created Bedford Institute of Oceanography at Dalhousie University in Halifax, Nova Scotia, before joining as a staff scientist at the Woods Hole Oceanographic Institution (WHOI) in 1961, where he spent the rest of his career before retiring in 1994.

In 1969, Teal and his then wife Mildred published a book on salt marshes for a lay audience titled *Life and Death of the Salt Marsh*. In clear and direct prose, they described the ecological importance of salt marshes, the beauty of these green

ribbons along much of the North American Atlantic coast, and the threats to their continued survival. Their book contributed significantly to efforts to protect coastal salt marshes and other wetlands, providing many reasons to value and respect them, including wildlife habitat, nursery grounds for juvenile fish and shellfish, and protection from storm surges. Prominent among these reasons was the outwelling hypothesis supporting coastal food webs.

The outwelling hypothesis spurred decades of research on the metabolism and carbon balances of salt marshes, including my own PhD research studying under Teal from 1974 to 1979. This research has shown carbon dynamics in marshes to be more complex than envisioned in the 1962 Teal paper. Primary production by marsh grasses is far greater when the belowground production is measured with aboveground biomass, and the uptake of oxygen by the marsh surface vastly underestimates respiration, which is dominated by sulfate-reducing

bacteria. Overall, salt marshes do not outwell a huge amount of organic carbon, and while some marshes export some carbon, others are net importers. Recent research has shifted from outwelling to sequestration of carbon in salt marshes, but earlier research stimulated by the outwelling hypothesis helped lay our current foundational understanding.

In 1970, Teal began what was to become the most important collaborative research of his career. With NSF funding, he and Ivan Valiela began the Great Sippewissett Salt Marsh project. Many graduate students and postdocs have worked on the project over the past 50+ years, studying a wide array of ecological processes. The project is perhaps best known for elucidating the importance of belowground primary production by marsh grasses and for the response of marshes to fertilization.

Although best known for his research on and love of salt marshes, Teal's interests were extremely broad. He allowed his students great leeway in the research

they took on, and students in the Teal lab focused on a range of topics including the subtle and long-lasting effects of oil pollution, consequences of high hydrostatic pressure on nerve functioning in deep-ocean organisms, and mercury pollution. The years I spent as a student there were among the most intellectually stimulating of my career.

Since retiring in 1994, much of Teal's focus was on his farm in Rochester, Massachusetts. He moved there in the late 1970s with his second wife to have more land than is affordable on Cape Cod. He delighted in building a house and barns, and in raising geese, ducks, chickens, and sheep, as well as growing hay and vegetables. The orchard he planted has over 50 varieties of apples. Teal also remained very active in environmental advocacy and in wetland restoration.

John Teal was a unique individual and an extraordinary scientist. He will be missed.

<https://www.wanderer.com/obituaries/john-moline-teal/>

Salt marsh, Sandwich, Massachusetts, USA

Photo: Lex Zhao



In Memoriam: George M. Woodwell

With deep sadness, Woodwell Climate Research Center announces the passing of Dr. George Masters Woodwell, a pioneer and visionary in the field of climate science; beloved family member, friend, and mentor; and Founder and Director Emeritus of the Center. He passed away at age 95 on 18 June 2024 surrounded by his family.

Woodwell dedicated his career to ecological research and to uplifting science to inform critical global policy and urgently needed solutions to some of the biggest environmental issues of the late twentieth century. He was steadfast in his belief that ecosystem-level understanding was critical, starting and leading ecological research programs within the University of Maine, Brookhaven National Laboratory, and the Marine Biological Laboratory.

Woodwell worked tirelessly to bring science into the public discourse. He was a strong scientific voice in the push to ban the pesticide DDT, conducted groundbreaking research on the ecological effects of nuclear radiation, and then turned his attention to what was at the time known as “the carbon dioxide problem.” He provided prescient testimony at the first US Congressional hearing on climate change in 1986, highlighting issues that have been enduring pillars of climate research since. He played an outsized role in building today’s ecosystem of science-based advocacy and policymaking, helping found preeminent environmental non-profits including Environmental Defense Fund, Natural Resources Defense Council, and World Resources Institute. He saw the need for international policy and governance to address climate change, guided by global scientific exper-

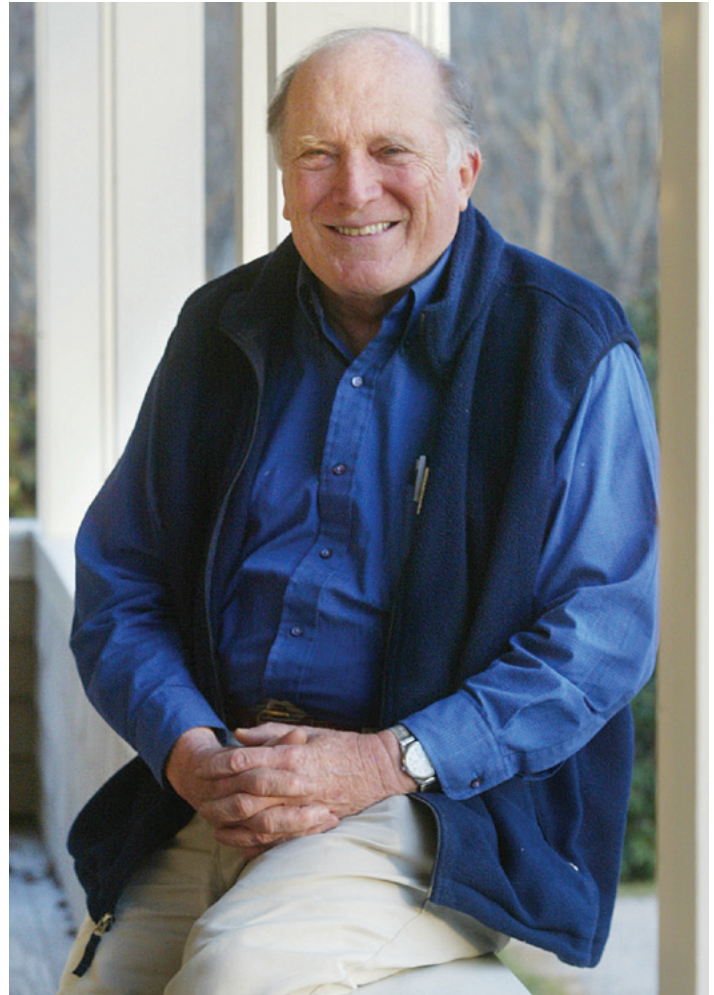
tise, and played important roles in the creation of what became the Intergovernmental Panel on Climate Change and the United Nations Framework Convention on Climate Change.

In 1985, he founded the Woods Hole Research Center—renamed Woodwell Climate Research Center in his honor in 2020—as an independent organization dedicated to conducting essential climate research and harnessing it to inform decision making at all levels of society.

Woodwell led the Center for more than twenty years and remained a trusted advisor to Center leadership to the end.

Woodwell published more than 300 scientific papers and authored five books. Among many honors, he was a member of the National Academy of Sciences, a Fellow of the American Academy of Arts and Sciences, and recipient of the 1996 Heinz Environmental Prize, the John H. Chafee Excellence in Environmental Affairs Award of 2000, and the Volvo Environment Prize of 2001.

He is survived by his wife, Katharine Rondthaler Woodwell, his children Caroline Woodwell (Chris DeForest),



Marjorie Woodwell (Woody Swan), Jane Woodwell (Chris Soper), John Woodwell (Marie Hull), and his grandchildren Katharine Soper, David Soper, John DeForest, and Robert DeForest. The family welcomes gifts in Woodwell’s memory to the [George M. Woodwell Endowment Fund](#).¹ For more information, please read the [Woodwell Climate Research Center full announcement](#).²

¹ <https://www.woodwellclimate.org/george-woodwell-fund/>

² <https://www.woodwellclimate.org/dr-george-woodwell-pioneer-in-climate-science-and-founder-of-the-woodwell-climate-research-center-passes-away-at-95/>



Announcing 2025 Travel Grants

The Wetland Foundation is soliciting applications for 2025 travel grants. We will accept applications from any student **currently enrolled full-time at an academic institution in the USA** and who meets the specific criteria for one of the types of grants listed below.

Conference Travel Grant Type 1 (up to \$1000): For advanced undergraduate and graduate students with limited funding who have never attended a wetland scientific conference. The grant will cover in person or virtual attendance costs.

Conference Travel Grant Type 2 (up to \$1600): For advanced undergraduate and graduate students with limited funding to present their wetland research findings at a conference. The grant will cover in person or virtual attendance costs.

Field Travel Grant Type 1 (\$1000): For outstanding graduate students with limited funding to defray travel expenses associated with thesis or dissertation research on wetlands.

Field Travel Grant Type 2 (\$600): For outstanding graduate students with limited funding to defray costs of a wetland field course or workshop.

Seneca Award (\$2000): For an outstanding student qualifying for a Field Type 1 grant AND whose research focuses on wetland plant ecology or restoration. See website for details.

Mission

The Wetland Foundation is a non-profit organization devoted to fostering wetland education and research, particularly in coastal marshes and mangrove forests.

Our mission is to enhance wetland education and research primarily by supporting students of wetland science with limited resources by providing travel grants to attend conferences, field courses, and to conduct field research.

**Applications due
December 18, 2024**

Scan Code To Visit Website



Policy Update: US Supreme Court Decision Could Have Major Impact on Environmental Regulations

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US Supreme Court Building, Washington D.C., USA

Photo: Mark Thomas

On 28 June, the Supreme Court of the United States (SCOTUS) released a decision¹ on a pair of cases—*Loper Bright Enterprises v. Raimondo*² and *Relentless, Inc. v. Department of Commerce*³—which challenged a NOAA Fisheries rule requiring the industry to cover the costs of observers on fishing vessels. While the case was ostensibly about fisheries management, the petitioners were fundamentally challenging the so-called Chevron doctrine or Chevron deference, based on a landmark 1984 SCOTUS ruling that courts should defer to an agency’s reasonable interpretation of

a law when the intent of Congress is ambiguous. This 40-year-old precedent acknowledged that Congress could not anticipate all scenarios and details when developing laws, thus providing flexibility for technical and scientific experts in federal agencies to fill in gaps, and requiring courts to defer to the expertise of these agencies if laws were challenged. A simple example might be if Congress passes a law requiring the federal government to limit a particular pollutant to levels that are not harmful to human health, but in the legislation, Congress leaves it to federal agency scientists to determine

what constitutes a harmful level based on the best available science; courts would then defer to the agency’s reasonable interpretation of the law if the law was challenged.

However, in their 6-3 decision on *Loper Bright Enterprises v. Raimondo* and *Relentless, Inc. v. Department of Commerce*, the Justices’ ruling overturned Chevron, giving authority to the courts to interpret statutes and overrule regulations developed by experts within federal agencies. The decision has sweeping implications for administrative regulations and rulemaking, particularly climate

change and environmental regulations including those affecting US coastal and estuarine habitats.^{4,5,6} It also upends decades of administrative law practices meant to protect citizens such as food and drug safety, public health regulations, labor and employment law (including workplace safety), consumer financial protections, transportation safety, social services such as Medicare and Medicaid, telecommunications rules, and more—essentially anything regulated by federal agencies that lacks explicit and clear direction from Congress.^{7,8} With the overturning of the Chevron doctrine, it is expected there will be many lawsuits against new and existing environmental regulations, potentially holding up enforcement of these regulations with years of litigation and ultimately allowing judges, not scientists and other experts, to interpret laws such as the Clean Water Act (CWA).

In addition, in another landmark

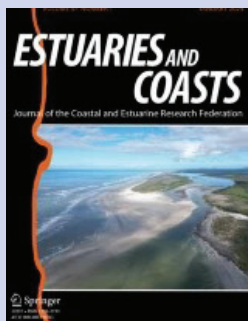
decision last year in the case of *Sackett v. Environmental Protection Agency*,⁹ SCOTUS ruled in favor of Sackett, effectively limiting the definition of Waters of the US (WOTUS) protected under the CWA to those with “continuous surface connections” to traditional navigable waters (e.g., permanent streams, lakes, rivers, oceans), thus removing protections from large swaths of wetlands, headwaters, and similar aquatic habitats. Previously, WOTUS was defined to include waters with a “significant nexus” to navigable waters, thus recognizing the hydrological connections to downstream navigable water bodies even without observable surface connections and acknowledging the important roles that upland, non-navigable wetlands and streams may play on the physical, chemical, and biological integrity of navigable waters. The Sackett case challenged this definition and whether the CWA required protection of these upstream systems. CERF, in partnership with 11 other

scientific societies, submitted an amicus brief¹⁰ in the Sackett case in support of a science-based definition of WOTUS; the brief provided a science-based argument for upholding the “significant nexus” test by summarizing the research on the connectivity of upland waters, including intermittent and ephemeral streams and wetlands, to the integrity of navigable aquatic ecosystems protected by the CWA. Unfortunately, the SCOTUS decision dismissed the hydrological science provided in the brief and largely eliminated upland wetlands and streams from CWA protection. These two decisions, along with other recent decisions, raises significant concern that many US environmental regulations may be rolled back and the power of federal environmental agencies such as the Environmental Protection Agency and National Oceanic and Atmospheric Administration to develop and enforce laws will be severely diminished.¹¹

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10. <https://bit.ly/WOTUSbrief>

Estuaries and Coasts Editors' Choice Papers



June 2024

Lumibao, C.Y. et al. 2024. Global Diversity and Distribution of Rhizosphere and Root-Associated Fungi in Coastal Wetlands: A Systematic Review. *Estuaries and Coasts* 47(4): 905-916. <https://rdcu.be/dOwm0>

July 2024

Beauvais, J. and J.E. Byers. 2024. Racial Composition and Homeownership Influence the Distribution of Coastal Armoring in South Carolina, USA. *Estuaries and Coasts* 47(5): 1151-1165. <https://rdcu.be/dOz5V>

Estuaries and Coasts Announces New Article Type for Understudied Coastal and Estuarine Systems

Paul A. Montagna¹ and Linda Deegan²

Estuaries and Coasts Coeditors in Chief

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² Woodwell Climate Research Center, Falmouth, Massachusetts, USA

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Estuaries and Coasts, the official journal of CERF, is excited to announce an open call for Estuary and Coast Signatures,¹ a new collection of articles that elevates the sharing of research and knowledge on understudied coastal and estuarine systems worldwide. We recognize the historical bias of estuarine research and publications, including those in *Estuaries and Coasts*, toward systems in North America, Western Europe, and other regions with greater resources. In contrast, relatively little is known or published about many regions in the global South and other under-resourced coastal and estuarine systems, which diminishes our global and holistic understanding of the science and management of estuaries and coasts. Previously, manuscripts that

were largely descriptive and place-based were outside the scope of *Estuaries and Coasts*, but in understudied regions, these descriptive and place-based manuscripts often provide critical baseline information on places that have had limited or no previous research. This has led to an inequity in international science publications and a lack of understanding of the variability of estuarine and coastal systems worldwide. Estuary and Coast Signatures are a type of Brief Report that describes estuaries and coasts that are currently under-represented or poorly characterized in literature worldwide. In addition to publication in the journal, Signatures will be highlighted in an open and ongoing online Collection hosted by, bringing further attention to these important contri-

butions. Signatures must improve understanding of the structure and function of estuaries and coasts by comparing the described system to other parts of the region or world. One approach is to compare similar measurements from other studies in a figure or table. Estuary and Coast Signatures, like all Brief Reports, are limited to 4,000 words inclusive of title and references and eight combined figures and tables. Please see the submission [guidelines](#)² to see requirements for submitting a Estuary and Coast Signatures Brief Report to this collection. Please also help us spread the word about this new article type and encourage colleagues studying under-represented or poorly characterized systems to consider publishing their studies in *Estuaries and Coasts*.

1. <https://link.springer.com/collections/edbibaeeac>

2. <https://link.springer.com/journal/12237/submission-guidelines>

Estuaries and Coasts Outstanding Reviewers



Estuaries and Coasts would not be successful without the hard work of

hundreds of volunteer peer-reviewers whose dedication and expertise play a crucial role in upholding the quality and integrity of the articles published in the journal. CERF recognizes the critical contributions of all our reviewers and thanks you for the generosity of your time. Reviewers are the lifeblood of the journal, and we feel it important to recognize those that go above and beyond in their service.

The *Estuaries and Coasts* editorial

board is proud to recognize the dedicated efforts of outstanding reviewers in each issue of CERF's Up! This recognition honors reviewers based on the number of reviews they have performed and their promptness in submitting these reviews.

For the period between 1 January and 30 June 2024, we are happy to highlight 20 outstanding reviewers for their significant contributions to the quality and success of *Estuaries and Coasts*.

Special thanks go out to Tracy Elsey-Quirk, who completed seven reviews!

All top 20 outstanding reviewers are:

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Jeremy Testa
Alan Whitfield
Guoyu Yin
Wei-dong Zhai
Wuchang Zhang

The Latest Coastal & Estuarine Science News (CESN)

Merryl Alber, CESN Editor, University of Georgia

Janet Fang, CESN Science Writer/Managing Editor

The mission of CESN is to highlight the latest research in the journal *Estuaries and Coasts* that is relevant to environmental managers. CESN is a free electronic newsletter that is posted online and delivered to subscribers on a bimonthly basis (six issues per year). CESN is available in both English and Spanish. Please visit www.cerf.science/cesn to read the full summaries and sign up to have future issues delivered to your email inbox. And please encourage environmental managers you work with to sign up as well.

La misión de CESN es destacar las últimas investigaciones en la revista *Estuaries and Coasts* que sean relevantes para los gestores ambientales. Es un boletín electrónico gratuito que se entrega a los suscriptores cada dos meses. Regístrate en www.cerf.science/cesn-spanish.

2024 CESN Issue 3

Fewer People, More Wildlife

Least Terns thrived in the Gulf of Mexico during the pandemic.

Source: Canales-Delgado, J.C. et al. 2024. Assessing Southern Gulf of Mexico Resilience: Least Tern Nesting Failure During the COVID-19 Pandemic.

Estuaries and Coasts. DOI: 10.1007/s12237-024-01341-y

<https://rdcu.be/dCHwG>

<https://cerf.memberclicks.net/cesn-2024-issue-3#Article1>

Healthy Mangrove Ecosystems are Resilient to Sea-Level Rise in the Marshall Islands

Transplanting techniques should mimic natural occurrences.

Source: Cramer, N.J. & J.C. Ellison. 2024. Atoll Mangrove Progradation Patterns: Analysis from Jaluit in the Marshall Islands.

Estuaries and Coasts. DOI: 10.1007/s12237-024-01331-0

<https://rdcu.be/dCHv4>

<https://cerf.memberclicks.net/cesn-2024-issue-3#Article2>

Lessons From Over 20 Years of SETs in Puget Sound

Estuaries can be resilient if sediment delivery is maintained.

Source: Davis, M.J. et al. 2024. Vulnerability to Sea-Level Rise Varies Among Estuaries and Habitat Types: Lessons Learned from a Network of Surface Elevation Tables in Puget Sound.

Estuaries and Coasts. DOI: 10.1007/s12237-024-01335-w

<https://rdcu.be/dEQjR>

<https://cerf.memberclicks.net/cesn-2024-issue-3#Article3>

Centuries-Old Shell Middens Help Stabilize Tampa Bay Shorelines

Protecting archaeological sites offers cultural as well as ecological benefits

Source: Rogers, J.A. & K. Jackson. 2024. Transformative Impacts of Sea-Level Rise, Storm Surge, and Wetland Migration on Intertidal Native Shell-Bearing Sites in Florida's Largest Open-Water Estuary, Tampa Bay, Florida, USA.

Estuaries and Coasts. DOI: 10.1007/s12237-024-01329-8

<https://rdcu.be/dCHvN>

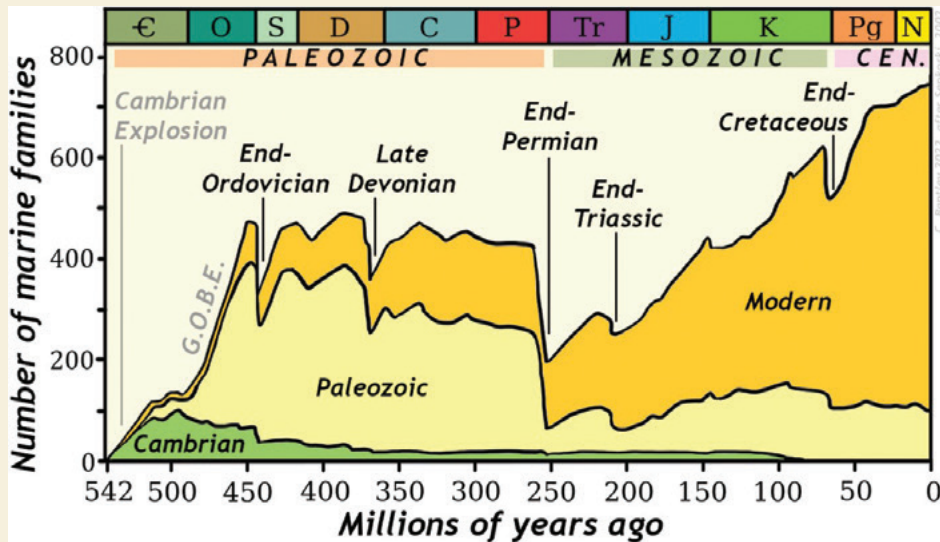
<https://cerf.memberclicks.net/cesn-2024-issue-3#Article4>

Mass Extinctions of Marine Species

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The five mass extinctions

Photo: [opengeology.org](https://www.opengeology.org/)

In the past 500 million years, life on Earth underwent five major mass extinctions of organisms in the fossil record when global extinction rates rose significantly above background levels in a short geological time. Now, many scientists note that the deleterious effects of humanity on the biosphere have launched the sixth mass extinction.

The end-Ordovician extinction of 440 million years ago (Mya) wiped out about 85% of all marine species, with hard hits on shelled brachiopods, bryozoans, and trilobites. During the Late Devonian extinction (364 Mya), dissolved oxygen levels plummeted, eliminating 15–20% of marine life. The worst event to befall life on Earth, the end-Permian extinction (252 Mya), was caused by massive volcanic eruptions in Siberia that triggered global warming. Seawater temperatures rose abruptly, causing a severe drop in oxygen levels. Around 96% of marine species, including all trilobites, went extinct. Rugose and tabulate corals disap-

peared, leaving a long gap of no reefs. Marine ecosystems took 4–8 million years to recover.

At the end-Triassic extinction (201 Mya), another period of volcanism warmed Earth and quadrupled atmospheric CO₂ levels, acidifying the oceans and making it difficult for marine organisms to build shells. Up to 20% of marine families were lost. A major asteroid impact near the Yucatan Peninsula caused the end-Cretaceous extinction (66 Mya), the one that led to the demise of dinosaurs. Around 80–90% of marine animals went extinct, including the ammonites and plesiosaurs. Now, in the Holocene Epoch (began 11,700 years ago) of the Quaternary Period, the planet is in the midst of another sharp loss of overall biodiversity, with extinctions happening hundreds of times faster than background rates. If unabated, another mass extinction could occur in a few hundred years. Climate change, destruction of habitat, pollution, over-harvesting, and introduction

of invasive species threaten up to a million species with extinction. Humans have drastically reduced populations of many marine species, often leading to local extinctions. But there have been fewer outright extinctions than among terrestrial species. This may be changing. Four-tenths of the 17,903 marine species on the IUCN Red List of Threatened Species are at risk of extinction from climate change. Boyce and others, writing in *Nature Climate Change* in 2022, estimated that under a high-emissions scenario, almost 90% of the ~25,000 marine species they examined will be at high risk of extinction by 2100. In a 2022 article in *Science*, Deutsch and Penn estimated that, given the current high greenhouse gas emissions, global warming alone could lead to a mass die-off of marine life by 2300, on par with the previous five extinctions. Keeping below a temperature rise of 2.0 °C would reduce risks by >70%. Global mean temperature is now approaching the 1.5 °C goal of the Paris climate agreement and humanity is not on track to stop it there. Signatures of the Industrial Age such as global warming, hypoxia, plastics, nuclear isotopes, and synthetic chemicals will be found in the sedimentary record millions of years from now. Many scientists argue this represents a new geological epoch, the “Anthropocene” (the human age). Extinctions open up space and new ecological niches for new species to emerge. After each of the five mass extinctions, biodiversity bounced back to varying extents. However, these recoveries took millions of years, far longer than would bode well for survival of *Homo sapiens*.

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