

Eelgrass, Herring, and Waterbirds: Shaping a healthy future for the San Francisco Bay

The fate of eight million people and a vast array of birds and other wildlife is tied to the health and resilience of the San Francisco Bay ecosystem.

The beaches, estuaries, bays, marshes, and tidal wetlands of San Francisco Bay provide essential habitat for a multitude of birds

and support a wide range of fish, shellfish, and other coastal wildlife. Its shallow estuary system and vast expanses of tidal mudflats, marshes, and underwater eelgrass meadows provide winter habitat for more than a million migratory birds, a productive nursery for many species of juvenile fish and shellfish, and a year-round home for diverse plants and animals.

However, coastal development and degradation, and climate change threats, including rising seas and extreme storm events, put these birds and ecosystems at risk—many coastal bird species are declining, some by as much as 80%. About one third of all seabird species have experienced severe population declines and are now considered globally threatened—in part because of declines in the availability of the forage fish that are the mainstay of their diets.

THE WEB OF LIFE THAT CONNECTS EELGRASS, HERRING, AND WATERBIRDS

San Francisco Bay's large eelgrass beds contribute to its beauty; they also provide nurseries for Pacific herring and support wintering waterbirds and



other wildlife. Eelgrass, herring, and waterbirds are inextricably entwined in this fragile urban ecosystem. Many species of birds and other marine wildlife depend on herring as a food source, and the herring, in turn, depend on intact eelgrass beds.

The loss of this eelgrass-herring ecosystem would put tens of thousands of wintering and migrating birds in jeopardy, impacting populations of species like American Wigeon and Surf Scoters up and down the Pacific Flyway migration route. And like other Pacific Flyway estuaries, the Bay faces a confluence of threats, including sea level rise and anthropogenic habitat destruction.

Audubon has published a comprehensive report identifying the greatest threats to eelgrass, herring, and waterbirds in San Francisco Bay—and the opportunities to address them. Our vision is that it will provide an actionable roadmap for the committed conservation effort needed today to protect the bay and its wildlife and communities for years to come.

The following pages of this summary include the highest priority threats and opportunities for conservation for each element, followed by Audubon's recommendations for next research steps.

The table below provides the top threats and opportunities to eelgrass, herring, and waterbirds in San Francisco Bay.

Challenge	Solutions
Direct Damage to Eelgrass	
Eelgrass loss and disturbance from boat anchors, chains, and other ground tackle.	<ul style="list-style-type: none"> • Limit mooring/anchoring or identify restricted areas to reduce eelgrass disturbance. • Conduct regular surveys of boats anchored and moored in eelgrass beds (e.g., for location and registration). • Protect focal eelgrass areas where watercrafts are prohibited.
Climate Change Impacts on Eelgrass	
Increasing frequency of warm temperature events, storms, and El Niño increases eelgrass degradation.	<ul style="list-style-type: none"> • Identify susceptible eelgrass beds and prioritize specific locations for restoration and conservation. • Develop management strategies that promote eelgrass resilience at local and regional scales. • Improve water quality to make eelgrass more resilient to climate change.
Challenges to Eelgrass Restoration Success	
Restoration success is influenced by factors such as unpredictable changes in water quality.	<ul style="list-style-type: none"> • Emphasize conservation and expansion of existing beds over restoration of new areas. • Assess input of nutrients (especially inflows to Richardson Bay) and take action to reduce inflows that may harm eelgrass. • Assess environmental conditions at successful and unsuccessful restoration sites to develop restoration criteria that will inform future projects. • Assess the impact of Canada Goose eelgrass consumption and bat ray disturbance at restoration sites; use findings to inform project planning.
Loss of Herring Habitat	
Localized eelgrass habitat loss observed at high priority spawning sites (e.g., Richardson Bay).	<ul style="list-style-type: none"> • Conserve a range of eelgrass and spawning sites to reduce effects of loss. • Conduct research and monitoring to determine causes of eelgrass decline.
Herring Fishing Pressure	
Herring stocks have highly variable recruitment (survival to adulthood) rates, which makes herring vulnerable to overfishing.	<ul style="list-style-type: none"> • Build recruitment into stock assessment model to improve understanding of sources of variability.
Reduced Forage Fish Availability	
Recent declines in herring spawn biomass may limit food availability for wintering birds.	<ul style="list-style-type: none"> • Measure the relationship between spawn biomass and waterbird count data in Richardson Bay. • Ensure fishing regulations support a sustainable herring population. • Identify priority spawn locations and take action to reduce threats to them.
Human Disturbance of Waterbirds	
Recreational activities such as boating and kayaking can prevent large groups of waterbirds from assembling at spawning sites.	<ul style="list-style-type: none"> • Limit recreational access to well-established spawning sites during spawning season. • Develop signage to educate and inform the public about spawning importance and problems of bird disturbance at major spawning sites.
Oil Spills	
Oil spills have immediate negative effects. Large spills can have long lasting effects on population dynamics.	<ul style="list-style-type: none"> • During oil spills, install barriers in front of Important Bird Areas such as Richardson Bay to protect birds from the oil. • Ensure a rapid cleanup response following oil spills and use mitigation funds to enhance Important Bird Areas in San Francisco Bay.



Herring eggs (*Clupea pallasii*) on eelgrass (*Zostera marina*) in San Francisco Bay. Photo: Ryan Bartling

Eelgrass: An Essential Estuary Element

Eelgrass beds improve water quality, sequester carbon, reduce wave action, protect shorelines, and provide essential habitat for fish that are a primary food for birds. Eelgrass is the foundation for a unique and valuable food web in San Francisco Bay, but is threatened by human activity (e.g., development, dredging, and boating), climate change (including impacts from sea level rise and warming ocean temperatures), limited restoration success, and a lack of both formal valuation and community understanding of its benefits.

RESEARCH AND POLICY PRIORITIES

Our report surfaces an urgent need for 1) additional research to maximize the conservation impact of restoration efforts and 2) strategic policy action to minimize impacts on and protect the critical eelgrass habitats of San Francisco Bay.

Research Recommendations
To better understand causes and consequences of bed expansion or contraction, conduct annual aerial extent surveys of eelgrass in summer and winter.
Monitor eelgrass recovery following disturbance; conduct a study following boat and anchor removal to determine how fast eelgrass recovers within disturbed areas.
Investigate response of eelgrass growth to temperature and light conditions at multiple intertidal and subtidal sites.
Find out whether herring prefer to spawn in eelgrass compared to other vegetation and rocks to determine how eelgrass influences herring reproductive success.
To inform future habitat protections for herring, quantify environmental conditions at focal spawn locations and in locations of the bay where herring do not spawn.
Quantify the primary controls on fish health by relating environmental conditions within the estuary to fish biomass and fish condition.
Integrate existing long-term seabird productivity data with existing eelgrass and herring data to prioritize conservation needs.
Compare Richardson Bay bird count data with other datasets to quantify the importance of herring for birds wintering in the sanctuary.
Quantify invertebrate diversity within focal eelgrass beds to understand the ecosystem benefits of the beds.
Quantify direct use of herring, eelgrass and other under water vegetation by waterbirds to support bird conservation initiatives in the estuary.

Policy Recommendations
Examine policies to re-route shipping lanes away from eelgrass beds.
Use findings from eelgrass damage assessments to inform policy decisions related to anchorages.
Designate sea-level rise refugia for eelgrass to allow for shoreward expansion.
Increase the network of Marine Protected Areas that could benefit eelgrass, including new coastal estuaries.
Designate herring spawning grounds as MPAs within coastal estuaries.

To learn how your support can make a difference for the birds and people that depend on a healthy San Francisco Bay, contact richardsonbaycenter@audubon.org