MEMORANDUM

AGENDA ITEM # 7

DATE: FEBUARY 17, 2023

TO: COUNCIL MEMBERS

FROM: STAFF

SUBJECT: FLORIDA'S CORAL REEF – DEP'S CORAL PROTECTION AND RESTORATION PROGRAM AND CORAL REEF CONSERVATION ACT REAUTHORIZATION (PASSED AS PART OF THE FY 2023 NATIONAL DEFENSE AUTHORIZATION ACT)

Please welcome Joanna C. Walczak, Administrator, Coral Protection and Restoration Program, Office of Resilience and Coastal Protection, Florida Department of Environmental Protection for a presentation.

Ms. Walczak has provided the following reference materials for your review:

1. Governor's Budget Highlights: Environment: https://www.flgov.com/wp-content/uploads/2023/02/FY-23-24-Governor-Rec-Budget-Highlights-FINAL-1.31.23.pdf
2. U.S. Coral Reef Conservation Act Reauthorization
3. Coral Reef Restoration for Risk Reduction (CR4): A Guide to Project Design and Proposal Development: https://coralreef.gov/assets/about/cr4_guide_nov2022_508.pdf

Recommendation:

Information Only.

Environment

Florida natural resources are the foundation of Florida's communities, economy, and way of life, and the protection of Florida's environment remains a key focus of Governor DeSantis. With record investments over the past four years, Florida has ushered in a new area of stewardship for Florida's natural resources, including the Everglades. The Framework for Freedom Budget continues this historic momentum, with significant investments made for Fiscal Year 2023-24. As part of more than $6.8 billion in funding to protect our environment, agriculture and natural resources, the budget includes over $3.5 billion specifically for the Department of Environmental Protection (DEP).

Continued Improvements for Water Quality, Quantity and Supply
In Executive Order 19-12, among other major environmental reforms, Governor DeSantis called for $2.5 billion to be invested over four years for the protection of water resources, an increase of $1 billion over the previous four years. The Governor surpassed that goal by securing over $3.3 billion. Governor DeSantis builds on this historic investment with Executive Order 23-06, calling for $3.5 billion over the next four years for Everglades restoration and protection of our water resources, including water quality and water supply. The Fiscal Year 2023-24 budget initiates this investment, by dedicating more than $1.1 billion.

The Framework for Freedom Budget includes more than $614 million for Everglades restoration projects, including:

- $58 million for Restoration Strategies.
- $182.2 million for the Comprehensive Everglades Restoration Plan (CERP).
- $86.3 million for the C-43 West Basin Reservoir Storage Project.
- $152 million for the EAA Reservoir to continue the momentum of this critical project to reduce harmful discharges and help send more clean water south of the Everglades.
- $50 million is included for specific project components designed to achieve the greatest reductions in harmful discharges to the Caloosahatchee and St. Lucie Estuaries as identified in the Comprehensive Everglades Restoration Plan Lake Okeechobee Watershed Restoration Project Draft Integrated Project Implementation Report and Environmental Impact Statement dated August 2020.
- $86.1 million is included for the Northern Everglades and Estuaries Protection Program.

The Framework for Freedom Budget also includes $370 million for targeted water quality improvements to achieve significant, meaningful and measurable nutrient reductions in key waterbodies across the state and to implement the recommendations of the Blue-Green Algae Task Force. This includes:

- $200 million for the wastewater grant program for projects to construct, upgrade or expand wastewater facilities, to provide advanced wastewater treatment and to convert from septic to sewer.
- $100 million for the new Indian River Lagoon (IRL) Protection Program for priority projects to improve water quality in the IRL.
- $50 million to accelerate projects to meet scientific nutrient reduction goals, called Total Maximum Daily Loads, which may include green infrastructure investments or land conservation to protect our water resources.
- $20 million for critical infrastructure including wastewater and stormwater projects that address water quality impairments and coral reef restoration in Biscayne Bay.

On top of the investment in targeted water quality improvements, the Framework for Freedom Budget includes $50 million to restore Florida's world-renowned springs. This funding may also be used for land acquisition to protect springsheds and is crucial to supporting homeowners and local communities as they work with the state to achieve septic and nutrient reduction requirements.

The Framework for Freedom Budget includes $85 million for the continued stabilization, water treatment, and closure of Piney Point.

The Framework for Freedom Budget invests $65 million to improve water quality and combat the effects and impacts of harmful algal blooms, including blue-green algae and red tide. The Framework for Freedom Budget includes the following:

- $10 million for innovative technologies and short-term solutions to aid in the prevention, cleanup and mitigation of harmful algal blooms.
- $10.8 million to increase water quality monitoring, support the Blue-Green Algae Task Force, and to maintain and improve the water quality public information portal.
- $30 million for harmful algal blooms mitigation to implement water quality treatment technologies to combat harmful algal blooms in Lake Okeechobee.
- $10 million to assist county governments with their responses to emergency conditions associated with harmful algal blooms and red tide events that may impact public health, Florida's environment and fragile ecosystems, including beaches and wildlife.
- $4.2 million in funding for continued support of research activities conducted by the Center for Red Tide Research.

$50 million is provided for the Alternative Water Supply Grant Program to help communities plan for and implement vital conservation, reuse and other alternative water supply projects. DEP will continue to engage local governments, industry, universities and water management districts to identify and research all viable

alternative water supply sources and is working to provide an assessment of funding needs critical to supporting Florida's growing economy.

Further Protection of our Valuable and Vulnerable Coastlines
In Fiscal Year 2021-22, Governor DeSantis championed the passage of the Resilient Florida Grant Program which enhances our efforts to protect our inland waterways, coastlines, shores and coral reefs, which serve as invaluable natural defenses against sea level rise.

The Framework for Freedom Budget invests over $406 million for resiliency, including $350 million for implementation of statewide resilience projects and $56 million for resiliency planning and coral reef protection.

Protecting Florida's 1,300 miles of coastline is critical to our growing economy and quality of life, as millions travel from around the world to visit our world-renowned beaches. The Framework for Freedom Budget includes $50 million in beach nourishment funding to continue addressing Florida's critically eroded shorelines. In addition, Governor DeSantis recommends $106 million for Hurricanes Ian and Nicole beach erosion recovery projects to fully fund DEP's *Hurricanes Ian and Nicole Recovery Plan for Florida's Beach and Dune Systems.*

Florida's Coral Reef Restoration and Recovery Initiative
Included within $21.2 million for coral reef protection is $10.2 million to implement Florida's Coral Reef Restoration and Recovery Initiative to restore 25 percent of Florida's Coral Reef by 2050. Through facilitating an unprecedented, evidence-based propagation and outplanting program conducted by the state and its partners, Florida's Coral Reef will be restocked with hardy populations of native corals and other keystone species to re-establish and strengthen natural reproduction, dispersal, and recruitment patterns. Florida's Coral Reef Restoration and Recovery Initiative will significantly enhance flood protection in Southeast Florida and strengthen coastal economies.

Apalachicola Bay Oyster Restoration
The Framework for Freedom Budget includes $15 million to support the ongoing oyster restoration operation in Apalachicola Bay. This investment will double the supported acreage from 1,000 to 2,000 acres of durable oyster habitat.

Investing in Clean Lands and Air
The Framework for Freedom Budget includes more than $194 million for the cleanup of contaminated sites with a focus on promoting redevelopment of these areas once cleanup has been completed. Working with federal and local partners, cleanup and redevelopment of these sites will ensure Florida's new businesses and growing

communities can safely develop and our economy can continue to grow. Specific investments include:

- $180 million for Petroleum Tanks Cleanup;
- $9 million for Dry Cleaning Solvent Contaminated Site Cleanup;
- $5.5 million for Hazardous Waste Contaminated Site Cleanup.

A Commitment to Florida's Prized Properties and Waterways

The Framework for Freedom Budget includes $145 million to protect our prized properties and waterways in Florida. This funding will ensure all Floridians have access to enjoy our pristine natural environment, while protecting these unique natural resources and investing in the management of our state-owned lands.

As land acquisition is vital to both our economic growth and environmental protection, the Framework for Freedom Budget includes $100 million for the Florida Forever Program, the state's premier conservation and recreation land acquisition program. This includes:

- $75 million for the Division of State Lands to acquire land with a focus on protecting our water resources for Floridians and visitors, including lands within the Florida Wildlife Corridor.
- $15 million for the Florida Communities Trust component of Florida Forever, which provides funding to local governments and eligible non-profit environmental organizations for the acquisition of community-based parks, open space and greenways that further outdoor recreation and natural resource protection needs.
- $10 million for the Florida Recreation Development Assistance Program (FRDAP), which provides competitive recreational grants to local governments for the acquisition and/or development of land for public outdoor recreation.

Florida's State Parks have won the National Gold Medal a record four times for having the best state park system in the nation. The Framework for Freedom Budget dedicates $45 million to infrastructure improvements and resource management with the goal of maintaining this high standard and ensuring all visitors and residents alike have access to these prized properties for generations to come.

Defending Florida's Everglades from Invasive Species

Governor DeSantis has prioritized efforts to remove the invasive Burmese python from the Everglades. The Framework for Freedom Budget includes up to $3.4 million for the Florida Fish and Wildlife Conservation Commission to remove pythons from the Everglades.

Investing in Florida's Agriculture and Citrus Industry
The Framework for Freedom Budget includes more than $2.7 billion for Florida's agricultural industry. In order to preserve Florida's iconic citrus industry, the budget invests $29.4 million for citrus research and the Citrus Health Response Program. This includes $15 million for the Department of Citrus for the expansion of the eCommerce and digital marketing program, which is focused on driving sales of Florida Citrus products through eCommerce partnerships with retail grocers and online shopping platforms.

Combatting Wildfires
Also, recognizing the importance of effectively combatting wildfires, the budget includes $11.5 million for wildfire suppression equipment and $4.9 million for road and bridge maintenance to allow for better access for land management and wildfire suppression activities.

TITLE C—CORAL REEF CONSERVATION

Subtitle A—Reauthorization of Coral Reef Conservation Act of 2000

SEC. 10001. REAUTHORIZATION OF CORAL REEF CONSERVATION ACT OF 2000.

(a) IN GENERAL.—The Coral Reef Conservation Act of 2000 (16 U.S.C. 6401 et seq.) is amended by striking sections 202 through 210 and inserting the following:

"SEC. 202. PURPOSES.

"The purposes of this title are—

"(1) to conserve and restore the condition of United States coral reef ecosystems challenged by natural and human-accelerated changes, including increasing ocean temperatures, changing ocean chemistry, coral bleaching, coral diseases, water quality degradation, invasive species, and illegal, unreported, and unregulated fishing;

"(2) to promote the science-based management and sustainable use of coral reef ecosystems to benefit local communities and the Nation, including through improved integration and cooperation among Federal and non-Federal stakeholders responsible for managing coral reef resources;

"(3) to develop sound scientific information on the condition of coral reef ecosystems, continuing and emerging threats to such ecosystems, and the efficacy of innovative tools, technologies, and strategies to mitigate stressors and restore such ecosystems, including evaluation criteria to determine the effectiveness of management interventions, and accurate mapping for coral reef restoration;

"(4) to assist in the preservation of coral reefs by supporting science-based, consensus-driven, and community-based coral reef management by covered States and covered Native entities, including monitoring, conservation, and restoration projects that empower local communities, small businesses, and nongovernmental organizations;

"(5) to provide financial resources, technical assistance, and scientific expertise to supplement, complement, and strengthen community-based manage-

ment programs and conservation and restoration projects of non-Federal reefs;

"(6) to establish a formal mechanism for collecting and allocating monetary donations from the private sector to be used for coral reef conservation and restoration projects;

"(7) to support rapid, effective, and science-based assessment and response to exigent circumstances that pose immediate and long-term threats to coral reefs, including—

"(A) coral disease outbreaks;

"(B) invasive or nuisance species;

"(C) coral bleaching;

"(D) natural disasters; and

"(E) industrial or mechanical disasters, including vessel groundings, hazardous spills, and coastal construction accidents; and

"(8) to serve as a model for advancing similar international efforts to monitor, conserve, and restore coral reef ecosystems.

"SEC. 203. FEDERAL CORAL REEF MANAGEMENT AND RESTORATION ACTIVITIES.

"(a) IN GENERAL.—The Administrator, the Secretary of the Interior, or the Secretary of Commerce may conduct activities described in subsection (b) to conserve and restore

coral reefs and coral reef ecosystems that are consistent with—

"(1) all applicable laws governing resource management in Federal and State waters, including this Act;

"(2) the National Coral Reef Resilience Strategy; and

"(3) coral reef action plans in effect under section 205, as applicable.

"(b) ACTIVITIES DESCRIBED.—Activities described in this subsection are activities to conserve, research, monitor, assess, and restore coral reefs and coral reef ecosystems in waters managed under the jurisdiction of a Federal agency specified in subsection (c) or in coordination with a State in waters managed under the jurisdiction of such State, including—

"(1) developing, including through the collection of requisite in situ and remotely sensed data, high-quality and digitized maps reflecting—

"(A) current and historical live coral cover data;

"(B) coral reef habitat quality data;

"(C) priority areas for coral reef conservation to maintain biodiversity and ecosystem structure and function, including the reef ma-

trix, that benefit coastal communities and living marine resources;

"(D) priority areas for coral reef restoration to enhance biodiversity and ecosystem structure and function, including the reef matrix, to benefit coastal communities and living marine resources; and

"(E) areas of concern that may require enhanced monitoring of coral health and cover;

"(2) enhancing compliance with Federal laws that prohibit or regulate—

"(A) the taking of coral products or species associated with coral reefs; or

"(B) the use and management of coral reef ecosystems;

"(3) long-term ecological monitoring of coral reef ecosystems;

"(4) implementing species-specific recovery plans for listed coral species consistent with the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.);

"(5) restoring degraded coral reef ecosystems;

"(6) reducing land-based stressors to coral reef ecosystems;

"(7) promoting ecologically sound navigation and anchorages, including through navigational aids

and expansion of reef-safe anchorages and mooring buoy systems, to enhance recreational access while preventing or minimizing the likelihood of vessel impacts or other physical damage to coral reefs;

"(8) monitoring and responding to severe bleaching or mortality events, disease outbreaks, invasive species outbreaks, and significant maritime accidents, including hazardous spill cleanup and the removal of grounded vessels;

"(9) conducting scientific research that contributes to the understanding, sustainable use, and long-term conservation of coral reefs;

"(10) enhancing public awareness, understanding, and appreciation of coral reefs and coral reef ecosystems and their ecological and socioeconomic value; and

"(11) centrally archiving, managing, and distributing on a public website data sets and coral reef ecosystem assessments, including the data repositories of the Coral Reef Conservation Program of the National Oceanic and Atmospheric Administration.

"(c) FEDERAL AGENCIES SPECIFIED.—A Federal agency specified in this subsection is one of the following:

"(1) The National Oceanic and Atmospheric Administration.

"(2) The National Park Service.

"(3) The United States Fish and Wildlife Service.

"(4) The Office of Insular Affairs.

"SEC. 204. NATIONAL CORAL REEF RESILIENCE STRATEGY.

"(a) IN GENERAL.—The Administrator shall—

"(1) not later than 2 years after the date of the enactment of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, develop a national coral reef resilience strategy; and

"(2) review and revise the strategy—

"(A) not less frequently than once every 15 years;

"(B) not less frequently than once every 5 years, in the case of guidance on best practices under subsection (b)(4); and

"(C) as appropriate.

"(b) ELEMENTS.—The strategy required by subsection (a) shall include the following:

"(1) A discussion addressing—

"(A) continuing and emerging threats to the resilience of United States coral reef ecosystems;

"(B) remaining gaps in coral reef ecosystem research, monitoring, and assessment;

"(C) the status of management cooperation and integration among Federal reef managers and covered reef managers;

"(D) the status of efforts to manage and disseminate critical information, and enhance interjurisdictional data sharing, related to research, reports, data sets, and maps;

"(E) areas of special focus, which may include—

"(i) improving natural coral recruitment;

"(ii) preventing avoidable losses of corals and their habitat;

"(iii) enhancing the resilience of coral populations;

"(iv) supporting a resilience-based management approach;

"(v) developing, coordinating, and implementing watershed management plans;

"(vi) building and sustaining watershed management capacity at the local level;

"(vii) providing data essential for coral reef fisheries management;

"(viii) building capacity for coral reef fisheries management;

"(ix) increasing understanding of coral reef ecosystem services;

"(x) educating the public on the importance of coral reefs, threats and solutions; and

"(xi) evaluating intervention efficacy;

"(F) the status of conservation efforts, including the use of marine protected areas to serve as replenishment zones developed consistent with local practices and traditions and in cooperation with, and with respect for the scientific, technical, and management expertise and responsibilities of, covered reef managers;

"(G) science-based adaptive management and restoration efforts; and

"(H) management of coral reef emergencies and disasters.

"(2) A statement of national goals and objectives designed to guide—

"(A) future Federal coral reef management and restoration activities authorized under section 203;

"(B) conservation and restoration priorities for grants awarded under section 211; and

"(C) research priorities for the reef research coordination institutes designated under section 213(b)(1)(B).

"(3) A designation of priority areas for conservation, and priority areas for restoration, to support the review and approval of grants under section 211(e).

"(4) Technical assistance in the form of general templates for use by covered reef managers and Federal reef managers to guide the development of coral reef action plans under section 205, including guidance on the best science-based practices to respond to coral reef emergencies that can be included in coral reef action plans.

"(c) CONSULTATIONS.—In developing all elements of the strategy required by subsection (a), the Administrator shall—

"(1) consult with the Secretary of the Interior, the Task Force, covered States, and covered Native entities;

"(2) consult with the Secretary of Defense, as appropriate;

"(3) engage stakeholders, including covered States, coral reef stewardship partnerships, reef research institutes and research centers described in sec-

tion 213, and recipients of grants under section 211; and

"(4) solicit public review and comment regarding scoping and the draft strategy.

"(d) SUBMISSION TO CONGRESS; PUBLICATION.—The Administrator shall—

"(1) submit the strategy required by subsection (a) and any revisions to the strategy to the appropriate congressional committees; and

"(2) publish the strategy and any such revisions on public websites of—

"(A) the Coral Reef Conservation Program of the National Oceanic and Atmospheric Administration; and

"(B) the Task Force.

"SEC. 205. CORAL REEF ACTION PLANS.

"(a) PLANS PREPARED BY FEDERAL REEF MANAGERS.—

"(1) IN GENERAL.—Not later than 3 years after the date of the enactment of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 and 2 years after the date of publication of each National Coral Reef Resilience Strategy, each Federal reef manager shall—

"(A) prepare a coral reef action plan to guide management and restoration activities to be undertaken within the responsibilities and jurisdiction of the manager; or

"(B) in the case of a reef under the jurisdiction of a Federal reef manager for which there is an action plan in effect as of such date of enactment, update that plan to comply with the requirements of this subsection.

"(2) ELEMENTS.—A plan prepared under paragraph (1) by a Federal reef manager shall include a discussion of the following:

"(A) Short- and medium-term coral reef conservation and restoration objectives within the jurisdiction of the manager.

"(B) A current adaptive management framework to inform research, monitoring, and assessment needs.

"(C) Tools, strategies, and partnerships necessary to identify, monitor, and address pollution, water quality, and other negative impacts to coral reef ecosystems within the jurisdiction of the manager.

"(D) The status of efforts to improve coral reef ecosystem management cooperation and inte-

gration between Federal reef managers and covered reef managers, including the identification of existing research and monitoring activities that can be leveraged for coral reef status and trends assessments within the jurisdiction of the manager.

"(E) Estimated budgetary and resource considerations necessary to carry out the plan.

"(F) Contingencies for response to and recovery from emergencies and disasters.

"(G) In the case of an updated plan, annual records of significant management and restoration actions taken under the previous plan, cash and noncash resources used to undertake the actions, and the source of such resources.

"(H) Documentation by the Federal reef manager that the plan is consistent with the National Coral Reef Resilience Strategy.

"(I) A data management plan to ensure data, assessments, and accompanying information are appropriately preserved, curated, publicly accessible, and broadly reusable.

"(3) SUBMISSION TO TASK FORCE.—Each Federal reef manager shall submit a plan prepared under paragraph (1) to the Task Force.

"(4) APPLICATION OF ADMINISTRATIVE PROCEDURE ACT.—Each plan prepared under paragraph (1) shall be subject to the requirements of subchapter II of chapter 5, and chapter 7, of title 5, United States Code (commonly known as the 'Administrative Procedure Act').

"(b) PLANS PREPARED BY COVERED REEF MANAGERS.—

"(1) IN GENERAL.—A covered reef manager may elect to prepare, submit to the Task Force, and maintain a coral reef action plan to guide management and restoration activities to be undertaken within the responsibilities and jurisdiction of the manager.

"(2) EFFECTIVE PERIOD.—A plan prepared under this subsection shall remain in effect for 5 years, or until an updated plan is submitted to the Task Force, whichever occurs first.

"(3) ELEMENTS.—A plan prepared under paragraph (1) by a covered reef manager—

"(A) shall contain a discussion of—

"(i) short- and medium-term coral reef conservation and restoration objectives within the jurisdiction of the manager;

"(ii) estimated budgetary and resource considerations necessary to carry out the plan;

"(iii) in the case of an updated plan, annual records of significant management and restoration actions taken under the previous plan, cash and noncash resources used to undertake the actions, and the source of such resources; and

"(iv) contingencies for response to and recovery from emergencies and disasters; and

"(B) may contain a discussion of—

"(i) the status of efforts to improve coral reef ecosystem management cooperation and integration between Federal reef managers and covered reef managers, including the identification of existing research and monitoring activities that can be leveraged for coral reef status and trends assessments within the jurisdiction of the manager;

"(ii) a current adaptive management framework to inform research, monitoring, and assessment needs;

"(iii) tools, strategies, and partnerships necessary to identify, monitor, and address pollution and water quality impacts to coral reef ecosystems within the jurisdiction of the manager; and

"(iv) a data management plan to ensure data, assessments, and accompanying information are appropriately preserved, curated, publicly accessible, and broadly reusable.

"(c) TECHNICAL ASSISTANCE.—The Administrator and the Task Force shall make reasonable efforts to provide technical assistance upon request by a Federal reef manager or covered reef manager developing a coral reef action plan under this section.

"(d) PUBLICATION.—The Administrator shall publish each coral reef action plan prepared and submitted to the Task Force under this section on the public website of the Coral Reef Conservation Program of the National Oceanic and Atmospheric Administration.

"SEC. 206. CORAL REEF STEWARDSHIP PARTNERSHIPS.

"(a) IN GENERAL.—To further community-based stewardship of coral reefs, coral reef stewardship partnerships for Federal and non-Federal coral reefs may be established in accordance with this section.

"(b) STANDARDS AND PROCEDURES.—The Administrator shall develop and adopt—

"(1) standards for identifying individual coral reefs and ecologically significant units of coral reefs; and

"(2) processes for adjudicating multiple applicants for stewardship of the same coral reef or ecologically significant unit of a reef to ensure no geographic overlap in representation among stewardship partnerships authorized by this section.

"(c) MEMBERSHIP FOR FEDERAL CORAL REEFS.—A coral reef stewardship partnership that has identified, as the subject of its stewardship activities, a coral reef or ecologically significant unit of a coral reef that is fully or partially under the management jurisdiction of any Federal agency specified in section 203(c) shall, at a minimum, include the following:

"(1) That Federal agency, a representative of which shall serve as chairperson of the coral reef stewardship partnership.

"(2) A State or county's resource management agency to the extent that such partnership covers a reef within such States or county's jurisdiction.

"(3) A coral reef research center designated under section 212(b).

"(4) A nongovernmental organization.

"(5) A covered Native entity culturally affiliated with the subject reef or ecologically significant unit, if any.

"(6) Such other members as the partnership considers appropriate, such as interested stakeholder groups and covered Native entities.

"(d) MEMBERSHIP FOR NON-FEDERAL CORAL REEFS.—

"(1) IN GENERAL.—A coral reef stewardship partnership that has identified, as the subject of its stewardship activities, a coral reef or ecologically significant component of a coral reef that is not under the management jurisdiction of any Federal agency specified in section 203(c) shall, at a minimum, include the following:

"(A) A State or county's resource management agency or a covered Native entity, a representative of which shall serve as the chairperson of the coral reef stewardship partnership.

"(B) A coral reef research center designated under section 212(b).

"(C) A nongovernmental organization.

"(D) Such other members as the partnership considers appropriate, such as interested stakeholder groups.

"(2) ADDITIONAL MEMBERS.—

"(A) IN GENERAL.—Subject to subparagraph (B), a coral reef stewardship partnership described in paragraph (1) may also include representatives of one or more Federal agencies.

"(B) REQUESTS; APPROVAL.—A representative of a Federal agency described in subparagraph (A) may become a member of a coral reef stewardship partnership described in paragraph (1) if—

"(i) the representative submits a request to become a member to the chairperson of the partnership referred to in paragraph (1)(A); and

"(ii) the chairperson consents to the request.

"(e) NONAPPLICABILITY OF FEDERAL ADVISORY COMMITTEE ACT.—The Federal Advisory Committee Act (5 U.S.C. App.) shall not apply to coral reef stewardship partnerships under this section.

"SEC. 207. BLOCK GRANTS.

"(a) IN GENERAL.—In each fiscal year beginning in fiscal year 2023 and subject to the availability of appropriations, the Administrator shall provide block grants of financial assistance of not less than $500,000 to each covered State to support management and restoration activities and further the implementation of coral reef action plans in effect under section 205 by covered States and non-Federal coral reef stewardship partnerships in accordance with this section. The Administrator shall review each covered State's application for block grant funding to ensure that applications are consistent with applicable action plans and the National Coral Reef Resilience Strategy.

"(b) RESPONSIBILITIES OF THE ADMINISTRATOR.—The Administrator is responsible for—

"(1) providing guidance on the proper documentation of expenditures authorized under this Act;

"(2) issuing annual solicitations to covered States for awards under this section; and

"(3) determining the appropriate allocation of additional amounts among covered States in accordance with this section.

"(c) RESPONSIBILITIES OF COVERED STATES.—Each covered State is responsible for documenting and reporting—

"(1) such State's use of Federal funds received under this Act; and

"(2) such expenditures of non-Federal funds made in furtherance of coral reef management and restoration as the Administrator determines appropriate.

"(d) COOPERATIVE AGREEMENTS.—Subject to the availability of appropriations, the Administrator may seek to enter into a cooperative agreement with a covered State to fund coral reef conservation and restoration activities in waters managed under the jurisdiction of such covered State that are consistent with the National Coral Reef Resilience Strategy and any applicable action plan under section 205.

"(e) ALL ISLANDS COMMITTEE.—The Administrator may enter into a cooperative agreement with the All Islands Committee of the Task Force to provide support for its activities.

"SEC. 208. CORAL REEF STEWARDSHIP FUND.

"(a) AGREEMENT.—The Administrator shall seek to enter into an agreement with the National Fish and Wildlife Foundation (in this section referred to as the 'Foundation'), authorizing the Foundation to receive, hold, and administer funds received under this section.

"(b) FUND.—

"(1) IN GENERAL.—The Foundation shall establish an account, which shall—

"(A) be known as the 'Coral Reef Stewardship Fund' (in this section referred to as the 'Fund'); and

"(B) serve as the successor to the account known before the date of the enactment of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 as the Coral Reef Conservation Fund and administered through a public-private partnership with the Foundation.

"(2) DEPOSITS.—The Foundation shall deposit funds received under this section into the Fund.

"(3) PURPOSES.—The Fund shall be available solely to support coral reef stewardship activities that—

"(A) further the purposes of this title; and

"(B) are consistent with—

"(i) the National Coral Reef Resilience Strategy; and

"(ii) coral reef action plans in effect, if any, under section 205 covering a coral reef or ecologically significant component of a coral reef to be impacted by such activities, if applicable.

"(4) INVESTMENT OF AMOUNTS.—

"(A) INVESTMENT OF AMOUNTS.—The Foundation shall invest such portion of the Fund as is not required to meet current withdrawals in interest-bearing obligations of the United States or in obligations guaranteed as to both principal and interest by the United States.

"(B) INTEREST AND PROCEEDS.—The interest on, and the proceeds from the sale or redemption of, any obligations held in the Fund shall be credited to and form a part of the Fund.

"(5) REVIEW OF PERFORMANCE.—The Administrator shall conduct a continuing review of all deposits into, and disbursements from, the Fund. Each review shall include a written assessment concerning the extent to which the Foundation has implemented the goals and requirements of—

"(A) this section; and

"(B) the National Coral Reef Resilience Strategy.

"(c) AUTHORIZATION TO SOLICIT DONATIONS.—

"(1) IN GENERAL.—Pursuant to an agreement entered into under subsection (a), the Foundation may accept, receive, solicit, hold, administer, and use any gift (including, notwithstanding section 1342 of

title 31, United States Code, donations of services) to further the purposes of this title.

"(2) DEPOSITS IN FUND.—Notwithstanding section 3302 of title 31, United States Code, any funds received as a gift shall be deposited and maintained in the Fund.

"(d) ADMINISTRATION.—Under an agreement entered into pursuant to subsection (a), and subject to the availability of appropriations, the Administrator may transfer funds appropriated for such purposes to carry out this title to the Foundation. Amounts received by the Foundation under this subsection may be used for matching, in whole or in part, contributions (whether in money, services, or property) made to the Foundation by private persons, State or local government agencies, or covered Native entities.

"SEC. 209. EMERGENCY ASSISTANCE.

"(a) IN GENERAL.—Notwithstanding any other provision of law, from funds appropriated pursuant to the authorization of appropriations under section 215, the Administrator may provide emergency assistance to any covered State or coral reef stewardship partnership to respond to immediate harm to coral reefs or coral reef ecosystems arising from any of the exigent circumstances described in subsection (b).

"(b) CORAL REEF EXIGENT CIRCUMSTANCES.—The Administrator shall develop a list of, and criteria for, circumstances that pose an exigent threat to coral reefs, including—

"(1) new and ongoing outbreaks of disease;

"(2) new and ongoing outbreaks of invasive or nuisance species;

"(3) new and ongoing coral bleaching events;

"(4) natural disasters;

"(5) industrial or mechanical incidents, such as vessel groundings, hazardous spills, or coastal construction accidents; and

"(6) such other circumstances as the Administrator determines appropriate.

"(c) ANNUAL REPORT ON EXIGENT CIRCUMSTANCES.—On February 1 of each year, the Administrator shall submit to the appropriate congressional committees, the Committee on Appropriations of the Senate, and the Committee on Appropriations of the House of Representatives a report that—

"(1) describes locations with exigent circumstances described in subsection (b) that were considered but declined for emergency assistance, and the rationale for the decision; and

"(2) with respect to each instance in which emergency assistance under this section was provided—

"(A) the location and a description of the exigent circumstances that prompted the emergency assistance, the entity that received the assistance, and the current and expected outcomes from the assistance;

"(B) a description of activities of the National Oceanic and Atmospheric Administration that were curtailed as a result of providing the emergency assistance; and

"(C) an assessment of whether further action is needed to restore the affected coral reef, recommendations for such restoration, and a cost estimate to implement such recommendations.

"SEC. 210. CORAL REEF DISASTER FUND.

"(a) AGREEMENTS.—The Administrator shall seek to enter into an agreement with the National Fish and Wildlife Foundation (in this section referred to as the 'Foundation'), authorizing the Foundation to receive, hold, and administer funds received under this section.

"(b) FUND.—

"(1) IN GENERAL.—The Foundation shall establish an account, to be known as the 'Coral Reef Disaster Fund' (in this section referred to as the 'Fund').

"(2) DEPOSITS.—The Foundation shall deposit funds received under this section into the Fund.

"(3) PURPOSES.—The Fund shall be available solely to support the long-term recovery of coral reefs from exigent circumstances described in section 209(b)—

"(A) in partnership with non-Federal stakeholders; and

"(B) in a manner that is consistent with—

"(i) the National Coral Reef Resilience Strategy; and

"(ii) coral reef action plans in effect, if any, under section 205.

"(4) INVESTMENT OF AMOUNTS.—

"(A) INVESTMENT OF AMOUNTS.—The Foundation shall invest such portion of the Fund as is not required to meet current withdrawals in interest-bearing obligations of the United States or in obligations guaranteed as to both principal and interest by the United States.

"(B) INTEREST AND PROCEEDS.—The interest on, and the proceeds from, the sale or redemption of, any obligations held in the Fund shall be credited to and form a part of the Fund.

"(5) REVIEW OF PERFORMANCE.—The Administrator shall conduct continuing reviews of all deposits into, and disbursements from, the Fund. Each such review shall include a written assessment concerning the extent to which the Foundation has implemented the goals and requirements of this section.

"(c) AUTHORIZATION TO SOLICIT DONATIONS.—

"(1) IN GENERAL.—Pursuant to an agreement entered into under subsection (a), the Foundation may accept, receive, solicit, hold, administer, and use any gift (including, notwithstanding section 1342 of title 31, United States Code, donations of services) to further the purposes of this title.

"(2) DEPOSITS IN FUND.—Notwithstanding section 3302 of title 31, United States Code, any funds received as a gift shall be deposited and maintained in the Fund.

"SEC. 211. RUTH D. GATES CORAL REEF CONSERVATION GRANT PROGRAM.

"(a) IN GENERAL.—Subject to the availability of appropriations, the Administrator shall establish a program (to be known as the 'Ruth D. Gates Coral Reef Conservation Grant Program') to provide grants for projects for the conservation and restoration of coral reef ecosystems (in this section referred to as 'coral reef projects') pursuant to pro-

posals approved by the Administrator in accordance with this section.

"(b) MATCHING REQUIREMENTS FOR GRANTS.—

"(1) IN GENERAL.—Except as provided in paragraph (3), Federal funds for any coral reef project for which a grant is provided under subsection (a) may not exceed 50 percent of the total cost of the project.

"(2) NON-FEDERAL SHARE.—The non-Federal share of the cost of a coral reef project may be provided by in-kind contributions and other noncash support.

"(3) WAIVER.—The Administrator may waive all or part of the matching requirement under paragraph (1) if the Administrator determines that no reasonable means are available through which an applicant can meet the matching requirement with respect to a coral reef project and the probable benefit of the project outweighs the public interest in the matching requirement.

"(c) ELIGIBILITY.—

"(1) IN GENERAL.—An entity described in paragraph (2) may submit to the Administrator a proposal for a coral reef project.

"(2) ENTITIES DESCRIBED.—An entity described in this paragraph is—

"(A) a covered reef manager or a covered Native entity;

"(B) a regional fishery management council established under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.);

"(C) a coral reef stewardship partnership seeking to implement a coral reef action plan in effect under section 205;

"(D) a coral reef research center designated under section 212(b); or

"(E) a nongovernmental organization or research institution with demonstrated expertise in the conservation or restoration of coral reefs in practice or through significant contributions to the body of existing scientific research on coral reefs.

"(d) PROJECT PROPOSALS.—Each proposal for a grant under this section for a coral reef project shall include the following:

"(1) The name of the individual or entity responsible for conducting the project.

"(2) A description of the qualifications of the individual or entity.

"(3) A succinct statement of the purposes of the project.

"(4) An estimate of the funds and time required to complete the project.

"(5) Evidence of support for the project by appropriate representatives of States or other government jurisdictions in which the project will be conducted.

"(6) Information regarding the source and amount of matching funding available to the applicant.

"(7) A description of how the project meets one or more of the criteria under subsection (e)(2).

"(8) In the case of a proposal submitted by a coral reef stewardship partnership, a description of how the project aligns with the applicable coral reef action plan in effect under section 205.

"(9) Any other information the Administrator considers to be necessary for evaluating the eligibility of the project for a grant under this subsection.

"(e) PROJECT REVIEW AND APPROVAL.—

"(1) IN GENERAL.—The Administrator shall review each coral reef project proposal submitted under this section to determine if the project meets the criteria set forth in subsection (f).

"(2) PRIORITIZATION OF CONSERVATION PROJECTS.—The Administrator shall prioritize the awarding of funding for projects that meet the criteria for approval described in—

"(A) subparagraphs (A) through (G) of subsection (f)(2) that are proposed to be conducted within priority areas identified for coral reef conservation by the Administrator under the National Coral Reef Resilience Strategy; and

"(B) subparagraphs (E) through (L) of subsection (f)(2) that are proposed to be conducted within priority areas identified for coral reef restoration by the Administrator under the National Coral Reef Resilience Strategy.

"(3) REVIEW; APPROVAL OR DISAPPROVAL.—Not later than 180 days after receiving a proposal for a coral reef project under this section, the Administrator shall—

"(A) request and consider written comments on the proposal from each Federal agency, State government, covered Native entity, or other government jurisdiction, including the relevant regional fishery management councils established under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et

seq.), or any National Marine Sanctuary or Marine National Monument, with jurisdiction or management authority over coral reef ecosystems in the area where the project is to be conducted, including the extent to which the project is consistent with locally established priorities, unless such entities were directly involved in the development of the project proposal;

"(B) provide for the merit-based peer review of the proposal and require standardized documentation of that peer review;

"(C) after considering any written comments and recommendations based on the reviews under subparagraphs (A) and (B), approve or disapprove the proposal; and

"(D) provide written notification of that approval or disapproval, with summaries of all written comments, recommendations, and peer reviews, to the entity that submitted the proposal, and each of those States, covered Native entity, and other government jurisdictions that provided comments under subparagraph (A).

"(f) CRITERIA FOR APPROVAL.—The Administrator may not approve a proposal for a coral reef project under this section unless the project—

"(1) is consistent with—

"(A) the National Coral Reef Resilience Strategy; and

"(B) any Federal or non-Federal coral reef action plans in effect under section 205 covering a coral reef or ecologically significant unit of a coral reef to be affected by the project; and

"(2) will enhance the conservation and restoration of coral reefs by—

"(A) addressing conflicts arising from the use of environments near coral reefs or from the use of corals, species associated with coral reefs, and coral products, including supporting consensus-driven and community-based planning and management initiatives for the protection of coral reef ecosystems;

"(B) improving compliance with laws that prohibit or regulate the taking of coral products or species associated with coral reefs or regulate the use and management of coral reef ecosystems;

"(C) designing and implementing networks of real-time water quality monitoring along coral reefs, including data collection related to turbidity, nutrient availability, harmful algal blooms, and plankton assemblages, with an em-

phasis on coral reefs impacted by agriculture and urban development;

"(D) promoting ecologically sound navigation and anchorages, including mooring buoy systems to promote enhanced recreational access, near coral reefs;

"(E) furthering the goals and objectives of coral reef action plans in effect under section 205;

"(F) mapping the location and distribution of coral reefs and potential coral reef habitat;

"(G) stimulating innovation to advance the ability of the United States to understand, research, or monitor coral reef ecosystems, or to develop management or adaptation options to conserve and restore coral reef ecosystems;

"(H) implementing research to ensure the population viability of coral species in United States waters listed as threatened or endangered under the Endangered Species Act of 1973 as detailed in the population-based recovery criteria included in species-specific recovery plans established under such Act;

"(I) developing and implementing cost-effective methods to restore degraded coral reef eco-

systems or to create geographically appropriate coral reef ecosystems in suitable waters, including by improving habitat or promoting success of keystone species, with an emphasis on novel restoration strategies and techniques to advance coral reef recovery and growth near population centers threatened by rising sea levels and storm surge;

"(J) translating and applying coral genetics research to coral reef ecosystem restoration, including research related to traits that promote resilience to increasing ocean temperatures, changing ocean chemistry, coral bleaching, coral diseases, and invasive species;

"(K) developing and maintaining in situ native coral propagation sites; or

"(L) developing and maintaining ex situ coral propagation nurseries and land-based coral gene banks to—

"(i) conserve or augment genetic diversity of native coral populations;

"(ii) support captive breeding of rare coral species; or

"(iii) enhance resilience of native coral populations to increasing ocean tempera-

tures, changing ocean chemistry, coral bleaching, and coral diseases through selective breeding, conditioning, or other approaches that target genes, gene expression, phenotypic traits, or phenotypic plasticity.

"(g) FUNDING REQUIREMENTS.—To the extent practicable based upon proposals for coral reef projects submitted to the Administrator, the Administrator shall ensure that funding for grants awarded under this section during a fiscal year is distributed as follows:

"(1) Not less than 40 percent of funds available shall be awarded for projects in areas of the Pacific Ocean subject to the jurisdiction or control of the United States.

"(2) Not less than 40 percent of the funds available shall be awarded for projects in areas of the Atlantic Ocean, the Gulf of Mexico, or the Caribbean Sea subject to the jurisdiction or control of the United States.

"(3) To the extent there are viable applications made by eligible coral reef stewardship partners, not more than 67 percent of funds distributed in each region in accordance with paragraphs (1) and (2) may be made exclusively available to projects that are—

"(A) submitted by a coral reef stewardship partnership; and

"(B) consistent with the coral reef action plan in effect under section 205 by such a partnership.

"(4) Of the funds distributed to support projects in accordance with paragraph (3), not less than 20 percent and not more than 33 percent shall be awarded for projects submitted by a Federal coral reef stewardship partnership, to the extent there are viable applications made by eligible Federal coral reef stewardship partnerships.

"(h) TASK FORCE.—The Administrator may consult with the Secretary of the Interior and the Task Force to obtain guidance in establishing priorities and evaluating proposals for coral reef projects under this section.

"SEC. 212. CORAL REEF RESEARCH.

"(a) REEF RESEARCH COORDINATION INSTITUTES.—

"(1) ESTABLISHMENT.—The Administrator shall designate 2 reef research coordination institutes for the purpose of advancing and sustaining essential capabilities in coral reef research, one each in the Atlantic and Pacific basins, to be known as the 'Atlantic Reef Research Coordination Institute' and the 'Pa-

cific Reef Research Coordination Institute', respectively.

"(2) MEMBERSHIP.—Each institute designated under paragraph (1) shall be housed within a single coral reef research center designated by the Administrator under subsection (b).

"(3) FUNCTIONS.—The institutes designated under paragraph (1) shall—

"(A) conduct federally directed research to fill national and regional coral reef ecosystem research gaps and improve understanding of, and responses to, continuing and emerging threats to the resilience of United States coral reef ecosystems consistent with the National Coral Reef Resilience Strategy;

"(B) support ecological research and monitoring to study the effects of conservation and restoration activities funded by this title on promoting more effective coral reef management and restoration; and

"(C) through agreements—

"(i) collaborate directly with States, covered Native entities, covered coral reef managers, nonprofit organizations, and

other coral reef research centers designated under subsection (b);

"(ii) assist in the development and implementation of—

"(I) the National Coral Reef Resilience Strategy; and

"(II) coral reef action plans under section 205;

"(iii) build capacity within non-Federal governmental resource management agencies to establish research priorities and translate and apply research findings to management and restoration practices; and

"(iv) conduct public education and awareness programs for policymakers, resource managers, and the general public on—

"(I) coral reefs and coral reef ecosystems;

"(II) best practices for coral reef ecosystem management and restoration;

"(III) the value of coral reefs; and

"(IV) the threats to the sustainability of coral reef ecosystems.

"(b) CORAL REEF RESEARCH CENTERS.—

"(1) IN GENERAL.—The Administrator shall—

"(A) periodically solicit applications for designation of qualifying institutions in covered States as coral reef research centers; and

"(B) designate all qualifying institutions in covered States as coral reef research centers.

"(2) QUALIFYING INSTITUTIONS.—For purposes of paragraph (1), an institution is a qualifying institution if the Administrator determines that the institution—

"(A) is operated by an institution of higher education or nonprofit marine research organization;

"(B) has established management-driven national or regional coral reef research or restoration programs;

"(C) has demonstrated abilities to coordinate closely with appropriate Federal and State agencies, and other academic and nonprofit organizations; and

"(D) maintains significant local community engagement and outreach programs related to coral reef ecosystems.

"SEC. 213. CORAL REEF PRIZE COMPETITIONS.

"(a) IN GENERAL.—Subject to the availability of appropriations, the head of any Federal agency with a representative serving on the United States Coral Reef Task Force established by section 10011 of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, may, individually or in cooperation with one or more agencies, carry out a program to award prizes competitively under section 24 of the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3719).

"(b) PURPOSES.—Any program carried out under this section shall be for the purpose of stimulating innovation to advance the ability of the United States to understand, research, or monitor coral reef ecosystems, or to develop management or adaptation options to preserve, sustain, and restore coral reef ecosystems.

"(c) PRIORITY PROGRAMS.—Priority shall be given to establishing programs under this section that address communities, environments, or industries that are in distress as a result of the decline or degradation of coral reef ecosystems, including—

"(1) scientific research and monitoring that furthers the understanding of causes behind coral reef decline and degradation and the generally slow recovery following disturbances, including changing ocean

chemistry, temperature-related bleaching, disease, and their associated impacts on coral physiology;

"(2) the development of monitoring or management options for communities or industries that are experiencing significant financial hardship;

"(3) the development of adaptation options to alleviate economic harm and job loss caused by damage to coral reef ecosystems;

"(4) the development of measures to help vulnerable communities or industries, with an emphasis on rural communities and businesses; and

"(5) the development of adaptation and management options for impacted tourism industries.

"SEC. 214. REPORTS ON ADMINISTRATION.

"(a) IN GENERAL.—Not later than 2 years after the date of the enactment of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, and every 2 years thereafter, the Administrator shall submit to the committees specified in subsection (b) a report on the administration of this title during the 2-year period preceding submission of the report, including—

"(1) a description of all activities undertaken to implement the National Coral Reef Resilience Strategy;

"(2) a statement of all funds obligated under the authorities of this title; and

"(3) a summary, disaggregated by State, of Federal and non-Federal contributions toward the costs of each project or activity funded, in full or in part, under this title.

"(b) COMMITTEES SPECIFIED.—The committees specified in this subsection are—

"(1) the Committee on Commerce, Science, and Transportation, Committee on Environment and Public Works, Committee on Energy and Natural Resources, and the Committee on Appropriations of the Senate; and

"(2) the Committee on Natural Resources and the Committee on Appropriations of the House of Representatives.

"SEC. 215. AUTHORIZATION OF APPROPRIATIONS.

"(a) IN GENERAL.—There is authorized to be appropriated to the Administrator $45,000,000 for each of fiscal years 2023 through 2027 to carry out this title which shall remain available until expended. Of such amounts, there is authorized to be appropriated for each such fiscal year—

"(1) $12,000,000 to carry out section 207;

"(2) $3,500,000 for activities authorized under section 211; and

"(3) $4,500,000 to be provided to the cooperative institutes designated under section 212(a) to carry out the functions described in such section.

"(b) ADMINISTRATION.—Not more than 10 percent of the amounts appropriated under subsection (a) may be used for program administration or overhead costs incurred by the National Oceanic and Atmospheric Administration or the Department of Commerce.

"SEC. 216. DEFINITIONS.

"In this title:

"(1) ADMINISTRATOR.—The term 'Administrator' means the Administrator of the National Oceanic and Atmospheric Administration.

"(2) ALASKA NATIVE CORPORATION.—The term 'Alaska Native Corporation' has the meaning given the term 'Native Corporation' in section 3 of the Alaska Native Claims Settlement Act (43 U.S.C. 1602).

"(3) APPROPRIATE CONGRESSIONAL COMMITTEES.—The term 'appropriate congressional committees' means the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Natural Resources of the House of Representatives.

"(4) CONSERVATION.—The term 'conservation' means the use of methods and procedures necessary to preserve or sustain native corals and associated spe-

cies as diverse, viable, and self-perpetuating coral reef ecosystems with minimal impacts from invasive species, including—

"(A) all activities associated with resource management, such as monitoring, assessment, protection, restoration, sustainable use, management of habitat, and maintenance or augmentation of genetic diversity;

"(B) mapping;

"(C) scientific expertise and technical assistance in the development and implementation of management strategies for marine protected areas and marine resources required by Federal law;

"(D) law enforcement;

"(E) conflict resolution initiatives;

"(F) community outreach and education; and

"(G) promotion of safe and ecologically sound navigation and anchoring.

"(5) CORAL.—The term 'coral' means species of the phylum Cnidaria, including—

"(A) all species of the orders Antipatharia (black corals), Scleractinia (stony corals), Alcyonacea (soft corals, organ pipe corals,

gorgonians), and Helioporacea (blue coral), of the class Anthozoa; and

"(B) all species of the order Anthoathecata (fire corals and other hydrocorals) of the class Hydrozoa.

"(6) CORAL PRODUCTS.—The term 'coral products' means any living or dead specimens, parts, or derivatives, or any product containing specimens, parts, or derivatives, of any species of coral.

"(7) CORAL REEF.—The term 'coral reef' means calcium carbonate structures in the form of a reef or shoal, composed in whole or in part by living coral, skeletal remains of coral, crustose coralline algae, and other associated sessile marine plants and animals.

"(8) CORAL REEF ECOSYSTEM.—The term 'coral reef ecosystem' means—

"(A) corals and other geographically and ecologically associated marine communities of other reef organisms (including reef plants and animals) associated with coral reef habitat; and

"(B) the biotic and abiotic factors and processes that control or significantly affect coral calcification rates, tissue growth, reproduction, recruitment, abundance, coral-algal symbiosis, and biodiversity in such habitat.

"(9) CORAL REEF ECOSYSTEM SERVICES.—The term 'coral reef ecosystem services' means the attributes and benefits provided by coral reef ecosystems including—

"(A) protection of coastal beaches, structures, and infrastructure;

"(B) habitat for organisms of economic, ecological, biomedical, medicinal, and cultural value;

"(C) serving as centers for the promulgation, performance, and training of cultural practices representative of traditional ecological knowledge; and

"(D) aesthetic value.

"(10) COVERED NATIVE ENTITY.—The term 'covered Native entity' means a Native entity with interests in a coral reef ecosystem.

"(11) COVERED REEF MANAGER.—The term 'covered reef manager' means—

"(A) a management unit of a covered State with jurisdiction over a coral reef ecosystem;

"(B) a covered State; or

"(C) a coral reef stewardship partnership under section 206.

"(12) COVERED STATE.—The term 'covered State' means Florida, Hawaii, and the territories of American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, Puerto Rico, and the United States Virgin Islands.

"(13) FEDERAL REEF MANAGER.—

"(A) IN GENERAL.—The term 'Federal reef manager' means—

"(i) a management unit of a Federal agency specified in subparagraph (B) with lead management jurisdiction over a coral reef ecosystem; or

"(ii) a coral reef stewardship partnership under section 206(c).

"(B) FEDERAL AGENCIES SPECIFIED.—A Federal agency specified in this subparagraph is one of the following:

"(i) The National Oceanic and Atmospheric Administration.

"(ii) The National Park Service.

"(iii) The United States Fish and Wildlife Service.

"(iv) The Office of Insular Affairs.

"(14) INSTITUTION OF HIGHER EDUCATION.—The term 'institution of higher education' has the

meaning given that term in section 101 of the Higher Education Act of 1965 (20 U.S.C. 1001).

"(15) INTERESTED STAKEHOLDER GROUPS.—The term 'interested stakeholder groups' means any of the following with interest in an applicable coral reef or ecologically significant unit of a coral reef:

"(A) A business.

"(B) A commercial or recreational fisherman.

"(C) A recreationalist.

"(D) A Federal, State, Tribal, or local government unit with related jurisdiction.

"(E) An institution of higher education (as such term is defined in section 101(a) of the Higher Education Act of 1965 (20 U.S.C. 1001(a)).

"(F) A nongovernmental organization.

"(16) NATIONAL CORAL REEF RESILIENCE STRATEGY.—The term 'National Coral Reef Resilience Strategy' means the National Coral Reef Resilience Strategy in effect under section 204.

"(17) NATIVE ENTITY.—The term 'Native entity' means any of the following:

"(A) An Indian Tribe (as defined in section 4 of the Indian Self-Determination and Education Assistance Act (25 U.S.C. 5304)).

"(B) An Alaska Native Corporation.

"(C) The Department of Hawaiian Home Lands.

"(D) The Office of Hawaiian Affairs.

"(E) A Native Hawaiian organization (as defined in section 6207 of the Elementary and Secondary Education Act of 1965 (20 U.S.C. 7517)).

"(18) NONPROFIT ORGANIZATION.—The term 'nonprofit organization' means any corporation, trust, association, cooperative, or other organization, not including an institution of higher education, that—

"(A) is operated primarily for scientific, educational, service, charitable, or similar purposes in the public interest;

"(B) is not organized primarily for profit; and

"(C) uses net proceeds to maintain, improve, or expand the operations of the organization.

"(19) RESTORATION.—The term 'restoration' means the use of methods and procedures necessary to enhance, rehabilitate, recreate, or create a functioning coral reef or coral reef ecosystem, in whole or in part, within suitable waters of the historical geographic range of such ecosystems, to provide ecological, economic, cultural, or coastal resiliency services associated with healthy coral reefs and benefit native populations of coral reef organisms.

"(20) RESILIENCE.—The term 'resilience' means the capacity for corals within their native range, coral reefs, or coral reef ecosystems to resist and recover from natural and human disturbances, and maintain structure and function to provide coral reef ecosystem services, as determined by clearly identifiable, measurable, and science-based standards.

"(21) SECRETARY.—The term 'Secretary' means the Secretary of Commerce.

"(22) STATE.—The term 'State' means—

"(A) any State of the United States that contains a coral reef ecosystem within its seaward boundaries;

"(B) American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, Puerto Rico, or the United States Virgin Islands; or

"(C) any other territory or possession of the United States or separate sovereign in free association with the United States that contains a coral reef ecosystem within its seaward boundaries.

"(23) STEWARDSHIP.—The term 'stewardship', with respect to a coral reef, includes conservation, restoration, and public outreach and education.

"(24) TASK FORCE.—The term 'Task Force' means the United States Coral Reef Task Force established under section 10011 of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023.".

(b) CONFORMING AMENDMENT TO NATIONAL OCEANS AND COASTAL SECURITY ACT.—Section 905(a) of the National Oceans and Coastal Security Act (16 U.S.C. 7504(a)) is amended by striking "and coastal infrastructure" and inserting ", coastal infrastructure, and ecosystem services provided by natural systems such as coral reefs".

(c) COMPTROLLER GENERAL REVIEW OF CORAL REEF CONSERVATION PROGRAMS AT THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION.—The Comptroller General of the United States shall, not later than 1 year after the date of the enactment of this Act, submit to Con-

gress and the National Oceanic and Atmospheric Administration a report that—

(1) examines the budget and accounting practices of the coral reef conservation programs of such Administration, including expenditure tracking across line and program offices;

(2) examines the process for determining appropriate project goals and funding priorities; and

(3) includes recommendations on policies or best practices that may improve the transparency and accountability of coral reef conservation programs.

(d) SAVINGS CLAUSE.—None of the amendments made by or provisions of this title may be construed to enlarge the management authority of a Federal agency or coral reef stewardship partnership to coral reefs and coral reef ecosystems outside the boundaries of such agency's or partnership's jurisdiction.

Subtitle B—United States Coral Reef Task Force

SEC. 10011. ESTABLISHMENT.

There is established a task force to lead, coordinate, and strengthen Federal Government actions to better preserve, conserve, and restore coral reef ecosystems, to be known as the "United States Coral Reef Task Force" (in this subtitle referred to as the "Task Force").

SEC. 10012. DUTIES.

The duties of the Task Force shall be—

(1) to coordinate, in cooperation with covered States, covered Native entities, Federal reef managers, covered reef managers, coral reef research centers designated under section 212(b) of the Coral Reef Conservation Act of 2000 (as added by this division), and other nongovernmental and academic partners as appropriate, activities regarding the mapping, monitoring, research, conservation, mitigation, and restoration of coral reefs and coral reef ecosystems;

(2) to monitor and advise regarding implementation of the policy and Federal agency responsibilities set forth in—

(A) Executive Order 13089 (63 Fed. Reg. 32701; relating to coral reef protection); and

(B) the National Coral Reef Resilience Strategy;

(3) to work in coordination with the other members of the Task Force—

(A) to assess the United States role in international trade and protection of coral species;

(B) to encourage implementation of appropriate strategies and actions to promote conservation and sustainable use of coral reef resources worldwide; and

(C) to collaborate with international communities successful in managing coral reefs;

(4) to provide technical assistance for the development and implementation, as appropriate, of—

(A) the National Coral Reef Resilience Strategy; and

(B) coral reef action plans under section 205 of that Act; and

(5) to produce a report each year, for submission to the appropriate congressional committees and publication on the public website of the Task Force, highlighting the status of the coral reef resources of a covered State on a rotating basis, including—

(A) a summary of recent coral reef management and restoration activities undertaken in that State; and

(B) updated estimates of the direct and indirect economic activity supported by, and other benefits associated with, those coral reef resources.

SEC. 10013. MEMBERSHIP.

(a) VOTING MEMBERSHIP.—The voting members of the Task Force shall be—

(1) the Under Secretary of Commerce for Oceans and Atmosphere and the Secretary of Interior, who shall be co-chairpersons of the Task Force;

(2) such representatives from other Federal agencies as the President, in consultation with the Under Secretary, determines appropriate; and

(3) the Governor, or a representative of the Governor, of each covered State.

(b) NONVOTING MEMBERS.—The Task Force shall have the following nonvoting members:

(1) A member of the South Atlantic Fishery Management Council who is designated by the Governor of Florida under section 302(b)(1) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1852(b)(1)).

(2) A member of the Gulf of Mexico Fishery Management Council who is designated by the Governor of Florida under such section.

(3) A member of the Western Pacific Fishery Management Council who is designated under such section and selected as follows:

(A) For the period beginning on the date of the enactment of this Act and ending on December 31 of the calendar year during which such date of enactment occurs, the member shall be se-

lected jointly by the Governors of Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands.

(B) For each calendar year thereafter, the Governors of Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands shall, on a rotating basis, take turns selecting the member.

(4) A member of the Caribbean Fishery Management Council who is designated under such section and selected as follows:

(A) For the period beginning on the date of the enactment of this Act and ending on December 31 of the calendar year during which such date of enactment occurs, the member shall be selected jointly by the Governors of Puerto Rico and the United States Virgin Islands.

(B) For each calendar year thereafter, the Governors of Puerto Rico and the United States Virgin Islands shall, on an alternating basis, take turns selecting the member.

(5) A member appointed by the President of the Federated States of Micronesia.

(6) A member appointed by the President of the Republic of the Marshall Islands.

(7) A member appointed by the President of the Republic of Palau.

SEC. 10014. RESPONSIBILITIES OF FEDERAL AGENCY MEMBERS.

(a) IN GENERAL.—A member of the Task Force described in section 10013(a) shall—

(1) identify the actions of the agency that member represents that may affect coral reef ecosystems;

(2) use the programs and authorities of that agency to protect and enhance the conditions of such ecosystems, including through the promotion of basic and applied scientific research;

(3) collaborate with the Task Force to appropriately reflect budgetary needs for coral reef conservation and restoration activities in all agency budget planning and justification documents and processes; and

(4) engage in any other coordinated efforts approved by the Task Force.

(b) CO-CHAIRPERSONS.—In addition to their responsibilities under subsection (a), the co-chairpersons of the Task Force shall perform the administrative functions of the Task Force and facilitate the coordination of the members of the Task Force described in section 10013(a).

(c) BRIEFING.—Not less than 30 days before each meeting of the Task Force, the program offices of the National Oceanic and Atmospheric Administration responsible for implementing this title shall provide a briefing to the relevant congressional committees on efforts and spending associated with such implementation.

SEC. 10015. WORKING GROUPS.

(a) IN GENERAL.—The co-chairpersons of the Task Force may establish working groups as necessary to meet the goals and carry out the duties of the Task Force.

(b) REQUESTS FROM MEMBERS.—The members of the Task Force may request that the co-chairpersons establish a working group under subsection (a).

(c) PARTICIPATION BY NONGOVERNMENTAL ORGANIZATIONS.—The co-chairpersons may allow nongovernmental organizations as appropriate, including academic institutions, conservation groups, and commercial and recreational fishing associations, to participate in a working group established under subsection (a).

(d) NONAPPLICABILITY OF FEDERAL ADVISORY COMMITTEE ACT.—The Federal Advisory Committee Act (5 U.S.C. App.) shall not apply to working groups established under this section.

SEC. 10016. DEFINITIONS.

In this subtitle:

(1) APPROPRIATE CONGRESSIONAL COMMITTEES.—The term "appropriate congressional committees" means—

(A) the Committee on Commerce, Science, and Transportation of the Senate;

(B) the Committee on Environment and Public Works of the Senate;

(C) the Committee on Energy and Natural Resources of the Senate; and

(D) the Committee on Natural Resources of the House of Representatives.

(2) CONSERVATION, CORAL, CORAL REEF, ETC.—The terms "conservation", "coral", "coral reef", "coral reef ecosystem", "covered reef manager", "covered State", "Federal reef manager", "National Coral Reef Resilience Strategy", "restoration", "resilience", and "State" have the meanings given those terms in section 216 of the Coral Reef Conservation Act of 2000, as added by this division.

Subtitle C—Department of the Interior Coral Reef Authorities

SEC. 10021. CORAL REEF CONSERVATION AND RESTORATION ASSISTANCE.

(a) IN GENERAL.—The Secretary of the Interior may provide scientific expertise and technical assistance, and

subject to the availability of appropriations, financial assistance for the conservation and restoration of coral reefs consistent with all applicable laws governing resource management in Federal, State, and Tribal waters, including—

(1) the National Coral Reef Resilience Strategy; and

(2) coral reef action plans in effect under section 205 of the Coral Reef Conservation Act of 2000, as added by this division, as applicable.

(b) CORAL REEF INITIATIVE.—The Secretary may establish a Coral Reef Initiative Program—

(1) to provide grant funding to support local management, conservation, and protection of coral reef ecosystems in—

(A) coastal areas of covered States; and

(B) Freely Associated States;

(2) to enhance resource availability of National Park Service and National Wildlife Refuge System management units to implement coral reef conservation and restoration activities;

(3) to complement the other conservation and assistance activities conducted under this Act or the Coral Reef Conservation Act of 2000, as amended by section 10001; and

(4) to provide other technical, scientific, and financial assistance and conduct conservation and restoration activities that advance the purposes of this title and the Coral Reef Conservation Act of 2000, as amended by this division.

(c) CONSULTATION WITH THE DEPARTMENT OF COMMERCE.—

(1) CORAL REEF CONSERVATION AND RESTORATION ACTIVITIES.—The Secretary of the Interior may consult with the Secretary of Commerce regarding the conduct of any activities to conserve and restore coral reefs and coral reef ecosystems in waters managed under the jurisdiction of the Federal agencies specified in paragraphs (2) and (3) of section 203(c) of the Coral Reef Conservation Act of 2000, as added by this division.

(2) AWARD OF CORAL REEF MANAGEMENT FELLOWSHIP.—The Secretary of the Interior shall consult with the Secretary of Commerce to award the Susan L. Williams Coral Reef Management Fellowship under subtitle D.

(d) COOPERATIVE AGREEMENTS.—Subject to the availability of appropriations, the Secretary of the Interior may enter into cooperative agreements with covered reef managers to fund coral reef conservation and restoration

activities in waters managed under the jurisdiction of such managers that—

(1) are consistent with the National Coral Reef Resilience Strategy; and

(2) support and enhance the success of coral reef action plans in effect under section 205 of the Coral Reef Conservation Act of 2000, as added by this division.

(e) DEFINITIONS.—In this section:

(1) CONSERVATION, CORAL, CORAL REEF, ETC.—The terms "conservation", "coral reef", "covered reef manager", "covered State", "National Coral Reef Resilience Strategy", "restoration", and "State" have the meanings given those terms in section 216 of the Coral Reef Conservation Act of 2000, as added by this division.

(2) TRIBE; TRIBAL.—The terms "Tribe" and "Tribal" refer to Indian Tribes (as defined in section 102 of the Federally Recognized Indian Tribe List Act of 1994 (25 U.S.C. 5130)).

Subtitle D—Susan L. Williams National Coral Reef Management Fellowship

SEC. 10031. SUSAN L. WILLIAMS NATIONAL CORAL REEF MANAGEMENT FELLOWSHIP.

(a) DEFINITIONS.—In this section:

(1) ALASKA NATIVE CORPORATION.—The term "Alaska Native Corporation" has the meaning given the term "Native Corporation" in section 3 of the Alaska Native Claims Settlement Act (43 U.S.C. 1602).

(2) FELLOW.—The term "fellow" means a National Coral Reef Management Fellow.

(3) FELLOWSHIP.—The term "fellowship" means the National Coral Reef Management Fellowship established in subsection (c).

(4) COVERED NATIVE ENTITY.—The term "covered Native entity" has the meaning given the term in section 216 of the Coral Reef Conservation Act of 2000, as added by this division.

(5) COVERED STATE.—The term "covered State" has the meaning given the term in section 216 of the Coral Reef Conservation Act of 2000, as added by this division.

(6) NATIVE ENTITY.—The term "Native entity" has the meaning given the term in section 216 of the Coral Reef Conservation Act of 2000, as added by this division.

(7) SECRETARY.—The term "Secretary" means the Secretary of Commerce.

(b) ESTABLISHMENT OF FELLOWSHIP PROGRAM.—

(1) IN GENERAL.—There is established a National Coral Reef Management Fellowship Program.

(2) PURPOSES.—The purposes of the fellowship are—

(A) to encourage future leaders of the United States to develop additional coral reef management capacity in States and local communities with coral reefs;

(B) to provide management agencies of covered States and covered Native entities with highly qualified candidates whose education and work experience meet the specific needs of each covered State or covered Native entity; and

(C) to provide fellows with professional experience in management of coastal and coral reef resources.

(c) FELLOWSHIP AWARDS.—

(1) IN GENERAL.—The Secretary, in consultation with the Secretary of the Interior, shall award a fellowship in accordance with this subsection.

(2) TERM OF FELLOWSHIP.—A fellowship awarded under this subsection shall be for a term of not more than 2 years.

(3) QUALIFICATIONS.—The Secretary, in consultation with the Secretary of the Interior, shall award a fellowship to individuals who have demonstrated—

(A) an intent to pursue a career in marine services and outstanding potential for such a career;

(B) leadership potential, actual leadership experience, or both;

(C) possession of a college or graduate degree in biological science, a college or graduate degree in resource management with experience that correlates with aptitude and interest for marine management, or both;

(D) proficient writing and speaking skills; and

(E) such other attributes as the Secretary, in consultation with the Secretary of the Interior, considers appropriate.

(d) MATCHING REQUIREMENT.—

(1) IN GENERAL.—Except as provided in paragraph (2), the non-Federal share of the costs of a fellowship under this section shall be 25 percent of such costs.

(2) WAIVER OF MATCHING REQUIREMENT.—The Secretary may waive the application of paragraph (1) to a fellowship if the Secretary finds that such waiver is necessary to support a project that the Secretary has identified as a high priority.

TITLE CI—BOLSTERING LONG-TERM UNDERSTANDING AND EXPLORATION OF THE GREAT LAKES, OCEANS, BAYS, AND ESTUARIES

SEC. 10101. PURPOSE.

The purpose of this title is to promote and support—

(1) the monitoring, understanding, and exploration of the Great Lakes, oceans, bays, estuaries, and coasts; and

(2) the collection, analysis, synthesis, and sharing of data related to the Great Lakes, oceans, bays, estuaries, and coasts to facilitate scientific research and operational decisionmaking.

Coral Reef Restoration for Risk Reduction (CR4): A Guide to Project Design and Proposal Development

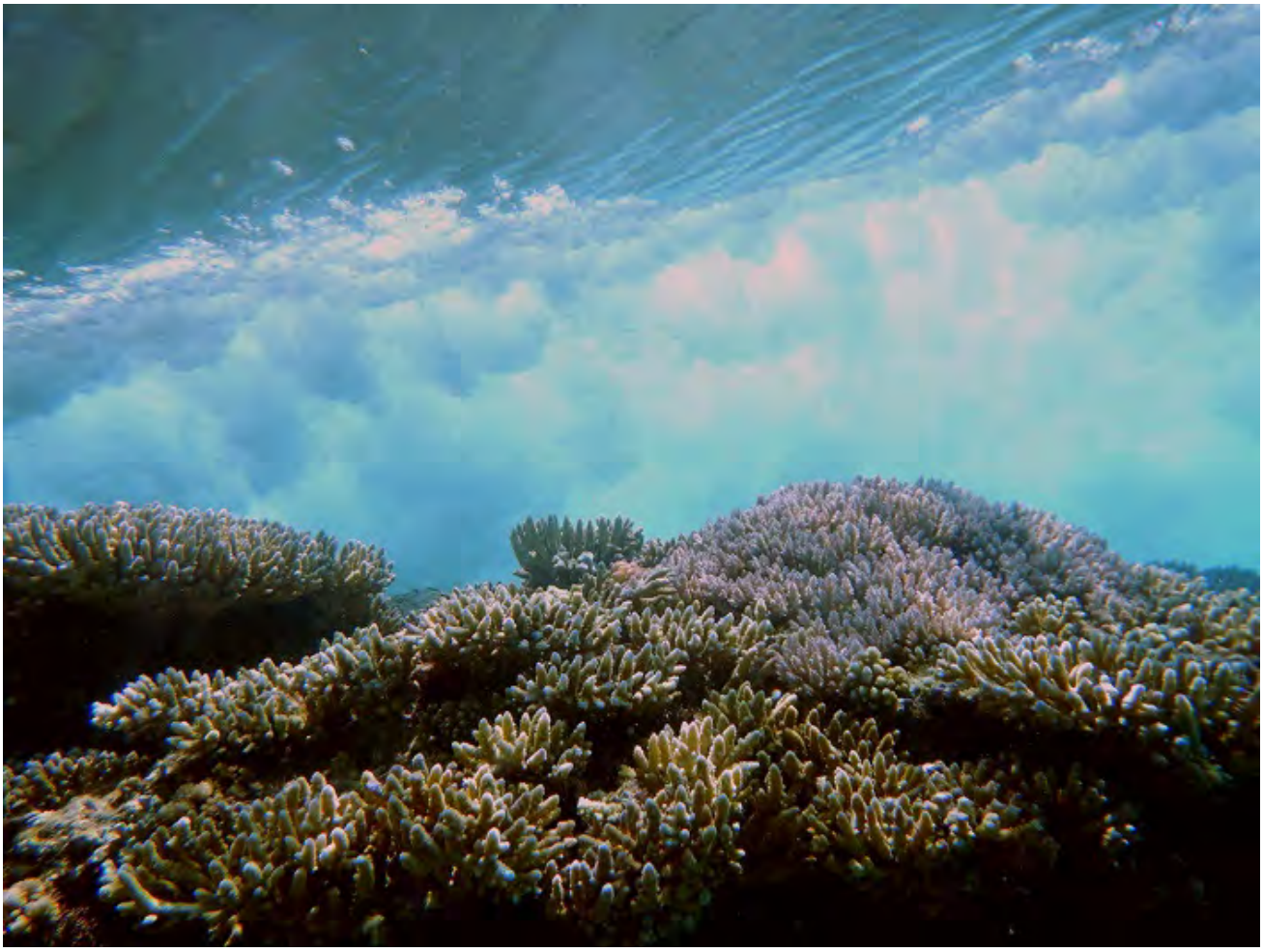

Photo credit: Curt Storlazzi, USGS.

Working Group

Austen E. Stovall, University of California Santa Cruz
Michael W. Beck, University of California Santa Cruz
Curt Storlazzi, U.S. Geological Survey
Juliette Hayes, US Army Corps of Engineers
Janan Reilly, Federal Emergency Management Agency
Jen Koss, National Oceanic and Atmospheric Administration
Doug Bausch, NiyamIT/FEMA Hazus

Acknowledgements

The authors would like to thank the many organizations and individuals, who generously contributed their time and expertise, including:

Brian Beck and Caroline Donovan, National Oceanic Atmospheric Administration
Michael Gill, Roberto Porro, Sara Upchurch, Tara Seibold, Sarah Watling, and Sean McNabb, Federal Emergency Management Agency
Joanna Walczak, Florida Department of Environmental Protection
Julia Leal, Stanford University
Tamaki Bieri and Alyssa Mann, The Nature Conservancy California
Kim Hum, The Nature Conservancy Hawai'i
Lisa Johnson, Department of the Interior Office of Insular Affairs
Ilsa Kuffner and Susan Cochran, United States Geological Survey
Hudson Slay, Environmental Protection Agency
Erin Derrington, CNMI Office of the Governor's Office of Planning and Development

We also acknowledge support from the AXA Research Fund (Michael W. Beck).

This report is the product of an inter-agency effort through the U.S. Coral Reef Task Force. Authors of this guide represent the following organizations and agencies:

Suggested Citation

Stovall AE, MW Beck, C Storlazzi, J Hayes, J Reilly, J Koss, D Bausch. 2022. Coral Reef Restoration for Risk Reduction (CR4): A Guide to Project Design and Proposal Development. [white paper]. University of California Santa Cruz. https://doi.org/10.5281/zenodo.7268962

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Introduction

The Federal Emergency Management Agency (FEMA), U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA), and University of California Santa Cruz (UCSC) are working through the U.S. Coral Reef Task Force to provide guidance on the development of coral reef restoration proposals for federal hazard mitigation funding.

What is coral reef restoration and what is coral reef restoration for risk reduction?

Typically, active coral restoration projects are designed to improve some ecological function of coral reef ecosystems through a variety of restoration methods (see Figure 1).

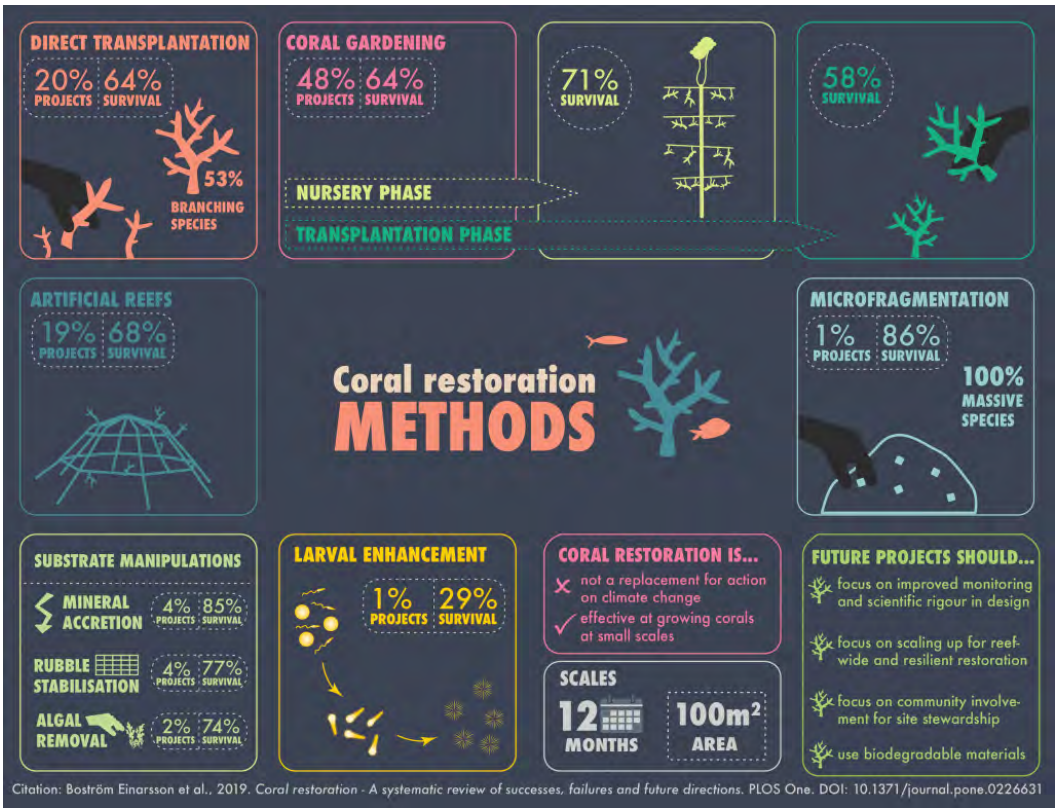

Figure 1. Coral restoration methods adapted from Bostrom-Einarsson et al. (2019).

Coral reef restoration for risk reduction (CR4) projects are designed to reduce flood or erosion risks by rehabilitating, recovering, and restoring reefs. This Guide focuses on projects for flood risk reduction. CR4 projects differ from solely ecological coral restoration projects, because CR4 projects aim to meet two different management objectives for environmental conservation and hazard mitigation. They often will require more specific placement and planning, detailed hydrodynamic analyses, and can require larger project scales to meet both objectives. CR4 is a relatively new approach and stakeholders including community leaders, natural resource managers, and government entities, may often not know when and where it can be used for flood risk reduction nor how to apply for hazard mitigation or recovery funding for CR4 projects.

How to Use this Guide

This Guide aims to provide potential project proponents from organizations to agencies an understanding of the key steps needed and critical information sources available to support CR4 proposals. This document guides potential applicants through the project conception, design, and implementation phases of a CR4 project. The Guide covers vital elements, including project scoping, identification of the project team, selection of site(s), benefit-cost analysis, identification of regulatory requirements, and potential funding opportunities.

Applications for federal assistance will usually need to be led and submitted by a local, state, territorial, or commonwealth agency. However, many stakeholders and project proponents can be involved in developing the project proposal and funding application. Further, the approaches outlined in this Guide can support many other nature-based projects and proposals beyond reef restoration for federal hazard mitigation funding.

PART I: BACKGROUND

Value of Coral Reefs

Coral reefs harbor significant biodiversity and provide a range of key ecosystem services (e.g., food provision, hazard mitigation, recreation) for people. Coral reefs are among the world's most diverse and biologically complex ecosystems. Despite covering less than 0.5% of the world's seafloor, coral reefs are home to more than 25% of known marine species. Coral reefs provide the primary subsistence source of protein for many island nations through fisheries and provide nursery habitat for many commercial species. They are also a major source of recreation and often a primary source of income through tourism. The total value of the world's coral reefs for tourism is estimated at $36 billion (Spalding et al. 2017). In the U.S., coral reef-related tourism (direct reef use) is valued at $550.8 million per year, with reef-adjacent tourism (reef existence driving visitors to certain locations) valued at $680.1 million per year (Spalding et al. 2017). In total, the tourism value of coral reefs in the U.S. is estimated to be about $1.2 billion per year (Spalding et al. 2017). When accounting for tourism, fisheries, and coastal protection, the total economic value of coral reefs in the U.S. is estimated at $3.4 billion (Brander and van Beukering 2013).

Figure 2. Healthy coral reef at Tumon Bay, Guam. Photo credit: Curt Storlazzi, USGS.

Figure 3. Healthy Elkhorn coral (Acropora palmata) near Buck Island, U.S. Virgin Islands. Photo credit: Curt Storlazzi, USGS.

Nature-based Solutions for Natural Hazard Mitigation

The Federal Emergency Management Agency (FEMA) identifies that "nature-based solutions (NBS) are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience." The U.S. Army Corps of Engineers (USACE) has focused on a subset of NBS called Natural and Nature-Based Features (NNBF) which are landscape features that are used to provide engineering functions relevant to flood risk management while producing additional economic, environmental, and/or social benefits (Bridges et al. 2021).

Figure 4. Examples of nature-based solutions. Credit: World Bank.

NBS are increasingly recognized as viable solutions for hazard mitigation of flooding and erosion (IUCN 2020). Recent work quantifies these NBS benefits socially and economically to support their use in meeting goals for hazard mitigation, risk reduction, and adaptation projects (Storlazzi et al. 2021; Reguero et al. 2021). NBS have many characteristics that can make them preferred alternatives over solely gray infrastructure for both communities and managers, including cost, appearance, and adaptability (FEMA 2020). Overall, implementing NBS can reduce the costs of future hazards and increase community resilience in the face of increasing climate impacts.

Coral Reefs as Nature-based Solutions

Coral reefs offer coastal protection services by reducing flooding and erosion through wave breaking and friction. On average, coral reefs dissipate 97% of wave energy before it reaches coastlines (Ferrario et al. 2014). Individual coral colonies induce drag on waves, further reducing wave energy and flooding reaching the shoreline (Quataert et al. 2015). Coral colonies grow together and alongside each other to form a reef, resulting in an even more significant reduction in wave energy and thus, a greater reduction in onshore flooding. The value of U.S. coral reefs for flood protection has been quantitatively assessed at greater than $1.8 billion annually for the direct benefits of avoided flood damages to property (Storlazzi et al. 2019; Reguero et al. 2021). The value of the coastal protection services provided by reefs can be retained or enhanced through active coral restoration, or CR4 (an NBS which seeks to meet conservation and hazard mitigation management goals). Potential reef restoration across Florida and Puerto Rico has been valued at $232 million and $40 million, respectively, in terms of the annual value for flood risk reduction (Storlazzi et al. 2021). The present value (PV) of potential large-scale reef restoration across Florida and Puerto Rico exceeds $3.75 billion; when reef restoration is considered an infrastructure project with a 50-year project lifetime at a 7% discount rate, the guidelines suggested by FEMA for hazard mitigation projects.

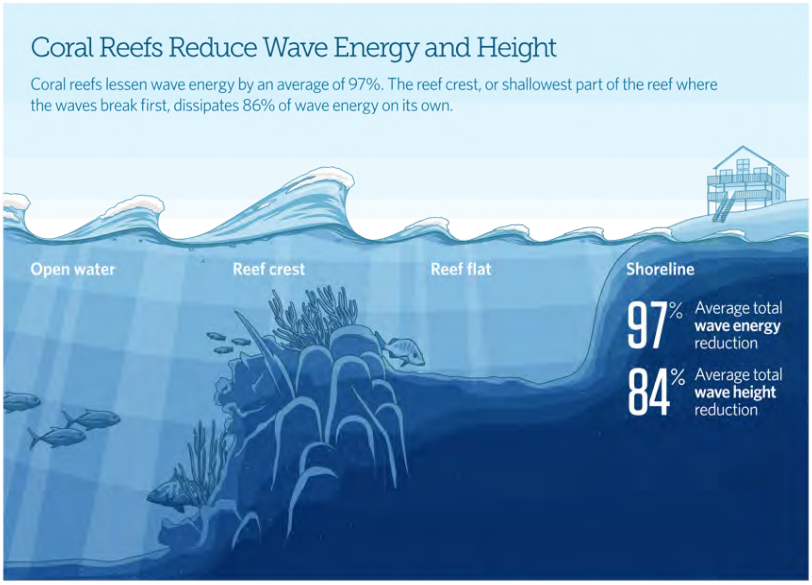

Figure 5. Coral reefs reduce wave energy by 97% on average. (Ferrario et al. 2014).

Current State of Coral Restoration

There are a rapidly growing number of coral reef restoration projects nationally and globally. Most of these efforts have focused on preserving reefs by reducing stressors (such as invasive

algae); growing juvenile corals in nurseries and planting them on reefs; or providing fish habitat. A smaller set of projects have used structural restoration of reefs, for example, to mitigate damage from ship groundings on reef crests (e.g., NOAA's Damage Assessment, Remediation, and Restoration Program). A small but growing number of projects have focused directly on reef restoration for coastal hazard risk reduction, or CR4 (Ferrario et al. 2014; Reguero et al. 2018). Habitat restoration projects designed to meet hazard mitigation objectives often use hybrid techniques that combine structural restoration using a gray infrastructure component (e.g., concrete) with a green infrastructure component (e.g., nursery-grown corals). Hybrid projects aim to meet conservation and hazard mitigation goals through the combination of gray and green infrastructure.

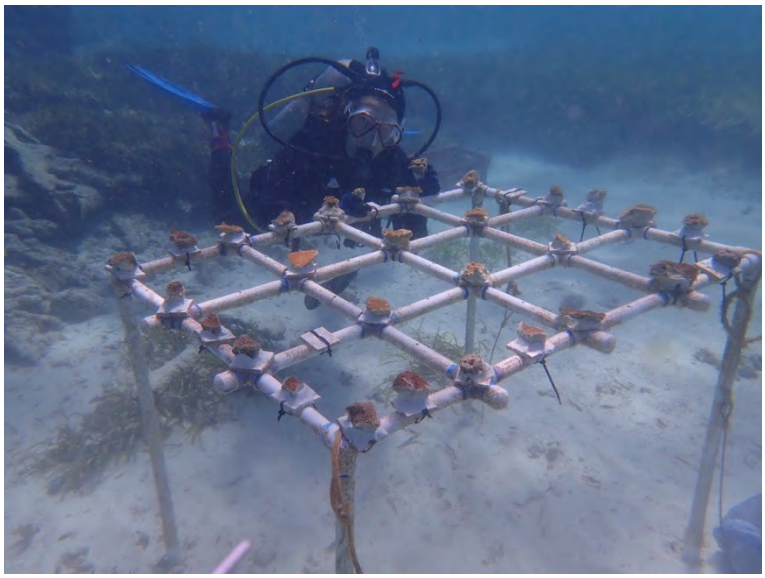

Figure 6. An in-situ table coral nursery structure with Elkhorn coral (A. palmata) fragments in the U.S. Virgin Islands. Photo credit: Austen Stovall.

Recent reviews of coral restoration project goals, objectives, and techniques highlight the somewhat limited focus of most restoration efforts (Bayraktarov et al. 2019; Bostrom-Einarsson et al. 2020). Most projects reviewed were of small scale (<100 m^2), with a short timeframe of implementation and monitoring (<18 months), focused mainly on fast-growing branching coral species, and utilized in-situ coral gardening methods (Bostrom-Einarsson et al. 2020). Techniques on the rise include ex-situ (land-based) nursery operations, microfragmentation, larval propagation, substrate stabilization, and the implementation of green-gray hybrid structures (Bostrom-Einarsson et al. 2020). The restoration techniques used in a specific project are usually based on a set of preselected, overarching goals or objectives for the restoration project but vary in scale and efficacy with the availability of resources and local capacity (Kaufman et al. 2021). Common goals or objectives include mitigating population decline and preserving biodiversity; recovering and sustaining fisheries production; re-establishing reef ecosystem structure and function; or responding to acute disturbances (Hein et al. 2021). There is a noticeable gap in restoration projects designed for the primary goal of reducing coastal hazard risks.

Coral restoration operations in the U.S. jurisdictions with coral reef resources are led by local or national non-profit conservation organizations, state or territorial coral programs, local universities or academic organizations, or citizen-led initiatives, often through partnerships among these organizations. The diversity of partnerships within coral restoration operations strengthens the likelihood of developing integrative CR4 projects. Each U.S. coral jurisdiction has a dedicated coral program within its relevant local government agency to lead decision-making, access funding, and ensure alignment with NOAA's Coral Reef Conservation Program

(CRCP). NOAA CRCP supports U.S. coral jurisdictions technically and financially and leads the development of federal guidance on coral conservation priorities. In recent years, restoration has been added as a pillar to the coral reef management priorities at the federal level in the U.S. Thus, the funding for and facilitation of coral restoration operations throughout the coral jurisdictions is growing. Many states and territories have expressed interest in using reef restoration as a strategy for enhancing coastal resilience.

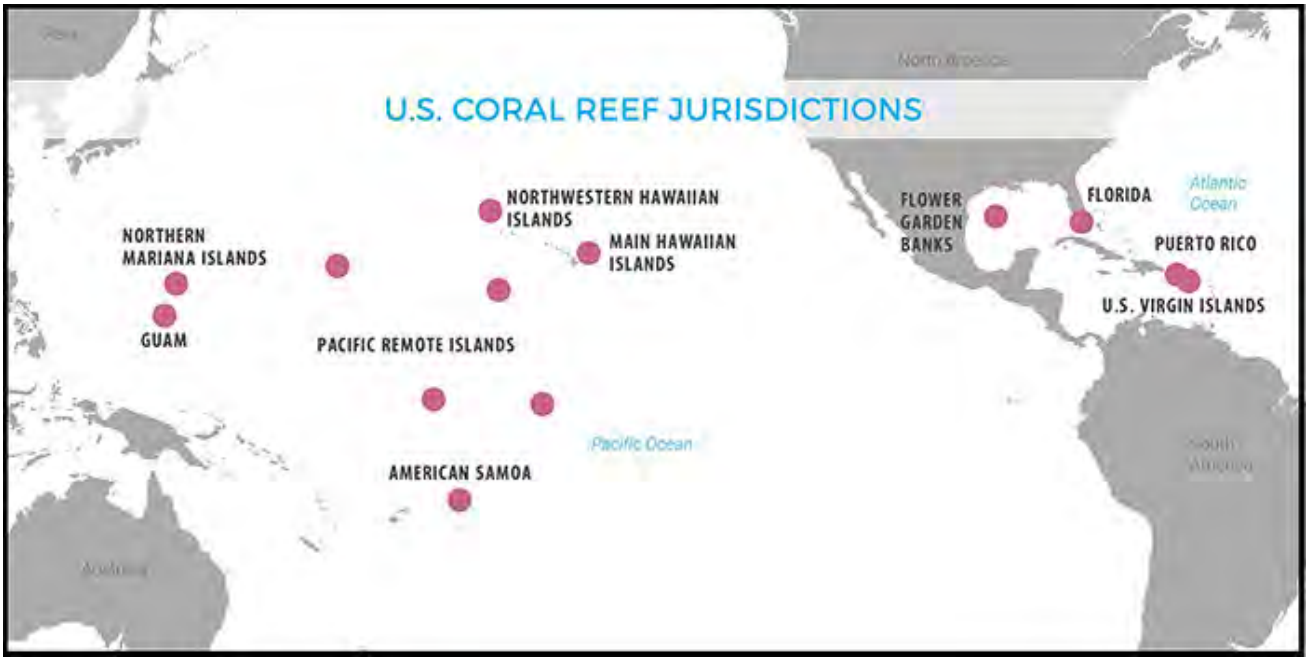

Figure 7. U.S. jurisdictions with coral reef resources. Credit: NOAA.

Coral Reefs and Climate Change

A great deal of concern has been raised about whether coral reefs, both natural and restored, can survive in the face of climate change. There are a few key points for consideration. While coral reefs have faced growing threats, there is evidence that areas of relatively high-functioning reef still exist around the world (Guest et al. 2018; Elahi et al. 2022). Despite the intense vulnerability of coral reefs to climate change, restoration is now one of the three accepted pillars necessary for the persistence of coral reef ecosystems: reduce global climate threats, improve local conditions, and invest in active restoration (Knowlton et al. 2021).

There is evidence that reefs can recover from large-scale stressors, such as bleaching from past El Niño events, and can be managed for recovery by reducing local stressors such as pollution, sedimentation, and destructive fishing (Pandolfi et al. 2011; Palumbi et al. 2014). A growing number of studies also show successful examples of coral reef restoration (Young et al. 2012; Bostrom-Einarsson et al. 2019). Further, select coral species have been observed to thrive in extreme conditions such as high elevated temperatures (Claar et al. 2020; Dandan et al. 2015) and low pH waters (Shamberger et al. 2014), suggesting that some coral populations still contain significant capacity to adapt to changing ocean conditions when adequately managed (Lowe et al., 2021). However, the rate of climate change is unprecedented, so increasingly innovative and significant interventions will be required for coral reef survival in the face of runaway climate change (NASEM 2019; Kleypas et al. 2021).

Figure 8. A coral reef in the Dominican Republic. Photo credit: Philip Hamilton, Ocean Image Bank.

A common concern expressed about restoration is that it should not be attempted until all the issues that caused coral mortality (e.g., global climate change, invasive species, sedimentation) are addressed. However, experience shows that flagship restoration sites can create the community drive and political will to address problems, especially at the local scale, which will provide other side benefits (e.g., cleaner beaches, better-managed watersheds) that would not be resolved otherwise. While it is preferable to reduce (or find sites with reduced) stressors ahead of time, in many cases, the restoration project can provide the impetus for communities to address these issues. For example, in Kāne'ohe Bay, HI, the removal of invasive algae preceded active coral restoration interventions at this site (Bahr et al. 2015). In general, adaptive management is critical to the success of coral restoration projects.

Figure 9. An aerial view of a reef in Kane'ohe Bay, Hawai'i. Photo credit: Toby Matthews, Ocean Image Bank.

Funding Mechanisms for Coral Reef Restoration for Risk Reduction

Current funding for active ecological coral restoration in the U.S. is divided among a handful of state, federal, and philanthropic sources, with an average amount of funding at $2.4 million (Hein & Staub 2021). Most funds are granted to government agencies and non-governmental organizations (NGOs) for local-scale ecological coral restoration involving direct outplant methodologies. Funding is typically tied to measurements of outplanting effort (e.g., number of outplants or hectares restored) rather than specific long-term goals of restoration success (e.g., flood risk reduction goals, socioeconomic goals) (Hein & Staub 2021). Additionally, the average, relatively short timeline of available funding (3.3 years) does not allow for adequate measures of long-term restoration success nor the implementation of adaptive management and long-term monitoring of projects (Hein & Staub 2021).

There are a small but growing number of CR4 projects, mainly internationally (e.g., Reguero et al. 2018; Zepeda-Centeno et al. 2018). To date, no CR4 projects have been funded through any U.S. federal funding opportunity, though some are currently under consideration. There is the potential to apply for large-scale CR4 projects through the relevant hazard mitigation funding opportunities described below.

Figure 10. Mars coral restoration project involving the use of rebar dome structures and out-planted corals. Photo credit: Mars Coral Reef Restoration, www.buildingcoral.com.

Federal Emergency Management Agency

Currently, the majority of grant funding in the U.S. for both pre-and post-disaster mitigation comes from FEMA. Mitigation actions differ from many disaster preparedness, response, and recovery activities, in that they are inherently preemptive and have a long-term goal of reducing hazard risk. As disaster spending increases year after year, FEMA is investing more resources in natural hazards mitigation to save taxpayer dollars and build more resilience to current and future

disasters. In 2020, FEMA recognized the value of using NBS and considering ecosystem services in mitigation projects by eliminating the former benefit-cost ratio (BCR) requirement of 0.75, allowing for the consideration of ecosystem service benefits for eligible projects regardless of BCR value. This update allows for the easier inclusion of NBS into risk-based mitigation projects (see Ecosystem Service Benefits in Benefit-Cost Analysis for FEMA's Mitigation Programs Policy).

FEMA Hazard Mitigation Assistance (HMA)

FEMA administers several hazard mitigation grant programs, collectively referred to as Hazard Mitigation Assistance (HMA). HMA includes the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance (FMA) Grant Program, and the Building Resilient Infrastructure and Communities (BRIC) Program (Figure 11). Eligible HMA applicants include states, federally recognized tribes, and territories, and the District of Columbia. Individuals cannot apply for HMA funding, but some NGOs may apply for HMGP funding. Applicants and sub-applicants to all programs must have a FEMA-approved hazard mitigation plan. Projects funded under HMA grants must align with the objectives and goals of the relevant hazard mitigation plan. Eligible mitigation activities differ for the various HMA programs. It is important to note that there is a cost-share responsibility for all HMA grants ranging from 75:25 to 90:10 federal:non-federal cost-share. In some cases, like under BRIC, Economically Disadvantaged Rural Communities (EDRCs) are eligible for reduced cost-share responsibility.

Hazard Mitigation Grant Program (HMGP)

HMGP funding is triggered by a major disaster declaration from the President under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), available on a sliding scale as a percentage of the estimated amount of total federal assistance for the disaster: up to 15% of the first $2 billion, up to 10% for amounts between $2 billion and $10 billion, and up to 7.5% for amounts between $10 billion and $35 billion. HMGP funding is available for all types of hazard mitigation across the state, tribe, or territory in which the disaster is declared. HMGP funds are administered by the affected state, tribe, or territory, so local communities interested in obtaining funding must work directly with the state or territory.

Building Resilient Infrastructure and Communities (BRIC) Program

BRIC funding is a nationally competitive program with funding available annually as a set aside of the estimated amount of total federal assistance for disasters (similar to HMGP). BRIC funding is available for all types of hazard mitigation, with specific program priorities outlined each year. FEMA will decide on the annual available funding each year; more information is available in the Notice of Funding Opportunity (NOFO).

Flood Mitigation Assistance (FMA) Grant Program

FMA funding is available annually via congressional appropriation through a national competition. Funding is limited to flood-related mitigation that reduces the risk of properties that repetitively flood and lessens future insurance claims for the National Flood Insurance Program (NFIP); more information is available in the NOFO.

FEMA Public Assistance (PA)

Additional hazard mitigation funding is also available as part of FEMA's largest grant program, Public Assistance (PA). PA provides funding to states, tribes, and territories when authorized as part of a presidential disaster declaration under the Stafford Act. PA provides funding for long-term recovery assistance to state, local, tribal, and territorial governments. As part of the long-term recovery assistance, PA authorizes permanent work, which includes efforts to repair, reconstruct or replace disaster-damaged public and eligible nonprofit facilities. These facilities include roads and bridges, water control facilities, buildings and equipment, utilities, parks, recreational facilities, and other public facilities.

During this recovery process, funding for mitigation is also available, known as PA 406 Mitigation (after Section 406 of the Stafford Act). Unlike the HMA grants, PA 406 mitigation funding is not competitive and does not have a funding cap. Funding is based on the eligible disaster damage to the facility and the cost-effectiveness of the proposed project. Like HMA grants, PA 406 mitigation typically has a 75% federal cost-share, but the President has the authority to increase the cost-share for any PA-declared disaster. Some common mitigation measures include floodproofing, replacing or upgrading existing materials with stronger or more resilient materials, elevating facilities or important equipment, adding protective materials like riprap or green infrastructure for erosion control, or replacing structures like culverts or pipes with multiple or larger structures. The proposed mitigation action for a PA project will depend on the public facility being protected.

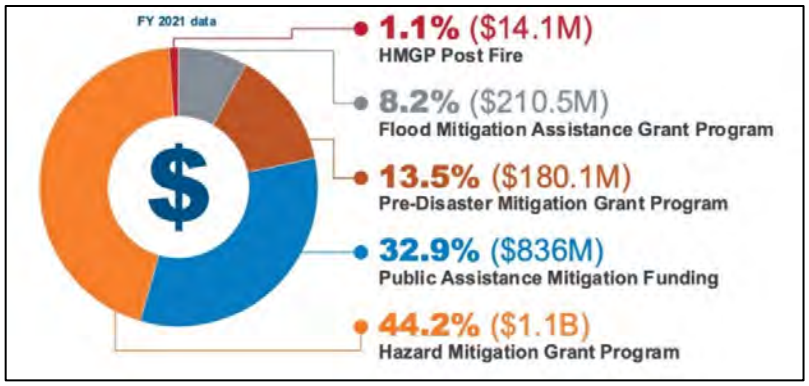

Figure 11. In FY2021 more than $2.34B in Hazard Mitigation Assistance Grants and Public Assistance Mitigation funds were delivered to states, local communities, tribes, and territories resulting in mitigation actions that will reduce risk. Note: Missing on this graph is the Building Resilience Infrastructure and Communities (BRIC) Program which was funded at $1B for FY2021.

United States Army Corps of Engineers

The United States Army Corps of Engineers (USACE) does not offer any federal grant programs for flood risk management projects. However, for larger flood risk reduction projects, the USACE can seek congressional authorization to evaluate flood risk and recommend specific flood mitigation project activities. For smaller projects, non-federal sponsors may request support from the USACE to evaluate potential flood risk reduction activities that might fit the Corps Continuing Authorities (CCA) program without congressional authorization. Since these potential funding avenues are not akin to a federal grant program, the process to include and propose a project is significantly different from most other grant application processes. However,

project components and considerations should align with the sections elucidated in this guide. Each of the 39 Corps Districts manages the CCA program to investigate and select relevant flood mitigation projects.

USACE Engineering with Nature

The USACE's Engineering with Nature (EWN) Program focuses on developing sustainable solutions for flood reduction using nature by considering social, environmental, and economic benefits. The EWN Program has technically and/or financially supported many NNBF and NBS projects over the past decade. Many NNBF projects have been highlighted in two Volumes of the EWN Atlases (Bridges et al. 2018, 2021), but at present, these have not included any CR4 projects. However, in 2022-2024 EWN will be supporting the assessment of CR4 projects developed as part of the Department of Defense DARPA Reefense program.

USACE Corps Continuing Authorities Program

Without specific authorization from congress, CCA allows the USACE to plan, design, and construct smaller flood risk management projects that align with Federal interests as described in Sections 14, 205, and 208 of the Flood Control Act of 1946, 1948, and 1954, respectively.

Other Hazard Mitigation Funds

National Fish and Wildlife Foundation & National Oceanic Atmospheric Administration National Coastal Resilience Fund

The National Coastal Resilience Fund (NCRF) supports the planning, implementation, and design of NNBF and NBS to help protect coastal communities from the impact of natural hazards and to increase resilience and ecosystem condition. The National Fish and Wildlife Foundation (NFWF) will invest in grants for projects in four priority areas: Community Capacity Building and Planning; Site Assessment and Preliminary Design; Final Design and Permitting; and Restoration and Monitoring.

National Fish and Wildlife Foundation America the Beautiful Challenge

The America the Beautiful Challenge (ATBC) is a grant program aimed at funding conservation and restoration projects across several focal areas, including improving ecosystem and community resilience to coastal flooding, drought, and other climate-related threats. ATBC funding is consolidated from several federal agencies and the private sector to support large-scale projects that meet shared conservation, resilience, and NBS priorities.

Department of the Interior Office of Insular Affairs Coral Reef and Natural Resources Initiative

The Coral Reef and Natural Resources (CRNR) Initiative provides grant funding for the management and protection of coral reefs and to combat invasive species in the U.S. insular areas. This includes the U.S. Territories of the U.S. Virgin Islands, Guam, American Samoa, Commonwealth of the Northern Mariana Islands, and Freely Associated States: Republic of Palau, Republic of the Marshall Islands, and the Federated States of Micronesia. The CRNR Initiative aims to improve the health of coral reef ecosystems and other natural resources in the U.S. insular areas for their long-term economic and social benefit. Priority is given to projects

that help the insular areas address a variety of threats to coral reef ecosystems and for prevention, control, and eradication of aquatic and terrestrial plant, insect, and animal invasive species. Grants can be provided to insular area local governments and non-profit organizations whose projects benefit the insular areas. Annual grant funding from this program is approximately $2.5 million. Examples of coral-related projects include, but are not limited to: decreasing land-based pollution that impacts coral reefs; mapping of coral reefs; coral restoration from Stony Coral Tissue Loss Disease; funding of specialized strike teams to identify, treat and remove evidence of disease; watershed management plans, restoration/monitoring in watershed areas; revegetation of deforested and eroded inland areas to decrease threat of erosion and sedimentation buildup on coral reef and inshore ecosystems; cleanup projects to protect the marine environment from sedimentation and runoff; and other outreach and education projects to protect coral reefs.

Reef Insurance

Some recent work has focused on the use of insurance to protect and restore coral reef ecosystems damaged by storms. This new funding pathway requires detailed scoping, intensive partnerships, and specific pre-existing conditions to be implemented (Secaira et al. 2019).

PART II: CR4 PROJECT ELEMENTS

Investigating, developing, and applying for funding for a CR4 project involves several distinct elements, steps, and methodologies. Below, we highlight the key considerations and provide step-by-step guidance for CR4 project realization.

Step 1. Pre-project Planning, Building Your Team, and Capacity Evaluation

Pre-project Planning

Before designing and measuring the costs and benefits of a CR4 project, it is essential to consider several baseline activities that will inform the application process. The following sections provide guidance on pre-project planning steps that will define a project's eligibility and streamline project development.

Meet with a Reef Resource Manager (if not already on your team)

The state or territorial agency responsible for managing coral reef ecosystems will differ for each jurisdiction but often reside within a coastal management and/or natural resource management agency. Consulting the relevant resource management entity should be one of the first steps in developing a CR4 project. Local resource managers will be able to provide critical information regarding permitting, extenuating reef ecosystem stressors, current and planned projects, relevant partners, and priority areas appropriate for a potential CR4 project. Further, contacting federal natural resource managers, such as NOAA, Environmental Protection Agency (EPA), or Department of the Interior (DOI), can help inform the application requirements and project timeline.

Application Timeline and Automatic Determinations of Ineligibility

State and federal application deadlines

State and federal application deadlines will vary based on the specific funding organization and program. For example, for the FEMA BRIC program, the application deadline for applicants (states, tribes, and territories) is set in the NOFOs each year. However, typically the application period opens in September and closes at the end of January. However, the application deadline for project submissions for sub-applicants (local/regional communities) will vary in each state, tribe, and territory. Those interested in submitting projects for BRIC funding should reach out to the State Hazard Mitigation Officer (SHMO) to identify localized deadlines and priorities.

FEMA HMA Project Ineligibilities

FEMA HMA mitigation grants have some specific ineligibility issues to consider when developing a potential coral reef restoration project. These ineligible project activities include:

- Projects that do not reduce the risk to people, structures, or infrastructure;
- Activities on federal lands or associated with facilities owned by another federal entity;
- Projects related to beach nourishment or re-nourishment;
- Projects that address, without an increase in the level of protection, the operation, deferred or future maintenance, rehabilitation, restoration, or replacement of existing structures, facilities, or infrastructure (e.g., dredging, debris removal, replacement of obsolete utility systems, or

bridges, maintenance/rehabilitation of facilities, including dams and other flood control structures).

For more information on project eligibility/ineligibility, please refer to the current FEMA Hazard Mitigation Assistance Guidance.

Permitting

Acquiring the necessary permits for a CR4 project could be the most challenging aspect of project development. Getting a project 'shovel-ready' for implementation requires at least 18-24 months and potentially longer depending on permitting processes in the particular jurisdiction. Additionally, the monitoring requirements outlined in certain permits should be carefully considered in terms of the additional cost or time needed to implement a project successfully. It may be appropriate to consider a phased project approach if consultation work will be necessary to evaluate the impact on critical habitats or species, for example. A phased project application typically assumes that the sub-applicant knows the project and proposed solution(s) but needs extra time and guidance for permit consultations. A project application with the necessary permits obtained or in process will be more highly considered by FEMA (FEMA 2015).

Building Your Team

Multiagency collaboration will be essential throughout the CR4 project planning process. Establishing relationships with actors across permitting, natural resource, and hazard management agencies and securing buy-in from the local community affected by the proposed CR4 project will streamline the project development and application process. Below, we elaborate on the non-exhaustive list of key players to consider and contact early in the project planning process.

Determine Resource Stakeholders and Champions

Adjacent communities and businesses are often the first to observe coral reef declines and threats. Thus, the ideation of a CR4 project may often originate from a community champion who has felt or seen significant loss from natural hazard impacts. Seeing the local reef ecosystem actively decline and feeling heavier impacts from coastal hazards can serve as the nexus of CR4 project development.

As an emerging strategy for coastal risk reduction, the current limitations and future benefits of CR4 projects are not yet widely understood. Although CR4 projects have the potential to provide substantial risk reduction benefits to an array of beneficiaries, project proponents and champions should have a clear understanding of the overarching goals and objectives of a proposed project, as well as where and when a CR4 project is appropriate.

Identify Lead Applicant

Figure 12. Shallow reef system in Turner Hole, St. Croix, USVI. Photo credit: Austen Stovall.

The lead applicant, or the organization responsible for submitting the project proposal, will differ depending on the source of funding. For FEMA HMA grants, the eligible applicant is the state, federally recognized tribe, or territory (typically the emergency management agency). For FEMA BRIC funding, the eligible applicant will submit one grant application consisting of an unlimited number of sub-applications from throughout the state, territory, or tribe. Eligible sub-applicants for BRIC are local governments (including cities, towns, counties, special district governments, or other state agencies) who must have a FEMA-approved hazard mitigation plan by the application deadline and at the time of grant funding obligation. While individuals and nonprofit organizations cannot be sub-applicants under BRIC, local governments can apply for funding on their behalf. Under FEMA's HMGP, nonprofits can apply as sub-applicants for mitigation funding. Regardless, alignment with local hazard mitigation priorities and resource management plans is beneficial. Thus, in most cases, partnerships are essential. While project proponents or champions can include NGOs, homeowners, and business operators, the lead applicant or sub-applicant requirements may differ for each funding application. Before the project proposal is developed, establishing relationships with all relevant key partners is essential to enhance the likelihood of application submission success.

Contact Key Local Partners

Local Coral Resource Manager: Partnership with a local resource manager will allow project proponents to utilize existing grant development and management resources, access expert knowledge of coral reef resources and understand the permits required to implement a restoration project. The local agency within which the resource manager resides will differ for each jurisdiction, but guidance for the seven U.S. states and territories with coral reef resources is below.

U.S. Coral Jurisdiction	Coral Resource Management Department
American Samoa	Department of Marine and Wildlife Resources
Commonwealth of the Northern Mariana Islands	Bureau of Environmental and Coastal Quality
Florida	Department of Environmental Protection
Guam	Bureau of Statistics and Plans
Hawai'i	Department of Aquatic Resources
Puerto Rico	Department of Land and Natural Resources

U.S. Virgin Islands	Department of Planning and Natural Resources

Local Emergency and Hazard Managers: For federal hazard mitigation funding opportunities, contact with the SHMO and/or local emergency management agency has the potential to strengthen a CR4 application. This partnership will allow the applicant to understand if and how CR4 projects fit into jurisdictional hazard mitigation priorities.

U.S. Coral Jurisdiction	**Local Emergency Management Agency**
American Samoa	American Samoa Territorial Emergency Management Coordination
Commonwealth of the Northern Mariana Islands	CNMI Homeland Security and Emergency Management
Florida	Division of Emergency Management
Guam	Guam Homeland Security Office of Civil Defense
Hawai'i	Hawai'i Emergency Management Agency
Puerto Rico	Puerto Rico Emergency Management Agency
U.S. Virgin Islands	Virgin Islands Territorial Emergency Management Agency

Local Coral Restoration Operator(s): Project proponents should also have established relationships with local coral restoration operators. Coral restoration operations can be led by NGOs, academic institutions, businesses and resource management agencies. Understanding the local coral restoration priorities and production capacity will influence the engineering design and lifespan of a CR4 project.

Federal, State and Local Permitting Entities: Permitting can often be a critical barrier to the development and implementation of CR4 projects. Obtaining the proper permits early in the project planning timeline helps improve project standardization and minimize impacts to sensitive resources. Establishing communication with the relevant permitting agencies is essential prior to project development and throughout the process. Local permit requirements will differ for each jurisdiction, but federal permit requirements may be triggered by legislation such as the Endangered Species Act, National Environmental Protection Act, or Coastal Zone Management Act and managed by agencies such as EPA or USACE.

Impacted Local Businesses: Local businesses impacted by flooding can potentially be critical stakeholders in the development of a CR4 project. The co-benefits of a CR4 project could be significant for these businesses, so their involvement, support, and even active contribution can increase the likelihood of project success.

Stakeholders & Community Buy-in

Figure 13. Reef Restoration and Tourism: Explaining Reef Restoration Activities with Public Divers near Bali, Indonesia. Photo credit: MW Beck.

The inclusion of and support from local stakeholders, community members, indigenous peoples, and traditional owners is critical to successfully implementing any reef restoration project, but even more so for CR4 projects. Stakeholders provide local hazard knowledge, key site selection considerations, and input on potential barriers to success or areas of opportunity. Public participation and input during project design may be required to comply with certain environmental and historic preservation laws. The involvement of communities with environmental justice concerns during project development can help identify where those communities may be experiencing disproportionate impacts from natural hazards or a proposed project and support the development of equitable solutions. In many cases, community involvement can bolster a potential project's success through direct participation in project implementation (e.g., job creation) or instilling community pride and protection of a CR4 project. Overall, the beneficial outcomes of a CR4 project will be felt by impacted stakeholders, so their involvement from the beginning is key to gaining support for a successful project proposal.

Capacity Evaluation

The development of a CR4 project, from design to application to implementation to monitoring, could necessitate the involvement of a third-party contractor to complete all or part of the project requirements. A thorough evaluation of local capacity for reef restoration, elements of CR4 project design, large-scale project implementation and monitoring, and application development, management, and dissemination is necessary to determine if guidance is needed for any or all parts of a CR4 project. For example, environmental engineers could give input on structural design and installation for a hybrid approach, or environmental economic consultants could help ease the heavy lifting required for the completion of a rigorous benefit-cost analysis (BCA).

Coral Restoration Operations

It is important to assess local coral restoration capacity to determine the ability of local restoration practitioners to fulfill the requirements of a proposed CR4 project. Limitations of coral growth rates, coral species available that will thrive in the selected location, and restoration methodologies will impact the design and scale of a CR4 project. Additionally, project proponents should evaluate the coral stock needed to implement a CR4 project, which could potentially extend the realistic timeframe for implementing a CR4 project depending on the current production capacity of restoration operations. While regions with well-established coral restoration operations could likely design, apply for, and implement a CR4 project sooner, regions with rapidly developing coral restoration operations can prioritize CR4 project goals as

they design and develop local operations. For example, jurisdictions with less-established coral restoration operations could keep CR4 projects in mind when developing scalable restoration methodologies that are able to produce robust coral stock for restoration projects.

Grant Development and Management Capacity

Project proposal development is a challenge, especially for FEMA and USACE applications, as these processes are very demanding in terms of time, detail, and effort. Project proponents must determine whether internal capacity is sufficient to design and lead a project, compile and submit an application, and communicate with essential partners. Project proponents should consider bringing on an external independent contractor for projects that exceed internal grant application management capacity. Existing partnerships may be able to financially or technically support the development and completion of key application components. For example, FEMA Region IX has established a cooperative technical partnership with The Nature Conservancy and Earth Economics/Radbridge Inc. to support the BCA components of Region IX HMA applications.

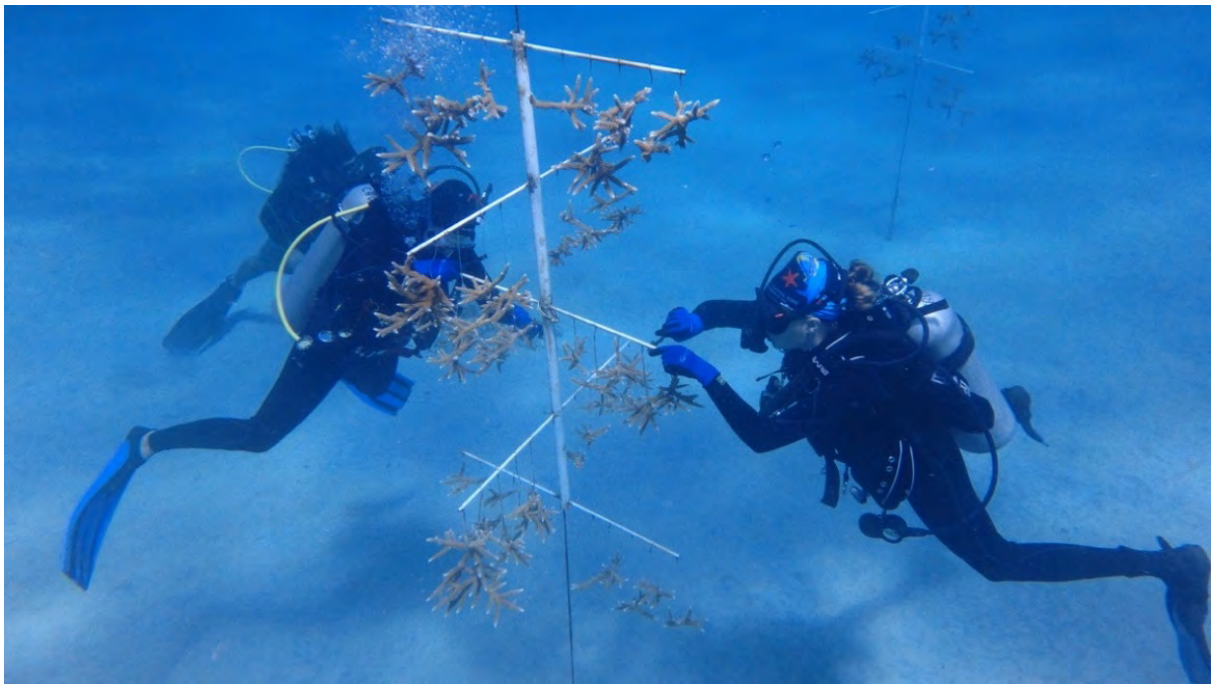

Figure 14. In-situ coral restoration nursery operation in the US Virgin Islands. Photo credit: Austen Stovall.

Step 2. Picking Your Site

For most projects, a critical step is initial site selection, which includes identifying where reef restoration is likely to yield significant risk reduction benefits relative to project costs and where stakeholders will have sufficient will and expertise to complete proposals and project development. It is essential to recognize that reef restoration designed for risk reduction will not be appropriate for every site where reef restoration may be desired. For projects designed to reduce flood risk, flooding and flood impacts must be focal components in measuring benefits and costs. Even though restored reefs can also have a significant impact on erosion reduction, these cannot be the primary benefit assessed for a flood risk reduction project.

Figure 15. An aerial view of Great Pond Bay on St. Croix in the USVI. Photo credit: Austen Stovall.

To be eligible for federal hazard mitigation or recovery funding, project proponents must assess *where reef restoration will likely have sufficient benefits for flood risk reduction to justify costs*. Hazard managers and agencies will ultimately assess the capacity of a project to reduce risk to property and people first, with any ecosystem services (such as recreation, tourism, and aesthetic values) as potential co-benefits.

There are some key resources that can help project proponents identify sites where reefs are likely to provide significant benefits for flood risk reduction (e.g., Beck et al. 2018, 2022; Storlazzi et al. 2019; Reguero et al. 2021). The maps and databases from these sources, particularly those from USGS & UCSC, provide a strong basis for initial screening on where sites might offer sufficient risk reduction (e.g., Figure 16).

Additional site-specific factors for consideration include identification of the stressors that might impede restoration success; the level of documented degradation or reef loss; knowledge of the pre-degradation coral community and the level of reef development (i.e., data on carbonate build-up and reef thickness); the level of interest in reef restoration from environmental managers, hazard managers, and the local community; the likelihood of permitting success for a restoration site (i.e., is the site in a marine protected area, around endangered species, or in a navigable waterway); and the level of local capacity for coral restoration (e.g., coral nurseries). Reaching out to environmental and historic preservation authorities early in project design and throughout the process can help determine the potential benefits and limitations of a priority project site or design and identify proposed solutions.

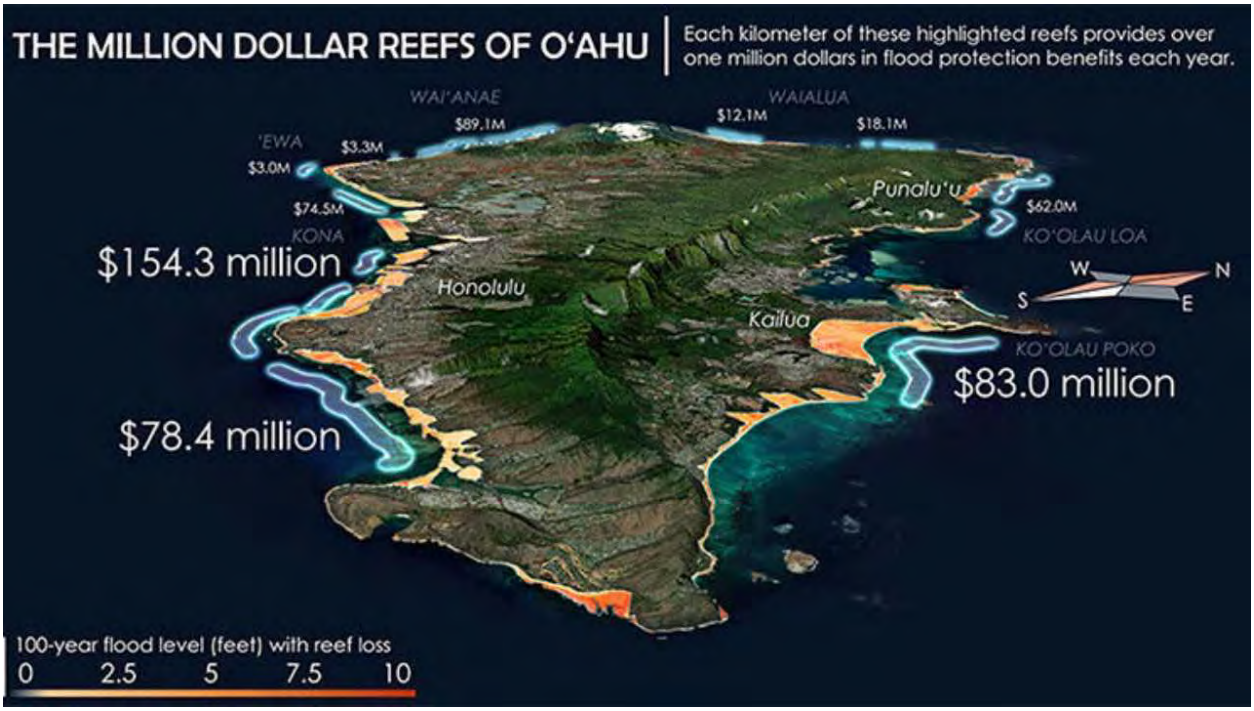

Figure 16. The highlighted reefs around O'ahu all provide greater than USD$1 million in expected flood reduction benefits per kilometer per year. The values in the figure are the sum of the annual expected benefits for reef sections that are several kilometers long (modified from Storlazzi et al., 2019; Reguero, 2021).

Step 3. Benefit-Cost Analysis

What is the benefit-cost analysis and why is it important?

A BCA is a method to determine the future risk reduction benefits of a hazard mitigation project compared to its costs. Mitigation projects funded by FEMA HMA and PA Mitigation grants are required by law to be cost-effective.

Estimating Project Benefits

The approaches and data under 'Picking Your Site' above provide examples of how to broadly estimate the benefits of existing reefs. Below we go into more depth on the approaches widely used in the scientific community for estimating the benefits of specific projects, which are valid for all types of risk reduction projects (e.g., dikes, seawalls, low crested breakwaters, and reefs). It is important to reiterate that the following steps will require significant technical expertise (e.g., hydrodynamic modeling, economic analysis, reef design) which may require additional capacity in the form of consultants or outside experts. Ultimately for a reef restoration project, proponents will have to identify the specific characteristics of the proposed restoration (e.g., restoration height, width and offshore location, depth) and model those site-based benefits. Restoration benefits for several idealized restoration scenarios were developed for the coral reef-lined coasts of Florida and Puerto Rico (e.g., Figure 17; Storlazzi et al. 2021); project proponents would need to modify these scenarios for their site-specific considerations.

Figure 17. Risk reduction benefits of reef restoration around San Juan, Puerto Rico. The full height of the bars indicates current expected flood risk in the 100-year floodplain. The blue bar tops indicate the risk that could be reduced with reef restoration; their height and color represent the expected benefit from restoration per 50,000 m^2 (hexagon max width = 277 m). Residual risk remains even after reef restoration. The orange line offshore indicates the location of potential reef restoration. The offshore polygon outlined in white represents the extent of current reef habitats. Modified from Storlazzi et al. (2021).

Below we highlight some of the critical steps and data required for assessing the benefits of reef conservation and restoration. Versions of this approach are widely used in risk science and by the risk industry and are being adapted for use with NBS (Barbier 2015; World Bank 2016; Storlazzi et al. 2019, 2021; Bridges et al. 2021; FEMA 2022; Reguero et al. 2021; Beck et al. 2022). These methods combine oceanographic, coastal engineering, ecologic, geospatial, social, and economic data and tools to provide a quantitative valuation of coastal protection benefits provided by potential coral reef restoration. The goal at this stage is to identify how, where, and when coral reef restoration could increase the coastal flood reduction benefits socially and economically. The method follows a sequence of steps that integrate physics-based hydrodynamic modeling, quantitative geospatial modeling, and social and economic analyses to quantify the hazard, the role of coral reef restoration in decreasing coastal flooding, and the resulting economic and social consequences.

Projecting the Coastal Hazards. To define the flooding hazards, a long (multiple decades) record, either from wave buoys or numerical wave model hindcasts of wave heights and periods for the site, is helpful. If the buoy or hindcast model output location is close to the proposed restoration site, such information can be used to drive the coastal flood models to derive nearshore wave time series for the site. If they are not close to the proposed site, the waves need to be translated to the site via dynamical or statistical methods.

Figure 18. Waves breaking on the Mesoamerican Reef near Cancun, Mexico. Photo credit: MW Beck.

Evaluating the Role of Coral Reefs in Coastal Protection. The nearshore wave time series at the site can be fit to a General Extreme Value (GEV) distribution to obtain the wave heights and wave periods associated with the different return-period storm events, such as the 1-year, 10-year, 20-year, 50-year, and 100-year storm return periods. The corresponding storm-return period extreme water levels for a given location can be computed from water level data at the nearest tidal station, which should include the effects of tropical cyclones.

The return value wave heights, wave periods, and extreme water levels are then propagated over the coral reefs using a physics-based, numerical coastal hydrodynamics and flood model. These models should either be two-dimensional depth-integrated ('2DH') or fully three-dimensional to accurately model the reef benefits. Reef height (bathymetry) and roughness (friction) are the critical factors that influence the effects of reefs on flooding. Friction is usually parameterized based on its relationship with coral cover (Sheppard et al. 2005; Quataert et al. 2015).

Reef Restoration Scenarios. Project proponents should identify potential reef restoration project designs (i.e., scenarios) that consider: (i) the likelihood of delivering flood reduction benefits, (ii) existing coral restoration practices, and (iii) permitting factors such as depth for potential navigational hazards. The restoration scenario(s) will be represented in the model based on width (cross-shore), length (alongshore), and height, as well as friction or hydrodynamic roughness, to quantify the waves and water levels over the restoration and the resulting coastal flooding.

Evaluating the Role of Potential Coral Reef Restoration in Increasing Coastal Protection. The return period (e.g., 10-year, 50-year) wave heights and wave periods can then be propagated over the coral reefs and modified to account for scenarios with and

without coral reef restoration using the same physics-based, numerical coastal hydrodynamics, and flood models.

Quantifying the Social and Economic Benefits of Potential Coral Reef Restoration. The differences with and without restoration in flood extent and depth are then used to quantify the avoided damages to people and property. The avoided damages to people are usually assessed based on census data, and the avoided damages to structures are based on data from granular, site-specific, local building data sources. Damages to the flooded structures are assessed by structure type (e.g., mobile homes) with flood-depth damage curves. The protection provided by reef restoration is ultimately assessed across three or more storm return intervals (e.g., 10-year, 50-year, 100-year, and 500-year storm return periods) to determine the annual expected protection provided by the coral reef restoration.

FEMA requires a 7% discount rate to be applied to future benefits, but the discount rate requirement for other agencies may vary. It is generally assumed that discount rates at this relatively high level will require that project benefits (i.e., flood reduction) be delivered early in a project (e.g., within the first year or two). Early delivery of flood reduction benefits likely means that reef restoration projects could not rely on planted coral fragments and growth alone and would need to pair structural (gray) and biological (green) restoration components for a hybrid approach. Still, there are scenarios where reef restoration could deliver significant returns on investment (i.e., B:C > 1) even if some of these benefits develop over time and with high discount rates (Beck et al. 2022).

FEMA BCA Toolkit

Most projects demonstrate cost-effectiveness using FEMA's BCA Toolkit software unless explicitly authorized by FEMA to use an alternate methodology. Cost-effective mitigation projects must have a BCR greater than or equal to 1.0 to demonstrate that the benefits outweigh the costs. FEMA's BCA toolkit requires specific data to be entered to evaluate the BCR, and documentation must be provided for any values entered unless they are a default within the tool. Projects are evaluated by property structure type, hazard type, mitigation action type, and the damage-frequency relationship (modeled damages, historic damages, professional expected damages). All projects require a project cost estimate, project useful life, and annual maintenance costs. Depending on the type of hazard, project, and damage-frequency relationship, different information about the damage history or avoided future damages is required. Additional benefits like ecosystem services can only be incorporated for some projects and hazard types. In 2022, FEMA released additional ecosystem service values, including for coral reefs and shellfish reefs. While the value for coral reefs includes some flood risk reduction benefits, the intent is that it can also be combined with other types of analysis to more fully quantify the risk reduction benefits that coral reefs provide. More information is available on FEMA's BCA website, which includes the BCA Toolkit, policy and guidance updates, and training materials.

Economic Analyses

When deemed appropriate or for planning purposes, economic impacts and benefits can be assessed quickly using the FEMA Flood Assessment Structure Tool (FAST). FEMA's FAST is freely available under the Hazus Open-Source Tools download. On its own, Hazus is currently

not acceptable to demonstrate cost-effectiveness. However, FAST can provide the economic losses with and without coral reef restoration by using flood risk reduction values from USGS/UCSC datasets showing flooding by storm return period in combination with other economic data of potential local benefits as described here.

FAST rapidly analyzes building-level flood risk using the Hazus flood model methodology. It was designed to make building-specific flood risk assessments quicker, simpler, and more resource-effective. Site-specific building data in a spreadsheet format are a required input that includes several attributes related to building vulnerability (e.g., building area, first-floor height, and foundation type). FAST includes a Help file that outlines the building data requirements, which is part of the FAST download. FEMA and USACE have developed national baseline inventories of structures that support this effort, including the National Structure Inventory (NSI). Several coral reef and mangrove test cases have been completed in Florida and Hawai'i using these data (Bergh et al. 2020; Stovall et al. 2022; Menendez et al. in press). Within FAST, Hazus provides a large library of damage functions that can be selected and assigned by the user. If not assigned by the user, defaults are provided as recommended by the expert panels and committees that developed these for Hazus. For user inputs, FAST requires hazard data in the form of depth grids with depth of water in feet. To estimate potential losses avoided as a result of the project, depth grids that represent the with and without project are required. FAST provides Average Annualized Losses (AAL) using two methods since AAL can better guide investment decisions over the life of the project. The first is a standard AAL method that requires a minimum of three return periods ranging anywhere between 10 and 1,000 years. The second is an exceedance probability function (PELV) AAL method (based on the actuarial curves developed by USACE and the FEMA NFIP) and requires only the 100-year return period. USGS has developed FAST-ready depth data for almost 2,000 miles of coral reef habitat based on the potential loss of the upper 1 meter of the reef system (Storlazzi et al. 2019). This compilation of information provides the framework to estimate the overall benefits of the coral reef system in reducing losses.

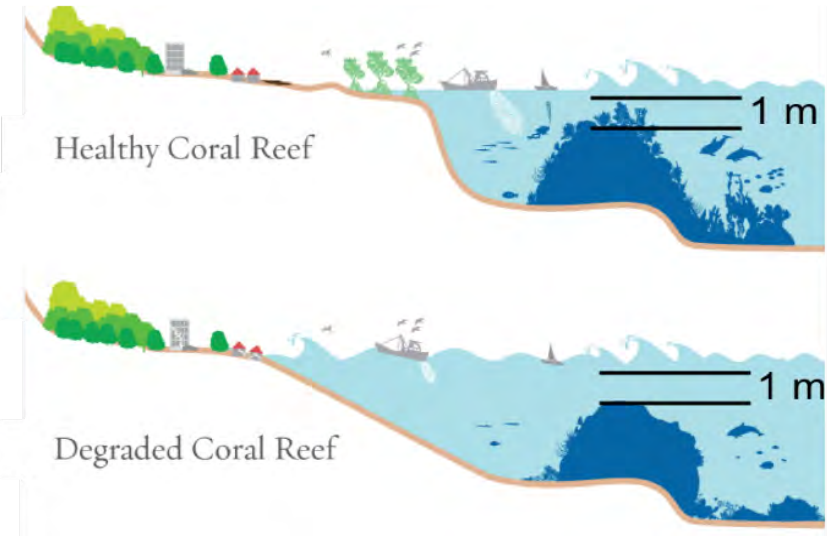

Figure 19. The loss of the top 1 m of reef has the potential to result in significantly increased flooding onshore. Credit: TNC.

Estimating Project Costs

Currently, few studies estimate project cost data for a CR4 project (Beck et al. 2022; Braithwaite et al. 2022), but many entities (e.g., engineering firms) can develop cost estimates based on analogous projects such as low-crested submerged breakwaters. Several studies review the costs

of coral outplanting from nurseries, also referred to as coral gardening (Bayraktarov et al. 2019). In most instances, nursery plantings will be at least one part of CR4 costs.

In 2014, Ferrario et al. (2014) reviewed the published cost of structural restoration projects and identified a median structural reef restoration cost of $1290 per meter. A more recent pilot project in Grenada was estimated to cost $3600 per meter (Reguero et al. 2018, 2019); this project involved structural restoration with sections higher than the 1-m considered by Ferrario et al. (2014). The project proponents noted that initial costs for this 30-m Grenada pilot project were likely significantly greater than expected final project costs as larger implementation would offer some economies of scale (Reguero et al. 2018).

Figure 20. A hybrid CR4 structure installed in Grenada to reduce wave energy. Photo credit: TNC.

Project proponents can work with local coral restoration practitioners and environmental/coastal engineers to get specific cost estimates for the region in which they plan to implement their project. Local environmental/coastal engineers can provide approximate costs for a submerged breakwater structure that might be used in a hybrid approach where corals are attached to a structural restoration component. For nursery-grown coral restoration, most cost estimates are typically for smaller-scale restoration projects. However, local coral restoration practitioners can provide local cost estimates for nursery-grown or other coral fragmentation methodologies. Then, the project proponent can use those local costs as the basis for the cost approximation for FEMA's BCA. Long-term maintenance and monitoring cost estimates are also limited for large-scale coral restoration projects and CR4 projects in particular. The largest comprehensive estimate of coral restoration costs, including maintenance and monitoring, to date is from the Florida Keys Mission Iconic Reefs project. However, the monitoring and maintenance costs associated with the Mission Iconic Reefs project are for monitoring ecological outcomes, not risk reduction. Thus, it is more appropriate to estimate monitoring and maintenance costs for a CR4 project based on the local monitoring and maintenance costs for a subtidal submerged breakwater rather than an ecological coral restoration project.

Step 4. Developing a Project Proposal

The process of developing and submitting a CR4 project proposal takes time and engagement from a broad array of stakeholders and experts. FEMA BRIC capability and capacity building (C&CB) funds can be used to support the facilitation and coordination of the team's effort for project scoping, regardless of the ultimate CR4 project funding source. Note that the state or territory manages all FEMA HMA funding, so it is vital to get in touch with the local emergency management agency or SHMO early to establish cross-sector project interest and prioritization. The SHMO will also help guide the application creation and submission process. Specific project proposal requirements, priorities, and contact information will be available in the FEMA, or other federal agency, grant program NOFO(s). For non-grant funding, the appropriate program manager in the local/regional agency office can be contacted to learn more.

Conclusion

There is promising interdisciplinary interest in the use of NBS for coastal flood risk reduction, particularly as NBS are identified in federal hazard mitigation funding opportunities such as FEMA BRIC. CR4 projects will rely on multiagency collaboration throughout the process of obtaining data, designing a project to reduce flooding, developing BCAs, and gaining support and permits from management agencies. There is growing evidence that coral reef restoration could be a technically and financially effective approach for coastal protection with supporting interest from stakeholders in local communities, territorial and state agencies, and businesses ranging from engineering contractors to insurance. However, challenges remain as there are only a few CR4 demonstration projects on which to inform the design and proposal development. Cooperative parties are actively working to overcome these barriers. The potential to integrate CR4 projects into the suite of hazard mitigation strategies for coastal communities will continue to grow as critical questions are answered, and interagency partners work together to advance CR4 as an attainable NBS.

References Cited

Bahr K.D., P.L. Jokiel, R.J. Toonen, 2015. The unnatural history of Kāne'ohe Bay: Coral reef resilience in the face of centuries of anthropogenic impacts. *PeerJ* 3:e950 https://doi.org/10.7717/peerj.950

Barbier, E. B., 2015. Valuing the storm protection service of estuarine and coastal ecosystems. *Ecosystem Services*, 11:32-38.

Bayraktarov, E., P.J. Stewart-Sinclair, S. Brisbane, L. Boström-Einarsson, M.I. Saunders, C.E. Lovelock, H.P. Possingham, P.J. Mumby, K.A. Wilson, 2019. Motivations, success, and cost of coral reef restoration. *Restoration Ecology*, *27*(5), pp.981-991.

Beck, M. W., I. Losada, P. Menendez, Reguero, B.G., P. Diaz Simal, F. Fernandez, 2018. The global flood protection savings provided by coral reefs. *Nature Communications*, 9:2186.

Beck, M. W., N. Heck, S. Narayan, P. Menéndez, B. Reguero, S. Bitterwolf, S. Torres-Ortega, G.-M. Lange, K. Pfliegner, V. McNulty, I. J. Losada, 2022. Return on investment for mangrove and reef flood protection. *Ecosystem Services* 56:101440.

Bergh, C., L. Bertolotti, T. Bieri, J. Bowman, R. Braun, J. Cardillo, M. Chaudhury, K. Falinski, L. Geselbracht, K. Hum, C. Lustic, E. Roberts, S. Young, M. Way, 2020. Insurance for natural infrastructure: Assessing the feasibility of insuring coral reefs in Florida and Hawai'i. The Nature Conservancy, Arlington, VA.

Boström-Einarsson, L., R.C. Babcock, E. Bayraktarov, D. Ceccarelli, N. Cook, S.C. Ferse, B. Hancock, P. Harrison, M. Hein, E. Shaver, A. Smith, 2020. Coral restoration–a systematic review of current methods, successes, failures and future directions. *PloS one*, *15*(1), p.e0226631.

Brathwaite, A., E. Clua, R. Roach, N. Pascal, 2022. Coral reef restoration for coastal protection: Crafting technical and financial solutions. *Journal of Environmental Management*, *310*, p.114718.

Brander & Beukering, P. van., 2013. The total economic value of U.S. coral reefs: A review of the literature. *NOAA Coral Reef Conservation Program*, 32.

Bridges, T. S., J. K. King, J. D. Simm, M. W. Beck, G. Collins, Q. Lodder, R. K. Mohan, eds. 2021. Overview: International guidelines on natural and nature-based features for flood risk management. Vicksburg, MS, U.S. Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/41946

Bridges, T. S., E. M. Bourne, J. K. King, H. K. Kuzmitski, E. B. Moynihan, B. C. Suedel, 2018. Engineering with nature: An atlas. ERDC/EL SR-18-8. Vicksburg, MS.

Bridges, T. S., E. M. Bourne, B. C. Suedel, E. B. Moynihan, J. K. King, 2021. Engineering with nature: An atlas, Volume 2. ERDC SR-21-2. Vicksburg, MS.

Claar, D. C., S. Starko, K.L. Tietjen, H.E. Epstein, R. Cunning, K.M. Cobb, A.C. Baker, R.D. Gates, J.K. Baum, 2020. Dynamic symbioses reveal pathways to coral survival through prolonged heatwaves. *Nature Communications*, *11*(1), 6097. https://doi.org/10.1038/s41467-020-19169-y

Dandan, S. S., J.L. Falter, R.J. Lowe, M.T. McCulloch, 2015. Resilience of coral calcification to extreme temperature variations in the Kimberley region, northwest Australia. *Coral Reefs*, *34*(4), 1151–1163. https://doi.org/10.1007/s00338-015-1335-6

Elahi, R., P.J. Edmunds, R.D. Gates, I.B. Kuffner, B.B. Barnes, I. Chollett, T.A. Courtney, J.R. Guest, E.A. Lenz, L.T. Toth, T.S. Viehman, I.D. Williams, 2022. Scale dependence of coral reef oases and their environmental correlates. *Ecological Applications*. https://doi.org/10.1002/eap.2651

Federal Emergency Management Agency (FEMA), 2020. Building community resilience with nature-based solutions: a guide for local communities. https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf

Federal Emergency Management Agency (FEMA), 2015. Hazard mitigation assistance guidance. https://www.fema.gov/sites/default/files/2020-07/fy15_HMA_Guidance.pdf

Federal Emergency Management Agency (FEMA), 2022. Hazus multi-hazard loss estimation methodology, flood model. *Hazus®-MH MR3 Technical Manual,* 471 p. https://www.fema.gov/sites/default/files/2020-09/fema_hazus_flood-model_technical-manual_2.1.pdf

Ferrario, F., M.W. Beck, C.D. Storlazzi, F. Micheli, C.C. Shepard, L. Airoldi, 2014. The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. *Nature Communications*, 5:3794.

Guest, J. R., P.J. Edmunds, R.D. Gates, I.B. Kuffner, A.J. Andersson, B.B. Barnes, I. Chollett, T.A. Courtney, R. Elahi, K. Gross, E.A. Lenz, S. Mitarai, P.J. Mumby, H.R. Nelson, B.A. Parker, H.M. Putnam, C.S. Rogers, L.T. Toth, 2018. A framework for identifying and characterising coral reef "oases" against a backdrop of degradation. *Journal of Applied Ecology*, *55*(6), 2865–2875. https://doi.org/10.1111/1365-2664.13179

Hein, M.Y., Staub, F., 2021. Mapping the global funding landscape for coral reef restoration. International Coral Reef Initiative. Available at: icriforum.org

Hein, M.Y., T. Vardi, E.C. Shaver, S. Pioch, L. Boström-Einarsson, M. Ahmed, G. Grimsditch, I.M. McLeod, 2021. Perspectives on the use of coral reef restoration as a strategy to support and improve reef ecosystem services. *Frontiers in Marine Science*, *8*, p.299.

International Union for Conservation of Nature (IUCN), 2020. Guidance for using the IUCN global standard for nature-based solutions, First edition. Gland, Switzerland, IUCN. https://portals.iucn.org/library/sites/library/files/documents/2020-021-En.pdf

Kaufman, L., I. B. Kuffner, T. Moore, T. Vardi, 2021. Chapter 23: Making restoration meaningful: A vision for working at multiple scales to help secure a future for coral reefs. Pages 567-580 *in* D. E. Vaughan, editor. Active Coral Restoration: Techniques for a Changing Planet. J. Ross Publishing.

Kleypas J., D. Allemand, K. Anthony, A. Baker, M.W. Beck, L.Z. Hale, N. Hilmi, O. Hoegh-Guldberg, T. Hughes, L. Kaufman, H. Kayanne, A. Magnan, E. Mcleod, P. Mumby, S. Palumbi, R. Richmond, B. Rinkevich, R. Steneck, C. Voolstra, D. Wachenfeld, J.-P. Gattuso, 2021. Designing a blueprint for coral reef survival. *Biological Conservation*, 257:109107.

Knowlton N, A.G. Grottoli, J. Kleypas, D. Obura, E. Corcoran, J.M. de Goeij, T. Felis, S. Harding, A. Mayfield, M. Miller, K. Osuka, R. Peixoto, C.J. Randall, C.R. Voolstra, S. Wells, C. Wild, S. Ferse, 2021. Rebuilding coral reefs: A decadal grand challenge. International Coral Reef Society and Future Earth Coasts 56 pp. http://coralreefs.org/wp-content/uploads/2021/07/ICRS_2021_Policy_Brief_high_resol.pdf

Lowe, R. J., E. McLeod, B. G. Reguero, S. Altman, J. Harris, B. Hancock, R. ter Hofstede, E. Rendle, E. Shaver, J. M. Smith, 2021. *Reefs*. *In* International guidelines on natural and nature-based features for flood risk management, T. Bridges et al. (eds), Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/41946

Menéndez, P., C. Lowrie, M.W. Beck. In press. Building mangrove capital: Assessing the benefit-cost ratio for mangrove restoration across the Wider Caribbean. The Nature Conservancy.

National Academies of Sciences, Engineering, and Medicine (NASEM), 2019. A decision framework for interventions to increase the persistence and resilience of coral reefs. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25424.

Pandolfi, J. M., S.R. Connolly, D.J. Marshall, A.L. Cohen, 2011. Projecting coral reef futures under global warming and ocean acidification. *Science*, 333:418–422.

Palumbi, S. R., D.J. Barshis, N. Traylor-Knowles, R.A. Bay, 2014. Mechanisms of reef coral resistance to future climate change. *Science*, 344:895–898.

Quataert, E., C.D. Storlazzi, A. van Rooijen, O.M. Cheriton, A. van Dongeren, 2015. The influence of coral reefs and climate change on wave-driven flooding of tropical coastlines. *Geophysical Research Letters*, 42:6407-6415.

Reguero, B. G., M.W. Beck, V. N. Agostini, P. Kramer, B. Hancock, 2018. Coral reefs for coastal protection: A new methodological approach and engineering case study in Grenada. *Journal of Environmental Management*, 210:146–161.

Reguero, B.G., C.D. Storlazzi, A.E. Gibbs, J.B. Shope, A.D. Cole, K.A. Cumming, K.A., M.W. Beck, 2021. The value of U.S. coral reefs for flood risk reduction *Nature-Sustainability*, 4:688–698.

Secaira Fajardo, F., K. Baughman McLeod, B. Tassoulas, 2019. A Guide on how to insure a natural asset. *The Nature Conservancy,* Arlington, VA.

Shamberger, K. E. F., A.L. Cohen, Y. Golbuu, D.C. McCorkle, S.J. Lentz, H.C. Barkley, H. C., 2014. Diverse coral communities in naturally acidified waters of a Western Pacific reef. *Geophysical Research Letters*, *41*(2), 499–504. https://doi.org/10.1002/2013GL058489

Sheppard, C., D.J. Dixon, M. Gourlay, A. Sheppard, R. Payet, 2005. Coral mortality increases wave energy reaching shores protected by reef flats in the Seychelles. *Estuarine, Coastal, and Shelf Science*, 64: 223–234.

Spalding, M., L. Burke, S.A. Wood, J. Ashpole, J. Hutchison, J., P. zu Ermgassen, 2017. Mapping the global value and distribution of coral reef tourism. *Marine Policy*, 82: pp 104-113

Storlazzi, C.D., B.G. Reguero, A.D. Cole, E. Lowe, J.B. Shope, A.E. Gibbs, B.A. Nickel, R.T. McCall, A.R. van Dongeren, M.W. Beck, 2019. Rigorously valuing the role of U.S. coral reefs in coastal hazard risk reduction. *U.S. Geological Survey Open-File Report 2019–1027*, 42 p., https://doi.org/10.3133/ofr20191027.

Storlazzi, C.D., B.G. Reguero, K.A. Cumming, A.D. Cole, J.A. Shope, L.C. Gaido, T.S. Viehman, B.A. Nickel, M.W. Beck, 2021. Rigorously valuing the coastal hazard risks reduction provided by potential coral reef restoration in Florida and Puerto Rico. *U.S. Geological Survey Open-File Report 2021–1054*, 35 p., https://doi.org/10.3133/ofr20211054.

Stovall, A.E., M.W. Beck, T. Bieri, A.N. Mann, J. Mojica, R. Schmidt, 2022. Unlocking FEMA's hazard mitigation funding for coral ref restoration: A feasibility study in Maui, Hawaii. The Nature Conservancy, Sacramento, CA. scienceforconservation.org

U.S. Census Bureau, 2022. TIGER products database. https://www.census.gov/programs-surveys/geography/guidance/tiger-data-products-guide.html

World Bank, 2016. Managing coasts with natural solutions: Guidelines for measuring and valuing the coastal protection services of mangroves and coral reefs. M.W. Beck & G-M. Lange, editors, World Bank, Washington, DC.

Young, C., S. Schopmeyer, D. Lirman, 2012. A review of reef restoration and coral propagation using the threatened genus *Acropora* in the Caribbean and Western Atlantic. *Bulletin of Marine Science*, *88*(4), 1075–1098. https://doi.org/10.5343/bms.2011.1143

Zepeda-Centeno C., I. Mariño-Tapia, E. McLeod, R. Rodríguez-Martínez, L. Alvarez-Filip, A.T. Banaszak, M. Escudero-Castillo, R. Silva-Casarín, E. Mendoza-Baldwin. M.W. Beck, E. Shaver, 2018. Guidance document for reef management and restoration to improve coastal protection: Recommendations for global applications based on lessons learned in Mexico. The Nature Conservancy, Mexico.