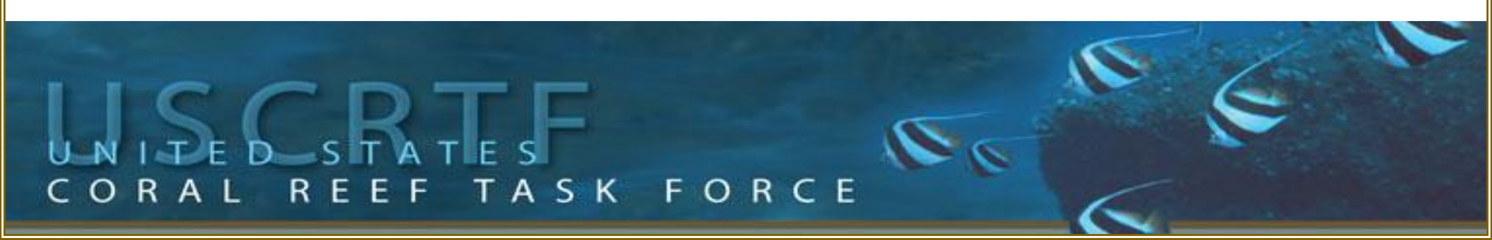
U.S. Coral Reef Task Force

Handbook on Coral Reef Impacts:
Avoidance, Minimization, Compensatory Mitigation, and Restoration

Prepared by:
U.S. Coral Reef Task Force
Coral Injury and Mitigation Working Group

December 2016



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EXECUTIVE SUMMARY

In response to the National Ocean Council's Implementation Plan (National Ocean Policy Implementation Plan, 2013) and U.S. Coral Reef Task Force's (USCRTF) Resolution 16.7, the USCRTF developed the *Handbook on Coral Reef Impacts: Avoidance, Minimization, Compensatory Mitigation, and Restoration.* The Handbook is a review of the federal authorities, existing policies, and federal agency, state, and territory roles and responsibilities; a compendium of current best practices, science-based methodologies for quantifying ecosystem functions or services; and a general overview of basic protocols available for use when assessing impacts to coral reef ecosystems, and mitigating or restoring for unavoidable impacts to coral reef ecosystems, including the use of appropriate compensatory action to replace the lost functions and services. The Handbook is a compilation of current coral reef mitigation and restoration best management practices.

The target audience for this Handbook includes project applicants, proponents, permittees or consultants for projects that may affect coral reefs, or for responsible parties (RP) and their consultants in the event of unplanned impact events. This Handbook is also intended to be a reference for resource managers who are charged with project permitting, damage response, impact mitigation, and habitat restoration.

This document is not official agency guidance, nor does it represent a comprehensive policy statement, and nothing herein replaces requirements contained within statute, codified in regulation, or agency policy, or guidance documents, and it is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or equity by a party against the United States, its departments, agencies, instrumentalities or entities, its officers or employees, or any other person.

Coral reefs are subject to numerous local, regional, and global stressors. Managers and regulators working to address impacts to coral reefs are further constrained by the difficulty in restoring and replacing these complex systems. Natural reefs are biologically, chemically, physically, and morphologically complex, take many years to develop, and are difficult to restore. Many coral species are particularly slow-growing (one-tenth of an inch per year) and long-lived (decades to centuries) resulting in a long response and replacement time.

While existing guidance and tools have been developed for mitigation and restoration of stream and wetland impacts, new guidance and tools are needed to guide mitigation and restoration for coral reef impacts due to their differences in ecological structure, function, and dynamics, and the difficulty in replacing lost functions. Mitigation and restoration technology for freshwater and terrestrial systems has a longer track record, and has been refined through substantial trial and error experience. When working in the marine environment, other factors such as site ownership, site protection, the remote and hazardous nature of working underwater, and long-term maintenance present challenging hurdles, and are presently managed on a case-by-case basis. To date, many mitigation options have only been implemented a few times and across a wide geographic area. Wide dissemination of the information learned from these mitigation options is needed to provide lessons learned to project proponents.

With the current worldwide decline of coral reef ecosystems, it is imperative that the United States consistently and effectively acts to avoid impacts to coral reef habitats. When impacts cannot be avoided, measures should be taken to minimize adverse impacts. Unavoidable impacts may warrant compensatory mitigation through appropriate actions to replace losses of functions and services. Consistent and targeted efforts should be made to address as many coral reef stressors that can be controlled by management and regulatory actions.

This Handbook provides a general summary of current avoidance, minimization, compensatory mitigation, and restoration strategies that may help address physical damage resulting from direct adverse impacts to coral reefs (e.g., dredging, placement of fill, vessel groundings, or accidental discharges like oil spills) and indirect adverse impacts to coral reefs (e.g., beach nourishment, sedimentation from poor land use practices, sedimentation from dredging or vessel movement, or storm water contaminants). In addition, the Handbook also reviews applicable policies and provides descriptions of various agency roles and responsibilities. The Handbook includes an evaluation framework for both planned impacts to coral reefs, and responding to unplanned impacts to coral reefs, recommendations for data collection for coral reef conditional assessment surveys, a summary of existing mitigation options for unavoidable impacts and key considerations for each option, and considerations for performance standards and monitoring of coral reef mitigation and restoration activities. Readers of this Handbook are advised to use this document for reference only. Although the Handbook is intended to summarize laws, regulations, policies, and best management practices it does not include a detailed overview of every agency's authorities, policies, and guidance. Readers are advised to always seek the guidance of the local, state, and federal agencies that may have regulatory authority over a project or trust resources that have been or will be impacted.

The USCRTF believes that due to the complex nature of the coral reef ecosystem, and the even more complex nature of identifying and providing appropriate compensatory mitigation for lost ecosystem services, the emphasis on maximizing avoidance and minimization of impacts cannot be overstated.

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ACRONYMS

ACI	After Control Impact
BACI	Before-After Control-Impact
BMP	Best Management Practice
CCY	Coral Colony Year
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended
CFR	Code of Federal Regulation
cm	Centimeter
CNMI	Commonwealth of the Northern Mariana Islands
CRCA	Coral Reef Conservation Act
CRCP	Coral Reef Conservation Program
CTP	Coral Transplantation Plan
CZMA	Coastal Zone Management Act
CWA	Clean Water Act
DA	Department of the Army
DARRP	Damage Assessment, Remediation, and Restoration Program
DGPS	Global Positioning System
DLNR	Hawaii's Department of Land and Natural Resources
DOC	Department of Commerce
DOD	Department of Defense
DOI	Department of the Interior
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ER	Engineering Regulation
ERP	Environmental Resources Permit
ESA	Endangered Species Act
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FKNMS	Florida Keys National Marine Sanctuary
FMP	Fishery Management Plan
FS	Florida Statute
FWCA	Fish and Wildlife Coordination Act
FWS	U.S. Fish and Wildlife Service
HI	State of Hawaii
JCP	Joint Coastal Permit
LEDPA	Least Environmentally Damaging Practicable Alternative
LiDAR	Light Detection and Ranging
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
MPRSA	Marine Protection Research and Sanctuaries Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NMFS	NOAA's National Marine Fisheries Service
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRDAR	Natural Resource Damage Assessment and Restoration
NWP(s)	Nationwide Permit(s)
ODMDS	Ocean Dredged Material Disposal Sites
OPA	Oil Pollution Act of 1990
RHA	Rivers and Harbors Act of 1899
REA	Resource Equivalency Analysis
RI	Rugosity Index
RP(s)	Responsible Party(ies)
SUPSALV	U.S. Navy Supervisor of Salvage
SURPA	Systems Unit Resource Protection Act
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USCG	U.S. Coast Guard
USCRTF	U.S. Coral Reef Task Force
USVI	U.S. Virgin Islands
WRDA	Water Resources Development Act

DISCLAIMER

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The “Handbook on Coral Reef Impacts: Avoidance, Minimization, Compensatory Mitigation, and Restoration” was formally adopted by the U.S. Coral Reef Task Force (USCRTF) on December 22, 2016.

The USCRTF was established in 1998 by Presidential Executive Order to lead U.S. efforts to preserve and protect coral reef ecosystems. The USCRTF membership is represented by 12 federal agencies; seven states, territories, and commonwealths; and three Freely Associated States.

The USCRTF helps build partnerships, strategies, and support for on-the-ground action to conserve coral reefs.

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1.0 BACKGROUND

1.1 Introduction

The purpose of this Handbook is to provide a summary of the current coral reef mitigation and restoration best management practices in the United States. This effort was adopted by the U.S. Coral Reef Task Force (USCRTF) that consists of 12 federal agencies and seven state or territorial governments that collectively strive to effectively manage the Nation's coral reefs.

With the current worldwide decline of coral reef ecosystems, it is imperative that the United States consistently and effectively acts to avoid impacts to coral reef habitats. When damage cannot be avoided, measures should be taken to minimize adverse impacts. Unavoidable impacts may warrant compensatory mitigation through appropriate actions to replace losses of functions and services. Consistent and targeted efforts should be made to address as many coral reef stressors that can be controlled by management and regulatory actions. This Handbook provides a summary of current avoidance, minimization, and compensatory mitigation and restoration strategies that may help address physical damage resulting from direct adverse impacts to coral reefs (e.g., dredging, placement of fill, vessel groundings, or accidental discharges like oil spills) and indirect adverse impacts to coral reefs (e.g., beach renourishment, sedimentation from poor land use practices, sedimentation from dredging or vessel movement, or storm water contaminants). Effectively addressing adverse physical impacts to coral reefs will increase their resilience to other stressors, including climate change and ocean acidification, and the likelihood that coral reefs will continue to provide the valuable services our communities depend upon now, and into the future. As addressed in Section 1.6 of this document, the success of individual mitigation activities may depend in part on the effects that other stressors are having on a coral reef. Working closely with the appropriate permitting and management agencies is critical to ensure there is a clear understanding of the expectations and requirements for successful mitigation considering these factors.

Federal agencies share responsibilities to avoid and minimize adverse impacts to, and to restore, aquatic ecosystems including coral reefs under the Clean Water Act (CWA), Executive Order (EO) 13089, the Magnuson-Stevens Fishery Conservation and Management Act (MSA),Oil Pollution Act (OPA), Rivers and Harbors Act of 1899 (RHA). Acknowledging these shared responsibilities, the USCRTF passed Resolution 8.4 in 2002 that established an interagency USCRTF working group to evaluate the effectiveness of coral reef mitigation efforts and to generate recommendations for the future. The resulting reports characterized federally funded and authorized compensatory mitigation projects in both the Atlantic/Caribbean and Pacific oceans, and documented the poor or unassessed rates of success for such projects to date (Bentivoglio, 2003 and Yoshioka et al., 2004). The reports recommended formalization of a mechanism (e.g., technical advisory or regional interagency teams) for information exchange between federal, state, and territorial resource trustees and regulatory agencies to provide consistency, and to improve successful implementation of approaches for coral reef compensatory mitigation.

Individual USCRTF working groups were convened to address issues surrounding planned and unplanned coral injuries and mitigation, respectively; these working groups eventually merged. State and territorial points of contact to the USCRTF identified a need to not only formalize communication between levels of government concerning the process of addressing impacts to coral reefs, but to document and share current best practices on topics such as coral reef impact characterization, compensatory mitigation, and restoration strategies. The long-term goal of the working group is to reduce administrative burden and achieve better outcomes by creating a path toward consistency for projects in each of the seven U.S. coral reef jurisdictions (American Samoa (AS), Commonwealth of the Northern Mariana Islands (CNMI), Commonwealth of Puerto Rico (PR), Guam, State of Florida (FL), State of Hawaii (HI), and the U.S. Virgin Islands (USVI)).

More recently, as part of the National Ocean Council's National Ocean Policy Implementation Plan (NOC, 2013) and USCRTF Resolution 16.7, the USCRTF has committed to completing and disseminating a reference handbook to include a review of the federal authorities; existing policies; federal, state, and territorial agency roles and responsibilities; a compendium of best practices and science-based methodologies for quantifying ecosystem functions or services; and a general overview of basic protocols for use when assessing impacts to coral reef ecosystems and mitigating or restoring for unavoidable impacts to coral reef ecosystems where warranted, including the use of appropriate compensatory action to replace the lost functions and services. The Handbook is a compilation of current coral reef mitigation and restoration best management practices. The Handbook is further supported by the *Presidential Memorandum: Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment*, issued November 3, 2015.

This Handbook is the first attempt to deliver such a product summarizing the current U.S. government practices for responding to both planned and unplanned coral reef impacts. In this document, the various legal authorities and respective entities are presented as well as the related considerations to effectively govern impacts to coral reef. While focused on the federal legal and regulatory authorities, this Handbook also identifies several relevant state and territorial coral reef related authorities. These include strategies for assessing impacts to coral reef resources associated with federal, state, or territorial regulatory and permitting activities, as well as response actions. Where coral reef impacts are expected from government actions, the potential requirements of rehabilitation and mitigation activities in coral reefs and/or nearby lands or waters to protect or improve coral reef ecosystems and/or associated habitats, and the ecological functions and services, are discussed.

The target audience for this Handbook includes project applicants, proponents, permittees, or consultants for projects that may adversely affect coral reefs, or for responsible parties (RP) and their consultants in the event of unplanned impact events. This Handbook is also intended to be a reference for resource managers who are charged with project permitting, damage response, impact mitigation, and habitat restoration.

This document is not official agency guidance, nor does it represent a comprehensive policy statement, and nothing herein replaces requirements contained within statute, codified in regulation, or agency policy, or guidance documents, and it is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or equity by a party against the United States, its departments, agencies, instrumentalities or entities, its officers or employees, or any other person.

For planned events, such as dredging or in-water construction, federal, state, and territorial authorities have varying definitions of mitigation, as well as different requirements for determining appropriate compensatory mitigation under those authorities. The most comprehensive regulations are the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) regulations for compensating for unavoidable losses of aquatic resources (33 Code of Federal Regulation (CFR) part 332 and 40 CFR part 230, subpart J) (i.e., the 2008 Mitigation Rule). As such, the "2008 Mitigation Rule" serves as the primary guide for designing coral reef compensatory mitigation. For the purposes of this document, "mitigation" for planned events refers to the process of first avoiding, then minimizing, and lastly—in cases where unavoidable loss of natural resource will occur—implementing compensatory mitigation. Compensatory mitigation is defined under the 2008 Mitigation Rule, and informed by the Essential Fish Habitat (EFH) consultation requirements under MSA §305(b), and the U.S. Fish and Wildlife Service (FWS) mitigation policy, dated November 21, 2016 (Federal Register, Volume 81, Number 224, pages 83440-83492), through the authority of the Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 470 et seq.), among others. In many cases, if projects are able to avoid and minimize impacts to coral reefs in the planning process, a federal action, such as a federal permit, may not require compensatory mitigation.

Additionally, this document summarizes the general process for unplanned events such as ship groundings. The process for unplanned events focuses on the replacement of public trust resources and is governed by specific authorities such as the OPA, National Marine Sanctuaries Act (NMSA), the Systems Unit Resource Protection Act (SURPA) (54 U.S.C. 100721), some state laws, and occasionally Admiralty Law.[1]

For both planned and unplanned events impacting coral reefs, individual federal, state, and/or territorial authorities have defined the actions necessary to mitigate for and restore unavoidable adverse impacts to coral reefs. This Handbook provides generalized descriptions of the actions typically conducted. Often the process is iterative. It is best to work closely with the appropriate federal, state, and/or territorial authorities as they will take into account any resource considerations specific to the project and help identify potential solutions when necessary.

With impacts of climate change and ocean acidification—such as sea level rise, warming sea surface temperatures, and decreasing pH—already threatening coral reefs and coastal communities, the USCRTF affirms that all coral reef conservation efforts should be considered within the context of these ongoing global changes (Resolutions 28.2 and 34.1). This view is consistent with EO 13653 "Preparing the United States for the Impacts of Climate Change," dated November 1, 2013, which directs federal agencies to "promote (1) engaged and strong partnerships and information sharing at all levels of government; (2) risk-informed decision-making and the tools to facilitate it; (3) adaptive learning, in which experiences serve as opportunities to inform and adjust future actions; and (4) preparedness planning" in order to improve the Nation's preparedness and resilience to these impacts. EO 13653 also directs each federal agency to "develop, implement, and update comprehensive plans that integrate consideration of climate change into agency operations and overall mission objectives." In various sections, this Handbook highlights considerations of climate change in mitigation planning. As with the variations in requirements for coral reef mitigation specific to each federal agency authority, each federal agency has variations in how to best incorporate climate change into coral reef impact assessments. Project proponents should work closely with the appropriate permitting authorities to determine how to address climate change considerations in their projects and mitigation actions.

In compiling this Handbook, it has become clear that there are both overlapping and potentially conflicting federal authorities and interpretations thereof, and therefore there may be a lack of

[1] The Foreign Claims Act (FCA) applies to damage claims outside of U.S. waters for damage caused by the federal government.

consensus and consistency on how to best manage those authorities. **However, there is agreement that due to the complex nature of the coral reef ecosystem, and the even more complex nature of identifying and providing appropriate compensatory mitigation for lost ecosystem services, the emphasis on maximizing avoidance and minimization of impacts is imperative.** These considerations apply to both planned and unplanned coral reef impact events. Despite the different legal authorities, the following factors are common to both planned and unplanned coral reef mitigation/response efforts:

1. Defining **planned actions** or determining the actions that lead to the **unplanned impacts** must be fully understood**.** Defining the actions that will lead to or have led to coral reef impacts will drive the decisions on appropriate next steps.

2. **Avoiding** impacts completely by not taking a certain action, or parts of an action, or re-designing the action to avoid adverse impacts to reefs. Avoiding impacts includes a cursory understanding of the affected environment. A more detailed characterization is needed when all avoidance and minimization actions have occurred (discussed in factor #4, below). In planned events, avoidance will occur in the planning stage to reduce impacts from an activity. Whereas, in the case of unplanned events, measures could be taken during response actions to prevent or reduce additional impacts to coral reefs.

3. **Minimizing** adverse impacts by limiting the magnitude of the action and its implementation (including effects of operations and maintenance activities). In planned events, minimizing may include selecting a less damaging alternative (not applicable to an unplanned impact). Minimizing impacts may be challenging during unplanned events but, similar to avoiding impacts, actions can be taken during the incident response phase to minimize additional injuries, such as defining an exit path for a grounded ship being removed from the coral reef.

4. Assessing the impacts by **accurately characterizing the affected environment.** In planned events where coral reef impacts have been avoided, a detailed characterization is often not required. In some cases, this more detailed assessment will lead to the identification of additional ways to avoid and minimize impacts to sensitive resources. For unplanned events, a full injury assessment is important in determining the nature and extent of the impacts to the coral reef and its ecosystem.

5. Compensating for unavoidable coral reef impacts in planned events can be accomplished by **replacing** the lost ecosystem functions or services. In the case of unplanned events, the target would be **replacement** of public trust resources, including lost ecosystem functions or services.

The Coral Reef Injury and Mitigation Working Group of the USCRTF developed this Handbook to summarize current practices, processes, and roles and responsibilities with a goal to increase consistency and success in the collective efforts to protect coral reef ecosystems. New tools and strategies for assessing coral impacts and mitigating for those impacts are being developed by agencies, project proponents, or responsible parties. As these tools and strategies mature in the future, the USCRTF will determine the most effective manner to provide updated information.

1.2 Definitions

Following are key terms and definitions used in this Handbook. Where possible, the terms and definitions were taken directly, or adapted from, existing regulations and policy documents. The definitions are provided to help readers work through this Handbook, not to redefine what is already written into statute and regulations. Readers should always confirm definitions with the appropriate permitting and management agencies for a specific project or event.

Activity: Options or actions that are proposed to occur in an area where coral reef habitat occurs or in an area with ecological or oceanographic connectivity that may convey adverse effects on coral reef habitat.

Adverse Effect (impact): Any impact that reduces quality and/or quantity of species or habitat (includes benthic community, water column, biological, chemical, and physical attributes) and may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific, or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (adapted from 50 CFR 600.810). When an adverse effect to coral reef species or habitat is likely to occur, project proponents/permittees should seek to avoid and minimize the effect and may be required to implement compensatory mitigation for the unavoidable effects.

Aquatic: Of or relating to freshwater, estuarine, and marine habitats.

Baseline: The condition of the natural resources and services that would have existed had the incident not occurred. Baseline data may be estimated using historical data, reference data, control data, modeling, or data on incremental changes (e.g., number of dead animals), alone or in combination, as appropriate (15 CFR 990.30).

Climate Change: Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014, Annex II: Glossary).

Compensatory Mitigation (includes compensate(d), compensation): Those activities taken for the purposes of offsetting impacts to coral reef ecosystems that remain after all appropriate and practicable avoidance and minimization has been achieved. Compensatory mitigation may be required to satisfy applicable federal, state, or territorial regulations. Compensatory mitigation activities may include, but are not limited to, the re-establishment, rehabilitation, establishment (creation), enhancement, and/or preservation of coral reef ecosystems and/or associated habitats (adapted from 33 CFR 332.2, 40 CFR 230, and MSA; 16 U.S.C. 1855 (b) §305(b)).

Compensatory Mitigation Plan: The plan developed by the project proponent or resource agency and determined to be sufficient by the permitting authority or resource trustee agencies that identifies the objectives, site selection, site protection instrument, baseline information, determination of credits and debits, mitigation work plan, maintenance plan, performance standards, monitoring requirements, long-term management plan, adaptive management plan, financial assurances, and other pertinent information to address requirements of the permitting authority (adapted from 33 CFR 332.4 and 40 CFR 230).

Condition: The relative state of an aquatic resource to support and maintain a community of organisms characterized by its species composition, diversity, and functional organization comparable to reference aquatic resources in the region (33 CFR 332.2 and 40 CFR 230). For the purpose of this document, as discussed in Section 2.1.4, condition assessments are used as an alternative to assess coral reef function.

Coral: Species of the phylum Cnidaria, including all species of the orders Antipatharia (black corals), Scleractinia (stony corals), Gorgonacea (horny corals), Stolonifera (organpipe corals and others), Alcyonacea (soft corals), and Helioporacea (blue coral) of the class Anthozoa; and all species of the families Milleporidea (fire corals) and Stylastreridae (stylasterid hydrocorals) of the class Hydrozoa.

Coral Reef: Limestone structures composed in whole, or in part, of living coral, skeletal remains, and including other corals, sessile marine animals, and plants. Reefs greatly vary in size from a few meters to several kilometers. Several individual reefs can form large reef complexes like the Great Barrier Reef of Australia, Papahānaumokuākea National Marine Monument, Great Bahama Bank, and the Florida Reef Tract.

Coral Reef Ecosystem: The system of coral reefs and geographically and ecologically-associated species, habitats, and environment, and the processes that control its dynamics. Often, other nearshore habitats such as seagrass, algae, and mangroves are part of the coral reef ecosystem.

Coral Relocation: Moving a coral from a site not associated with an impact (e.g., a nursery location) to another site (e.g., a proposed compensatory mitigation site) (see Section 4.3, Option 3).

Coral Transplantation (Translocation): Moving a coral from one site proposed for impact to another site, typically associated as an action to minimize impacts from a planned activity (see Section 2.2.3.2).

Credit: A unit of measure (e.g., a functional or areal measure or other suitable metric) representing the accrual or attainment of aquatic functions at a compensatory mitigation site. The measure of aquatic functions is based on the resources restored, established, enhanced, or preserved (33 CFR 332.2).

Debit: Debit means a unit of measure (e.g., a functional or areal measure or other suitable metric) representing the loss of aquatic functions at an impact or project site. The measure of aquatic functions is based on the resources impacted by the authorized activity (33 CFR 332.2).

Enhancement: The manipulation of the physical, chemical, or biological characteristics of an aquatic resource to heighten, intensify, or improve a specific aquatic resource function(s). Enhancement results in the gain of selected aquatic resource function(s), but may also lead to a decline in other aquatic resource function(s). Enhancement does not result in a gain in aquatic resource area.

Establishment: The manipulation of the physical, chemical, or biological characteristics present to develop an aquatic resource that did not previously exist.

Ecosystem Functions (Function(s)): The physical, chemical, and biological processes that occur in coral reef ecosystems or associated ecosystems (33 CFR 332.2 and 40 CFR 230). For the purpose of this document, as discussed in Section 2.1.4, there is currently limited ability to assess coral reef function, and therefore condition assessment is used generally.

Ecosystem Services: The benefits that human populations receive from functions that occur in ecosystems (adapted from 33 CFR 332.2 and 40 CFR 230). Alternatively, the functions performed by a natural resource for the benefit of another natural resource or the public (15 CFR 990.30).

Federal Action: Any actions, authorization (permits, grants licenses, etc.), funding use or distribution, or efforts undertaken by a federal agency.

Impact: Refers to planned or unplanned loss of ecological functions or services.

Direct Impacts: Impacts that are caused by the planned or unplanned activity and occur at the same time and place (adapted from 40 CFR 1508.8(a)).

Cumulative Impacts: Impacts that result from the incremental impact of the action (i.e., the direct and indirect impacts caused by the action) when added to the impacts of other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes those other actions (40 CFR 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Assessment of cumulative impacts requires identifying a baseline condition, describing how that condition has changed over time as a result of past actions, and how that condition is expected to change as a result of present actions and reasonably foreseeable future actions (adapted from "Considering Cumulative Effects under the National Environmental Policy Act," Council for Environmental Quality, 1997).

Indirect Impacts: Impacts that are caused by, or associated with, the planned or unplanned activity. Impacts can be later in time, or farther removed in distance, but are still reasonably foreseeable (adapted from 40 CFR 1508.8(b)).

Permanent Impacts: Impacts that result in a complete loss of the resource with no ability for reasonable natural recovery in the foreseeable future (e.g., removing coral reefs from a navigation channel).

Planned Impacts: Those regulated activities that have the potential to impact coral reef ecosystems, which may require consultation between the permitting authority and resource trustees and approval from a permitting authority prior to implementation.

Temporary Impacts: Impacts that are short-term, where the resource is expected to recover to a certain level of function through natural processes (e.g., sediment accumulation on coral reef areas adjacent to channel dredging that would likely be removed by natural wave flushing).

Unplanned Impacts: Those activities that are not planned, anticipated, scheduled, or otherwise expected, and have impacts on coral reef ecosystems (e.g., vessel groundings, anchor and cable drags, or impacts unassociated with a planned project).

In-kind: A resource of a similar structural or functional type to the impacted resource (33 CFR 332.2 and 40 CFR 230).

Injury: An observable or measurable adverse change in a natural resource, or impairment of a natural resource service. Injury may occur directly or indirectly to a natural resource and/or service. Natural resource trustees are authorized by OPA to assess damages for "injury to, destruction of, loss of, or loss of use of" natural resources. The definition of injury incorporates these terms. The definition also includes the injuries resulting from the actual discharge of oil, a substantial threat of a discharge of oil, and/or related response actions. Injury can include adverse changes in the chemical or physical quality, or viability of a natural resource (i.e., direct, indirect, delayed, or sub-lethal effects). Potential categories of injuries include adverse changes in: survival, growth, and reproduction; health, physiology, and biological condition; behavior; community composition; ecological processes and functions; physical and chemical habitat quality or structure; and services to the public. Although injury is often thought of in terms of adverse changes in biota, the definition of injury under the OPA regulations is broader. Injuries to non-living natural resources (e.g., oiled sand on a recreational beach), as well as injuries to natural resource services (e.g., lost use associated with a fishery closure to prevent harvest of tainted fish, even though the fish themselves may not be injured) may be considered. (15 CFR 990.30)

Mitigation (Sequential Mitigation): For the purposes of this Handbook this definition includes the sequential process involving first **maximum avoidance**, second **minimization** of unavoidable impacts, and then only after completion of minimization proceeding to **compensatory mitigation** for any unavoidable impacts as the third step. Determination of the requirement for compensatory mitigation is at the discretion of the permitting authority in accordance with applicable regulatory requirements. Compensatory mitigation may not be required if the remaining unavoidable impacts are not significant enough to warrant compensatory mitigation under the applicable permitting authority's regulations and policies.

Objectives: The description of the resource type(s) and amount(s) that will be restored as part of a mitigation plan or restoration project. Objectives identify whether an activity will re-establish, re-habilitate, establish (create), and/or preserve habitat. The objectives may also identify specific functions or services to be provided by the restoration of coral reef ecosystems and/or associated habitats (adapted from 33 CFR 332.4 and 40 CFR 230).

Ocean Acidification: Ocean acidification refers to a reduction in the pH of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon dioxide from the atmosphere, but can also be caused by other chemical additions or subtractions from the ocean (IPCC, 2014, Annex II Glossary).

Off-site: A location that is not within the area of project activities, neither located on the same parcel of land or reef habitat area as the impact site, nor a parcel of land or reef habitat area contiguous to the parcel containing the impact site (adapted from 33 CFR 332.2 and 40 CFR 230).

On-site: A location that is within the area of project activities.

Options: A variety of actions or methods that may be considered by a project proponent to restore coral reef ecosystems and/or associated habitats.

Out-of-kind: A resource of a different structural and/or functional type from that of the impacted resource (33 CFR 332.2 and 40 CFR 230).

Outplanting: Taking a coral grown in a coral nursery, placing, and often attaching it onto the coral reef or an artificial structure.

Performance Standards: Observable or measurable physical (including hydrological), chemical, and/or biological attributes that are used to determine if a restoration or compensatory mitigation project meets its objectives (33 CFR 332.2, 40 CFR 230 or Engineering Regulation (ER) 1105-2- 100, 3-5.b(8)). This is synonymous with "performance criteria."

Permitting Authority: The federal, state, or territorial agency issuing the permit or license that authorizes an activity. There may be multiple permitting authorities with varying requirements for a single activity.

Preservation: The removal of a threat to, or preventing further decline of, aquatic resources by an action in or near those aquatic resources; includes activities commonly associated with the protection and maintenance of aquatic resources through the implementation of appropriate legal and physical mechanisms; does not result in a gain of aquatic resource area or functions (adapted from 33 CFR 332.2 and 40 CFR 230).

Project Proponent: The entity proposing the impact or restoration activity, including but not limited to: applicant, permittee, or responsible party.

> **Applicant:** An individual or entity who proposes actions that could result in a planned adverse impact to coral reef resources who applies for authorization to conduct such activities from a permitting authority.
>
> **Permittee:** An individual or entity whose actions, once authorized by a permitting authority, result in a planned adverse impact to coral reef resources.

Responsible Party: The individual, entity, or instrumentality whose actions result in an unplanned adverse impact to coral reef resources. The entity could be a federal, state, territorial, or tribal government or agency. When a vessel causes a coral injury, the responsible party may be broadly defined as the owner, operator, or manager of a vessel that caused an unplanned adverse impact or in some cases the instrumentality or vessel itself will be a responsible party. In some laws and regulations, responsible party is also used to define entities responsible for aspects of planned activities. For the purpose of this handbook, responsible party is only used to refer to unplanned activities.

Recovery Plan: A document drafted by the FWS or National Marine Fisheries Service (NMFS) for threatened or endangered species that identifies: (1) objective, measurable criteria which, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions necessary to achieve recovery of the species; and (3) estimates of the time and costs required to achieve the plan's goal (adapted from the Endangered Species Act (ESA) §4(f)).

Re-establishment: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former aquatic resource; results in rebuilding a former aquatic resource, and a gain in aquatic resource area and function (adapted from 33 CFR 332.2 and 40 CFR 230).

Rehabilitation: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded aquatic resource; results in a gain in aquatic resource functions, but not a gain in aquatic resource area (adapted from 33 CFR 332.2 and 40 CFR 230).

Resource: Functional groups, including physical, chemical, and biological structure, a habitat type, or ecosystem of concern. The resource may refer to coral reef ecosystems, other habitats, or ecosystems that are being restored to improve the functions of coral reef ecosystems.

Restoration: Manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning self-sustaining natural or historic structure and functions (Needelman, et al. 2012).

> **Primary Restoration (Active):** Physical relief restoration that, when combined with biological restoration, returns injured natural resources and services toward baseline sooner than natural recovery. The determination that primary restoration has been completed is dependent upon meeting specific procedural requirements and performance standards as defined by the appropriate regulatory authorities.
>
> **Compensatory Restoration:** Any action taken to compensate for losses of natural resources and services that occur from the date of the unplanned incident until recovery (adapted from 15 CFR 990.30).

Site Stabilization: Any action that will minimize potential for further injuries in an impacted area due to destabilized substrate (e.g. rubble/debris removal, fracture stabilization).

Transect: A standardized unit used to sample an impact area. A transect can be at a permanent or randomly selected location once the boundaries of a survey area have been defined. A transect always consists of a standard length with a defined width. These measurements may change depending on the circumstances and the resource being surveyed. These transects are commonly designated by using a surveyors tape to lay a straight line on the bottom, then a surveyor can record data points within the area of the transect. Different sampling methods can then be applied depending on the resources being surveyed. Transects may be used for multiple purposes, such as defining ecological distributions; distribution of sediments over hardbottom habitat; the ratio of rocky substrate versus loose (unconsolidated) sediment substrate; mitigation rock or modules versus loose sediments where rock or modules are deployed; evaluating distribution of coral reef injuries; and distribution of natural and artificial subjects on bottom and land.

1.3 Legal and Policy Summary

There are numerous laws and regulations that govern activities in and around coral reef ecosystems. In many instances multiple federal and state or territorial laws or regulations may apply to different aspects of the same activity. Project proponents may be most familiar with the RHA §10, CWA, ESA, EFH consultation under MSA §305(b), and FWCA, which include requirements for planned activities, and with the Natural Resource Damages Assessment and Restoration (NRDAR) requirements for unplanned impacts to coral reefs. Appendix I provides a more comprehensive list of laws and regulations that apply to activities and impacts within coral reef ecosystems. However, this list should not be considered an exhaustive list of every relevant federal, state, or territorial authority.

1.4 Roles and Responsibilities

Across federal, state, and territorial agencies there are numerous legal authorities governing the planning, response, and damage assessment relative to coral reef impacts. Table 1 summarizes the main roles and responsibilities for various federal, state, and territorial agencies relative to coral reef impacts including avoidance, minimization, response to unplanned events, damage assessments, restoration, and compensation for loss of coral reef functions and services. A more detailed list is provided in Appendix I. This list should not be considered an exhaustive list of all federal, state, or territorial legal authorities, roles, and responsibilities. There may be additional local (e.g., city or county) requirements that apply to a particular project; those are not discussed here and would need to be explored with the appropriate local agency. Information on specific agency mandates, whether they play a lead or a participatory or consulting role, is included where available.

Project proponents and Responsible Parties (RPs) for planned and unplanned activities that may impact the marine environment, respectively, must comply with the applicable laws and regulations that apply to their project. Examples of planned and unplanned activities include, but are not limited to, anchor blocks, shoreline hardening, mooring or marker buoys, dumping, abandoned vessels, pier construction, dredging, land-based activities resulting in sediment or contaminant loads to coastal habitats, coastal road construction, wastewater treatment plant development and discharge, vessel groundings, or cable drags. The planned project or unplanned event scope, location, funding source(s), sponsor, agency with management and trust resources, and extent of impacts will dictate which authorities apply and which agencies must be consulted. As a general practice, project proponents and RPs should begin contacting the primary permitting authority or agency that has ownership or management authority over the coral reef resources that will be, or have been, impacted. Once initial contact has been made, early consultation and coordination with the other appropriate permitting, resource, and trustee agencies is strongly encouraged to determine the requirements for a particular project. Depending on the requirements within the authorities, some agencies may not be required to comment or respond to the inquiry.

Project proponents and RPs are reminded that a permit or approval from one agency does not negate other permit requirements. An activity may require permits from federal agencies as well as state and territorial agencies.

Table 1: Summary of trustee agency roles and responsibilities in the event of coral reef impacts.

Agency	Planned	Unplanned
Federal		
EPA	**Legal Authorities:** • CWA §404: Review and comment on dredge and fill material placement permits issued by USACE. Potential denial or restriction of use of defined areas for disposal. • CWA §301, §303 and §402: Addresses water quality standards and uses,	**Activities:** • Reporting of oil and hazardous substance spills under OPA. • Emergency response planning as member of Oceanic Regional Response Team (inland federal coordinator).

Agency	Planned	Unplanned
EPA (cont.)	measures to address impaired water quality, and permitting of discharge of pollutants. • CWA §309: Enforcement of the prohibition against unpermitted discharge, and permit violations under §402 and §404. • Marine Protection Research and Sanctuaries Act of 1972 (MPRSA): Designation of Ocean Dredged Material Disposal Sites, review of alternative site selections, and concurrence on permits issued by USACE. **Participatory Authorities:** • National Environmental Policy Act (NEPA) and Clean Air Act §309: Conducts NEPA analyses when applicable. Reviews other federal agencies' Environmental Impact Statements.	
FWS	**Legal Authorities:** • Antiquities Act. • ESA §7, §4(d), and §10. (Sea turtles on land)[2]. • FWCA. • Marine Mammal Protection Act (MMPA). • Migratory Bird Treaty Act (MBTA). • Sikes Act. • Lacey Act. • Conservation in Trade of Endangered Species (CITES). • National Invasive Species Act (NISA). **Participatory Authorities:** • NEPA. • CWA §404. • Federal Consistency for the Coastal Zone Management Act	**Legal Authorities:** • Antiquities Act. • NRDAR (OPA). • ESA §7 (Interagency Consultation). • MMPA. • MBTA. • Sikes Act. • CITES. • NISA. • Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). **Activities:** • Oil spill scientific and emergency response. • Vessel grounding response, assessment and restoration.

[2]ESA consultations related to sea turtle activity and habitat on land often involve analysis of impacts to the coastal habitats that may also have direct or indirect impacts on the adjacent coral reefs.

Agency	Planned	Unplanned
FWS (cont.)	(CZMA). • Compact of Free Association Agreement between the United States of America and the Republic of the Marshal Islands (RMI), Compact of Free Association Agreement between the United States of America and Federated States of Micronesia (FSM), and Compact of Free Association Agreement between the United States of America and Republic of Palau (Palau). (Commonly referred to as the Compact of Free Association for RMI, FSM, and Palau).	• Compact of Free Association for RMI, FSM, and Palau.
Department of Navy (Navy)	**Activities:** • Land manager for coastal and waterways associated with naval facilities.	**Activities:** • U.S. Navy Supervisor of Salvage (SUPSALV), Fleet Task Forces, or Military Sealift Command act as On-Scene Commander for incident response. • SUPSALV integrates environmental planning and coral subject matter experts into incident response teams as soon as possible after the incident to ensure response plans consider environmental and natural resource concerns in parallel with the contingency response to adaptively manage and mitigate damage in real time.
National Oceanic and Atmospheric Administration (NOAA)	**Legal Authorities:** • Antiquities Act. • EFH (MSA §305(b)). This is separate and apart from the CWA. • ESA §7 Consultation and ESA §4(d), §6 (potential funding source to states and territories for coral recovery), and §10. • FWCA. • MMPA. • CZMA. • NMSA.	**Legal Authorities:** • Antiquities Act. • NRDAR Procedures (OPA). • CERCLA. • EFH Protection (MSA §305(b)). • ESA §7 (Interagency Consultation). • Natural Resource Trustee Representation (National Contingency Plan and OPA). • MMPA. • NMSA.

BACKGROUND

Agency	Planned	Unplanned
NOAA (cont.)	**Participatory mandates:** • NEPA. • CWA §404. • Sikes Act. • Compact of Free Association for RMI, FSM, and Palau. **Activities:** • NMFS provides technical assistance to states that issue National Pollutant Discharge Elimination System (NPDES) permits for large power plants and manufacturing facilities that withdraw at least 2 million gallons of cooling water.	• Compact of Free Association for RMI, FSM and Palau. **Activities:** • Oil spill scientific support and emergency response. • Vessel grounding response, assessment and restoration.
National Park Service (NPS)	**Legal Authorities:** • Antiquities Act. • 54 U.S. Code (USC) Chapters 1001-1007(Formerly Known as the NPS Organic Act) cover general provisions, establishment of the NPS, areas of the system, and resource management. • National Park Unit enabling legislation. • NEPA within NPS units. • Permitting agency for any activity within an NPS unit. • 36 Code of Federal Regulations (CFR). • Superintendent Compendiums. **Activities:** • Land manager of coral reef ecosystems, coastal and nearshore resources.	**Legal Authorities:** • SURPA (54 USC 100721). • OPA. • CERCLA. • Enforcement Authority within NPS Units. • Antiquities Act. • CWA. • ESA. • Lacey Act. • 36 CFR (including damage to natural features). • Superintendents Compendiums. **Activities:** • Oil spill emergency response. • Vessel grounding emergency response, damage assessment, and restoration. • Unplanned event emergency response, damage assessment, and restoration. • Permitting agency for any activity within a NPS unit.
USACE USACE (cont.)	**Legal Authorities:** • CWA, §404. • RHA, §9 and §10. Enforcement authority for unauthorized activities. • MPRSA, §103. • In general, various Water	**Legal Authorities (triggered by some unplanned events):** • CWA, §404. • RHA, §10. • MPRSA, §103. • RHA, §14 and codified in 33 USC 408 (§408).

Agency	Planned	Unplanned
	Resource Development Acts (WRDA) authorize USACE to implement certain water resource management projects in partnership with non-federal cost-sharing sponsors, such as harbor improvements and aquatic ecosystem restoration. • RHA, §14 (33 USC 408) (*Taking possession of, use of, or injury to harbor or river improvements).* • NEPA – documentation for decisions on permit applications and federal water resources projects.	**Activities:** • USACE engagement varies based on the type, size, and impact of an unplanned event. Many unplanned events may be addressed within the Nationwide Permits, requiring limited USACE notification. However, planned but unauthorized activities (e.g., construction of unauthorized boat ramps, dredging beyond the Department of the Army (DA) permit authorized limits, installation of unauthorized piers or mooring buoys, etc.) would be addressed via enforcement and compliance requirements in applicable legal mandates. • USACE can issue after-the-fact permits to authorize such activities, or take other steps to resolve unauthorized activities.
US Coast Guard (USCG)	**Legal Authorities:** • OPA: administration of OPA planning and responses, investigations of collisions or allusions, and maintenance of aids to navigation may be suitable content. • ESA: Enforcement Authority. • MSA: Enforcement Authority.	**Legal Authorities:** • OPA: Administration of OPA planning and responses, investigations of collisions or allusions, and maintenance of aids to navigation may be suitable content. • ESA: Enforcement Authority. • MSA. Enforcement Authority.
States and Territorial Governments		
Commonwealth of the Northern Mariana Islands (CNMI) CNMI (cont.)	**Legal Authorities:** • Coastal Resource Management Rules and Regulations. • Non-Commercial Fish and Wildlife Regulations. • Submerged Lands Act. • Commonwealth Environmental Protection Act. • Fish, Game and Endangered Species Act. • Moratorium on Seaweed, Sea Grasses, and Sea Cucumber. • Fair Fishing Act.	**Legal Authorities:** • Coastal Resource Management Rules and Regulations. • Non-Commercial Fish and Wildlife Regulations. • Commonwealth Environmental Protection Act. **Activities:** • Under Coastal Resource Management regulations, issues and enforces permits in the CNMI coastal zone. Assesses damage to reefs and issues penalties for

Agency	Planned	Unplanned
	• Protecting of Rays and Sharks. • Shark Finning Prohibition.	unplanned coral impact. • Under non-Commercial Fish and Wildlife regulations, assess damage to fish and wildlife. • Under the Commonwealth Environmental Protection Act, assess damage to water quality and reef.
State of Florida (FL)	**Legal Authorities**: Florida Department of Environmental Protection (FDEP) • Florida State Constitutional authority over all natural resources in FL, including submerged lands - Chapters 253 and 258, Florida Statue (F.S.). • Florida Coastal Management Program - Chapter 380, F.S., Part II, Coastal Planning and Management. • Environmental Resource Permit (ERP) Program - Chapter 373, Part IV, F.S. • Joint Coastal Permit (JCP) Program - Sections 161.021, 161.041 and 161.055, F.S., Rule 62B-41, Florida Administrative Code (F.A.C.).	**Legal Authorities**: Florida Fish and Wildlife Conservation Commission • Constitutional authority over marine life, wild animal life and freshwater aquatic life (Article IV, §9). • Assigned the powers, duties, responsibilities, and functions to develop restoration and management techniques for habitat and enhancement of plant and animal populations; and respond to and provide critical technical support for catastrophes including oil spills, ship groundings, major species die-offs, hazardous spills, and natural disasters (20.331, F.S.).
Guam	**Legal Authorities:** • EO 78-37. Coastal Zone Resource Policies. • EO 2013-05: Coral Reef Resource Policies. • Fish and Wildlife Regulations. • Guam Endangered Species Act (territorial law). • Submerged Lands Act; and Guam Exclusive Economic Zone. • Organic Act of Guam. • Guam Environmental Policy Act. • Guam Water Pollution Control Act. • Guam Territorial Seashore Protection Act.	
State of Hawaii (HI) HI (cont.)	**Legal Authorities:** • Constitutional authority over all natural resources in HI, including submerged lands. • State of Hawaii Endangered Species Act (state law). • Hawaii Environmental Impact Statements (Hawaii Revised Statutes (HRS) T19, Ch.343). Department of Health (DOH)	**Legal Authorities:** • Constitutional authority over all natural resources in HI, including submerged lands. • State of Hawaii Endangered Species Act (state law). • Environmental Response Law (HRS, T10, Ch. 128D) **Activities:**

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Agency	Planned	Unplanned
	• CWA §401 Water Quality Certification. **Activities:** Department of Land and Natural Resources (DLNR) • DLNR Umbrella Aquatic Mitigation Bank.	DOH: • Potential enforcement related to pollution discharges.
Commonwealth of Puerto Rico (Puerto Rico)	**Legal Authorities:** • Organic Law of the Planning Board of Puerto Rico. • Public Environmental Policy Law of the Environmental Quality Board. • Organic Law of the Administration of Regulations and Permits. • Puerto Rico Permits Process Reform Act	
U.S. Virgin Islands (USVI)	**Legal Authorities:** • Establishment of Wildlife and Marine Sanctuaries. • Protection of Indigenous, Endangered and Threatened Fish, Wildlife and Plants. • Water Pollution Control. • Commercial Fishing. • Environmental Protection. • Virgin Islands Coastal Zone Management Act.	

1.5 Coral Reef Ecosystems

Across regulatory and management agencies and associated mandates, there is no consistent definition of coral reefs (Table 2). These inconsistencies can lead, and have led, to challenges and reduced effectiveness when implementing strategies aimed at reducing and mitigating impacts to coral reefs. The definitions are provided to assist the reader work through this Handbook, not to redefine what is already written into statute and regulations. Readers should always confirm definitions with the appropriate permitting and management agencies.

As noted in Section 1.2, for the purposes of this Handbook, the following definitions are used. These definitions were chosen as they were inclusive of various regulatory definitions.

Coral: Species of the phylum Cnidaria, including all species of the orders Antipatharia (black corals), Scleractinia (stony corals), Gorgonacea (horny corals), Stolonifera (organpipe corals and others), Alcyonacea (soft corals), and Helioporacea (blue coral) of the class Anthozoa; and all species of the families Milleporidea (fire corals) and Stylastreridae (stylasterid hydrocorals) of the class Hydrozoa.

Coral Reef: Limestone structures composed in whole, or in part, of living coral, skeletal remains, and including other corals, sessile marine animals, and plants.

Coral Reef Ecosystems: The system of coral reefs and geographically and ecologically-associated species, habitats, and environment, and the processes that control its dynamics.

Table 2: A summary of definitions for the terms "coral reef" and "coral reef ecosystem" across regulatory and management agency mandates.

Law, Statute, Regulation, or Agency	Definition of Coral Reef	Definition of Coral Ecosystem
Coral Reef Conservation Act (CRCA) of 2000 *16 U.S.C. §§6401-6409*	Any reefs or shoals composed primarily of corals.	Coral and other species of reef organisms (including reef plants) associated with coral reefs, and the nonliving environment factors that directly affect coral reefs, that together function as an ecological unit in nature.
EO 13089 *63 Federal Register (FR) 32701 (June 11, 1998).*		U.S. coral reef ecosystems means those species, habitats, and other natural resources associated with coral reefs in all maritime areas and zones subject to the jurisdiction or control of the U.S. (e.g., federal, state, territorial, or commonwealth waters); including reef systems in the south Atlantic, Caribbean, Gulf of Mexico, and Pacific Ocean.
CWA §404(b)(1) Guidelines *40 CFR 230*	Coral reefs consist of the skeletal deposit, usually of calcareous or siliceous materials, produced by the vital activities of anthozoan polyps or other invertebrate organisms present in growing portions of the reef.	
South Atlantic Fishery Management Council's Fishery Management Plan (FMP) for Coral, Coral Reefs and Live/Hardbottom Habitat of the South Atlantic Region (Coral FMP).	Hardbottoms, nearshore hardbottoms, deepwater hardbottoms (including deepwater banks), patch reefs, and outer bank reefs.	
Caribbean Fishery Management Council's FMP for Corals and Reef-associated Plants and Invertebrates	Biologically constructed reef framework with or without active coral growth.	The interdependence of species in a community with one another and with their non-living environment.

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Law, Statute, Regulation, or Agency	Definition of Coral Reef	Definition of Coral Ecosystem
Florida Coral Reef Protection Act *F.S. 403.93345*	1) Limestone structures composed wholly or partially of living corals, their skeletal remains or both, and hosting other coral, associated benthic invertebrates, and plants, or 2) Hardbottom communities, also known as live bottom habitat or colonized pavement, characterized by the presence of coral and associated reef organisms or worm reefs created by the *Phragmatopoma* species.	

Coral reefs are among the most biologically diverse ecosystems on Earth, despite the fact that they comprise less than one percent of the planet's area. Healthy coral reefs are important not only for their biodiversity, but for the essential ecosystem services they provide such as coastal protection, supporting fisheries, jobs, recreation, tourism, educational, social and cultural opportunities, and medicinal products. These ecosystem services are important socio-economically to the financial welfare in the states and territories where coral reefs occur, and support the national economy, as well. For example, the northern 100 miles of the Florida Reef Tract provides for more than 60,000 jobs and more than six billion dollars to the state economy each year (Johns, et al., 2001). However, coral reefs are declining in the United States, and around the world, due to an increasing array of both natural and anthropogenic impacts. Threats from global issues such as climate change and ocean acidification, natural events such as hurricanes and diseases, and localized human-induced effects such as unsustainable fishing practices, recreational impacts, sedimentation, and pollution individually and cumulatively affect coral reef health and functions.

Coral reef ecosystems under the jurisdiction of U.S. federal, state, and territorial government agencies occur in both the Atlantic/Caribbean and Pacific Ocean basins (Figure 1). Within the Atlantic/Caribbean/Gulf of Mexico region there are natural coral reefs located in and around the USVI, Puerto Rico, Navassa Island, southeast Florida (including the Florida Keys), and the northwestern Gulf of Mexico. Coral reefs in the Pacific region occur in American Samoa, the Hawaii archipelago, the Pacific Remote Islands (Palmyra Atoll, Baker Island, Jarvis Island, Johnston Atoll, Kingman Reef, Wake Atoll, and Howland Island), Midway Island, and the Mariana Islands archipelago (CNMI, Guam, and the Pacific Freely Associated States (RMI, FSM, and Palau)).

Approximately 70 species of scleractinian corals inhabit the reefs in the Atlantic/Caribbean/Gulf of Mexico region (Spalding, et al., 2001). The coral reefs in the region include fringing, patch, spur and groove, and wall formations and can be found near shore, mid-shelf, and at shelf edges. Atlantic/Caribbean/Gulf of Mexico reefs contain fewer species of scleractinian coral compared to their Pacific counterparts. In recent years, the region's reefs have significantly declined due to coral bleaching events, disease outbreaks, loss of herbivore populations, loss of framework building species, and introduction of invasive species. Compounding these losses, due to their proximity to heavily populated coasts, many of the region's reefs are directly threatened by human activities such as coastal and upland development, vessel impacts, and unsustainable fishing. In NOAA's 2008 State of the Reefs Report, the majority of key reef resources in the Atlantic/Caribbean/Gulf of Mexico region were reported to be in poor or fair condition, with the exception of Flower Garden Banks, located over 100 miles offshore of Texas, which was reported to have key resources in good or excellent condition (Waddell, 2008).

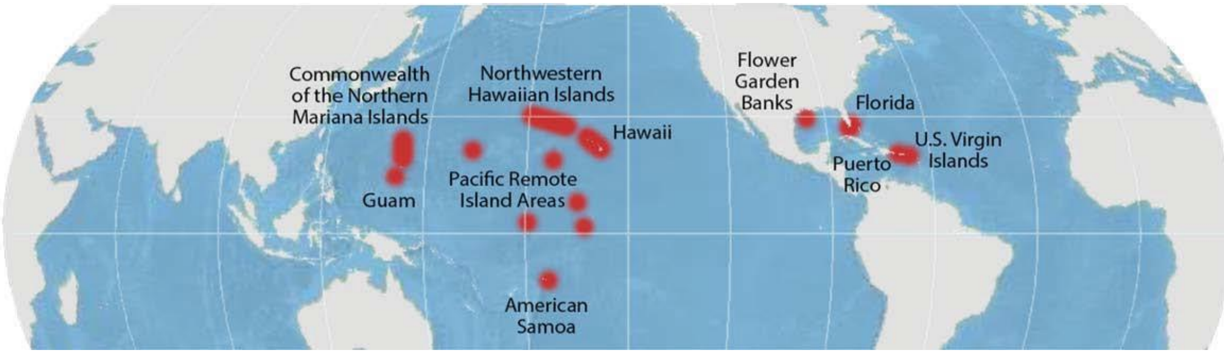

Figure 1: Map of tropical coral reef ecosystems within the United States. This map provides the general geographic distribution of U.S. coral reef habitat. For project-specific information, more detailed habitat maps should be consulted and in-water assessments may be required. Image courtesy of NOAA.

Pacific coral reefs have similar formations and can form variable geomorphic types, including fringing and barrier reefs, atolls, and numerous smaller forms like pinnacles, knolls, patch reefs, as well as coral reef shoals or banks. While many reefs can be found close to heavily populated islands, others are remote and far removed from many human and land-based impacts. Pacific reefs are very diverse, with some regions containing more than 60% of known tropical coral species (Veron, 2000). Pacific reefs are affected by many of the same stressors impacting Atlantic/Caribbean reefs. However, U.S. Pacific reefs are in much better condition overall than their Atlantic/Caribbean/Gulf of Mexico counterparts. U.S. Pacific reefs are rated good or excellent in NOAA's 2008 report, with the exception of harvested reef fish species and macroinvertebrates, which are reported to be in poor condition in the main Hawaiian Islands and fair condition throughout the rest of the Pacific.

1.6 Challenges to, and Opportunities for, Effective Coral Reef Impact Avoidance, Minimization, Compensatory Mitigation, and Restoration

Coral reefs are subject to numerous local, regional, and global stressors. Managers and regulators working to address impacts to coral reefs are further constrained by the difficulty in restoring and replacing these complex systems. Natural reefs are biologically, chemically, physically, and morphologically complex; take many years to develop; and are difficult to restore. Many coral species are particularly slow-growing (one-tenth of an inch per year) and long-lived (decades to centuries), resulting in a long response and replacement time.

While existing guidance and tools have been developed for stream and wetland mitigation and restoration, it is necessary to develop guidance and tools specific to coral reef systems. The development, structure, and function of coral reefs are quite different from the development, structure, and functions of streams and wetlands. Therefore, the guidance and tools needed for coral reef mitigation will be substantially different. Some basic principles for stream and wetland mitigation might be useful for coral reef mitigation, but ecologically successfully coral reef mitigation requires that those basic principles be translated for coral reefs. Mitigation and restoration technology for freshwater and terrestrial systems has a longer track record and has been refined through substantial trial and error experience. When working in the marine environment, other factors such as determining boundaries of site ownership, site protection, the remote and hazardous nature of working underwater, and long-term maintenance of sites present challenging hurdles and are presently managed on a case-by-case basis. It is important to note that the initial focus should always be on avoidance and minimization. It is possible that through such measures compensatory mitigation may not be needed. If unavoidable loss of coral reef resources is going to occur, compensatory mitigation is likely needed. In marine systems, environmental and anthropogenic variables are more difficult to control compared to terrestrial systems. These factors tend to increase the cost and uncertainty of activities intended as compensatory mitigation or restoration of lost coral reef area and associated services and functions relative to similar efforts in terrestrial ecosystems, reinforcing the need to avoid impacts as much as practicable.

Historically, compensatory mitigation for coral reef losses has been poorly designed and documented, and inadequately monitored so that demonstration of success is significantly lacking (Bentivoglio, 2003 and Yoshioka, et al., 2004). While a variety of mitigation options have been implemented, many have only been implemented a few times. Therefore, there is not a complete understanding of what types of coral reef compensatory mitigation and restoration can be successful and what thresholds are necessary for coral reef recovery. Work continues to be done to address these gaps.

In the Pacific, a few of the compensatory mitigation efforts have included education, establishment of marine protected areas (MPAs), watershed recovery actions to improve a degraded coral reef, coral transplantation, coral relocation, and installation of mooring buoys. Based on recent scientific findings associated with coral recovery, some of these strategies for compensatory mitigation may not be as effective as originally assumed (Bentivoglio, 2003 and Yoshioka, et al., 2004). Chapter 4 identifies some of the challenges and considerations for various mitigation options. In the Atlantic and to a lesser degree in the Caribbean, boulder-based artificial reef construction was historically a common mitigation activity. However, boulder-based artificial reef construction is becoming less common given the challenges of artificial reefs fully replacing all the functions and services (i.e., equitable compensation) of a natural coral reef (Gilliam, 2012 and Thanner et al., 2006). Most of the efforts taken to date to compensate for coral reef impacts have focused on indirect impacts, and seek to improve the long-term health of coral reef resources. For example, placement and maintenance of aids to navigation can directly and indirectly improve the quality of coral reef habitats and prevent future loss of habitat by preventing ship groundings, but will not address the replacement of functions and services lost in a coral reef area.

More recently activities in an adjacent watershed of a nearby land mass or island (e.g., reforestation, storm water controls, wetland enhancement) have been considered as attractive components of compensatory mitigation. While these efforts usually target replacement of lost resources, it still represents a net loss in coral reef area. Greater effort is also needed in developing and defining ecological assessment tools and sensitive indicators to ensure measurable performance standards that can evaluate the outcome or success of a particular mitigation or restoration action.

Further complicating the implementation of successful compensatory mitigation are the ongoing effects that climate change and ocean acidification have on coastal and coral reef ecosystems and, by extension, on the ability to successfully manage implemented compensatory mitigation activities. While direct global changes such as increased temperature and acidification cannot be controlled by the project proponent or coral reef manager implementing the compensatory mitigation action, there is growing scientific understanding of the mechanisms by which these drivers interact with and exacerbate other stressors that project proponents or coral reef managers may be able to control. As a result, there is a rapidly expanding body of theory and tools to help with designing coral reef mitigation or restoration activities to be as effective as possible within the context of these changes. Stein et al., 2014 provides a comprehensive review of this information for all natural resources, and a tailored version of the approach for coral reef management is under development (West et al., 2016). Therefore, while the Handbook aims to focus on the current status of mitigation planning and response, more information is likely to be available in the future to help project proponents and coral reef managers make adjustments to maximize management success in light of the shifting environmental context of climate change and ocean acidification.

The sections that follow lay out general structured frameworks for addressing planned and unplanned impacts to coral reef ecosystems. These frameworks are not inclusive of all agencies, regulations, policies, and guidance so project proponents and RPs should always consult with the appropriate agencies and only use this information as a reference. There are certain elements of each process that can be consistent regardless of the type of impact that might occur. However, due to the unique circumstances of each project or activity, and the large variations among affected habitats, there will need to be individual consideration on a project-by-project basis. While it is possible to develop comprehensive coral reef restoration strategies, these strategies require substantial specialized planning, conservative assignment of benefits, long recovery horizons that account for climate change, robust adaptive management, well-defined financial assurances, and well-established partnerships. Implementing such strategies is usually very costly, and again emphasizes the strong need to focus on avoidance as the recommended course of action wherever possible.

It is also critical to highlight that discussion and approaches tend to center around coral. However, the effort is clearly focused on coral reef ecosystems. In coral-dominated systems, it is assumed that if corals can be recovered, or successfully show a trajectory toward recovery, over the long term the coral reef ecosystem will recover and subsequently all the functions and services provided by the coral reef ecosystem will successfully be restored. Additionally, there are numerous examples of other resources that when dominant will drive the mitigation process, such as mangrove systems, seagrass beds, algae beds, or unique assemblages of fish or crustaceans. Although not addressed in this Handbook, a note should be made that planned or unplanned events that may impact coral reefs may also impact other non-natural resources including infrastructure (e.g., piers, aids to navigation, and signage) or historic resources such as shipwrecks. These types of resource impacts should be handled on a case-by-case basis with the appropriate agencies.

2.0 EVALUATION FRAMEWORK FOR PLANNED IMPACTS TO CORAL REEF ECOSYSTEMS

Planned activities in tropical marine waters such as harbor improvements (e.g., deepening, pier and breakwater construction or repairs), shoreline hardening, outfall construction, construction of offshore energy and aquaculture facilities, or delineation of anchorage areas often impact corals. This chapter is intended to provide a general framework to guide project proponents and agency staff through the steps for planning, permitting, and implementing planned activities.

For planned activities that are likely to impact coral reefs (e.g., dredge and/or fill, shoreline development, in-water construction, and capital improvement maintenance projects), multiple federal, state, and territorial permits may be required. There are certain elements of the process for assessing the impacts to coral reefs associated with a planned activity that are consistent, regardless of the type of impact that might occur. However, due to the unique circumstances of each project or activity, the large variations among affected habitats, and the variations in requirements for different permitting authorities, permitting authorities will consider each project individually to determine the appropriate process and requirements. Depending on the impacts associated with a planned activity, the generalized process described in Figure 2 may apply, as is, or may include additional steps or multiple iterations. The size and type of the impact will likely affect the complexity of the response process.

It is always recommended that the relevant permitting authorities and land management agencies be consulted as early as possible in the planning process to avoid unnecessary costs and time delays. At a minimum, a project proponent should consult with the USACE about permit requirements. Pre-application meetings with USACE and appropriate agencies—such as EPA, NMFS, FWS, and state and territorial marine resource regulatory and management agencies, discussed further in Section 2.1.1—provide a useful venue to consult early with the applicable federal, state, and local agencies.

The following generalized planning steps may be needed for work with the potential to impact coral reefs, depending on the scope of the project.

- Map and characterize coral reef resources within the impact area.
- Quantify direct and indirect impacts of the project as proposed (including permanent and temporary effects).
- Analyze alternative project sites and designs as early as possible in the process.
- Define post-project actions such as monitoring and adaptive management.

If there will be unavoidable loss of coral reef resources, then the next steps may be needed.

- When required, develop a mitigation plan including identification of mitigation sites and determination of the amount of compensatory mitigation required (e.g., functional or conditional assessment).
- Assess resources at compensatory mitigation site(s) and estimate recovery potential.
- Develop a comprehensive biological and water quality (e.g., turbidity) monitoring plan where data collection occurs before, during and after project construction/implementation. The purpose of this monitoring is to assess the actual extent of impacts and to detect and correct problems as they develop.
- Implement the compensatory mitigation plan including any associated construction

management, site protection, financial assurances, performance standards, monitoring and long-term management activities required by the permitting authority.
- Review plans for post project actions, such as monitoring to assess progress toward performance standards.
- Implement potential adaptive management measures or additional mitigation if the performance standards are not met.

This generalized process is depicted in Figure 2. These steps for planned impacts will be considered and described sequentially in more detail throughout Chapter 2.

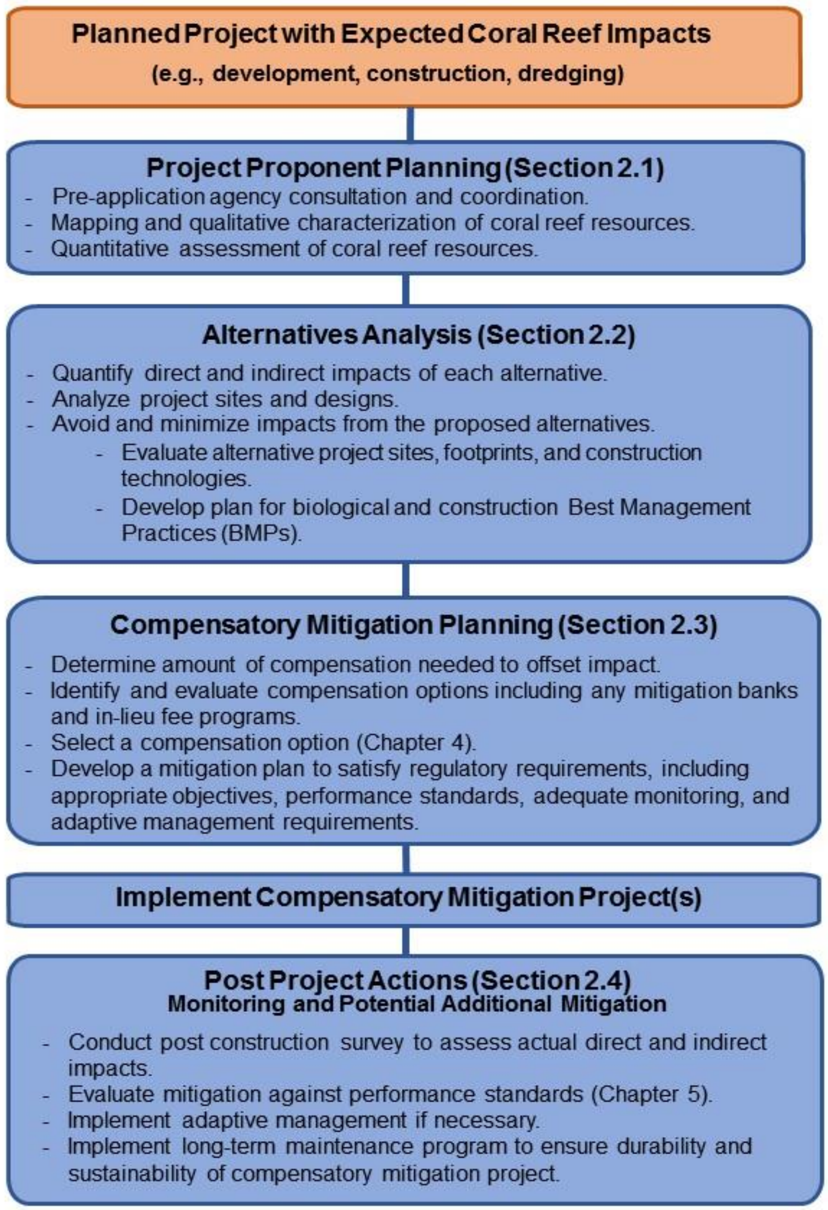

Figure 2: A generalized process for addressing planned impacts to coral reefs.

The generalized process may be modified based on the requirements of various permitting authorities, or on a project-by-project basis depending on the degree to which coral reef resources may be impacted by a planned activity. For planned activities, the alternatives analysis involves early consideration of how to avoid and minimize adverse impacts to coral reefs, and what might be required for compensatory mitigation if there are unavoidable losses to coral reefs. The project proponent should consult with the permitting authorities and other key agencies regarding alternative technologies for project construction, such as alternative dredging technologies to maximize impact avoidance. In addition, the project proponent will also have to consider cumulative impacts of the planned activity in relation to other past, present, or reasonable foreseeable activities in the vicinity.

2.1 Project Proponent Planning

All in-water coastal construction will likely need a suite of federal, state, and local permits (such as a DA permit or a State CWA §401 Water Quality). Federal actions, including federal permit decisions, must comply with NEPA and other applicable federal laws (e.g., EFH consultation under MSA §305(b), ESA, and FWCA). States and territories often have equivalent state or local procedures for many of their permitting decisions. Project proponents should identify those required permits and meet with the permitting authorities early in the planning process. Each of these permits and authorizations have specific information needs that are best identified and coordinated with relevant agencies early. For example, if there are coral species that are listed under ESA, or designated critical habitat, compensatory mitigation plans for various permitting authorities, such as a DA permit, are typically incorporated as part of the overall proposed action. This unique consideration reinforces the importance of working closely with NMFS on how to appropriately address compensatory mitigation when consulting under ESA.

2.1.1 Pre-Application Agency Consultation and Coordination

Pre-application meetings with the appropriate permitting authorities at the federal, state, territorial, or local level are strongly recommended to discuss clearance protocols, survey methods, required permits and consultations, project-specific issues or challenges with potential compensatory mitigation activities if unavoidable impacts are likely, and other information that would likely be required for a particular project. In these application meetings, requesting attendance of other agencies with permitting or reviewing authorities for the project is encouraged. This may include, but is not limited to, USACE, EPA, NMFS, FWS, and the state and territorial marine resource, water quality, and coastal zone regulatory and management agencies. If there will likely be unavoidable loss of coral reef resources that may require compensatory mitigation, project proponents are highly encouraged to consider reserving a contingency of funds early in the planning process to address potential information and planning needs in developing and implementing a mitigation plan (see Section 2.3.2). Early discussions with the appropriate regulatory agencies will help determine potential contingency amounts.

Project proponents and RPs are reminded that a permit or approval from one agency does not negate other permit requirements. An activity may require permits from federal agencies as well as state and territorial agencies.

EXAMPLE PROCESS FROM FWCA

The FWS has an evaluation framework for water resources development under the FWCA that many may find useful in evaluating the alternatives, potential impacts, and compensatory mitigation needs for projects. This framework shows an alternative format for structuring the permitting process. As is highlighted in this example, each project proponent agency or permitting authority has similar but different methods for evaluating impacts. Please be sure to talk with the appropriate permitting authority to see what may be necessary for their processes. The key information the FWS looks for in their evaluation are:

1. Specify the resources likely to be evaluated.
   a) Identify the types, kinds, or categories of resources of concern (habitat, species, and life stages).
   b) List types of impacts to be evaluated.
2. Adopt an evaluation method.
   a) Determine how project impacts on coral reef resources will be measured.
   b) Select a method that will measure change in quantity and quality of each resource category.
3. Define the baseline conditions and significant resources likely to be impacted.
4. Determine the most probable future resource condition without a project. Describe the difference between the future without and the future with the project.
5. Define Coral Reef Resource Planning Objectives.
   a) Identify opportunities to conserve resources.
   b) Identify obstacles that may hinder meeting objectives.
6. Define the project alternatives, including project design, implementation, and operational-related activities that may impacts fish and wildlife resources.
7. Determine the most probable future resource condition with identified Project Alternatives: assess the future with the project.
8. Define impacts: Identify and describe the effects of project alternative plans on coral reef resources.
   a) Compare conditions with and without the project.
   b) Describe all impacts (direct, indirect, and cumulative (consider location of impact, duration of impact, and magnitude of impact on coral reef resources)).
9. Evaluate and compare project alternatives:
   a) What is the significance of coral reef resources?
   b) Will impacts to coral reef resources be avoided or minimized?
   c) Has sufficient compensatory mitigation been planned to offset unavoidable impacts?
10. Formulate conservation measures: avoid, minimize, rectify (repair, rehabilitate, or restore), reduce or eliminate impact over time (maintenance operations), compensation (replace resources).
11. Develop recommendations:
    a) Identify projects for compensatory mitigation.
    b) Scientifically monitor mitigation.
    c) Define performance standards for mitigation.
    d) Effectiveness of implemented mitigation.
    e) Best management practices (avoid/minimize).
    f) Adaptive management.

(Adapted from Smalley and Mueller, 2004.)

2.1.2. Mapping and Qualitative Characterization of Coral Reef Resources

Part of the project planning and permitting process includes data collection. Data about the resources in the proposed project area are required to support and inform the planning and permitting process. Diver-conducted surveys of the sea floor and benthos are generally required to characterize the coral reef and other biological resources that are likely to be impacted by in-water construction work. A variety of acceptable methods can be employed to collect the information necessary to adequately characterize the biological resources to guide avoidance and minimization activities and assess compensatory mitigation requirements for unavoidable adverse impacts. Two tiers of data collection categories are generally recommended.

Tier 1: Qualitative Assessment The first step in this process is a qualitative characterization of the types of habitat and communities found in the project footprint and adjacent areas. Depending on the size and extent of impact, the qualitative characterization can range from a diver geo-locating major features, habitat boundaries, or sensitive resources, to a more detailed and georeferenced habitat map. Based on the qualitative assessment, a permitting authority may determine that no significant adverse impacts are likely to result and no further surveys, impact assessments, or mitigation would be needed. A permitting authority may alternatively determine that additional quantitative information (Tier 2) is needed.

Tier 2: Quantitative Assessment Based on the Tier 1 qualitative assessment/habitat map, the need for additional quantitative survey of corals and other habitats can be determined. This determination is predicated on the complexity of the coral reef resources, the size of the impact area, and extent of expected impacts. If impacts cannot be avoided or mitigated with common best management practices (BMPs), then quantitative assessments may be necessary.

The two tiers of biological assessment (qualitative and quantitative assessments) are described in more detail below, and in Section 2.1.3. While this section focuses on planned activities, the mapping methodologies discussed herein are often useful for unplanned activities. Project proponents and Responsible Parties (RPs) need to work closely with the permitting authorities or resource trustees to determine assessment requirements and appropriate methodologies.

2.1.2.1 Qualitative Coral Reef Assessment and Habitat Mapping

A qualitative benthic assessment and characterization is a critical first step in determining the distribution and location of habitats and other resources within and adjacent to a planned project site. The characterization should cover areas of expected direct and indirect impacts from the proposed action(s). The distribution of habitats and the occurrence of any resources of concern (e.g., endangered species or unusually large coral colonies) within a project site may guide the development of a scientifically defensible quantitative survey design for the habitats and strata of concern, including coral reefs.

Due to the highly variable nature (e.g., size, footprint, location, scope, and scale) of coastal development projects there is no “one size fits all” approach for coral reef qualitative surveys. For small projects or homogeneous sites, a rudimentary map or general characterization of the area that includes resources of concern may be sufficient. However, most projects can benefit from development of a qualitative benthic habitat map as a first step. Various federal, state, or territorial agencies may have existing characterization maps that may contain some of the information needed. Once again, it is important for project proponents to discuss with the appropriate permitting authorities what may be needed for a specific project and what readily available information may be referenced.

Qualitative surveys and benthic habitat maps have important applications. Habitat maps can provide an overall spatial perspective to the project area and its resources, provide information used to inform the alternatives analysis (see Section 2.2), guide the avoidance and minimization measures, and provide information for planning appropriate compensatory mitigation for unavoidable adverse impacts (see Section 2.3). Additionally, habitat maps can be used to inform, plan, scale, and determine the quantitative sampling approaches, strata, and the samples needed per strata to provide an acceptable level of confidence in the site characterization (see Section 2.13). The qualitative habitat characterization may also be used for development of performance standards for the mitigation site and comparisons of the mitigation site(s) with the impact site.

Numerous habitat mapping methods exist that can adequately characterize a project area. Methods utilized can be based on remote sensing technologies and/or *in-situ* data collection. The method selected depends on multiple factors, including the size, location, and scale of the project site, desired minimum mapping unit, advantages and disadvantages of methods available, available data, resources, capacity, and logistical limitations

The use of unique or alternative habitat mapping efforts should be discussed prior to application with the permitting authorities to ensure appropriate compliance. Habitat maps derived from remote sensing products may have significant limitations in data interpretation and may require *in-situ* validation of classifications. However, diver-based *in-situ* methods have significant scale limitations for large projects; hence, larger projects may require a combination of remote sensing and *in-situ* (both instrument and diver) methodologies to produce a reliable habitat map.

Habitat maps should have a well-defined methodology description so the user can understand how the maps were generated and the information the maps contain. As much as is practical, the methods should be standardized or congruent with existing methods. Terminology and the classification scheme used should be clearly defined and consistent with the Coastal and Marine Ecological Classification Standard (June 2012) as adopted by the U.S. Federal Geographic Data Committee.

It is recommended that habitat maps contain a common set of information that provides specific information key to the overall project planning, natural resource characterization, and permitting review process for the proponent and regulatory agencies. Based on a review of the benthic habitat mapping conducted to date for planned activities, the recommended common information includes:

- Survey dates.
- Location (geo-referenced latitude and longitude when possible).
- Name of person(s) or party conducting survey.
- Project area defined, which includes area of the direct impact and potential areas subject to secondary impacts.
- Methodology description:
    - A detailed description of the method used to collect data and generate the maps.
    - A clear description of how habitats are defined that include biotic (e.g., benthic organisms) and abiotic features (habitat geomorphology) of the area.

  - Minimum mapping unit or the amount of area surveyed within the project area.
  - The classification system used for habitats and the resources assessed (e.g., NOAA National Centers for Coastal Ocean Science, 2007).
- Identification of mapping methods for other biological resources (e.g., fish, invertebrates, algae, seagrass, ESA-listed species, and other species of concern).
- Review of existing data (light detection and ranging (LiDAR), multiband imagery such as World-View 2/3, Quickbird, IKONOS satellite imagery, backscatter and multi-beam data, or other digital elevation model data) and habitat maps (NOAA Habitat Benthic Maps or other area-specific maps) within and adjacent to the project area.

Additionally, some components and information to consider when generating habitat maps include:

- Estimate total area mapped (in acres (ac) or square meters (m^2)).
- Estimate total area of proposed project footprint (ac or m^2), including potential area of direct and indirect impacts.
- Estimate total area of each habitat within the mapped area, impacted by direct project footprint, and if possible, the area of secondary impacts (ac or m^2).
- Identify, locate, and highlight boundaries of habitat geomorphology (e.g., reef geomorphology zone and reef geomorphology structure).
- Identify, locate, and characterize coral abundance, colony morphologies, and sizes (e.g., particularly large, unique, or rare colonies) to the extent feasible within the project area.
- Identify, locate, and characterize algal abundance and key functional groups within the project area.
- Identify, locate, and characterize invertebrate groups or species considered important in the project area.
- Identify, locate, and characterize known threatened or endangered species listed under ESA.[3]
- Identify and locate nearby habitats that may provide important ecological links (e.g., seagrass beds and mangroves).
- Identify areas of special interest or regulatory oversight such as special aquatic sites (CWA 404(b)(1) guidelines), EFH, ESA designated critical habitat, MPAs, or other spatial designations.
- Highlight areas identified as special high-value or high-function features (e.g., protected species, breeding areas, very large coral heads, high density coral).

For small projects with minimal impacts, a qualitative survey and map may be all that is required. The EFH provisions of the MSA §305(b) (50 CFR Part 600) state that the level of detail needed for an EFH assessment should be commensurate with the complexity and magnitude of the potential adverse effect of the action. Thus, for larger projects or projects that impact especially high quality biological resources, additional quantitative biological assessments are likely to be needed; these are discussed in Section 2.1.3.

Figure 3 is an example of a qualitative benthic habitat map for relative coral abundance at Nawiliwili Harbor, Hawaii. The Nawiliwili Harbor habitat map was based on the standard mapping protocol used by the FWS Pacific Islands Fish and Wildlife Office. The habitat map showed that most of the coral habitat is outside of the federal navigation channel and can be

[3] Coral reef species identification should be as consistent as possible given established references, but field identification may be inconclusive.

avoided during dredging. The map also showed that there are some coral areas that may be subject to indirect impacts from sedimentation. This habitat map helped provide useful information to the project proponent, USACE, in determining potential adverse impacts, and avoidance and minimization measures for those impacts, early in the planning process.

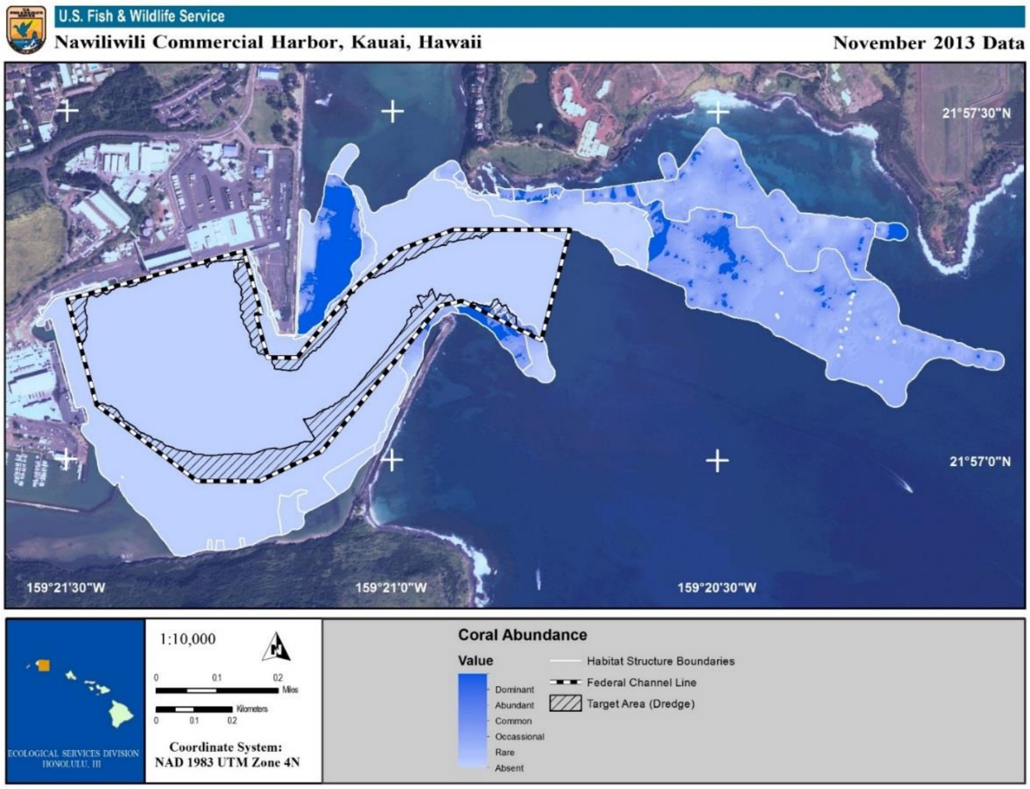

Figure 3: Habitat map of Nawiliwili Harbor, Kauai, Hawaii. The map shows the areas to be dredged within the federal channel as hatched. Coral abundance is shown in shades of blue. The proposed dredging avoids direct impacts to corals, but has potential indirect impacts to corals from sedimentation (habitat map courtesy of Mr. Tony Montgomery, FWS Honolulu).

2.1.3 Quantitative Coral Reef Resource Surveys

Once adequate habitat mapping, as determined by the appropriate permitting authorities based on the project scope and potential impact, has been conducted for a planned coral reef impact site, the coral reef and other biological resources located within the area may need to be assessed quantitatively. Permitting authorities and resource trustee agencies should be consulted to reach agreement on any additional, and more detailed data that may be necessary. Additional information gathered is also intended to be integrated into the habitat map. If additional assessment is required, recommended sampling considerations and reporting expectations are described in this section.

Assessment of the temporal and spatial extent of direct, indirect, and cumulative impacts should be considered as part of a complete biological resource survey. Even within a single state or territory, depending on the location of the project, there may be various permitting authorities that have their own survey protocols and minimum reporting requirements (e.g., Florida Keys National Marine Sanctuary (FKNMS) Benthic Survey Protocols) that should be consulted and taken into consideration when developing project-specific biological resource survey methodologies.

The following is a general list of recommended steps and data to fully describe the impacted area and design the compensatory mitigation, if required. This information is based on a review of biological resource surveys conducted to date for planned activities. The suite of parameters measured for a quantitative assessment will likely be project-specific. Some items on this list will be unnecessary, whereas other types of data not on this list may be included. In addition to the project footprint, adjacent coral reef areas may need to be surveyed to address potential indirect impacts. In some cases, it is also useful to quantitatively assess control or reference site(s) outside of the area of project impacts. This data can inform potential compensatory mitigation actions if unavoidable adverse impacts are likely, or the assessment of impacts from regional stressors not related to the project.

- Divide area into strata and determine the amount of quantitative sampling needed to reliably characterize the abundance of key benthos, including corals.
- Select methods for biological resource surveys (e.g., number of surveys, sampling stratification; locations, type of transects (belt, quadrat, etc.), or number of transects per site).
- Assess abundance and distribution of protected species (including ESA listed species): species, species distribution and density, location, noted behavior, and expected use of area.
- Determine biological, physical, and chemical data needed to characterize the site.
- Assess coral species, species richness, size class abundance, density, partial coral mortality, and morphology (branching, encrusting, table, massives, etc.).
- Asses algal species and percent cover.
- Assess sponge genera, size class distribution, and density.
- Assess fish species abundance by size class.
- Determine benthic percent cover, including coral, algae, and general substrate (mud, rock, sand, etc.).
- Determine topographic complexity (rugosity or complexity) for each habitat type.
- Collect fine-scale bathymetry to document reef geomorphology may be needed in some cases. This information is often necessary for hydrodynamic modeling and calculations of frictional drag and wave propagation across reefs to understand the potential services the reef is providing in terms of shoreline protection.
- Collect planar/various other photographic images
- For the Atlantic/Caribbean, collect Octocoral density, Octocoral genera richness and Octocoral size class distribution.
- Document any significant variation of the coloration, bleaching, paling, disease, and partial colony mortality of the corals, to understand the current stress the reefs may be under, and their potential resiliency to indirect impacts.

As noted above, this is a general list of steps and data to be collected for a quantitative assessment and other measures may be required for some projects.

The following information is also desirable for some projects that require compensatory mitigation to model replacement and recovery for a compensatory mitigation site. This information can be useful for both the impact area as well as any affiliated compensatory mitigation site in which unavoidable adverse impacts are likely.

- ***Baseline size frequency structure*** **–** Measures of the spatial distribution or frequency of coral sizes by morphology within the survey area at the impact site.
- ***Recruitment rates (best fit, calculated, or observed)*** **–** Estimates of the recruitment rate for new coral colonies in the survey area at the impact site.
- ***Proportional survival*** **–** Estimates of coral survival over time in relation or in proportion to the overall survey area. Determined from change across size frequency distributions gathered at the planned impact site prior to construction.
- ***Growth*** **–** Estimates of the growth rate of the coral within the survey area. Best fit: measured at impact site, mitigation site, and/or inferred from literature.

Additional useful information for quantitative surveys regarding the sampling design and effort, transect location, surveys of additional organisms, and conventions for organism counting is summarized below.

Sampling design: In some cases it may be desirable to stratify project areas into separate habitat categories (e.g., shallow vs. deep, horizontal vs. slope, rugged micro-relief vs. flat, middle vs. outer reef, fore vs. back reef, high vs. low coral density). Targeted fixed sites may provide more useful information to determine temporal changes and are recommended for indirect impact sites and mitigation sites.

Sampling effort: The appropriate number of sampling locations per habitat and number of transects per sampling site depend on project size and site characteristics. If previous data exist, such as the type of information listed earlier in this section, conducting a power analysis or other methods are recommended to assist in determining the appropriate number of transects per habitat. Other methods to determine the appropriate number of sampling sites per habitat and transects per sampling site may include species-area curves, performance curves, bootstrap estimates, and Pearson's product moment correlations. If no such data exist, it is recommended that state, federal, and academic coral reef experts be consulted to determine appropriate sample size.

Transect location: Biological resource surveys, for the purposes of assessing planned impacts, should be conducted at each sampling site identified on the habitat map of the impact site. Benthic transects should be oriented in the way that would best characterize the coral reef community. Typically transects are oriented perpendicular to the reef slope or parallel to depth contour lines. However, other methods depending on the reef characteristics, may include transect plots along the gradient of reef slope, or a plotless intercept method in a "fish bone" design (i.e., a long transect following the slope gradient and short transects perpendicular to the long transect following depth contours as in Loya, 1978). If there is minimal or no reef slope (i.e., similar depth contour), a random heading (0˚ to 360 ˚), rounded to the nearest 10˚, can be generated and used to determine the direction of transects. In the case of spur-and-groove habitat, it may be appropriate to orient transects along the coral habitat "spurs" in order to characterize the coral reef community impacted and avoid confounding the results with sand habitat (i.e., "grooves"). Heading restrictions are appropriate to ensure transects do not overlap and are kept within the specific habitat being surveyed.

Additional organism surveys: Additional surveys for keystone organisms should be identified with the appropriate regulatory agencies in pre-assessment coordination. These additional organism surveys may target important invertebrate species such as specific urchin groups, unique mollusk or crustacean assemblages, crown of thorns starfish, soft coral, sponges, observed large fish, sea turtles, and protected coral species.

Organism counting for scleractinian coral, octocoral, and sponge surveys: A variety of conventions exist to determine which coral, sponge, octocoral, and other colonies are counted in sampling (e.g., entire colony within belt/quadrat, any part within the belt/quadrat, greater than or equal to (≥) 50% within the transect). Zvuloni, et al. (2008) provide a review of size-frequency distribution biases that result from different counting methods with line-intercept, quadrat, and belt transect methods. Zvuloni, et al. (2008) provide equations to correct for biases identified in these common sampling methods, and also offer suggestions for nonbiased methodologies. The effects of sampling bias are minimized by using the same methodology within a Before-After Control-Impact (BACI) design framework. Once a method is selected, it must be used in all surveys (i.e., pre- and post-project, inside/outside impact area, mitigation sites, and future monitoring) so as to produce comparable results. Methods that are known to generate size-frequency distribution biases should implement the proper mathematical corrections to accurately characterize a site (see Zvuloni, et al., 2008 for details).

Absent adequate assessment, the precautionary principle would be applied and reasonable assumption would be used to err on the side of the resource, presuming that resources are present and impacts will need to be avoided and minimized. If the regulatory agency believes compensatory mitigation may be necessary, an adequate assessment should be done to determine the activity-specific compensatory mitigation requirements needed to offset the impacts.

2.1.4 Functional Assessment vs. Condition Assessment

The 2008 Mitigation Rule recommends that condition or functional assessments be used to assess the extent of impacts, where these tools are developed and available. Both functional and condition assessments examine functions, but use different approaches. Functional assessments generally evaluate individual functions. Whereas condition assessments aggregate functions to determine the ecological integrity of an aquatic resource, and thus infer the level of functions being performed (Stevenson and Hauer, 2002; Fennessy et al., 2007; Stein et al., 2009). In other words, the condition of an aquatic resource is an integration of its functions, and if its functions are performing at a high level, its condition will also be rated at a high level (Fennessy et al., 2007). Condition assessments use an index or scoring to provide a measure of the ecological condition of a reef. Functional assessments, however, use indicators to estimate or infer the level of each function being performed (e.g., energy absorption, nitrogen fixation, nursery habitat, and food production) performed by a coral reef. At this time, the coral reef assessment methods in use are best described as condition assessments.

The purpose of compensatory mitigation is to compensate for the loss of coral reef and affiliated ecosystem functions and services. Table 3 below, presents some of these ecosystem functions and the corresponding services for coral reefs. Based on the experience of coral reef permitting authorities in the Atlantic, Caribbean, and Pacific, the ability to conduct effective functional assessments is currently limited by technology, state of the science, cost, and the timeframe necessary to make decisions.

Table 3: Ecosystem functions and corresponding goods and services for coral reefs (adapted from Costanza, et al., 1997, and Moberg and Fouke, 1999).

Ecosystem Functions	Corresponding Goods and Services	Examples within Coral Reefs
Maintenance of the integrity of ecosystem response to environmental fluctuations through capacitance and damping.	Regulation of disturbances.	Coastal protection and sediment retention.
Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment.	Nitrogen fixation, CO_2 assimilation, and Ca budget control.
Regulation of trophic dynamics within populations.	Biological control.	Feeding places within an ecosystem and between ecosystems.
Provision of habitat for resident and transient populations.	Refugia.	Habitat and nursery space.
Provision of extractable food as a portion of gross primary production.	Food production.	Fish, invertebrates, algae, plants and other edible products.
Provision of extractable raw materials as a portion of gross primary production.	Raw materials.	Sand, coral block, algae and plants, and materials for medicine, curio, and jewelry.
Provision of recreational opportunities.	Recreation.	Tourism, recreational fishing, sport.
Provision of non-commercial use opportunities.	Cultural.	Aesthetic, cultural, religious, spiritual and intrinsic values.

The 2008 Mitigation Rule recommends the use of functional or condition assessments, or other suitable metrics. Some individual federal, state, and territorial agencies, non-governmental organizations, and academia have developed recommended guidelines and protocols for condition assessments. Regional recommendations for condition assessments within the Pacific Islands are being developed, but no target date for completion has been set. Similar work is needed in the Atlantic/Caribbean.

2.2 Alternatives Analysis

An alternatives analysis performed properly and early in project formulation can reduce project costs, streamline permitting, and result in avoidance and protection of valuable marine resources (Yocom et al., 1989). An alternatives analysis is a process by which a project proponent or decision-maker looks at potential alternative actions or activities that could meet the intended purpose of the planned activity and address the need for that activity. The laws, regulations, and procedures that may apply to activities in coral reef ecosystems all require some level of alternatives analysis to ensure that project proponents and decision-makers are fully considering the environmental impacts of an action (e.g., NEPA, ESA, MSA, and CWA). The CWA §404(b)(1) Guidelines (40 CFR 230), referred to as the Guidelines, provide a framework for alternatives analysis and implementing avoidance and minimization actions before considering compensatory mitigation. The approach from the Guidelines can be applied to planned impacts to coral reefs, even if those impacts do not require a DA permit from USACE. The fundamental precept of the Guidelines is that discharge of dredged or fill material to a regulated aquatic habitat, such as coral reefs, should not occur unless it can be demonstrated that such discharges, either individually or cumulatively, will not result in unacceptable adverse effects on the aquatic ecosystem.

ALTERNATIVES ANALYSIS AND THE CWA §404

When a planned project includes actions that are regulated under CWA §404 (e.g., placement of dredged or fill material), specific requirements are placed on the alternatives analysis. Under CWA §404(b)(1) Guidelines, the fundamental precept is "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences" (40 CFR 230.10(a)). This is referred to as the "least environmentally damaging practicable alternative" or LEDPA. The preferred alternative must be the LEDPA. A "practicable alternative" is considered any alternative that is "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of the overall purpose" (40 CFR 230.10(a)(2)).

CWA §404(b)(1) Guidelines also state that impacting "special aquatic sites" is "among the most severe environmental impacts" covered by the Guidelines (40 CFR 230.1(d)). Coral reefs, seagrass, and vegetated shallows are considered "special aquatic sites" (40 CFR 230.44). Therefore, when a planned project also includes proposed impacts to a "special aquatic site" and the activity "does not require access or proximity siting within the special aquatic site" (40 CFR 230.10(a)(3)), there is also a rebuttable assumption that practicable alternatives are available that would not involve discharges into special aquatic sites and that those practicable alternatives have less impact on the aquatic ecosystem. If the project proponent is able to demonstrate there are no other practicable alternatives, then the focus is on ensuring that the impacts are avoided and minimized to the extent practicable and that unavoidable impacts are compensated when appropriate. Please review the full text of the Guidelines (40 CFR 230) for more detailed information on burdens of proof and required analysis. Local USACE Regulatory Offices are also available to explain the requirements on a project-specific basis.

For activities that require DA permits in accordance with CWA §404, USACE is responsible for determining compliance with the Guidelines, and the permit applicant may be required to provide information to USACE to assist in that compliance determination. For proposed CWA §404 decisions, EPA may provide comments to USACE identifying its views regarding compliance with the Guidelines. The Guidelines require documentation of avoidance and minimization of impacts to aquatic resources prior to consideration of compensatory mitigation for unavoidable adverse impacts. For activities that require DA permits in accordance with RHA §10, mitigation requirements are described in 33 CFR 320.4(r), as well as the 2008 Mitigation Rule.

2.2.1 Quantifying Direct and Indirect Impacts

To fully consider the environmental impacts of various alternatives, the direct, indirect or secondary, and cumulative impacts of the project on coral reef, other biological resources, and habitat types need to be identified. Although defined differently in various laws, regulations, and policies, the definition in NEPA for direct and indirect impacts is commonly used (40 CFR 1508.8). Direct impacts are caused by the action or activity and occur at the same time and place. Indirect impacts (also known as secondary impacts or effects) are caused by the action or activity and are later in time or farther removed in distance, but are still reasonably foreseeable. Whether an impact is direct or indirect is not based on the severity of the impact, but rather whether the impact resulted from an action elsewhere or directly from an action on site.

It is useful for a project description to include a table of projected direct and indirect impacts for each habitat type, and whether the impacts are permanent (e.g., fill) or temporary (e.g., sedimentation). Indirect impacts can be difficult to quantify, so at times might be described qualitatively.

While agencies may define direct versus indirect impacts differently, generally in the marine environment, common actions having direct impacts include, but are not limited to:

- Dredging to widen or deepen harbors and channels, or to maintain channel depth.
- Depositing fill in marine waters to build piers, breakwaters, and protect eroding shorelines.

Common actions having indirect impacts in the marine environment include, but are not limited to:

- Sedimentation impacts from turbidity plumes. Sediments may bury, abrade, or shade corals, resulting in physiological stress or mortality.
- Degradation of marine resources caused by induced excess human use. For example, if a project provides expanded docking or mooring for recreational and commercial vessels, overuse of nearby fishing or diving sites may degrade the condition of aquatic resources outside of the project footprint.
- Shading impacts on marine resources. Constructing overwater structures such as piers may change light levels and indirectly degrade the habitat underneath.
- Discharge of land-based pollutants. Land-based activities that have no direct impact to coral reef or nearshore habitat may result in significant indirect impacts from nutrients or pollutants if not adequately controlled and treated before discharge to the ocean.

In some instances, the damages associated with indirect or secondary impacts may exceed those caused by the direct impacts of a project. Therefore, comprehensive quantification of indirect impacts is important for defining the full scale of project impacts and for the purpose of determining compensatory mitigation.

If indirect impacts are a substantial concern for a planned activity, project proponents may need to include monitoring of turbidity, sedimentation, and coral condition before, during, and after the construction activity or action to appropriately account for the indirect impacts. Careful monitoring can detect problems that need to be corrected in real time, allow for adaptive management to meet any requirements and standards, and determine if compensatory mitigation requirements for unavoidable adverse impacts need modification. Post-dredging surveys can determine if the dredging was restricted to the permitted area, or if the dredge caused direct impacts outside of the permitted area. Project proponents need to work closely with the appropriate permitting authorities to determine when this type of monitoring may be most effective.

Some of the more common indirect impacts encountered by resource managers and regulators are those associated with sedimentation caused by dredging activities. A variety of dredge plume models are designed to estimate indirect impacts from sedimentation. For example, the USACE has developed models for assessing such indirect impacts to provide site-specific data on the potential extent of impacts (Johnson et al., 2000). Such models have been used to assess impacts from hopper overflow and dredging activities. A good example of where models have been used to assess the site and project-specific extent of impacts is “Numerical assessment of the dispersion of over spilled sediment from a dredge barge and its sensitivity to various parameters” (Mestres et al., 2014). These models could also be used to determine which BMPs will result in the least amount of indirect impacts on the nearby sensitive hardbottom habitats. The Permanent International Association for Navigation Congresses (PIANC) guidance also recommends that predictive modeling be performed as it is a “critical tool for accurate assessment of dredging and port construction impacts on corals” (PIANC, 2010). One concern regarding the accuracy of these models in coral reef areas, is that dredge plume models often fail to include thresholds for turbidity and sedimentation rates that are protective of corals and other sensitive aquatic life.

2.2.2 Analyzing Project Sites and Designs

Once the direct and indirect impacts of project alternatives have been identified and summarized by habitat type, then the project proponent should consider what additional modifications might be made to avoid and minimize impacts to the coral reef ecosystems by analyzing project sites and designs. Avoidance and minimization are not only integral steps in the mitigation process, they have also been shown to be more cost effective than the compensatory mitigation analysis and implementation process.

Planned activities that are likely to cause minor impacts may require less rigorous analysis of alternatives and may be able to readily avoid and minimize impacts to meet applicable federal, state, or territorial requirements. Planned activities with larger impacts to the aquatic environment, either individually or cumulatively, will likely require greater assessment specificity, as well as analysis, to meet appropriate avoidance, minimization, and compensatory mitigation requirements.

If a DA individual permit is required, the NEPA decision document (environmental assessment (EA) or environmental impact statement (EIS)) requires an alternatives analysis. For RHA §10, the USACE regulations at 33 CFR 320.4(r) also require consideration of avoidance and minimization, as well as compensatory mitigation. For CWA §404, USACE will need to determine the LEDPA, based on documentation from the applicant and input from the regulatory agencies. Whether for a DA permit or other federal, state, or territorial permits, the applicant needs to strive to provide the most accurate information for describing the proposed project, the project purpose, and a defined set of criteria used for screening each of the alternatives (e.g., project site, operational logistics, area of impact, presence of marine resources, social and cultural impacts, and itemized costs). If the applicant has sound reasoning as to why an alternative is desirable or should not be considered, these views should be presented with detailed justifications.

For those alternatives that are determined to be practicable, further analysis of avoidance and minimization should be conducted to identify the alternative that will result in the least adverse impacts. To clearly represent the variations in alternatives and impacts, a good practice is to include a project map and description of the direct and indirect project footprints of the different project alternatives. The project map should include locations and configurations of any fill material, physical structures, dredging, or other work that contribute to impacts. In some cases, habitat maps exist for proposed project areas, or they are developed during the environmental review process or during the ESA, EFH, or FWCA consultations.

Overlaying the footprints of the alternatives onto a benthic habitat map facilitates comparison of the alternatives and documentation of the

EXAMPLE: COLLABORATIVE ALTERNATIVES ANALYSIS PROCESS

The Māʻalaea Harbor navigation improvement project on the island of Maui, Hawaii, proposed expanding the existing breakwater to improve access to a small boat harbor during certain wave conditions. Between 1982 and 1998, public comments on the environmental impact statement (EIS) raised concerns regarding potential impacts to coral reef habitats and other issues. Due to funding constraints encountered when addressing the complex issues around coral reef mitigation, it took until 2012 for the project proponents—State of Hawaii and USACE—to make a final decision on the project.

As a result of public comment, the project proponents modified the alternatives analysis approach, to be a more collaborative process with resource agencies and community groups. When updating models to better scale the breakwater, USACE engaged with federal resource agencies to improve understanding of the resource, and communicate navigational and engineering constraints and technical issues for the project. In re-evaluating potential alternatives, USACE engaged FWS and NMFS in a phased approach to impact assessment, first mapping the extent of the coral reef habitat and rating areas of higher quality that would benefit from protection (i.e., avoidance). Based on the initial mapping, the potential alternatives were overlaid and re-evaluated to see where the best opportunity to maximize avoidance and minimization was. Through collaboration with community groups and users in 2010, USACE and the State of Hawaii developed a better understanding of the navigational constraints for the harbor, and how users were adapting to the conditions.

Based on the input of the users, resource agencies, and the expertise of the coastal engineers, it was determined that the best solution for the State of Hawaii was to terminate the proposed breakwater expansion and instead focus on facility improvements to better protect the vessels while moored. This avoidance and minimization measure was decided in large part by comparing the potential costs of coral reef compensatory mitigation along with construction costs versus the potential benefits derived by the users of Māʻalaea Harbor.

process. Visualizing the different project footprints on a habitat map aids identification of any areas of special significance (e.g., special aquatic sites, EFH, ESA critical habitat, or sites where protected species are located) within the direct and indirect impact areas. Use of alternative footprint habitat overlays allows project proponents to see where designs can be modified to avoid and minimize impacts to sensitive areas to the maximum extent practicable. Evaluating alternatives and modifying project designs to achieve avoidance and minimization of impacts through the use of habitat map overlays, is an effective way to document compliance with environmental requirements such as NEPA or state or territorial equivalent laws and regulations.

An analysis of alternatives should include examination of opportunities for use of upland areas and other aquatic sites that would result in less adverse impact on the aquatic ecosystem and environment, especially for habitats with specific regulatory designations, such as coral reefs and seagrass beds (designated as special aquatic sites under CWA, EFH under MSA, and in some areas critical habitat under ESA).

The range of alternatives to consider may include:

- Upland alternatives that do not involve in-water work.
- Alternative sites with little to no coral reef resource (i.e., avoidance).
- Non-structural alternatives that meet the project purpose. For example, improved navigation technology or aids to navigation may meet the purpose of improving safety without the need for construction.
- Modifications to project size and footprint to avoid or minimize impacts to coral reefs and other sensitive ecosystems.
- Modifications to project design, which may include using pilings instead of fill, moving the facility shoreward to reduce in-water work, and reducing the length or width of a pier or breakwater.
- Alternative methods that avoid or minimize impacts such as horizontal directional drilling instead of trenching.

The result of the analysis of a full range of alternatives is identification of the practicable alternative with the smallest impact to the marine environment or to coral reefs and other sensitive sites. For projects permitted by USACE under the CWA, the alternatives analysis must demonstrate that the preferred alternative is the LEDPA.

Per the Presidential Memorandum: *Incorporating Ecosystem Services into Federal Decision Making* issued in October 2015, federal agencies are also directed to take into consideration the full range of benefits and trade-offs among ecosystem services associated with potential federal actions, including benefits and costs that may not be recognized in private markets because of the public-good nature of some ecosystem services.

2.2.3 Avoid and Minimize Impacts

Avoidance and minimization of impacts starts early in the alternatives analysis, with quantifying the direct and indirect impacts and analyzing the project sites and designs. Once a preferred alternative is identified by the project proponent through these measures and in consultation with the permitting authorities, additional avoidance and minimization can occur through such actions as evaluating construction technologies, and implementing biological or construction BMPs. The alternatives analysis and avoidance and minimization process is often iterative. For example, identification of a new construction technology may allow for a previous project site with less coral reef habitat that was determined to be technically infeasible to be reconsidered. Investigation into BMPs that were previously thought to be effective at reducing an impact may not be practicable at the project site, requiring reconsideration of other BMPs or other projectsites. This section provides information on best practices for in-water construction and dredging, and coral transplantation, which are often-used avoidance and minimization approaches used during planned impact activities.

2.2.3.1. Best Management Practices for In-water Construction and Dredging

A suite of BMPs should be employed during all in-water construction and dredging activities to minimize impacts. It is recommended that these construction projects develop a BMP plan in advance of starting work. The BMP plan should be specific to the site, equipment used, local conditions, and aquatic resources at risk. This section provides a menu of recommended BMPs for construction and dredging in marine waters. In addition, climate change adaptation BMPs are recommended where practicable, such as those defined in *A Reef's Manager's Guide to Coral Bleaching* (Marshall and Schuttenberg, 2006).

The range of BMPs discussed here is intended to present examples, and is not definitive. Federal, state, and local government entities may have BMP guidance, and these recommendations should be identified and incorporated during the permitting process. The FDEP's BMP guidance for dredge and fill projects in tropical systems is an excellent resource for consideration (FDEP CRCP, 2008).

Biological BMPs:

- Clean vessels and construction equipment that may have any contact with the water to prevent introduction of alien and invasive species.
- Cease work during coral spawning periods.
- Avoid work during coral bleaching events.
- Transplant or relocate living corals and sensitive macro-fauna outside the impact footprint (see Section 2.2.3.2).

Construction BMPs:

- Reduce operational impact by using equipment or methods that minimize sediment resuspension (e.g., suction dredge, environmental bucket).
- Ensure that water column, current, and wave characteristics (circulation, temperature, biological attributes) are maintained as much as practicable during construction, and are restored post construction.
- Maintain ocean and coastal hydrodynamics (sedimentation, volume, flow) as much as practicable during construction, and restore post construction.
- Prevent, if possible, all discharge to the ocean of storm water, return flows, and contaminants from construction and dewatering in nearby uplands, or apply appropriately strict sediment and contaminant limits to any unavoidable discharges.
- Avoid upland and shoreline earth-moving activities during rainy season.
- Establish protocols for confining the work area and ceasing operation due to inclement weather.
- Establish a contingency plan for removing equipment and securing the work site during storms.

- Use silt curtains or other similar methods to confine suspended sediments for in-water activities when practicable.
- Reduce potential contact with the substrate by equipment and tools.
- Minimize the duration of in-water work.
- Prevent unnatural heating or cooling of water resources.
- Prevent chemical spills, discharge, and site contamination.
- Properly size dredged material containment or dewatering operations to prevent or control overflow or return flow.
- Dewater dredged material by evaporation and infiltration whenever possible, and manage any return flows to remove particulates and chemical contaminants before discharge.
- Avoid construction and earth moving activities during rainy periods and contain storm water to prevent discharge of sediment-laden water to the ocean.

Dredging BMPs:

The 2010 PIANC guidance, “Dredging and Port Construction around Coral Reefs,” includes BMPs specific to dredging operations. These include:

- Choice of equipment.
- Prevention of leakage from equipment.
- Controlling the production rate.
- Overflow at keel-level and use of the environmental valve.
- Minimize propeller wash by limiting vessel movements to high tide.
- Restricted overflow.
- Environmental windows (periods of coral stress, tidal direction).
- Silt curtains, where appropriate.
- Define and manage work during appropriate wave and weather conditions.

The USACE paper “Dredging-Induced Near-Field Re-suspended Sediment Concentrations and Source Strengths” provides guidance on methods to evaluate and reduce the amount of sediment suspension through operational means (Collins, USACE, 1995). This document can be used to develop BMPs for cutterhead dredges such as:

- Require ladder swing direction opposite to tangential velocity of the cutter head blades.
- Require full burial of the cutterhead.

Additional BMPs for dredging operations:

- Enclosed clamshell dredge buckets reduce maximum suspended sediment concentrations by more than 50% (from 200mg/l to less than 80mg/l) (Welp et al., USACE, 2001). Enclosed clamshells (so called “environmental buckets”) must also be operated to minimize sediment suspension and fall-back. Vent flaps must close, and velocity of bucket drop and retrieval must be controlled to be slower than typical (unrestricted) bucket cycle times.
- Water quality and benthic impacts can result from the turbidity and suspended sediments from overflow from hopper dredges or through-hull decanting of scows that are mechanically loaded; these impacts can be reduced or eliminated by eliminating overflow or through-hull decanting. Concentrations of suspended sediment within 200 meters of the dredge are documented to be one to two orders of magnitude higher when

overflow is allowed (Palermo et al., USACE, 1990, and Collins, USACE, 1995). In order to minimize impacts to coral and hardbottom communities, overflow should be prohibited or restricted. It is recommended that overflow/through-hull flow restrictions be applied at the time of permitting and in contract specifications.

- To minimize potential impacts to adjacent benthos and reef habitats associated with transport of material to the Ocean Dredged Material Disposal Sites (ODMDS), vessels transiting to and from the ODMDS should be restricted to navigation channels. It is recommended that the MPRSA 103 permit and the dredging project contract specifications include this restriction as a condition of the permit and contract.
- To minimize potential impacts, vessels transporting dredged material should not be permitted to leak, spill, or overflow while transiting to and from the ODMDS, including within the navigation channels. It is recommended that the MPRSA 103 permit and the dredging project contract specifications include these restrictions as conditions of the permit and contract.
- Financial assurances and compensatory mitigation requirements (see Section 2.3.2) should be established in the permit and contract language to ensure that any violations of the specifications are addressed.

For potentially useful indicators of coral reef condition in relation to sediment and water quality stressors, please refer to the USCRTF Watershed Partnership Initiative Priority Ecosystem Indicators, dated February 2016.

2.2.3.2 Best Practice Considerations for Coral Transplantation

Corals are broadly distributed on various substrates, with a general preference for hardbottom. Many coastal dredge and fill projects will have corals within the project footprint. After the footprint of the dredge and fill activity has been minimized to the extent practicable, and an effective BMP plan is in place for construction and dredging, transplantation of corals out of the project footprint can be an important component of minimization. In addition, where corals may be indirectly impacted outside of the project footprint from sedimentation associated with the dredge and fill activity, transplantation of at-risk corals may also be part of the minimization action.

Transplantation of corals is not considered avoidance because the corals being transplanted as a result of a proposed activity would otherwise retain maximum functionality if left alone. Transplantation reduces the loss of corals, and by extension, reduces or minimizes a project's impact. For this reason, the act of transplantation is most appropriate in the minimization category.

The logic behind coral transplantation as minimization, is that the functions associated with the coral will also be transferred through the transplantation process. However, successful transfer of functions with transplantation does not always occur, such as when the receiving site has less-than-ideal physical conditions (e.g., solar irradiance, depth, water motion) that may limit the natural growth, reproduction, and survival of the transplanted corals, or when some of the species and size classes at the impact site may not be transplantable. In addition, some mortality is likely to occur during the transplantation process. The potential for coral losses during and after transplantation should be accounted for in mitigation planning and when determining the amount of compensatory mitigation needed to offset losses. On a coral reef, when coral transplantation is used for minimization there are additional considerations to those functions associated with the coral. There are also ecosystem services associated with the other resources at the site that need to be accounted for in the overall mitigation effort. These include, but are not limited to, services associated with other invertebrates, algae, fish, substrata, refugia, connectivity.

After all practicable alternatives and measures to avoid impacts have been exhausted, coral transplantation could be recommended for most projects, large and small, to minimize losses of this important resource. Depending on the species and the size of the corals present, and the number of corals needing transplantation out of the project footprint, it may be possible to transplant most of the corals away from the impact site with relatively good survival, thereby avoiding or significantly lessening the requirement for compensatory mitigation. For projects with large impacts to corals, the unavoidable impacts after accounting for transplantation, may also be large. In this case, compensatory mitigation may be required to offset permanent coral losses (e.g., corals not transplanted), permanent loss of waters (fill), and/or permanent alteration of habitat (e.g., depth, light penetration, current regime, and substrata) from dredging.

Project proponents should work with the appropriate permitting authorities to determine the appropriate transplanting criteria based on the project, the species present, and the species size and health. Multiple agencies, including the State of Hawaii DLNR Division of Aquatic Resources, NMFS, and the FKNMS are developing protocols for removal of corals, handling during transport, holding in aquaria, and attaching corals at the receiving site. This process is not perfect, but success and survival are improving as experience is gained. Certain corals (e.g., encrusting forms and small fragile corals) are difficult to remove from the native substrate and transplant success may not be achievable. Some mortality is to be expected during removal, transport, and holding. In some cases, trying to relocate small colonies may result in detrimental damage to the adjacent resource or a high mortality rate of the coral species being transplanted.

Selection of suitable receiving sites for transplanted corals is of critical importance. Factors to consider include:

- Potential for future destructive impacts at the receiving site (e.g., future dredging or harbor expansion).
- Potential for the receiving site to be impacted by construction activities (e.g., sediment plumes, dredge anchors and lines).
- Potential for spread of invasive species, disease, or predators to the receiving site.
- Substrate stability of the receiving site and potential impacts of sand transport, scouring, and burial.
- Ability of transplanted corals to adapt to physical conditions at the receiving site.
- Capacity of the site to accommodate numbers of transplants.
- Potential site vulnerability/resilience to effects of climate change and other stressors.

To optimize success of coral transplantation, it is recommended that a Coral Transplantation Plan (CTP) be submitted to the appropriate permitting authority with the permit application, such as the DA permit application for in-water work in or near coral reefs. CTPs should include methods, criteria for selection of colonies to transplant (and not transplant), performance and survival standards, suitable locations to transplant the corals, protection and management plans, identification of monitoring duration to determine performance standards are met, and reporting elements that reflect progress toward performance standards. The CTP should include a performance standard for survival of the transplanted colonies. In general, transplanted colonies should be tagged and geo-located so that colony growth and mortality can be tracked. An example CTP is included in Appendix IV.

A recommended performance standard for transplantation is no less than 75% survival after two years. In the Atlantic and Caribbean, it is common for coral transplantation projects to reach the performance requirement of 80% of corals exhibiting successful re-attachment and positive linear growth after two years of monitoring. If survival falls short of performance standards, additional compensatory mitigation may be required to compensate for these unexpected losses. Project proponents should be aware that some permitting authorities require that coral transplantation be monitored for a minimum of five years.

Monitoring of corals after transplantation should be aimed at determining progress toward performance standards, and at a minimum should assess percent survival. Reference or control sites are useful to include in the monitoring of transplanted and relocated corals, to compare the success and survival of transplanted corals with undisturbed corals, and in this way account for natural stresses unrelated to the relocation/transplantation. For example, if a large percentage of coral in the reference area were to be killed by bleaching, then high survival numbers at the transplantation site would not be expected.

In some cases, corals transplanted from an impact site may be a component of compensatory mitigation (see Chapter 4 Option 3). For example, if a compensatory mitigation project's objective is restoration of a site where coral has been degraded by sedimentation, an array of management actions may be components of the restoration plan. In this example, these may include transplantation of corals, targeted erosion control measures on land to control the sediment source, physical removal of sediments at the site, and restrictions on harvesting of herbivores. All four management actions are deemed necessary for successful site recovery, and coral transplantation would likely shorten recovery time, and therefore temporal losses.

Consideration of coral transplantation as a component of compensatory mitigation should be discussed with the permitting authority on a case-by-case basis. It should be understood that transplantation of corals is either a minimization measure that reduces the size of the impact, or a component of compensatory mitigation, but cannot be counted as both. As discussed in Chapter 4, coral relocation moves corals from a non-impact site, such as a nursery, to a new location. Coral relocation is different than transplantation where corals are being moved from an impact site to a new location. However, information on transplantation protocols may be applicable to coral relocation activities.

In Florida, some compensatory mitigation credit has been given for outplanting corals from a coral nursery to a pre-approved wild site. An example from Florida, of the evolution of coral mitigation science, particularly coral propagation and relocation, and artificial reef performance, as well as important lessons-learned and considerations for applying these strategies in planned (and unplanned) impact scenarios, are presented in the following case study.

THE EVOLUTION OF MITIGATION SCIENCE IN SOUTHEAST FLORIDA

The northern third of the Florida Reef Tract is sited off of a highly-urbanized shoreline that supports one-third of the State's population (6 million people). Physical impacts to these coral reefs are caused by a variety of activities including human use, port expansion, beach renourishment, major vessel groundings, and placement of fiber optic cables. Approaches to best mitigate these impacts have evolved over time, in part, as a result of improvements in stony coral relocation success, advances in coral propagation and outplanting throughout Florida and the U.S. Caribbean, and field studies that evaluate the equivalency of artificial reefs constructed to provide compensatory mitigation for impacts to natural reefs.

Until the early 2000s the placement of limestone boulder reefs or pre-fabricated reef modules was viewed as a popular approach to offset impacts to natural hardbottom and coral reef habitats. Artificial reefs have been deployed for fishery management and habitat enhancement for many years (Seaman, 2000). For decades, this approach demonstrated success in serving as fish aggregating devices, replacing some functions that reef structure provides, and as a way to reduce fishing pressure from natural coral reef areas. During this time, experimental approaches were being tested to relocate corals outside of impact areas; however, until recently, data were limited to support inclusion of coral relocation as a best practice for minimizing coral impacts.

Between 2000 and 2010 results from key studies and monitoring reports from coral relocation efforts became accessible to the southeast Florida natural resource management community. Studies have shown small corals have been successfully transplanted, exhibiting greater than 80% survivorship after 13 months (Brownlee, 2010). Monty et al. (2006) successfully transplanted 250 corals (14 species) ranging from 5 to 40 centimeters in diameter with a high rate of survivorship after 13 months, with eight coral species having 100% survivorship. Thornton et al. (2000) transplanted 271 corals from an outfall pipe in Broward and after 27 months, with 98% survival of the corals, as compared to 83% survival for corals on the nearby natural substrate. Stephens (2007) documented 92 - 100% of the transplants salvaged from a Broward County coastal construction impact site survived after 18 to 24 months. In addition, after 18 months of monitoring corals relocated from a beach renourishment project impact area, 100% of corals monitored remained securely attached, none showed evidence of disease, and over 97% of the colonies were showing active tissue growth over the cement (NOVA Southeastern University Oceanographic Center, 2006). Results from these studies supported the adoption of stony coral relocation as a routine BMP to minimize impacts to corals in southeast Florida.

While issues such as minimum size class criteria for stony coral relocation and relocation of other reef organisms such as giant barrel sponges (i.e., *Xestopongia muta*), octocorals and gorgonians with strong central spines are still under evaluation. The general consensus among resource trustees and within the regulatory community is that stony corals greater than 10 centimeters in diameter can be successfully relocated. The size of relocatable corals, however, can vary across sites and can be considerably smaller for selected species. The basic target for success as an impact minimization measure is 85% survival of transplanted coral and no net loss of live tissue of transplanted coral after two years of monitoring.

During the same time period, coral propagation and outplanting techniques were improving. Coral colonies from propagation nurseries, and salvaged from impact areas have been successfully

THE EVOLUTION OF MITIGATION SCIENCE IN SOUTHEAST FLORIDA (CONTINUED)

outplanted to natural and artificial substrates (Brownlee, 2010; Epstein et al., 2001; Horoszowski-Fridman et al., 2011; Monty et al., 2006; Rinkevich, 2005; Stephens, 2007; and Thornton et al., 2000). NOAA's Restoration Center successfully uses this approach to mitigate damages to Caribbean reefs from vessel groundings. This mitigation approach is rated most favorably in southeast Florida based on coordination with 25 coral resource trustees and scientists working in Florida and the U.S. Caribbean (Ladd, 2012). Coral propagation and outplanting, predominantly using *Acropora* species (spp.), has been successfully used over the past decade in Florida and in the Caribbean for reef rehabilitation. Efforts to date have primarily focused on *Acropora* spp. because these species exhibit faster growth rates than other Caribbean coral species, reproduce predominantly via asexual fragmentation, and can be propagated efficiently using both in-water and shore-based nurseries. Propagation and outplanting techniques are now being developed for additional Caribbean coral species. Scientifically-vetted best practices for nursery propagation, outplanting, and monitoring have been developed, and are used by nursery managers in the Florida Keys, Broward County, Puerto Rico, USVI, and other Caribbean islands to reproduce *Acropora* spp. asexually (Johnson et al., 2011). The FDEP has noted that recent micro-fragmenting techniques have offered hope for propagating slow-growing reef-building corals like *Orbicella spp.*

Also during the same time period, efforts were underway to examine the equivalency between natural and artificial reefs. Miller et al. (2009) examined four artificial reefs constructed of boulders in the Florida Keys 12 years after installation, and found the benthic communities on reference and boulder reefs were dissimilar. Cyanobacteria were abundant on boulder reefs (~8 to 33% cover), but virtually absent on natural reference reefs (0 to 6 percent cover). Cyanobacteria are not often quantified as a separate functional group in monitoring studies, but can inhibit coral recruitment, kill live coral tissue, limit coral recovery, and reduce overall coral cover (Kuffner et al., 2006). The most recent and inclusive study of boulder-based artificial reefs was conducted by Gilliam (2012). This review examines 10 artificial reefs offshore of Miami- Dade, Broward, and Palm Beach counties. The oldest of these reefs was examined 17 years after installation.

While the species richness of stony corals observed was similar between artificial and natural reefs, Gilliam (2012) concluded the overall composition of the benthic communities inhabiting the boulder reefs was dissimilar from those at reference sites. Smaller, "weedier" species were more common on boulder reefs. Larger, reef-structure-forming species were more common on the natural reefs. The giant barrel sponge, which is an important functional group for habitat structure and nutrient cycling, was completely absent from all boulder reefs examined. The density and species richness of gorgonians were also lower on boulder reefs compared to natural reefs. As the information above has become socialized within the natural resource management and regulatory community, combination approaches are commonly seen as more scientifically sound and effective ways of minimizing and compensating for coral reef impacts. Coral relocation as a minimization measure has become a routine BMP. In some cases, the corals are moved to artificial substrates to "jump start" the mitigation services. In addition, combination approaches using coral relocation, artificial reefs, and coral propagation and outplanting are being evaluated as a way to integrate BMPs from the coral reef damage assessment community with that of coastal coral reef managers and regulators in Florida.

2.3 Compensatory Mitigation Planning

2.3.1 Determining the Amount of Compensatory Mitigation Needed to Offset Impacts

The final determination on the amount of compensatory mitigation needed to offset unavoidable adverse impacts is made by the appropriate permitting authority in accordance with applicable regulatory requirements. For example, for projects that require USACE authorization, final determination as to whether compensatory mitigation is required, or not, for a specific project lies with the USACE. EPA, NMFS, and FWS often provide comments and recommendations regarding the need for compensatory mitigation during their review of project proposals and biotic surveys. In the case of small projects where impacts to corals are not significant, and where a range of avoidance and minimization measures are applied, there may be no compensatory mitigation required. For larger projects where there are permanent impacts and unavoidable losses, compensatory mitigation is likely to be required to replace those losses.

The goal of compensatory mitigation is to replace lost functions and services caused by unavoidable impacts. The determination of compensatory mitigation requirements for any project will vary based on the applicable authorities governing the activity, as well as the size and condition of the coral reef and affiliated ecosystems being impacted. Project proponents should work closely with the appropriate regulatory agencies and resource trustees in determining the compensatory mitigation requirements and processes as they pertain to their proposed project. Federal, state, and territorial permitting authorities have varying definitions of mitigation, as well as different requirements for determining appropriate compensatory mitigation under their applicable laws, regulations, and policies. If there is a conflict between the project proponent and multiple permitting authorities, the agencies with legal authority define how to resolve such conflicts.

As stated in Section 1.1, the 2008 Mitigation Rule is the most comprehensive regulation for evaluating coral reef impacts and determining the required compensation for losses of aquatic resources. The 2008 Mitigation Rule establishes requirements and standards for the replacement of unavoidable, permitted losses of aquatic resources, and the functions and services they provide. Compensatory mitigation requirements must be commensurate with the amount and type of impact. A major focus of this approach is replacement of lost ecosystem functions and services.

The EFH provisions of MSA §305(b) also provide authority for evaluating planned events that will impact essential fish habitat on coral reefs similarly using avoidance, minimization, and offset considerations.

2.3.1.1 Challenges in Determining Compensatory Mitigation Requirements

Studies to evaluate compensatory mitigation success for coral reefs prior to the 2008 Mitigation Rule, found that mitigation often consisted of financial compensation for natural resources or out-of-kind compensation (Bentivoglio, 2003 and Yoshioka et al., 2004). Most of the coral preservation or restoration efforts were either never implemented or never monitored so their ecological performance was difficult to evaluate. The complexity of coral reef ecosystems, the uncertainty of recovery and restoration, the incorporation of climate impacts, and the lack of baseline data for coral reefs pose great challenges in effectively implementing effective

compensatory mitigation. Challenges associated with current mitigation strategies include the lack of monitoring on past mitigation efforts in order to document success (or lack thereof), and that many coral restoration efforts that have been implemented are insufficient in duration to provide conclusive evidence of recovery in what are often slow-growing coral reef ecosystems. Additionally, the state of coral reef restoration science has only recently become available, and has not yet been incorporated into models and tools like those readily available for scaling compensatory mitigation in wetlands.

The recommended strategy for coral reef mitigation emphasizes avoidance and minimization of impacts because compensatory mitigation for coral reefs is very challenging and expensive, and has substantial risk and uncertainty. There is limited experience in implementing successful coral reef restoration activities (Bentivoglio, 2003 and Yoshioka et al., 2004).

In light of these challenges, if coral reef restoration is chosen and approved as acceptable compensatory mitigation, both the impact and mitigation sites need to be characterized. Models are often used to determine how much restoration is needed at the mitigation site to replace the losses at the impact site. These models were not specifically developed for coral reefs and therefore require modification. These models compare resource types (kind, size, abundance) to determine debts and credits for similar resources. While this is a fairly straightforward mathematical process, when there are significant differences between impact and mitigation sites in kind, size, or abundance of corals, the models need to be adjusted to account for these differences. Additionally, a mechanism for defining trade-offs of corals of the same kind but different sizes, and between different species between sites is recommended. The following list frames some of the key considerations that must be addressed in completing this process.

- What are the specific “operational measures” to predict future conditions (e.g., coral growth rates, water quality requirements, anticipated water temperature changes/climate changes, recruitment sources)? This information tends to be site-specific, rather than derived from a larger scale (e.g., regional or island-wide). To a large extent, there is presently a high level of uncertainty in modeling future conditions
- What is the extent of temporal loss for aquatic resources, between the time of impact and the projected date of full recovery at the compensatory mitigation site, to achieve replacement of lost resources?
- What is the likelihood of success? Success for mitigation and restoration activities is typically defined as meeting a sufficient level of ecological performance. Often there is a lot of uncertainty regarding project success and it is difficult to define the degree of uncertainty. Additional compensatory mitigation may be required by the permitting authority if the proposed compensatory mitigation fails, or is only partially successful. In some models for calculating compensatory mitigation needs for coral reefs, the likelihood of success is called the “risk factor” (e.g., the State of Florida’s Uniform Mitigation Assessment Method).
- What are the uncertainties associated with the success of the compensatory mitigation? Mitigation plans should address uncertainty, including adaptive management plans and financial assurances, to be implemented if outcomes are different than intended.
- What is the methodology being used to scale the compensatory mitigation activity? There is no preferred methodology for defining confidence interval (e.g., precautionary principle, “most likely,” least cost).
- How far removed (in geographic location) is the compensatory mitigation project? The proposed compensatory mitigation should be acceptable to the regulatory agencies in

  terms of offsetting the permitted impacts at the impact site. There should be consideration of on-site and off-site alternatives to determine which is most appropriate and practicable to offset the permitted impacts. For example, an off-site compensatory mitigation option that reduces or reverses a stressor that adversely affects corals might be a more effective compensatory mitigation alternative than an on-site compensatory mitigation project that doesn't address the stressor(s) that impair the coral reef.

- Is the compensatory mitigation project in-kind (aquatic resource of similar structural and functional type to the impacted resource) or out-of-kind? Out-of-kind compensatory mitigation may require more compensatory mitigation than in-kind.
- How will the compensatory mitigation activity be provided long-term protection?
- If required by the permitting authority, what financial assurances will be provided to ensure that funding is available to complete, monitor, and manage the compensatory mitigation activity?
- What activities are needed for long-term operation and management of the compensatory mitigation activities and how will those be funded (if required by the permitting authority)? For example, while mitigation activities are intended to be self-sustaining there may be a need for ongoing invasive species monitoring and control or debris removal.

Through efforts to define and implement appropriate compensatory mitigation in coral reef ecosystems, several additional challenges and limitations have been identified, including the following.

- Difficulty in defining a "mitigation credit" for mitigation banks and in-lieu fee programs.
- Difficulty in dealing with dissimilar resources at impact and compensatory mitigation sites.
- A limited number of projects have required compensatory mitigation for coral reefs to date, therefore experience is limited.
- Limited record of demonstrated ecological performance. Past compensatory mitigation projects were not implemented, not adequately monitored, and/or lacked performance standards.
- Potentially costly and time-intensive data collection. The same level of information for assessments is needed at both the impact and the compensatory mitigation sites, which may be costly and time-intensive depending on the project.
- Difficulty in defining recovery potential for temporary impacts and at the mitigation sites.
- Lack of knowledge about stressor thresholds for coral reefs (e.g., water quality conditions required for recovery).
- Inability or infeasibility to alleviate some stressors successfully (e.g., climate change: ocean warming, sea level rise, ocean acidification).
- Limited knowledge of the ecosystem functions and services of coral reefs provided on natural versus man-made coral habitat. Currently, man-made coral habitat is addressed on a case-by-case basis.
- Coral reef-related compensatory mitigation projects start out with a high degree of uncertainty due to the complex local and global stressors that cumulatively act to degrade the ecosystem over time, resulting in potential shifting baselines,[4] which may ultimately increase the risk of failure for the project.

While there are challenges to determining the compensatory mitigation required for coral reef

[4] Shifting baseline refers to the condition where regional or global stressors cause an entire ecosystem (e.g., all coral reefs) to change from a previous point in time. Even the high-quality coral reefs today may not have the same species assemblages and conditions as those coral reefs in the past. The coral reefs of the future may not have the same species assemblage or conditions as the coral reefs of today due to global stressors such as sea level rise or changing sea temperatures.

impacts, there are opportunities for improvement. There currently are no feasible local actions that can be taken to alter shifts in temperature and biochemistry associated with climate change and ocean acidification. However, there is a growing body of evidence that shows such impacts can be reduced by implementing efforts at a local level to increase reef resilience. There are a number of tools and approaches that acknowledge, and account for these stressors, in planning for projects. Ecological performance can also be improved by applying lessons learned from past coral reef ecosystem compensatory mitigation efforts (e.g., same teams working on similar actions, learning from past experiences, and making improvements to future efforts). There are efforts underway in the Pacific by an interagency team to address some of the issues and challenges in coral reef assessments, analysis of coral reef impacts, and identification of potential compensatory mitigation requirements. Similar work is needed in the Atlantic/Caribbean.

2.3.1.2 Analytical Tools for Determining Compensatory Mitigation Requirements

Once the impact and compensatory mitigation sites have been assessed, appropriate analytical tools to inform the compensation of lost functions are needed. As a starting point, in looking for possible modeling options, it has been logical to borrow from prior wetland modeling efforts. Those efforts fell largely into two categories, indexing and equivalency. Some assert that because of the complexity of fauna and habitats in coral reefs, indices may oversimplify reef condition and inadequately describe replacement of lost function. For this reason, many consider the coral reef habitat equivalency analysis (HEA) modeling concept more effective. HEA modeling has been used with success in injury cases (see Section 3.5.1).

Present efforts assume that characterizing the condition of coral reefs is an appropriate proxy for function as a best science approach. In all cases, the limiting factor in identifying appropriate coral reef compensatory mitigation options, is finding a tool that can be applied with relative ease, and provide a repeatable, reasonable, and acceptable description of compensation needed to replace lost functions and services.

In coral dominated systems, the modeling of replacement of loss is tied to the corals, because of the length of time it takes them to recover, and that they serve as structure for other fauna. Where other organisms dominate a coral reef ecosystem, those alternate fauna (e.g., seagrass, mangroves, soft corals, or macroalgae) could be used as surrogates for coral reef recovery, with the assumption that recovery of these alternate species that establish more quickly, indicate that the coral reef ecosystem as a whole is on a trajectory for successful recovery. The same information must be collected for any potential compensatory mitigation site with additional consideration given to recovery potential—the baseline of present condition at the recovery site compared with historical conditions and what could be recovered through proposed restoration activities as compensatory mitigation.

Assessment tools to determine compensatory mitigation from other aquatic habitats, such as wetlands and streams, have required significant adjustments to be used in coral reef systems for the following reasons:

- Experience in the study of coral reef habitats and coral reef restoration is more limited.
- The number of successful coral reef restoration or coral reef compensatory mitigation projects implemented to date is limited.
- The dominant organisms within coral reefs are more diverse and slower growing than

- those in wetland communities, requiring longer monitoring periods to confirm successful implementation.

To date there is no universally accepted model to determine the amount of coral reef compensatory mitigation. HEA is a tool that uses a defined unit, such as acre or coral colony years, to compare the impact area with a proposed restoration site. The determination of the appropriate unit of measure for HEA would need to be made in consultation with the applicable permitting authorities. The model could compare acres of coverage by the same forms of coral or compare the size and species of corals. This is done by characterizing the resources to be lost and tallying them against those to be recovered at the compensatory mitigation sites. A requirement of the model is that the same characterization data must be gathered at both the impact site and the proposed compensatory mitigation site. HEA has many assumptions, and has challenges in determining equivalence for dissimilar resources, as well as defining recovery potential at proposed recovery areas. A complicating factor of this method is the requirement to use similar units for both the impact area and the compensatory mitigation site. In wetlands, traditionally, the units have been an area-based unit combined with a measure of condition. However, in coral reef ecosystems, it is very difficult to define coral reef area units that are similar between reef sites. As a result, other units, like coral colony years, are often selected, and trade-off models for dissimilar units have been developed. Additionally, accounting for temporal losses and likelihood of success is challenging due to limited science and examples of success to frame these parameters. Present efforts are conducted on a case-by-case basis.

2.3.2 Develop a Mitigation Plan

A draft mitigation plan should accompany any permit applications and should include plans to provide long-term protection and management of the mitigation project. The 2008 Mitigation Rule includes a description of 12 elements that should be included in a mitigation plan. Even if the proposed project is not subject to the 2008 Mitigation Rule, these components are useful to consider when planning for protection and restoration of aquatic resources. The level of detail in the mitigation plan should be commensurate with the scope and scale of the impacts. The elements of a mitigation plan include:

- Objectives and method of compensation.
- Site selection.
- Site protection instrument describing legal arrangements.
- Baseline information on the mitigation site.
- Determination of credits.
- Mitigation work plan.
- Maintenance plan.
- Performance standards.
- Monitoring requirements.
- Long-term site management plan.
- Adaptive management plan.
- Financial assurances.

2.4 Post-Project Actions

2.4.1 Conducting Post-construction Surveys

Ideally, any required compensatory mitigation should be implemented before the start of construction. If not implemented before construction, then the compensatory mitigation action would be implemented no later than when the construction activity impacts the resource of concern. Sometimes, the permitting authority may allow the compensatory mitigation action to be implemented after the construction. In these cases, the compensatory mitigation action should be completed as soon as possible, in order to minimize temporal losses. Temporal losses for coral reefs may be substantial because of the slow rate of coral growth and recruitment.

Surveys, such as those discussed in Section 2.2.1, may be needed post-construction to determine the actual losses to aquatic resources. Due to the difficulty in predicting indirect impacts, such as sediment and turbidity impacts during construction, the indirect impacts may be over- or under-estimated in the planning stage. The post-construction survey provides a method to adjust the amount of compensatory mitigation necessary to address the actual amount of loss occurred. The permitting authorities will determine what level of detail is needed for the post-construction survey in consultation with other agencies as appropriate.

2.4.2 Long-Term Management of Compensatory Mitigation

Implementing the compensatory mitigation action is only the beginning of the process of ensuring unavoidable losses to coral reef resources are adequately replaced per applicable laws and regulations. Once the compensatory mitigation action is constructed, appropriate measures need to be incorporated to ensure the long-term durability and sustainability of the compensatory mitigation action.

Directly after the compensatory mitigation action is executed, the project proponent begins to implement a monitoring program as approved by the permitting authorities to ensure the compensatory mitigation action is meeting its identified performance standards. Duration of monitoring will be determined by the permitting authority. Compensatory mitigation actions are typically monitored for 10 years, but the duration may be shorter or longer depending on how quickly the compensatory mitigation action is expected to meet its performance standards. In the event that the compensatory mitigation action is not performing as anticipated, implementation of adaptive management measures may be necessary. Chapter 5 provides more information on performance standards, monitoring, and adaptive management.

Once the permitting authority has concurred that the compensatory mitigation action is meeting the targeted performance standards, regular management of the compensatory mitigation action will likely still be necessary. Depending on the compensatory mitigation action, regular management may be minimal. In some cases, such as if control of invasive species is required, regular management may be a substantial commitment. Project proponents should identify the long-term management activities of the compensatory mitigation during the planning process, and discuss long-term management commitments and expectations with the permitting authority.

2.4.3 Unauthorized Impacts to Coral Reefs During Construction

Accidents happen and may be noted during construction or during the post-construction survey. When unauthorized impacts happen during a planned activity (e.g., cable drag, anchoring, turbidity plumes associated with a permitted dredging project, and dredging occurring outside of permitted area), it is important to work closely with the regulatory and management agencies to quickly quantify and address the unauthorized impacts. Depending on the type of unauthorized impact, injury characterization and response steps may follow the protocols outlined in Chapter 3. Responses may include agency enforcement action or an increase in compensatory mitigation requirements in accordance with applicable laws and regulations.

2.5 Emerging Tools and Strategies

As mentioned throughout this document, mitigating and restoring coral reef ecosystems is a relatively new science compared to mitigation and restoration of many other aquatic and terrestrial habitats. The science of, and management strategies for, coral reef mitigation and restoration continue to evolve. This section highlights a few emerging strategies for addressing the challenges of coral reef compensatory mitigation and restoration.
There are efforts underway in the Pacific by an interagency team to address some of the issues and challenges related to compensatory mitigation for coral reefs. The team aims to develop a series of "tools," including a coral reef assessment methodology suitable for assessing condition at impact and mitigation sites, a model for determining replacement of lost resources, tools for incorporating temporal loss and uncertainty into mitigation requirements, and recommendations on mitigation performance standards and mitigation monitoring. Similar work is needed in the Atlantic/Caribbean.

2.5.1 Mitigation Banks and In-Lieu Fee Programs

Tools such as in-lieu fee programs and mitigation banks, which have been developed to improve compensatory mitigation efforts for other habitats, are being considered for use in coral reef ecosystems. Use of in-lieu fee programs and mitigation banks have the potential to provide more effective compensatory mitigation outcomes because they usually conduct those activities within a larger contiguous area rather than multiple small and disconnected projects spread out over many different sites. These programs are generally overseen by government agencies or conservation organizations with experience and a track record in restoration, and thus have a high likelihood of success. In the 2008 Mitigation Rule, USACE and EPA established a preference for using federally approved in-lieu fee programs and mitigation banks for compensatory mitigation over permittee-responsible mitigation sites. These tools and associated terms are defined below, and a short discussion of activities currently underway to develop these tools for use in coral reef systems follows.

A significant challenge for these programs in marine systems is ownership, because government entities often own the submerged land, thus coral reefs are not usually privately owned. Legal agreements or permit approvals may be required for private entities to establish banks on government-owned submerged land.

A **mitigation bank** is a site, or suite of sites, where resources (e.g., coral reef ecosystems, wetlands, streams, riparian areas) are restored, established, enhanced, and/or preserved for the purpose of providing compensatory mitigation for impacts authorized by federal, state, or territorial permitting authorities. In general, a mitigation bank sells compensatory mitigation credits to a project proponent/permittee whose obligation to provide compensatory mitigation is then transferred to the mitigation bank sponsor. Credits are the unit of measure (e.g., a functional or area measure or other suitable metric) representing an attainment of ecological functions or condition at a compensatory mitigation site. The measure of function is based on the resources restored, established, enhanced, or preserved. Credits are defined specifically for each mitigation bank or in-lieu fee program, depending on the appropriate metrics or tools available for the resource type or the geographic area. Credits may be defined as acres, through the results of ecological assessment methods, such as functional or condition assessments, or other types of metrics. The operation and use of a mitigation bank are governed by a mitigation banking instrument approved by the applicable permitting authority (33 CFR 332.2 and 40 CFR 230).

Hawaii is developing a proposal representing the first mitigation bank for coral reefs. The Hawaii DLNR mitigation bank site currently focuses on protection and restoration of corals in Kaneohe Bay. For more information on this effort, contact the USACE Honolulu District Office or Hawaii DLNR.

An **in-lieu fee program** is one involving the restoration, establishment, enhancement, and/or preservation of aquatic (includes both freshwater and marine) resources through funds paid to a governmental or non-profit natural resource management entity to satisfy compensatory mitigation for impacts authorized by federal, state, or territorial permitting authorities.

Similar to mitigation banks, an in-lieu fee program sells compensatory mitigation credits to project proponents/permittees whose obligation to provide compensatory mitigation is then transferred to the in-lieu fee program sponsor. However, subject to the approval of the permitting authority the in-lieu fee program may be allowed to sell “advance” credits prior to full implementation of the activity. The rules governing the operation and use of in-lieu fee programs are somewhat different from the rules governing operation and use of mitigation banks. The operation and use of an in-lieu fee program is governed by an in-lieu fee program instrument approved by the applicable permitting authority (33 CFR 332.2 and 40 CFR 230).

The USACE Honolulu District has received a proposal by the Micronesia Conservation Trust for an in-lieu fee program on Guam that would consist of terrestrial and marine compensatory mitigation projects to establish, restore, enhance, and/or preserve coral reefs. That project is currently on hold. For more information, contact USACE Honolulu District Office.

3.0 FRAMEWORK FOR RESPONDING TO UNPLANNED CORAL REEF IMPACTS

Unplanned impacts to coral reefs are caused by actions such as ship groundings, anchor drags, or exposure to oil and hazardous substances that cause injury to the reefs. There are certain elements of the processes for evaluating planned and unplanned coral reef impacts that are similar, such as minimizing response actions to reduce further injury, quantifying the impact, determining replacement value, evaluating restoration options, and quantifying the amount of restoration needed to restore the injury. However, there are many legal authorities that govern the response to, assessment of, and the determination of damages for unplanned coral reef events. Depending on the nature and location of the incident, there are multiple legal pathways that could be triggered at the federal, state, or territorial level.

As lead agencies can differ based on location of the injury (even within states and territories), it is recommended that the RP always consult with the land management agency first. Additional regulatory and management authorities will need to be consulted prior to taking any response action. For events that occur within the boundaries of a National Park or National Marine Sanctuary, specific laws and regulations apply (e.g., for National Parks, the SURPA and for Marine Sanctuaries, the NMSA). For impacts due to oil or hazardous substance exposure, the NRDAR provisions found in OPA or CERCLA may apply. In cases where coral species listed as threatened or endangered under the ESA or their designated critical habitat are potentially impacted, consultation with NMFS may be required prior to any response action. State, territorial, or local laws may also apply and a detailed list of regulations that cover response and restoration activities to coral reef injury is found in Appendix I. Based on these laws and regulations, permits may also need to be obtained to authorize the recovery action.

In the aftermath of an unplanned impact the first priority, after human health and safety, is eliminating the source of the injury, such as a removing a grounded vessel or cleaning up an oil spill. Once the emergency actions have been completed, the process typically moves into conducting an injury assessment and determining restoration needs. The assessment and restoration methods listed in the following sections can be similar regardless of the source of injury, although there may be case-by-case variation. Again, the specific federal, state, territorial, or local agencies must be engaged early in the response to determine the specific laws, regulations, policies, and guidance that cover any response and restoration activities.

3.1 Natural Resource Damage Assessment and Restoration

Under OPA or CERCLA, NRDAR is the legal process that federal agencies, together with the states and tribes, use to evaluate the impacts of oil spills, hazardous waste sites, and ship groundings on natural resources, both along the nation's coast and throughout its interior. The agencies, referred to collectively as natural resource trustees, work together to identify the extent of natural resource injuries, the best methods for restoring them, and the type and amount of restoration required. In smaller vessel groundings, large groundings with no threat of oil or hazardous materials releases, and other unplanned events, other processes are used. Although similar to NRDAR there can be many variations depending upon the land management agency that has had trust resources impacted, and the legal authority under which those agencies work. For example, the NPS has specific guidance for unplanned events, which can be found in the 2003 NPS Damage Assessment and Restoration Handbook.

The intent of the NRDAR process is to document, then restore, rehabilitate, replace, or acquire the equivalent of injured natural resources and services. It is not designed to impose punitive measures upon the RP, nor obtain money for other purposes, although some agencies have additional authorities to seek criminal and civil penalties associated with unplanned events. An injury is defined as any observable or measurable adverse change in a natural resource, or resource service. Extent of injury and restoration actions are usually determined relative to a baseline, which is defined as the condition that would have existed had the injury not occurred. Baseline is not necessarily constant, nor is it the same as the condition that occurred immediately prior to the injury, or the same as a long-term average condition. Following injury, primary restoration actions are intended to return the injured resource to baseline, while compensatory restoration provides compensation for the interim services or resources lost until the injury recovers. In addition to natural resource losses, impacts to coral reefs can also create losses to human use. Lost human use is not addressed in this Handbook.

The legal authorities that provide for damage assessment and restoration authorities vary (OPA, CERCLA, NMSA, SURPA, and individual state statutes) and, depending on the nature and location of the incident, there are multiple legal pathways that could be triggered at the federal, state, or territorial level. However, all generally follow the framework outlined below:

- A **preliminary assessment** is conducted to determine whether any impacts have occurred. Scientists may collect data, review scientific literature, and use mathematical models to help predict the effects of the incident on trust resources.
- A formal **injury assessment and restoration determination or planning** phase, during which the trustees quantify the injuries through scientific and economic studies and then identify potential restoration projects to offset the loss (e.g., beach and shoreline enhancements, creation of oyster reefs or other shellfish habitats, and programs to monitor the recovery of species and habitats). Under OPA, the restoration plan is released for public feedback. However, this is not a requirement of all legal authorities.
- **Restoration selection and implementation** aims to return the injured resources to their original condition and compensate the public for interim losses, e.g., the time it takes the resources to recover, as well as lost human use of the resources. Throughout the damage assessment process, the co-trustees may decide to work with the RP (the entity whose property or actions caused the injury). The RP may be requested to pay for the assessment and restoration, and may be invited to participate in restoration activities.

The process of determining restoration projects is driven by law, science, economics, and under OPA public input, and is led by designated federal, state, territorial, and tribal trustee agencies. The outcome of the damage assessment process is generally a settlement with an RP for "damages," which can include agency response costs, the trustees' cost of the damage assessment, and the cost of restoration (to be implemented by the trustees or RP), monitoring, and trustee oversight. Under OPA, in the event that the RP refuses to pay damages, NOAA and its co-trustees may file a lawsuit or submit a claim to the Oil Spill Liability Trust Fund.

Restoration under the damage assessment process generally falls into one of three categories outlined below:

- **Emergency Restoration** actions are those taken by trustees to prevent or reduce continuing resource injuries and avoid potentially irreversible loss of natural resources. In the case of unplanned coral reef impacts, these can include righting and stabilizing dislodged corals, removal or stabilization of rubble, and removal of other immediate threats such as anti-fouling paint.

- **Primary Restoration** includes actions conducted by trustees to return injured natural resources to the condition that would have existed if the incident had not occurred (this condition is usually referred to as the baseline). Some natural resources (such as coral reefs) might recover very slowly, or not even recover at all, from injuries. Trustees are authorized to conduct primary restoration to speed the recovery of the injured resources, such as reconstructing physical habitat that was destroyed, or taking measures to protect or increase the population of a threatened or endangered species. In the case of coral reef injuries this can include rebuilding structural complexity of the impact site, augmenting biological recovery with coral transplants, removing opportunistic species that could result in a phase shift at the site, or other actions that would facilitate recovery the injury site to baseline. Primary restoration will also include monitoring to ensure that recovery of the resource impacts is proceeding.

- **Compensatory Restoration** includes actions conducted by the trustees to address the lost natural resource services that accrue from the date of injury until recovery to pre-spill conditions is completed. These projects typically occur offsite of the injuries but in rare occasions can also be onsite. While the resource is impaired, it is unable to provide services on which other parts of the ecosystem and the public rely. Trustees are authorized to ensure that compensatory restoration projects are implemented to compensate the public for these interim losses.

UNPLANNED IMPACTS

3.2 Response and Resource Protection

Following notification of the appropriate federal, state, and territorial agencies that an unplanned impact has occurred, emergency response activities may be initiated by a response agency and/or other resource agencies. The section below outlines two response actions that are specific to coral environments:

3.2.1 Vessel and/or Debris Removal

Activities may be undertaken to remove the source of the impact (e.g., refloat and/or remove the vessel in the event of a grounding) and to prevent additional impacts such as fuel or oil release, or injury caused by debris associated with the initial impact. In consultation with the appropriate agencies, the response agency may be required to prevent additional impacts resulting from the response prior to initiating emergency response actions. There are numerous examples of unplanned impacts to coral reefs resulting from vessel groundings in which the emergency response activities resulted in significant additional damage to the resource (e.g., the T/V Margara Puerto Rico grounding in 2006 and the M/V Jireh grounding in Puerto Rico in 2012). BMPs to avoid and minimize natural resource injuries to coral reef habitat benefit everyone involved, in that avoiding and minimizing these injuries reduces overall settlement costs to industry, as well as, helps resource agencies fulfill their mandates for public trust resources. Below is a list of BMPs that may help minimize the potential for additional impacts during a vessel removal. This list is not all-inclusive and the trustee and regulatory agencies will make the final decisions as to when these activities are appropriate.

- Determine a vessel extraction path that will have the least impact to the surrounding coral habitat (may or may not be the same as the ingress path). This process can be facilitated through the use of bathymetric charts, aerial/satellite photography, and rapid area surveys by qualified divers (this practice is codified within the Wildlife sections of some USCG Area Contingency Plans and should only be undertaken in conjunction with emergency response actions to ensure the safety of participants collecting data).

- Temporary buoys should be used to mark the extraction path and differential global positioning system (DGPS) plots of the extraction path should be input into the grounded vessel and all towing vessels' navigational systems to assist the salvers in staying on course to avoid coral areas to the maximum extent possible.

- Portable DGPS units should be maintained at the bow and stern of the grounded vessel at all times to record any shift in the vessel's position, as well as to record an accurate track of the extraction path prior to sinking.

- Grounded vessels often choose to take on ballast water to stabilize vessel and prevent rolling while salvage efforts are mobilized. Caution is needed in taking this action due to increased risk of impacts to resources, and the potential for releasing invasive species when the ballast water is released. As a general practice, petroleum products often are removed immediately to prevent a spill.

- If anchoring or mooring the grounded vessel or salvage vessels, minimize the number of anchors or spuds, control drag, and seek appropriate anchoring locations devoid of sensitive benthic habitats like coral reefs and sea grasses.

- Take actions to avoid prop scars and prop wash injuries to marine resources with all vessels, barges, and tugboats involved in salvage operations. In shallow water, avoid using the propulsion systems and, if possible, moor the tugs and use a ground tackle system to provide maneuvering and pull.

- Salvage activities should be conducted at sufficient tide and water depths to minimize any risk to reef resources and other sensitive habitats.

- Create and use designated anchorage areas that have been surveyed by divers and are absent of coral. It is further recommended that all anchors be placed with the assistance of divers to avoid all coral resources. Anchoring should not occur outside of the designated anchor grid boxes.

- Use floating lines for anchoring and salvage operations or secure lines to prevent line sweeping of coral and sea bed. If non-floating lines are used, line sweeping should be accounted for within the designated anchorage area.

- Install, monitor, and remove underwater equipment or booms to prevent coral damage or fish and wildlife entrapment.

3.2.2 Response-based Protection Tactics

Response-based protection tactics may be undertaken to “minimize or mitigate” impacts to natural resources or services. When there is a threat of oil or hazardous materials releases, decisions regarding response actions are made by response agencies, with technical input from resource agencies. When there is no threat of a release the decisions for response actions may fall to the land management agency. Response actions can be implemented either by a response agency (e.g., USCG), or an RP under the authority of the response agency or land management agency. These actions could include proactively removing and relocating sensitive resources such as corals, in order to minimize damage, allow the removal of a grounded vessel, to enable responder access, or refloat the vessel.

3.3 Emergency Stabilization and Triage

Often, it is possible to act to protect or save damaged corals and other organisms from additional impacts and mortality through site stabilization and biological triage.

3.3.1 Substrate Stabilization

Fractured substrate and loose rubble is of concern in large reef injuries associated with vessel groundings and commercial anchor drags. Unless fractured substrate is repaired, it may continue to erode the reef framework. Un-stabilized rubble may roll around and cause additional damage to the site and/or previously un-impacted areas if it is not removed. Rubble may need to be stabilized and/or incorporated into reef framework repair. However, rubble not used in those processes may need to be disposed of appropriately. Depending on the size and severity of the injury, substrate stabilization may be incorporated into the larger primary restoration plan.

3.3.2 Biological Triage

Biological triage activities should occur as soon as possible following an injury. Fractured, dislodged, and overturned corals have a short window of opportunity in which they can be salvaged and stabilized. The goal of biological triage is to save those organisms that are at risk of mortality and/or loss from fragmentation or dislodgment from the reef. Biological triage may occur simultaneously with the initial site assessment, and should consist of saving as many at-risk corals as possible. Any biological triage activities that are conducted should be coordinated so as not to interfere with any response activities and evidence or data collection.

3.4 Assessing Impacts

During this phase, quantitative surveys are conducted to identify and quantify the negative impacts of the incident, including those resulting from cleanup or other actions taken as part of a response. Ecological studies are conducted to evaluate how, and to what degree, natural resources may have been injured. Morphological and geological studies may be conducted to evaluate the impacts to the substrate. Economic studies are used to determine how recreational activities, such as fishing and swimming, have been affected. If other resources such as infrastructure or cultural/historical resources have been impacted, the assessment will also include the nature and extent of those injuries including losses to the services those resources provide.

There are multiple assessment methods that can be used to characterize the extent of a coral reef impact. The degree of data collection necessary will be informed by multiple considerations such as those discussed above. A useful injury assessment should provide an estimate of the size of the impact, types and amounts of substrate damage, and reef habitat complexity, and describe the coral community composition including coral densities, size distribution, and species diversity. When possible, the injury assessment is used to compare the impact site to an un-impacted reference site that may have also been assessed, to provide baseline information for targeting restoration actions (Quataert et al., 2015). This information is used to quantify the injury to coral reef resources, inform the development of a restoration plan, and scale compensatory restoration options.

The following discussion of assessment techniques is based on the current detailed site assessment protocol that is used by the NOAA Damage Assessment and Restoration Program in responding to vessel groundings. The use of these techniques may vary by agency and other federal, state, and territorial agencies may use additional techniques not listed here.

3.4.1 Mapping the Impact Site

The size of the impact can be estimated using multiple methods depending on the resources available. The use of traditional methods (measuring tapes, lines and buoys, and surface DGPS) can be difficult and time consuming, and can introduce measurement errors. While there is a possibility for error, these methods are sufficient for preliminary assessments to estimate the scale of the impact, and in cases where funding for more advanced assessment techniques is limited. These methods may also be sufficient to calculate damages when assessing small injuries.

In cases where there is a large impact, an underwater sonar mapping system like Aquamap is a good alternative, as it can precisely map the dimensions of the impact. Both side scan and multi-beam bathymetric survey methods are excellent remote mapping methodologies. A photomosaic of the impacted and surrounding reef area is an excellent tool for collecting high-definition, large format images. Photography of the impacted and non-impacted reef sites should be performed as soon after the grounding as possible in order to visualize the contrast of white impacted reef, compared with the surrounding un-impacted reef. These actions provide photographic evidence of the entire site that can be used to help inform activities in the field, both pre- and post-reef restoration. If the technology is available, high-definition video of the site should be collected by divers in addition to photographs of the site.

3.4.2 Coral Community Composition

In order to describe the reef community present at various grounding sites, transects are typically performed outside the impact area by trained marine scientists. For injuries impacting large areas, 10 m^2 (10 m x 1 m) belt transects are typically performed. For injuries impacting smaller areas, normally four transects are sufficient. Within each transect the following data are recorded:

- The number of each coral type to lowest taxon (hard or soft corals where applicable).
- The size class of each colony (maximum height or width).

- Condition of each coral (live, partial mortality, bleached, healthy, etc.).

The data collected help determine the density of corals, their size distribution, species composition, and condition of the colonies found on the reefs outside the impact area. Depending on the reef community, other groups are sometimes included in the sampling protocol (e.g., sponges, giant clams). This information provides a better understanding of the resources lost within each of the grounding sites. The number and location of transects to be performed are determined once the extent of the impact has been delineated. A minimum of 10 transects should be distributed around the perimeter of the impact, as long as the reference area that is being surveyed is believed to be similar to the impacted habitat. Sometimes transects cannot be done immediately adjacent to the impact because there is the potential for partial impacts from the grounding, or different habitat types are present. In that situation, areas that are as similar as possible to the impact are surveyed.

Sampling sites can be stratified into different habitat types immediately adjacent to the injury to represent resources lost in those specific zones. Since coral demographics are highly influenced by depth, care should be taken to make site comparisons within similar depth zones. Depending on the reef type, belt transects are normally positioned perpendicular to the reef slope and include both spurs and grooves along the reef shelf at the same depth as the impact. Some transects may be placed inshore of the impact if the depth remains constant. If there is a change in depth, it could affect the composition of the reef community in the assessment area. Once transects are laid out, the location of each transect is mapped or recorded using buoys and a handheld DGPS. The direction and depth of each transect are also recorded.

3.4.3 Topographic Complexity

In order to estimate the topographic complexity of an impacted reef, measurements are taken to calculate the Rugosity Index (RI). RI is the ratio between the total length of a chain and the length of the same chain when molded to a reef surface. A perfectly flat surface has an RI of one. Higher numbers indicate a greater degree of architectural complexity. Rugosity transects are typically performed using a 10 to 20 m chain in similar areas as the belt transects. Measurements focus on the structural complexity of the reef substrate itself, and do not include octocorals. Side scan and multi-beam bathymetric surveys are an excellent method to conduct site rugosity calculations. The survey can cover 100% of the area, rather than the measurements a diver can collect by chain, which would then be averaged across the whole site. Bathymetric survey methods are safer (no divers in the water), faster (one boat, one day), and replicable, and the results can be pulled into graphic outputs that all users can understand. Transects can be cut through the survey data to calculate the RI for any of the locations on the impact site. Topographic complexity may also be calculated on multiple scales using LiDAR data (Brock et al., 2006).

Large sandy areas are normally left out of the rugosity measurements since they are usually identifiable in the mapping process, and are not included in the lost habitat estimates. Sand channels may or may not be included depending on the habitat type, size of sand channels, whether or not sand channels were able to be mapped, and how the rugosity measurements will be used. In addition to being a strong indicator of habitat refuge, rugosity is also a key measure of coastal protection in dissipating wave and water energy.

There are two accepted equations to calculate rugosity: $R = (l/d)$ and $C = (1 - (d/l))$, where "*R*" is a measure of rugosity, "*C*" measures complexity, "*l*" is the length of the fully extended chain, and "*d*" is the distance covered by the conformed chain. Returning rugosity to within 10% of the reference area is recommended as a restoration performance criteria target after groundings. To clarify this restoration target, the calculation method used must be specified. If the rugosity calculation (*R*) is used, then the rugosity should be returned to within five percent of the reference area. If the complexity equation (*C*) is used, 10% may be acceptable.

3.5 Scaling Compensation

The general framework used for determining how much a compensatory restoration action will offset a resource injury over time is referred to as the scaling approach. Where planned restoration actions are going to provide the same or comparable resources or services, the objective of scaling is to ensure that the quantity of the resources or services provided through restoration will be equivalent to interim losses (with discounting). Resource-to-resource or service-to-service techniques are usually rooted in the HEA or a Resource Equivalency Analysis (REA) method (Julius et al., 1995; Milon and Dodge, 2001).

3.5.1 Habitat/Resource Equivalency Analysis

The HEA method is generally used where the resource injury and/or the restoration action can (i) be generalized into categories (e.g., reef flat, reef crest, or outer reef) that represent their overall habitat services and functions and (ii) where the overall services per unit of injury (percent of service loss) or restoration (percent of service gain) and rate of recovery (shape and time) can be applied uniformly over a discrete area of injury or area of restoration. As mentioned in Section 2.3.1.2, HEA may also be used for crediting associated with DA permits for CWA §404 authorizations, mitigation banks, or in-lieu fee programs. Injury assessment data (e.g., degree and duration of oiling) are often used to attribute a degree of service loss for areas similarly affected, as well as, to predict an overall recovery timeframe for that area. Even in this relatively simple model, site-specific differences in coral abundance, coral and invertebrate species assemblages, location of other marine habitats such as seagrass, and other factors may need to be taken into account.

In order to effectively use HEA/REA, the spatial and temporal extent of the injury must first be quantified. This can be accomplished with a variety of field assessment approaches. An incremental approach can be used in which lost area or lost organisms are measured. A before-after-control-impact (BACI) monitoring design can be used to compare changes in abundance before and after an impact between control and impact sites (this is less commonly done for unplanned impacts, but can be appropriate for intentional injuries, such as development). After Control Impact (ACI) can be used to compare relative abundances between control and impact sites; while less powerful than BACI (because poorly executed ACI can confound natural differences in trajectory among sites), ACI is often the best tool available for injury assessment following coral reef groundings. There are also a variety of ways to quantify biota, including:

- Counts per m^2, extrapolated to a total population estimate.
- Percent cover, extrapolated to total m^2 of biota.
- Biomass per unit area, extrapolated to total biomass.
- Volume per unit area, extrapolated to total volume of a species.

It is the process of determining how to quantify the lost biota at a site that, by default, ultimately selects a "metric" for the HEA/REA calculation.

Generally speaking, indices (such as scores or ranks), qualitative data (rare, common, etc.) and quadrat counts (using arbitrary rules for counting what is in or out) are problematic metrics, because they are difficult to defend for objectivity, or extrapolate to determine total loss. For coral reef injuries, the most common metrics are percent coral cover, total amount (hectares, etc.) of a given type of habitat, or counts (direct or extrapolated) of coral colonies by species and size categories. While typically more time-intensive to gather, count data is often more informative. Count data can provide an itemized inventory of colonies—which can be used to help calculate recovery (by providing detailed species demographic information), and can be modeled to account for differences in services provided among species or colony sizes. Some injuries may cause a relatively small loss in total coral cover, but result in a huge loss in the total number of coral colonies; count data is particularly useful in such instances. If needed, count data can also be used to back-calculate to alternative metrics such as percent cover, tissue, etc. while the reverse is more problematic.

Once the metric is selected, an HEA or REA is used to balance injury loss against restoration gain. Custom-developed spreadsheets, such as those used by NOAA, or publicly available HEA freeware (Kohler and Dodge, 2006) can be used to perform HEA. Though some federal agencies have utilized HEA/REA to work across habitat or ecosystem types, HEA/REA works best when the injured and restored habitats are directly comparable. The mathematical framework is relatively straightforward, but fundamentally an HEA is only as good or reliable as the input data for the calculation.

A summary of the current REA scaling approach being used for coral reef injuries is described in the section below:

3.5.2 Example Coral REA Scaling Approach

A coral reef is a significantly more complex ecological system than the habitats for which REA and HEA were originally conceived. From site to site, reefs may be highly variable in terms of structure, rugosity, core species, species assemblages, and species diversity. Each reef "habitat" may also have many different core species of various sizes/ages. Further, each coral species present, is itself both a specific living resource and a feature that helps define a reef's particular characteristics and services as habitat to other dependent natural resources. One square meter of reef can easily contain more than 20 individual stony or octocorals plus numerous other species (algae, sponges, invertebrates, crustaceans, small fish, etc.) that help comprise and/or rely upon the reef ecosystem.

Depending on the type and degree of impacts and environmental setting, some individual resources may have the potential to recover relatively quickly (in years) while others (e.g., large and/or rare corals) may have very long recovery horizons (decades to centuries) or may never recover at all.

In the U.S. Caribbean, generalizing losses and restoration relationships across all injured corals would likely result in under- or overestimation of interim coral losses and compensatory restoration needs. Therefore, a model comprised of a matrix of independent REAs that considered the injuries to, and recovery characteristics of, each core reef component (by species class) would better represent the complexities associated with the coral reef losses.

Such a model would also provide a better estimate of both the interim coral losses, and the scale of restoration needed to restore the same or comparable resources or services to compensate for those losses. As described in Kolinski et al. (2007) and Viehman et al. (2009), this modified type of REA uses a resource-to-resource method that references the number organisms lost and the number gained through restoration. This approach examines the size distribution of species or functional groups of different corals and allows for comparisons between ecological services. This method allows for the quantification and aggregation of losses across species, taking into account the different species injured, the sizes/ages lost, anticipated recovery rates, and, similarly, to identify the scale of the proposed restoration required to restore or replace coral species comparable to those lost over time.

Using this approach, the metric for scaling is a coral colony year (CCY). A CCY is not equal to the coral age. CCY is a proxy for services provided and/or, in the case of any injury, lost during a one-year period of time for a particular size and type of coral. While the initial CCY value is only directly comparable to others within the same size/species group, equivalency between sizes and groups can be gained by utilizing a combination of a linear size and service weighting. The key inputs into this analysis are the size/species distribution and the recovery time. The analysis also considers discounting and other inputs used in REA, such as relative function, time to maturity, and project lifespan.

3.6 Coral Reef Restoration

3.6.1 Development of Restoration Alternatives

The goal of restoration planning is to identify and implement restoration actions that are appropriate to restore the natural resources or services equivalent to those injured or lost. As noted previously, restoration planning may involve two components: primary restoration and compensatory restoration.

Restoration planning may be approached with the view that the injured areas are part of an integrated coral reef ecosystem and that restoration should be sited in a relevant geographical area. In addition, restoration actions should be consistent with local community objectives, and will also need to be consistent with the land management agencies' policies.

Potential project ideas vary but could generally be grouped into the following restoration alternatives (other options may be available that are not listed here):

- **Enhancement of Corals and Coral Reef Ecosystems**
  This alternative is comprised of projects or activities that would directly enhance corals or other elements of the reef ecosystem. Potential projects could include coral transplantation, propagation of corals for relocation, translocation, and propagation of other keystone species such as *Diadema antillarum* (long spiny sea urchin).

- **Restoration of Existing and Future Impacts to Coral Reefs**
  This alternative would include projects or activities that would restore coral reefs that have been impacted but where restoration would otherwise not occur. Potential projects could include the restoration at historic, orphan grounding sites to improve recovery, emergency restoration of corals harmed by future orphan groundings, and/or storm events.

- **Prevention of Future Physical Impacts to Coral Reefs**
  This alternative encompasses projects or activities that would be likely to prevent future physical harm to coral reefs, such as from vessel groundings, anchoring on reefs, smothering by invasive algae, and marine debris. Potential projects could include improved AIDS TO NAVIGATION, improved nautical charts, improvements to pilotage systems for commercial vessels, and removal of marine debris that is harmful to or threatens to harm coral resources.

- **Elimination and Reduction of External Reef Stressors**
  This alternative would include projects or activities that would decrease other external reef threats and stressors, such as from pollution, climate change, and overfishing. Potential projects could include implementation of BMPs to reduce land-based sources of pollution, improving MPA effectiveness, and implementation of projects to promote reef resilience.

- **Restoration of Associated Habitats**
  This alternative would include projects or activities that would restore habitats commonly associated with coral reefs (but not the reefs themselves) and/or habitats that support the same fish species as coral reefs. Potential projects could include mangrove restoration, seagrass restoration, and coastal wetlands restoration.

3.6.2 Evaluation of Restoration Alternatives

The following criteria are generally used to evaluate restoration project alternatives and identify the restoration actions proposed for implementation (based on OPA but can be applicable to other unplanned events):

- **The extent to which each alternative is expected to meet the restoration goals and objectives:** This criterion addresses whether or not the restoration project can fully restore lost resources. In essence, to what degree can the project make the environment and public "whole" again after an injury.

- **The likelihood of success of each restoration alternative:** The technical factors that represent risk to successful project implementation, project function, long-term viability, and sustainability of a restoration action need to be considered prior to implementation. Alternatives susceptible to future degradation or loss, such as due to subsidence or erosion, are considered less viable. In addition, also consider whether difficulties in project implementation are likely and whether long-term maintenance of project features is likely to be necessary and feasible.

- **The extent to which each alternative will avoid collateral injury to natural resources as a result of implementing the alternative:** Restoration actions should not result in significant additional losses of natural resources and should minimize the potential to affect surrounding resources during implementation. Restoration actions with less potential to adversely impact surrounding resources are generally viewed more favorably. Compatibility of a restoration action with surrounding land use, and potential conflicts with endangered species are also considered.

- **The extent to which each alternative benefits more than one natural resource or service:** This criterion addresses the interrelationships among natural resources, and between natural resources and the services they provide. Projects that provide benefits to more than one resource and/or yield more beneficial services overall are viewed more favorably.

- **The effect of each alternative on public health and safety:** Restoration actions that would negatively affect public health or safety are not appropriate.

- **The cost to carry out the alternative:** When all other evaluation criteria above are considered equal between alternatives, then the costs of implementation factor into the evaluation of restoration alternatives. Factors that can affect and potentially increase the costs of implementing a restoration alternative can include project timing, access to the restoration site (e.g., with heavy equipment or for public use), acquisition of state or federal permits, acquisition of the land needed to complete a project, measures needed to provide for long-term protection of the restoration site, and the potential liability from project construction. The cost of monitoring sufficient to document restoration performance is a necessary component.

However, the first criterion listed above has generally been a primary consideration, because it is critical to ensure that restoration will make the public whole for resource injuries and losses attributed to an incident. The evaluation of restoration alternatives using these criteria involves a balancing of interests in order to determine the best way to meet the restoration objective.

3.6.3 Development of Performance Criteria and Success Monitoring

Performance criteria define short-term milestones that, if met, will provide reasonable assurance of project success in the long term. Monitoring provides the information necessary to determine whether the project is trending toward these milestones, or whether corrective action may be appropriate. Monitoring protocols may vary depending on the type of restoration required at different sites.

Following are examples of performance criteria developed by NOAA's Restoration Center for primary restoration of a Caribbean vessel grounding site:

- Topographic complexity created by the non-live-coral substratum is returned to within 10% of agreed reference areas using the calculation for topographic complexity that is $C = (1-d/l)$.

- Coral reef structures are expected to remain stable and intact. Corrective actions will be necessary if substantial loss of reattached material occurs (approximately 10% or more) or if dislodged or failing coral reef structures are likely to cause ancillary damage to the restored area or to adjacent reef.

An example from NOAA's Restoration Center of success monitoring for restoration of that same Caribbean vessel grounding site is as follows:

- Restoration monitoring will be conducted at scheduled intervals following construction. Annual monitoring events will assess the structural stability of the restoration features, survival and stability of the reattached corals, and recruitment/colonization trends to determine that recovery is underway. The post-restoration monitoring plan would be initiated 90 days after construction is completed. After this, data would be collected annually for five years, and then again at years seven and 10. A temperature logger would be deployed at the site during the initial monitoring and changed out during each of the subsequent monitoring events to account for potential climate change stressors that may impact the rate of recovery. Other visits may be required periodically to inspect the restoration site for potential damage due to effects of storms or other events. The schedule and objectives of a sample post-construction monitoring event are shown in Table 4.

Table 4: Example of a Post-Construction Monitoring Strategy.

Monitoring Objective	Characteristics to Evaluate	Methods
Structural Stability.	Scouring at the base of coral reef structures.	Tagging individual structures, photo- documentation, data collection, observations throughout the site.
	Stability of coral reef structures (e.g., stable, loose, detached or missing).	Tagging individual structures, photo- documentation, data collection, observations throughout the site.
Coral Recruitment and Colonization.	Settlement and survival of coral recruits.	Permanent 50 cm X 50 cm quadrats.
	Community composition of biota colonizing the restoration structures.	Permanent 50 cm X 50 cm quadrats, belt transects.
Coral Reattachment success.	Survival and stability of coral transplants.	Tagging individual colonies, photo-documentation, and data collection.

3.6.4 Post-Restoration Actions

The evaluation of service loss resulting from an impact, and gains from a restoration activity, are usually based on the assumption that both coral reef structure and biota provide overall coral reef services. Outside of the NPS, provided that coral reef structure is stable and the impacted area is returned by the restoration effort to rugosity levels similar to reference reef areas, the injury to the habitat component of service may be considered fully restored.

The biotic component of service is typically estimated by using reference transect data from adjacent areas to estimate the abundance and size distribution of biota that were impacted. After taking into account the survival of reattached biota in the injury area, the total surviving reattached corals would be subtracted from the estimates of total impacted corals to quantify the remaining loss of biological resources.

Corrective actions or compensatory mitigation may be necessary if the selected coral reef restoration actions are not meeting the performance criteria set forth in the restoration plan. These corrective actions may be minor or major.

4.0 CORAL REEF COMPENSATORY MITIGATION AND RESTORATION OPTIONS

The purpose of this section is to identify potential options that could be implemented as part of a coral reef restoration or compensatory mitigation activity, to meet federal, state, or territorial regulatory requirements, and to increase the chances of success of compensatory mitigation or restoration actions. Options suitable to be considered as compensatory mitigation activities are a subset of the broadly defined restoration activities, and must meet more stringent requirements by the permitting authority. Often similar goals, objectives, and methodologies are needed to identify, plan, and implement a restoration activity as a compensatory mitigation activity. For DA permits issued by USACE, compensatory mitigation plans must address the 12 mitigation plan elements listed in section 2.3.2, and described more fully, at 33 CFR 332.4(c) and 40 CFR 230.

This section also provides information that can be used to evaluate whether options may be suitable for compensatory mitigation and/or restoration. The approval and permitting requirements and process for restoration projects vary between regulating authorities and funding organizations.

The options identified herein are not exhaustive but are based on review of proposed and/or implemented restoration activities. Depending upon the goals or objectives of a particular restoration or compensatory mitigation activity, the project proponent may combine several options together to meet those goals or objectives. In many cases the options listed in this chapter have been implemented as part of ecological restoration grants or activities, and not as compensation for a planned or unplanned injury. When activities are not implemented as compensation for a planned or unplanned coral reef injury, the degree of monitoring and performance evaluation may not be as thorough as would be required under a permitted compensatory mitigation activity.

Restoration or compensatory mitigation activities should be planned and designed to meet the goals, objectives, and other requirements of those projects. Based on lessons learned, this section identifies potential opportunities or challenges that a project proponent may need to consider if incorporating these options into a coral restoration or compensatory mitigation plan. For each option, jurisdictions are identified where the options or specific activities have been implemented, either as general restoration activities, or compensatory mitigation.

This document represents the best available and most current information to date. This does not supersede or substitute for agency regulations or mandates. ***Please contact the appropriate agency(ies) for more specific information.*** See Appendix II for contact information for federal, state, and territorial agencies.

For compensatory mitigation, permanent loss should be permanently replaced. How this is accomplished varies across agencies, regions, and projects. Presently, it is essential that project completion be defined within the compliance processes.

4.1 The Approval Process

4.1.1 Compensatory Mitigation Projects

Coral restoration activities may be conducted as compensatory mitigation for permits issued by federal, state, or territorial permitting authorities, or to fulfill enforcement requirements for unplanned coral resource impacts. The project proponent or RP should coordinate with the appropriate permitting or enforcement authorities to determine if there are any applicable regulations, guidance, or policy documents relevant to the coral restoration activity. For activities requiring USACE permits, the 2008 Mitigation Rule and its requirements apply.[5] ***The approval of the final compensatory mitigation plan lies with the applicable permitting authority.*** Project proponents and RPs need to work directly with the appropriate permitting or enforcement authorities (e.g., USACE, EPA, FWS, NMFS, and/or state or territorial agencies) to identify specific requirements and processes for developing their compensatory mitigation plans. The development of compensatory mitigation proposals is usually the responsibility of the permit applicant.

4.1.2 Restoration Projects

The approval requirements and process for restoration projects vary between the applicable regulations. A project proponent or RP should coordinate directly with the appropriate agencies to identify approval and associated permitting requirements. Restoration projects, regardless of the funding source, must comply with all regulatory requirements, as applicable, including any required federal, state, territorial, or local permits—such as DA permits issued by USACE. Project proponents should contact the appropriate federal, state, territorial, or local permitting authorities to determine if permits are required for the restoration projects.

Consideration of the most appropriate restoration approach by regulatory and management agencies and the project proponent or RP can inform the selection of options for coral reef restoration. There are various restoration approaches and the selection of a particular approach will be dependent on the ecological target(s), agency missions, and stakeholder interests and values.

4.2 Evaluating the Options

Many coral reef compensatory mitigation or restoration options are complementary and can be combined to increase the likelihood of project success and effective replacement of lost coral reef habitat, functions, and services. The strategic use of multiple options may be especially crucial to counteract the amplified stresses associated with climate change and ocean acidification (Stein et al., 2014).

Compensatory mitigation, or offset for coral reef ecosystems, is a relatively new science. Like restoration science for other aquatic habitats, such as wetlands or streams, it will take time and testing of methods to develop a solid compensatory mitigation standard for coral

[5] For USACE Civil Works projects the components of a mitigation plan as outlined in the 2008 Mitigation Rule apply. However, USACE Civil Works mitigation analysis follows the requirements in ER 1105-2-100.

EXAMPLE: DETERMINING THE BEST OPTION FOR "COMBINATION STRATEGIES"

With large activities that may have unavoidable impacts to complex coral reef ecosystems, it is often difficult to identify one type of compensatory mitigation action that would be adequate to address all of the lost functions and services resulting from the unavoidable impacts. Often "combination strategies" may be required. An example of how to determine the best "combination strategy" can be found in the USACE Cost Effectiveness/Incremental Cost Analysis requirements for ecosystem restoration and compensatory mitigation in the Civil Works Planning program. Under the USACE Civil Works planning process, after all avoidance and minimization measures are incorporated to the extent practicable, USACE determines—with consultation with resource agencies—the targeted compensatory mitigation requirements for the unavoidable impacts in terms of functional improvement to the habitat. Through an incremental analysis focusing on how different compensatory mitigation strategies or combinations of strategies at the same site or multiple sites improve the habitat, USACE first determines which individual strategies are acceptable to address different functional losses. Then USACE looks at what combination of the acceptable strategies provide the best return on investment in terms of habitat created.

For example, a project that results in both biological and structural losses will likely require a combination of biological and structural mitigation. If multiple sites are proposed, USACE also evaluates and consults with other federal and state agencies to determine if the site locations are acceptable to address the functional losses from a perspective of a large coral reef system. In such an example, available alternatives may include increasing herbivore populations, improving water quality through removal of introduced sediments and nutrients, and removal of a nuisance algal species at Site A, and enhancement of coral structure to increase fish refugia and shore protection at Site B. These four activities would be compared individually, and in combination, to see which would provide the best option to address the individual functions that are needed to meet the compensatory mitigation requirement or target.

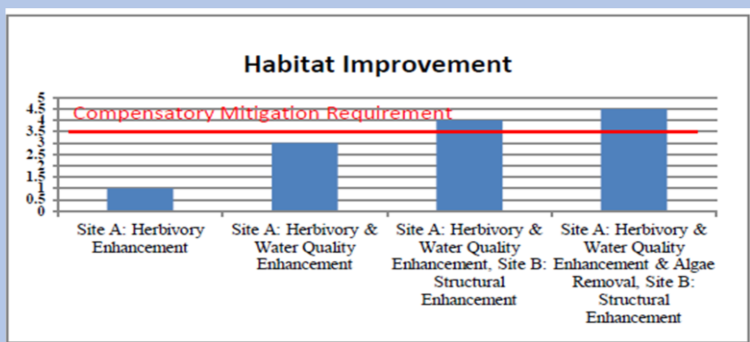

Figure 4: Example of Incremental Analysis comparison of compensatory mitigation alternatives.

While structural enhancement may rank high for its abilities to compensate for structural losses, it is not always appropriate to compensate for biological losses. However, in this example herbivory enhancement, water quality improvements, or algae removal may be available alternatives that do address biological losses. Therefore, to meet the compensatory mitigation requirement or target, it will take a combination of structural enhancement at Site B, and herbivory enhancement and water quality improvements at Site A, and/or algae removal at Site A. An analysis of the available compensatory mitigation sites/options, likelihood of success, and cost are then used to determine which combination of the structural and biological alternatives provides the best return on investment. Figure 4 depicts an example where the combination of herbivory enhancement and water quality improvements at Site A and structural enhancements at Site B together may meet the compensatory mitigation requirement for habitat improvement. However, when algae removal is added at Site A there is minimal added improvement to the habitat, or minimal return on investment for the additional effort.

reef ecosystems. In the arena of unplanned coral reef impacts, there have been valuable advances in defining replacement, and these lessons should be shared across agencies and regions to maximize the transfer of knowledge and development of standards. Cost of a particular option can be difficult to quantify, because cost is location-specific and highly variable across options. Additionally, regulations are not consistent on how cost should be considered. For example, under NRDAR cost is only a deciding factor when all others are equal. Therefore, cost has not been included in the description of the various options that follow. For the NRDAR process, public comment may also weigh in as a factor in determining appropriate mitigation options. More detailed information on potential compensatory mitigation and restoration options is included in the following section. Information provided is categorized as follows:

Option Description: A general description of the option. The description also identifies other options that may be complementary and result in increased success.

***Case Study Examples*:** This section includes examples of projects that have included activities associated with that option. In most cases, the options have been implemented as restoration activities, or for purposes other than coral reef compensatory mitigation or compensatory restoration. There is limited experience in implementing these options as compensatory mitigation or compensatory restoration. This information can guide a project proponent to potential sources of information.

***Possible Activities*:** A list of various activities or methods related to the option.

***Considerations*:** This section considers key questions to determine which options may be best suited to meet compensatory mitigation or restoration requirements. The questions include:

- What is the target resource/habitat being restored or mitigated?
- What is the primary objective of the option going to address?
- What are specific functions or services that the option is likely to provide?

***Opportunities*:** The opportunities listed are general considerations to help the project proponent identify which of these options may be best suited to their situation. The opportunities may not apply to all projects and locations and additional opportunities may exist that have not been identified.

***Challenges*:** This section identifies challenges particular to that option that may help the project proponent in determining the level of effort or coordination that may be necessary to propose or implement the option. The challenges may not apply to all projects and locations, and additional challenges may exist that have not been identified.

It is necessary to consider that the type of impact is critical in the determination of mitigation appropriateness. For example, if impacts are direct removal of coral reef habitats, then creation (e.g., boulder reefs) may be the most appropriate type of compensatory mitigation. If impacts are a temporary degradation of the function of a coral reef ecosystem, then alternative mitigation methods, such as outplanting of corals, may be appropriate. Nursery grown corals and outplanting activities are worthwhile. However, these activities do not replace all of the

functions provided by natural coral reefs. It is also important to consider that nursery grown species may not reflect the natural community composition of reefs. For example, slow-growing species or species that are not listed under ESA may be underrepresented in nursery stocks. Therefore, a portfolio of compensatory mitigation and restoration options is presented in Section

4.3 that can be used as a tool for developing combination strategy proposals as described.

The ability to establish appropriate performance criteria that can be quantitatively evaluated is still needed for most agencies to permit innovative mitigation options with limited or no history of successful implementation. Therefore, it is imperative to work with the regulatory and management agencies to select appropriate suites of options before investing significant time or effort on their development.

4.3. Portfolio of Compensatory Mitigation and Restoration Options

OPTION 1: Water Quality Improvements Implement water quality improvement activities within the watershed to reduce erosion, runoff, sediment, and pollutant loads that are impacting the near shore waters.
Case Study Examples: Kaneohe Bay sewage diversion (Evans et al., 1986 and Hunter and Evans, 1995), Hawaii; removal of tuna effluent from Pago Pago Harbor, American Samoa; erosion control in Kahoolawe, Hawaii (Jokiel et al., 1995).
Possible Activities:
• Terrestrial revegetation. • Wetlands/stream restoration, enhancement. • Storm water BMPs. • Erosion control practices. • Wastewater system improvements. • Land acquisition, conservation easements, or protection of stabilized buffer areas.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Improving water quality improves the coral habitat. • ***Primary objective:*** Reduce sediment and nutrient loading. Credit can only be received for new work that only resulted from mitigation, for example, not as response to a violation. • ***Specific functions or services provided:*** Improved water quality would indirectly improve coral habitat condition, support recruitment and increased growth/fecundity, and improve recreational human use services provided by the habitat.
Opportunities:
• Potential to address a primary stressor to many coral reef ecosystems at the source. • Science supports coral reef restoration with water quality improvements (Clark & Edwards, 1999; Futch et al., 2011; Jokiel et al., 1995). • Existing technology/ BMPs available for many storm water and wastewater improvements. • In line with USCRTF watershed partnership initiative (Resolution 28.1).
Challenges:
• Difficult to link specific water quality improvements to amount of coral functional lift. • Best when watershed plans or pollution budgets exist for the site, otherwise may require studies and planning prior to implementation to identify priority locations for action. • May take a long time to see coral reef response. • Some sites may require large-scale implementation to significantly reduce sediment loads and runoff volumes. • Challenges associated with land ownership, maintenance, and long-term management of water quality management measures. • Climate change impacts may require altering the design of water quality improvement activities (e.g., due to a change in runoff because of extreme events or sea level rise) for them to be effective.

OPTIONS

EXAMPLE: IMPROVING WATER QUALITY TO MITIGATE FOR CORAL IMPACTS

Pollution control activities in watersheds adjacent to coral reefs have been approved as compensatory mitigation for unavoidable coral impacts associated with some in-water projects. Such strategies may include: terrestrial revegetation, stream or conveyance stabilization, stream and wetland restoration, stream and coastal buffers, storm water retention and treatment, and wastewater treatment improvements. The theory behind use of these types of strategies is that by improving terrestrial areas upland, or adjacent to coral reef habitats, transport of land-based sources of pollution (e.g., sediment, nutrients, chemicals, pathogens) can be reduced, thereby improving water quality in receiving waters. Land-based sources of pollution are a primary threat to coral reefs; they can reduce coral growth and reproduction, increase incidence of harmful algal species, and cause diseases of reef organisms. The intended benefit to corals from pollution control activities is restoration of water quality conditions that are conducive to reef health, coral spawning, and recruitment.

A significant challenge in implementing water quality strategies as compensatory mitigation has been quantifying the ecological targets: What reduction in terrestrial pollutants must occur to achieve a particular gain in coral and thus achieve project success? This uncertainty is a barrier to determining the amount of mitigation required to achieve the desired result. However, water quality improvements have been demonstrated to result in coral improvement. Ongoing work to quantify the relationship between sediment loads and suspension and coral condition will help address this uncertainty.

There are two projects in Guam that illustrate particular challenges with this approach, and should be considered when evaluating compensatory mitigation options intended to improve water quality: **Kilo Wharf** and **Alpha Bravo**. It is important to recognize that both of these projects were permitted prior to 2008, thus the mitigation plans were not subject to the current standards of the 2008 Mitigation Rule.

The **Kilo Wharf** project consisted of dredge and fill to enlarge an existing wharf within Apra Harbor, Guam. The project was estimated to result in direct dredge and fill impacts to 4.75 ac of marine habitat, including approximately 0.4 ac of coral reef. To offset the losses associated with direct impacts of wharf expansion, reforestation of approximately 500 ac of grassland in Cetti Bay watershed was planned. Cetti Bay has been significantly impacted by erosion and sediment inputs from the adjacent watershed, affecting water quality and degrading its coral reefs. In this case, the size of the reforestation effort was determined by negotiation, as no data or models were available to estimate the amount of reforestation and reduction in sediment loads required to restore the Cetti Bay reefs. This project encountered challenges to the implementation of the reforestation effort. Local hunters use burning as a strategy to make game more visible, resulting in uncontrolled fires that destroy existing and replanted vegetation and expose soil. In this case, if legal protections for the land being reforested in perpetuity, such as a conservation easement, were implemented as part of the mitigation plan, the likelihood of success would have improved. No monitoring of sediment loads or coral recovery was required, therefore data to evaluate the success of this mitigation project are lacking.

The **Alpha Bravo** project involved fill for pier construction and dredging of 103 ac in Apra Harbor, Guam. Dredging impacted approximately 7.1 ac of coral. Off-site revegetation of a wetland area and reforestation of slopes above a stream and reservoir in the Piti watershed were approved as compensatory mitigation for impacts to corals. Similar to the Kilo Wharf mitigation, the amount of revegetation undertaken was not based on knowledge of the effectiveness of the action in terms of coral restoration. While reforestation progress has been made, this project was not required to monitor sedimentation or to accomplish coral reef recovery. The requirement to monitor the coral reef system to track changes and complete the reforestation strategy would have improved the understanding of the effectiveness of this approach.

For more information on the Kilo Wharf or Alpha Bravo projects contact the USACE Honolulu District Regulatory Office.

OPTION 2: Enhance/increase herbivore (e.g., fish, urchins) populations Conduct activities that will enhance or increase populations of herbivorous fish and invertebrates on coral reefs. This is particularly appropriate where algal overgrowth is a direct threat to corals.
Case Study Examples: Kahekili Fishery Management Area, HI; *Tripneustes gratila* culture and outplanting in Kaneohe Bay, Oahu, HI*; Diadema antillarum* aquaculture and outplanting, FL.
Possible Activities:
• Herbivore aquaculture and release onto reefs. • Herbivore fishery management.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Improving the herbivore population reduces algae and enhances coral recruitment and survival. • ***Primary objective:*** Reduce invasive species and/or detrimental algae abundance. • ***Specific functions or services provided:*** improved reef habitat supports recruitment, biodiversity, and invasive species control and improves recreational human use value.
Opportunities:
• Science supports importance of herbivores in maintaining healthy reefs. • Benthic herbivores (urchins) can target specific areas (will not swim away like fish can). • Demonstrated to increase coral growth and decrease macro-algal cover on reefs (in small scale). • Culture is potentially feasible for some fish and invertebrate species. • May shorten recovery time or enhance functional gains of natural coral reefs when combined with other mitigation options (e.g., coral reef restoration). • Could result in long-term benefits if populations are maintained.
Challenges:
• Some target species are difficult to culture. • Public support for fishery restrictions can be challenging. • May be difficult to define functional benefits (because it has not been done yet). • May require perpetual re-stocking. • Need to identify areas that could benefit from herbivore enhancement. • Harvesting control would be needed to maintain released herbivore populations in wild.

OPTION 3: Coral relocation and corals of opportunity.
Collection and movement of at risk or damaged corals out of project footprint or damage area and stabilizing them either on-site, in a nursery for holding, or an alternate location.

Case Study Examples: Broward Segment III Shore Protection Project (FL), Key West (FL), HI (in progress).

Possible Activities:

- Collection of damaged coral colonies or fragments resulting from natural or anthropogenic direct impacts (e.g., corals of opportunity).
- Movement of at-risk corals from a project site.
- Relocating impacted or at-risk corals to suitable areas such as nurseries, adjacent reef areas, or restoration sites.

Considerations:

- ***Targeted resource/habitat being restored/mitigated:*** Rescue, stabilization, and storing or outplanting of at-risk corals enhances coral reef habitat quality by restoring biological and structural components of the habitat.
- ***Primary objective:*** Preserve coral colonies and live coral cover.
- ***Specific functions or services provided:*** Preservation of impacted or at-risk corals supports biodiversity, coral reef structure, and recreational and coastal protection human use services.

Opportunities:

- Successful relocations have been implemented.
- Rescues organisms that would otherwise be lost.
- May shorten recovery time of mitigation sites if used in conjunction with other mitigation projects (e.g., coral reef restoration).
- May increase coral reproduction and larval supply.
- Provides live topographic complexity that could further develop.
- May be advantageous for ESA listed corals.
- Opportunity to expand the scope to include octocorals and sponges.

Challenges:

- May require unconventional approaches to define functional benefits.
- Potential to spread disease or other invasive species with transplanted corals.
- Not all species and sizes may be able to be transplanted.
- Additional work is needed on relocation/transplantation techniques for non-coral organisms (e.g., large habitat forming sponges).
- Consider assessment of relative reef resilience to assist in the selection of nursery and relocation/transplantation sites.

OPTION 4: Offsite placement of physical structure This option could include multiple types of offsite structures (including artificial reefs) placed in an effort to compensate for coral reef that was impacted.
Case Study Examples: Port of Miami Phase I; Bal Harbor beach re-nourishment; Broward County Beach Shore Protection Project Segment III (all FL).
Possible Activities:
• Placement of material in a way that mimics natural coral reef structure. • Deposition of boulders or other artificial material. • Deposition of coarse dredge spoil. • Placement of artificial reef modules. • Outplanting of corals of opportunity or corals relocated as impact minimization onto structure.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Providing artificial structure has the potential to enhance fish and invertebrate habitat and coral establishment. • ***Primary objective:*** To provide replacement substrate for the portions of the resource that were lost due to impacts or injuries. • ***Specific functions or services provided:*** Providing replacement structure has the potential to enhance recruitment substrate for biological reef components and enhance recreational and coastal protection human use services.
Opportunities:
• Artificial structures have been implemented in most jurisdictions as a fisheries enhancement tool. • Ample monitoring reports and literature available to help define functional benefits. • Methodology for deployment/implementation relatively straightforward. • Permission to place artificial structure within federal/state/territorial government owned submerged lands for compensatory mitigation generally is provided along with the impact authorization. • If properly designed, can provide durable and stable substrate for recruitment of some coral species. • Beneficial use potential to make reef structures from dredged coral. • Potential to divert stressors from natural reefs to artificial reefs (e.g., diving). • Much has been learned that can inform defining performance standards and monitoring. • When used in conjunction with coral transplantation/relocation, could reduce time for coral function replacement.
Challenges:
• There is debate about whether constructed reefs can provide equivalent coral reef structure function and services to natural reef systems. • Constructed reefs can have different, simpler structure and function than natural reef systems (Gilliam, 2012; Miller et al., 2009). • May require additional regulatory reviews/approvals to place structure within waters regulated by federal, state, or territorial governments. • Could result in significant additional negative impacts in some situations (e.g., aggregation of fish at detriment to other areas, easier fishing, change in water movement, physical damage in storms, unnatural blooms, and loss of existing habitat) (Kuffner et al., 2006). • Site selection criteria must be established to minimize adverse effects to natural coral reefs. • Difficult to design in a manner that mimics natural areas. • Impacts to un-vegetated soft bottom habitats not well-understood.

OPTION 5: Removal of Marine Debris and Derelict Vessels This option includes activities that would remove marine debris and/or derelict vessels, thereby reducing threats to coral reef habitat from future or sustained impacts from the debris.
Case Study Examples: Mitigation in Florida Keys National Marine Sanctuary for corals and seagrass (FL); removal of vessels at Palmyra atoll.
Possible Activities:
• Removal and disposal of derelict vessels. • Removal of derelict fishing gear and other debris. • Removal of tires.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Removal of marine debris reduces threats to coral reef habitat. • ***Primary objective:*** Reduce physical damage to corals by removing marine debris. In some cases, remove pollution sources that can negatively affect reef habitat (e.g., algal blooms caused by metals from ship hulls). • ***Specific functions or services provided:*** Removal of marine debris would protect sessile biological components of coral reef habitat and enhance recreational human use services.
Opportunities:
• May provide opportunities for community involvement and outreach. • Easy to scale benefits. • Many past programs as models. • May help reduce stress on existing coral. • Recent tsunamis provide good opportunities. • May facilitate recovery of degraded sites. • May prevent additional damage to coral reefs by moving debris that could migrate with storm and wave action into un-impacted areas. • Considered a visual enhancement.
Challenges:
• Depending on the source of the marine debris, this may only provide short-term benefits (if one-time removal) or require a long-term commitment. • Marine debris can be a chronic issue that may require long-term/permanent commitment or site protection requirements. • May be difficult to define measurable performance standards. • Need to remove fuel. • Disposal options can be complicated and/or expensive. • RPs can generally be identified for large affected sites, leaving only very small sites for use as compensatory mitigation. • If there are regulations in place requiring the RP for the orphaned vessel or grounding to address removal and injuries, may not be able to be used as compensatory mitigation.

OPTION 6: Enhance Compliance Capacity

This option includes activities to meet compliance capacity gaps to manage MPAs or pro-active coral reef restoration areas (i.e., not associated as compensatory activities for planned or unplanned activities) or increasing education and awareness of existing federal, state, and territorial coral reef protection laws and requirements. It may also include increasing awareness and compliance with recommended actions to address unregulated issues impacting coral reefs (e.g., no authority to modify certain land use, recreational, or fishing practices that may be adversely impacting coral reefs).

It is not acceptable to supplement funding for existing enforcement operations under designated federal, state, or local regulatory authorities.

Case Study Examples: There are currently no examples of this option being used as an element of compensatory mitigation or restoration, but this option is well-suited as a component of an overall mitigation package, as such enhancements to management actions can positively impact coral reef habitat condition.

Possible Activities:

- Fund staff to provide compliance oversight (overtime, night pay, special surveillance activity).
- Purchase of equipment to aid compliance activities (vessel, drop cameras, DGPS units).
- Support for or development of new volunteer surveillance with ability to call in enforcement officers.
- Conduct a threat assessment—inventorying threats to resources, identifying those threats that can be thwarted or influenced, and then prioritizing/assigning responsibility and actions to reduce threats.

Considerations:

- ***Targeted resource/habitat being restored/mitigated****:* Enhanced compliance capacity can protect coral reefs, their structure, and their associated communities from negative impacts.
- ***Primary objective:*** Supplement enhanced compliance with targeted performance standards for an existing restoration project that was not implemented in association with a legal requirement (e.g., not associated with a planned or unplanned activity). This enhancement could improve the success of these other restoration options.
- ***Specific functions or services provided:*** Enhancing compliance with measures to reduce unregulated threats to coral reefs or providing outreach and awareness of existing federal, state, or territorial coral protection regulations would improve coral reef habitat quality and associated biological communities.

Opportunities:

- Provides good awareness and outreach, which could improve area-wide or jurisdiction-wide compliance.
- Enhanced compliance of performance standards at proactive restoration sites could help reduce stress on existing coral communities (e.g., stress from overfishing).
- When used in conjunction with other options, may help to ensure overall project success.
- Enhanced compliance at an MPA site or other area may increase awareness and reduce local stressors on a habitat or species.

Challenges:

- Need to ensure that compliance activity where capacity needs to be increased is not already an enforcement responsibility of a federal, state, territorial, or local agency.
- Need to ensure that funds for the compliance activity are not illegally or inappropriately supplementing a federal, state, territorial, or local program.
- Providing funds for long-term compliance support of appropriate activities may be difficult to maintain.
- Difficult to define performance standards and measures of success for increasing compliance capacity in terms of relating it directly to recovery of coral reef resources.

CHALLENGES WITH MARINE PROTECTED AREAS

MPAs are defined as "any area of the marine environment that has been reserved by federal, state, tribal, or territorial laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (EO 13158). Large MPAs can include a zoning framework —a variety of smaller zones—to address various management objectives, such as no-take reserves where all extraction is prohibited, or areas that may be zoned to accommodate multiple uses. MPAs have been used effectively to regulate activities that can result in negative impacts to corals, including physical damage from improper vessel use, recreational overuse, and unsustainable or undesirable fishing practices.

MPAs appear to be an attractive option for consideration, in that they could provide an appropriate mechanism for long-term protection of compensatory mitigation activities if long-term management funds are allocated for the management and enforcement of the MPA. MPAs also provide a mechanism to prevent destruction or adverse modification of the coral reef habitat by managing human activities, such as fishing and recreation, to limit impacts from overuse. There is the potential for the establishment of an MPA to be considered as generating compensatory mitigation credit through preserving coral reefs that are at risk of future degradation.

However, MPAs as a compensatory mitigation tool can be problematic. The first challenges arise in scaling of compensatory credit and addressing management costs over the long term. The social and cultural considerations may be more involved due to the perception of stakeholders and resource users having to bear the cost of compensatory mitigation or restoration for an impact through regulation of their activities. There are also legal, financial, and human resource commitments that are necessary for an MPA to be effective at meeting stated goals, objectives, and performance standards.

If an MPA approach were to be pursued, the use of relative reef resilience assessment and resilient MPA design tools should be part of the establishment process for new MPAs, expanding existing MPAs, and/or to consider additional restrictions (McClanahan et al., 2012; Gombos et al., 2013; Green et al., 2014; Maynard et al., 2015). Reef resilience assessments include, among other things, incorporation of climate change considerations into those actions. This would be especially important in the case of existing MPAs as this assessment and analysis could provide spatial recommendations for new management activities or restrictions.

Activities aimed at increasing the effective management capacity of existing MPAs might be suitable as mitigation tools. However, in each case, careful estimates of benefits attributed to increasing the effective management capacity of existing MPAs, or creating new MPAs, should be performed and compared to losses in natural reef or hardbottom ecosystems as a result of a project impact.

OPTION 7: Nuisance species removal Removal of nuisance and harmful species such as invasive algae, crown of thorns, and lionfish would reduce threats to coral reef habitats.
Case Study Examples: Lionfish (FL and USVI); Supersucker (Kaneohe Bay, Oahu, HI).
Possible Activities:
• Removal derbies or tournaments. • Supersucker removal of invasive algae. • Bounties to collect and remove nuisance species (e.g., lionfish). • Volunteer efforts to remove nuisance species. • Removal of corallivores (snails, crown of thorns).
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Removal of nuisance or invasive species would improve coral reef habitat and condition of biological components. • ***Primary objective:*** Removal of nuisance or invasive species that compete with, or prey upon, corals. • ***Specific functions or services provided:*** Removal of nuisance or invasive species from reef habitat would restore coral reef habitat and function, natural species composition and diversity, and enhance recreational human use services.
Opportunities:
• Has been successful in Hawaii for some invasive algae. • Potential for immediate restoration of some habitat functions in the short term. • Provides for increased outreach opportunities and public awareness. • Potential to use volunteers to assist in removal. • Advances have been made in the science and techniques of invasive species removal in many jurisdictions. • May prevent accelerated habitat decline caused by outbreaks/overgrowth of nuisance species.
Challenges:
• Based on available techniques, some invasive species are nearly impossible to control once they become established. • Some locations may require long-term and ongoing removal strategies to meet performance standards. • Long-term solutions to nuisance algae must also involve nutrient reduction and/or herbivory enhancement. • Corallivore removal can expedite recovery.

OPTION 8: Recreational Mooring Buoys
The purchase and installation of recreational mooring buoys could help to prevent future impacts to coral reefs and allow recovery of sites impacted by overuse.

Case Study Examples: FKNMS, FL; Hilo Harbor, HI.

Possible Activities:

- Purchase of mooring supplies and equipment.
- Installation of new permanent moorings.
- Maintenance of broken moorings.
- Use surveys.

Considerations:

- ***Targeted resource/habitat being restored/mitigated:*** Coral reef habitat, sessile biological components, reef structure.
- ***Primary objective:*** Prevent anchor and human use damage to corals and allow recovery of sites degraded from overuse.
- ***Specific functions or services provided:*** Coral reef structure and habitat, biological components of habitat, and recreational and coastal protection human use services.
- Requires USACE authorization under the RHA.

Opportunities:

- Recreational mooring buoys have been implemented in many jurisdictions as a method to manage and reduce impacts to coral reef ecosystems.
- May prevent some damage from boat anchors.
- For compensatory mitigation, mooring buoys could be categorized as taking actions to reduce stressors on a habitat or species.
- Implementation is relatively straightforward.
- Potential for positive social and/or recreational impacts.

Challenges:

- Potential for habitat improvement is unknown and not demonstrated.
- May require additional enforcement capacity.
- May be limited to only those federal, state, and territorial agencies that have authority to implement and enforce recreational mooring activities.
- Requires long-term maintenance.
- May require additional regulatory reviews or approvals to place structure within waters regulated by federal, state, or territorial governments.
- Potential for damage to reefs from overuse at mooring sites.
- Depending on location and proposed restrictions, potential for increased tension between user groups and agency regulating and enforcing use.

OPTION 9: Aids to Navigation The purchase and installation of navigational aids could help to prevent future impacts to coral reefs and provide for increased enforcement of protected areas.
Case Study Examples: There are currently no examples of this option being used as an element of compensatory mitigation or restoration.
Possible Activities:
• Purchase of supplies and equipment. • Installation of aids to navigation. • Maintenance of navigation aids.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Coral reef habitat, biological components, reef structure. • ***Primary objective:*** Preservation of existing reef areas through prevention of groundings. • ***Specific functions or services provided:*** Coral reef habitat, recreational, coastal protection, and human use services. • Requires USACE authorization under the RHA. • Requires state and USCG approval.
Opportunities:
• Relatively low-cost opportunity to prevent damage in areas where navigation problems exist or where MPA boundaries are unclear. • May prevent unplanned vessel grounding impacts. • May reduce the need for widening and deepening harbor entrance channels and turning basins.
Challenges:
• Established baseline documentation of vessel impacts is needed prior to implementation in order to accurately credit any benefit or impact reduction resulting from the project. • Difficult to predict functional lift. • Project is more preventative than direct restoration.

OPTION 10: Control and removal of terrigenous sediment deposits. The physical removal of sediment from coral reef habitat could enable biological recovery after smothering, and reduce future threats from sediment re-suspension and movement.
Case Study Examples: There are currently no examples of this option being used as an element of compensatory mitigation or restoration. In Lake Worth Lagoon (FL) this has been done for seagrass restoration, see: **http://www.co.palm-beach.fl.us/erm/lakes/estuarine/ibis/**.
Possible Activities:
• Suction dredging. • Sand capping. • Mitigation actions, including soil stabilization and erosion control practices that reduce sediment inputs into the water column that can adversely affect coral reef habitat. • Improvement in freshwater sheet flow and ground water discharge to reduced suspended solid and chemical contaminants as well as ocean water circulation to minimize sedimentation.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Coral reef habitat, biological components. • ***Primary objective:*** Restore reef substrate conditions to promote re- establishment of coral reef ecosystem. • ***Specific functions or services provided:*** Restoration of reef substrate would improve coral reef ecosystem condition, function, and recreational human use services.
Opportunities:
• Enables or potentially accelerates habitat recovery. • Circulation improvements in habitat. • Best practices from the treasure salvage industry could be adopted or refined.
Challenges:
• When proposing this activity near an active harbor basin, consideration needs to be given to the potential for ongoing introduction of terrigenous sediments and/or resuspension of terrigenous sediments and the potential impact on the mitigation location. • Need to combine with water quality improvement/erosion control options to reduce future inputs of sediments. • Often difficult to determine how much sediment needs to be removed to have a measurable recovery of coral reef resources. • Removal process requires appropriate equipment and methodology to reduce potential impacts to entrainment of sensitive species. • If there is potential for sediments to be contaminated, may require additional regulatory reviews/approvals, including sediment testing, to address disposal requirements. • As compensatory mitigation, may require federal/state mechanism to meet site protection requirements (e.g., Fisheries Management Area designation).

OPTION 11: Active coral population enhancement (propagation and outplanting)
Propagation of corals in a nursery setting using best husbandry practices. Corals can be used for mitigation or restoration activities.

Case Study Examples: Coral nurseries in FL, Puerto Rico, USVI; HI (in progress).

Possible Activities:

- In-water coral propagation (nurseries).
- Land-based propagation (aquaria).
- Corals of opportunity/caching.
- Outplanting of coral colonies into restoration locations.
- Remove corallivores (snails).

Considerations:

- ***Targeted resource/habitat being restored/mitigated:*** Coral reef habitat and structure.
- ***Primary objective:*** Improve coral reef ecosystem condition by increasing rugosity, habitat complexity, and live coral cover.
- ***Specific functions or services provided:*** Coral reef habitat, structure, function, species diversity, and recreational and coastal protection human use services.
- Using local corals that have been identified as, or cultured to be more resistant and/or resilient to climate change, ocean acidification, and/or disease, can maximize success.

Opportunities:

- Successful examples in Atlantic/Caribbean.
- Recent advances in scaling the mitigation requirement could inform planning.
- Growing list of successes and protocols developed (e.g., for staghorn coral *Acropora cervicornis*).
- Result in net gain of coral colonies.
- Genetic bank to safeguard against extreme events.
- Corals from coastal construction project impact areas could be used for propagation.
- Potential to enhance coral reproduction.
- For land-based propagation, ability to control conditions and relatively easy to monitor growth.
- Could enhance recovery strategies for ESA listed corals.
- Predator removal can expedite settlement and survivorship.

Challenges:

- Need to have multiple in-water sites to minimize risk of impact from mortality events and weather events.
- May have to increase capacity of existing nurseries or build new nurseries for large-scale projects.
- Outplanting site selection criteria are needed (with consideration of relative resilience assessment in this process).
- Requires maintenance (e.g., predator removal).
- As compensatory mitigation, may require federal/state mechanism to meet site protection requirements (e.g., Fisheries Management Area designation).
- May require additional regulatory reviews/approvals to place structures or outplantings within waters regulated by federal, state, or territorial governments.
- Predator removal can be labor-intensive.

OPTION 12: Sand and rubble stabilization or removal Stabilization or removal of sand and rubble generated by an impact to minimize physical damage to existing coral reef habitat and improve the chance for natural recovery (Gilliam, 2012) to occur.
Case Study Examples: Cape Flattery, HI
Possible Activities:
• Removal of rubble or sand to offshore or land-based dumping areas. • Stabilization of rubble or sand using cement or artificial structures. • Dredging sand and rubble.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Coral reef habitat, sessile biological organisms. • ***Primary objective:*** Reduce physical damage to coral reef habitat caused by loose rubble and sand generated by an impact. • ***Specific functions or services provided:*** Coral reef species diversity.
Opportunities:
• May facilitate recovery at sites that currently cannot recover naturally. • May increase connectivity between natural reef communities. • May help to prevent future direct impacts from loose material. • Easier to implement at a small scale.
Challenges:
• If there is potential for sediment to be contaminated, may require additional regulatory reviews/approvals, including sediment testing, to address disposal requirements. • BMPs for removal need to be developed. Large-scale activities may be complex to implement. • May lose functions provided by sand and rubble communities. • As compensatory mitigation, may require federal/state/territorial government approval or permit to place artificial structure in submerged lands.

OPTION 13: Stabilization and enhancement of impacted coral reef structure On-site action to stabilize and enhance impacted coral reef structure after an impact; structure should be comparable in order to mimic size, complexity, and height of the original community, and provide appropriate surface for recruitment and natural recovery. This option could help to prevent future direct impacts from loose material.
Case Study Examples: FKNMS Wellwood grounding site.
Possible Activities:
• Engineering services. • Construction services. • Removal of debris. • Re-cementing severed corals. • Coral propagation and outplanting.
Considerations:
• ***Targeted resource/habitat being restored/mitigated:*** Coral reef habitat, structure, biological components. • ***Primary objective:*** Improve the quality of damaged reef habitat. • ***Specific functions or services provided:*** Coral reef habitat, structure, function, species diversity, and recreational and coastal protection human use services.
Opportunities:
• Successful examples in FL for grounding scars. • Allows natural recruitment and could be seeded with transplants from impact area or nursery-reared corals. • Restores function and habitat structure. • Easier to implement at a small scale. • Able to define functional benefits.
Challenges:
• Must ensure coral reef stability in wave events. • As compensatory mitigation, may require federal/state/territorial government approval or permit to remove unconsolidated substrata from submerged lands.

5.0 PERFORMANCE STANDARDS AND MONITORING

Effective compensatory mitigation or restoration is the replacement or improvement of ecosystem functions and services by achieving the objectives of compensatory mitigation or restoration projects. Objective and verifiable performance standards are critical for assessing the success of a compensatory mitigation or restoration project in meeting those objectives. Since each compensatory mitigation activity has its own unique conditions and requirements, performance standards define what success looks like for that specific project—clarifying for the project proponent and the permit authorities when the compensatory mitigation activity will be considered completed. Performance standards are benchmarks for evaluating the attainment of project objectives, and allow project evaluators to determine if the site is developing into the desired resource type and providing the expected functions. Performance standards are normally established prior to implementing a compensatory mitigation or restoration project, and the standards should be based on attributes that are observable or measurable. Performance standards will usually be tailored to the objectives that are specific to the individual project, because each site and its restoration potential will likely be different. Since there have only been a limited number of coral reef compensatory mitigation activities implemented, and site conditions for each are unique, hypothetical performance standards are provided in this section to provide examples for a project proponent to consider when developing performance standards.

It is generally recommended that each project have performance standards in three categories. All three are observable, measurable, trackable, and necessary for the sustainability of the site. Performance measures are needed to better ensure successful and sustainable compensatory mitigation and restoration activities given the uncertainty inherent in coral reef restoration projects. The categories are:

- Administrative Measures.
- Ecological Performance Standards.
- Adaptive Management Measures.

5.1 Administrative Measures

Administrative measures ensure work is accomplished, monitored, maintained, and managed, and that corrective actions are taken as needed. These are the easiest performance measures to define and track. Administrative measures may include: the entity responsible for implementing the project; the financial arrangements including provisions for short-term (guarantees for any construction and monitoring) and long-term funding (including financing); the size of the project site; the work to be done to reduce stressors or transplant corals; the parameters to be measured; requirements for marking and protecting the compensation area; and frequency of monitoring.

PERFORMANCE STANDARDS & MONITORING

Hypothetical example Administrative Standards:

- Coral Lovers Forever shall outplant 10,000 staghorn coral (*Acropora cervicornis*) nubs > 3 cm to Polypy Bay at depths of 3 - 10 m between January 1 and March 30, 2015 using methods “x”, “y”, and “z”.
- Percent survival and percent partial colony survival of outplanted staghorn coral in Polypy Bay shall be monitored at six months, one year, and annually for five years.

- Reports summarizing current and past survival shall be submitted to Department of Coral Protection within two months after completion of monitoring. Reports shall include an executive summary, monitoring methods, a graph showing percent survival over time, and recommended corrective actions.
- Department of Coral Protection shall remove invasive macroalgae by the Supersucker from 20 ac of patch reef in Polypy Bay by January 1, 2015.
- The number of fishing violations based on inspections for four hours per week at random times shall decline by 75% from baseline.

5.2 Ecological Performance Standards

Ecological performance standards ensure that the compensatory mitigation project or restoration site achieves the ecological condition expected as a result of the restoration. Ecological performance standards should assess the ecological response to a compensatory mitigation action or restoration action, to help determine whether the activity is going to result in the desired ecological structure, function, or condition. Ecological performance standards are also used to assess the ecological response to compensatory mitigation or restoration actions, to help determine whether the compensatory mitigation project or restoration project will be providing the desired ecological functions and services. Ecological performance standards can measure reduction in stressors, such as fishing pressure, algal cover, sediment inputs, or water quality conditions. Performance standards intended to measure stressor reduction based on water quality monitoring and pollutant inputs should be used with caution. These parameters are extremely variable, and expensive to measure reliably. It is very challenging to distinguish real changes resulting from implementation of pollution controls from natural variation in pollutant concentrations and loads. Existing information collected by other entities may be available to define baseline conditions and monitor changes. For example, where available, U.S. Geological Survey stream gauges may be collecting useful information related to water quality parameters.

In addition, or alternatively, ecological measures can involve structural or condition measurements of the coral reef ecosystem. Structural and condition measurements may be based on measurements or metrics used in the condition or functional assessment method, and/or comparisons to reference sites where human disturbance is minimal. For example, ecological measures may involve percent coral cover, number of colonies by size and/or morphology, number of coral species, and abundance or biomass of herbivorous fish. Ecological performance standards should also take into account the expected stages of restoration or recovery. This allows performance standards to reflect measurements of ecosystem attributes that are expected to be exhibited during the required monitoring period, which might occur when the project is still in the restoration or recovery stage (i.e., these measurements may be different from those of fully restored/recovered ecosystems). Tailoring ecological performance standards to different stages of recovery will also help Identify potential problems early, signaling the need to potentially initiate adaptive management strategies.

Hypothetical examples of Ecological Performance Standards:

- Based on monthly water quality samples at three sites, the mean nitrate concentration shall decline at least 20% from baseline values measured monthly for one year prior to restoration actions.

- Average percent macroalgal cover shall be <10% each quarter.
- Average density of coral colonies shall be >3 per m^2. At least 15% of colonies must be >40 cm.
- Survival of transplanted coral colonies must be >80% over five years. Partial colony survival must average >50%.

Useful information on ecological performance standards and potential thresholds, especially as it relates to measuring performance of land-based pollution reduction measures, can be found in the USCRTF's Watershed Partnership Initiative Priority Ecosystem Indicators (2016).

5.3 Adaptive Management Measures

Adaptive management measures are typically considered as an aspect of administrative measures. However, adaptive management measures may also apply to ecological performance standards. If an existing ecological performance standard were not adequate to evaluate the performance, it may need to be modified to better evaluate the success of the compensatory mitigation activity. For example, the performance standard may have defined an acceptable level of sediment or turbidity in the water that is too large of a range to distinguish a difference in coral recovery; that performance standard may need to be modified to better distinguish the changes in sediment and turbidity to evaluate if the compensatory mitigation activity is on the desired trajectory. For compensatory mitigation activities that may have a high risk or uncertainty of success in part of the performance, it is a good practice to develop an adaptive management plan to identify when and what type of corrective actions may be needed if the activity is not meeting the performance standards. USACE developed "The application of adaptive management to ecosystem restoration projects" (Fischenich et al., 2012). This report is a good resource for understanding how to develop adaptive management plans for restoration and compensatory mitigation actions. Following are hypothetical examples of adaptive management standards.

Hypothetical examples of Adaptive Management Standards:

- In the event that >50% of outplanted staghorn coral die or are lost within the first five years, an equal number of nubs >5 cm will be outplanted to Polypy Bay within three months of the mortality.
- In the case that an unforeseen event severely damages the Polypy Bay restoration project and impedes recovery, Coral Lovers Forever shall convene a meeting within one month of the event with Department of Coral Protection to determine how to proceed with this or an alternative restoration project. Coral Lovers Forever shall be prepared to present options for consideration.

5.4 Monitoring and Reporting of Project Performance

Monitoring provides the information necessary to determine whether a project is progressing toward the stated performance standards. If the project is not meeting performance standards or targets as anticipated, adaptive management or other corrective actions may be necessary to get the mitigation area on a track to success. Monitoring programs should be created along with the development of the compensatory mitigation plan, to ensure that the monitoring strategy is consistent with the performance standards and provides an effective incremental assessment of the mitigation action's progress toward successfully meeting those standards. When monitoring programs are developed after the mitigation plan and/or developed separately by third parties, a wide variety of information may be collected on the area but that information may not be relevant to measuring the mitigation areas progress toward successfully meeting the performance standards. Assessing progress of the restoration project is critical because decisions about adaptive management will be based on progress toward achieving performance standards. The monitoring program must include the specific parameters to be measured or assessed by the applicable performance standards. The monitoring report should include data to demonstrate whether a particular performance standard is met. The monitoring program may also identify adaptive management or corrective actions that can be taken to attempt to achieve the performance standards that are not being met.

Performance monitoring need not be as comprehensive as the initial characterization of the impact site. In fact, performance monitoring might focus entirely on measuring stressor reduction, rather than on condition of the coral reef ecosystem. In most cases, ecological performance monitoring should use coral ecosystem assessment methods that are compatible with the original impact characterization so that recovery can be assessed against the original loss. A common problem with monitoring programs is that many criteria may be monitored, but unless the monitoring program was appropriately designed to answer the correct question (i.e., the success criteria), the data may fail to directly address progress toward the performance standards.

Compensatory mitigation or restoration projects should specify monitoring and reporting requirements. These requirements should include the frequency of monitoring, which performance standards should be assessed at a particular time during the monitoring period, the content of monitoring reports, and when monitoring reports need to be submitted to regulatory agencies, resources agencies, or other parties (e.g., annual monitoring reports). Monitoring reports should be made available to interested parties to share information on project outcomes and lessons learned to advance the science and practice of coral reef compensatory mitigation and restoration.

6.0 RECOMMENDATIONS AND NEXT STEPS

This Handbook is the first attempt to document and summarize the current state of practice with respect to addressing coral reef impacts from planned and unplanned activities. As stated earlier, agreement and consistency is growing across the regulatory and management agencies about BMPs for mitigation and restoration of impacts. However, there may still be challenges working with multiple agencies that have varying mandates and policies.

With the ongoing and increasing threats from climate change and ocean acidification, project proponents should work closely with the appropriate permitting authorities to determine how to address climate change considerations in their projects and mitigation actions. Incorporating climate change considerations in mitigation planning helps to incorporate risk-informed decision-making, adaptive learning, and preparedness planning, as promoted in EO 13653. Climate change adaptation is a burgeoning area—including growing availability of information, resources, and tools. As these tools become more readily available, the USCRTF will seek the best methods to share this information with USCRTF members, stakeholders, and the public.

The USCRTF is particularly well-suited to facilitate the sharing of information on the continued evolution of coral impact response. All the relevant federal, state, and territorial agencies that deal with either planned or unplanned impacts to corals are members of the USCRTF. Many of these agencies have participated in the Coral Injury Working Group, and in the development of this Handbook. As noted within the Handbook, addressing coral reef impacts is complex, and there is a great deal of uncertainty surrounding many of the currently available options and tools.

It is the recommendation of USCRTF, that due to the complex nature of the coral reef ecosystem, and the even more complex nature of identifying and providing appropriate compensatory mitigation for lost ecosystem services, the emphasis on maximizing avoidance and minimization of impacts cannot be overstated.

There are many emerging tools and strategies for addressing coral impacts from planned or unplanned events. As more options are implemented, BMPs will be better defined for the avoidance, minimization, compensation for, and restoration of impacts to coral reefs. In its role in facilitating the sharing of information that promotes the protection and restoration of coral reefs, the USCRTF will determine the most effective manner to provide updated information as tools, strategies, and BMPs mature in the future.

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APPENDICES

Appendix I – Legal and Policy Summary

There are numerous laws and regulations that govern activities in and around coral reef ecosystems. In some instances, activities in coral reefs may trigger multiple authorities across various federal, and state, or territorial agencies. Project proponents may be most familiar with the permitting requirements under CWA §404, and EFH consultation requirements under MSA §305(b) for planned activities, and with the NRDAR requirements for unplanned impacts. Appendix I provides a more comprehensive list of laws and regulations that apply to activities and impacts within coral reef ecosystems. However, this is not an exhaustive list of every relevant federal, state, territorial, or Tribal authority.

The following two tables present the federal (Table 5), and state or territorial (Table 6) laws, regulations, and statutes that govern activities that may impact coral reefs. Specific sections of various regulations have been listed separately, because they are particularly applicable to activities that may impact coral reefs; however, it should be noted, that they are not the only sections of the relevant policies listed here that may apply in each situation. Links to the full language for each have been provided where possible.

Table 5: Collection of federal laws and regulations that govern activities that may impact coral reefs.

Statutes, Regulations, and Policies	Implementing Agencies	Description
Abandoned Shipwreck Act 43 U.S.C. §§2101-2106	NPS	Requires states to protect and preserve abandoned shipwrecks in their waters for recreational and historical purposes, encouraging the creation of underwater parks to provide additional protection.
Antiquities Act/National Monuments 54 U.S.C. §320301	U.S. President	Authorizes the President to designate landmarks, structures, and "other objects of historic or scientific interest" as national monuments.
Clean Water Act 33 U.S.C. §§1251-1387 and it's implementing regulations.	EPA, USACE, and States/Territories (S/T)	The CWA prohibits the unauthorized discharge of pollutants into U.S. waters in an effort to restore and maintain physical, chemical and biological integrity of waters. Particular sections of note include: • CWA §301, the prohibition against unauthorized discharge, technology-based pollutant reduction requirements for industrial and municipal permittees. • CWA §303 water quality standards (WQS) program. States, tribes, and territories establish designated uses, water quality criteria, and an anti-degradation policy for waters within their jurisdictions, which are then submitted to EPA for review and approval or disapproval. Water quality standards are not "effective" for Clean Water Act purposes until approved or established by EPA. • CWA §309, EPA authority to initiate administrative and judicial enforcement of the prohibition against unpermitted discharge, and violations of discharge permits and dredged material permits.

Statutes, Regulations, and Policies	Implementing Agencies	Description
		• CWA §316(b), implemented through discharge permits, requires that the location, design, construction, operation, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts. • CWA §319, nonpoint source management control program, federal grant program administered by states, tribes, and territories. • CWA §401, water quality certifications, administered primarily by states and territories discharges associated with any federally licensed or permitted activity comply with approved water quality standards. • CWA §402, National Pollutant Discharge Elimination System, discharge permitting programs administered primarily by states and territories subject to EPA minimum program requirements and permit oversight, but also by EPA in some jurisdictions. Point discharges are permitted under NPDES. • CWA §404, permitting program for discharge of dredged or fill material in waters of the United States, administered by USACE with oversight by EPA. EPA approves and oversees the delegation of CWA §404 authority to states and ensures state programs meet minimum program requirements and oversight. • Compensatory Mitigation for Losses of Aquatic Resources, regulatory program applicable to CWA §404 permitting, commonly known as the 2008 Mitigation Rule, 33 CFR Part 332, implemented by the USACE and EPA.
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 42 U.S.C. Ch.103	EPA	CERCLA, commonly known as Superfund, provides broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment and created a tax on the chemical and petroleum industries. In addition, CERCLA provides for the assessment and restoration of Natural Resource Damages.
Coastal Barriers Resources Act (CBRA) 16 U.S.C. §§3501-3510	NOAA and S/T	CBRA encourages the conservation of hurricane prone, biologically rich coastal barriers by restricting federal expenditures that encourage development, such as federal flood insurance. Areas within the CBRS can be developed provided that private developers or other non-federal parties bear the full cost.
Coastal Zone Management Act (CZMA)	NOAA and Dept. of Interior (DOI)	CZMA provides federal funding to assist states in developing and administering coastal zone management plans (CMPs) to carry out its purpose to

Statutes, Regulations, and Policies	Implementing Agencies	Description
16 U.S.C. §§1451-1466		"preserve, protect, develop, and where possible, to restore or enhance the resources of the Nation's coastal zone for this and succeeding generations." CZMA §307, commonly called the Federal Consistency Provision, requires that federal actions, within and outside the coastal zone, that have reasonably foreseeable effects on any coastal use (land or water) or natural resource of the coastal zone be consistent with the enforceable policies of a state's federally approved coastal management program.
Coral Reef Conservation Act (CRCA) 16 U.S.C. §§6401-6409	NOAA and DOI	CRCA aims to preserve and protect coral reef ecosystems, to effectively manage those ecosystems with the aid of scientific research, and to fund programs consistent with those goals. It requires, in conjunction with existing environmental laws, coral reefs to be monitored, mapped, and researched in order to better understand how to manage their ecosystems.
Endangered Species Act of 1973 (ESA) 16 U.S.C. §1531 et seq.	NOAA, FWS, and USCG	ESA provides for the conservation of endangered and threatened species and for the conservation of "the ecosystems upon which endangered species and threatened species depend." USCG has enforcement authority.
Executive Order 13089 – Coral Reef Protection 63 FR 32701 (June 11, 1998)	USCRTF	The EO creates task force charged with overseeing the mapping and monitoring of all U.S. coral reefs, researching coral degradation, conserving and restoring coral reefs, and promoting coral reef conservation internationally.
Executive Order 13158 - Marine Protected Areas 65 FR 34909 (May 31, 2000)	NOAA and DOI	The EO is intended to (a) strengthen the management, protection, and conservation of existing MPAs and establish new or expanded MPAs; (b) develop a scientifically based, comprehensive national system of MPAs representing diverse U.S. marine ecosystems, and the Nation's natural and cultural resources; and (c) avoid causing harm to MPAs through federally conducted, approved, or funded activities.
Fish and Wildlife Coordination Act (FWCA) 16 U.S.C. §§661-667e	FWS, NMFS, and S/T	FWCA states that "whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, …or modified for any purpose whatever, …by any department or agency of the U.S., or by any public or private agency under Federal permit or license, such department or agency first shall consult with the FWS, and with the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and

Statutes, Regulations, and Policies	Implementing Agencies	Description
		improvement thereof in connection with such water-resource development."
Lacey Act 16 U.S.C. §§3371-3378	NOAA and FWS	The Lacey Act prohibits the importation, exportation, sale, receipt, acquisition, or purchase of any fish, wildlife, or plant taken in violation of U.S., foreign, or Indian tribal law or in interstate or foreign commerce in violation of any state or foreign law.
Magnuson Stevens Fishery Conservation and Management Act (MSA) 16 U.S.C. §§1801-1891	NMFS and USCG	In the regulatory context, one of the most important provisions of the MSA for conserving fish habitat is that which requires federal agencies to consult with NMFS when any activity proposed to be permitted, funded, or undertaken by a federal agency may have adverse effects on designated EFH. The consultation requirements in the MSA direct federal agencies to consult with NFMS when any of their activities may have an adverse effect on EFH. Furthermore, with goals to reduce bycatch and overfishing, fishery management plans may prohibit or limit fishing practices that are harmful to coral reefs. MSA directly protects deep-sea corals through the Deep-Sea Coral Research and Technology Program, as well as the MSA's authorization to designate zones to protect deep-sea corals. Coral reefs designated as essential fish habitat in FMPs will receive additional protection. USCG has enforcement authority.
Marine Mammal Protection Act (MMPA) 16 U.S.C. §§1361-1423	NOAA and FWS	MMPA prohibits the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine products in the United States. The MMPA states that the essential habitats, which may include coral reef ecosystems, used by marine mammals should be protected, and marine mammals should be protected from the harmful actions of man. NMFS can authorize take under certain activities and conditions.
The Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972 33 U.S.C. §§1401-1445	USACE and EPA	MPRSA, specifically Title I, sometimes referred to as the Ocean Dumping Act, generally prohibits (1) the transportation of material from the United States for the purpose of ocean dumping; (2) transportation of material from anywhere for the purpose of ocean dumping by U.S. agencies or U.S.-flagged vessels; (3) dumping of material transported from outside the United States into the U.S. territorial sea. A permit is required to deviate from these prohibitions. The standard for permit issuance is whether the dumping will "unreasonably degrade or endanger" human health, welfare, or the marine environment. USACE issues permits for the ocean disposal of dredged material; EPA issues permits for other materials. Disposal sites are designated by EPA. USACE authorizes clean dredged material disposal in consultation with EPA.

Statutes, Regulations, and Policies	Implementing Agencies	Description
MARPOL – International Convention for the Prevention of Pollution by Ships		The objective of MARPOL is to limit ship-borne pollution by restricting operational pollution and reducing the possibility of accidental pollution. MARPOL specifies standards for stowing, handling, shipping, and transferring pollutant cargoes, as well as standards for discharge of ship-generated operational wastes. The United States is party to Annexes I-III, V, and VI and they have been incorporated into U.S. law. Although Annex IV has not been ratified, the United States has equivalent regulations under the CWA for the treatment and discharge of sewage from vessels.
National Environmental Policy Act (NEPA) 42 U.S.C. §§4321-4370	CEQ, applies to all federal agencies	NEPA requires all federal agencies to analyze the potential environmental impacts of their proposed actions "significantly affecting the quality of the human environment," which could include actions' effects on coral reef ecosystems.
National Marine Sanctuaries Act (NMSA) 16 U.S.C. §§1431-1445	NOAA and S/T	NMSA designates "areas of the marine environment which are of special national significance" as national marine sanctuaries, providing for their protection, management, and conservation.
Natural Resource Damage Assessment and Restoration (NRDAR) Procedures 43 CFR 11 42 U.S.C. 9651(c)	DOI and Dept. of Commerce	NRDAR is the legal process that federal agencies like NOAA, together with the states and Indian tribes, use to evaluate the impacts of oil spills, hazardous waste sites, and ship groundings on natural resources both along the Nation's coast and throughout its interior.
54 U.S.C. Chapters 1001-1007 cover general provisions, establishment of the NPS, areas of the system, and resource (formerly known as the NPS Organic Act)	NPS	54 U.S.C. §§1001-1007 establishes the NPS and authorizes it to regulate the National Park System.
Presidential Memorandum: Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment. (November 3, 2015)	DOI, USDA, EPA, and NOAA	The memorandum directs agencies to adopt a clear and consistent approach for avoidance and minimization of, and compensatory mitigation for, the impacts of their activities and the projects they approve.

Statutes, Regulations, and Policies	Implementing Agencies	Description
Presidential Memorandum: Incorporating Natural Infrastructure and Ecosystem Services in Federal Decision-Making. (October 7, 2015)	Federal Agencies	The memorandum directs federal agencies to factor the value of ecosystem services into federal planning and decision-making.
Oil Pollution Act (OPA) 33 U.S.C. §§2701-2762	USCG, EPA, and NOAA	OPA created a comprehensive prevention, response, liability, and compensation regime to deal with vessel- and facility-caused oil pollution to U.S. navigable waters. OPA greatly increased federal oversight of maritime oil transportation, while providing greater environmental safeguards by: • Setting new requirements for vessel construction and crew licensing and manning. • Mandating contingency planning. • Enhancing federal response capability. • Broadening enforcement authority. • Increasing penalties. • Creating new research and development programs. • Increasing potential liabilities. • Significantly broadening financial responsibility requirements. Full description can be found at http://www.uscg.mil/npfc/About_NPFC/opa.asp under the OPA Overview Section.
Resource Conservation and Recovery Act (RCRA) 40 CFR Parts 239 – 282. 42 U.S.C. §6901 et seq.	EPA	RCRA regulates the management of solid waste (e.g., garbage), hazardous waste, and underground storage tanks holding petroleum products or certain chemicals to protect human health and the environment from the potential hazards of waste disposal, to conserve energy and natural resources, to reduce the amount of waste generated, and to ensure that wastes are managed in an environmentally sound manner.
Rivers and Harbors Act of 1899 (RHA) 33 U.S.C. §§401-426	USACE	RHA regulates construction and prohibits the discharge of “any refuse matter of any kind” into navigable waters in the United States. Of particular note, RHA §10 applies to physical structures or work in navigable waters.
Sikes Act *16 USC §§670a-670o*	Dept. of Defense, NOAA, and FWS	Sikes Act requires development of integrated natural resource management plans for military installations in consultation with FWS and NOAA.
System Unit Resource Protection Act 54 U.S.C. 100721 (SURPA)	NPS	Gives NPS authority to seek damages from responsible parties for injuries to system unit resources within park system units. System unit resources include natural, cultural, and facility living or non- living resources. Also give NPS the authority to retain damages to be used to restore resource injuries.

Statutes, Regulations, and Policies	Implementing Agencies	Description
Water Resources Development Act Citations include, but are not limited to: WRDA 1986, Pub.L. 99–662 WRDA 2000, Pub.L. 106–541 WRDA 2007, Pub.L. 110–114; WRRDA 2014, Pub. L 113-121	USACE	The WRDAs provide the authority for the federal government to assist states and territories in the development of water resource management activities including navigation, flood risk management, and aquatic ecosystem restoration. Eligible projects are shown to have a federal interest to national economic development and/or national ecosystem restoration goals and objectives.

Table 6: Summary of state and territorial laws and regulations that govern activities that may impact coral reefs.[6]

Statutes, Regulations, and Policies	Implementing Agencies	Description
Commonwealth of the Northern Mariana Islands (CNMI)		
Coastal Resource Management Rules and Regulations (NMIAC 15-10)	Division of Coastal Resources Management	Chapter 15-10 primarily outlines permitting criteria and enforcement of permitting for projects in the coastal zone. The law states that "significant adverse impacts to reefs and corals shall be prevented" and there shall be no "destruction of reefs and corals not associated with permitted projects." (a) Lagoon and Reef Area of Particular Concern (APC); Management Standards. (b) Lagoon and Reef APC; Use Priorities. (1) General Lagoon and Reef APCs. (2) Lagoon and Reef APC; Managaha. (3) Lagoon and Reef APC; Anjota Island. (4) Lagoon and Reef APC; Coral Reefs. (f) Mitigation of Adverse Impact. Wherever practicable, adverse impact of the proposed project on the environment shall be mitigated. **http://www.cnmilaw.org/mediawiki-1.21.2/index.php?title=15-10**
Coastal Resources Management Act of 1983 (2 CMC §§1501 et seq).	Division of Coastal Resources Management	This law established DCRM and outlines its purpose, including: manage ecologically significant resource areas for their contribution to marine productivity and value as wildlife habitats, and preserve the functions and integrity of reefs, marine meadows, salt ponds, mangroves, and other significant natural areas. **http://www.cnmilaw.org/pdf/public_laws/03/pl03-47.pdf**
Non-Commercial Fish and Wildlife Regulations (NMIAC 85-30.1)	Division of Fish and Wildlife (DFW)	Collection of Hard Corals Prohibitions: The collection and/or removal from the waters of the CNMI of any and all species of hard Hermatypic reef building corals, soft corals, or stony hydrozoans, is prohibited, except as specifically allowed by this section. Marine Reserves: The Director may acquire and designate aquatic habitats or easements as marine reserves in accordance with 2 CMC §5104(a)(5). Marine reserves are created to protect important fish and aquatic species populations and their habitats.**http://www.cnmilaw.org/mediawiki-1.21.2/index.php?title=85-30.1**
Submerged Lands Act 2 CMC §§ 1201 et seq.	Department of Lands and Natural Resources	The purpose of this chapter is to provide for water and non-water-dependent uses of CNMI-owned submerged lands and to provide for the exploration, development of, and extraction of petroleum deposits

[6] Depending on the federal action, some of the state and territorial laws may not apply. Work closely with the state or territorial regulatory office to determine which laws apply to the proposed activity.

Statutes, Regulations, and Policies	Implementing Agencies	Description
		or mineral deposits in submerged lands of the Northern Mariana Islands. **http://www.cnmilaw.org/pdf/cmc_section/T2/1211.pdf** The department shall consider the natural values of CNMI-owned submerged lands as wildlife habitat, natural area preserve, representative ecosystem, or spawning area prior to issuing any initial lease or authorizing any change in use. The department may withhold from leasing lands which it finds to have significant natural values, or may provide within any lease for the protection of such values. **http://www.cnmilaw.org/pdf/cmc_section/T2/1221.pdf**
Commonwealth Environmental Protection Act 2 CMC §§ 3101 et seq.	Division of Environmental Quality (DEQ)	The legislature declares that it is the policy of the CNMI: • To affirmatively protect the right of each person to a clean and healthful public environment. • To establish and enforce environmental standards to protect and preserve the marine resources of CNMI. This law charges DEQ with administering water quality programs and regulating earth-moving, including disturbances to the sea floor, lagoon bottom, or coral reef. **http://www.cnmilaw.org/pdf/cmc_section/T2/3111.pdf**
Water Quality Standards	Bureau of Environmental and Coastal Quality	9.6 (b)(3) Dredging and Discharge of Dredged of Fill Material. Dredging and the discharge of dredged or fill material can adversely affect colonies of reef building organisms by burying them, by releasing contaminants such as hydrocarbons into the water column, by reducing light penetration through the water, and by increasing the level of suspended particulates. Coral organisms are extremely sensitive to even slight reductions in light penetration or increases in suspended particulates (i.e., turbidity). These adverse effects will cause a loss of productive colonies which in turn provide habitat for many species of highly specialized aquatic organisms. For activities which have the potential to adversely affect coral reproduction, a stoppage period of 21 days, starting five days after the late May or early June full moon (to be determined by DEQ), is required. The stoppage period, if determined to be applicable, shall be no less than twenty one (21) calendar days. In determining whether an activity has the potential to affect coral spawning, DEQ shall consider all of the following:

Statutes, Regulations, and Policies	Implementing Agencies	Description
		1) the magnitude of the sediment plume generated by the proposed activity; 2) the most likely extent and direction(s) of drift of the sediment plume; 3) the type of sediment and its composition; and 4) the proximity of broadcast spawning coral species to the proposed activity and expected sediment plume.
Fish, Game and Endangered Species Act 2 CMC §§5101 et seq.	DFW	The protection of fish, game, and endangered and threatened species is vested exclusively in the department. This law gives DFW jurisdiction over fish and wildlife including determining the status of, and any requirement for the survival of, resident species of fish, wildlife, or plants. **http://www.cnmilaw.org/pdf/cmc_section/T2/5104.pdf**
Moratorium on Seaweed, Sea Grasses, and Sea Cucumber 2 CMC §5601	Coastal Resources Management Office	There is hereby established for a period of at least ten years a moratorium on the harvest of all non-commercially grown seaweed, sea grass, or sea cucumbers or other edible echinoderms. Any hotel directly fronting or adjacent to the Saipan lagoon shall be exempted from subsection (a). The Coastal Resources Management Office in consultation with the DFW shall promulgate rules governing the area of allowance for the removal of seaweed and sea grass. **http://www.cnmilaw.org/pdf/cmc_section/T2/5601.pdf**
Fair Fishing Act 2 CMC §5631	Department of Lands and Natural Resources	Except as provided in subsections (b) and (c), it shall be unlawful for any commercial and non-commercial fishermen to use explosives, poisons, electric shocking devices, scuba tank or hookah when fishing for reef fish and harvesting other marine life within waters of CNMI. **www.cnmilaw.org/pdf/cmc_section/T2/5631.pdf**
Protecting of Rays and Sharks 2 CMC §5641, §5642	DFW	It shall be unlawful for any person, within the CNMI or any place subject to the jurisdiction thereof, to knowingly, or with wanton disregard for the consequences of his act, feed, take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or in any manner any ray, alive or dead, or any part thereof, without being permitted to do so as provided in this section, or to violate any permit or regulation issued pursuant to this section. **http://www.cnmilaw.org/pdf/cmc_section/T2/5641.pdf**

Statutes, Regulations, and Policies	Implementing Agencies	Description
		It is unlawful for any person, within the nearshore waters of the CNMI to knowingly, or with wanton disregard for the consequences of his act feed in any manner any shark, without first obtaining a permit from the Director of the DFW, or violates any permit or regulation issued pursuant to this section. **http://www.cnmilaw.org/pdf/cmc_section/T2/5642.pdf**
Shark Finning Prohibition 2 CMC §5651	Department of Lands and Natural Resources	It shall be unlawful for any person to possess, sell, offer for sale, trade, or distribute shark fins in the CNMI. **http://www.cnmilaw.org/pdf/cmc_section/T2/5651.pdf**
State of Florida		
Environmental Resource Permitting Florida Statute (F.S.) §373.129., .413 & .414	Florida Department of Environmental Protection (FDEP)	Within FDEP the Submerged Lands and Environmental Resources Program (SLERP) administers Environmental Resources Permits (ERPs). ERPs regulate activities involving the management and alteration of surface water flows. This includes upland construction activities that generate storm water runoff, which contributes to such aspects as: • Runoff quantity (i.e., storm water attenuation and flooding of other properties) in both wetlands and uplands; • Water quality (i.e., storm water treatment) in both wetlands and uplands; and, • Dredging and filling in most surface waters and wetlands (whether isolated or connected to other waters). In addition, this includes the alteration of mangroves. The ERP also handles the submerged lands authorization for any construction on or use of submerged lands owned by the state of Florida. The ERP program is authorized pursuant to Chapter 373, Part IV, F.S., Management and Storage of Surface Waters and implemented by a variety of Florida Administrative rules. A list of the rules are available at the following webpage: **http://www.dep.state.fl.us/water/wetlands/erp/rules/guide.htm**. A Joint Coastal Permit (JCP) program involves concurrent processing of applications for a coastal construction authorization, an ERP, and a sovereign submerged land authorization. A JCP is required for construction activities on Florida's natural sandy beaches, adjacent state sovereignty lands and associated inlets, or activities that are likely to have a material physical effect on existing coastal

Statutes, Regulations, and Policies	Implementing Agencies	Description
		conditions, natural shore processes, or inlet processes. The JCP is authorized pursuant to Sections 161.021, 161.041 and 161.055, F.S., Rule 62B-41, F.A.C., Rules and Procedures 22 Florida Coastal Management Program Guide for Application for Coastal Construction Permits, and Rule 62B-49, F.A.C., Joint Coastal Permits and Concurrent Processing of Proprietary Authorizations.
Surface Water Quality Standards Florida Administrative Code (F.A.C) 62 – 302.500 & 530	FDEP	62-302.500, F.A.C. – Minimum & General Criteria. Turbidity cannot exceed 29 Nephelometric Turbidity Units (NTUs) above natural background conditions in Class I – V Waters. Turbidity cannot exceed ambient background conditions in Aquatic Preserves due to their status as Outstanding Florida Waters (OFW). 62–302.530, F.A.C. – Surface WQ Standards. This rule defines the general state water quality standards for all activities. If an activity will potentially violate these standards, then it will likely require a FDEP permit (ERP or Joint Coastal Permit) unless eligible for exemption.
Permit Guidelines, Mixing Zones F.A.C. 62 – 4.242 &.244	FDEP	62-4.242&.244, F.A.C. – Mixing Zones. Mixing zones can be granted for selected projects that otherwise can't meet water quality standards within close proximity to the construction activity. More information is available at: **https://www.flrules.org/gateway/RuleNo.asp?title =PERMITS&ID=62- 4.244**
Protection of Sovereign Submerged Lands F.S. §253.04	FDEP	Chapter 253 FS addresses the state's administration of public lands and property of this state. The statute provides direction regarding the acquisition, disposal, and management of all state lands. The Board of Trustees of the Internal Improvement Trust Fund (Board) of the state is vested and charged with the acquisition, administration, management, control, supervision, conservation, protection, and disposition of all lands owned by the state, except for lands acquired for certain purposes. **18-14, F.A.C.,** implements the fine schedule for violations.
Pollution Control F.S. § 403.121 & .201 (& others)	FDEP	§403.121, F.S.: The Environmental Litigation Reform Act (ELRA): Allows swifter, more efficient use of administrative process for imposing damages and penalties (up to $10,000 per offense). Outlines administrative penalties for specified violations rules and statutes. §403.141 and §403.161, F.S. Allow imposition of damages and civil liability for causing pollution that

Statutes, Regulations, and Policies	Implementing Agencies	Description
		harms aquatic life. Remedies are all judicial rather than administrative. For adjusted penalties >$10,000, FDEP instead considers program specific guidelines for characterizing violations and assessing penalties. If a settlement cannot be reached consistent with FDEP's Settlement Guidelines for Civil and Administrative Penalties (FDEP Directive 923), FDEP will file an enforcement action in state court.
Florida Coastal Management Program Chapter 380, F.S., Part II, Coastal Planning and Management	FDEP	FDEP's Florida Coastal Office, is charged with overseeing the state's coastal management program and handles the following Florida Coastal Management Program (FCMP) activities: • Compiles and submits the federal applications for receiving funds pursuant to the CZMA. • Adopts rule procedures and criteria for the evaluation of Coastal Partnership Initiative (CPI) and state agency sub-grant applications for funds allocated to the state under the CZMA. • Administers the Coastal and Estuarine Land Conservation Program (CELCP), a federally-funded land acquisition program. • Conducts the CZMA § 309 assessment and strategies for coastal resource issues. • Administers the Beach Access Sign Program, the Beach Warning Flag Program, and the Rip Current Awareness Program. • Prepares routine program updates to incorporate annual statutory changes. • Guides the coordination of the Federal Consistency review process. "Federal Consistency" is the requirement that federal actions that affect any land, water, or natural resource of a state's coastal zone must be consistent with the enforceable policies of the state. The FCMP federal consistency process consists of a network of 24 Florida Statutes (i.e., enforceable policies) administered by FDEP and a group of partner agencies responsible for implementing the statutes.
Joint Coastal Permit F.S. §161.054 & .055	FDEP	The Joint Coastal Permit (JCP) Program allows FDEP to concurrently process applications for coastal construction permits, environmental resource permits, and sovereign submerged lands authorizations. The consolidation of these programs and the assignment of responsibility to a single bureau has eliminated the potential for conflict between permitting agencies and helped ensure that reviews

Statutes, Regulations, and Policies	Implementing Agencies	Description
		are conducted in a timely manner. JCP permit applications are forwarded to the USACE from FDEP or SFWMD for separate processing and review.
Marine Life Rule 68B-42.009, F.A.C.	Florida Fish and Wildlife Conservation Commission (FWC)	Harvest of any hard or stony coral (Order Scleractinia), black coral (Order *Antipitharia*), fire coral (Genus *Millepora*), or sea fans (*Gorgonia flabellum or G. ventalina*) is prohibited.
Special Activity License 68B-8, F.A.C.	Florida FWC	Authorization required for the collection or take of corals for education, research, enhancement, restoration, or mitigation activities.
Coral Protection in State Parks F.S.§258.008(3)(a)	FDEP	Any person who engages in any of the following activities within the boundaries of a state park without first obtaining the express permission of the Division of Recreation and Parks commits a misdemeanor of the second degree, punishable as provided in s. 775.082 or s. 775.083, and shall be ejected from all property managed by the division: (a) Cutting, carving, injuring, mutilating, moving, displacing, or breaking off any water-bottom formation or coral. (b) Capturing, trapping, or injuring a wild animal. (c) Collecting plant or animal specimens. (d) Leaving the designated public roads in a vehicle. (e) Hunting.
Rules Relating to Endangered or Threatened Species 68A-27, F.A.C.	Florida FWC	Staghorn coral (*Acropora cervicornis*) Elkhorn coral (*Acropora palmata*) Pillar coral (*Dendrogyra cylindrus*) Lobed star coral (*Orbicella annularis*) Mountainous star coral (*Orbicella faveolata*) Boulder star coral (*Orbicella franksi*) Rough cactus coral (*Mycetophyllia ferox*)
Guam		
E.O. 78-37	Bureau of Statistics and Plans, Guam Coastal Management Program	***Coastal Zone Resource Policies:*** Sets forth criteria and enforceable policies determining permitting for projects in the coastal zone. This law establishes management policies for Guam's ecologically significant resource areas for their contribution to marine productivity and value as wildlife habitats, and preserves the functions and integrity of reefs, beaches, marine preserves, mangroves, hydrological systems, and other significant natural coastal areas.
E.O. 2013-05	Bureau of Statistics and Plans, Guam Coastal Management Program	***Coral Reef Resource Policies***: Establishes the Guam Coral Reef Initiative Coordinating Committee to develop, update, and monitor Guam's Local Action Strategies, funding, and determine management policies to preserve the function and integrity of Guam's coral reef ecosystems.
Fish and Wildlife Regulations	Guam Department of	Statutory and regulatory rules governing fish and wildlife resources for the territory of Guam, including

Statutes, Regulations, and Policies	Implementing Agencies	Description
(5 Guam Code Annotated, Chapter 63, Article 1, §§63101 et seq.)	Agriculture, Division of Aquatic and Wildlife Resources	coral protection, hunting and fishing regulation, and 5 existing limited take Marine Preserves.
Guam Endangered Species Act 5 Guam Code Annotated, Chapter 63, Article 2, §§63201 et seq.	Guam Department of Agriculture, Division of Aquatic and Wildlife Resources	***Protection of Fish, Game, and Wildlife:*** Protects fish, game, and wildlife, including determining the status of, and any requirement for the survival of, resident species of fish, wildlife, or plants; particularly any species of plant or wildlife which appears likely, within the foreseeable future, to become endangered and which has been so designated by the Guam Department of Agriculture, or that has been determined to be listed as an endangered or threatened species pursuant to the U.S. ESA.
Submerged Lands Act; and Guam Exclusive Economic Zone (Ocean Resources) Public Law 93-435	Department of Land Management	***Submerged Lands of Guam:*** Provides for water and non-water-dependent uses of Guam-owned submerged lands; for concurrent local and federal jurisdiction for civil and criminal offenses; and for Guam's ownership of the rights to management, exploration, development of, and extraction of petroleum or mineral deposits in submerged lands of Guam; and the natural values of Guam-owned submerged lands as wildlife habitat, natural area preserve, representative ecosystem, or spawning area with respect to leasing or authorizing any use of these submerged lands.
Organic Act of Guam Article 1§1704 et seq.; & 1 Guam Code Annotated § 402	Department of Land Management	Concurrent Resource natural resource jurisdiction on submerged lands adjacent to federal property and oversight of submerged lands from the high tide mark out to three miles in territorial waters.
Guam Environmental Protection Agency Act 10 Guam Code Annotated, Chapter 45, §§45101 et seq.	Guam Environmental Protection Agency	***Water Quality Standards:*** Provides that the policy of Guam is to affirmatively protect the right of each person to a clean and healthful public environment; and to establish and enforce environmental standards to protect and preserve the environmental health of Guam, including its marine resources. This law charges Guam EPA with administering water quality programs and regulating earth-moving, including disturbances to the sea floor, lagoon bottom, or coral reef.
Guam Water Pollution Control Act 10 Guam Code Annotated, Chapter 47, §§47101 et seq.	Guam Environmental Protection Agency	***Water Pollution Control:*** Prohibits the discharge of pollutants into or upon all of the waters of Guam, including inland waters and coastal waters, beaches, or lands adjoining the coasts of Guam. Pollution is defined as the presence in the outdoor atmosphere or waters of Guam any one or more substances or pollutants in quantities which are or may be potentially harmful or injurious to life, including wildlife, fish and aquatic life; and which may

Statutes, Regulations, and Policies	Implementing Agencies	Description
		progressively obstruct agricultural, industrial, recreational, and other beneficial uses of water.
Guam Territorial Seashore Protection Act 21 Guam Code Annotated, Chapter 63, §§63101 et seq.	Guam Department of Land Management, and Guam Land Use Commission	***Seashore Reserve:*** Creates a Seashore Reserve area in Guam, consisting of the land and water area of Guam extending seaward to the ten-fathom contour, and recognizes that the Seashore Reserve is a distinct and valuable natural resource belonging to all the people of Guam and existing as a delicately balanced ecosystem; provides for the protection of the natural, scenic, historical resources, wildlife, marine life, and other ocean resources, and the natural environment of the seashore reserve by limiting and prescribing development within the Seashore Reserve area.
State of Hawaii		
Hawaii Constitution, Article XI		***Art. XI, §1 (Conservation and Development of Resources)*** *"For the benefit of present and future generations, the State and its political subdivisions shall conserve and protect Hawaii's natural beauty and all natural resources, including land, water, air, minerals and energy sources, and shall promote the development and utilization of these resources in a manner consistent with their conservation and in furtherance of the self- sufficiency of the State. All public natural resources are held in trust by the State for the benefit of the people."* This section embodies Hawaii's public trust doctrine. ***Art. XI, §2 (Management and Disposition of Natural Resources)*** ***Art. XI, §6 (Marine Resources)*** *"The State shall have the power to manage and control the marine, seabed and other resources located within the boundaries of the State, including the archipelagic waters of the State, and reserves to itself all such rights outside state boundaries not specifically limited by federal or international law."* ***Art. XI, § 11 (Exclusive Economic Zone)***
Hawaii Revised Statute (HRS) Chapter 343	Depends	Chapter 343 is Hawaii's Environmental Policy Act (HEPA). Chapter 343 requires that an agency or applicant prepare an environmental assessment or an environmental impact statement if a proposed action meets any of nine "triggers" listed in the statute.
HRS Chapter 171	Department of Land and Natural Resources (DLNR)	Chapter 171 addresses Hawaii's management of its public lands (including submerged lands) through the DLNR. DLNR is tasked with managing and administering the "aquatic life, aquatic life sanctuaries, public fishing areas, boating, ocean

Statutes, Regulations, and Policies	Implementing Agencies	Description
		recreation, coastal programs . . . and other functions assigned by law." DLNR is authorized to recover natural resource damages for violations of the chapter. Violations include engaging in prohibited activities or prohibited uses.
HRS Chapter 183C	DLNR	Chapter 183C provides a framework for Hawaii to manage lands in the conservation district, including the ocean and submerged lands, in a manner that protects and preserve the natural ecosystems within them. DLNR is responsible for managing lands in the Conservation District. These responsibilities include the following: maintaining an inventory of lands classed conservation lands; identifying and zoning lands in the district; establishing conditions on use and categories of use and activities; adopting rules; and setting and enforcing land use regulations. HRS § 183C-7 describes the penalties for violating the chapter: "Any person violating this chapter or any rule adopted in accordance with this chapter shall be fined not more than $15,000 per violation in addition to administrative costs, costs associated with land or habitat restoration, and damages to public land or natural resources, or any combination thereof." Willful violations may result in an additional fine of "up to $15,000 per day per violation for each day in which the violation persists." In addition, the Board of Land and Natural Resources "may set, charge, and collect the fine based on the value of the natural resource that is damaged, the market value of the natural resource damaged, and any other factor it deems appropriate, such as the loss of the natural resource to its natural habitat and environment and the cost of restoration or replacement. The remedies provided for in this subsection are cumulative and in addition to any other remedies allowed by law."
HRS Chapter 187A	DLNR	Chapter 187A authorizes DLNR to manage and administer Hawaii's aquatic life and aquatic resource including: 1) establish, manage, and regulate public fishing areas, artificial reefs, fish aggregating devices, marine life conservation districts, shoreline fishery management areas, refuges, and other areas pursuant to title 12; 2) enforce all laws relating to the protecting, taking, killing, propagating, or increasing of aquatic life within the State and the waters subject to its jurisdiction; 3) issue permits for take of aquatic life and recover penalties for violations of the chapter; and 4) formulate and from time to time recommend to the governor and legislature such additional legislation necessary or desirable to implement

Statutes, Regulations, and Policies	Implementing Agencies	Description
		the objectives of title 12.
HRS Chapter 190	DLNR	Chapter 190 provides that all of Hawaii's marine waters are constituted marine life conservation areas to be managed by DLNR. Under HRS § 190-3, DLNR is responsible for adopting rules regulating the take and conservation of marine species, including rules that prohibit the disruption, alteration, and degradation of marine environment. HRS § 190-4.5 requires DLNR to adopt rules for the regulation of boating, anchoring, and mooring in the conservation area.
HRS Chapter 195D	DLNR	Chapter 195D is Hawaii's version of the U.S. ESA: "*Any species of aquatic life, wildlife, or land plant that has been determined to be an endangered species pursuant to the ESA shall be deemed to be an endangered species under this chapter and any indigenous species of aquatic life, wildlife, or land plant that has been determined to be a threatened species pursuant to the ESA shall be deemed to be a threatened species under this chapter. The department may determine, in accordance with this section, however, that any such threatened species is an endangered species throughout all or any portion of the range of such species within this State.*" DLNR is authorized to issue licenses for the take of certain species for limited durations of time. Chapter 195D also contains provisions for conservation programs and habitat conservation plans.
HRS Chapter 200	DLNR	Chapter 200 governs ocean recreation and coastal areas programs, including limitations of private use of ocean waters, permits for boat harbors, and boating laws.
Hawaii Administrative Rule (HAR) Chapter 13-95	DLNR	"Live rock" defined as any natural hard substrate to which marine life is visibly attached or affixed. "Stony coral" defined as any invertebrate species belonging to the Order Scleractinia, characterized by having a hard, calcareous skeleton that are native to the Hawaiian Islands. It is unlawful for any person to: 1) take, break, or damage any stony coral or live rock; 2) damage any stony coral or live rock by any intentional or negligent activity causing the introduction of sediment, biological contaminants, or pollution into state waters; or, 3) to sell any live rock or stony coral, except that stony coral rubble pieces or fragments imported for the manufacture and sale of coral jewelry, or dead stony coral obtained through legal dredging

Statutes, Regulations, and Policies	Implementing Agencies	Description
		operations in Hawaii for agricultural or other industrial uses, may be sold.
HAR Chapters 13-(28, 29, 30, 31, 32, 33, 34, 35, 37, 37, 38)	DLNR	These chapters govern Marine Life Conservation Districts.
HAR Chapter 124	DLNR	Chapter 124 expands on Hawaii's Endangered Species Act (HRS Chapter 195D), including prohibited activities; scientific, propagation, and educational permits; and lists of indigenous, threatened, and endangered wildlife.
2010 Hawaii Coral Reef Strategy	DLNR	The 2010 Hawaii Coral Reef Strategy (HCRS) is the guiding coral reef management document used by the DLNR Division of Aquatic Resources with support from the NOAA Coral Reef Conservation Program.
2013 Hawaii Ocean Resources Management Plan	Office of Planning, various	The Hawaii Ocean Resources Management Plan (ORMP) is a comprehensive state plan that provides a framework for ocean and coastal resource management in Hawaii. The ORMP lists marine resources and coral reefs as management priorities 4 and 5, respectively.
HAR Chapter 11-54	Department of Health (DOH)	Establishes beneficial uses and water quality standards for all waters, enables biological criteria, and includes bottom criteria for coral reefs.
HAR Chapter 11-55	DOH	Hawaii's NPDES rules regulating point discharges including construction general permit for sites > 1 ac and municipal storm water.
Puerto Rico		
Organic Law of the Planning Board of Puerto Rico (Law 75) 5-24-1975	Puerto Rico Planning Board (PRPB)	The PRPB is responsible for setting standards for the development of a society based on a sustainable economy, while conserving and protecting the environment for the benefit of future generations. The PRPB is composed of several programs and subprograms responsible for permitting, project design, and land use including the Coastal Zone Unit which implements the Federal Consistency evaluation process according to CZMA regulations.
Public Environmental Policy Law of the Environmental Quality Board (Law 416) 9-22-2004	Environmental Quality Board (EQB)	The EQB has the principal function of protecting and conserving the environment using the resources necessary to impede or eliminate environmental damage and maintain a balance between economic development and the environment. The EQB Water Quality Area division is required to monitor, protect, improve, and maintain water quality in water bodies in order to achieve the propagation and preservation of desirable species and human consumption of water, among other uses. This area determines whether waters can be used for domestic, recreational, agricultural, and industrial purposes, as well as establishing regulations for the disposal of wastewater from these activities.

Statutes, Regulations, and Policies	Implementing Agencies	Description
Organic Law of the Administration of Regulations and Permits (Law 76) 5-24-1975	Administration of Regulation and Permits (ARPE)	The primary function of ARPE is to apply existing laws, ordinances, or regulations to the use and development of lands, construction, use or alteration of buildings or structures, and the installation of signs and announcements island-wide. Any building development requires ARPE permit and in most cases an endorsement from DNER.
Puerto Rico Permits Process Reform Act (Law 161)	Office of Permits Management (OGPE)	Act 161 created the OGPE to improve the quality and efficiency in the management of the process regarding the evaluation of applications for the approval or denial of final determinations and permits for the development of construction projects in Puerto Rico. The Environmental Compliance Division of the OGPE is responsible for conducting the environmental impact review under the Law 416 and issuing its recommendations. This division also evaluates "Green Permits" as categorical exclusions if the proposed project complies with green design guidelines.
U.S. Virgin Islands		
Establishment of Wildlife and Marine Sanctuaries Virgin Islands Code (VIC) Ch 1 Subch VII §96 - 99	USVI Department of Planning and Natural Resources (DPNR)	Gives authority to Commissioner of DPNR to establish wildlife and marine sanctuaries inside which, without a permit, no one can take or possess any bird, fish, or other wildlife from the designated sanctuary or throw, place, or deposit any waste within a designated sanctuary. Establishes the St. Croix East End Marine Park (STXEEMP) and authorizes the territorial system of marine parks. This authority has since been used to create the St. Thomas East End Reserve.
Protection of indigenous, endangered and threatened fish, wildlife and plants 12 VIC Ch 2 §101-107	DPNR	Establishes the Endangered Species Preservation Commission, which has the responsibility to take action to identify and preserve threatened and endangered species in the territory and implement the U.S. ESA. Covers all animal life including all coral reef vertebrate and invertebrate species, mangroves, and seagrasses. Permits for exceptions may be issued by the Commissioner on a case-by-case basis. Examples: scientific research, aquarium collectors, propagation activities, etc.
Water Pollution Control 12 VIC Ch 7 §181 - 198	DPNR	Declares public policy of the USVI to conserve the waters of the USVI and to protect, maintain, and improve the quality thereof for public water supplies, the propagation of wildlife, fish, and aquatic life, and for domestic, recreational, and other legitimate beneficial uses; to provide that no waste be discharged into any waters of the USVI without

Statutes, Regulations, and Policies	Implementing Agencies	Description
		treatment. Authorizes the USVI to implement the provisions of the CWA.
Commercial Fishing 12 VIC Ch 9A §301 - 326	DPNR – Division of Fish and Wildlife	To preserve, manage, and protect the fishery resources, to regulate fishing and to secure its increase and development in all marine, estuarine and freshwaters within the jurisdiction of the USVI. This document is broad when referring to limits on seasons and size; it is simply setting up the authority of the commissioner to determine the limitations. Species-specific size regulations and closed seasons are found in the Virgin Islands Rules and Regulations.
Environmental Protection 12 VIC Ch 13 §531-539	DPNR – Environmental Protection Program	States that the lands and waters comprising the watersheds of the USVI are great natural assets and resources. Improper development of land results in changed watershed conditions, which can negatively impact fish and marine life. In order to protect these resources, it is necessary to establish by law an environmental protection program for land development to prevent soil erosion.
Virgin Islands Coastal Zone Management act of 1978 12 VIC Ch 21 §901 - 914	DPNR – Coastal Zone Management Program (CZMP)	Establishes the Coastal Zone Management Program and defines its many goals concerning the protection and sustainable development of the coastal zone and the limiting of any negative impact on natural resources. Approves the coastal land and water use plan. Gives CZMP power to recommend designation of areas of particular concern (APCs).

Appendix II – Agency Contact Information

Table 7: Federal Agency Contact Information for coral reef impacts.

Federal Agencies		
Agency	**Atlantic/Caribbean Office**	**Pacific Office**
FWS	**Florida** South Florida Ecological Services Field Office Vero Beach, FL (722) 562-3909 **Puerto Rico & USVI** Caribbean Ecological Services Field Office Boqueron, PR (787) 851-7297 **https://www.fws.gov/southeast/**	Pacific Islands Fish and Wildlife Office 300 Ala Moana Boulevard Room 3-122, Box 50088 Honolulu, HI 96850 (808) 792-9400 (808) 792-9580 fax **http://www.fws.gov/pacificislands/**
EPA	**Florida:** EPA Region 4 Sam Nunn Atlanta Federal Center 61 Forsyth Street, SW Atlanta, GA 30303-8960 (404) 562-9900 **http://www2.epa.gov/aboutepa/about- epa-region-4-southeast** **Puerto Rico & USVI:** EPA Region 2 290 Broadway New York, NY 10007-1866 (212) 637-3000 **http://www2.epa.gov/aboutepa/epa-region-2**	EPA Region 9 – Pacific Islands Contact Office PJKK Federal Building 300 Ala Moana Blvd., Room 5-152 Honolulu, HI 96850 (808) 541-2710 **http://www.epa.gov/region9/islands/**
NPS	National Park Service National Damage Assessment Office Environmental Quality Division Resource Protection Branch 1201 Oakridge Dr. Fort Collins, CO 80525	National Park Service National Damage Assessment Office Environmental Quality Division Resource Protection Branch 1201 Oakridge Dr. Fort Collins, CO 80525
NOAA - NMFS	NOAA Fisheries Service Southeast Regional Office 263 13th Avenue South St. Petersburg, FL 33701 (727) 824-5301 **http://sero.nmfs.noaa.gov/**	NOAA Fisheries Service Pacific Islands Regional Office NOAA Inouye Regional Center (IRC) 1845 Wasp Blvd., Bldg. 176 Honolulu, HI 96818 (808) 725-5000 **http://www.fpir.noaa.gov/**
USCG	USCG Seventh District Brickell Plaza Federal Building 909 SE 1st Avenue Miami, FL 33131-3050 **https://www.uscg.mil/d7/**	USCG Fourteenth District 300 Ala Moana Blvd, Room 9-204 Honolulu, HI 96850-4982 **https://www.uscg.mil/d14/**

USACE	U.S. Army Corps of Engineers Jacksonville District Office P.O. Box 4970 Jacksonville, FL 32232-0019 (904) 232-2568 **http://www.saj.usace.army.mil/**	U.S. Army Corps of Engineers Honolulu District Office Building 230, Room 302 Ft. Shafter, HI 96858 (808) 835-4004 **http://www.poh.usace.army.mil/**

Table 8: State and Territorial Agency contact information for coral reef impacts.

State and Territorial Agencies		
Jurisdiction	**Agency**	**Contact**
American Samoa	American Samoa Department of Marine and Wildlife Resources	DMWR Building – Fagatogo Pago Pago, AS 96799 Ph: (684) 633-4456 **http://www.americansamoa.gov/department-of-marine-wildlife**
CNMI	CNMI Bureau of Environmental and Coastal Quality	Gualo Rai Center, Suite 201F P.O. Box 501304 Saipan, CNMI Ph: (670) 664-8525 **www.crm.gov.mp**
Florida	Florida Department of Environmental Protection	Florida Coastal Office 3900 Commonwealth Blvd. Tallahassee, FL 32399-3000 Ph: (850) 245-2095 **http://www.dep.state.fl.us/coastal/**
	Florida Fish and Wildlife Commission, Division of Marine Fisheries	Farris Bryant Building 620 S. Meridian Street Tallahassee, FL 32399-1600 (850) 487-0554 **http://myfwc.com/**
Guam	Guam Bureau of Statistics and Plans, Coral Reef Conservation Program.	Bureau of Statistics and Plans, Coral Reef Conservation Program 513 Ricardo J. Bordallo Governor's Complex W. Marine Corps Drive Adelup, Guam 96910
Hawaii	Department of Land and Natural Resources	Kalanimoku Building 1151 Punchbowl St. Honolulu, HI 96813 Ph: (808) 587-0400 **http://dlnr.hawaii.gov/**
Puerto Rico	Oficina de Gerencia de Permisos (OGPe)	P.O. Box 41179 San Juan, PR 00940-1179 (787) 721-8282
USVI	Department of Planning and Natural Resources	Cyril E. King Airport Terminal Building, 2nd Fl. St. Thomas, VI 00802 Ph: (340) 774-3320 **http://dpnr.vi.gov/**

Appendix III – Coral Reef Mitigation and Restoration Planning: Endangered Species Considerations for Listed Corals

Endangered Species Act

A total of 25 reef-building coral species are listed under the ESA, including seven Caribbean species and 18 Indo-Pacific species. The seven listed Caribbean species are all found in U.S. waters. Of the 18 listed Indo-Pacific species, seven species are confirmed in U.S. waters, five species may occur in U.S. waters but have not been confirmed, and the remaining six species are known to occur only in foreign waters. The following sections provide background information, and a summary of the ESA's regulatory processes for listed corals within U.S. waters.

Background

In 2006, Caribbean elkhorn (*Acropora palmata*) and staghorn corals (*A. cervicornis*) were listed as threatened under the ESA (71 FR 26852). These species occur within the U.S. waters of Florida, Puerto Rico, and the U.S. Virgin Islands, as well as throughout the wider Caribbean. In 2008, a final "ESA §4(d) rule" prohibiting the take of these listed species was published (73 FR 64264), and critical habitat was designated within U.S. waters (73 FR 72210). In 2014, an additional 20 coral species were listed as threatened, which included five Caribbean species and 15 Indo-Pacific species (79 FR 53852). In 2015, three foreign coral species were listed as endangered under the ESA (80 FR 60560). The number of listed corals confirmed found in each U.S. geographic area varies, as shown in Table 9 below. For more general information on listed corals, including distributions and species reports, please see the NMFS Pacific Islands Regional Office and Southeast Regional Office ESA Corals webpages:

http://www.fpir.noaa.gov/PRD/prd_coral.html
http://sero.nmfs.noaa.gov/protected_resources/coral/

Table 9: ESA-listed corals confirmed in U.S. waters, by geographic area.

Threatened Corals *Listed as Threatened in 2006	**Confirmed in These Geographic Areas**			
Caribbean Waters	**Florida-Atlantic**	**Puerto Rico**	**USVI**	**Gulf of Mexico**
*Acropora cervicornis**	X	X	X	
*Acropora palmata**	X	X	X	X
Mycetophyllia ferox	X	X	X	
Dendrogyra cylindrus	X	X	X	
Orbicella annularis	X	X	X	X
Orbicella faveolata	X	X	X	X
Orbicella franksi	X	X	X	X

Threatened Corals *Listed as Threatened in 2006	**Confirmed in These Geographic Areas**			
Pacific Waters	**Guam**	**CNMI**	**PRIA**	**American Samoa**
Acropora globiceps	X	X	X	X
Acropora jacquelineae				X
Acropora lokani				
Acropora pharaonis				
Acropora retusa	X		X	X
Acropora rudis				
Acropora speciosa			X	X
Acropora tenella				
Anacropora spinosa				
Euphyllia paradivisa				X
Isopora crateriformis				X
Montipora australiensis				
Pavona diffluens				
Porites napopora				
Seriatopora aculeata	X	X		

Regulatory Processes

As of November 2015, the ESA's regulatory processes for listed corals within U.S. waters differs substantially between the two Caribbean species listed in 2006, versus the 20 Caribbean and Pacific species listed in 2014, even though all are listed as threatened. For the species listed in 2006, take was prohibited with two exceptions by the 4(d) rule, and critical habitat was designated, both in 2008 (see above citations). The regulatory implications of the ESA §4(d) rule are that it is illegal to directly or incidentally "take,[7] listed Caribbean *Acropora* corals without authorization from NMFS, with two exceptions for specific research and restoration activities. Such authorization is provided either by ESA §7 consultation (for federal actions) or ESA §10 conservation planning (for non-federal actions). The regulatory implication of the critical habitat rule is that federal actions cannot destroy or adversely modify designated critical habitat. For the species listed in 2014, take has not been prohibited and critical habitat has not been designated, nor have either been proposed, although both could be in the future. For all listed coral species, whether listed in 2006 or 2014, federal actions cannot jeopardize their continued existence. Thus, federal actions that may affect listed corals are subject to ESA §7 consultation to ensure that jeopardy is avoided, as described in more detail below.

ESA §7 consultation is the ESA's primary regulatory process that affords protection to listed corals and their designated critical habitats occurring within U.S. waters. ESA §7 requires federal agencies to ensure that actions they authorize, fund, or carry out do not jeopardize the existence of any species listed under the ESA, or destroy or adversely modify their designated critical habitats. Thus, ESA §7 requires consultation by the federal "action agency" (the agency authorizing, funding, or carrying out the action) with NMFS on any action that may affect listed corals or their designated

[7] The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 USC 1532(19)).

critical habitats. For such actions, ESA §7 consultation provides opportunities to reduce the impact of the proposed action on listed corals through both informal and formal process. Informal consultation is limited to proposed federal actions that are not likely to adversely affect listed corals, and may result in implementation of measures to minimize impacts of the action on listed corals. For proposed federal actions that cannot avoid adversely affecting listed corals, formal consultation is carried out to ensure that the action does not jeopardize the listed species. Formal consultation typically requires implementation of measures to minimize impacts of the proposed federal action to listed corals. In both informal and formal consultation, collaboration between the action agency and NMFS staff can provide significant conservation benefits for listed corals and coral reef ecosystems. In the case of proposed federal actions that also affect designated critical habitat for the two Caribbean corals listed in 2006, ESA §7 consultation includes analysis of the impact of the action on critical habitat, and may result in measures to minimize the actions' impacts on it.

For more information on ESA §7 and listed corals, please see the NMFS Pacific Islands Regional Office and Southeast Regional Office ESA § 7 webpages:

http://www.fpir.noaa.gov/PRD/prd_esa_section_7.html
http://sero.nmfs.noaa.gov/protected_resources/section_7/index.html

Appendix IV – Example of a Coral Transplantation Protocol

Florida Fish and Wildlife Conservation Commission (FWC) Coral and Octocoral Mitigation Relocation Recommendations – August 2016

FWC Coral and Octocoral Visual Health Assessment Protocols for Mitigation Relocation Activities – July 2016

Florida Fish and Wildlife Conservation Commission (FWC)
Coral and Octocoral Mitigation Relocation Recommendations

FWC Authorization Required

A Stock Collection and Release, Special Activity License (SAL) is required for all marine species relocation activities statewide, including but not limited to mitigation relocation activities. Information on the SAL Program and applications are available here: http://myfwc.com/license/saltwater/special-activities/

Definitions

For purposes of these Recommendations:

1) "Coral" is a fragment or colony of any species of the Order **Scleractinia**, Order **Antipitharia,** and Genus ***Millepora*.**
2) "Interior waterways" are aquatic areas that have experienced physical restructuring of the shoreline (e.g., inner port harbors, marinas), or naturally occurring areas of low flushing (e.g., shallow bays, seawalls.)
3) "Listed or Proposed" are species that are state-listed pursuant to 68A-27, F.A.C., federally-listed pursuant to the Endangered Species Act, or proposed to be federally-listed pursuant to the Endangered Species Act.
4) "Octocoral" is a colony of any species of the Subclass **Octocorallia,** excluding encrusting octocorals (e.g., *Erythropodium caribaeorum, Briareum asbestinum*).
5) "Relocation" includes all activities that move coral or octocoral fragments or colonies from one place to another (e.g., transplanting, outplanting), including but not limited to moving them into and out of temporary holding locations (e.g., cache, staging, acclimation locations) or nurseries.

Coral and Octocoral Removal and Relocation

Removal and relocation of corals and octocorals to suitable sites in regionally appropriate densities (current or historical) should occur on all coastal projects where complete avoidance is not possible. These coral and octocoral removal and relocation activities should be considered as minimization of project impacts and not as compensatory mitigation. Coral and octocoral removal and relocation activities conducted to minimize project impacts can be accommodated in both Florida Uniform Mitigation Assessment Method (UMAM) and Habitat Equivalency Analysis (HEA) mitigation assessment methodologies, and would result in lower amounts of compensatory mitigation required for the project relative to the amount of mitigation that would be required if coral and octocoral removal and relocation was not performed. Compensatory mitigation should be required for all corals and octocorals that will not be removed and relocated.

On a case-by-case basis, the FWC will evaluate any request for removal and relocation of corals that are not listed or proposed and are considered by the FWC to be sub-adult sized, to be used as a compensatory mitigation measure to offset the loss of indirect effects (i.e., secondary impacts)[8] that are temporary (e.g., temporary reduction in larval output, temporary reduction in settlement). Evaluation of such requests will be based on available and

[8] Indirect effects (impacts) as defined by 40 CFR §1508.8.

appropriate documentation of sub-adult relocation activities (e.g., literature, monitoring reports), and amount of credit that is proposed to be provided for such activities.

Coral and octocoral removal and relocation activities should not occur during times of severe stress (e.g., disease outbreak, coral bleaching, cold stress, significant algal blooms), or from locations being impacted by significant stress events (e.g., areas being impacted by dredging activities or storm water run-off events), unless there are extreme circumstances that warrant an exception. FWC will support coral and octocoral removal and relocation activities during times of severe stress or from locations being impacted by significant stress events on a case-by-case basis when resource or project impacts are imminent and cumulatively harmful, and when benefits outweigh potential risks. Please see the "Health Assessment" section of these Recommendations for exceptions that are applicable to coral and octocoral removal and relocations during times of severe stress or from locations being impacted by significant stress events.

Coral Removal and Relocation Activities

For purposes of these Recommendations, the FWC has determined corals that are ≥ 5 cm (measured as live tissue diameter - continuous live tissue patch with a diameter of 5 cm or greater) to be adult, although corals < 5 cm have been observed to be reproductive (Soong 1993, Lazar et al. 2011, Coastal Eco-Group Inc., 2015.) The FWC determination of adult coral size was not solely based on reproductive capabilities and additionally considered:

1) At the 5 cm size, corals have a sufficient number of polyps and colony structure to obtain a positive identification using standard surveying methodologies. Corals below this size would require different surveying methodologies.
2) Corals ≥ 5 cm are generally considered to be adults (Bak and Engel 1979, Miller et al. 2000), based on average growth rates (Vaughn 1915) and estimated age of sexual maturity (Connell 1973.)

The FWC recommends removal and relocation of <u>all</u> listed or proposed species of corals regardless of size, unless a coral displays signs of disease pursuant to the attached "FWC Coral and Octocoral Visual Health Assessment Protocols." The species that are currently listed or proposed are as follows:

- *Acropora cervicornis* (ESA and state listed as Threatened)
- *Acropora palmata* (ESA and state listed as Threatened)
- *Dendrogyra cylindrus* (ESA and state listed as Threatened)
- *Mycetophyllia ferox* (ESA and state listed as Threatened)
- *Orbicella annularis* (ESA and state listed as Threatened, formerly *Montastraea*)
- *Orbicella faveolata* (ESA and state listed as Threatened, formerly *Montastraea*)
- *Orbicella franksi* (ESA and state listed as Threatened, formerly *Montastraea*)

For coral species that are not listed or proposed, the FWC recommends removal and relocation of <u>all</u> adult corals (corals ≥ 5 cm in diameter), unless a coral displays signs of disease pursuant to the attached "FWC Coral and Octocoral Visual Health Assessment Protocols." Corals ≥ 5 cm in diameter can be successfully relocated. Brownlee (2010) successfully transplanted small corals (*Siderastrea siderea, Dichocoenia stokesii,* and *Porites porites*) with greater than 80 percent survivorship after 13 months. Monty et al. (2006)

successfully transplanted 250 corals (14 species) ranging from 5 to 40 cm in diameter with a high rate of survivorship. These corals were monitored for 13 months. Eight species had 100 percent survivorship, including 78 *Siderastrea siderea*. Thornton et al. (2000) transplanted 271 corals from an outfall pipe in Broward County to an articulated concrete mat. *Siderastrea siderea* comprised 90 percent of the corals <1 to 100 square centimeters in size. After 27 months, 266 of the corals had survived (87 percent), as compared to 83 percent survival for corals on the nearby natural substrate. In addition, Stephens (2007) analyzed monitoring data from a transplantation effort that salvaged multiple species of coral from a coastal construction impact site in Broward County; survival of the species ranged between 92 and 100 percent during monitoring periods varying between 18 and 24 months.

The potential exists for corals to break upon removal. For smaller-scale relocation activities and for all listed or proposed species (regardless of relocation activity size), it is feasible for all fragments <u>of the same broken coral</u> to be kept together and reattached as close together as possible (like puzzle pieces – reattached within 0 - 5 cm apart from one another), to promote successful fusing. The re-constructed corals should be considered as one single coral for monitoring purposes. Research has shown that fragments of the same genet are known to readily and successfully fuse (Raymundo and Maypa 2004). For larger-scale restoration activities, only fragments of broken corals that are ≥ 5 cm in live tissue diameter should be relocated and reattached, and considered as separate corals for monitoring purposes.

The FWC has further prioritized coral species for removal and relocation (in addition to species identified above) in the event that all corals ≥ 5 cm in diameter will not be removed and relocated. These coral species have been prioritized and binned based on a high conservation value (i.e., rare, slow-growing, low genetic diversity, slow to recover, sensitive to stress, poor-recruiter, high post-settlement mortality), and the list is as follows:

HIGH PRIORITY SPECIES

- Order Antipatharia
- *Agaricia fragilis*
- *Agaricia lamarcki*
- *Colpophyllia natans*
- *Dichocoenia stokesii*
- *Diploria labyrinthiformis*
- *Favia fragum*
- *Isophyllia* spp.
- *Leptoseris cucullata*
- *Madracis* spp.
- *Manicina areolata*
- *Meandrina meandrites*
- *Montastraea cavernosa*
- *Mussa angulosa*
- *Mycetophyllia* spp.
- *Oculina diffusa*
- *Oculina robusta*
- *Solenastrea hyades*

MEDIUM PRIORITY SPECIES

- *Eusmilia fastigiata*
- *Porites divaricata, P. furcata, P. porites*
- *Pseudodiploria* spp. (formerly *Diploria*)
- *Siderastrea siderea* ≥10 cm
- *Solenastrea bournoni*
- *Stephanocoenia intersepta* ≥10 cm
- *Undaria* spp. (formerly *Agaricia*)

LOW PRIORITY

A lower amount of effort should be attributed to removing and relocating the following species, and compensatory mitigation should be designed to offset the loss of any corals not relocated. Alternatively, if the impact area is dominated by these species, effort would be justified to remove and relocate the following species:

- *Porites astreoides*
- *Siderastrea radians*
- *Siderastrea siderea* <10 cm
- *Stephanocoenia intersepta* <10 cm
- *Cladocora arbuscula*
- *Phyllangia* spp.
- *Scolymia* spp.

FWC supports efforts to relocate corals that are less than 5 cm (sub-adult sized), however we are aware that this may increase project costs due to additional survey design measures needed to accurately identify corals of this small size. For corals that will not be relocated (of any size), FWC recommends coordination with permitted/approved coral nursery/research facilities within the region to determine if they have interest and financial resources to remove corals or accept donated corals.

Octocoral Removal and Relocation Activities

The FWC recommends removal and relocation of all *Gorgonia* species and other octocoral species $\geq$ 10 cm in height, based on the prioritized list below. Similar to corals, these octocoral species are also prioritized based on a high conservation value (i.e., state prohibited species, conservation need, local abundance/density, growth rates, relocation success, and ability to recover naturally). In general, more robust rod species are slow growing and have low recruitment, but transplant well and seem to recover quickly from being transplanted (e.g., growing a new holdfast over attachment material) (Brinkhuis 2009). Plumes are low on the list because they recruit very quickly after a disturbance and have high growth rates so their potential for natural recovery is greater. Additionally, more delicate plume species have less tissue (e.g., thinner tissue = less potential/resources for healing after clipping) and are inferior transplantation candidates. However, plumes can be transplanted successfully (Brinkhuis 2009). The prioritized list is as follows:

- *Antillogorgia* (formerly P*seudopterogorgia*)
- *Eunicea*
- *Gorgonia* (state prohibited species)
- *Leptogorgia*
- *Muricea*
- *Muriceopsis*
- *Plexaura*
- *Plexaurella*
- *Pseudoplexaura*
- *Pterogorgia*

In addition to the species previously listed, the following are priority genera if deeper relocation sites are targeted (>60 ft. or >18 m):

- *Diodogorgia*
- *Ellisella*
- *Iciligorgia*
- *Swiftia*
- *Telesto*

Florida Fish and Wildlife Conservation Commission (FWC)
Coral and Octocoral Visual Health Assessment Protocols for Mitigation Relocation

Temporary Holding of Corals and Octocorals Prior to Reattachment

If corals and octocorals will be placed in a temporary holding location after removal and prior to reattachment at the relocation site (for caching, staging, acclimation, etc.), the FWC recommends the following criteria be adhered to:

1) The temporary holding location for corals and octocorals must be located in a stable area (e.g., low energy, low sedimentation, minimal temperature flux, minimal freshwater input), and err conservatively on the side of being slightly farther from expected project-associated direct and indirect impact areas.
2) Corals must be maintained in a temporary holding location where sediment does not collect, be affixed to an elevated structure, or placed in a suspended container in a manner wherein they are above the sea floor and do not touch each other. If corals are to remain in the temporary holding location for longer than two weeks, they must be cemented or epoxied to an elevated structure or to the sea floor.
3) Octocorals must be maintained in a temporary holding location where sediment does not collect, be affixed to an elevated structure, or placed in a suspended bag in a manner wherein they are above the sea floor and have adequate water flow (i.e., bags should not be crowded). If octocorals are to remain in the temporary holding location for longer than two weeks, they must be attached with zip ties by their holdfast or base to an elevated array or line system previously installed on the sea floor. Orientation is less important, but octocorals must not touch each other.
4) The installation of any structure to facilitate the temporary holding of corals and octocorals prior to reattachment must also be authorized pursuant to permits that authorize the placement of structures on submerged lands (e.g., Environmental Resource Permit (ERP), Joint Coastal Permit (JCP), USACE Dredge and Fill Permit, Florida Keys National Marine Sanctuary Permit).

Relocation Site Selection

The FWC recommends that the selection of an appropriate relocation site(s) for both corals and octocorals meet the following general criteria:

1) Relocation site must be suitable reef habitat, be within the known range of the species or genera, and have historic presence of the species to be relocated (in recent decades).
2) Optimally, the relocation site should be located in similar water depths and have similar physical conditions (e.g., light availability, water quality, water circulation) to those at the removal site.
3) Optimally, the relocation site should have similar substrate orientation to removal site; i.e., if corals or octocorals are being removed from a vertical or sloped elevated surface, then the relocation site should have similar vertical or sloped areas for relocation.
4) The relocation site must be as close in proximity to the removal area as possible to preserve the functional ecosystem value of the surrounding areas provided by the resources to be relocated, but err conservatively on the side of being slightly farther from expected project-associated direct and indirect impact areas.
5) Relocation site must not contain large amounts of loose rubble and should not be a high energy environment (Edwards and Clark 1998).

6) Relocation site must not be located within a direct or indirect impact area for any permitted, authorized or reasonably foreseeable marine coastal construction activity (e.g., dredging, beach nourishment, pipeline or communication cable installations), or within exclusion or buffer areas (e.g., military, aquaculture).
7) Relocation site must have adequate and appropriate space to allow for: a) colony growth, tissue re- colonization and plating based on colony size, species growth rates, and maximum size capacity; and b) attachment density commensurate with regionally appropriate densities.

Health Assessment

To minimize the risk that diseases are not being spread from the removal area to a temporary holding or relocation site, the FWC recommends a visual health assessment of each coral or octocoral slated for temporary holding or direct relocation be conducted immediately prior to removal pursuant to the attached "FWC Coral and Octocoral Visual Health Assessment Protocols" (Health Protocols). Corals and octocorals exhibiting visual signs of disease should not be removed, held temporarily, or relocated. **Exceptions:**

1) As identified in the "Coral and Octocoral Removal and Relocation" section of these Recommendations, there may be extreme circumstances in which the FWC will support coral and octocoral removal and relocation during times of severe stress or significant stress events. For corals and octocorals that will be removed and relocated during times of severe stress or from locations being impacted by significant stress events, FWC can provide an exception on a case-by-case basis from the "bleaching and partial bleaching" and "stress indicators" criterion identified in the Health Protocols ("Coral Visual Health Assessment" section, numbers 1)a. and 1)e. respectively, and "Octocoral Visual Health Assessment" section, numbers 2)a. and 2)e. respectively.) If an exception is provided by the FWC, these corals and octocorals may be removed and relocated provided that all other criterion in the Health Protocols are met.
2) Corals and octocorals surviving in interior waterways have demonstrated resilience in spite of the poor environmental conditions they are growing in and as such, have strong survival capabilities (potentially genetic) that are highly valued. Corals and octocorals that will be removed and relocated from interior waterways are provided with an automatic exception from the "bleaching and partial bleaching" and "stress indicators" criterion in the Health Protocols ("Coral Visual Health Assessment" section, numbers 1)a. and 1)e. respectively, and "Octocoral Visual Health Assessment" section, numbers 2)a. and 2)e. respectively), and may be removed and relocated provided that all other criterion identified in the Health Protocols are met.

Corals and octocorals held in a temporary holding location should again be visually assessed for health pursuant to the Health Protocols immediately prior to removal from the temporary holding location and reattachment at the relocation site. **Exception - The visual health assessment does not need to be conducted for corals and octocorals that have been maintained in a temporary holding location for 48 hours or less.** Any corals or octocorals displaying signs of disease in the temporary holding location should either be: a) removed, disposed of and not reattached, or b) donated for ex-situ research.

If the visual health assessment is required as a condition of a permit, the FWC also requests documentation of the following information as identified in the Health Protocols be included as a requirement for any post-relocation reporting requirements:

1) Numbers of corals by species and size that were viable candidates for relocation but were not removed and relocated because they failed the visual health assessment, must be noted in any post-relocation reporting documentation.
2) Corals that are located in a temporary holding location when the visual health assessment is conducted and are exhibiting visual signs of disease must be removeand disposed of or donated for ex-situ research, and disposition must be noted in any post-relocation reporting documentation.
3) Numbers of corals that are relocated containing boring sponges of the Genus *Cliona* must be noted in any post-relocation reporting documentation.
4) Numbers of relocated corals that are experiencing active predation and the type of predation (prior to removal of predators) must be noted in any post-relocation reporting documentation.

Removal, Relocation and Reattachment Methodologies

The FWC is available to provide technical expertise to assist with the review or development of appropriate methodologies for the removal, relocation, and reattachment of corals and octocorals for mitigation purposes. The FWC would appreciate the ability to provide additional comments on relocation methodologies and relocation methodology revisions if such information becomes available in the future.

Staff of the Florida Department of Environmental Protection – Coral Reef Conservation Program, NOAA Florida Keys National Marine Sanctuary (Monroe County) and NOAA National Marine Fisheries Service are also available to provide technical expertise on coral removal, relocation and reattachment based on lessons learned on the Florida Reef Tract. Contacts for each of these agencies respective programs can be provided on request.

Mitigation Plans

The FWC is available to provide technical expertise to assist with the development of appropriate mitigation plans to avoid, minimize, and offset project impacts. The FWC would appreciate the ability to provide additional comments on mitigation plans and mitigation plan revisions if such information becomes available in the future.

Monitoring Plans

The FWC recommends corals and octocorals that are removed and relocated specifically for mitigation purposes are monitored for overall survival and attachment success at one week (may be conducted at any time during the seven days beginning the day immediately after the day relocation is conducted), one month, three months, six months, one year and two years post-relocation. The FWC emphasizes the need for all of these recommended monitoring events to be performed and the recommended activities/data collection identified below performed during the monitoring events, in order to appropriately determine achievement of performance standards and mitigation success.

At time of relocation

1) If the total quantity of corals or octocorals (considered separately for monitoring purposes) to be relocated comprises less than 4,000 colonies: select a representative subset of relocated corals/octocorals to be used for monitoring events, comprising 25% (or 1,000

corals/octocorals maximum) of the total number of corals/octocorals relocated. This subset must be representative of the species composition and size classes of the total relocated corals/octocorals, with no less than 10 corals/octocorals of each species monitored. If less than 10 corals/octocorals are relocated from a species, all relocated corals/octocorals of that species must be included in the subset. It is possible that for smaller-scale relocation projects, one or both of these requirements will result in all of the relocated corals/octocorals needing to be monitored.

2) Tag or map this subset (including assignment of an identification number for each coral/octocoral) so that they can be tracked individually over time for monitoring events.
3) This same subset of corals/octocorals must be used for all of the monitoring events.
4) If the total quantity of coral/octocorals to be relocated exceeds 4,000 colonies, the FWC will reach a consensus with the applicant and the permitting agency on the number of representative subset corals/octocorals that will be monitored (the minimum will be 1,000 corals/octocorals),

During each monitoring event

1) All loose or detached relocated corals/octocorals (not just the ones from the monitoring subset) must be re-affixed to their structure or substrate.
2) Data to be collected for each monitoring event for the monitoring subset are as follows (recommended data sheet is attached):

- Identification (species, ID#)
- Attachment success (firm, loose, detached, missing)
- Coral size – maximum diameter and maximum height. Coral max diameter is measured as the outward-facing surface of the colony (perpendicular to the axis of growth). The maximum diameter measurement includes both living tissue and dead areas of the colony. Coral max height is measured parallel to the axis of growth, perpendicular to growth bands, as viewed from the side of the colony.
- Coral Skeletal Area – this is not data that needs to be collected; this is calculated based on coral max diameter and height metrics that are collected ((D+H)/2)^2
- Coral Tissue Condition – the visual estimate of percent live/dead tissue cover per colony – percent live tissue (including bleached tissue) + percent dead tissue = 100%
- Coral Tissue Area Index - this is not data that needs to be collected; this is calculated based on coral max diameter, max height, and % live tissue metrics that are collected ((D+H)/2)^2*%L
- Octocoral size – maximum height measured from the base of the holdfast attachment to the top of the colony (following the axis of growth) as seen from the side
- Presence of conditions (bleaching, predation, disease, *Cliona*)
- Within Comments/Observations section, note any anomalous conditions of interest, including "reconstructed colony" as described above in the *Coral Removal and Relocation Activities* section.

The data requested for collection are specific to determining overall survival and attachment success, thus determining achievement of performance standards for mitigation actions (i.e., mitigation success), and assist with determining potential factors that may have contributed to the inability for mitigation actions to achieve performance standards (i.e., mitigation failure) such as regional disease or bleaching events, severe storm events, relocation contractor performance, etc.

Reporting Schedule
The data collected during each monitoring event must be submitted according to the following schedule:

- One week event – information must be submitted within 14 days post-event
- One month through 2 year monitoring events - information must be submitted within 30 days post-event

The FWC is available to provide technical expertise to assist with the development of monitoring plans to help gauge mitigation success and identify project impacts, and would appreciate the ability to provide additional comments on monitoring plans and monitoring plan revisions if such information becomes available in the future.

Performance Standards
Corals
In order to assess mitigation success, FWC recommends evaluating overall survival of relocated corals via Tissue Area Index. A Tissue Area Index is calculated by averaging the coral maximum diameter and coral maximum height, then squaring the average dimension to determine Skeletal Area, then multiplying by the percent live tissue; formula as follows: ((D+H)/2)^2*%L (Williams and Miller 2012). All of the metrics needed to determine Tissue Area Index are requested for collection in the Monitoring section above, and reflected in the data sheet provided. **Overall survival** of corals shall be defined as no net loss in pooled (by species) Tissue Area Index or an increase in pooled (by species) Tissue Area Index.

The performance standard to determine mitigation success for coral relocation activities should be at least 85 percent **overall survival** (as defined directly above) of all relocated species, with secure substrate attachment, two years after relocation.

Octocorals
In order to assess mitigation success, FWC recommends evaluating overall survival of relocated octocorals via maximum height, and this metric is requested for collection in the Monitoring section above and reflected in the data sheet provided. Overall survival shall be defined as no change in maximum height or an increase in maximum height.

The performance standard to determine mitigation success for octocoral relocation activities should be proposed by the applicant, and supported by available and appropriate documentation of octocoral relocation activities (e.g., literature, monitoring reports.) FWC will review these proposals as they are submitted to determine if the documentation submitted supports the performance standard as proposed.

The FWC is available to provide technical expertise to assist with the development of coral and octocoral performance standards, and would appreciate the ability to provide additional comments on performance standards and performance standard revisions if such information becomes available in the future.

Summary
In summary the FWC recommends:

- Coral and octocoral removal and relocation activities should be considered as

- minimization of project impacts and not as compensatory mitigation. However, the FWC will evaluate any request for removal and relocation of corals that are not listed or proposed and are considered by the FWC to be sub-adult sized, to be used as a compensatory mitigation measure to offset the loss of indirect (secondary) impacts.

- Removal and relocation of all listed or proposed corals of any size, unless they display signs of disease pursuant to the attached "FWC Coral and Octocoral Visual Health Assessment Protocols" (Health Protocols.)

- Removal and relocation of all non-listed or proposed adult corals (corals ≥ 5 cm in live tissue diameter) and octocoral species ≥ 10 cm in height, unless they display signs of disease pursuant to the attached Health Protocols.

- Both temporary holding sites (for caching, staging, acclimation, etc.) and relocation sites should be selected pursuant to the criteria provided in these Recommendations.

- A visual health assessment should be required for each coral or octocoral immediately prior to removal and relocation (for temporary holding or direct relocation) pursuant to the attached Health Protocols. Corals and octocorals exhibiting visual signs of disease should not be removed, held temporarily, or relocated (unless identified exceptions are applicable or provided by the FWC.) Documentation of specific items identified in the "Health Assessment" section above is requested for inclusion as part of any required post-relocation reporting requirements.

- Relocated corals should be monitored at one week (may be conducted at any time during the seven days beginning the day immediately after the day relocation is conducted), one month, three months, six months, one year and two years post-relocation. A data sheet is provided to facilitate capturing the data requested for monitoring purposes. Again, the FWC **emphasizes** the need for all of these recommended monitoring events to be performed in order to appropriately determine mitigation success.

- The performance standard to determine mitigation success for coral relocation activities should be at least 85 percent overall survival (defined as no net loss in pooled (by species) Tissue Area Index or an increase in pooled (by species) Tissue Area Index) of all relocated species, with secure substrate attachment, two years after relocation.

- The performance standard to determine mitigation success for octocoral relocation activities should be proposed by the applicant, and supported by available and appropriate documentation of octocoral relocation activities (e.g., literature, monitoring reports.) FWC will review these proposals as they are submitted to determine if the documentation submitted supports the performance standard as proposed.

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CORALS

Definitions

For purposes of these Protocols:

1) "Coral" is a fragment or colony of any species of the Order **Scleractinia**, Order **Antipitharia,** and Genus ***Millepora***.
2) "Bleaching" for purposes of coral relocation is defined as 100% of coral tissue is discolored due to the loss or reduction in number of endosymbiotic algae (zooxanthellae (Genus *Symbiodinium*)). During bleaching, tissue is present but is pale to white in color.
3) "Interior waterways" are aquatic areas that have experienced physical restructuring of the shoreline (e.g., inner port harbors, marinas), or naturally occurring areas of low flushing (e.g., shallow bays.)
4) "Partial bleaching" is where only a portion of the coral has lost its zooxanthellae, and the remaining areas of tissue appear normal in color.
5) "Old mortality" is the non-living portion of exposed coral skeleton that has been overgrown by algae and other biofouling organisms and where the corallite structure has eroded over time and is no longer identifiable. *Not to be confused with "recent mortality."
6) "Recent mortality" is the non-living portion of recently exposed coral skeleton (i.e., skeleton is white and corallite structures are intact and identifiable), including the development of fine "fuzz" or turf algae on exposed skeleton (i.e., skeleton is yellowish in appearance and corallite structure may be slightly eroded but still identifiable), indicating that the mortality occurred within a couple of weeks prior to observation. *Not to be confused with "old mortality."
7) "Relocation" includes all activities that move coral fragments or colonies from one place to another (e.g., transplanting, outplanting), including but not limited to moving them into and out of temporary holding locations (e.g., cache, staging, acclimation locations) or nurseries.

Coral Visual Health Assessment

Each coral fragment or colony selected for relocation must be visually assessed pursuant to these Protocols to ensure that they appear to be in good health and are free from suspected disease. This visual health assessment must be conducted immediately prior to removal from each and any location, and may need to be conducted more than once before the relocation activity is completed (e.g., immediately prior to removal from an original collection location, a culture location (nursery), or a temporary holding location established for purposes of caching, staging, acclimation, etc.). **<u>Exception</u> - The visual health assessment does not need to be conducted for coral fragments or colonies that have been maintained in a temporary holding location for 48 hours or less.**

Coral fragments or colonies that are located in an original collection or culture location when the visual health assessment is conducted and are exhibiting visual signs of disease may not be removed and relocated to other in-water locations. Coral fragments or colonies that are located in a temporary holding location when the visual health assessment is conducted and are exhibiting visual signs of disease must be removed and disposed of, and this disposition must be noted in any post-relocation reporting documents. **Field personnel conducting coral visual health assessments should be proficient with species identification, and trained in coral disease, predation identification and removal, and survey techniques to assure accuracy of the assessment.** Each coral fragment or colony must meet the following criteria prior to relocation:

1) Show no visible signs of disease based on the presence of:
    a. Bleaching or partial bleaching. **Exceptions:**
        1. Partial bleaching is acceptable for relocation of specific coral species for which it is recognized as a part of these coral species' normal, healthy state. These coral species are as follows: *Oculina* spp.*, Agaricia fragilis, Helioseris cucullata, Orbicella franksi*, *Siderastrea radians*, and *Undaria humilis.* Partial bleaching <2 cm on healthy, growing branch tips is also considered acceptable and normal for branching coral species including *Acropora cervicornis*, *Acropora palmata*, *Acropora prolifera, Millepora alcicornis* and *Millepora complanata*.
        2. As identified in the Mitigation Relocation Recommendations, "Coral and Octocoral Removal and Relocation" section, there may be extreme circumstances in which the FWC will support coral removal and relocation during times of severe stress or significant stress events. On a case-by-case basis, FWC can provide exception to this criterion for corals that will be removed and relocated during times of severe stress or from locations being impacted by significant stress events.
        3. Exception to this criterion is automatically provided for corals that are being removed and relocated from interior waterways as identified in the Mitigation Relocation Recommendations, "Health Assessment" section.
    b. Recent mortality greater than 1% tissue loss exposing underlying skeleton. **Exception** - Old mortality is acceptable for corals that are to be relocated.
    c. Active disease (e.g., white/black/yellow/red band diseases, white pox or plague diseases, white *Beggiatoa* mats, dark (purple) spot/blotch diseases, growth anomalies).
    d. Suspect disease indicators (e.g., bands, spots, microbial mats, cyanobacteria colonization).
    e. Stress indicators (e.g., tissue sloughing, swelling, or thinning; excessive sedimentation; excessive mucous production). **Exceptions:**
        1. As identified in the Mitigation Relocation Recommendations, "Coral and Octocoral Removal and Relocation" section, there may be extreme circumstances in which the FWC will support coral removal and relocation during times of severe stress or significant stress events. On a case-by-case basis, FWC can provide exception to this criterion for corals that will be removed and relocated during times of severe stress or from locations being impacted by significant stress events.
        2. Exception to this criterion is automatically provided for corals that are being removed and relocated from interior waterways as identified in the Mitigation Relocation Recommendations, "Health Assessment" section.
    f. Predators or evidence of predation from organisms that cannot be removed (e.g., peeled off) prior to relocation such as: fireworms (*Hermodice caruncunculata)*, snails (e.g., *Coralliophila abbreviata, Thais deltoidea)*, or damselfish (e.g.,

Stegastes planifrons, Microspathodon chrysurus); invasive, encrusting and/or overgrowing tunicates (e.g., Genus *Symplegma*, Genus *Botryllus*), sponges, octocorals (e.g., *Erythropodium caribaeorum, Briareum asbestinum*), or zoanthids (e.g., Genus *Palythoa*). **Exception** - Corals containing boring sponges of the Genus *Cliona* are acceptable for relocation. Numbers of corals that are relocated containing boring sponges of the Genus *Cliona* must be noted in any post-relocation reporting documents.

2) Corals that are experiencing active predation (e.g., presence in feeding position along tissue loss margin of *Coralliophila abbreviata* and/or *Hermodice carunculata*), may be relocated once all predators are removed. Numbers of relocated corals that are experiencing active predation and the type of predation (prior to removal of predators) must be noted in any post-relocation reporting documents.

OCTOCORALS

Definitions

For purposes of these Protocols:

1) An "octocoral" is a colony of any species of the Subclass **Octocorallia***,* excluding encrusting octocorals (e.g., *Erythropodium caribaeorum, Briareum asbestinum*).
2) A "rod" is characterized as having thick branches, and usually secondary branches with thick tissues.
3) A "seafan" is characteristically fan shaped with interconnected net-like branching with thin tissues.
4) A "plume" is characterized as having thin pinnate (feather-like) branches and branchlets with thin tissues.
5) A "holdfast" is the base of an octocoral that attaches the colony to the substrate.
6) The "axis" of an octocoral is the central supporting skeletal structure made out of proteinaceous gorgonin that is dark brown to black in color.
7) "Bleaching" for the purposes of octocoral relocation is defined as 100% of octocoral tissue is discolored due to the loss or reduction in number of endosymbiotic algae (zooxanthellae). During bleaching, tissue is present but is pale to white in color.
8) "Partial bleaching" is where only a portion of the octocoral tissue has lost its zooxanthellae, and the remaining areas of tissue appear normal in color. *Note that octocorals rarely bleach and generally tend to exhibit partial bleaching at their branch tips closest to the water's surface.
9) "Recent mortality" is the non-living portion of recently exposed octocoral axis skeleton (i.e., axis is dark brown to black), including the development of fine "fuzz" or turf algae on exposed axis, indicating that the mortality occurred within a few days prior to observation. *"Old mortality" is not determinable in octocorals.
10) "Relocation" includes all activities that move octocoral colonies from one place to another (e.g., transplanting, outplanting), including but not limited to moving them into and out of temporary holding locations (e.g., cache, staging, acclimation locations) or nurseries.

Octocoral Visual Health Assessment

Each octocoral colony selected for relocation must be visually assessed pursuant to these Protocols to ensure that they appear to be in good health and are free from suspected disease. This visual health assessment must be conducted immediately prior to removal from each and any location, and may need to be conducted more than once before the relocation activity is completed (e.g., immediately prior to removal from an original collection location, a culture location (nursery), or a temporary holding location established for purposes of caching, staging, acclimation, etc.). **Exception** - The visual health assessment does not need to be conducted for octocoral colonies that have been maintained in a temporary holding location for 48 hours or less.

Octocoral colonies that are located in an original collection or culture location when the visual health assessment is conducted and are exhibiting visual signs of disease may not be removed and relocated to other in-water locations. Octocoral colonies that are located in a temporary holding location when the visual health assessment is conducted and are exhibiting visual signs of disease must be removed and disposed of, and this disposition must be noted in any reporting or monitoring documents. **Field personnel conducting octocoral visual health assessments should be proficient with species identification, and trained in octocoral disease, predation identification and removal, and survey techniques to assure accuracy of the assessment.** Each octocoral colony must meet the following criteria prior to relocation:

1) Rod, plume, and seafan colonies must have at least 10 cm (approx. 4”) of linear growth (height).
2) Show no visible signs of disease or mechanical injury based on the presence of:
    a. Bleaching or partial bleaching. **Exceptions:**
        1. As identified in the Mitigation Relocation Recommendations, “Coral and Octocoral Removal and Relocation” section, there may be extreme circumstances in which the FWC will support octocoral removal and relocation during times of severe stress or significant stress events. On a case-by-case basis, FWC can provide exception to this criterion for octocorals that will be removed and relocated during times of severe stress or from locations being impacted by significant stress events.
        2. Exception to this criterion is automatically provided for octocorals that are being removed and relocated from interior waterways as identified in the Mitigation Relocation Recommendations, “Health Assessment” section.
    b. Recent mortality greater than 5% of tissue loss exposing axis.
    c. Active disease (e.g., purple spot, aspergillosis, red band disease, black wasting disease, and growth anomalies (severely altered morphology of tissues and skeleton)).
    d. Suspect disease indicators (e.g., bands, spots or rings (identified by severe dark purpling (25% or greater) or blackening of tissues); microbial mats; cyanobacteria colonization).
    e. Stress indicators (e.g., tissue sloughing or swelling; excessive sedimentation; excessive mucous production). **Exceptions:**
        1. As identified in the Mitigation Relocation Recommendations, “Coral and Octocoral Removal and Relocation” section, there may be extreme circumstances in which the FWC will support octocoral removal and relocation during times of severe stress or significant stress events. On a case-by-case basis, FWC can provide exception to this criterion for octocorals that will be removed and relocated during times of severe stress or from locations being impacted by significant stress events.

    2. Exception to this criterion is automatically provided for octocorals that are being removed and relocated from interior waterways as identified in the Mitigation Relocation Recommendations, “Health Assessment” section.

3) Octocorals that are experiencing active predation (e.g., presence of predators, including *Cyphoma gibbosum* and/or *Hermodice carunculata*, in feeding position along tissue loss margin), may be relocated once all predators are removed. **Exception** – Colonies of *Gorgonia ventalina* with active predation of the nudibranch *Tritonia hamnerorum*, cannot be relocated.