

# Endangered Species Act Legal and Policy Review of Interventions to Increase the Persistence and Resilience of Coral Reefs

August 2020



NOAA web page for elkhorn coral: <https://www.fisheries.noaa.gov/species/elkhorn-coral>.



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## List of Acronyms

CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
ESA	Endangered Species Act
FR	Federal Register
FWS	U.S. Fish and Wildlife Service
NASEM	National Academies of Sciences, Engineering, and Medicine
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OPR	Office of Protected Resources

## Introduction

In 2018, the National Oceanic and Atmospheric Administration (NOAA) commissioned the National Academies of Sciences, Engineering, and Medicine (NASEM) to review and evaluate the rapid development of research on novel ecological, genetic, and environmental coral intervention strategies. These so-called “interventions” have the potential to enhance recovery and sustainability of corals. The NASEM report *A Research Review of Interventions to Increase the Persistence and Resilience of Coral Reefs* (NASEM 2019; hereafter NASEM Report) was completed in 2019. Informed by the NASEM Report, NOAA developed an *Action Plan on Coral Interventions* (NOAA in press). A key action in the agency’s Action Plan was to review potential implications of the interventions on Federal policy. The National Marine Fisheries Service (NMFS) Office of Protected Resources (OPR) was tasked to lead a policy review under the Endangered Species Act (ESA). A team consisting of staff from OPR, Southeast Region, Pacific Islands Region, and NOAA General Counsel conducted the review (see [Appendix I](#)).

## Purpose

The purpose of this legal and policy review is to examine the 23 coral interventions identified in the NASEM Report (2019) in light of considerations and requirements of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*). The goal of the review is to provide guidance on ESA considerations and requirements as NMFS considers testing and implementing the suggested interventions as outlined in the NOAA *Action Plan on Coral Interventions* (NOAA in press).

## Scope

For purposes of this legal and policy review, we interpret ESA considerations as those ESA policies, guidance documents, practices, and legal opportunities related to the 23 interventions regardless of taxa. We interpret ESA requirements as the legal requirements of the ESA and its implementing regulations. This would include the need to obtain an ESA permit, qualify for an ESA exemption, or engage in ESA inter-agency consultation with NMFS. ESA requirements also include applicable legal requirements under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which is implemented in the United States through the ESA, and can include obtaining a CITES permit, certificate, or other required document.

Although the ESA requirements and considerations described below apply generally to listed species, a species’ status as endangered or threatened and where it occurs are factors that determine the relevant ESA requirements and considerations. As of August 2020, there

are 25 ESA-listed corals. Three foreign species (i.e., the species' current and historical ranges occur entirely under the jurisdiction of other countries) are listed as endangered species (*Tubastraea floreana*, *Siderastrea glynni*, and *Cantharellus noumeae*) while the other 22 species are listed as threatened species. In addition, 1,567 coral species are protected under CITES.

While this legal and policy review focuses on the aforementioned requirements and considerations under the ESA, we cannot anticipate all the decisions and considerations inherent in implementing the 23 interventions. Other factors to consider in the appropriateness and timing of implementation include, but are not limited to, consistency with agency priorities and availability of funding, facilities, agency staff, and partners. To demonstrate some of these considerations, we provide two case studies related to several of the interventions described in the NASEM Report (see Boxes 1 and 2).

## How to Use this Document

This legal and policy review first provides the 23 interventions from the NASEM Report with the associated ESA requirements and considerations (i.e., policies, practices, and legal opportunities) related to each intervention (see the section *Coral Interventions – Applicable ESA Requirements and Considerations* and Table 1). The associated ESA requirements and considerations are hyperlinked in Table 1 to the relevant sections in the *Discussion of ESA Requirements and Considerations* section of this review. Second, following Table 1 is the discussion of pertinent statutory and regulatory provisions, policies, and guidance documents, some of which are referenced in Table 1 but some of which are more broadly applicable than to specific interventions. This *Discussion of ESA Requirements and Considerations* section also includes key agency coral documents such as existing coral recovery and management plans. The relevant sections in this review provide hyperlinks to the original source (e.g., ESA statutory section) to which they refer.

Although this legal and policy review provides summary discussions from the source material that are pertinent to the 23 interventions, the reader should go to the original source material for its entire and exact content. This review is meant to provide the user with a quick reference of the intervention(s) of interest, a summary description of the applicable ESA requirements and considerations, and links to the relevant material within the legal and policy review. In addition, this review does not contain complete information on all potentially applicable laws. Other potentially applicable laws include generally applicable Federal laws such as the National Environmental Policy Act (NEPA) and laws specific to certain locations such as the National Marine Sanctuaries Act, as well as State wildlife and environmental protection laws. Users of this legal and policy review should consult and review all applicable Federal and State laws to ensure that their activities comply with all legal requirements.



## Coral Interventions – Applicable ESA Requirements and Considerations

**Table 1** contains the 23 interventions from Table 6.1 of the NASEM Report (see Appendix II; NASEM 2019) and the ESA requirements, considerations, and applicable policies for each with a link to the relevant discussion in the *Discussion of ESA Requirements and Considerations* section below.

Although there are sections in the NASEM Report on how to do each intervention, the specific details of an individual project will affect the ESA requirements and considerations. Factors that will affect the requirements and considerations include issues such as the status of the coral species (endangered vs. threatened, whether CITES-listed), whether specimens will be imported or exported, whether there are prohibitions on take, import, export, etc. for threatened species through a 4(d) rule, whether there is a recovery plan or genetic management plan for the species, whether the project could affect other ESA-listed species, and whether a federal agency is conducting, funding, or authorizing the project. The team conducting this review inferred which activities regulated under the ESA or CITES were most likely implicated by each intervention. However, persons involved with implementation of the interventions should discuss their actual activities with NMFS staff in advance to determine whether and in what manner their work may trigger a restriction under the ESA or CITES.

**Table 1. 23 NASEM interventions with a brief description of what each is (see Appendix II; NASEM 2019) and the ESA requirements and considerations applicable to each intervention. Note: 'E' = endangered; 'T' = threatened.**

Intervention	What It Is	ESA Requirements	ESA Considerations
<b>Genetic and Reproductive Interventions</b>			
<p><b>1</b> <b>Managed Selection</b></p>	<p><i>Creating increased frequency of existing tolerance genes</i></p>	<ul style="list-style-type: none"> <li>• If collecting (i.e., taking) E corals in U.S. waters or on the high seas &amp; maintaining <i>ex situ</i>, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If <i>in situ</i> monitoring in U.S. waters or on the high seas will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Any import into or export from the U.S. of E coral would require a research or enhancement permit under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with Caribbean Acropora <a href="#">4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of 4(d) rule for same activities described above for E corals (form of permit varies).</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a project involves activities such as collecting corals or monitoring that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving activities such as collecting corals or monitoring will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• To the extent Managed Selection includes relocation, see consideration of establishing an experimental population under <a href="#">ESA sec 10(j)</a>. See Intervention <a href="#">#17 Managed Relocation</a>: Assisted Migration and Intervention <a href="#">#18 Managed Relocation</a>: Introduction to New Areas.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act.<sup>B</sup></li> </ul>



Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>2</b> <b>Managed Breeding: Supportive Breeding</b></p>	<p><i>Enhancing population size by captive rearing and release</i></p>	<ul style="list-style-type: none"> <li>• If collecting (i.e., taking) E corals in U.S. waters or on the high seas, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If conducting breeding, maintaining broodstock, or other associated activities will result in take of E corals not already authorized, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Any import into or export from the U.S. of E coral would require a research or enhancement permit under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If release of captive-bred offspring will result in take of either E corals in the wild population or the released offspring, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with Caribbean <a href="#">Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies). No ESA permit required for take caused by qualifying restoration activities (as defined in the rule) by agents or employees of specified government agencies.</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a project involves activities such as collecting corals from the wild or releasing captive-bred corals that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving collecting corals or releasing captive-bred corals will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act.<sup>B</sup></li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>3</b> <b>Managed Breeding: Outcrossing Between Populations</b></p>	<p><i>Introducing diversity from other populations through breeding</i></p>	<ul style="list-style-type: none"> <li>• If collecting (i.e., taking) E corals in U.S. waters or on the high seas, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If conducting breeding, maintaining broodstock, or other associated activities will result in take of E corals not already authorized, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Any import into or export from the U.S. of E coral would require a research or enhancement permit under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If release of captive-bred offspring will result in take of either E corals in the wild population or the released offspring, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule</a> for T elkhorn &amp; staghorn coral. Scientific and enhancement permit required under terms of the 4(d) rule for same activities described above for E corals (form of permit varies). No ESA permit required for take caused by qualifying restoration activities (as defined in the rule) by agents or employees of specified government agencies.</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a project involves activities such as collecting corals from the wild or releasing captive-bred corals that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving collecting corals or releasing captive-bred corals will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: Specific points within the policy include that appropriate controlled propagation will be: <ul style="list-style-type: none"> <li>○ based on specific consideration of (a) the potential ecological and genetic effects of the removal of individuals for controlled propagation purposes on wild populations, and (b) the potential effects of introductions of artificially bred animals or plants on the receiving population and other resident species. (Point 4)</li> <li>○ based on sound scientific principles to conserve genetic variation and species integrity. Intercrossing will not be considered for use in controlled propagation programs unless recommended in an approved recovery plan or supported in an approved genetic management plan. (Point 5)</li> <li>○ conducted in a manner to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that propagated individuals are behaviorally and physiologically suitable for introduction. Determination of biological "suitability" may include, but should not necessarily be limited to, analysis of geomorphological similarities of habitat, genetic similarity, phenotypic characteristics, stock histories, habitat use, and other ecological, biological, and behavioral indicators. (Point 6)</li> <li>○ conducted in a manner that takes all known precautions to prohibit the potential introduction or spread of diseases and parasites into controlled environments or suitable habitat. (Point 7)</li> <li>○ conducted in a manner that will prevent the escape or accidental introduction of individuals outside their historic range. (Point 8)</li> </ul> </li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>4</b> <b>Managed Breeding: Hybridization Between Species</b></p>	<p><i>Creation of novel genotypes through breeding</i></p>	<ul style="list-style-type: none"> <li>• If one or both species of parental stock is an E or T species, see ESA requirements applicable to collecting, breeding, maintenance, release, import, and export under <a href="#">Interventions #1 - #3</a> (Managed Selection and Managed Breeding).</li> <li>• If hybrid offspring from E or T parental stock have E or T status, see ESA requirements applicable to breeding, maintenance, release, import, and export under <a href="#">Interventions #1 - #3</a> (Managed Selection and Managed Breeding).</li> <li>• If neither species of parental stock is ESA listed, no ESA requirements directly apply to activities with specimens from the parental stock, such as collecting, breeding, maintenance, or release (but see possible ESA requirements below related to incidental take caused by activities with non-ESA listed hybrid corals).</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a project involves activities such as collecting corals from the wild or releasing hybrid corals that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving collecting corals or releasing hybrid corals will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• For hybrids determined to have T status, an ESA 4(d) rule that governs take, import, export, and other activities could provide control over development and management of hybrids both in captivity and upon release to the wild.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: Specific points within the policy include that appropriate controlled propagation will be: <ul style="list-style-type: none"> <li>○ based on specific consideration of (a) the potential ecological and genetic effects of the removal of individuals for controlled propagation purposes on wild populations, and (b) the potential effects of introductions of artificially bred animals or plants on the receiving population and other resident species. (Point 4)</li> <li>○ based on sound scientific principles to conserve genetic variation and species integrity. Intercrossing will not be considered for use in controlled propagation programs unless recommended in an approved recovery plan or supported in an approved genetic management plan. (Point 5)</li> <li>○ conducted in a manner to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that propagated individuals are behaviorally and physiologically suitable for introduction. Determination of biological "suitability" may include, but should not necessarily be limited to, analysis of geomorphological similarities of habitat, genetic similarity, phenotypic characteristics, stock histories, habitat use, and other ecological, biological, and behavioral indicators. (Point 6)</li> <li>○ conducted in a manner that takes all known precautions to prohibit the potential introduction or spread of diseases and parasites into controlled environments or suitable habitat. (Point 7)</li> <li>○ conducted in a manner that will prevent the escape or accidental introduction of individuals outside their historic range. (Point 8)</li> </ul> </li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>5</b> <b>Gamete and Larval Capture and Seeding</b> (Note: Gametes and larvae are included in the definition of “fish or wildlife” in the ESA and the definition of “specimen” in CITES, and therefore have the same legal status as other specimens of the species)</p>	<p><i>Collection and manipulation in the field and laboratory and release into the wild</i></p>	<ul style="list-style-type: none"> <li>• If collecting (i.e., take) E coral gametes or larvae in U.S. waters or on the high seas, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If conducting breeding, maintaining broodstock, or other associated activities in a laboratory will result in take of E parental stock or gametes/larvae not already authorized, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Any import into or export from the U.S. of E coral would require a research or enhancement permit under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If gamete and larval capture and seeding will be used to “be outcrossed <i>in situ</i> or in the laboratory... to create chimeric colonies or hybrids,” see ESA requirements applicable to Intervention <a href="#">#4 Managed Breeding: Hybridization Between Species</a>.</li> <li>• If release of E coral gametes or larvae will result in take of the gamete/larvae or take of targeted E coral at the release site, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a project involves activities such as collecting or release of coral gametes/larvae that “may affect” other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving collecting corals or releasing coral gametes/larvae will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• To the extent seeding of E or T species is used to establish new populations, there is the option of designating an experimental population through the development of an <a href="#">ESA 10(j) rule</a> for proposed relocation of T or E corals to a location entirely separate geographically from other non-experimental populations of the same species. Such designation would provide regulatory treatment of E coral specimens as if a T species (i.e., through development of <a href="#">4(d) rule</a>), <a href="#">section 7</a> conferring only if determined a nonessential experimental population (except in areas under NPS or FWS Refuge jurisdiction), and no ESA critical habitat designated if determined a nonessential experimental population.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: Specific points within the policy include that appropriate controlled propagation will be: <ul style="list-style-type: none"> <li>○ based on specific consideration of (a) the potential ecological and genetic effects of the removal of individuals for controlled propagation purposes on wild populations, and (b) the potential effects of introductions of artificially bred animals or plants on the receiving population and other resident species. (Point 4)</li> <li>○ based on sound scientific principles to conserve genetic variation and species integrity. Intercrossing will not be considered for use in controlled propagation programs unless recommended in an approved recovery plan or supported in an approved genetic management plan. (Point 5)</li> <li>○ conducted in a manner to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that propagated individuals are behaviorally and physiologically suitable for introduction. Determination of biological “suitability” may include, but should not necessarily be limited to, analysis of geomorphological similarities of habitat, genetic similarity, phenotypic characteristics, stock histories, habitat use, and other ecological, biological, and behavioral indicators. (Point 6)</li> <li>○ conducted in a manner that takes all known precautions to prohibit the potential introduction or spread of diseases and parasites into controlled environments or suitable habitat. (P. 7)</li> <li>○ conducted in a manner that will prevent the escape or accidental introduction of individuals outside their historic range. (Point 8)</li> </ul> </li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>6</b> <b>Coral Cryopreservation</b></p>	<p><i>Frozen storage of gametes and other cells for later use and transport</i></p>	<ul style="list-style-type: none"> <li>• If freezing or holding of E coral gametes, embryos, or other specimens will result in take and has not already been authorized, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If cryopreservation involves importing, exporting, or collecting (i.e., taking) E coral or activities associated with breeding, maintaining, or holding E coral, see ESA requirements for Intervention <a href="#">#5 Gamete and Larval Capture and Seeding</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: See also the specific exception: Actions involving cryopreservation or other methods of conserving biological materials, if not intended for near-term use in controlled propagation or the reintroduction into the wild of listed species, are exempt from this policy. When and if reintroduction to the wild requires the use of these materials, such activities would come under the scope of this policy.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>7</b> <b>Genetic Manipulation: Coral</b></p>	<p><i>Altering coral genes for new function</i></p>	<ul style="list-style-type: none"> <li>• If genetically manipulated corals have E or T status, see ESA requirements applicable to breeding, maintenance, release, import, and export under <a href="#">Interventions #1 - #3</a> (Managed Selection and Managed Breeding).</li> <li>• If specimens for producing genetically manipulated coral are an E or T species, see ESA requirements applicable to collecting, breeding, maintenance, release, import, and export under <a href="#">Interventions #1 - #3</a> (Managed Selection and Managed Breeding).</li> <li>• If neither specimens used for producing genetically manipulated specimens nor resulting specimens are ESA listed, no ESA requirements apply to direct activities with those specimens, such as collecting, breeding, maintenance, or release. But see possible ESA requirements below related to incidental take caused by activities with genetically manipulated corals.</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a project involves activities such as collecting corals from the wild or releasing genetically manipulated corals that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving collecting corals or releasing genetically manipulated corals will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> <li>• If genetic manipulation does not involve introduction of genetic material from another coral species, ESA requirements are similar to those for Intervention <a href="#">#6 Coral Cryopreservation</a>.</li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: Specific points within the policy include that appropriate controlled propagation will be: <ul style="list-style-type: none"> <li>○ based on specific consideration of (a) the potential ecological and genetic effects of the removal of individuals for controlled propagation purposes on wild populations, and (b) the potential effects of introductions of artificially bred animals or plants on the receiving population and other resident species. (Point 4)</li> <li>○ based on sound scientific principles to conserve genetic variation and species integrity. Intercrossing will not be considered for use in controlled propagation programs unless recommended in an approved recovery plan or supported in an approved genetic management plan. (Point 5)</li> </ul> </li> </ul>



Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>8</b> <b>Genetic Manipulation: Symbionts</b> (Note: This analysis presumes that intervention activities are conducted on symbionts alone, separate from associated E or T corals.)</p>	<p><i>Altering symbiont genes for new functions</i></p>	<ul style="list-style-type: none"> <li>• No applicable ESA or CITES requirements unless algal symbionts are listed under ESA or CITES in the future.</li> <li>• In the event algal symbionts are listed under the ESA or CITES in the future, provisions for plant species would apply under <a href="#">ESA sec 9, sec 4(d)</a>, and <a href="#">sec 10</a> and under <a href="#">CITES</a>.</li> <li>• In the event that non-algal symbionts are listed under the ESA or CITES in the future, provisions for fish or wildlife would apply under <a href="#">ESA sec 9, sec 4(d)</a>, and <a href="#">sec 10</a> and under <a href="#">CITES</a>.</li> </ul>	
<b>Physiological Interventions</b>			
<p><b>9</b> <b>Pre-exposure</b></p>	<p><i>Using stress exposure to make colonies more tolerant</i></p>	<ul style="list-style-type: none"> <li>• If directed exposure to a stressor will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If directed exposure to a stressor will not result in take of E corals, no ESA authorization is needed.</li> <li>• If pre-exposure activities involve collecting (i.e., taking) and maintaining E corals from the wild or importing or exporting E corals, see ESA requirements applicable to collecting, breeding, maintenance, release, import, and export under Intervention <a href="#">#2 Managed Breeding</a>: Supportive Breeding.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves activities such as exposure of a stressor that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving exposure of a stressor will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d)</a> rule (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>10</b> <b>Algal Symbiont Manipulation</b></p>	<p><i>Changing algal symbionts to more tolerant types</i></p>	<ul style="list-style-type: none"> <li>• If manipulation (either in the wild or in the laboratory) of algal symbionts occurs in conjunction with associated E corals, ESA prohibitions on take (i.e., harass, wound, kill) may apply. This may include "intentionally infecting" E coral larvae or juveniles with manipulated symbionts.</li> <li>• If activities associated with symbiont manipulation will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(10)(A)</a>.</li> <li>• If algal symbiont manipulation includes for an E coral species "deliberate infection of coral juveniles with particular symbionts" and then release of those juveniles through "outplanting to natural reef environments" in a manner that will result in take of either targeted E corals in the wild population or the released juveniles, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves manipulation of algal symbionts in the wild that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving manipulation of algal symbionts in the wild will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d)</a> rule (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>11</b> <b>Microbiome Manipulation</b></p>	<p><i>Maintaining/increasing abundance of the native or new beneficial microbes</i></p>	<ul style="list-style-type: none"> <li>• If microbiome manipulation (either in the wild or in the laboratory) occurs in conjunction with E or T corals, ESA prohibitions on take (i.e., harass, wound, kill) may apply. This would include adding a microbiome cocktail into the holobiont of an E or T coral host with manipulated microbiomes.</li> <li>• If microbiome manipulation will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If microbiome manipulation includes deliberate infection of an E coral holobiont with particular microbiomes and then "outplanting to natural reef environments" in a manner that will result in take of either targeted E corals in the wild population or the released corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves manipulating coral microbiomes in reef systems that "may affect" T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving manipulating coral microbiomes in reef systems will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<b>12</b> <b>Antibiotics</b>	<i>Adding antibiotics to control pathogenic microbes</i>	<ul style="list-style-type: none"> <li>• If application of antibiotics will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involving application of antibiotics "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving application of antibiotics will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or applicable <a href="#">ESA sec 4(d)</a> rule (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>
<b>13</b> <b>Phage Therapy</b>	<i>Adding phage viruses to control pathogenic microbes</i>	<ul style="list-style-type: none"> <li>• If application of phage therapy either <i>in situ</i> or <i>ex situ</i> will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involving phage therapy "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving phage therapy will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<b>14</b> <b>Antioxidants</b>	<i>Reducing cellular oxidative damage derived from stress using chemical treatments</i>	<ul style="list-style-type: none"> <li>• If application of antioxidants will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involving application of antioxidants "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving application of antioxidants will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>
<b>15</b> <b>Nutritional Supplementation</b>	<i>Using nutrients to improve fitness and increase stress tolerance</i>	<ul style="list-style-type: none"> <li>• If nutritional supplementation will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involving nutritional supplementation "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving nutritional supplementation will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<b>Coral Population and Community Interventions</b>			
<p><b>16</b> <b>Managed Relocation: Assisted Gene Flow</b></p>	<p><i>Increasing abundance of stress-tolerant genes or colonies within population range</i></p>	<ul style="list-style-type: none"> <li>• If collecting (i.e., taking) E corals in U.S. waters or on the high seas, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If release of E corals will result in take of either targeted E corals in the wild population or the released E coral, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If managed relocation will involve import into or export from the U.S. of E coral, a research or enhancement permit would be required under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies). No ESA permit required for take caused by qualifying restoration activities (as defined in the rule) by agents or employees of specified government agencies.</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a managed relocation project involves activities such as collecting or releasing corals that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a managed relocation project involving activities such as collecting or releasing corals will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• Option for development of <a href="#">ESA 10(j) rule</a> to designate an experimental population for the purposes of relocating T or E corals to a location entirely separate geographically from other non-experimental populations of the same species. Such designation would provide regulatory treatment of E coral specimens as if a T species (i.e., through development of <a href="#">4(d) rule</a>), <a href="#">section 7</a> conferencing only if determined a nonessential experimental population (except in areas under NPS or FWS Refuge jurisdiction), and no ESA critical habitat designated if determined a nonessential experimental population.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: Specific points within the policy include that appropriate controlled propagation will be: <ul style="list-style-type: none"> <li>○ conducted in a manner to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that propagated individuals are behaviorally and physiologically suitable for introduction. Determination of biological "suitability" may include, but should not necessarily be limited to, analysis of geomorphological similarities of habitat, genetic similarity, phenotypic characteristics, stock histories, habitat use, and other ecological, biological, and behavioral indicators. (Point 6)</li> <li>○ conducted in a manner that takes all known precautions to prohibit the potential introduction or spread of diseases and parasites into controlled environments or suitable habitat. (Point 7)</li> </ul> </li> </ul>



Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>17</b> <b>Managed Relocation: Assisted Migration</b></p>	<p>Moving stress-tolerant or diverse genes or colonies just outside species' range</p>	<ul style="list-style-type: none"> <li>• If collecting (i.e., taking) E corals in U.S. waters or on the high seas, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If release of E corals may result in take (i.e., harass, wound, kill) of the released E coral, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If managed relocation will involve import into or export from the U.S. of E coral, a research or enhancement permit would be required under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies). No ESA permit required for take caused by qualifying restoration activities (as defined in the rule) by agents or employees of specified government agencies.</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a managed relocation project involves activities such as collecting or releasing corals that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a managed relocation project involving activities such as collecting or releasing corals will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• Option for development of <a href="#">ESA 10(j) rule</a> to designate an experimental population for the purposes of relocating T or E corals to a location entirely separate geographically from other non-experimental populations of the same species. Such designation would provide regulatory treatment of E coral specimens as if a T species (i.e., through development of <a href="#">4(d) rule</a>), <a href="#">section 7</a> conferencing only if determined a nonessential experimental population (except in areas under NPS or FWS Refuge jurisdiction), and no ESA critical habitat designated if determined a nonessential experimental population.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: Specific points within the policy include that appropriate controlled propagation will be: <ul style="list-style-type: none"> <li>○ conducted in a manner to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that propagated individuals are behaviorally and physiologically suitable for introduction. Determination of biological "suitability" may include, but should not necessarily be limited to, analysis of geomorphological similarities of habitat, genetic similarity, phenotypic characteristics, stock histories, habitat use, and other ecological, biological, and behavioral indicators. (Point 6)</li> <li>○ conducted in a manner that takes all known precautions to prohibit the potential introduction or spread of diseases and parasites into controlled environments or suitable habitat. (Point 7)</li> <li>○ conducted in a manner that will prevent the escape or accidental introduction of individuals outside their historic range. (Point 8)</li> </ul> </li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>18</b> <b>Managed Relocation: Introduction to New Areas</b></p>	<p><i>Moving stress-tolerant or diverse genes or colonies to new regions</i></p>	<ul style="list-style-type: none"> <li>• If collecting (i.e., taking) E corals in U.S. waters or on the high seas, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If release of E corals will result in take of the released E coral, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• If managed relocation will involve import into or export from the U.S. of E coral, a research or enhancement permit would be required under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies). No ESA permit required for take caused by qualifying restoration activities (as defined in the rule) by agents or employees of specified government agencies.</li> <li>• Any import, introduction from the sea, or export of CITES-listed coral would require the appropriate permit, certificate, or other document under <a href="#">CITES</a>.</li> <li>• If a managed relocation project involves activities such as collecting or releasing corals that "may affect" other T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a managed relocation project involving activities such as collecting or releasing corals will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> <li>• Option for development of <a href="#">ESA 10(j) rule</a> to designate an experimental population for the purposes of relocating T or E corals to a location entirely separate geographically from other non-experimental populations of the same species. Such designation would provide regulatory treatment of E coral specimens as if a T species (i.e., through development of <a href="#">4(d) rule</a>), <a href="#">section 7</a> conferencing only if determined a nonessential experimental population (except in areas under NPS or FWS Refuge jurisdiction), and no ESA critical habitat designated if determined a nonessential experimental population.</li> <li>• <a href="#">Policy Regarding Controlled Propagation</a> of Species Listed Under the Endangered Species Act<sup>B</sup>: Specific points within the policy include that appropriate controlled propagation will be: <ul style="list-style-type: none"> <li>○ conducted in a manner to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that propagated individuals are behaviorally and physiologically suitable for introduction. Determination of biological "suitability" may include, but should not necessarily be limited to, analysis of geomorphological similarities of habitat, genetic similarity, phenotypic characteristics, stock histories, habitat use, and other ecological, biological, and behavioral indicators. (Point 6)</li> <li>○ conducted in a manner that takes all known precautions to prohibit the potential introduction or spread of diseases and parasites into controlled environments or suitable habitat. (Point 7)</li> <li>○ conducted in a manner that will prevent the escape or accidental introduction of individuals outside their historic range. (Point 8)</li> </ul> </li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<b>Environmental Interventions</b>			
<b>19</b> <b>Shading: Atmospheric</b>	<i>Sky (Cloud) brightening to relieve light and heat stress</i>	<ul style="list-style-type: none"> <li>• If atmospheric shading will result in directed take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves atmospheric shading that "may affect" T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving atmospheric shading will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>
<b>20</b> <b>Shading: Marine</b>	<i>Reducing sunlight to relieve light and heat stress</i>	<ul style="list-style-type: none"> <li>• If marine shading will result in directed take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves marine shading that "may affect" T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required <a href="#">under ESA sec 7(a)(2)</a>.</li> <li>• If a project involving marine shading will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>21</b> <b>Mixing of Cool Water</b></p>	<p><i>Pumping cool water onto reef to reduce heat stress</i></p>	<ul style="list-style-type: none"> <li>• If mixing of cool water will result in directed take (e.g., harassment, wounding, or death) of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a> (especially where such mixing is experimental and outcomes may be unknown).</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves mixing of cool water that "may affect" T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving mixing of cool water will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>22</b> <b>Abiotic Ocean Acidification Interventions</b></p>	<p><i>Reducing CO<sub>2</sub> levels chemically</i></p>	<ul style="list-style-type: none"> <li>• If abiotic ocean acidification will result in directed take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves acidification activities (e.g., dosing with chemicals, bubble stripping the water column of CO<sub>2</sub>, adding and/or weathering limestone) that "may affect" T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving acidification activities (e.g., dosing with chemicals, bubble stripping the water column of CO<sub>2</sub>, adding and/or weathering limestone) will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

Intervention	What It Is	ESA Requirements	ESA Considerations
<p><b>23</b> <b>Seagrass Meadows and Macroalgal Beds</b></p>	<p><i>Reducing daytime CO<sub>2</sub> levels biologically. Includes planting seagrass or macroalgae using seedlings or seeds.</i></p>	<ul style="list-style-type: none"> <li>• If introduction/ transplanting of seagrass meadows or macroalgae beds will result in take of E corals, a research or enhancement permit would be needed under <a href="#">ESA sec 10(a)(1)(A)</a>.</li> <li>• Compliance with <a href="#">Caribbean Acropora 4(d) rule for T elkhorn &amp; staghorn coral</a>. Scientific and enhancement permit required under terms of the <a href="#">4(d) rule</a> for same activities described above for E corals (form of permit varies).</li> <li>• If a project involves introduction/ transplanting of seagrass meadows or macroalgae beds that "may affect" T or E corals or non-coral T or E species or adversely modify or destroy designated critical habitat and the activity is authorized, funded, or carried out by a Federal agency, interagency consultation would be required under <a href="#">ESA sec 7(a)(2)</a>.</li> <li>• If a project involving introduction/ transplanting of seagrass meadows or macroalgae beds will cause incidental take of T or E corals or non-coral T or E species and the project is not authorized, funded, or carried out by a Federal agency, an incidental take permit would be needed under <a href="#">ESA sec 10(a)(1)(B)</a> (for E species) or an applicable <a href="#">ESA sec 4(d) rule</a> (for T species).<sup>A</sup></li> </ul>	<ul style="list-style-type: none"> <li>• For T species other than elkhorn &amp; staghorn coral, an <a href="#">ESA 4(d) rule</a> could govern activities associated with import, export, take (e.g., collection, harassment, wounding, killing), captive management, captive breeding, relocation, and release. For an example, see the <a href="#">Caribbean Acropora elkhorn &amp; staghorn 4(d) rule</a>.</li> </ul>

<sup>A</sup> An ESA section 10(a)(1)(B) incidental take permit is not available for incidental take of E species that occurs on the high seas.

<sup>B</sup> The Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act (65 Fed. Reg. 56916, Sept. 20, 2000) contains 14 points for what a controlled propagation program for ESA-listed species should be consistent with. For purposes of this table, in some instances we point out specific points within the policy to focus the considerations, even though all points apply. Persons involved with the interventions should read the entire policy to understand the breadth of considerations and associated risks.



## Discussion of ESA Requirements and Considerations

This section describes the provisions of the ESA and accompanying implementing regulations, if any, that inform the requirements and considerations related to coral conservation and the 23 interventions. The full content of the ESA can be found at [ESA of 1973](#).

This section is organized into an overview of relevant sections of the ESA and NMFS' ESA implementing regulations and then applicable policy and guidance documents. Table 1 (above) contains the 23 interventions with links to the following ESA requirements and considerations applicable to each intervention.

## ESA Prohibitions and Exceptions to the Prohibitions

### *ESA Section 9*

After a species of fish or wildlife<sup>1</sup> is listed as endangered (note: for threatened species see section 4(d) below), section 9 makes it unlawful for any person<sup>2</sup> subject to the jurisdiction of the United States to engage in prohibited acts with such species, with certain exceptions to the prohibitions provided in sections 6(g)(2)<sup>3</sup>, 9, and 10. One of the prohibited acts is to “take” endangered fish and wildlife, which is defined in section 3 of the ESA to mean harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct. “Harm” is defined in NMFS' ESA implementing regulations at Title 50 of the Code of Federal Regulations (CFR), section 222.102 ([50 CFR 222.102](#)) (see [ESA Implementing Regulations](#) section below). Any State may enact laws and regulations on taking that are more restrictive, but not less restrictive, than those provided for under the

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<sup>1</sup> “Fish or wildlife” is defined broadly to include not only live or dead whole specimens but also parts, products, eggs, and offspring.

<sup>2</sup> Under the ESA, a “person” is defined broadly under section 3 to include not only individuals but also corporations, partnerships, trusts, associations, and any other private entity along with any State, local, Federal, or foreign government and any other entity subject to the jurisdiction of the United States.

<sup>3</sup> For purposes of this legal and policy review, the exception to the ESA take prohibition provided in section 6(g)(2) does not apply. As of August 2020, NMFS cooperative agreements with States have been established under section 6(c)(1) (fish or wildlife) based on the State's ability to authorize and conduct investigations of resident species, establish programs (including the acquisition of land or aquatic habitat or interests therein) for the conservation of resident endangered or threatened species, and provide public participation for designating resident species as threatened or endangered. For the cooperative agreements between NMFS and the States, these provisions must be complied with and plans must be included to give immediate attention to those resident species determined to be threatened or endangered and that are in need of urgent conservation. NMFS is authorized to provide financial assistance to States with these cooperative agreements. However, these cooperative agreements do not affect the applicability of the take prohibition for resident species as set forth in section 9(a)(1) for endangered species or established for a threatened species under section 4(d).

ESA, so persons engaged in activities that may result in the take of an ESA-listed species should also consult the laws of their State.

The entire list of prohibited acts for endangered fish and wildlife is:

- import into or export from the United States;
- take any such species within the United States or the territorial sea of the United States;
- take any such species on the high seas;
- possess, sell, deliver, carry, transport, or ship any such species taken in violation of section 9;
- deliver, receive, carry, transport, or ship in interstate or foreign commerce and in the course of a commercial activity;
- sell or offer for sale in interstate or foreign commerce; or
- violate any ESA regulation pertaining to such species.

Under section 9(b)(1), a narrow exception applies to the import/export prohibition and the prohibition against violating regulations for endangered or threatened fish and wildlife that were held in captivity or in a controlled environment on the date the species was listed under the ESA, provided that the holding and any subsequent holding or use was not in the course of a commercial activity. This exception for fish and wildlife held in captivity or in a controlled environment does not apply to the prohibition against take.

After a species of plant is listed as endangered (note: for threatened plants see section 4(d) below), section 9 makes it unlawful for any person subject to the jurisdiction of the United States to engage in prohibited acts with such species, with certain exceptions to the prohibitions provided in sections 9 and 10. There is no “take” prohibition for plants.

Prohibited acts for endangered plants are:

- import into or export from the United States;
- remove and reduce to possession from areas under Federal jurisdiction; maliciously damage or destroy on an area under Federal jurisdiction; remove, cut, dig up, or damage or destroy on any other area in knowing violation of any State law or regulation or in the course of violating a State criminal trespass law;
- deliver, receive, carry, transport, or ship in interstate or foreign commerce and in the course of a commercial activity;
- sell or offer for sale in interstate or foreign commerce; or
- violate any ESA regulation pertaining to such species.

For both fish and wildlife and plants, it is also unlawful under section 9(g) for any person subject to the jurisdiction of the United States to attempt to commit, solicit another person to commit, or cause to be committed any offense that is listed under section 9.

This legal and policy review presumed that individuals and entities participating in one or more of the coral interventions would not be doing so on a commercial or monetary basis (e.g., not engaged in selling ESA-listed coral specimens in interstate or foreign commerce, not engaged in acts such as shipping or receiving ESA-listed coral specimens in interstate or foreign commerce in the course of a commercial activity). Therefore, the focus of the ESA requirements in Table 1 is on the more likely activities, such as the import or export of coral specimens for research or interventions that may result in the taking (e.g., harassing, harming, wounding, killing, or collecting) of coral specimens. Nonetheless, persons participating in the coral interventions should be aware of restrictions related to commercial use of endangered and threatened species.

Section 9 also prohibits any person subject to the jurisdiction of the United States from engaging in any trade or possessing any specimens contrary to the provisions of CITES.

#### ***ESA Section 4(d)***

Section 4(d) of the ESA provides the authority for NMFS to develop both the prohibitions and exceptions to those prohibitions for threatened species of fish, wildlife, and plants. Whereas the prohibitions and exceptions for endangered species are set by the statute and apply automatically upon listing a species as endangered, prohibitions and exceptions for a threatened species are not automatically applied and are established by the agency through regulation. NMFS issues regulations that it deems necessary and advisable to provide for the conservation of these species. In addition, NMFS may apply any of the section 9 prohibitions for endangered species to threatened species. To date, only two species of corals listed as threatened species under the ESA (*Acropora cervicornis* (staghorn coral) and *A. palmata* (elkhorn coral)) have been afforded protections through section 4(d) regulations. See the below section on regulations for staghorn and elkhorn corals.

#### ***ESA Section 4(d) Regulations for Elkhorn and Staghorn Corals***

This section describes the ESA section 4(d) protective regulations for two species of corals listed as threatened species under the ESA, *Acropora cervicornis* (staghorn coral) and *A. palmata* (elkhorn coral).

By regulation, NMFS has applied all of the prohibitions applicable to endangered species under ESA section 9(a)(1) to threatened elkhorn and staghorn corals, with certain exceptions. Thus, among other things, the import, export, take, sale or offer for sale in interstate or foreign commerce, and transport or similar acts in interstate or foreign commerce in the course of a commercial activity are prohibited unless covered by one of the following exceptions. Exceptions from the prohibitions include for 1) scientific research and enhancement (either through authorization from a specified natural resource agency or under ESA section 10(a)(1)(A)), 2) take for restoration activities conducted by

any agent or employee of certain governmental agencies when authorized by an existing authority, and 3) take that is incidental to otherwise lawful activities. Activities under most of these exceptions require a permit. Restoration activities covered by the exception are defined as “methods and processes used to provide aid to injured individual elkhorn or staghorn coral.” The complete regulations are found at [50 CFR 223.208](#).

### *ESA Section 10*

Section 10(a) of the ESA provides exceptions to the section 9 prohibitions for endangered species (including allowing activities such as import, export, take, and sale) through the issuance of permits by NMFS for scientific purposes, to enhance the propagation or survival of the affected species, and for take that is incidental to, and not for the purpose of, carrying out of an otherwise lawful activity. Section 10(j) provides for the development of regulations to relax restrictions associated with establishing experimental populations of endangered or threatened species. Details on permit requirements are at: <https://www.fisheries.noaa.gov/permits-and-forms#protected-resources>.

### *ESA Section 10 Implementing Regulations*

This section describes the ESA implementing regulations for section 10(a)(1)(A), 10(a)(1)(B), and 10(j) requirements that may be helpful in understanding the section 10 requirements when considering the 23 interventions.

- **50 CFR 222.307 Permits for incidental taking of species.** Permits may be issued under section 10(a)(1)(B) of the ESA to authorize the otherwise prohibited take of endangered species (or threatened species, if take has been prohibited through a section 4(d) rule) where that take is incidental to an otherwise lawful activity. Applications for an incidental take permit must include, among other things, a conservation plan that specifies the anticipated impact on the species and its habitat and steps that will be taken to monitor, minimize, and mitigate such impacts.
- **50 CFR 222.308 Permits for scientific purposes or for the enhancement of propagation or survival of species.** Permits may be issued under section 10(a)(1)(A) of the ESA to authorize take or any of the other prohibited acts (import, export, sale, transport in the course of commercial activity, etc.) for scientific purposes or for the enhancement of the propagation or survival of the affected endangered species (or for threatened species, if take or other activities have been prohibited through a section 4(d) rule) and under such terms and conditions as NMFS may prescribe. In deciding whether to issue a permit, the agency considers, among other things, whether the permit would further a bona fide and necessary or desirable scientific purpose or would enhance the propagation or survival of the species, taking into account the benefits anticipated on behalf of the species.

- **50 CFR 222.501-504 Experimental populations.** Section 10(j) of the ESA allows for the establishment of experimental populations (through the release of eggs, propagules, or individuals) upon a finding that the population will further the conservation of the species. The term *experimental population* means any introduced and/or designated population (including any offspring) when, and at such times as, the population is wholly separate geographically from nonexperimental populations of the same species. If there is partial overlap with nonexperimental populations of the same species at certain times but the experimental population is wholly separate at other times, specimens of the experimental population are considered as part of the listed entity in the area of overlap. That is, experimental status will only be recognized outside the areas of overlap and when the times of geographic separation are reasonably predictable (e.g., fixed migration patterns, natural or man-made barriers).

Members of an experimental population that is classified as *nonessential* are treated for purposes of section 7 interagency consultation as if the species were proposed to be listed under the ESA (and therefore conferencing, not consultation, with NMFS is required), unless the Federal agency action occurs within an area of the National Park System or the National Wildlife Refuge System. Critical habitat is not designated for nonessential experimental populations. Finally, all members of a nonessential experimental population are treated as a threatened species (even if the species is listed as endangered), allowing for the development of an ESA section 4(d) rule to tailor prohibitions and any exceptions to the prohibitions appropriate for the needs of the population.

## ESA Consultation Process

### ESA Section 7

Section 7(a)(2) of the ESA requires each Federal agency to consult with NMFS to insure any action that the Federal agency authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in destruction or adverse modification of designated critical habitat<sup>4</sup> for the species. Federal agencies must also confer with NMFS on any actions that are likely to jeopardize the continued existence of any species proposed to be listed under the ESA or result in destruction or adverse modification of proposed critical habitat. See the implementing regulations (below) for a brief description of how Federal agencies should meet these requirements.

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<sup>4</sup> Critical habitat has been designated for elkhorn (*A. palmata*) and staghorn (*A. cervicornis*) corals ([50 CFR 226.216](#)).

## ***ESA Section 7 Implementing Regulations***

This section describes the implementing regulations for interagency consultation that may be helpful in understanding the obligation to consult and the scope of such consultation when considering the 23 interventions. To the extent that an ESA section 10 permit would be required, NMFS would consult on the issuance of the permit, and potential permit applicants (e.g., States, researchers) should be aware of their roles and responsibilities under the consultation process.

- **50 CFR 402.12 Biological assessments.** Biological assessments evaluate the potential effects of the action<sup>5</sup> on listed and proposed species and designated and proposed critical habitat. Biological assessments determine whether any such species or critical habitat are likely to be adversely affected by the action and are used in determining whether formal consultation or a conference is necessary. Where listed species and/or designated critical habitat occur in the action area<sup>6</sup>, a biological assessment is required for Federal actions that are “major construction activities” and must be completed before any contract for construction is entered into and before construction is begun. If conducting a biological assessment will involve the taking of a listed species, a permit under ESA section 10 or an exception under section 4(d) regulations (for threatened species) is required.
- **50 CFR 402.14 Formal consultation.** Formal consultation is required when a Federal action may affect listed species or designated critical habitat. The exception is when a biological assessment or informal consultation results in a determination that the action is not likely to adversely affect any listed species or designated critical habitat. Any request for formal consultation may encompass a number of similar individual actions within a given geographical area, a programmatic consultation, or a segment of a comprehensive plan. Regardless of the scope of the consultation, the Federal agency must consider effects of the action or actions as a whole. During formal consultation, NMFS reviews all relevant information provided by the Federal agency using the best scientific and commercial information available. The Service evaluates the current status and environmental baseline of the listed species or designated critical habitat and the effects of the action and cumulative effects<sup>7</sup>, which are added to the environmental baseline. Based on its evaluation, NMFS issues an opinion as to whether the action is likely to jeopardize

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<sup>5</sup> *Effects of the action* means all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action.

<sup>6</sup> *Action area* means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

<sup>7</sup> *Cumulative effects* are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation.



the continued existence<sup>8</sup> of any listed species or result in the destruction or adverse modification<sup>9</sup> of designated critical habitat. For a jeopardy or adverse modification determination, NMFS works with the Federal agency and any applicant on the availability of reasonable and prudent alternatives. The NMFS opinion will include a statement concerning incidental take, if such take is reasonably certain to occur, to ensure the take will not violate section 7(a)(2) and section 9, and, in the case of marine mammals, where the incidental take is also authorized pursuant to section 101(a)(5) of the Marine Mammal Protection Act of 1972. The incidental take statement sets forth the terms and conditions (including, but not limited to, reporting requirements) that must be complied with by the Federal agency or any applicant to implement the measures specified as a result of the formal consultation. The statement will also specify the procedures to be used to handle or dispose of any individuals of a species actually taken. In order to monitor the impacts of incidental take, the Federal agency or any applicant must report the progress of the action and its impact on the species to NMFS as specified in the incidental take statement.

## **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**

CITES is an international treaty that is implemented by the United States through sections 8A and 9(c) of the ESA. As of August 2020, the import, export, and introduction from the sea of about 5,800 species of wildlife (including 1,567 species of coral) and 30,000 species of plants are regulated under CITES. Regulated specimens include not only live specimens, but also dead specimens and any readily recognizable parts and products (e.g., tissue samples, gametes). The parties to the Convention have specified which forms of coral are readily recognizable by Resolution.

The [Convention](#), [Resolutions](#) that provide detail on interpretation and implementation of the Convention, and [Appendices](#) that list protected species can be found at [CITES.org](https://www.cites.org), the official website administered by the CITES Secretariat. U.S. implementing regulations for CITES are found at [50 CFR part 23](#).

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<sup>8</sup> *Jeopardize the continued existence of* means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

<sup>9</sup> *Destruction or adverse modification* means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.



## ESA Recovery Plans

### *ESA Section 4(f)*

Section 4(f) of the ESA requires the development and implementation of a recovery plan for the conservation and survival of ESA-listed species, unless NMFS finds that such a plan would not promote the species' conservation. Each recovery plan includes (to the maximum extent practicable) three components: 1) site-specific management actions that are necessary to achieve the plan's goal to conserve the species (referred to as recovery actions or, in some older plans, recovery tasks); 2) objective, measurable criteria which, when met, would result in a determination that the species be removed from the list of endangered and threatened species (referred to as recovery criteria); and 3) estimates of the time required and the cost to carry out those measures needed to achieve de-listing of the species and to achieve intermediate steps toward that goal.

Recovery plans serve as the guide for NMFS' conservation and management of an ESA-listed species and therefore are an important consideration in any management actions for the species, such as controlled propagation programs. A recovery plan for elkhorn and staghorn coral was completed in 2015 (see the section below for details).

### ***Recovery Plan for Elkhorn (*Acropora palmata*) and Staghorn Coral (*A. cervicornis*)***

A recovery plan has been developed for two species of coral: elkhorn coral (*A. palmata*) and staghorn coral (*A. cervicornis*). Recovery actions contained in the plan include reducing the impact of major threats to the species, monitoring to provide information on the status of the species, research to fill information gaps important for conservation, and restoration to increase abundance of populations. Two recovery actions related to addressing the effects of climate change include interventions to increase resilience to climate stress.

Recovery Action 10 is to “develop and implement environmentally sound mechanisms to reduce local impacts of temperature stress.” The description identifies the need for geo-engineering solutions to both increase surface ocean alkalinity and reduce thermal stress to alleviate short-term, local effects of climate stress. It also notes that local mitigation efforts to increase alkalinity and reduce bleaching should be critically evaluated in terms of risks and benefits.

Recovery Action 11 is to “research and develop mechanisms to enhance adaptation/acclimation of elkhorn and staghorn corals to increases in climate stress.” The action identifies the need to research and test biological or physiological enhancements that might improve these species' resistance to climate changes (both the cnidarian host and symbionts). It also warns of potential physiological tradeoffs of seemingly adaptive traits (e.g., thermally tolerant genotypes might

display slower growth or reduced reproductive potential) that may occur with any biological or physiological interventions.

## Applicable ESA Policy and Guidance Documents

### ***Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act.***

The [Policy Regarding Controlled Propagation of Species Listed Under the ESA](#) (65 Fed. Reg. 56916, Sept. 20, 2000; FWS and NMFS 2000), published jointly by NMFS and the U.S. Fish and Wildlife Service (together, the Services), addresses the role of controlled propagation in the conservation and recovery of species listed as endangered or threatened under the ESA. For the purposes of the policy, controlled propagation refers to the production of individuals, generally within a managed environment, for the purpose of supplementing or augmenting a wild population(s), or reintroduction to the wild to establish new populations. The policy provides guidance and establishes consistency for use of controlled propagation as a component of a listed species recovery strategy. The policy states that though controlled propagation has a supportive role in the recovery of some listed species, it is not a substitute for addressing factors responsible for a listed species' decline. The Services' first priority is to recover wild populations in their natural habitat wherever possible, without resorting to the use of controlled propagation.

The scope of the policy encompasses ESA candidate, proposed, and listed species indigenous to the United States and its territories for which the Services have, or intend to prepare, recovery plans. This policy focuses primarily on those activities involving gamete transfer and subsequent development and grow-out of offspring in a laboratory, botanical facility, zoo, hatchery, aquarium, or similarly controlled environment.

The policy consists of 14 points (which are summarized here) that controlled propagation will be:

1. Used as a recovery strategy only when other measures employed to maintain or improve a listed species' status in the wild have failed, are determined to be likely to fail, are shown to be ineffective in overcoming extant factors limiting recovery, or would be insufficient to achieve full recovery.
2. Coordinated with conservation actions and other recovery measures, as appropriate or specified in recovery plans that will contribute to, or otherwise support, the provision of secure and suitable habitat.
3. Based on the specific recommendations of recovery strategies identified in approved recovery plans or supplements to approved recovery plans whenever practical.

4. Based on specific consideration of the potential ecological and genetic effects of the removal of individuals for controlled propagation purposes on wild populations and the potential effects of introductions of artificially bred animals or plants on the receiving population and other resident species.
5. Based on sound scientific principles to conserve genetic variation and species integrity. Intercrossing<sup>10</sup> will not be considered for use in controlled propagation programs unless recommended in an approved recovery plan or supported in an approved genetic management plan<sup>11</sup>.
6. Preceded, when practical, by the development of a genetics management plan based on accepted scientific principles and procedures. All efforts will be made to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that propagated individuals are behaviorally and physiologically suitable for introduction. Controlled propagation activities should not be initiated without obtaining required permits and other authorizations as necessary. Programs involving the controlled propagation of ESA-listed species for research purposes identified in final recovery plans and in which progeny will not be reintroduced to the wild are exempt from this policy.
7. Conducted in a manner that takes all known precautions to prohibit the potential introduction or spread of diseases and parasites into controlled environments or suitable habitat.
8. Conducted in a manner that will prevent the escape or accidental introduction of individuals outside their historic range.
9. Conducted, when feasible, at more than one location in order to reduce the potential for catastrophic loss at a single facility when a substantial fraction of a species or important population segment is brought into captivity.
10. Coordinated, as appropriate, with organizations and qualified individuals both within and outside the Services—other Federal agencies and State, Tribal, and local governments.
11. Conducted in a manner that will meet the Services' information needs and that will be in accordance with accepted protocols and standards.

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<sup>10</sup> "Intercross" is defined in the policy as "any instance of interbreeding or genetic exchange between individuals of different species, subspecies, or distinct population segments of a vertebrate species." On February 7, 1996 (61 FR 4710), the Services published a proposed policy and rule on intercrosses and their progeny. Because the proposed intercross policy and rule was not finalized, we do not include its description in this legal and policy review or discuss it further. The full content of the proposed policy and rule can be found at: the [Proposed Policy and Proposed Rule on the Treatment of Intercrosses and Intercross Progeny](#).

<sup>11</sup> As of August 2020, NMFS does not have a genetics management plan for corals. However, NMFS has several genetics management plans for salmonids related to hatcheries. See, for example, the salmon and steelhead hatcheries website: <https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/salmon-and-steelhead-hatcheries-west-coast>

12. With limited exceptions, implemented only after a commitment to funding is secured.
13. Prior to releases of propagated individuals, tied to development of a reintroduction plan, unless this information is already contained in an approved recovery plan, species survival plan, or equivalent document that has received the approval of the appropriate Service. On implementation, periodic evaluations must be made to assess project progress and consider new scientific information and the status of habitat conservation efforts.
14. Conducted in accordance with the regulations implementing the ESA, Marine Mammal Protection Act, Animal Welfare Act, Lacey Act, Fish and Wildlife Act of 1956, and the Services' procedures relative to NEPA.

Considerations for the use of controlled propagation include genetic and ecological risks associated with introducing to the wild species bred and reared in a controlled environment. If controlled propagation is identified as an appropriate strategy for recovery, it must be conducted in a manner that will, to the maximum extent possible, preserve the genetic and ecological distinctiveness of the listed species and minimize risks to existing wild populations. Risks that must be evaluated in the planning of controlled propagation programs include:

- Removal of natural parental stock that may result in an increased risk of extinction by reducing the abundance of wild individuals and reducing genetic variability within naturally occurring populations;
- Equipment failures, human error, disease, and other potential catastrophic events that may cause the loss of some or all of the population being held or maintained in captivity or cultivation;
- Potential for an increased level of inbreeding or other adverse genetic effects within populations that may result from the enhancement of only a portion of the gene pool;
- Potential erosion of genetic differences between populations as a result of mixed stock transfers or supplementation;
- Exposure to novel selection regimes in controlled environments that may diminish a listed species' natural capacity to survive and reproduce in the wild;
- Genetic introgression, which may diminish local adaptations of the naturally occurring population;
- Increased predation, competition for food, space, mates, or other factors that may displace naturally occurring individuals, or interfere with foraging, migratory, reproductive, or other essential behaviors; and
- Disease transmission.

## ***Management Plan for Caribbean Acropora Population Enhancement***

This section describes the management plan for Caribbean *Acropora* that informs considerations for some of the 23 interventions. The full plan can be found at the [Management Plan for Caribbean Acropora Population Enhancement](#).

The purpose of the management plan for *Acropora palmata* and *A. cervicornis* is 1) to ensure adherence to the Policy Regarding Controlled Propagation of Species Listed under the ESA, and 2) to ensure active propagation of elkhorn and staghorn corals maximizes the species' recovery potential as informed by the goals, actions, and criteria identified in the Acropora Recovery Plan. The Management Plan pertains to any efforts to propagate *A. palmata* or *A. cervicornis* when the intention is to release propagated individuals for reintroduction or augmentation of existing populations, or to establish or maintain refugia populations (populations removed from the wild). The management plan describes recommendations that have been developed to: 1) reduce the impact of collection and propagation of corals in nurseries on wild populations of corals and other marine life, 2) reduce the chances of introduction and spread of disease, 3) increase the chances of successfully culturing and outplanting colonies, 4) ensure genetic diversity and species integrity is maintained both in wild and outplanted populations, and 5) aid in record keeping and tracking of collected, propagated, and outplanted corals.

Although it was written before the NASEM Report, the plan provides guidance relevant to some of the interventions described in the NASEM Report (NASEM 2019), particularly with regard to reducing health and genetic risks when propagating these two species for population enhancement purposes. Many of the interventions rely on existing coral restoration practices, facilities, and professionals to implement the interventions. Thus, the factors considered in the plan should also underlie any interventions that make use of propagation facilities. The plan is meant to be a living document informed by the evolving science of coral propagation and restoration. The NMFS Southeast Region anticipates updating the plan to address propagation of the other ESA-listed Caribbean corals for population enhancement and to incorporate more of the interventions described in the NASEM Report.

The plan outlines four considerations for coral propagation:

- **health:** Currently, coral disease etiology is largely unknown. Disease is believed to be more prevalent in stressed corals, and there is some stress associated with handling and moving corals. Also, disease is endemic in the wild population, and global climate stress continues to impact wild, cultured, and outplanted corals alike. Practices to reduce the risk of disease introduction or transfer are described in the plan and focus on reducing the risk of disease introduction when placing corals into a nursery environment, reducing the spread of disease while in culture, and minimizing the risk of disease when outplanting back to the reef.

- **genetics:** Factors to consider include how selective propagation will affect the genetic structure of restored populations and the genetic diversity of the microbial and algal communities (zooxanthellae) that reside within the coral host. Asexual propagation methods that can produce a large number of genetically identical clones are of particular concern because of the possibility of swamping the population with a small number of genotypes. Practices are described in the plan to reduce the genetic risk including culturing and outplanting many genotypes, housing individual genotypes in multiple locations to reduce the risk of losing entire genotypes due to catastrophic events, and exposing sexually produced larvae to local zooxanthellae and microbial communities. The plan supports research on algal and microbial community culture and inoculation, selection in coral culture and outplanting efforts, targeted translocation of coral genotypes, and selective coral breeding, but it identifies maintenance of genetic diversity as a primary concern in both culture and outplanting for population enhancement. The plan does not support hybridization between species as a population enhancement technique. While acknowledging that research is warranted, the plan identifies outcrossing more resistant/resilient genotypes of the same species, rather than performing crosses between species, as the preferred path to preserve genetic distinctiveness and limit introgression of genes of one species into the other.
- **culture:** Corals can be cultured in *ex situ* and *in situ* nurseries. *In situ* nurseries are in water and use some sort of structure to attach corals. Any nursery structure that uses suspended line has the potential risk of entanglement with marine life, which may have consequences if it is a protected species like threatened and endangered sea turtles. Recommendations are provided in the plan to reduce the risk of entanglement as well as for nursery siting and regular maintenance important for keeping corals alive and healthy. All colonies in nurseries should be tracked for genetic relationships (i.e., track which fragments came from which parent colony). For *ex situ* nurseries, the plan provides recommendations for water quality, water flow, temperature, and light levels that are important factors influencing coral condition and growth.
- **outplanting:** Outplanting sites must coincide with species' needs. For *Acropora*, depth and reef zone are important selection factors. Other aspects to consider when choosing outplant sites include historical presence of *Acropora* and presence of stressors.



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**Box 1. Elkhorn Coral Cross-Population Breeding Project**

*In Florida, the population of elkhorn coral (*A. palmata*), a species listed as threatened under the ESA, has become increasingly reduced in number, colony size, and genotypic diversity over the past two decades, ultimately increasing reproductive isolation (Williams et al. 2020). In an effort to address these declines and introduce more genetic diversity into the Florida population, a project was undertaken to test whether cryopreserved sperm could be used to assist gene flow between genetically isolated populations (Hagedorn et al. 2018). Sperm were collected from Florida, Puerto Rico, and Curaçao under applicable permits and cryopreserved. The cryopreserved sperm were combined with freshly collected eggs from Curaçao for in vitro fertilization experiments. After fertilization, the resulting larvae were shipped to two facilities in Florida where they were settled on tiles and maintained ex situ. The experiments were highly successful and produced over 4,700 larval settlers (Hagedorn et al. 2018).*

*This experiment used reproductive interventions, including coral cryopreservation and outcrossing between populations, identified in the NASEM Report, and if the colonies are eventually released into the wild, supportive breeding and gamete capture and seeding can be added to the list. However, the corals remain in captivity in land-based facilities. Some of the colonies are planned for lab-based stress tolerance experiments, but the remaining colonies are beginning to grow too large to house and too costly to maintain.*

*Several risks have been identified that should be considered when deciding whether these corals should be released into the wild. The first is outbreeding depression (the reduction in fitness that may occur when two genetically distant populations are crossed) and/or swamping (local genotypes are replaced by the genotypes resulting from the crosses between the genetically distant populations). These considerations were identified in the NASEM Report and are particularly important if the colonies resulting from crossed populations produce larvae that will be transported outside the reef system where they originated. The second is the possibility that the crossed population colonies could be susceptible to infectious disease or novel symbionts and provide a conduit back to native colonies. An example of this is the bird flu where viruses naturally present in wild bird populations that do not cause much of a problem can infect domestic poultry and other species and cause severe illness and mortality. The final risk is that not introducing new genotypic and allelic diversity into the Florida population may result in local extirpation. Time is running short as the Florida population continues to decline. Ultimately, the Federal and State agencies that permit research and restoration in Florida will have to decide, hopefully with the input of other stakeholders including researchers, conservation organizations, and natural resource management agencies, what risks they are willing to take.*

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## **Box 2. White Abalone Captive Propagation and Enhancement**

*In California, white abalone (*Haliotis sorenseni*), a marine snail listed as endangered under the ESA in 2001, continues to decline and shows few signs of natural recovery despite the removal of the main threat to the species, overfishing, 23 years ago (Catton et al. 2016). The white abalone recovery team identified human intervention through a captive propagation and enhancement program as the primary recovery action to reduce extinction risk (NMFS 2008). Broodstock collected from natural reefs in California in 1999, 2000, and 2004 produced several captive cohorts, totaling hundreds of thousands of first generation white abalone that were to be placed on native reefs to restore wild populations. Unfortunately, most of these abalone befell an unexpected fate. A disease known as Withering Syndrome spread throughout the rearing facility and caused mass mortality of the captive white abalone. Prior to this time, there was no evidence to suggest that white abalone were susceptible to this bacterial infection and disease was not identified as a factor in the decline of the species in the wild (Hobday et al. 2000).*

*With this setback, the recovery partners refocused on developing tools to prevent further losses of abalone that survived the disease outbreak and reduce the risk of future outbreaks in captive facilities (Friedman et al. 2007). The protective measures included: antibiotic treatments (Moore et al. 2019); water and kelp treatment to prevent the introduction of the pathogen into captive breeding facilities; a stricter regimen of health monitoring; and expanding the number of captive facilities to reduce the impact of a catastrophic event at any one facility.*

*The captive breeding program has steadily rebounded over the last decade, but not without several challenges that have required multiple assessments of risks and benefits. For example, reliable methods for inducing reproduction of broodstock has been limited, especially among the remaining wild-collected broodstock. This resulted in a decrease in genetic diversity within an increasingly large captive population. Over roughly the same time frame, a small number of adult white abalone were observed in the wild for the first time since 2004. Experts debated the pros and cons of collecting additional wild broodstock. The benefits of collection included the possibility that these animals may be reproductively conditioned in nature and therefore more likely to produce abundant and healthy gametes. Assuming gamete production occurs, new wild adult broodstock would inject novel genes into the captive population, increasing the potential for meeting production and enhancement goals. Risks associated with collection included mortality during collection and removal of abalone that might otherwise have an opportunity to reproduce in nature. NMFS identified a cautious path forward. A phased collection of new wild broodstock, with strict conditions that minimize risk to the wild population, is underway and includes: 1) collection of abalone that are reproductively isolated from potential mates; or 2) collection of abalone that are living in unsuitable and/or dangerous habitats; and 3) the ability to return healthy white abalone to the wild if they are not helping to increase the genetic diversity of the captive population after several years. In 2019 and 2020, the captive breeding program produced two new cohorts of first generation captive white abalone for the first time since the early 2000s. Currently, the program holds over 30,000 captive-bred white abalone, from multiple genetic lineages. A large portion of these white abalone will be placed in the wild over the next 3-4 years in order to achieve NMFS' overall goal of recovering white abalone populations in the wild throughout their range.*

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## Conclusion

This document serves as a guide for identifying ESA requirements and considerations for each of the 23 coral interventions identified by the NASEM Report. Depending on the particular details of each project, various restrictions and regulatory requirements of the ESA and CITES may apply. These include, but are not limited to, prohibitions on taking and importing specimens, as well as consultations, permits, and other authorizations, and other requirements and considerations for ESA-listed corals, other protected species, and any designated critical habitat that may be adversely modified or destroyed by activities related to the project. Additionally, some interventions may be of higher priority based on expected benefit, potential risk, and management needs. Applicable policies such as the Policy Regarding Controlled Propagation of Species Listed under the Endangered Species Act and guidance documents such as recovery plans and management plans should be consulted to ensure consistency with agency management and recovery goals. Those who wish to undertake projects to implement any of the coral interventions are encouraged to discuss their project with their regional NMFS office to help determine how the ESA and CITES may apply. Researchers, resource managers, and others should also discuss with their regional NMFS office and their legal counsel what steps they need to take to be in compliance with the ESA, CITES, and all other applicable laws.

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## Appendices:

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II. Table 6.1 from National Academies of Sciences, Engineering, and Medicine 2019  
 (A RESEARCH REVIEW OF INTERVENTIONS TO INCREASE THE PERSISTENCE AND RESILIENCE OF CORAL REEFS)

**TABLE 6.1** Overview of Interventions Examined in This Report

Intervention	What It Is	Current Feasibility	Potential Scale	Limitations	Risks
<b>Genetic and Reproductive Interventions</b>					
Managed Selection	Creating increased frequency of existing tolerance genes	In laboratory and at small local scales	Local reef scale; potentially transgenerational	Needs large populations	Decrease in genetic variation
Managed Breeding; Supportive Breeding	Enhancing population size by captive rearing and release	Success with some species at small scales	Local reef population; potentially transgenerational	Depends on sufficient population sampling and recruitment success of released individuals	Decrease in genetic variation
Managed Breeding; Outcrossing Between Populations	Introducing diversity from other populations through breeding	Demonstrated in laboratory for a few species	Local reef population; potentially transgenerational	Requires transport of gametes or colonies across distances and field testing across generations	Outbreeding depression; native genotypes may be swamped
Managed Breeding; Hybridization Between Species	Creation of novel genotypes through breeding	Demonstrated in laboratory for a few species	Local reef population; potentially transgenerational	Limited ability to create hybrids; requires testing for fertility and fitness	Outbreeding depression; competition with native species
Gamete and Larval Capture and Seeding	Collection and manipulation in the field and laboratory and release into the wild	Feasible at local scales	Laboratory to local reef scale; potentially transgenerational	Site-specific reproductive timing, recruitment success can be poor	Limited genetic diversity; selection for laboratory versus field success
Coral Cryopreservation	Frozen storage of gametes and other cells for later use and transport	Feasibility is high for sperm, and growing for other tissue types	Materials can be transported globally	Requires excess gametes, larvae, or tissues	Long-term survival uncertain; genetic variation reflects only current conditions

Genetic Manipulation: Coral	Altering coral genes for new function	Technically feasible for larvae	Would occur in laboratory; can be self-perpetuating	Gene targets and cellular raw material unidentified, long lead time to roll out to reefs	Might alter wrong genes; unknown risks
Genetic Manipulation: Symbionts	Altering symbiont genes for new function	Not yet feasible	Would occur in laboratory; can be self-perpetuating	Technology not established; gene targets and cellular raw material unidentified	Might alter wrong genes; kill target cells; unknown risks
<b>Physiological Interventions</b>					
Pre-exposure	Using stress exposure to make colonies more tolerant	In laboratory and small-scale field trials	Local reef scale; may be temporary or transgenerational	Difficult to scale up beyond local	Could be detrimental if applied incorrectly
Algal Symbiont Manipulation	Changing algal symbionts to more tolerant types	Observed after bleaching events; demonstrated in laboratory	Individual coral colony or large spawning events; unknown longevity	Difficult to scale; easier for some coral species than others	Ecological tradeoffs, e.g., slower growth
Microbiome Manipulation	Maintaining/ increasing abundance of the native or new beneficial microbes	Demonstrated in laboratory and nursery facilities for limited coral species	Locations on reefs to reef scale; applied at times of stress	Reef-wide delivery mechanisms are lacking; lack of known beneficial microbes; little understanding of direct or indirect effects	Potential to increase deleterious microbes, decrease beneficial ones
Antibiotics	Adding antibiotics to control pathogenic microbes	Used in aquaculture and demonstration in small-scale field trials	Laboratory, aquarium, and colonies on reef; requires repeated application	Lack of specificity to target pathogens limits effectiveness	Promote antibiotic resistance in deleterious microbes; destabilization of native beneficial microbiomes

*continued*



**TABLE 6.1** Continued

Intervention	What It Is	Current Feasibility	Potential Scale	Limitations	Risks
Phage Therapy	Adding phage viruses to control pathogenic microbes	Demonstrated in laboratory experiments	Local reef scale; potential to self-propagate	Lack of identified target coral pathogens	Undesirable gene transfers across microbial populations; impact on beneficial microbes
Antioxidants	Reducing cellular oxidative damage derived from stress using chemical treatments	Demonstrated in some laboratory experiments	Laboratory only; requires repeated application	Little understanding of direct or indirect effects	May affect other reef species
Nutritional Supplementation	Using nutrients to improve fitness and increase stress tolerance	Regular use in coral research and aquaculture	Laboratory and aquarium; requires repeated application	Poor understanding of balanced coral diets; reef-wide delivery mechanisms are lacking	Shifts carbon, nitrogen, and phosphate balance and may benefit coral competitors
<b>Coral Population and Community Interventions</b>					
Managed Relocation: Assisted Gene Flow	Increasing abundance of stress-tolerant genes or colonies within population range	Technically feasible with information gaps regarding successful methods	Regional reef scale; can be permanent	Uncertain maintenance of stress tolerance over time	Moving nontarget genes; ecological tradeoffs
Managed Relocation: Assisted Migration	Moving stress-tolerant or diverse genes or colonies just outside species' range	Technically feasible with information gaps regarding project design	Regional reef scale; can be permanent	Uncertain maintenance of stress tolerance and persistence over time between locations	Moving nontarget genes, species, and microbes; ecological tradeoffs

Managed Relocation: Introduction to New Areas	Moving stress-tolerant or diverse genes or colonies to new regions	Untested though technically feasible with information gaps regarding project design	Global movement impacting individual reef scale; can be permanent	Uncertain maintenance of stress tolerance and persistence over time between locations	High risk of moving nontarget genes, species, and microbes; ecological tradeoffs
<b>Environmental Interventions</b>					
Shading: Atmospheric	Sky brightening to relieve light and heat stress	Untested	Local to regional scale; temporary	Needs appropriate atmospheric conditions and technology	Altered light regimes; aerosol (salt) deposition
Shading: Marine	Reducing sunlight to relieve light and heat stress	Operational at small scales	Sites within reefs; temporary	Retention and advection limit application	Altered light regimes; plastic pollution
Mixing of Cool Water	Pumping cool water onto reef to reduce heat stress	Small-scale field tests with unknown efficacy	Local reef scale; temporary	Energetically costly or impossible to scale up	Altered physical and chemical (pH, nutrients) regimes
Abiotic Ocean Acidification Interventions	Reducing CO <sub>2</sub> levels chemically	Effective in small-scale laboratory experiments	Sites within reefs depending on environmental setting; requires consistent input	Costly to scale up chemical quantities	Impact of chemicals on environment
Seagrass Meadows and Macroalgal Beds	Reducing daytime CO <sub>2</sub> levels biologically	Some efficacy shown in field measurements	Local reefs depending on environmental setting; long-term benefit	Limited environmental settings; need to remove macroalgae	Detritus; altered nutrient loads; competition from macroalgae; increased CO <sub>2</sub> at night