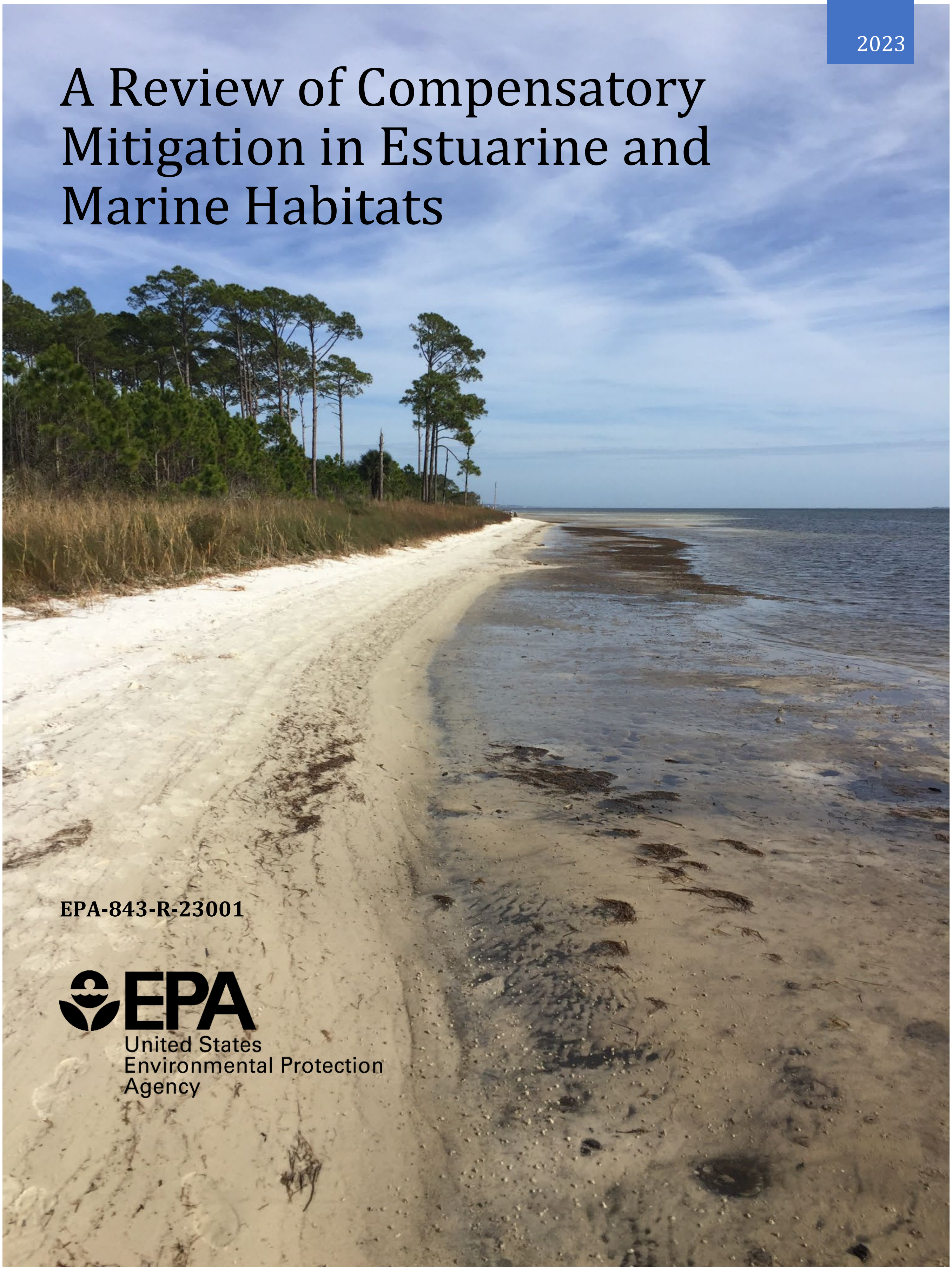


2023

A Review of Compensatory Mitigation in Estuarine and Marine Habitats

EPA-843-R-23001

United States Environmental Protection Agency

Acknowledgements

Principle authors of this report were Emily French and Brian Topping (EPA Headquarters). Thank you to the reviewers, including Steve Martin from USACE Institute for Water Resources (retired); Susan Marie-Stedman from NOAA Headquarters; David O'Brien from NOAA Fisheries; Jennifer Siu from EPA Region 9; Palmer Hough, Betsy Valente and Brittany Bennett from EPA Headquarters; Aisling O'Shea from Massachusetts Department of Fish and Game ILF Program; and Kristina Tong from USACE Seattle District. They offered their expertise, including input on multiple drafts, and immeasurably improved this report.

Thank you also to the staff at the USACE's Seattle, San Francisco, Los Angeles, Galveston, Jacksonville, Norfolk, and New England district offices for providing us with records on permittee-responsible mitigation and assisting with interpreting ORM records.

Finally, we acknowledge the third-party mitigation providers who explained the landscape and habitats at their sites and shared their monitoring methods and performance standards. Thank you for the time that you took to exchange many phone calls and emails with us.

We appreciate the assistance from all the aforementioned groups in writing this report and are thankful for their commitment to improving estuarine and marine compensatory mitigation.

Cover photo from Gulf Islands National Seashore (National Park Service) in Florida, an area where the four habitats primarily featured in this report coexist. Photo by Emily French.

Disclaimer

This review of compensatory mitigation in estuarine and marine habitats was conducted in support of the Clean Water Act 404(b)(1) Guidelines including the 2008 Final Rule Compensatory Mitigation for Losses of Aquatic Resources. It has been subjected to review by EPA and approved for release. The mention of trade names or commercial products does not constitute endorsement or recommendation for use. This review is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation with the United States. Anyone may decide to use the information provided in this document or not. This document is not a regulation itself, nor does it change or substitute for statutory provisions within EPA or USACE regulations. Thus, it does not impose legally binding requirements on EPA, USACE, States, or the regulated community.

Contents

Glossary

404 Program: A program established by Section 404 of the Clean Water Act regulating the discharge of dredge and fill material into waters of the U.S. that is implemented primarily by U.S. Army Corps of Engineers (USACE) or authorized states[1] and the Environmental Protection Agency (EPA).

Ambient monitoring site: A monitoring site that is not necessarily tied to a restoration project; it may be a naturally-occuring population of organisms or a natural habitat area monitored for preservation or research purposes.

Assessment methodology: The mechanism or tool used to evaluate either the loss of functions or services at a permitted impact site or a gain in functions or services provided at an associated compensation site.

Compensatory mitigation: Within the 404 Program, this refers to the restoration, establishment (creation), enhancement, or preservation of wetlands, streams, or other aquatic resources for the purpose of offsetting unavoidable adverse impacts.

Credits: A unit of measure representing the accrual or attainment of aquatic functions or services at a compensatory mitigation site.

DARTER (Data on Aquatic Resources Tracking for Effective Regulation): EPA database that receives data from the USACE ORM (OMBIL Regulatory Module) database.

District: Refers to a USACE district office.

ILF (In Lieu Fee): A sponsor that collects funds from multiple permittees in order to pool the financial resources necessary to build and maintain the compensatory mitigation site(s). The sponsor is a public agency or non-profit organization.

ILF site: A compensatory mitigation project developed by an ILF to offset permitted losses of aquatic resource functions and services.

Impact: In this report, impact refers to the adverse effects of a discharge of dredge or fill material into an aquatic resource.

In-kind: Compensatory mitigation that provides a resource of a similar structural and functional type to the impacted resource.

Instrument: Refers to a mitigation bank or ILF's binding legal agreement and any associated exhibits/attachments.

---

[1] As of November 2022 Michigan, New Jersey and Florida has been authorized to implement the 404 permitting program for certain waters.

IRT (Interagency Review Team): A group of federal, tribal, state, and/or local regulatory and resource agency representatives that reviews documentation for and advises the group chairs (USACE district and any other agency chairing the IRT) regarding establishment and management of a mitigation bank or an ILF program or site.

Focal habitats: Seagrass, oysters, tidal flats, and shallow water.

Mitigation bank: A compensatory mitigation site with credits for sale that correspond to habitat area. Mitigation banks collect funds from permittees that have impacted habitat at another location. Mitigation bank sponsors are typically private organizations. Also referred to as "bank" throughout report.

ORM (OBMIL Regulatory Module): An USACE database that stores permit information, including 404 Program permit information.

Out-of-kind: Compensatory mitigation that provides a resource of a different structural and functional type than the impacted resource.

Oysters: Bivalve mollusks found in estuarine and marine, intertidal, and subtidal areas.

PRM (Permittee-responsible mitigation): Compensatory mitigation performed by the permit applicant or their contractor.

Provider: Any entity providing compensatory mitigation or restoration services.

RIBITS (Regulatory In-Lieu Fee and Bank Information Tracking System): A national web-based application used by multiple federal agencies to track mitigation bank and ILF credits and details.

Seagrass: Rooted, vascular, salt-tolerant plants that exist in subtidal and intertidal areas.

Shallow water: Subtidal, vegetated or unvegetated estuarine or marine waters (see introduction section for more information).

Sponsor: The entity that establishes and operates a bank or ILF program (i.e., mitigation bank or ILF program sponsor).

Third-party mitigation: Compensatory mitigation performed by a mitigation bank or ILF program.

Tidal flats: Intertidal, unvegetated, low-energy areas comprised of fine-grained material.

Waters of the U.S.: Aquatic resources regulated under the Clean Water Act.

Executive Summary

Environmental restoration, the ecological improvement of natural resources, can be voluntary or can be required by regulation. Section 404 of the Clean Water Act (CWA) is an example of a regulation that requires environmental restoration (or compensatory mitigation when used in this context) to be performed when certain unavoidable environmental impacts occur. The CWA Section 404 Program regulates the discharge of dredged or fill material into waters of the United States, including in coastal habitats.

Despite the efforts of voluntary and regulated restoration, coastal habitats continue to diminish in area and ecosystem functioning. To help assess the state of these efforts and to better inform mitigation decisions, this report reviews compensatory mitigation that has taken place under the CWA Section 404 Program in estuarine and marine habitats. Broadly, the report quantifies estuarine and marine third-party mitigation providers, then narrows the focus to seagrass, oyster, tidal flat, and shallow water habitats to provide examples of project types, monitoring methods, and performance standards. A review of large-scale voluntary restoration projects involving seagrass, oyster, tidal flat, and shallow water habitats is also included.

This report documents practices from across the country, which may be useful for federal and state regulators who review permittee-responsible and third-party mitigation project proposals, and for mitigation and other restoration providers. Based on available information from the CWA Section 404 Program databases, permits, and mitigation bank and ILF (In-Lieu Fee) program documentation, estuarine and marine mitigation projects were found to comprise a small but significant proportion of all compensatory mitigation projects: 2% of banks, 21% of ILF programs, 9% of ILF program sites, and 5% of PRM (permittee-responsible mitigation). Compared to tidal flat and shallow water projects, seagrass and oyster mitigation projects were found to have more comprehensive monitoring methods and performance standards, and project area (size) may be more commonly measured and tracked. Seagrass mitigation may also be occuring in-kind more often than oyster, tidal flat, and shallow water mitigation. Preservation projects reviewed generally had fewer monitoring methods or performance standards than restoration, establishment, or enhancement projects.

From this baseline review of existing practices for estuarine and marine compensatory mitigation, recommendations are made for future research and for CWA Section 404 program effectiveness. The challenges of providing compensation for impacts to, or in the form of, unstructured habitats (i.e., tidal flats) are discussed, alongside recommendations for record-keeping and development of assessment protocols.

Introduction

Wetlands, streams, and other aquatic resources in the U.S. are intrinsically valuable and essential to public health and well-being. However, humans are constantly modifying water bodies, including those in coastal areas where high population densities occur. Although statutes and regulations exist to protect aquatic resources, they also authorize impacts, which lead to direct, indirect, and cumulative effects. In 1989, President George H. W. Bush established the national "no net loss of wetlands" policy, which set the groundwork for agencies across the federal government to begin balancing wetland loss with reclamation and restoration efforts so the total acreage of wetlands across the U.S. would not decrease. However, "no net loss" is a goal, and does not mean no losses occur; wetlands and other aquatic resources are still lost through permit actions and unregulated activities. To offset impacts, regulatory programs can require mitigation for impacts, and voluntary programs also protect and restore wetlands, helping to pursue the goal of no net loss of wetlands overall.[2]

The Clean Water Act Section 404 program (hereafter, 404 Program) uses compensatory mitigation to not only protect against wetland loss, but also loss of other aquatic resources, including streams and coastal aquatic habitats. Compensatory mitigation is the offsetting of unavoidable impacts to wetlands or other aquatic resources resulting from a 404-permitted activity with wetlands or aquatic resources that function similarly and are of comparable size and value. Broadly, the 404 Program regulates the discharge of dredged and fill material into waters of the United States[3], unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities). When potential permittees propose activities that will cause impacts to aquatic resources, they must show that steps have been taken to avoid impacts, that the remaining potential impacts have been minimized, and that compensation will be provided for all remaining unavoidable impacts[4]. The U.S. Army Corps of Engineers[5] (USACE) and Environmental Protection Agency (EPA) jointly administer the 404 Program, through which USACE issues tens of thousands of permits each year (Vanderbilt et al. 2015).

The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), Fish and Wildlife Service (FWS), and state and local agencies coordinate and consult alongside EPA and USACE on 404 Program project reviews. Project size, impact type, affected habitat, permit type, and permit conditions dictate whether compensatory mitigation will be required. Compensatory mitigation can be provided though a third party (a mitigation bank or In-Lieu-Fee [ILF] Program) or through a project initiated by the permittee (permittee-responsible mitigation or PRM), and usually falls into one of four

---

[2] For more information about federal funding sources for wetlands protection and restoration see https://www.epa.gov/wetlands/federal-funding-wetlands.
[3] For the definition of "waters of the United States," see: https://www.epa.gov/wotus.
[4] For more information on the CWA Section 404 regulatory program, see: https://www.epa.gov/cwa-404/permit-program-under-cwa-section-404.
[5] Michigan, New Jersey, and Florida have assumed the administration of the CWA Section 404 regulatory program for many of the waters in their respective states. For more information about state and tribal assumption of the Section 404 regulatory program, see: https://www.epa.gov/cwa404g.

categories: restoration, preservation, establishment (creation), or enhancement. The 2008 Mitigation Rule, which revised and expanded rules governing how compensatory mitigation projects are developed, reviewed, and implemented, requires performance standards to be established for compensatory mitigation sites and monitoring reports to be submitted to assess progress (33 CFR 332.4(c) and 40 CFR 230.94(c)). The 2008 Mitigation Rule also includes a provision for difficult-to-replace resources, encouraging in-kind compensation (33 CFR 332.3(e)(3)/40 CFR 230.93(e)(3)).

Despite the efforts of both regulatory and voluntary programs, aquatic resources in coastal areas continue to diminish in area and ecosystem functioning. In back-to-back reports, FWS and NOAA found that coastal wetlands have suffered considerable losses during the past 20 years (Stedman and Dahl 2008, Dahl and Stedman 2013). Coastal areas are not only threatened by development but also by a suite of other stressors such as saltwater intrusion, sea level rise, non-native species, and water quality impairment. A continuation of such aquatic resource losses in coastal areas could result in an inability of coasts to buffer water quality, increased flooding and vulnerability to storm surges, and extensive habitat loss (Rezaie et al. 2020, Li et al. 2018).

This report reviews compensatory mitigation that has taken place in estuarine and marine areas under the 404 Program. Although coastal wetlands and aquatic resources are diverse and include freshwater and saltwater habitats, this report focuses exclusively on saltwater habitats and specifically on seagrass, oysters, tidal flats, and shallow water (referred to as 'focal habitats' throughout), which are among the habitats referred to as "special aquatic sites" under the 404(b)(1) Guidelines (EPA 1980)[6]. In the past, 404 Program staff at EPA have noted that they had few examples to reference when compensation is needed for impacts to these habitats, potentially because there are fewer permits involving these habitats being issued (compared to freshwater wetlands and streams). To maximize examples of projects involving seagrass, oysters, tidal flats and shallow water, a review of voluntary restoration and ambient monitoring projects is also included in this report.

Objectives

The objectives of this report include the following:

1. To understand how much estuarine and marine compensatory mitigation is occuring across the U.S.;
2. To better inform mitigation decisions for seagrass, oysters, tidal flats, and shallow water habitats by (a) examining what types of compensatory mitigation projects exist and what monitoring and performance criteria are used to evaluate them, and (b) by providing references to voluntary restoration and ambient monitoring projects for the same habitats.

[6] The 404(b)(1) Guidelines (EPA 1980), a regulation central to the 404 Program, acknowledges that some high-value habitats are especially difficult to replace and discourages the issuance of permits that would result in their degradation or loss. The regulation identifies "special aquatic sites" that include seagrass (40 CFR 230.43), mudflats (40 CFR 230.42), and sanctuaries or refuges (40 CFR 230.40), which are often created to protect oysters.

Although there are other federal programs that require compensation for adverse impacts, such as Natural Resource Damage Assessment or USACE Civil Works, only 404 Program compensatory mitigation is evaluated in this report. This report provides information that may be useful to federal and state regulators who review permittee-responsible and third-party compensatory mitigation proposals, and to mitigation providers who develop and implement compensatory mitigation projects.

The focal habitats

Oysters, seagrass, and tidal flats are found along shorelines nationwide and are common features of estuaries and coastal bays. The three habitats co-occur in temperate areas of the contiguous U.S., in shallow or intertidal waters.

Seagrasses are rooted vascular underwater or intertidal plants, distinguishing them from algae (e.g., kelp) which do not have roots. Seagrasses grow in contiguous 'beds' or patches. Seagrass beds or patches may fluctuate in size and location seasonally and from year to year. Ten native seagrass species are found in the continental U.S.: *Zostera marina* (commonly called eelgrass)*, Ruppia maritima, Halodule wrightii, Syringodium filiforme, Thalassia testudinum, Halophila engelmannii*, *Halophila decipiens*, *Halophila johnsonii, Phyllospadix scouleri,* and *Phyllospadix torreyi*. One non-native seagrass species, *Zostera japonica*, is featured in this report. The term 'seagrass' rather than 'submerged aquatic vegetation' (SAV) is used here to identify salt-tolerant SAV species found in estuarine and marine settings.

Oysters are bivalve mollusks found in areas with estuarine and marine salinities. They grow in subtidal waters and sometimes intertidal areas depending upon climate (exposure to extreme hot or cold air temperatures can desiccate or freeze oysters). There are two oyster species native to the continental U.S.: *Crassostrea virginica* (commonly called Atlantic oysters) found on the east and gulf coasts, and *Ostrea lurida* (commonly called Olympia oysters) found on the west coast. Both species have been heavily exploited commercially, with only a small percentage of their historic native populations remaining. Although both species formed three-dimensional reef structures historically, few natural reefs persist, and often, oysters are only found in patchy clumps. They are also found as two-dimensional restoration projects, on reef balls or oyster castles as part of restoration projects, or on shell bags or shell hash placed along living shorelines for restoration. For the purposes of this report, and because few classic three-dimensional oyster reefs still persist, all oyster presence was counted when searching for compensatory mitigation projects. One non-native oyster species, *Crassostrea gigas* (commonly called Asian oyster), is featured in this report.

Tidal flats can be broad, low-energy sheltered flats with fine-grained material; narrow, fringing areas bordering salt marsh; or tidal creeks, which are unvegetated channels exposed at low tide. Tidal flats occur in intertidal, estuarine or marine, relatively low-energy areas. EPA regulations define mudflats as "broad, flat areas along the sea coast and in coastal rivers…exposed at extremely low tides and inundated at high tides… substrate containing organic material and particles smaller in size than sand… unvegetated or vegetated only with algal mats" (40 CFR 230.42).

Because the definition of tidal flats may vary, projects are only included in this report if mitigation documentation or bank or ILF representatives self-identified as having tidal flat (mudflat/sand flat) presence. Tidal flat areas that mitigation providers expected to become vegetated in the future to produce tidal marsh are not included. Additionally, the term 'tidal flat' is used throughout this report, as opposed to 'mudflat', to be inclusive of sand flats, which are tidal flats located near high energy areas (e.g., oceans). However, sandy, high-energy beaches are not included in this report.

Shallow water is defined in this report as subtidal (permanently covered by water) estuarine or marine area, vegetated or unvegetated, with or without biogenic (e.g., oyster) structures. 'Shallow' is a relative term; its definition changes depending on the region of the U.S. and who is defining it. For instance, an EPA shallow water research conference defined shallow water as "all marine and estuarine waters within four meters below mean low water (MLW), including the intertidal zone" (Reilly et al. 1999), while other publications have defined shallow water as between MLW and two meters deep (Bilkovic et al. 2009).

After consideration of the variability in turbidity and in light penetration depth in estuarine and marine waters nationwide, three meters MLW was chosen as the cutoff depth for 'shallow water' for the purposes of this report. However, compensatory mitigation documentation obtained for this research rarely stated water depth at mitigation sites, making it difficult to say that every mitigation example featured in this report conforms to this depth range (zero to three meters MLW). Ultimately, the authors' best professional judgment was used, and the nature of mitigation projects included, for example creosote piling removal or preservation of an embayment, seemed unlikely to exhibit water depths greater than three meters.

Data on seagrass, oysters, tidal flats, and shallow water habitats can be collected using aerial photography, sonar surveys, and in-situ diving and wading surveys. Common methods for monitoring seagrass and oyster populations involve measuring the density and size of plants or individuals. Tidal flat and shallow water monitoring may include water quality measurements, sediment toxicity, grain size, infauna, fish communities, and other wildlife presence.

Box 1- Habitat types explored in this report

Seagrass: Rooted, vascular, salt-tolerant plants that exist in subtidal and intertidal areas. Not to be confused with seaweed or macroalgae such as kelp.

Oysters: Bivalve mollusks found in estuarine and marine, intertidal, and subtidal areas. Few natural three-dimensional structures remain due to overexploitation.

Tidal flats: Intertidal, unvegetated, low-energy areas comprised of fine-grained material. Present in estuarine and marine areas, and can appear as wide flats, salt marsh fringe or intertidal channels.

Shallow water: Subtidal, vegetated or unvegetated estuarine or marine waters with or without biogenic structures.

Value and status of the focal habitats

Seagrass, oysters, tidal flats, and shallow water provide important habitat for both commercially valuable species and small fish and invertebrates that are essential components of the coastal ocean food web. Oysters and seagrasses are ecosystem engineers, providing structure and refuge with their shells, canopies, and roots. Native and migrating shorebirds use tidal flats to feed, and tidal flat and shallow water areas harbor abundant infauna, including marine worms, clams, and crustaceans (Ray 2000). Tidal flats and shallow water interspersed among structured habitats (like mangroves, salt marsh, seagrass, or oysters) create a mosaic of foraging areas for predators (Orth et al. 1984, Whitlow and Grabowski 2012, Kellogg et al. 2013).

All of the focal habitats improve water quality by functioning as coastal filters that trap and remove excess nutrients and suspended sediments before they are exported to the ocean (Mcglathery et al. 2007, Kellogg et al. 2018). Oysters and seagrasses assimilate nitrogen, phosphorus, and carbon into their tissue and shell, sequestering it temporarily or permanently depending upon the persistence of populations and whether the tissue and shell are buried, consumed, or exported (Newell et al. 2004, Fourqurean et al. 2012). Benthic microalgae, which occur at the sediment-water interface in intertidal and shallow subtidal areas, function as a cap to retain sediment and nutrients (Pedersen et al. 2004). Oysters and seagrasses create heterogeneity in sediments and aid in delivering organic matter to the surface, both of which facilitate denitrification (removal of nitrogen from the system) (Newell et al. 2005, Ward et al.1984, Aoki et al. 2019).

There is no nationwide analysis for how much seagrass, oyster, tidal flat, or shallow water areas have decreased in acreage over time; however, some data and examples are available. In the Chesapeake Bay, the largest estuary in the U.S., the oyster population is currently less than 1% of historical levels (Wilberg et al. 2010). Eelgrass, one of two primary seagrass species in the Chesapeake Bay, was historically abundant but has declined in area by 64% over the last three decades (Richardson et al. 2018). In Maine, overfishing has significantly reduced the abundance and diversity of species associated with tidal flats (Brown and Wilson 1997). Along the Gulf of Mexico coast, several species of migratory shorebirds are declining due to loss of coastal wetlands, including tidal flats and sandy beaches (Withers 2002). Shallow water losses in the Gulf of Mexico are being offset as storms and sea level rise, causing the conversion of coastal marshes to shallow water habitat (Dahl 2011).

Aside from habitat conversion, a ubiquitous accelerant to the degradation of these habitats is reduction of water quality, such as changes in water temperature, nutrients, and alkalinity. Seagrasses and oysters are more vulnerable to mortality during sustained high water temperatures (Moore and Jarvis 2008, Lowe et al. 2017, Green et al. 2019), and the frequency of high-temperature events is predicted to rise. Excess nutrients from water pollution may cause epiphytic algal growth on seagrass, which can prevent photosynthesis (Dennison et al. 1993, Short and Burdick 1995). Oysters are threatened by rapidly increasing acidity and CO_2 levels in estuaries, which can decrease shell growth, size, and strength (Hettinger et al. 2012, Waldbusser et al. 2011), leading to a reduction in the number of juvenile oysters that survive into adulthood. Water quality impairment also has negative effects on shallow water and tidal flats; the deposition of excess suspended solids can have cascading detrimental effects on tidal flat benthic communities (Reimer et al. 2015), and water contamination can cause fish kills and harm to shorebirds (Hargreaves et al. 2011).

EPA's National Estuary Program (NEP), a network of 28 sites, and NOAA's National Estuarine Research Reserve System (NERRS), a network of 29 sites, are among the restoration and preservation programs around the country helping to conserve oysters, seagrass, tidal flats, and shallow water habitat. These two programs preserve over one million acres of estuaries. The National Park Service (NPS) also preserves thousands of acres of estuaries. Examples of large-scale restoration include Chesapeake Bay's "10 Tributaries by 2025" program, which began restoring oysters in 10 rivers in 2013, and the "Seagrass Restoration in Virginia's Coastal Bays" project, which began in 1999. These efforts have respectively been called the largest oyster and seagrass restoration projects in the nation. Tampa Bay is an example of a successful water quality improvement project. It is a shallow bay with an average depth of 12 ft and includes oyster, tidal flat, and seagrass habitat. Point source runoff reduction was part of a nutrient management strategy implemented in the 1980s, and subsequently, the Bay has experienced a 60% reduction in total nitrogen load and marked water quality improvements in shallow water habitat (Greening et al. 2011).

Methods

This report reviews compensatory mitigation implemented by third parties (mitigation banks and ILF programs) and permittees, in addition to voluntary restoration and ambient monitoring sites. The information is organized into subsections: third-party mitigation, permittee-responsible mitigation, and voluntary restoration and ambient monitoring. The results sections for each resource type also include a monitoring and performance subsection in which third-party and PRM are discussed.

The aim of this report is to represent the most up-to-date and comprehensive information available. However, some relevant information was inaccessible (e.g., monitoring reports). To avoid potentially incomplete or misleading comparisons among specific projects, names of third-party providers and Department of the Army permit numbers are not identified in the body of this report. Instead, they are listed in Appendix A (Tables 2 and 3).

Third-party mitigation

RIBITS search- The USACE database RIBITS (Regulatory In-Lieu Fee and Bank Information Tracking System)[7] was queried for banks, ILF programs, and ILF sites where the focal habitats were present. The search was conducted in March 2019 and was updated in February 2021. The database was searched for third-party compensation in several ways. First, the "Bank Summary Interactive" report was searched by the "Cowardin system list" field for estuarine and marine sites (specifically, the search was performed using the following string of terms: marine|estuarine|tidal|subtidal|intertidal|E1|E2|M1|M2). Then, the "Bank Credit Classification Summary by Jurisdiction" report was searched, and the "Credit Classification Type" and "Credit Classification" fields were filtered by the same terms. Because some bank/ILF sites that were expected to appear in the search results but did not, the reports for 23 keywords related to the focal habitats were also searched (Appendix A Table 1). A few bank/ILF sites were also found by panning within the RIBITS map viewer. Finally, through discussions with bank and ILF representatives, several ILF sites were discovered that were not on RIBITS. If the ILF program was on RIBITS already, these programs' sites were included.

These search methods returned banks and ILFs that are selling, have sold, or are approved to sell estuarine and marine credits (statuses in RIBITS included "sold out," "approved," and "terminated"). Pending banks were not included because their status could change before approval or could never be approved, and no umbrella banks appeared in the search results. Several pending ILF sites were included because their programs were approved, their sites secured, and their plans were available for Interagency Review Team (IRT) review.

Documentation requests and analysis- At present, identifying third-party providers that have seagrass, oyster, tidal flat, or shallow water habitat presence from RIBITS data is not straightforward because credit types are named broadly (for example, "wetland" or variants of Cowardin classes, like "E1"). Other fields within RIBITS records also do not

[7] https://ribits.ops.usace.army.mil/.

typically have specific habitat information. Therefore, studying instruments, mitigation plans, and monitoring reports from the RIBITS cyber repository was necessary. These materials were downloaded and reviewed for presence of the focal habitats, and for compensatory mitigation project types, performance standards, and monitoring methods. If none of the focal habitats were mentioned in this documentation, the bank or ILF representative designated on RIBITS was contacted and asked if they knew of the presence of these habitats on their sites. The bank/ILF was not included in the results section of this report if the bank or ILF representative was unsure whether the habitats were present at their sites.

Permittee-responsible mitigation

DARTER search- EPA's DARTER (Data on Aquatic Resources Tracking for Effective Regulation) database was queried to find examples of compensatory mitigation projects that involved the focal habitats in April 2019. DARTER houses information about USACE decisions and milestones in the permitting process from the USACE ORM (OMBIL Regulatory Module)[8] database.

Permit actions were downloaded from DARTER and retained if any one of 22 mitigation-related fields were filled out. The remaining projects were filtered by three fields: mitigation type, regulation project was authorized under (e.g., Clean Water Act, Rivers and Harbors Act, or blank) and Cowardin (Cowardin 1979) classification. Unlike RIBITS, which has only third-party mitigation projects, DARTER has projects with compensation provided by all three mitigation mechanisms (permittee-responsible, mitigation bank, or ILF). Therefore, to avoid duplication from the third-party mitigation RIBITS search, only projects with "permittee-responsible mitigation"' under the mitigation type field were retained.

Next, only projects authorized under CWA Section 404 were retained. Finally, projects were filtered by Cowardin classification to retain only estuarine and marine projects. A small number of projects were eliminated based on manual screening of the state field, for example, for projects that occurred within inland states, the information in the Cowardin classification field was assumed to be a typo. The resulting records were used to determine states with the highest frequency of permits potentially requiring compensatory mitigation in the focal habitats.

Permit requests and analysis- The five states with the most estuarine and marine compensatory mitigation projects according to the search process were selected.[9] Project managers (hereafter, PMs) from each of the six corresponding USACE districts (hereafter, districts) were established as points of contact and were emailed a request for permits, mitigation plans, and any available monitoring reports for the projects. The documentation received was reviewed to investigate whether it involved one of the focal habitats. If it did, impacts and compensation details were noted.

Only projects that could be verified as having been permitted were included in this report. Note, some projects are permitted but never built, and if the permitted impacts do not

[8] https://permits.ops.usace.army.mil/orm-public#.

[9] Anticipating a large volume of permits, the PRM aspect of the study was limited to five states due to time and resource constraints.

occur, the compensatory mitigation does not occur either. Although mitigation information was taken from the most recent information available for each project, in some cases only the permit was available, which made it difficult to determine whether the mitigation project occurred. In the results sections, the actions detailed in permits are referred to in the past tense, unless documentation received indicated they are still in progress. Finally, most project documentation referred directly to "compensatory mitigation," although some referred to "mitigation." It was assumed that "mitigation" was used to mean "compensatory mitigation," and all references in this report to "mitigation" are to compensatory mitigation.

Voluntary restoration and ambient monitoring

A review of voluntary restoration and ambient monitoring projects assisted with understanding which monitoring methods and performance standards were typical for seagrass, oysters, tidal flats, and shallow water. Ambient monitoring is monitoring that is not necessarily connected to a restoration project, and such monitoring can occur on natural populations of organisms or habitat areas. Voluntary restoration is restoration that was not required by a regulatory program. Ambient monitoring and voluntary restoration programs can help inform monitoring methods and performance standards developed for compensatory mitigation projects. To find examples of these types of projects, an internet search was performed, and the documentation retrieved was reviewed for project type and monitoring and assessment information. In many cases, especially for national programs, follow up and clarification with a program representative was necessary to ask for more documentation and verify the methodology was current. The programs and projects (Appendix A, Table 5) are global, regional, and local but are mainly large-scale.

Results: Inventory

Third-party mitigation

Sixty-one IRT-approved mitigation banks and ILFs from RIBITS were categorized as estuarine and/or marine. While vetting documentation, it became apparent that several of the banks and ILFs had only freshwater habitats and were likely miscategorized. Ultimately, 54 programs with estuarine or marine habitat were found in the search (38 banks and 16 ILF programs). The ILF programs include 111 sites (Figure 1a and b, Appendix A Tables 2 and 3). The number of estuarine or marine ILFs and banks constitutes 2% of banks, 21% of ILFs, and 9% of ILF sites on RIBITS. Forty-four banks and ILFs across 18 states included seagrass, oyster, tidal flat, and/or shallow water (subtidal) habitats (Table 1).

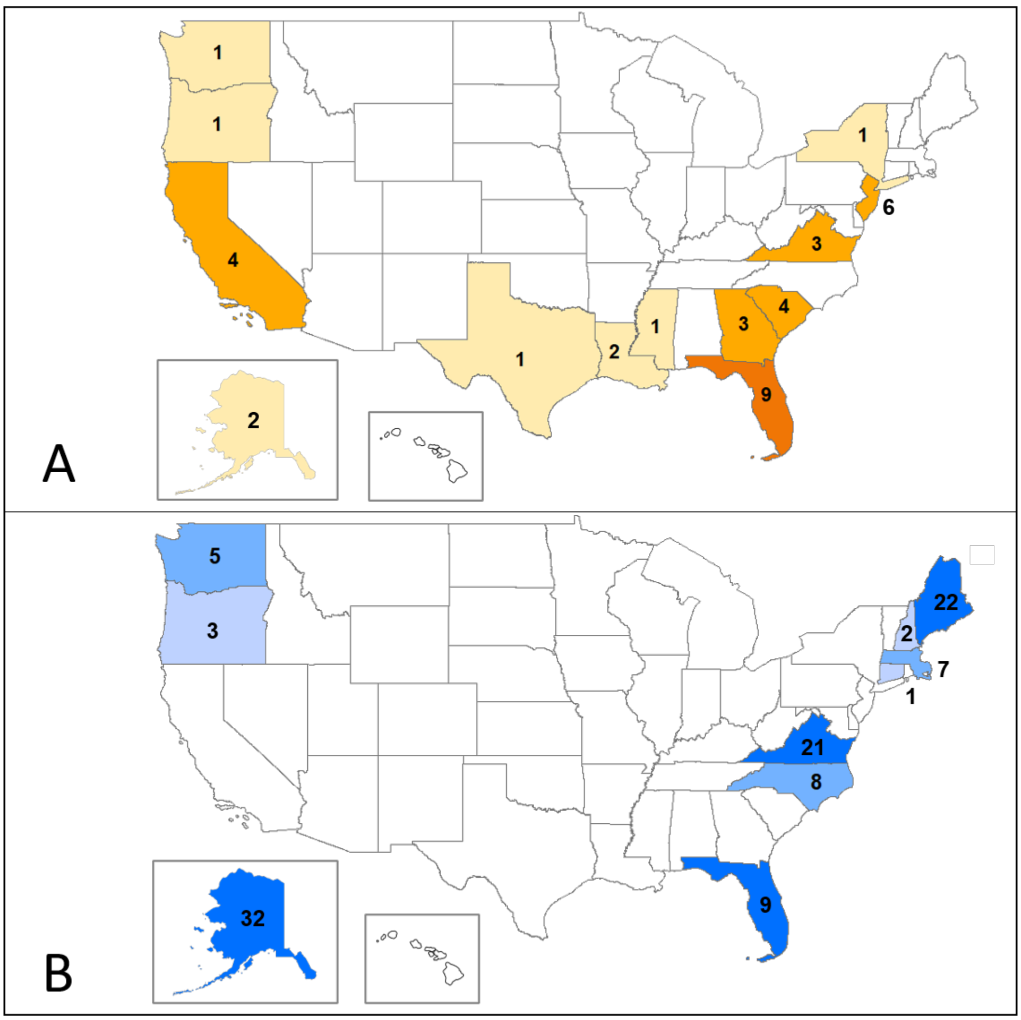


Figure 1- A: The number of banks with estuarine or marine habitats per state, B: The number of ILF sites with estuarine or marine habitat per state.

State	Seagrass	Oysters	Tidal flat	Shallow water
Alaska	2	-	5	2
California	2	-	2	4
Connecticut	-	1	-	-
Florida	4	2	1	6
Georgia	-	-	-	1
Louisiana	-	-	-	1
Maine	1	-	1	-
Massachusetts	1	1	-	1
Mississippi	-	-	-	1
New Hampshire	-	1	-	1
New Jersey	-	-	6	6
New York	-	-	1	1
North Carolina	-	1	1	1
Oregon	-	-	-	2
South Carolina	-	-	2	2
Texas	-	-	1	1
Virginia	1	2	2	2
Washington	1	1	2	-
Totals	**12**	**9**	**24**	**32**

Table 1- Third-party mitigation providers (ILF programs and banks) with focal habitats present by state (some programs and banks have more than one focal habitat present).

A few unusual circumstances were revealed during the review process. Although four banks had tidal flat habitat, bank representatives explained that it was not the final desired habitat and that they were expected to vegetate, so they were not considered tidal flat for the purposes of this report. There were also two banks in Florida where seagrass and tidal flats were present within the bank boundaries, but sponsors were not issuing credits for those areas, so those habitats were not counted as being present. Additionally, several banks indicated uncertainty regarding oyster or seagrass presence as they did not conduct monitoring of the underwater portions of the project site. Finally, in the results sections for each resource type, area (in the form of acreage) is not given for third-party mitigation projects, though it is for PRM projects; third-party mitigation projects were often mosaics of habitats and did not provide area measurements for the focal habitats in their properties.

Permittee-responsible mitigation

The initial search for projects that required compensatory mitigation in DARTER resulted in 29,158 projects, which were then filtered and screened. Many records were not able to be used because they were not labeled as a CWA Section 404 project (21% of 29,158) or because they were not labeled as permittee-responsible (61%). There were 9051 remaining records, 487 of which had a Cowardin class of estuarine or marine (5%). The remaining records, which spanned 21 states, were sorted by state and the five states with the most records were selected for data collection. The states with the most projects were Washington, Virginia, California, Florida, and Texas, with 260 projects total. The search was performed on records from mid-2007 (ORM records began to be loaded into DARTER starting in 2007) to April 2019.

PMs at corresponding district offices sent documentation on 214 of the 260 projects, and studying the documents revealed that 55 of them involved the focal habitats (Table 2). PMs reported some difficulty in locating and accessing records for various reasons. For instance, some districts' records were digitized while others were not. The records provided for each permit rarely contained a copy of each of the three requested documents (permit, mitigation plan, and at least one monitoring report). PMs provided the following types of documents: Nationwide Permit Verification letters, Letters of Permission, Department of the Army Permits, Memorandum for the Record, mitigation compliance reports, monitoring reports, mitigation plans, IRT correspondence, and USACE internal correspondence. However, the project packets received rarely included more than a few of these document types.

State	USACE district	# Projects PMs provided	# Permitted projects where mitigation involved focus habitats	Seagrass	Oysters	Tidal flat	Shallow water
California	LA	15	2	-	-	1	1
	San Francisco	21	8	5	-	2	1
Virginia	Norfolk	43	5	2	3	-	-
Texas	Galveston	7	2	-	1	-	1
Washington	Seattle	47	28	1	-	1	26
Florida	Jacksonville	81	11	5	1	-	5
Totals		**214**	**56**	**13**	**5**	**4**	**34**

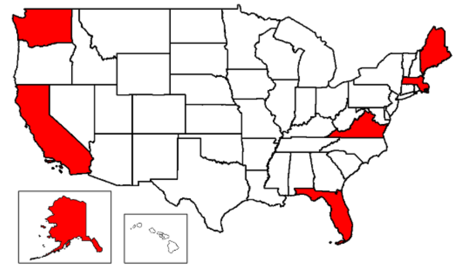
Table 2- The number of permittee-responsible projects with focal habitats present at their mitigation sites by state and USACE district (some projects have more than one focal habitat present).

Most mitigation project permits were issued post-2008 (Appendix A, Table 4), and most involved restoration, establishment, or enhancement rather than preservation. In the results section for each resource type, area is given (in the form of acreage) for permittee-responsible mitigation as permit documentation usually included it.

Voluntary restoration and ambient monitoring

Although the internet search was not exhaustive, 17 examples of worldwide, national, and regional restoration and ambient monitoring programs that monitor seagrass, oysters, tidal flats, or shallow water were found (Appendix A Table 5). There was no shortage of academic studies with thorough monitoring and performance standards, but because those studies' goals were research-oriented and more complex than the average mitigation project, they were not included.

Results: Seagrass



Seagrass mitigation projects (third-party or PRM) reviewed in this section occurred in the states in shown in red.

Third-party mitigation

There were 12 third-party mitigation providers (three banks, nine ILFs) with seagrass presence at their sites. The age of sites ranged widely, one bank began restoring seagrass areas in the 1990s while one bank and one ILF have not yet implemented their seagrass restoration components (as of 2021). The seagrass at most sites was eelgrass, though several programs in the southeast worked with *H. wrightii, S. filiforme* and *T. testudinum*. Half of the providers were preserving existing populations of seagrass at their sites, the remainder of the providers were restoring, creating, or enhancing seagrass in a variety of ways. Several providers transplanted seagrass from donor beds to restoration sites and one provider distributed seeds to facilitate seagrass reestablishment. Three providers employed topographical restoration techniques (removing fill or bringing propeller scars and other trenches up to a suitable elevation for seagrass colonization), including one provider that used dredged material. After topographical restoration, seagrass was either transplanted or expected to recruit to the area naturally. One provider installed bird stakes, which are platforms for birds to land on that enhance sediment nutrients and facilitate colonization of seagrass populations (Fourqurean et al. 1995). Finally, one provider removed a tidal restriction, which allowed seagrass to colonize part of the bank area.

Permittee-responsible mitigation

There were 13 PRM projects, all of which restored, created, or enhanced seagrass beds (there were no preservation projects) and were permitted or began somewhat recently, between 2010-2018. The majority of projects took place in Florida and California. While all of the seagrass mitigation projects in California, Washington, and Virginia involved eelgrass, Florida's projects involved *H. wrightii, S. filiforme, R. maritima,* and *T. testudinum*., as well as the non-native *Halophila ovalis*. Projects ranged in size from 0.005 to 2.61 acres, but most were small, less than one acre.

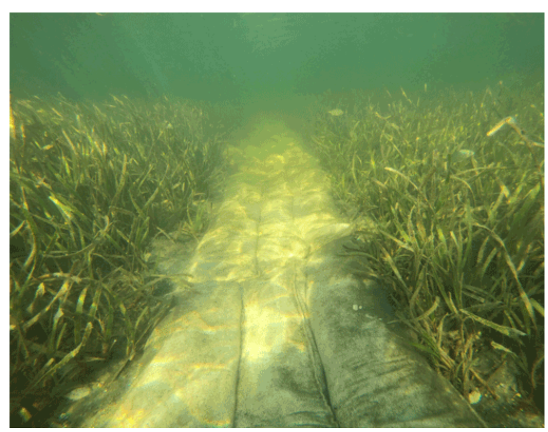


Figure 2- Sediment tubes used for seagrass restoration in St. Joseph Bay, Florida. Photo by Florida DEP.

Mitigation project types consisted of transplantation from donor beds, topographical restoration, and seed distribution. Topographical restoration projects included excavating uplands, placing sediment tubes in boat propeller scars (Figure 2), and filling in a channel dredged though a historic seagrass flat. Multiple projects mentioned the use of dredged material to construct the mitigation area. Seed distribution projects involved a university laboratory collecting flowering shoots of seagrass, extracting mature seeds, and seeding designated areas as compensatory mitigation. Impact types included public park projects in which boat ramps, jetties, trails, and culverts were installed. Impacts also included installing poles for power lines, roadway and shoreline improvement projects, dredging at a private residence, and a commercial dock installation.

Monitoring and performance

Most third-party and PRM seagrass projects were restoration, enhancement, or establishment projects that had an acreage goal. A few projects had 'areal expansion of seagrass beds' as a performance standard, although it was informal because there was no set time limit or area goal. Monitoring methods and performance standards for the restoration, enhancement, and establishment projects centered around canopy height, shoot density, and percent cover. Most projects required in-situ monitoring, while a few monitored seagrass beds via aerial surveys (these project types differed in that they used seeds rather than transplants for restoration). One project used side-scan sonar for monitoring its restored seagrass populations; although the sites were over ten years old, the provider was interested in obtaining additional credits. Some third-party providers had preservation sites, none of which had monitoring or performance standards for the seagrass present. Several projects simply required noting land-use changes or landscape alterations (on foot or by plane), and several required taking photos, some at established locations (photo points).

The majority of restoration, enhancement, or establishment projects required reference seagrass areas to be assessed in conjunction with monitoring the mitigation areas. These projects usually required percent cover (and sometimes density and canopy height) at the mitigation site to be equivalent to the reference site at the end of a monitoring period. However, one project required percent cover to be equivalent to reference sites for two consecutive years only within the monitoring period. Another required 80% cover and density of reference site levels by the end of the monitoring period.

Seagrass mitigation projects in California follow performance standards established in the California Eelgrass Mitigation Policy (or CEMP, NMFS 2014) or its predecessor, the Southern California Eelgrass Mitigation Policy. The CEMP establishes a preference for in-kind eelgrass compensatory mitigation, requires compensatory mitigation at a 1:1.2 ratio, and requires at least five years of in-situ monitoring. Although the CEMP does not include a suggested set of monitoring methods, it does have a suggested set of performance standards for area, percent cover and shoot density at zero and six months and at years one to five (Appendix A, Table 6).

Projects with in-situ monitoring used quadrats and transects to measure percent cover. Several projects used the Braun-Blanquet method, which gives seagrass cover inside a quadrat a score between one and five (Bell et al. 2008), while several estimated percent cover using a grid within a quadrat (Rezek et al. 2019). Many projects used fixed transects, while a few others selected transects or monitoring areas randomly. Performance standards required that percent cover increase over time.

Several projects included informal (not quantitative) observance and notation of seagrass epifauna (fish and invertebrates), epiphytes, macroalgae, and bioturbation. One project also measured the prevalence of eelgrass wasting disease, which is caused by a pathogen and periodically occurs in North American and European eelgrass populations

(Smithsonian 2018). A pending project proposes installing signage to increase seagrass bed visibility to boaters. The associated performance standard is a decrease in the number of boat scars over time. One project plans to measure sediment grain size within seagrass beds. In Florida, because seagrass species are so numerous, the number species present was also monitored in several projects.

Voluntary restoration and ambient monitoring

Mitigation projects retrieved in the search (Box 2) had similar monitoring methods to voluntary restoration and ambient site monitoring programs. One difference between the two was size: ambient and voluntary monitoring or restoration projects were typically larger than compensatory mitigation sites and as a result could use aerial surveys rather than in-situ monitoring. Ambient monitoring/restoration projects were also sometimes more technical, measuring attributes like epifauna that live in seagrass beds. Voluntary restoration and ambient monitoring projects did not typically assign performance standards. Finally, no voluntary restoration projects modified the seafloor level to a depth at which seagrass could grow; this was only seen in compensatory mitigation projects.

There are many examples of worldwide, national, regional, and local seagrass restoration and monitoring programs. One program, Zostera Experimental Network, which was grant-funded for six years but has been terminated, monitored ambient populations of eelgrass at 15 sites worldwide. Another worldwide monitoring program is SeagrassNet, which at one time had 122 sites across 33 countries, although not all sites are currently operational. On a national scale, NOAA's NERRS and EPA's NEP monitor seagrass at the reserves and sites where it is present. For mapping resources, marinecadastre.gov hosts a national seagrass layer that is a composite of data from state websites (NOAA and BOEM, 2019).

There are a few examples of regional seagrass monitoring programs. The Virginia Institute of Marine Science has annual aerial surveys at sites across the Chesapeake Bay (Virginia and Maryland). Some sites in this program have been monitored since the late 1980s. The Florida Department of Environmental Protection (FL DEP) has an Aquatic Preserve Program with 41 sites where seagrass is monitored where it is found. The Tampa Bay NEP has been conducting aerial surveys and monitoring transects since the mid-1990s. Finally, a large-scale eelgrass restoration project in Virginia's Coastal Bays monitors restored populations and is billed as the world's largest seagrass restoration project.

Box 2- Common practices for monitoring seagrass mitigation sites

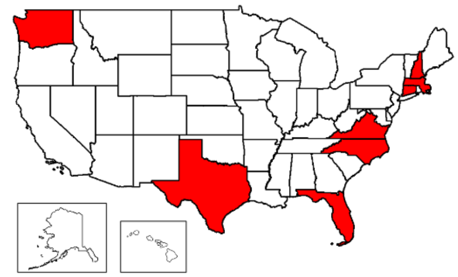
Common monitoring metrics: Percent cover, shoot density, area, canopy height

Other monitoring metrics: Wasting disease, water quality improvement, qualitative assessments of epifauna, nekton, macroalgae, or bioturbation

Monitoring types: In-situ survey, aerial survey, sonar survey

Performance standards: Typically involved yearly documentation of progress toward an acreage, percent cover and/or shoot density goal compared to reference site(s)

Results: Oysters



Oyster mitigation projects (third-party or PRM) reviewed in this section occurred in the states in shown in red.

Third-party mitigation

Nine third-party mitigation providers (one bank, eight ILFs) had oyster presence at their sites. Site ages ranged from early 2000s to not-yet-completed (as of 2021). The oyster species across all sites was *C. virginia* (or eastern oyster), except for one ILF site which had *C. gigas* (Asian oyster). About half of the providers were restoring, creating, or enhancing oyster areas or reefs, while the other projects were preserving existing populations or had created shoreline structure onto which wild oysters had recruited (providers had not necessarily created the structures for this purpose). Techniques used by the five providers restoring, creating, or enhancing oyster areas include deposition of oyster shell or other shell types (e.g., clam) for natural recruitment (when wild oyster larvae attach to hard structures) or seeding reefs with 'spat-on-shell' (juvenile oysters attached to shell, Figure 3).

Permittee-responsible mitigation

Five oyster PRM projects in Virginia, Texas, and Florida were permitted between 2005-2019. All projects involved the eastern oyster. All projects were enhancement, establishment, or restoration projects as opposed to preservation. Two projects were small (<0.01 acre) while the other three ranged from 0.6 to 1.1 acres.

Project types included constructing oyster areas using oyster shell and other materials like crushed concrete, payments to a non-profit for the purchase of oyster shell for restoration purposes, constructing a shoreline structure to which oysters recruited, and moving existing oysters out of a project's impact footprint. The project that moved existing oysters built a 15-inch reef base outside of the impact area that oysters and associated material were transferred to. Most PRM projects (four of five) expected natural recruitment, while one project moved live existing oysters. No spat-on-shell (Figure 3) were used. Impact types were public (a city building a seawall, a utility company installing poles for power lines, and a military base building a training facility) as well as commercial (a dredged material transfer facility, bulkhead construction at a restaurant, and two commercial dock facilities).

Figure 3- 'Spat on shell', juvenile oysters attached to a recycled oyster shell in a hatchery setting. Photo by Emily French.

Monitoring and performance

Monitoring methods and performance standards for PRM and third-party projects were not available for every oyster mitigation project. A few third-party preservation sites with oyster presence did not do any oyster-focused monitoring. Several PRM projects either did not have monitoring methods and performance standards or were unable to locate the documents that would have had them. Across oyster mitigation projects that did have monitoring methods and/or performance standards, common methods and standards were related to oyster density, shell height, and area. All projects with methods and/or standards required in-situ monitoring (no acoustic or aerial surveying). Among third-party preservation sites with oyster presence, a few providers had chosen to measure density or other attributes of the oysters present.

Only a few projects stipulated comparison of oyster mitigation areas with reference areas. Performance standards for those projects required that the mitigation area must have similar or better recruitment and survival to a nearby reference area.

In-situ monitoring required shell height measurements. Shell height is measured in centimeters from the hinge to the top of the shell and measurements are used to bin oysters into size classes (typically spat, juvenile, and adult or simply small and large). Young (<6 months) oysters typically experience higher mortality rates than adult oysters (Bartol et al. 1999), therefore collecting data on size classes can help gain insight into the pressures a given population is experiencing.

Several projects took qualitative measurements of oyster-associated organisms, such as fish, sessile organisms, oyster predators (in particular, oyster drills and boring sponges), and fouling organisms. These projects also had qualitative performance standards, such as 'improving water quality and habitat in the area' or 'wild oyster recruitment and survival'.

One project tested for common oyster diseases caused by the parasites *Haplosporidium nelsoni* and *Perkinsus marinus.* Another project measured volume of brown and black shell, which is a proxy for whether reef substrate is buried and therefore unavailable for colonization (black) or temporarily covered in mud (brown). Several projects had construction-type performance standards, such as 'shell must be distributed across the mound structure' or 'oyster bed establishment will be considered successful when the concrete base is 18 inches high'. Finally, several projects measured the proportion of live to dead oysters present.

Voluntary restoration and ambient monitoring

Although monitoring methods and performance standards were not available for every oyster mitigation site, when sites did have them, methods and standards (summarized in Box 3) were similar to those from voluntary restoration and ambient monitoring sites. Additionally, unlike seagrass projects, several oyster ambient monitoring/voluntary restoration projects had performance standards.

Examples of nationwide ambient monitoring programs include NOAA's NERRS program, which monitors oysters on at least four of its 29 reserves. Although several reserves are monitoring the eastern oyster, one west coast reserve is monitoring the Olympia oyster. In terms of regional programs, in Chesapeake Bay, spurred by the Chesapeake Bay Agreement

(2014) and Executive Order 13508, oyster restoration in ten tributaries began in 2012 and is currently ongoing. The restoration efforts differ by tributary. In some, juvenile oysters and substrate (cultch or rock) are deployed. In others, only cultch is deployed for wild juvenile oysters to attach to. Another large restoration project, Half Moon Reef, is located in Matagorda Bay on the Texas coast. This project, which began in 2014, uses limestone as substrate and has a hybrid approach: half the reef is a sanctuary, and the other half is open to commercial harvest.

There were three other examples of statewide programs, all of which monitor ambient populations: the Maryland Department of Natural Resources annual fall oyster recruitment survey (a historic survey initiated in the 1950s), the North Carolina Department of Marine Fisheries oyster sanctuary survey, and the FL DEP Aquatic Preserve program. The FL DEP program has 41 sites and monitors many habitats, including oysters if they are present. Across the nation, oyster restoration is popular and in the public eye; and there is no shortage of smaller projects than those represented here that involve restoration or monitoring of ambient populations.

Box 3- Common practices for monitoring oyster mitigation sites

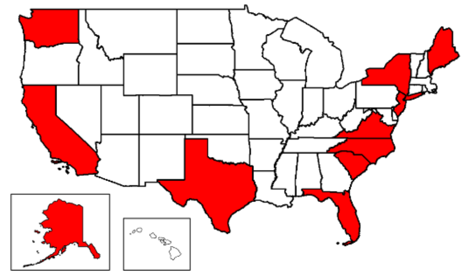
Common monitoring metrics: Density, shell height, area

Other monitoring metrics: Proportion of live to dead oysters, amount of surface and buried shell, oyster disease presence, natural recruitment, qualitative assessments of associated reef organisms and fouling

Monitoring types: In-situ survey

Performance standards: Area and height goals for reef base (construction-type specifications), density goals, similar recruitment and survival to a nearby reference reef

Results: Tidal flats



Tidal flat mitigation projects (third-party or PRM) reviewed in this section occurred in the states in shown in red.

Third-party mitigation

There were 24 third-party mitigation providers (17 banks, seven ILFs) with tidal flat presence at their sites. The age of the sites ranged widely; one bank was established in 1998 while another bank is currently building their site (as of 2021). More providers were restoring, enhancing, or creating tidal flats as opposed to preserving them (about 15 as opposed to 9), and banks tended to restore, create, or enhance tidal flats while ILFs tended to preserve them. Often, tidal flats were not the main focus of a given mitigation project, but part of a mosaic of estuarine or marine habitats. For some projects, this made it difficult to determine the compensatory mitigation method (restoration, enhancement, establishment, or preservation).

Most of the providers that restored, created, or enhanced tidal flats were enhancing or restoring them by removing a tidal restriction from a wetland complex. A few providers had different approaches. One enhanced tidal flat by adding shell to enhance infauna and epifauna plant and animal communities and another created tidal flat for salmon habitat. Preservation sites with tidal flats ranged from marshes with intertidal channels, to barrier island habitats known for being migratory bird habitat, to expansive tidal flats in areas with a large tidal range.

Permittee-responsible mitigation

There were only four PRM sites with tidal flats, and all were establishment, enhancement, or restoration projects. One of the sites also had a tidal flat preservation component. All were permitted somewhat recently, between 2006 and 2017, and were in California and Washington. Although two projects did not report the size of the tidal flats (or the documentation obtained did not state it), the other two projects' tidal flat areas were large (4.33 and 9.40 acres). Two projects created tidal wetland areas with salt marsh, fringing tidal flats, and intertidal channels. One of the projects used dredged material for construction. Another project rehabilitated an existing tidal flat but did not go into detail about the methods (or the documentation obtained did not state the methods). Impact types included bridge replacement projects and roadway improvement and re-grading projects.

Figure 4- A mudflat in New Jersey, photo by Mark Renna.

Monitoring and performance

Most third-party and PRM projects' tidal flat components were not assigned distinct monitoring methods or performance standards. A few had performance standards related to construction specifications (measuring acreage and hydrology by measuring elevation and inundation). Tidal flats were often co-located with marsh restoration, which required monitoring and had quantitative performance standards. Tidal flat preservation projects had very limited monitoring; the extent of which was establishing photo points, removing trash, looking for anthropogenic impacts on the site, and taking notes on general site conditions. If tidal flats were monitored, it was usually in-situ, although a few projects took aerial photos.

Other monitoring methods- Several tidal flat mitigation projects had more varied monitoring methods, although they were often qualitative and most did not have accompanying performance standards. A few projects sampled infauna, epifauna, surveyed bird usage, and seined for fish when there was water overlying the tidal flats, and one project compared these values to a reference site. A few projects measured water quality when the flats were inundated with water. One project made observations of algal growth on the flats. Three related sites (owned by the same mitigation provider) had performance standards for hydrology and non-native plant presence. At two of the three sites, photo points were established for time-lapse photos of a tidal cycle, a tidal gauge was placed to monitor tide height, and observations of erosion were noted. Two sites sampled sediment and fish and invertebrate tissue for heavy metals, in accordance with state guidance.

Voluntary restoration and ambient monitoring

No monitoring programs for which tidal flats were the sole focus were found within voluntary restoration and ambient monitoring. Therefore, it was not possible to compare monitoring methods and performance standards for tidal flats to compensatory mitigation. There are several programs that use aerial survey data to map wetlands and soil types (Fish and Wildlife Service's National Wetlands Inventory, Natural Resource Conservation Service's soil survey, and NOAA's Coastal Change Analysis Program), and although the data may capture tidal flats, they do not provide meaningful information about their characteristics or condition. Regional examples were also sparse, but one restoration and one research project were found. In southern California, a consortium of federal, state, and non-profit partners is currently restoring mudflats in the San Elijo Lagoon. These groups are planning to monitor the abundance and diversity of birds, fishes, and invertebrates, and to monitor water quality overlying the intertidal flats (San Elijo Lagoon Restoration 2021). Finally, U.S. Geological Survey (USGS) executed a tidal marsh sea level rise modeling survey that required field data collection at nine sites in Washington and Oregon, some of which included tidal flats. Monitoring included delineations of tidal mudflat area, gathering elevation data, and inundation frequency (Thorne et al. 2015).

Box 4- Common practices for monitoring tidal flat mitigation sites

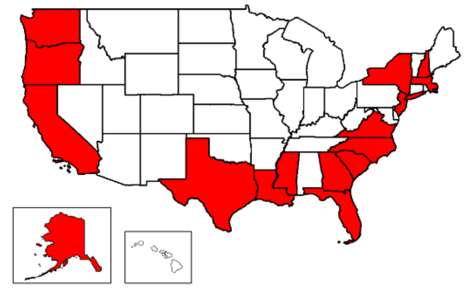
Common monitoring metrics: Construction-type specifications (as-built area, tidal hydrology), taking photos, informal monitoring for human disturbance

Other monitoring metrics: Infauna and epifauna abundance and diversity, water quality measurements, fish population surveys, heavy metal presence in sediment and fish, qualitative assessments of bird foraging

Monitoring types: In-situ survey, aerial survey

Performance standards: Mainly construction-related (area, hydrology)

Results: Shallow water



Shallow water mitigation projects (third-party or PRM) reviewed in this section occurred in the states in shown in red.

Third-party mitigation projects

There were 32 third-party mitigation providers (22 banks, 10 ILFs) from states across the country with shallow (subtidal) water at their sites. It was very difficult to tell whether waters were subtidal at providers' sites from RIBITS documentation, most required follow-up with a bank or ILF representative. The age of the sites ranged from 1996 to not-yet-completed (as of 2021). Most providers restored, enhanced, or created shallow water. There were few projects that preserved shallow water exclusively (about six of the 32). Most restoration, enhancement, and establishment projects involved reconnecting waterways via removal of tidal restrictions by creating channels and removing fill. Examples of tidal restrictions found in third-party documentation included mosquito ditching, rice farming impoundments, dikes, and former roadway construction.

One provider improved benthic habitat and water quality of shallow water areas by remediating sediment by neutralizing polyaromatic hydrocarbon (PAH) contaminants. A few providers created shallow water by converting uplands. Several providers created seagrass or oyster areas. When providers preserved shallow water habitat, it was generally part of large, multi-acre wetland complexes.

Permittee-responsible mitigation projects

Figure 5- Example of a shallow water impact- installation of poles for power lines. Photo from a Jacksonville district permit.

The 34 PRM projects that included shallow water habitat were permitted between 2003-2019. Projects occurred across Florida, Texas, California, and Washington, though the majority of the projects were in Washington (26 projects). Of the Washington PRM projects, most were small (<0.1 acre), although a few were larger (<1 acre). Several of the Florida, Texas, and California projects did not have sizes listed; the projects that did ranged widely in size from 0.004 to 10 acres. One project removed derelict fishing gear from a 581-acre open water area, however, the actual mitigation footprint was not listed and would have been much smaller. Like the third-party projects, most PRM projects restored, enhanced, or created shallow water rather than preserving it.

In Washington, the most common compensatory mitigation project types were removal of creosote-treated pilings, removal of subtidal or intertidal debris, removal of overwater structures such as docks, and placement of gravel to enhance forage fish spawning habitat. Creosote piling, intertidal and subtidal debris, and overwater structure removal frequently occurred nearby or on the same site as the impact. Debris removal included items such as fishing gear (nets, crab pots), old bulkhead and boat ramp material (concrete, other rubble), tires, and a grounded vessel. One other mitigation project included establishment of a 'shoreline cutback' to create shallow water. Compensatory mitigation projects from Florida, Texas, and California involved rehabilitating a former dredged material storage site and restoration of channels and lagoons that were part of wetland complexes. One permittee planned to construct a stormwater treatment system, and two removed tidal restrictions. Several projects removed derelict structures, including creosote pilings and unused riprap.

The majority of the impacts were from the building of docks and associated structures at private residences. There were also several public projects, including installing public utility structures, building boat ramps, parks, seawalls, a military facility, bridge building and repair projects, and one channel dredging project. Finally, the few commercial impacts included bulkhead repair and pier-building projects.

Monitoring and performance

Many (about half) of the third-party mitigation providers did not have monitoring methods or performance criteria for shallow water areas. Monitoring across PRM projects was simple, and most projects did not have performance standards. The most common monitoring methods and performance standards for PRM projects were taking photos and requiring submittal of documentation that demonstrated compensatory mitigation was complete. A few projects also required monitoring for adequate hydrology and collection of qualitative information on wildlife use of the area (however, this was not always exclusive to the shallow water habitat area present at the site). Water quality monitoring, fish surveys, or other monitoring of shallow water characteristics were not required in any of the PRM projects assessed.

Monitoring methods and performance standards for third-party providers' sites were often written such that it was difficult to determine whether they applied to shallow subtidal water areas exclusively, or to intertidal areas, tidal flats, vegetated areas, or the general wetland complex. Following up with bank or ILF representatives did not always provide clarification, so it is possible that some of the following monitoring methods and performance standards may have been geared more toward intertidal than subtidal areas.

Most third-party monitoring and performance standards centered around hydrologic conditions and water quality measurements. Providers measured hydrologic characteristics by collecting water level, temperature, and salinity data from tide gauges and sensors and by taking photos during the tidal cycle. A few providers took water quality measurements using basic parameters (salinity, temperature, pH, dissolved oxygen) from fixed stations or on surveys at regular intervals. Several providers monitored wildlife in the shallow water areas at their sites. Fish population characteristics (diversity, abundance) were measured using dip nets, traps, and seining. One provider divided fish present into feeding guilds and tropic position. The same provider also monitored the wading bird population. A different provider monitored salinity and fish populations to understand whether hydrologic modifications offsite were affecting fish populations. Many of the providers monitoring wildlife established performance standards and reference sites for the comparison of compensatory mitigation site data.

A few unique shallow water enhancement, restoration, and establishment projects are highlighted herein. One provider that remediated sediment monitored the restoration area by testing sediment samples and fish tissue for PAH concentrations and monitored benthic infauna for abundance, diversity, and biomass. The performance standard was a sediment PAH concentration below a set threshold. Another provider who was restoring a tidal connection had the most complex monitoring methods and performance standards of any shallow water mitigation project: the provider measured hydrology, water quality, fish and wading bird populations, chlorophyll in the water column (as a proxy for algal presence), light transmittance, and abundance and diversity of infauna. Each monitoring parameter had a specific threshold to be met in relation to a reference site.

Voluntary restoration and ambient monitoring

A variety of project types within both compensatory mitigation and voluntary restoration and ambient monitoring made it difficult to compare monitoring methods an performance standards. Water quality improvement projects in shallow estuarine and marine waters are being conducted across the U.S. at the national, regional, and local levels. Examples of nationwide water quality testing programs that include monitoring in estuarine and marine habitats include EPA's National Aquatic Resource Survey programs (National Wetland Condition Assessment and the National Coastal Condition Assessment). The NOAA NERRS and EPA NEP sites also measure water quality at many of their sites via fixed stations or on surveys at regular intervals. Examples of regional water quality monitoring programs include the NPS Eutrophication survey, the FL DEP Aquatic Preserve Program, as well as many state-specific coastal water quality monitoring programs.

There are also many programs that purport to improve shallow water in ways other than improving water quality, such as the Maryland Artificial Reef Program, which sinks structures to create fish habitat in the Chesapeake Bay and in shallow coastal areas on the ocean side of the state. Another example is the California Coastal Conservancy, which maintains a program that removes creosote pilings from San Francisco Bay. Creosote-contaminated sediments and pilings negatively affect fish by causing lesions and problems with spawning (Malins et al. 1985, Vines et al. 2000).

Box 5- Common practices for monitoring shallow water mitigation sites

Common monitoring metrics: Water quality monitoring, hydrologic monitoring via tide gauges, fish diversity

Other monitoring metrics: Reef-associated organism species diversity and size class, sediment toxicity, fish tissue toxicity, sediment infauna abundance and diversity, light levels, oxidation/reduction potential

Monitoring types: In-situ survey, sonar survey

Performance standards: Varied from project to project and were not consistent

Discussion

The goal of this report was to review compensatory mitigation in estuarine and marine habitats, which are less prevalent than freshwater wetlands and streams within the 404 Program. The search results showed that estuarine and marine habitats were present across 21 of 23 coastal states at 2% of banks, 21% of ILF programs, 9% of ILF program sites, and represent 5% of PRM permit actions.

Limitations of the search- This report represents a comprehensive compilation of nationwide third-party mitigation that has been tracked in RIBITS and involves estuarine or marine habitats. However, the goal of finding comprehensive PRM from five states was not achieved. The search results could not generate a complete inventory of PRM involving the focal habitats because of blank fields and missing information in the DARTER database and incomplete documentation provided by USACE districts. Consequently, the permits obtained likely represent only a fraction of the PRM that has occurred involving the focal habitats. An example illustrates how many PRM projects may have been missed: Florida Fish and Wildlife Service collected 130 USACE Jacksonville district permits over a five-year period for seagrass impacts (personal communication with Margaret Hall; projects referenced in Rezek et al. 2019); however, only 13 were obtained via this report's search process, which spanned 12 years. As another example, the California Eelgrass Mitigation Policy references 66 eelgrass mitigation projects in Southern California alone over the past 35 years (NMFS 2014), while only eight were found from this report's search. Therefore, although the PRM results in this report can inform mitigation work and policy, they do not provide a complete picture of estuarine and marine mitigation projects occurring nationwide that involve seagrass, oysters, tidal flats, and shallow water.

The perception of the 404 Program as only wetlands- The 404(b)(1) Guidelines (EPA 1980) emphasize the value of habitats that are not traditionally considered to be wetlands, such as vegetated shallows, sanctuaries, refuges, and mudflats. However, 404 Program practitioners historically have tended to associate the CWA 404 Program with wetlands, but not subtidal and unvegetated intertidal coastal areas. Perhaps consequently, and because it has been common with wetland mitigation projects, the 404 Program has historically focused on emergent vegetation when creating an estuarine or marine compensatory mitigation project or assessing its success. A specific focus on emergent or terrestrial vegetation for evaluating wetlands and riparian areas may be partially responsible for the infrequent requirement for compensatory mitigation for submerged and unvegetated habitats.

Several of the permits that were reviewed authorized discharges of dredged or fill material that would impact tidal flats, but did not propose compensatory mitigation, stating that the impact areas were not jurisdictional waters of the United States. One permit stated that the proposed project, which was sited in shallow water, would not affect any aquatic resources that would require compensatory mitigation. Many other projects found during this research included CWA 404 permits issued for activities that would impact shallow water and intertidal areas, and yet compensation did not appear to be required. Moreover, many projects included monitoring methods and performance standards for vegetated intertidal or subtidal areas but excluded unvegetated areas that were part of the same compensation project. Several compensatory mitigation projects converted tidal flat into salt marsh. Finally, two permits that were reviewed identified tidal flats on the impact site as special aquatic sites under the 404(b)(1) Guidelines, but the impacts were ultimately compensated with out-of-kind mitigation. The exclusion of some estuarine and marine habitats from requirements for compensatory mitigation, together with a broad lack of recognition of the important functions of and compensation opportunities for these habitats, will continue to result in impacts, habitat fragmentation, and cumulative degradation.

Credit types and categorization in RIBITS- At present, although a simple RIBITS search for estuarine and marine credits will elicit many of the banks, ILFs, and ILF sites that exist nationwide, it will not reveal every provider and site with estuarine or marine habitat. This is because RIBITS uses a mixture of Cowardin Classification and more general terms (such as 'wetland') to describe credit types. To find an up-to-date record of estuarine and marine sites in RIBITS, several different searches were conducted, in addition to reading through documentation from the cyber repositories and engaging in follow-up discussions with bank and ILF representatives. This credit type issue is exacerbated when searching for habitats more specific than just estuarine or marine, such as seagrass. For instance, although 12 providers (banks or ILFs) had seagrass presence at their sites, a RIBITS search revealed only one, and although 24 providers had tidal flat presence at their sites, none were returned when "tidal flat", "mudflat," or "mud flat" was searched. The lack of standardized naming conventions for habitat types in RIBITS made this type of investigation more difficult, but more importantly, it creates a barrier for permittees searching for in-kind compensatory mitigation for their estuarine and marine impacts. Additionally, a small number of sites were not in RIBITS because they were old or simply had never been uploaded.

Other barriers to mitigation for specific habitats- Documentation for third-party and PRM sites often did not include a clear description of tidal flat or shallow water presence, especially when these habitats were part of a mosaic of other habitats such as salt marsh. These projects also did not measure area of these habitats, and instead, their presence was recorded as part of the total area of the mitigation project. This practice precludes tracking of how the habitat is changing over time and of its suitability for being used as compensation. Oyster and seagrass area was measured more often than tidal flat and shallow water in the projects analyzed.

Simple ratios, calculator tools, and assessment methods have been developed to assist permittees and regulators translate impacts to compensatory mitigation required (e.g. Chiavacci et al. 2022). There are calculator tools that recognize the presence of oysters, seagrass, tidal flats, and shallow water (e.g., the Interim Hydrogeomorphic functional assessment developed for Galveston District), and guidance documents that provide detail on best mitigation practices, some of which include simple ratios (e.g., the California Eelgrass Mitigation Policy and Florida's Guidance on Surveys for SAV Compensatory Mitigation Projects). Despite these tools, however, the authors of this report are not aware of any assessment methods that measure attributes of these habitats and attempt to translate them into credits.

Seagrass, oyster, tidal flat, and shallow open water assessment methods for compensatory mitigation purposes should be developed. These assessments should calculate how much compensation a mitigation site has provided or how much compensatory mitigation will be required to offset a specific impact. At present, there are a few assessment methods that acknowledge the presence of the focal habitats, but none that consider their attributes (for example, density and shell height of oysters) for making mitigation decisions. There is a wide body of seagrass and oyster restoration data available, as well as detailed state-level seagrass mitigation guidance (Hinton A and B 2020, NMFS 2014) that would make developing assessment methods a straightforward task. For tidal flats and shallow water, assessment methods should be developed that consider a lack of traditional structure, and instead emphasize other attributes, such as infauna presence or water quality thresholds.

Lack of monitoring and standards at preservation sites- Most third-party preservation projects did not have quantitative performance standards or monitoring beyond photo points and occasional surveillance. Although mitigation projects are designed to be self-sustaining, the sustainability of a preservation site cannot be measured if baseline information is not captured. Further, without habitat delineations and measurements such as water quality, a site could become degraded such that compensation is no longer equivalent to the impact, but no corrective actions would be required.

Seagrass mitigation observations- The information compiled in this study suggests that compensatory mitigation for seagrass impacts is better established compared to the other focal habitats. Seagrass mitigation projects' monitoring methods and performance standards were usually thorough and aligned with typical monitoring and performance standards used in voluntary restoration/ambient monitoring projects. Additionally, multiple localities (FL, CA, OR, Chesapeake Bay, New England District) have developed compensation guidance for SAV impacts (Hinton A and B 2020, Oregon Department of State Lands 2019, USACE New England District 2020, NMFS 2014, and Chesapeake Bay Program 1995). In California, a state with many well-documented eelgrass mitigation projects, the failure rate of transplantation is 13% (NMFS 2014), which prompted the California Eelgrass Mitigation Policy (CEMP) to establish 1.2:1 as the minimum restoration threshold for a mitigation area.

Oyster mitigation observations- Monitoring methods and performance standards for oyster areas were not common among third-party sites, but several PRM sites did not appear to have them. However, the PRM aspect of this report had a small sample size and therefore it is unclear how often oyster PRM occurs without monitoring or performance standards. Regardless, creating oyster habitat without establishing plans to monitor it first is not recommended. Oyster restoration is complex, and factors for project failure include, but are not limited to, predation, shell stock depletion, and lack of recruitment (Mann and Powell 2007). Mitigation providers and restoration practitioners may view the establishment of structure to be a net benefit whether wild oysters eventually recruit to it or not; however, this hands-off approach precludes gauging the success of the project.

Tidal flat mitigation observations- Tidal flats were frequently present among third-party providers with estuarine or marine habitat (24 of 54 providers), but very few had associated monitoring methods or performance standards. Most projects (third-party and

PRM) restored, enhanced, created, or preserved tidal flats as part of a mosaic of estuarine wetlands rather than focusing on tidal flats exclusively. In permit documentation, several permittees mentioned that existing tidal flat was previously disturbed and therefore low value, especially if it was constructed from dredged material.

Tidal flats can be labeled as low-value resources because of their lack of structure (that is visible to the human eye), which is thought of as the cornerstone of habitat. Media attention is greater and therefore public perception is better for some coastal habitats compared to others, which consequently makes them favored for protection and research (Duarte et al. 2008). Tidal flats rank low on this list, with some considering them “barren” or “stinky” (Faris 1990 or Melinkoff 1990 for example). A decade ago, seagrass was labeled the “ugly ducking” in this regard (Duarte et al. 2008). In this report’s review of compensatory mitigation projects, tidal flats were often characterized as secondary, less-desirable habitats that are unable to sustain vegetation.

Shallow water mitigation observations- PRM documentation appeared to show that compensatory mitigation requirements for shallow water impacts are inconsistent around the country. Twenty-eight permits for shallow water projects in the Seattle district were obtained, but only eight from the five other districts combined. If other districts were also requiring compensatory mitigation for impacts to shallow water, a similar number of projects should have been obtained. Additionally, in many of the reviewed projects, it was difficult to discern whether shallow subtidal water was present because of a lack of description of the mitigation areas and a lack of depth measurements.

It is not surprising that the 404 Program has struggled with marine and estuarine shallow water compensation. First, because establishment of shallow water habitat would be at the expense of other habitats (terrestrial or aquatic) and second, public perception is such that unstructured habitats are often not regarded to be as desirable as structured habitats. However, compensation, ideally in-kind, should be required for impacts to shallow water; this could be carried out by improving existing subaqueous areas. The diverse suite of projects reviewed in this report demonstrate a variety of options available for shallow water improvement. For example, the Seattle district is allowing removal of over and in-water structures, including creosote pole removal and derelict vessel removal, in areas both on and off-site with respect to the impact. Two other districts approved large-scale projects to remove derelict crab pots as compensatory mitigation. One ILF is remediating sediment formerly contaminated with creosote. Other projects are installing stormwater filtration devices to improve water quality and installing pea gravel to improve fish spawning habitat. Tidal restriction removal projects are also common across the country.

Finally, mitigation providers have been authorized to add substrate (often to create artificial reef structures) but also to remove substrate for the stated purpose of improving shallow water areas. For example, one ILF is constructing an artificial reef from stone and concrete with the intent of attracting fish and sessile invertebrates, while a PRM site removed stone riprap and described it as “creation of benthic habitat.” An important consideration when deciding to add substrate is whether subtidal structure previously existed in the area. A critical perspective of artificial reef programs would be that without rigorous monitoring and performance criteria, they are essentially a means of material disposal.

Further challenges these habitats face- It is important to note that successful restoration of seagrass, oyster, tidal flat, and shallow water habitat faces many challenges, including sea level rise, non-native species presence, and warming temperatures. Although studying sea level rise implications was not an objective of this report, several third-party providers have pending projects that take sea level rise into account. One project involves high and low salt marsh vegetation and the ability for the marsh to migrate landward. Another project proposes to continually excavate uplands to match sea level rise for seagrass mitigation, since the deeper edges of the beds would die off with increased depth of overlying water. In the Pacific Northwest, regulators and mitigation providers are already grappling with non-native species. One PRM applicant did not propose and was not required to mitigate for impacts to non-native eelgrass (*Z. japonica)*. A third-party provider with extensive populations of a non-native oyster (*C. gigas*) is currently debating whether to use the oyster areas for mitigation credits.

Future research- Interested researchers should continue compiling information on marine and estuarine compensatory mitigation, as well as information about other, lesser-known habitats that could be affected by the issuance of CWA Section 404 permits. Documentation alone will not be enough to understand project and compensation outcomes, and future researchers should plan to reach out to agency staff and mitigation providers for additional details and context.

Recommendations

Improving mitigation practices

The use of standardized assessment methods, monitoring metrics and performance standards for oyster, seagrass, tidal flat, and shallow water habitat can lead to more efficient review of permits and compensatory mitigation proposals in addition to improved performance at mitigation sites. The following recommendations could also improve compensatory mitigation outcomes:

1. For tidal flat habitat:
    - Develop a clear definition of tidal flats (currently, there is confusion about whether marsh edges, tidal creeks, unvegetated portions of living shorelines, intertidal areas seaward of bulkheads, and other intertidal areas are tidal flats).
    - Identify and assess tidal flats at impact sites, and where appropriate require compensatory mitigation.
    - Assess tidal flats at impact sites that are constructed of dredged materials, do not assume they are degraded.
2. For shallow water habitats:
    - Identify and assess shallow water at impact sites, and where appropriate require compensatory mitigation.
    - Consider the many creative solutions for providing in-kind compensatory mitigation for shallow water impacts that have been implemented, such as sediment rehabilitation, removal of debris and creosote piles, placement of habitat gravel, installation of stormwater treatment devices, and restoration of tidal connections.
3. Include monitoring and performance standards for seagrass, oysters, tidal flats, and shallow water when they are present at preservation sites.
4. For seagrass and oyster mitigation projects, draw project ideas, monitoring methods, and performance standards from the wide body of literature and data that is available from voluntary restoration projects.
5. When seagrass, oysters, tidal flats, or shallow water habitat is part of a mosaic of habitats affected by an impact OR established, restored, enhanced, or preserved for compensatory mitigation, the footprint (area) of each of these habitats should be measured to ensure accurate crediting.
6. Consider the history of nonpoint sources and other unregulated impacts on an area's current presence of oysters, seagrass, tidal flats, and shallow water.

Improving documentation and record-keeping

Including the appropriate markers for aquatic resource type (for instance, Cowardin classification) when tracking permitted impacts and compensatory mitigation projects is essential to enable anyone beyond those directly involved in the project to find it. The ability to learn from compensatory mitigation practices over time also depends on the availability of relevant information in project files, especially the approved mitigation plan, monitoring reports, and instrument or MFR. This report was made possible because of the many regulators across the country who took the steps necessary to appropriately fill in this documentation, even when it was not mandatory, however, many projects and their lessons were missed.

Recommendations for ensuring that documentation will support future discovery by regulators looking for examples or others studying regulatory practices are:

1. Ensure the Cowardin classification field is populated for:
    - For PRM- Impacts and mitigation entries in the ORM database.
    - For third-party mitigation: all RIBITS credits.
2. Make mitigation documentation digitally accessible, especially:
    - For PRM- the permit, mitigation plan, MFR, and monitoring reports
    - For third-party mitigation- the instrument, instrument modifications, mitigation plans, and monitoring reports
3. Monitoring reports should include the monitoring methods and performance criteria that were required in the permit, mitigation plan or bank/ILF instrument, for reference and in case documentation is seperated.
4. Monitoring methods and performance criteria should be included in a defined section(s) in the permit, mitigation plan or bank/ ILF instrument.
5. Develop templates for bank or ILF instruments that include descriptions of all habitat types present at mitigation sites, maps, and corresponding tables that clearly identify credit types and the habitats they represent.

Next steps for research

Like the field of environmental restoration, the field of compensatory mitigation is multifaceted and ever evolving. Advancements in research often lead to improvements in compensatory mitigation practices and assessments. Compiling this report revealed an array of agency staff, students, academics, and stakeholders who were in the process of researching compensatory mitigation related topics. Future research to inform compensatory mitigation practices for oyster, seagrass, tidal flat, and shallow water habitats include:

1. Develop assessment methods that can be used for regulatory purposes for seagrass, oyster, tidal flat, and shallow water habitats. The methods must be able to assess changes at impact and compensatory mitigation sites.
2. Develop monitoring methods and performance standards unique to tidal flat compensatory mitigation projects. Ideas include aerial photos and mapping, water quality measurements when the area is submerged, area and elevation measurements, sediment properties like grain size or toxic substance concentration, biological properties such as algae or infauna presence, and/or wading or migratory bird usage.
3. Develop monitoring requirements and performance standards unique to shallow water mitigation projects. Ideas include tracking water quality (standard parameters like salinity, temperature, dissolved oxygen, and pH but also chlorophyll and suspended

solids, which may require laboratory analysis), toxic substance concentration of sediments, light penetration, and fish abundance, diversity, and/or health.

4. Assess restoration success at a variety of locations to inform setting appropriate mitigation ratios for different habitat types. For seagrass, success rates and mitigation ratios are available in the California Eelgrass Mitigation Policy (NMFS 2014). Several projects featured in this report buffered against seagrass variability by planting an area greater than the impact site (a higher ratio of compensation to impact).

Training opportunities

Training on seagrass, oyster, tidal flat, and shallow water habitats is needed. Potential training topics include functions and services, applicability of the CWA Section 404 requirements, and how to assess and compensate for impacts to each habitat.

References

Aoki, L. R., McGlathery, K. J., Oreska, M. P. (2020). Seagrass restoration reestablishes the coastal nitrogen filter through enhanced burial. *Limnology and Oceanography*, *65*(1), 1-12.

Bartol, I. K., Mann, R., Luckenbach, M. (1999). Growth and mortality of oysters (Crassostrea virginica) on constructed intertidal reefs: effects of tidal height and substrate level. *Journal of Experimental Marine Biology and Ecology*, *237*(2), 157-184.

Bilkovic, D. M., Herschner, C. H., Rudnicky, T., Nunez, K., Schatt, D. E., Kileen, S., Berman, M. (2009). Vulnerability of shallow tidal water habitats in Virginia to climate change.

Bell, S. S., Tewfik, A., Hall, M. O., Fonseca, M. S. (2008). Evaluation of seagrass planting and monitoring techniques: implications for assessing restoration success and habitat equivalency. *Restoration Ecology*, *16*(3), 407-416.

Brown, B., Wilson Jr, W. H. (1997). The role of commercial digging of mudflats as an agent for change of infaunal intertidal populations. *Journal of Experimental Marine Biology and Ecology*, *218*(1), 49-61.

Chesapeake Bay Program (1995). Guidance for Protecting Submerged Aquatic Vegetation in Chesapeake Bay from Physical Disruption. Accessed 2-25-21: https://www.chesapeakebay.net/what/publications/guidance_for_protecting_submerged_aquatic_vegetation_in_chesapeake_bay1.

Chiavacci, S.J., French, E.D., and Morgan, J.A., 2022, Database of biodiversity, habitat, and aquatic resource quantification tools used for market-based conservation in the United States (ver. 2.0, June 2022): U.S. Geological Survey data release, https://doi.org/10.5066/F79G5M3X.

Cowardin, L. M. (1979). Classification of wetlands and deepwater habitats of the United States. Fish and Wildlife Service, US Department of the Interior.

Dahl, T.E. 2011. Status and trends of wetlands in the conterminous United States 2004 to 2009. U.S. Department of the Interior; Fish and Wildlife Service, Washington, D.C. 108 pp

Dahl, T.E. and Stedman, S.M. (2013) Status and trends of wetlands in the coastal watersheds of the Conterminous United States 2004 to 2009. U.S. Department of the Interior, Fish and Wildlife Service and National Oceanic and Atmospheric Administration, National Marine Fisheries Service. (46 p.)

Dennison, W. C., Orth, R. J., Moore, K. A., Stevenson, J. C., Carter, V., Kollar, S., Bergstrom, P. W., Batiuk, R. A. (1993). Assessing water quality with submersed aquatic vegetation. *BioScience*, *43*(2), 86-94.

Duarte, C. M., Dennison, W. C., Orth, R. J., Carruthers, T. J. (2008). The charisma of coastal ecosystems: addressing the imbalance. *Estuaries and coasts*, *31*(2), 233-238.

Faris, G. (1990, Jan 19). Disappearing coastal mudflats are 'the habitat of the overlooked'. Los Angeles Times. https://www.latimes.com/archives/la-xpm-1990-01-19-me-144-story.html

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., Aposotolaki, E. T., Kendrick, G. A., Krause-Jensen, D., McGlathery, K. J., Serrano, O. (2012). Seagrass ecosystems as a globally significant carbon stock. *Nature geoscience*, *5*(7), 505.

Fourqurean, J. W., Powell, G. V., Kenworthy, W. J., Zieman, J. C. (1995). The effects of long-term manipulation of nutrient supply on competition between the seagrasses Thalassia testudinum and Halodule wrightii in Florida Bay. *Oikos*, 349-358.

Green, T. J., Siboni, N., King, W. L., Labbate, M., Seymour, J. R., Raftos, D. (2019). Simulated marine heat wave alters abundance and structure of Vibrio populations associated with the Pacific Oyster resulting in a mass mortality event. *Microbial ecology*, *77*(3), 736-747.

Greening, H. S., Cross, L. M., Sherwood, E. T. (2011). A multiscale approach to seagrass recovery in Tampa Bay, Florida. *Ecological Restoration*, *29*(1-2), 82-93.

Hargreaves, A. L., Whiteside, D. P., Gilchrist, G. (2011). Concentrations of 17 elements, including mercury, in the tissues, food and abiotic environment of Arctic shorebirds. *Science of the Total Environment*, *409*(19), 3757-3770.

Hettinger, A., Sanford, E., Hill, T. M., Russell, A. D., Sato, K. N., Hoey, J., Forsch, M., Page, H. N., Gaylord, B. (2012). Persistent carry-over effects of planktonic exposure to ocean acidification in the Olympia oyster. *Ecology*, *93*(12), 2758-2768.

Hinton, J. (2020). A. Guidance on Surveys for Potential Impacts to Submerged Aquatic Vegetation. *Florida Department of Environmental Protection.* https://floridadep.gov/rcp/beaches-inlets-ports/documents/guidance-surveys-potential-impacts-submerged-aquatic-vegetation.

Hinton, J. (2020). B. Guidance on Surveys for Submerged Aquatic Vegetation Compensatory Mitigation Projects. *Florida Department of Environmental Protection*. https://floridadep.gov/rcp/beaches-inlets-ports/documents/guidance-surveys-submerged-aquatic-vegetation-compensatory.

Kellogg, M. L., Cornwell, J. C., Owens, M. S., Paynter, K. T. (2013). Denitrification and nutrient assimilation on a restored oyster reef. *Marine Ecology Progress Series*, *480*, 1-19.

Kellogg, L., Brush, M., Cornwell, J. (2018). An Updated Model for Estimating the TMDL-Related Benefits of Oyster Reef Restoration. Virginia Institute of Marine Science and University of Maryland.

Li, X., Bellerby, R., Craft, C., Widney, S. E. (2018). Coastal wetland loss, consequences, and challenges for restoration. *Anthropocene Coasts*, *1*(1), 1-15.

Lowe, M. R., Sehlinger, T., Soniat, T. M., La Peyre, M. K. (2017). Interactive effects of water temperature and salinity on growth and mortality of eastern oysters, Crassostrea virginica:

a meta-analysis using 40 years of monitoring data. *Journal of Shellfish Research*, *36*(3), 683-697.

Malins, D. C., Krahn, M. M., Myers, M. S., Rhodes, L. D., Brown, D. W., Krone, C. A., McCain, B. B., Chan, S. L. (1985). Toxic chemicals in sediments and biota from a creosote-polluted harbor: relationships with hepatic neoplasms and other hepatic lesions in English sole (Parophrys vetulus). *Carcinogenesis*, *6*(10), 1463-1469.

Mann, R., and Powell, E. N. (2007). Why oyster restoration goals in the Chesapeake Bay are not and probably cannot be achieved. *Journal of Shellfish Research*, *26*(4), 905-917.

Melinkoff, E. (1990, Jan 6). Exposing the rich life in the mudflats. Los Angeles Times. https://www.latimes.com/archives/la-xpm-1990-01-06-vw-385-story.html.

McGlathery, K. J., Sundbäck, K., Anderson, I. C. (2007). Eutrophication in shallow coastal bays and lagoons: the role of plants in the coastal filter. *Marine Ecology Progress Series*, *348*, 1-18.

Moore, K. A., and Jarvis, J. C. (2008). Environmental factors affecting recent summertime eelgrass diebacks in the lower Chesapeake Bay: implications for long-term persistence. *Journal of Coastal Research*, (55), 135-147.

National Oceanic and Atmospheric Administration and Bureau of Ocean and Energy Management (2019). *Data Registry.* Marine Cadastre.gov/data

National Marine Fisheries Service (2014). California Eelgrass Mitigation Policy and Implementing Guidelines. Accessed 2-25-21: https://media.fisheries.noaa.gov/dammigration/cemp_oct_2014_final.pdf

Newell, R. I., Fisher, T. R., Holyoke, R. R., Cornwell, J. C. (2005). Influence of eastern oysters on nitrogen and phosphorus regeneration in Chesapeake Bay, USA. In *The comparative roles of suspension-feeders in ecosystems* (pp. 93-120). Springer, Dordrecht.

Newell, R. I. (2004). Ecosystem influences of natural and cultivated populations of suspension-feeding bivalve molluscs: a review. *Journal of Shellfish research*, *23*(1), 51-62.

Oregon Department of State Lands (2019). A guide to the removal-fill permit process. Accessed 3-1-21: https://www.oregon.gov/DSL/WW/Documents/Removal_Fill_Guide.pdf.

Orth, R. J., Heck, K. L., van Montfrans, J. (1984). Faunal communities in seagrass beds: a review of the influence of plant structure and prey characteristics on predator-prey relationships. *Estuaries*, *7*(4), 339-350.

Pedersen M.F., Nielsen SL, Banta GT (2004). Interactions between vegetation and nutrient dynamics in coastal marine ecosystems: an introduction. In: Nielsen SL, Banta GT, Pedersen MF (eds) Estuarine nutrient cycling: the influence of primary producers, Kluwer Academic, Dordrecht, p 1–16

Richardson, J. P., Lefcheck, J. S., Orth, R. J. (2018). Warming temperatures alter the relative abundance and distribution of two co-occurring foundational seagrasses in Chesapeake Bay, USA. *Marine Ecology Progress Series*, *599*, 65-74.

Ray, G. L. (2000). Infaunal assemblages on constructed intertidal mudflats at Jonesport, Maine (USA). *Marine Pollution Bulletin*, *40*(12), 1186-1200.

Reimer, J. D., Yang, S. Y., White, K. N., Asami, R., Fujita, K., Hongo, C., Shingo, I., Kawamura, Maeda, I., Mizuyama, M., Obuchi, M., Sakamaki, T., Tachihara, A., Tamura, A., Tanahara, A., Yamaguchi, A., Jenke-Kodama, H. (2015). Effects of causeway construction on environment and biota of subtropical tidal flats in Okinawa, Japan. *Marine Pollution Bulletin*, *94*(1-2), 153-167.

Reilly, F. J., Spagnolo, R. J., Ambrogio, E. (1999). Marine and estuarine shallow water science and management: The interrelationship among habitats and their management. *Estuaries*, *22*(3), 731-734.

Rezek, R. J., Massie, J. A., Nelson, J. A., Santos, R. O., Viadero, N. M., Boucek, R. E., Rehage, J. S. (2020). Individual consumer movement mediates food web coupling across a coastal ecosystem. *Ecosphere*, *11*(12), e03305.

Rezaie, A. M., Loerzel, J., Ferreira, C. M. (2020). Valuing natural habitats for enhancing coastal resilience: Wetlands reduce property damage from storm surge and sea level rise. *PloS one*, *15*(1), e0226275.

San Elijo Lagoon Restoration (2021). Nature Collective. https://thenaturecollective.org/project/san-elijo-lagoon-restoration/.

Short, F. T., Burdick, D. M., Kaldy, J. E. (1995). Mesocosm experiments quantify the effects of eutrophication on eelgrass, Zostera marina. *Limnology and oceanography*, *40*(4), 740-749.

Smithsonian (2018). Eelgrass wasting disease has new enemies: Drones and artificial intelligence. *ScienceDaily*. Retrieved December 16, 2020 from www.sciencedaily.com/releases/2018/09/180918110956.htm.

Stedman, S. M. and Dahl, T. E. (2008) Status and trends of wetlands in the coastal watersheds of the Eastern United States 1998 to 2004. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Department of the Interior, Fish and Wildlife Service. (32 pages)

Thorne, K. M., Dugger, B. D., Buffington, K. J., Freeman, C. M., Janousek, C. N., Powelson, K. W., Gutenspergen, G.R., Takekawa, J. Y. (2015). *Marshes to mudflats—Effects of sea-level rise on tidal marshes along a latitudinal gradient in the Pacific Northwest* (No. 2015-1204). U.S. Geological Survey.

U.S. Army Corps of Engineers New England District (2020). New England District Compensatory Mitigation Guidance. Accessed 10-4-21:

https://www.nae.usace.army.mil/Portals/74/docs/regulatory/Mitigation/Compensatory-Mitigation-SOP-2020.pdf?ver=EWhCrK70ZfmPr--8x0K5Jg%3d%3d.

Vanderbilt, F., Martin, S., Olson, D. (2015). The Mitigation Rule Retrospective: A Review of the 2008 Regulation Governing Compensatory Mitigation for Losses of Aquatic Resources. U.S. Army Corps of Engineers Institute for Water Resources.

Vines, C. A., Robbins, T., Griffin, F. J., Cherr, G. N. (2000). The effects of diffusible creosote-derived compounds on development in Pacific herring (Clupea pallasi). *Aquatic Toxicology*, *51*(2), 225-239.

Ward LG, Kemp W.M., Boynton W.R. (1984). The Influence of waves and seagrass communities on suspended particulates in an estuarine embayment. Mar Geol 59:85-103

Waldbusser, G. G., Voigt, E. P., Bergschneider, H., Green, M. A., Newell, R. I. (2011). Biocalcification in the eastern oyster (Crassostrea virginica) in relation to long-term trends in Chesapeake Bay pH. *Estuaries and Coasts*, *34*(2), 221-231.

Whitlow, W. L., and Grabowski, J. H. (2012). Examining how landscapes influence benthic community assemblages in seagrass and mudflat habitats in southern Maine. *Journal of Experimental Marine Biology and Ecology*, *411*, 1-6.

Withers, K. (2002). Shorebird use of coastal wetland and barrier island habitat in the Gulf of Mexico. *The Scientific World Journal*, *2*, 514-536.

Wilberg, M. J., Livings, M. E., Barkman, J. S., Morris, B. T., Robinson, J. M. (2011). Overfishing, disease, habitat loss, and potential extirpation of oysters in upper Chesapeake Bay. *Marine Ecology Progress Series*, *436*, 131-144.

Appendix A- Data and tables

Table 1- Search Terms for third-party Mitigation in RIBITS

Habitat	Terms
Tidal flat	Tidal flat Mud flat Mudflat
Seagrass	Seagrass Sea grass Zostera SAV Submerged aquatic vegetation Widgeongrass Phyllospadix Syringodium Halodule Thalassia Halophila turtle grass eelgrass eel grass manatee grass shoal grass widgeon grass
Oyster	oyster crassostrea virginica ostrea lurida

Table 2- Third-Party Mitigation Providers: Banks

Reference #	State	Bank name	Year bank established	Focal Habitats Present
1	AK	Natzuhini Bay Mitigation Bank	2004	Tidal flat, shallow water
2	AK	Trillium Mitigation Bank	2019	Tidal flat
3	CA	Colorado Lagoon Mitigation Bank	2020	Tidal flat, seagrass, shallow water
4	CA	Navy Region Southwest San Diego Bay Eelgrass Mitigation Bank	2008	Seagrass, shallow water
5	CA	Port of Los Angeles	2017	Shallow water
6	CA	San Francisco Bay Wetland Mitigation Bank	2011	Tidal flat, shallow water
7	FL	Bear Point Mitigation Bank	2004	None
8	FL	CGW Mitigation Bank	2008	None
9	FL	Florida Gulf Coast Mitigation Bank	2016	None
10	FL	FP&L Everglades Phase I Mitigation Bank	2009	Seagrass, shallow water
11	FL	Horseshoe Creek	2020	None
12	FL	Little Pine Island Mitigation Bank	1996	Shallow water
13	FL	Mangrove Point	2020	Tidal flat, oyster
14	FL	North Florida Saltwater Marsh Mitigation Bank	2013	None
15	FL	Tampa Bay Mitigation Bank	2008	Shallow water
16	GA	Tronox	2008	None
17	GA	Tucker Mitigation Bank	2000	Shallow water
18	GA	Salt Creek Mitigation Bank	2017	None
19	LA	Chef Menteur Pass Mitigation Bank	2010	Shallow water
20	LA	Rockefeller Refuge A, B and C	2004	None
21	MS	Rhodes Lake Mitigation Bank	2008	Shallow water

Reference #	State	Bank name	Year bank established	Focal Habitats Present
22	NJ	Evergreen Abbot Creek Mitigation Bank	2015	Tidal flat, shallow water
23	NJ	Evergreen Great Bay Mitigation Bank	2018	Tidal flat, shallow water
24	NJ	Evergreen MRI3 Mitigation Bank	2012	Tidal flat, shallow water
25	NJ	Marsh Resources/Meadowlands	1999	Tidal flat, shallow water
26	NJ	Richard P. Kane Wetland Mitigation Bank	2010	Tidal flat, shallow water
27	NJ	Evergreen Stipson's Island Mitigation Bank	2011	Tidal flat, shallow water
28	NY	NY City Small Business Services Saw Mill Creek Mitigation Bank	2018	Tidal flat, shallow water
29	OR	Wilbur Island Mitigation Bank	2008	Shallow water
30	SC	Clydesdale Mitigation Bank	2013	Shallow water
31	SC	Congaree Carton	2005	Tidal flat
32	SC	Murray Hill	2018	Shallow water
33	SC	SCDOT Huspa Creek East and West Mitigation Bank Sites	1998	Tidal flat
34	TX	Gulf Coastal Plains Mitigation Bank	2016	Tidal flat, shallow water
35	VA	Chesapeake Land Development Tidal Bank	2004	Tidal flat
36	VA	Goose Creek	1982	None
37	VA	New Mill Creek Tidal Mitigation Bank	2018	Tidal flat
38	WA	McHugh Demonstration Wetland Bank	1999	None

Table 3- Third-Party Mitigation Providers: ILFs and Sites

Reference #	State	ILF name	Year ILF established	Number of marine/ estuarine sites	Site Names	Focal habitats present
1	AK	Great Land Trust	2011	2	Fish Creek, Campbell Creek	Tidal flat
2	AK	Southeast Alaska Land Trust	1998	25	Auk Nu Cove Conservation Easement, Branta Lot 2, Crescent Bay Conservation Easement, Eagles Reach Lot 2, Eagles View Lot 1B, Farragut Estuary Conservation Easement, Gandercall Lot 3, Gandercall Lot 4, Great Horned Owl Lot 2, Grey Goose Lot 2, HAKALA Lot 2, Hilda Creek & Accretion Conservation Easement, Hinz II Lot 1B, Honsinger Wetlands, King Conservation Easement, Lazy G Acres Lot 2, Lobaugh Conservation Easement, Moon Meadow Lot 2, Morning Meadow Lot 3, Morning Meadow Lot 4, Nelson Homestead Conservation Easement, Sherry Lot 2, Sherry Lot 3, Sunny Point Park #3 Lot 1 & Lot 2, Wigeon Ponds Lot 2 Deed Restriction	Seagrass, tidal flats, shallow water
3	AK	The Conservation Fund AK	2010	5	AR-4, AR-1, SW-2, SW-3, SW-4	Seagrass, tidal flats
4	CT	CT ILF program	2011	1	Stratford Point	Oyster
5	FL	Keys Environmental Restoration Fund	1998	Between 3-10*	Lignumvitae Seagrass Scar 1999, Lignumvitae Seagrass Stake Array 1999, Lignumvitae Seagrass Sites 2005	Seagrass, shallow water
6	FL	Keys Restoration Fund	2015	4	Bahia Honda A, Bahia Honda B, Crane Point Hammock, Lignumvitae Seagrass	Seagrass, shallow water

Reference #	State	ILF name	Year ILF established	Number of marine/ estuarine sites	Site Names	Focal habitats present
7	FL	Northwest Florida Water Management District	2015	2	Dutex, Live Oak Point	Shallow water, seagrass, oyster
8	MA	MA Dept. of Fish and Game	2014	8	Upper Great Marsh, Rough Meadows, Town Farm, Eelgrass Restoration, Parker River Connector, Eelgrass restoration (Salem, MA), Oyster Reef (Nantucket)	Seagrass, shallow water, oyster
9	ME	Maine Natural Resources Conservation Program	2011	22	Whiskeag Creek, Indian River, Meadow Brook Wetlands, Brookings Bay, Maquoit Bay, Basin Cove/Curtis Cove, St. George River Tidal, Weskeag Wetlands, Mil Pond Tidal Restoration, Kate Furbish Restoration, Wallace Shore Road, Long Cove Wetlands, Parker Head Road, Little River Restoration, Old Pond- Demska, Middle Bay-Liberty, Smelt Brook Intertidal Restoration, Spring Point (Hog Bay), Fixing Furbish (Phase 1), Rouse island, Strawberry Creek, Willow Brook Culvert Replacement	Tidal flat, seagrass
10	NC	N.C. Dept. of Mitigation Services	2010	9	Balance Farm, Hammock's State Park, Camp Lejeune, Sturgeon City, Lengyel, Sawmill, Bird Island, Maritime Museum, Pamlico Sound Oyster Reef	Tidal flat, oyster, shallow water
11	NH	NH Aquatic Resources Mitigation Program	2018	2	Cutt's Cove, SALMON-PISC Oyster Reef	Oyster, shallow water

Reference #	State	ILF name	Year ILF established	Number of marine/ estuarine sites	Site Names	Focal habitats present
12	OR	OR Dept. of State Lands	2009	3	Pixieland, Kilchis River Preserve, Tamara Quays	Shallow water
13	VA	Living River Restoration Trust	2018	2	Paradise Creek, Money Point	Oyster, shallow water
14	VA	Virginia Aquatic Resources Trust Fund	1995	19	Cumberland Marsh, Rappahannock Phragmites Control, Crows Nest (Phase 1), Crows Nest (Phase 2), VCU, Northwest River (Kellam Rigato), Dragon Run (Milby), Thompson, Hampton, Dameron Marsh, SAV Beds, SAV Beds 2, Virginia Coast Reserve (oyster restoration), New Point Comfort, Eastern VA Phragmites Control, Dameron Marsh, Church Neck, VMRC oyster reef, Lower Chickahominy River	Seagrass, oyster, shallow water
15	WA	Hood County Coordinating Council	2012	4	Anderson, Big Beef, Olson, Dewatto	Tidal flat, seagrass, oyster
16	WA	King County Mitigation Reserves	2011	1	Chinook Wind Mitigation Project	Tidal flat

**For the official tally of ILF sites, three rather than ten was used to be conservative*

Table 4- Department of the Army Permits

Reference #	State	DA NUMBER	Mitigation habitat	Year permit issued
1	FL	SAJ-1999-03746	Shallow water	2003
2	FL	SAJ-2003-04783	Shallow water	2015
3	FL	SAJ-2004-01945	Seagrass	2010
4	FL	SAJ-2004-08169	Shallow water	2007
5	FL	SAJ-2005-05399	Shallow water	2018
6	FL	SAJ-2008-04801	Seagrass	2012
7	FL	SAJ-2010-00817	Seagrass	2013
8	FL	SAJ-2013-00319	Oyster, shallow water	2013
9	FL	SAJ-2014-02406	Seagrass	2015
10	FL	SAJ-2014-03521	Seagrass	2017
11	TX	SWG-2012-00203	Shallow water	2013
12	TX	SWG-2014-00905	Oyster	2014
13	CA	SPL-2010-00028	Shallow water	2010
14	CA	SPL-2010-01129	Seagrass	2011
15	CA	SPL-2011-00463	Seagrass	2012
16	CA	SPL-2012-00172	Tidal flat	2017
17	CA	SPL-2013-00146	Seagrass	2013
18	CA	SPL-2015-00569	Seagrass	2017
19	CA	SPL-2015-00651	Seagrass	2016
20	CA	SPL-2016-00825	Tidal flat	2017
21	CA	SPN-2005-293680	Tidal flat	2006
22	CA	SPN-2016-00053	Shallow water	2016
23	VA	NAO-2001-03946	Oyster	2019
24	VA	NAO-2003-01984	Oyster	2014
25	VA	NAO-2010-02401	Oyster	2012
26	VA	NAO-2014-00463	Seagrass	2014
27	VA	NAO-2015-00310	Seagrass	2016
28	WA	NWS-2010-00968	Tidal flat	2010
29	WA	NWS-2011-00183	Shallow water	2014
30	WA	NWS-2011-00761	Shallow water	2017
31	WA	NWS-2012-00699	Shallow water	2013
32	WA	NWS-2012-00759	Shallow water	2013
33	WA	NWS-2012-01110	Seagrass	2014
34	WA	NWS-2012-01175	Shallow water	2014
35	WA	NWS-2013-00171	Shallow water	2014
36	WA	NWS-2013-00419	Shallow water	2013
37	WA	NWS-2013-01124	Shallow water	2013
38	WA	NWS-2014-00159	Shallow water	2015
39	WA	NWS-2014-00433	Shallow water	2015

Reference #	State	DA NUMBER	Mitigation habitat	Year permit issued
40	WA	NWS-2014-00804	Shallow water	2017
41	WA	NWS-2014-00890	Shallow water	2016
42	WA	NWS-2014-01177	Shallow water	2017
43	WA	NWS-2015-00291	Shallow water	2015
44	WA	NWS-2015-00601	Shallow water	2016
45	WA	NWS-2015-00696	Shallow water	2016
46	WA	NWS-2015-00971	Shallow water	2016
47	WA	NWS-2016-00200	Shallow water	2016
48	WA	NWS-2016-00320	Shallow water	2016
49	WA	NWS-2016-00324	Shallow water	2016
50	WA	NWS-2016-00902	Shallow water	2017
51	WA	NWS-2017-00809	Shallow water	2018
52	WA	NWS-2012-01111	Shallow water	2013
53	WA	NWS-2013-00213	Shallow water	2013
54	WA	NWS-2013-00245	Shallow water	2015
55	WA	NWS-2014-00736	Shallow water	2015

Table 5- Ambient monitoring programs

Type	Program or Survey Name
Worldwide	SeagrassNet program
	Zostera Experimental Network (ZEN) program
National	EPA NARS NCCA survey
	EPA NARS NWCA survey
	FWS Status and Trends/National Wetlands Inventory program
	National Park Service Eutrophication Survey
	NOAA NERRS program
	EPA NEP program
Multi-State	VIMS Annual Aerial Seagrass Survey
	10 Tributaries by 2025 NOAA Oyster Restoration
	USGS Marshes to Mudflats project
State	Maryland DNR Fall Recruitment Survey
	Florida DEP Aquatic Preserve Program
	VIMS Long-Term Seagrass Transect Program
	North Carolina DMF Sanctuary Survey
	Seagrass restoration in Virginia's coastal bays
	San Elijo Lagoon Restoration project, California

Table 6- California Eelgrass Mitigation Policy Performance Standards

Month	Standard
0	Monitoring should confirm the full coverage distribution of planting units over the initial mitigation site as appropriate to the geographic region.
6	Persistence and growth of eelgrass within the initial mitigation area should be confirmed, and there should be a survival of at least 50 percent of the initial planting units with well-distributed coverage over the initial mitigation site. For seed buoys, there should be demonstrated recruitment of seedlings at a density of not less than one seedling per four (4) square meters with a distribution over the extent of the initial planting area. The timing of this monitoring event should be flexible to ensure work is completed during the active growth period.
12	The mitigation site should achieve a minimum of 40 percent coverage of eelgrass and 20 percent density of reference site(s) over not less than 1.2 times the area of the impact site.
24	The mitigation site should achieve a minimum of 85 percent coverage of eelgrass and 70 percent density of reference site(s) over not less than 1.2 times the area of the impact site.
36	The mitigation site should achieve a minimum of 100 percent coverage of eelgrass and 85 percent density of reference site(s) over not less than 1.2 times the area of the impact site.
48	The mitigation site should achieve a minimum of 100 percent coverage of eelgrass and 85 percent density of reference site(s) over not less than 1.2 times the area of the impact site.
60	The mitigation site should achieve a minimum of 100 percent coverage of eelgrass and 85 percent density of reference site(s) over not less than 1.2 times the area of the impact site.

Appendix B- Out-of-kind mitigation

Introduction- The 2008 Mitigation Rule upholds a preference for in-kind (of the same type) mitigation to increase likelihood that the functions and services that are lost at the impact site will be gained at a mitigation site.[10] Out-of-kind compensatory mitigation, however, can be considered if in-kind replacement is not possible, is unlikely to adequately compensate for the impact, or out-of-kind mitigation is environmentally preferable. For instance, out-of-kind mitigation can be proposed when a mitigation provider believes that the habitat proposed to be used as mitigation will better serve the aquatic resource needs of the watershed/ecoregion. Out-of-kind mitigation often results in a higher mitigation ratio (amount of compensation to impact).

Methods- Records from DARTER were used for this analysis (see PRM section of the Methods in the main report). The objective was to find projects that either impacted or provided compensatory mitigation involving seagrass, oysters, tidal flats, and shallow water (Table 1) to determine the proportion of in- and out-of-kind projects.

Results- Fifty-eight projects were used for the out-of-kind analysis; among them, 11 projects compensated out-of-kind. The majority of the projects (26 of 58) were from Washington state and consisted of shallow water impacts that were compensated for in-kind.

Seagrass impacts were mostly mitigated for in-kind; there was only one project (in California) with seagrass impact that mitigated out-of-kind. The impact was to surf grass (*P. torreyi*), a type of seagrass that grows in rocky intertidal habitats, and a contribution was made to a local non-profit for kelp (macroalgae) restoration in its place. The 14 other in-kind seagrass mitigation projects were from California, Virginia, Washington, and Florida, with the most being from California and Florida.

Oyster compensation occurred equally between in-kind and out-of-kind projects. There were three out-of-kind projects that took place in Virginia. In one project, tidal flat and shallow water were impacted to stabilize a pier and build a bulkhead at a restaurant, and a contribution was made to a non-profit to buy oyster shell for oyster restoration in return. In another, tidal flat was dredged to build a multi-use facility (a dredged material transfer station and canoe launch). A contribution was made to the same non-profit to buy oyster shell for oyster restoration in return. Finally, an oyster restoration project was permitted as compensatory mitigation for a shipping facility that was building new structures by placing fill in unvegetated intertidal and shallow water areas. The three in-kind projects were from Texas and Florida.

There were five projects that impacted tidal flats and compensated out-of-kind compared to three that mitigated in-kind. One Texas project was permitted to impact sand tidal flats to build a residential development and coastal prairie pothole construction was approved as compensatory mitigation; another Texas project impacted tidal flats to build a recreation

[10] 33 CFR 332.3(e) / 40 CFR 230.93(e)

center and approved creation of a lagoon as mitigation. Of two Florida projects that impacted tidal flats, one restored salt marsh and installed stormwater filtration systems, and the other planted mangroves as compensation. In Virginia, a project that dredged a mudflat to build a multi-use facility (mentioned above) purchased shell for oyster restoration as compensatory mitigation. The three in-kind projects were from Washington and California.

There were six out-of-kind projects that involved shallow water compared to 30 in-kind projects. In Texas, two permits were issued for fill of shallow water areas, for modification of a shipping channel and construction of a shipping facility, and salt marsh was created to compensate for each one. A third Texas project used shallow water to compensate for an out-of-kind impact; a tidal flat was impacted to build a recreation center, and mitigation was creating a lagoon (mentioned above). In Virginia, there were three projects that impacted shallow water and compensated out-of-kind (two have already been mentioned above). The third permit impacted tidal flat and shallow water by placing fill for a bulkhead. The permittee was approved to create on-site salt marsh as mitigation. In-kind compensatory mitigation projects came from Florida, California, and Washington.

Discussion- The ratio of in-kind to out-of-kind compensation observed was roughly 4:1, but this figure is based on limited data. These examples can inform mitigation work and policy but do not completely represent the amount of out-of-kind compensatory mitigation occurring in seagrass, oyster, tidal flat and shallow water areas nationwide. Other examples of out-of-kind projects that involve these habitats exist. For instance, a recently permitted (2020) large infrastructure project in Maryland is impacting wetlands but is compensating via oyster restoration. Another Maryland project where streams were impacted used estuarine shallow water mitigation (removal of crab pot debris) as compensation. The most instances of out-of-kind projects in the dataset came from oyster and tidal flat habitats. Oysters may be used as out-of-kind mitigation because they are a popular form of restoration that receives public support.

For many projects, it was difficult to understand from the documentation available which habitats were impacted and which habitats were used as mitigation. If it was not possible to tell, the projects were excluded from this analysis. In some projects, a matrix of different habitats was impacted, and a matrix of different habitats was used as compensation. Project documentation did not always make it clear which mitigation habitat was intended to compensate for which impact habitat (i.e., in- or out-of-kind), and thus those projects were also excluded. Finally, there were situations where the impact or mitigation habitats were simply not described. For instance, permit documentation for a bulkhead build does not typically describe the habitat it is impacting, even though it could be a subaqueous area, tidal flat, intertidal area, etc.

There were also several projects that withdrew credits from a PRM site that was functioning as a bank, but because information about the PRM site was not within the permit documentation, there was no way of knowing what habitats were present at the site. This was the case with four permitted projects in Florida with seagrass impacts; all withdrew credits from two different PRM sites, but those projects could not be included in this analysis.

The reasoning for using out-of-kind mitigation should be clearly explained in the Memorandum for the Record (MFR) for PRM projects, along with a description of which habitat is being exchanged for which habitat. For this research, the most important document to obtain was the MFR, which described both impact and mitigation, and that anyone undertaking this type of research in the future should request these documents.

Table 1- In-kind and out-of-kind mitigation

Reference #	State	In kind/ out-of-kind	DA #	Impact habitat	Mitigation habitat
1	CA	In kind	SPN-2016-00053	Shallow water	Shallow water
2	CA	In kind	SPL-2010-00028	Shallow water	Shallow water
3	CA	In kind	SPL-2010-01129	Seagrass	Seagrass
4	CA	In kind	SPL-2011-00463	Seagrass	Seagrass
5	CA	In kind	SPL-2012-00172	Tidal flat	Tidal flat
6	CA	In kind	SPL-2013-00146	Seagrass	Seagrass
7	CA	In kind	SPL-2015-00569	Seagrass	Seagrass
8	CA	In kind	SPL-2015-00651	Seagrass	Seagrass
9	CA	Out-of-kind	SPL-2011-00333	Seagrass	Macroalgae-kelp
10	FL	In kind	SAJ-1999-03746	Shallow water	Shallow water
11	FL	In kind	SAJ-2004-01945	Seagrass	Seagrass
12	FL	In kind	SAJ-2008-01022	SAV	SAV
13	FL	In kind	SAJ-2008-04801	Oyster, seagrass	Oyster, seagrass
14	FL	In kind	SAJ-2010-00817	Seagrass	Seagrass
15	FL	In kind	SAJ-2013-00319	Oyster, shallow water	Oyster, shallow water
16	FL	In kind	SAJ-2014-02406	Seagrass	Seagrass
17	FL	In kind	SAJ-2014-03521	Seagrass	Seagrass
18	FL	Out-of-kind	SAJ-2017-01640	Tidal flat	Mangrove
19	FL	Out-of-kind	SAJ-2004-03490	Oyster, tidal flat	Oyster, salt marsh, stormwater filtration devices
20	TX	In kind	SWG-2014-00905	Oyster	Oyster
21	TX	Out-of-kind	SWG-2011-00303	Shallow water	Salt marsh
22	TX	Out-of-kind	SWG-2011-00561	Tidal flat	Prarie pothole

Reference #	State	In kind/ out-of-kind	DA #	Impact habitat	Mitigation habitat
23	TX	Out-of-kind	SWG-2012-00602	Shallow water	Salt marsh
24	TX	Out-of-kind	SWG-2012-00203	Tidal flat	Shallow water
25	VA	In kind	NAO-2014-00463	Seagrass	Seagrass
26	VA	In kind	NAO-2015-00310	Seagrass	Seagrass
27	VA	Out-of-kind	NAO-1992-02651	Tidal flat, shallow water	Salt marsh
28	VA	Out-of-kind	NAO-2001-03946	Tidal flat, shallow water	Oyster
29	VA	Out-of-kind	NAO-2003-01984	Shallow water	Oyster
30	VA	Out-of-kind	NAO-2010-02401	Tidal flat	Oyster
31	WA	In kind	NWS-2010-00968	Tidal flat	Tidal flat
32	WA	In kind	NWS-2011-00183	Shallow water	Shallow water
33	WA	In kind	NWS-2011-00761	Shallow water	Shallow water
34	WA	In kind	NWS-2012-00699	Shallow water	Shallow water
35	WA	In kind	NWS-2012-00759	Shallow water	Shallow water
36	WA	In kind	NWS-2012-01110	Seagrass	Seagrass
37	WA	In kind	NWS-2012-01175	Shallow water	Shallow water
38	WA	In kind	NWS-2013-00171	Shallow water	Shallow water
39	WA	In kind	NWS-2013-00419	Shallow water	Shallow water
40	WA	In kind	NWS-2013-01124	Shallow water	Shallow water
41	WA	In kind	NWS-2014-00159	Shallow water	Shallow water
42	WA	In kind	NWS-2014-00433	Shallow water	Shallow water
43	WA	In kind	NWS-2014-00804	Shallow water	Shallow water
44	WA	In kind	NWS-2014-00890	Shallow water	Shallow water
45	WA	In kind	NWS-2014-01177	Shallow water	Shallow water
46	WA	In kind	NWS-2015-00291	Shallow water	Shallow water

Reference #	State	In kind/ out-of-kind	DA #	Impact habitat	Mitigation habitat
47	WA	In kind	NWS-2015-00601	Shallow water	Shallow water
48	WA	In kind	NWS-2015-00696	Shallow water	Shallow water
49	WA	In kind	NWS-2015-00971	Shallow water	Shallow water
50	WA	In kind	NWS-2016-00200	Shallow water	Shallow water
51	WA	In kind	NWS-2016-00320	Shallow water	Shallow water
52	WA	In kind	NWS-2016-00324	Shallow water	Shallow water
53	WA	In kind	NWS-2016-00902	Shallow water	Shallow water
54	WA	In kind	NWS-2017-00809	Shallow water	Shallow water
55	WA	In kind	NWS-2012-01111	Shallow water	Shallow water
56	WA	In kind	NWS-2013-00213	Shallow water	Shallow water
57	WA	In kind	NWS-2013-00245	Shallow water	Shallow water
58	WA	In kind	NWS-2014-00736	Shallow water	Shallow water