Hawaii Division of Aquatic Resources Coral Restoration Implementation Guide

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"*It is the regulatory community, with the advice and assistance of any and all interested parties, who must determine the appropriate balance between vital research and preservation, not those who perform the research*" (Hargrove 2008).

The following represents the Hawaii Division of Aquatic Resources (DAR) guidance for review of, and implementation requirements for, proposed coral restoration projects to occur in Hawaiian waters. It includes discussions and concerns regarding sourcing, collecting, holding, growing, and outplanting of Hawaiian corals; modifying benthic habitats, and monitoring of restoration sites; based on previously established protocols at the Hawaii Coral Restoration Nursery, and the Division's established coral permitting review procedures[1]. Of particular importance, anyone who proposes to conduct restoration activities in Hawaii must describe in detail how they propose to:

A. **Source** their corals; including minimizing collection site impacts and aquatic invasive species (AIS) and disease issues. What is the specific source location and its unique issues and concerns? What sizes and species of corals are they targeting? What impact will their take of coral have on the source site itself? What is the loss of ecological services and functions from their sourcing activity, and over what time period?

B. **Transport** their corals; including minimizing vector ecology issues.

C. **Hold** and maintain their live corals; including both coral and ecosystem health issues. What steps will be taken to quarantine corals and for what period? How will corals be tracked through the restoration process, and how will mortality / health concerns be recorded? What professional qualifications do their staff and facility have to maintain Hawaiian coral?

D. **Acclimatize** their live corals prior to re-introduction into the wild.

[1] Much of this material originated in articles by the primary author on coral disease and on Hawaii permitting concerns.

E. **Modify** and prepare their restoration site including maintenance of biodiversity and ecosystem dynamics, phase shift and invasive species concerns.

F. **Outplant** their corals; including transporting to outplant site, and monitoring concerns and frequency. What impact(s) will their outplant of coral have on the restoration site? What ecological services and functions will be gained from their activity and over what time period?

G. What is the applicant's recognized **expertise** in Hawaiian coral, coral restoration, coral husbandry and Hawaiian coral reef ecology. Have they demonstrably recognized and addressed Hawaiian coral reef impact concerns such as AIS, ecological phase shifts, and biodiversity loss with their proposed project?

Each state, territory, jurisdiction and country has their own regulations for commercial, community and research-related coral restoration activities, but in each case, local Natural Resource Trustees (NRTs) oversee their implementation. In some cases, jurisdictions overlap, requiring multiple permits, and frequently require separate and independent permitting processes. In addition, many universities, research institutions, and funding agencies have research review committees and experimental ethics policies, which result in additional strict rules governing the collection, holding, and re-introduction of live animals such as stony corals into the natural environment. In general, it is the responsibility of the coral restoration practitioner (permit applicant) to contact the NRT(s), whether in the local, state or national jurisdiction of their country or an external jurisdiction, and obtain information on their obligations and all the proper permits for their proposed restoration activity well in advance. In issuing a permit for restoration activities the NRT agency must evaluate the ethical, ecological, and economic impacts the proposed activity may have, not just on the coral reef to be restored, but on the source reef and any effects caused in between; all of these components require the NRT agency to determine the risk(s) involved across a spectrum of potential primary and secondary impacts. In Hawaii, the primary NRT for coral reefs and corals is the Hawaii Department of Land & Natural Resources (DLNR) and its Division of Aquatic Resources (DAR).

Coral reefs are among the most complex of nature's ecosystems. To allow applicants to attempt to conduct restoration of such complex systems without sufficient knowledge as to coral reef ecology in general, the unique features or functions of the targeted reef specifically, or how it differs from other coral reefs elsewhere, would be irresponsible on the State's part. A reasonable question by DAR is whether the restoration applicant has sufficient background in the unique ecology and impact regimes of Hawaiian coral reefs to prevent and/or minimize secondary and tertiary impacts from their proposed activities. Therefore, an applicant's experience in conducting restoration field work similar to that proposed plays an important role in the natural resource trustee's ability to determine risks associated with the proposed field work, identify possible direct and indirect natural resource impacts, and minimize potential conflicts arising with user groups in the targeted areas. Consequently, the applicant should be ready to address significant questions concerning their minimum field experience with corals, restoration techniques with concerns to their viability in Hawaii, health and disease, Aquatic Invasive Species (AIS) and respective vector ecology, and their documented ability to maintain healthy corals during various stages of the proposed restoration. The answers to these questions are important in regards to the State's responsibility to evaluate the applicant's ability to conduct the proposed activities safely and within acceptable margins of managed risk to the user groups, general public, and trust resources within both the targeted area and adjacent habitats.

While the State recognizes that many proposed restoration techniques and projects are novel and innovative, and that the whole field of Coral Restoration Science is relatively new; Public Trust doctrine and Hawaii's own State Constitution both mandate that the highest premium be placed on environmental protection concerns above any research or outside interest in conducting new and novel restoration activities in Hawaii.

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I. Definitions:

The following definitions are used throughout this document.

Coral Growth Forms Terminology:

Branching Forms = Colony forms that are bush-like or tree-like with colony extensions growing out as branches (Example: *Pocillopora*, *Acropora*). Usually imperforate corals.

Encrusting Forms = Colony form that is relatively flat and covers/encrusts a substrate where it occurs (Example: *Montipora*).

Massive Forms = Often mound-like colony forms that can become rather large over time (Example: *Porites*). Usually perforate corals.

Coral **Mitigation** = Actions taken to directly modify or decrease a negative impact affecting coral colonies.

Corals of Opportunity = Loose corals resulting from both natural and anthropogenic disturbances that may be available for use for restoration. In practice, rarely do such corals provide good material for other restoration projects and are best used for on-site direct restoration. A 'Corals of Opportunity Site' is a location where temporally 'Corals of Opportunity' exist.

Coral **Restoration =** The process of returning coral species diversity, colony size, form, and numbers, back to a pre-impact event state. Coral restoration may include growing colonies created asexually or sexually from source corals in either land-based (ex-situ) or in-water (in-situ) nurseries, directly translocating coral colonies or fragments from intact areas to impacted reefs, or to transplant corals to substrate stabilization structures or other forms of artificial reefs with or without grow-out in a nursery program.

Coral Specimen Terminology:

Coral **Colony** = an intact, delineated, clonal, and genetically-identical assemblage of live, interconnected coral polyps[2] within a connected skeletal matrix.

Coral **Fragment** = A loose, broken, or intentionally cut section of a live colony **< 20 cm** in diameter (i.e. longest length).

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[2] Single polyp corals such as *Fungia*, *Diaseris*, and *Cycloseris* are counted as a coral colony under this definition in so much as to allow for their regulation, data keeping purposes and to determine ecological services and functions.

Coral **Nubbin** = A loose, broken, or intentionally cut tip of a live colony (usually a branch or finger tip) **< 5 cm** in diameter (i.e. longest length).

Coral **Microfragment** = A loose, broken or intentionally cut section of a live colony, fragment, or nubbin **< 2 cm** in diameter (i.e. longest length).

The following guidelines for conversion to colony metrics (for cumulative data keeping purposes and to analyze take impacts) will be used:

- 5 fragments = 1 coral colony
- 10 nubbins = 1 coral colony
- 50 microfragments = 1 coral colony

Coral Types:

There are two basic types of stony corals:

Imperforate corals are those where the live tissue exists primarily on the outside of the skeleton and are characterized by fast-growing branching species (Example: *Pocillopora*, *Acropora*);

Perforate corals are those where the tissue extends deeper into the skeleton and are characterized by slow-growing massive forms (Example: *Porites*).

The two forms express distinctly different properties and effects that are critical to understand from a restoration standpoint. For example, imperforate corals grow far better than perforate corals in in-water nurseries.

Ecological Phase Shift: Discernable changes caused by disturbance to an ecosystem whereby it shifts from one stable state to another, often resulting in changes to trophic dynamics, keystone species, biodiversity and biomass. This can occur with even small-scale disturbances to certain coral species on a reef, and is most pronounced with endemic and/or specialist species.

Emergency Restoration: A special form of restoration that is undertaken during, or immediately after, an impact event where the primary purpose is to curtail additional impact from occurring. Example: stabilizing and securing large overturned massive corals that could roll around with wave action and cause new damage to adjacent coral areas.

Ex-Situ Coral Nurseries: Land-based facilities where coral fragments or progeny are grown under human-controlled conditions.

Genet: The colonies, fragments, or pieces of coral that all come from a single genetically-identical source.

In-Situ Coral Nurseries: Artificial (usually line, tree-like, or platform) structures in the marine environment where coral fragments are grown under natural environment conditions.

Micropredators: Certain corals can harbor small invertebrate predators (micropredators; usually molluscs, flatworms or arthropods), examples include predatory nudibranchs on *Porites*, predatory flatworms on *Montipora*, and predatory gastropods on *Pocillopora* and *Fungia*. Micropredators are often difficult to detect without experience except upon close inspection. Presence of cryptic egg cases and discrete tissue loss are often the first signs of an infestation.

Natural Resource Trustee (NRT) Agency: Under the concept that natural resources are not owned individually but are held in trust for the public, certain agencies are established in law as the recognized trustees for such resources.

Outplant Sites: The specific locations where nursery-grown or translocated corals are placed in the field; often this is the site of restoration or mitigation. For Hawaii, outplant sites are most often measured in square meters not acres.

Restoration Practitioner: The individual, group or agency conducting the restoration activity. While an individual is often listed as the permittee, usually restoration is conducted by a group, company or agency, requiring other legal documents in addition to the various individual permits.

Sensitive Area: A site where due to its protected status or unique features is vulnerable to human impacts.

Source Coral: A coral colony or portion thereof used for growing other corals for outplanting and restoration purposes.

Source Sites: A specific location where a source coral is collected.

Translocated Coral: A coral colony or portion thereof moved from one location to another for mitigation or restoration purposes.

User Overlap: A situation where multiple marine user groups (tourists, fishers, military, researchers, recreational boaters, commercial boaters, shipping, etc,) all use the same body of water during the same time period[3].

[3] Defined as multiple use of the same body of water not the habitat or coral resource.

II. Overall Rationale for Regulating Coral Restoration Activities in Hawaii:

Prior to analysis of site and species impacts, the proposed rationale for the take of the protected resource (coral or live rock) should be evaluated along the following guidelines:

A. Given that the average coral species in Hawaii naturally grows at an extremely slow rate of approximately 1 - 2 cm/year (Minton, 2013); how does the applicant offset the lost ecological services and functions for the source coral(s) for the time period required for full replacement[4] (outside of the actual restoration activity itself)? Does the applicant differentiate between effects on perforate versus imperforate corals? **Does the applicant demonstrate the required understanding of the unique aspects of Hawaiian coral ecology required to minimize their impacts?**

B. Coral Restoration activities usually involve manipulation and handling of corals; such manipulation often causes stress and small amounts of damage to the corals involved. The arrangement and placement of corals in the environment requires knowledge about their specific ecology and natural history to minimize such stress and maximize their ability to survive under the new conditions imposed by the restoration activity. Given the extremely slow natural growth rates in Hawaii and the extremely high degree of endemism, knowledge about, and experience with, Hawaiian coral species is required along with experience in maintenance and husbandry of corals under the conditions required. **Does the applicant demonstrate the required knowledge and experience in general coral husbandry and life support systems? Does the applicant demonstrate the required expertise, experience and means to maintain healthy coral for the period under which the corals would be under their care?**

C. Does the proposed collection of coral and/or the coral restoration activity demonstrably and directly benefit the people of the State of Hawaii, the management of the affected resource (by species or site), or the direct management of protected Hawaiian coral statewide?

It is hard to rationalize, where an ecological concern is raised, regulating the take or other impact of coral restoration activities on a specific site or island alone and not consider its long-term effect within the State as a whole. Note that this argument is very different than a population argument for regulation. As such, and unless stated differently, all suggested permitting guidelines below are based on State-wide concerns.

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[4] The State of Hawaii uses a Hawaii Ecological Services and Functions Characterization tool (MS Excel) available through the Division of Aquatic Resources.

With the above concerns under consideration, DAR provides these following suggestions for review[5] and incorporation into both coral restoration proposals and permitting conditions. In addition to legal requirements, coral restoration practitioners have an ethical obligation to follow best practice standards which include minimization of negative impact to source and outplant sites; decontamination of dive and scientific gear; taking steps to ensure that species, disease agents and other types of samples are not translocated between reefs, sites, islands, states, or countries; and using a source collection and outplanting strategy that is as environmentally friendly and ecologically-rational as possible.

III. Regulated Coral Restoration Activities:

All activities associated with the take, impact, or manipulation of stony coral or live rock are regulated in Hawaii; this includes (but is not limited to) collection, transport, holding, manipulation, modification, and outplanting. Additionally, concerns involving invasive species, modification of submerged substrates (such as creating and maintaining in-situ coral nurseries), impacts to other protected species, water quality, pollution and biodiversity impacts may be of concern and regulated. In some cases, transport of specimens, including live animals, fixed tissue samples, gametes and other products, parts, and derivatives may also require State, federal and/or international permits (i.e., CITES permit). Finally, there are coral restoration activities within land-based facilities that may impact coral reefs and can come under permitted regulation, for example but not limited to, flow-through seawater systems and recirculating laboratory seawater systems used for holding or culturing of coral reef specimens and effluent from facilities and where it is deposited.

IV. What Might Coral Restoration Be in The Near Future?

What may restoration look like in the near future with the advent of climate change? Hawaii will need to develop a suite of restoration tools designed specifically for the wide assortment of expected interventions necessary to address Hawaiian coral reef impacts due to climate change. Each of these to-be-developed tools pose a series of risks that need to be evaluated prior to permitting approval. Amongst the most likely tools and interventions to be considered:

A. Coral Population and Community Structure Interventions

- Increase Reef Structure and Stabilization
    - Coral Nurseries (In-situ /Ex-situ)
    - Use of Artificial Reefs as Replacement for Natural Habitat

[5] In general, items in **bold blue** should be discouraged from impact and/or take for reasons high-lighted.

- Reproduction and Recruitment
  - Gamete Capture to Enhance Population Structure
  - Enhanced Sexual Fertilization
  - Enhanced Asexual Larval Capture
  - Larval Seeding to Enhance Population Structure
  - Manipulation of Reproductive Seasons

- Maintain Hawaii's Unique Biodiversity
  - AIS Control Projects
  - Expand Existing Rare Hawaiian Coral Arks

- Managed Relocation
  - Assisted Gene Flow
  - Assisted Migration
  - Introduction to New Areas

- Increase Field Sizes of Hawaiian Corals
  - Ex-situ Nurseries
  - Grafting Large Colonies

B. Ecological and Environmental Adjustments

- Macro Algae Control
- Biocontrol Mechanisms
- Enhancements to Herbivory

C. Environmental Engineering Interventions

- Shading
- Cool Water Mixing
- Reducing Acidification (CO_2)

D. Trophic Interventions

- Limit Removal of Herbivores
- Greater Restrictions on Human Use of Wild Corals

E. Coral Physiological Interventions

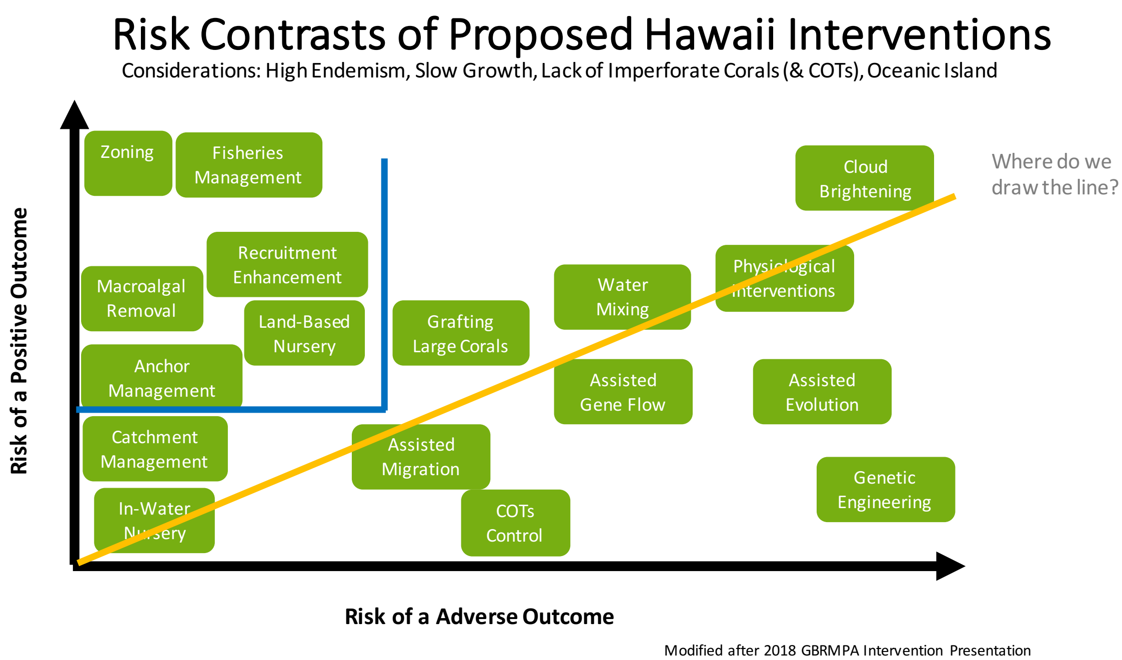
- Pre-Exposure, Algal Symbiont and/or Microbiome Manipulation
- Antioxidants, Antibiotics, Nutritional Supplements
- Stronger Regulation of Endocrine Disrupters

F. Coral Genetics and Assisted Evolution

- Managed Selection
- Managed Breeding
- Genetic Manipulation

G. Coastal Intervention Components

- Coastal Hardening
- Enhancement of Coastal Buffers (Beaches, Wetlands)
- Existing and Proposed Infrastructure Modification
- Enhanced Management of Water Quality and Runoff



<u>PERMITTING RECOMMENDATION</u>: Any restoration activity (other than emergency restoration) conducted on live coral at a scale of greater than 1 m^2 should go before the Hawaii Board of Land and Natural Resources for approval through a public comment process.[6]

V. Using the DAR Coral Ecological Services and Functions Tool to Determine Coral Restoration Targets

The DAR Coral Tool provides an Ecological Characterization Value (ECV) through comparative evaluation for determining necessary coral colonies (sizes,

[6] Permitting Conditions and Recommendations will be highlighted in **bold black**.

forms, species and numbers) to be produced based on the type of impacts incurred, and can also be used for evaluating multiple proposed restoration or compensatory mitigation projects, so that the focus is on replacement of the lost ecological services and functions associated with an impact event and its mitigation.

A. The tool utilizes three simple input variables:

1. Coral Colony Size Range
(0 – 10 cm, >10 – 20 cm, >20 – 40 cm, >40 – 80 cm, >80 – 160 cm, >160 cm)

2. Coral Colony Species

3. Subhabitat Type That Colony is (will be) Attached To

B. Primary Assumptions of the Tool:

1. **Different growth forms of corals provide different service values** (i.e. a large massive coral provides different ecological services and functions compared to the same sized encrusting coral).

2. **Different size coral colonies of the same species have different functional values**. Simply put: big coral colonies provide different services than small colonies. In Hawaii, because of high latitude reefs and much cooler surface waters, corals grow at rates far slower than most other locations, resulting in large corals being much older (and therefore more valuable for that metric) than similar-sized colonies elsewhere. In addition, because of this slow growth rate, the recovery time for large colonies is far longer.

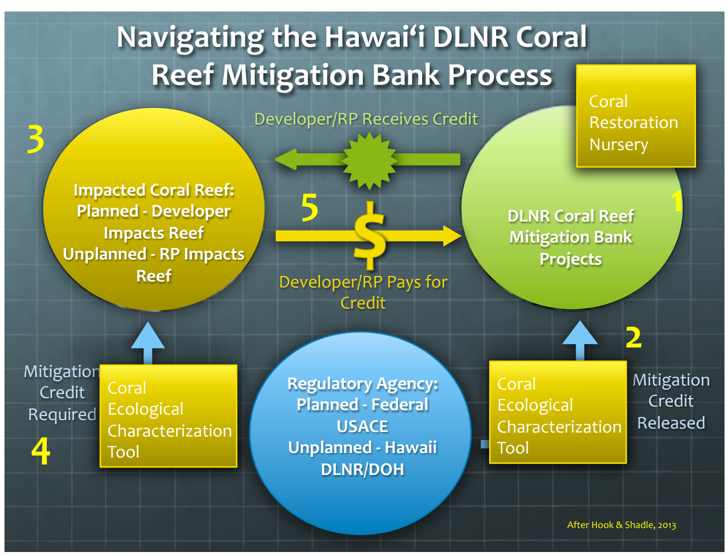
3. **In Hawaii, different species of corals occur naturally at different levels of rarity; rarer species are more vulnerable to impacts.** The State places value relative to level of rarity and recognizes that rare species have functional traits distinctly different from more common species, thus these unique traits take on a level of value associated with their vulnerability which is enhanced with the coral's rarity.

4. **Approximately 25% of the coral species in Hawaii are endemic, found nowhere else in the world. Such species have no replacement pool outside of Hawaii and hold a special value as endemics.** The tool takes this into account and values endemic species based on this measurement of uniqueness to the State.

5. **Different habitat types incur different functional values for the same species of coral.** The same-sized colony of a coral species growing atop a pier piling in a protected harbor has different functional values than the same colony growing as part of a natural coral reef (for

example, a coral on the piling does not contribute at all to wave protection, sand formation, or energy into the reef ecosystem).

The Coral Ecological Services and Functions tool was developed by the State of Hawaii to account for these different values inherent in different coral species of different size classes that grow in different habitats and sub-habitats. It directly addresses differences in coral type, size, and functional / services value for use in decisions regarding costs and effectiveness of restoration versus compensatory mitigation and to set values for colonies to be impacted[7]. The tool can be used with any Hawaiian stony coral species. The ecological services and functional value of coral found in nature is defined as the product of habitat value and individual coral values given to their morphology, rarity, endemism and size class with the ECV-metric acting as a unit-less metric. The valuation tool itself is very simple and does not require extensive knowledge beyond inputting a few variables: the species of coral for each colony impacted; the size of each colony impacted; and the type of sub-habitat (substrate) each colony occurs on. Each of these is selected from pre-provided lists. The tool itself is very transparent and provides guidance along each step as to what it is doing. The total coral Ecological Characterization Value **(ECV)** is then simply tabulated as the product of each of the individual metrics: ECV = Sum [Subhabitat (H) x Coral Colony Characteristics (Form (F) x Size (S) x Rarity (R) x Endemism (e))]. The tool can be incorporated both for evaluating planned (shoreline development, dredging) and unplanned (vessel groundings, spills, natural disasters) events that cause direct impact to coral reef communities along with any natural resource trustee restoration activities to address them. The metrics presented can then be easily used for establishing both restoration and compensatory mitigation targets.



The tool was originally developed for use in mitigation actions.

[7] The DAR Coral Ecological Services and Functions Tool has been successfully used in penalty settlements, mitigation, and restoration projects for planning, funding and impact determination.

Note that a primary reason to use the tool is to specifically show that the benefit of a proposed restoration action involving an outplanted coral is greater than the benefit of the existing ecological services and functions for the source colonies at the source site.

Given the above, one could meet this concern by fast-growing the source coral in such a way as to produce two outplanted colonies of larger size than the source material; one of these outplants would go to the proposed restoration site, the second would be returned to the original source site in order to compensate for the original source coral[8].

> **PERMITTING RECOMMENDATION: Restoration projects should use the DAR Coral Ecological and Services Tool to determine amounts of restoration required in order to provide greater assurance of mitigation for lost services and functions.**

VI. General Permitting Considerations

There are many natural resource and impact issues associated with coral restoration that DAR may consider when permitting such activities. Prior to any serious discussion regarding permitting guidelines, a series of basic assumptions need to be articulated regarding the State's regulatory authority relative to potential coral restoration within a defined coral reef area:

A. The State of Hawaii regulatory agency (DLNR) has legal authority to issue permits regulating the coral reef restoration activities in question[9].

B. The corals and other marine organisms within the area are fully regulated by the State.

C. The geographical area of interest has discrete boundaries within the area of influence of the NRT regulatory agency (DLNR through its various Divisions).

D. For activities to occur within a defined and regulated Marine Protected Area (MPA); such an area restricts take, disturbance, or impact without permit.

E. The NRT agency issuing permits has access to recognized experts in the fields of Natural Resource Damage Assessment (NRDA) and Restoration related to coral reefs, endangered and protected marine species, AIS, vector ecology, coral reef ecology, biosecurity issues, water quality issues, and coral disease issues. These experts should act as permit application reviewers, declaring any

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[8] If fast grown to a larger size, the source coral site would receive a gain in ecological services and functions that would more than compensate for the temporary loss of the source material during the time it was in the nursery.

[9] Under the 1959 Admissions Act, Congress specifically stated as law that all appurtenant reefs in Hawaii are part of the State of Hawaii. See Appendix II for more information.

conflict-of-interest for any sort of personal, commercial, or collegial relationship with the applicant. Both the US federal government and State/Territorial governments have legal Ethic Codes which apply to their employees. Concerns regarding an employee's association with people or institutions gaining permits usually falls under the 'Fair Treatment' clause of such codes. Critical, independent, and public review by recognized experts cannot be over-emphasized.

For most jurisdictions, at least one, and often multiple, NRTs will have an established and legally-recognized regulatory authority over the suite of activities involved with coral restoration activities both within the jurisdiction itself, and the movement of any material into, within, or out-of, the jurisdiction. In Hawaii, all stony corals and live rock are fully owned and solely regulated by the State of Hawaii, all reefs are part of the State's legally-owned submerged lands, and activities within State waters may be regulated by both the State and federal government (primarily Hawaii Department of Land and Natural Resources, Hawaii Department of Health, the U.S. Army Corps of Engineers (USACE, for navigable waters of the U.S. under the Rivers and Harbors Act), National Oceanographic and Atmospheric Administration (NOAA, for listed endangered marine species such as sea turtles, monk seals and cetaceans under the Endangered Species Act (ESA) or the Marine Mammal Act), and the Environmental Protection Agency (EPA, for Clean Water Act (CWA) regulated activities); see Appendices I & II for specific authorities).

VII. Restoration Practitioner Overall Qualifications:

Given the substantial risks for many jurisdictions that accompany allowing corals to be collected, modified, transplanted or outplanted, along with the range of possible secondary and tertiary impacts involved with these activities, it is imperative that minimal qualifications for applicants be established for each jurisdiction. This takes on greater significance for those areas where the research involves recognized rare coral species or associated species, or regulated geographical areas (e.g., MPAs). **In a jurisdiction such as Hawaii, average natural growth rates are exceedingly slow, and correspondingly, recovery rates are extremely slow. There is also extremely high natural endemism across native marine phyla, and the natural coral reef habitats exist extremely close to increasingly developed shorelines along with a wide, overlapping range of users and impacts. As such, extra review and considerations along with permit conditions need to be implemented as there is a much greater risk of negative effect associated with these regulatory decisions.** At a minimum, issues such as an applicant's educational background, along with their field and practical coral restoration experience (especially as it applies to the jurisdiction's unique geographical areas) and ecological knowledge (as it applies to the specific reefs and corals to be affected) should be substantiated and meet pre-established minimum standards (see below).

Evidence of minimal educational and practical experience on the part of the applicant is required to discern their ability to properly identify target restoration species, recognize unique aspects of the species' or reef ecology, and to minimize both primary and secondary impacts from their proposed restoration activities. Questions often asked of applicants may include:

> Can the applicant accurately identify the target Hawaiian coral species in the field compared to other similar Hawaiian coral species?[10]
>
> Does the applicant(s) have the minimum documented scientific and practical experience with Hawaiian corals, disease, AIS, vector ecology, and restoration science to conduct the proposed activities safely and within acceptable margins of managed risk to the public and Trust resources?
>
> Is this the applicant's first time conducting the proposed specific type of restoration using the proposed gear, coral species, and either selected source or outplant site locations?

In cases where an applicant does not meet the minimum standards established by the Hawaii Division of Aquatic Resources, supervised extremely small-scale pilot projects under strict controls (and conducted at non-sensitive and low-impact sites) may be required to bring the applicant up to the required standards prior to allowing expanded, independent field restoration activities. In areas where this is not feasible or desired, the NRT agency will need to balance the benefits and risks of the proposed restoration work, the benefit of the activities to the resource and the jurisdiction versus the potential risks of allowing the restoration activity to be conducted by an unqualified (as per the jurisdiction's educational requirement) applicant.

For most jurisdictions, evidence of minimal educational experience is required because of the species or areas under protection, or concerns regarding the ability of the applicant to discern the proper species or recognize unique aspects of the species' ecology. In Hawaii, this takes on greater significance due to the extremely slow natural growth (i.e. recovery) rates of Hawaiian corals, the extremely high rate of endemism, and the limited nature of Hawaiian coral reefs due to their oceanic island basis (i.e. coral reefs directly adjacent to shore with deep surrounding water).

[10] The DAR Coral Restoration Nursery maintains over 62 Hawaiian species of coral at its facility and can provide targeted comparative instruction in field identification for DLNR-approved restoration projects.

<u>PERMITTING RECOMMENDATION</u>: Applicants for permits to conduct coral restoration should have a minimum of 1 year experience in Hawaiian coral ecology and demonstrate previous experience with successful coral restoration projects. Applicants should be evaluated as to their ability to discern with a high degree of accuracy the specific Hawaiian coral species they are targeting for collection and/or use. Scale of the project will determine the need for additional demonstrated experience.

VIII. Restoration Focus:

In most jurisdictions, applications for permits for restoration activities, restoration research, or educational restoration projects that involve interactions with the natural resource generally include information about the project (e.g., project abstract), the methods, the materials and species to be used (including the numbers of colonies and genotypes), and the protocols being proposed. In addition, it often includes the proposed location and duration of the restoration activities, environmental impacts (direct or indirect), long-term monitoring plans, a strong rationale for the project (i.e., why the activity needs to be conducted, how or why are the methods appropriate for the activity), and an explanation of the applicant's qualification and financial ability to complete the project while minimizing environmental impacts.

The applicant should describe the restoration activity in sufficient detail for the State to be able to assess it based on their constraints and requirements and provide clear details on the potential impacts and risks associated with the proposed activity.

In the best scenarios, the rationale for conducting the restoration should come from the NRT agency itself as part of a long-range plan to address critical needs. This is rarely the case, and more often it is the applicant expressing their research interest or perceived needs for managers to the NRT. In these cases, an analysis of the proposed activity's relationship to existing natural resource management priorities for the jurisdiction is needed. Questions may include:

What is the zoning for the proposed area to be impacted?

What are the expressed objectives or uses for the proposed impact area?

<u>PERMITTING RECOMMENDATION</u>: Funding itself is NOT the driver for conducting restoration activities in Hawaii. Given its unique ecological, social and cultural conditions, any proposed restoration activity needs to be carefully assessed for impacts in advance (including risk assessments (see Appendix VII)) and usually should go before the Hawaii Board of Land and Natural Resources for approval through a public comment process. If the restoration project is of such a scale or the risk of negative impacts is significant, the Board may require a financial bond or other means to guarantee the ability to mitigate negative impacts associated with the project.

IX. Issues Associated with Sourcing Corals

Hawaii requires a formal Special Activity Permit (SAP) in order to gather live coral samples. In some cases, an agency representative may be required to accompany the restoration applicant during all collection activities in the field. Hawaii DAR requires that copies of raw data or summaries be provided to their agency relating to coral collection activities.

A. Of prime concern in regard to establishing appropriate limits on live coral collection is:

1. A formal evaluation of the restoration project design in regard to whether the number of species and genets proposed by the applicant is excessive (from a resource management perspective). **Note: the evaluation is not necessarily based on the statistical significance of the sampling size, but rather on the risk of significant resource impact posed by the sampling design.**

2. Limitations on the species allowed for collection. Often applicants propose working on a broader spectrum of species than is necessary or desirable from the NRT perspective of limiting negative impact or managing ecological risk. Additionally, prior to formal 'proof-of-concept' results, limiting initial restoration efforts to the most common species and/or the ones with the least likely ecological impacts is preferred.

3. Number of corals collected. Most jurisdictions list specific numbers of allowed collections. In some cases, annual caps on take are set in advance of permit requests, specifically with regard to cumulative take of samples from all sources (i.e., all activities, research and other) by species and/or area. Conversion to colony units may be required in order to determine a common metric for reporting cumulative take of a specific species or at a specific site. Additionally, the lost ecological

services and functions caused by the collection activity can be determined through use of the DAR Coral Ecological Services and Functions Tool.

4. Allowable size of individual fragments to be collected. Some jurisdictions limit the size of fragments collected from a coral colony based on the type of growth form of the colony or species and their known growth rates. Additionally, encouraging fragmentation at the growing edges of colonies will limit collateral damage. In general, take of whole colonies will be discouraged and DAR staff will promote limited take of fragments or nubbins to the least amount possible. Targeting of nubbins or fragments by the applicant can only occur if the remainder of the colony is relatively unharmed by the collection method[11], otherwise even collection of small-sized targeted fragments will count as a take of an entire colony. Any colonies targeted for take that are less than 20 cm in diameter will also count as single colonies for cumulative data keeping purposes.

5. Size of individual colonies targeted for extractive activities. It is not unusual to restrict collections from colonies over a certain size in order to maximize protection of the equivalent of 'old growth' corals, especially when collections from conspecific younger colonies will likely bear little significant difference relative to the management needs of the proposed activity. For nearly all Hawaiian species, targeting coral colonies over 1 m in size is strongly discouraged given the extremely slow recovery rate of Hawaiian corals[12].

6. Identification of organisms targeted for extraction. Critical to most extractive research is the need to accurately identify potential target colonies to species and to limit collection to identified (and approved) species only. Lack of expertise in species identification on the part of the applicant raises significant warnings about their qualifications to conduct the field work and minimize damage to non-targeted resources. DAR may require evidence of accurate Hawaiian coral species identification field ability as a condition of coral collection[13].

7. Inspection. Some jurisdictions conduct target inspections of collected coral (Gulko *et al*., 2015). The inspections (announced or unannounced) can occur where the organisms are landed (i.e., at the dock on arrival), at the holding facility or occasionally, at the collection site (more often in MPAs). Inspections represent a formal oversight of the permitted

[11] Inherently, fragmentation always harms the source colony, leaving the site of fragmentation more susceptible to disease/bacterial infections or AIS infestation.

[12] Due to the extremely slow growth rate of Hawaiian corals and the resulting age of these large colonies.

[13] The Hawaii Coral Restoration Nursery holds over 62 native Hawaiian coral species and can assist with targeted Hawaiian coral species identification testing and evaluation.

activity and violations constitute grounds for serious legal action by the NRT in many jurisdictions.

8. **Wherever possible, necessary take of live coral (where AIS and other issues can be mitigated) will be directed to areas already impacted by human activities versus relatively unimpacted or protected areas.**

B. Sources of Coral for Restoration Projects in Hawaii (The Good, The Bad, & The Ugly…)

In Hawaii, there are a number of possible sources of live coral for collection for coral restoration projects as described below:

1. Source Corals from the Targeted Restoration Site Itself

a. Advantages: Same genetic material and biodiversity, already adapted to the existing site conditions, minimal novel AIS and disease concerns.

b. Disadvantages: Affects natural recovery at the site, impacts an area that may have little available coral to donate to a restoration technique, may pose high risk to existing rare or unusual coral populations.

c. Note: Need to differentiate between taking already impacted (loose, fragmented) corals from the site compared to unimpacted corals at the site.

2. Source Corals from Other Natural Reef Sites

a. Advantages: May provide for higher quality corals or extirpated species to re-introduce to a restoration site. May restore biodiversity to a restoration site.

b. Disadvantages: Causes new impact to a un-impacted area which needs to be mitigated and compensated for. Increases risk of novel AIS, disease, pollution or parasites being introduced to the restoration site. May modify biodiversity at source site.

c. Note: Use of this technique will require mitigating for the take of the coral outside of its use for restoration. In Hawaii, given the slow natural recovery rates of native corals, this may require the use of some sort of fast-growth technique in order to minimize loss of ecological services and functions at the donor (source) site. May require detailed health assessments and quarantine.

3. Source Corals from Corals of Opportunity Sites

a. Advantages: High likelihood of already fragmented corals for collection without having to harm intact corals. May restore biodiversity to restoration site.

b. Disadvantages: May cause new impact to unimpacted area; increases risk of novel AIS, disease, pollution or parasites being introduced to the restoration site. May cause new impact to an already impacted area; removes recovering corals from an impact site. May modify biodiversity at source site. Fragments may be too stressed to use. Original impact event may have stressed corals to the point of enhancing cyanobacteria and other potential negative endosymbionts in the source corals to be used.

d. Note: Use of this technique may require mitigating for the take of the coral outside of its use for restoration. May require detailed health assessments and quarantine.

4. Source Corals from Harbors and Man-Made Structures

a. Advantages: Corals from harbors have undergone numerous human-caused disturbance events over time and may be more resistant to novel disturbances. Take of harbor corals has far lower lost ecological services and functions than take of corals from natural reefs. May restore biodiversity to restoration site.

b. Disadvantages: High risk of novel AIS, disease, pollution or parasites being introduced to the restoration site. Higher likelihood of incorporated pollutants and heavy metals in coral skeletons.

c. Need to differentiate corals collected from natural substrate versus man-made substrate within harbors. Critical that pre-collection health assessments be thorough and well-documented. Requires detailed health assessments and quarantine.

d. 'Man-made structures' outside of harbors might include Fish Aggregation Devices (FADs), Offshore Fish Aquaculture Pens, Submerged Artificial Reefs (originally put in for fish habitat enhancement) and Submerged Wreck sites.

5. Source Corals by Propagating Larvae from Existing Nursery Corals

In some circumstances, it may be possible to propagate larvae from existing corals in captivity to use for projects. Maintaining coral larvae (planulae) in suspension requires daily coral husbandry care. This technique needs to be further developed and refined in Hawaii[14].

6. **Source Corals by Propagating Larvae from Wild Reef Corals**

   In some circumstances, it may be possible to propagate larvae from existing corals at the restoration site or another site to use for projects. In this instance, the gamete bundles or brooded larvae would be treated as limited impacts to the parent colony and fall into the advantages and disadvantages discussed above. Maintaining coral larvae (planulae) in suspension requires daily coral husbandry care. This technique needs to be further developed and refined in Hawaii[14].

The State of Hawaii DLNR (through DAR) needs to determine the best source to be used for each restoration project, taking into account the risks, recovery rates, and benefits involved. Strongly suggest the use of a risk assessment (See Appendix VI) to determine the viability of the proposed source sites in comparison to each other.

PERMITTING RECOMMENDATION: The use of well-maintained quarantine systems (and other means) should be required for corals collected from outside of an established restoration area and for corals collected from harbors and areas known to contain high amounts of AIS, pollutants, or disease.

C. Geographic Issues

1. **Outside Hawaii**
   a. It is illegal to bring live corals into Hawaii without a permit. Depending on site of origin and intended use, multiple State (Department of Agriculture (DOA) and DLNR) and Federal (U.S. Fish and Wildlife Service (USFWS) and NOAA) permits may be required.

   b. **Current State policy is NOT to allow live coral of any kind to be imported into the State**. Corals cannot be legally brought into the State without a proper Hawaii Department of Agriculture (HDOA) permit. CITES permits would be additionally required for importation of corals from outside the United States.

2. **Inter-Island**
   a. Movement of live corals between islands in Hawaii requires legal permission from DLNR. Concerns to be addressed include impact

[14] Given the low survivability of settled larvae and the extremely slow growth rate of corals in Hawaii, these concerns need to be factored in to the use of this method relative to a measure of restoration success.

on the source site; movement of AIS, disease, pollutants, heavy metals, and modification of genetic diversity.

b. Corals collected from commercial and small boat harbors have the highest risks for the above concerns[15] and should have greater review and stricter permit conditions.

c. Applicant should have an established quarantine facility designed to hold live coral which has been inspected and approved by DAR (see Appendix III, Requirements for Facilities Holding Live Coral).

3. Within an Island

a. Least relative concern for collection of coral for restoration purposes.

b. Corals collected from commercial and small boat harbors, Pearl Harbor, and Kaneohe Bay, have the highest risks and should have greater review and stricter permit conditions. Concerns to be addressed include impact on the source site, movement of AIS, disease, pollutants, heavy metals, and modification of genetic diversity. Effects from invasive species can occur as a result of the translocation of associated species (symbionts, microbial community) and are described in greater detail below.

4. Within an established Marine Protected Area (MPA)

a. Highest concern for collection of live coral. Most jurisdictions have restrictive requirements for permitting activities within MPAs; many completely prohibit manipulative research and extractive activities within their MPA boundaries. In Australia, the Great Barrier Reef Marine Park Authority (GBRMPA) requires institutional accreditation with the NRT as an entry requirement into their research permitting protocols (GBRMPA 2008).

b. Hawaii has traditionally prohibited manipulative research or actions within its no-take MPAs that would disturb natural coral habitat if such work could be done elsewhere. Activities have been allowed if it was critical to the management of the MPA itself. Often scientists will view a no-take MPA as a reference for relatively un-impacted areas, but the State has viewed any extraction, even for research, within no-take MPAs as a strongly prohibited activity.

c. In general, **collection or impact to corals at identified sensitive areas (including MPAs) should be discouraged**, and should meet the strictest levels of review and permitting conditions. Rationale

[15] Along with certain extremely high risk embayments such as Kaneohe Bay and Pearl harbor, where large varieties of AIS are known to persist.

for take must be established and convey both a unique and justified need, along with a strong expectation of benefit as described at the top of the document.

<u>PERMITTING RECOMMENDATION</u>: A strong focus on species rarity at the site and existing site protection should be considered prior to approving any site for collection activity. Except in the most extreme circumstances, collection within established marine protected areas should not be allowed.

D. Corals to be Targeted from Identified Sensitive Areas in State Waters

In general, **collection or impact to corals at identified sensitive areas should be discouraged**, and if required, should meet the <u>strictest</u> levels of review and permitting conditions. Rationale for take must be established and convey both a unique and justified need, along with a strong expectation of benefit as described at the top of the document. Identified Sensitive Areas in Hawaii include:

1. Northwestern Hawaiian Islands
   - i. **Northwestern Hawaiian Islands State Refuge**
2. Kauai County
   - i. **Waters Immediately Surrounding Offshore Islets**
   - ii. **Waters Surrounding Kaula Rock**
   - iii. **Mana Barrier Reef Complex**
3. Oahu
   - i. **MLCDs**
   - ii. **Paiko Lagoon**
   - iii. **Waters Immediately Surrounding Offshore Islets**
4. Maui County
   - i. **Waters Immediately Surrounding Offshore Islets**
   - ii. **MLCDs**
   - iii. **Ahihi-Kinau Reserve**
   - iv. **Deep Reef Areas**
   - v. **West Molokai Nearshore Area**
   - vi. **Kahikili**
   - vii. **Oluwalu to Macgregor Point**
5. Hawaii County
   - i. **Waters Immediately Surrounding Offshore Islets**
   - ii. **MLCDs**
   - iii. **Puako**

<u>PERMITTING RECOMMENDATION</u>: Except in extreme circumstances, collection within identified sensitive areas within State waters should not be allowed.

E. Corals to be Targeted for Source Material

1. Growth Forms

a. Certain growth forms of coral pose difficulties in their collection and should only be attempted by recognized experts. Specifically, encrusting forms often require significant breakage of underlying substrate in order to collect; additionally, this form often fragments into smaller pieces upon collection and requires extra handling and care.

b. Large massive forms represent extremely old colonies where fragment collection can cause slow-to-recover impacts that often are not necessary; strong efforts should be made to ensure large corals remain intact and not allow fragmented collections from these colonies.

c. Imperforate corals require extra care in handling so as not to damage the external tissue. In general, imperforate corals are more sensitive to short term impacts.

2. Source Colony Sizes

a. **Any impacts to intact colonies larger than 1 m in diameter should be prohibited.** For those rare occurrences where larger colonies must legitimately be targeted, evaluation of the rationale for planned impacts and take must be established and convey both a unique and justified need related to the specific size of the colony and the species, along with a strong expectation of benefit as described at the top of the document. Strong prohibitions on numbers of samples and types of impact must be used with large source colonies.

b. Fragments and nubbin collections should be from the outermost, peripheral edges of a colony to minimize damage to the source colony itself.

PERMITTING RECOMMENDATION: Wherever possible, focus should be on collection of colonies smaller than 40 cm, or collection of fragments from colonies smaller than 40 cm.

3. Endemic versus Non-endemic

a. The following Hawaiian species are considered endemic: ***Porites compressa, Porites brighami, Porites duerdeni, Porites evermanni, Porites hawaiiensis, Porites pukoensis, Porites annae, Pocillopora ligulata, Pocillopora molokensis, Montipora capitata, Montipora flabellata, Montipora dilitata, Montipora patula, Montipora***

studeri, Leptoseris tubulifera, Psammocora verrilli. Acabaria bicolor, Sinularia molokensis, Sarcothelia edmondsoni.

b. Collection of endemic corals should be strongly controlled given the lack of replacement material outside of Hawaii. That said, limited, small scale collection of common endemics may be considered along with specific collection site concerns.

4. **Fast-Growing versus Slow-Growing Colonies** (see coral growth terminology)
   a. The following coral genera are thought to grow relatively faster than other Hawaiian species: *Pocillopora,* certain *Montipora* spp.

   b. Studies have shown that the large massive corals **(*Porites,* certain growth forms of *Pavona*) are amongst the slowest growing**. **Wherever possible, impacts to large (> 1 m diameter) massive coral colonies should be prohibited**.

   c. Deep water corals are thought to grow slower than shallower water corals due to decreased light at deeper depths. These forms are often more delicate and have thin skeletons.

   d. **Applicants should directly demonstrate how they will offset the recovery time and lost ecological services and functions at the source site from their collection**.

5. Common Species[16]
The following coral species are thought in general to be more common in shallow Hawaiian waters: *Porites lobata, Porites compressa, Pocillopora meandrina, Montipora patula, Montipora capitata*; however, the reviewer should look at the known distribution of the target species at the specific target sites to determine appropriate levels of take.

6. Uncommon Species[15]
The following coral genera are thought in general to be less common in shallow Hawaiian waters (though they may have high abundance at certain select sites): *Pocillopora eydouxi* (large colonies), *Montipora flabellata, Montipora studeri, Porties evermanni, Porites rus, Leptastrea spp., Pavona spp. Cyphastraea spp., Psammocora stellata, Cycloseris spp., Fungia scuteria.* **In general, impacts to these species should be discouraged at sites where they are known to be uncommon or rare, and large intact colonies should be protected against any impact.**

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16 Sources: Gulko 1998, Hoover 1999, Fenner 2005.

7. **Rare Species**[15]

The following coral genera are thought to be relatively rare in shallow waters surrounding the Main Hawaiian Islands: ***Acropora spp., Coscinaraea wellsi, Porites brighami, Porites duerdeni, Porites pukoensis, Porites annae, Porites solida, Porites monticulosa, Pocillopora molokensis, Pocillopora ligulata, Montipora dilatata, Montipora studeri, Gardinoseris planulata, Psammocora verrilli. Psammocora nierstraszi, Psammocora haimeana, Psammocora superficialis, Diaseris spp., Acabaria bicolor, Sinularia molokensis***.

No impact to these colonies should be allowed without the strictest levels of review and permitting conditions. Rationale for take must be established and convey both a unique and justified need related to the specific species, along with a strong expectation of benefit as described at the top of the document. Strong prohibitions on numbers of samples and types of impact must be used.

8. **Endangered Species Act (ESA)-Listed Coral Species**

There are currently no ESA-listed corals in Hawaii. However, it is possible that some rare endemic Hawaiian coral species may be listed in the near future under the State's Endangered Species Law (HRS §195D).

F. Health Issues for Source Corals

1. **Biosecurity Concerns**

Similar to an AIS protocol (below), a Biosecurity Protocol should be a permit condition involved in evaluating and collecting source corals. Of specific concern should be a documented valuation of health regarding any coral collected and requirement of quarantine for collected specimens. Questions to consider regarding biosecurity might include:

a. Does the applicant have sufficient background in maintaining viable biosecurity measures to prevent contamination or release of organisms or cultures under their care?

b. To what level of biosecurity should the applicant be qualified and asked to maintain?

c. At a minimum, full documentation (including photos, see Appendix IV) and health inspection should be required, both in the field prior to collection, and again on the surface, prior to placing in Quarantine.

2. **Aquatic Invasive Species (AIS)**

An AIS Protocol should be a permit condition involved in evaluating and collecting source corals. Of specific concern should be a documented valuation of AIS at the collection site and in the immediate vicinity of the source coral. Questions to consider regarding AIS might include:

a. Does the applicant have sufficient background in detecting and evaluating AIS to prevent contamination or release with organisms or cultures under their care?

b. Are the source coral sites located within areas of high AIS concern?

c. At a minimum, full documentation (including photos, see Appendix IV) and health inspection, both in the field prior to collection, and again on the surface, prior to placing in Quarantine.

Primary groups of species of concern include invasive algae, cyanobacteria, sponges, and other cnidarians (mostly hydroids, non-scleractinian anthozoans, and early life history stages of certain scyphozoans). **In general, the more that a species exhibits clonal, colonizing or overgrowth traits, the greater the concern about its ability to be a species of concern from a AIS perspective.**

Primary activities that raise AIS concerns include the following:

a. Personal Dive Gear. A researcher or coral collector's dive gear, specifically neoprene and nylon clothing (wetsuit, booties, gloves, buoyancy compensator, and fins, mask, snorkel) if not properly cleaned and completely dried out, can serve to transport small fragments of AIS from a previous dive site. Many of these organism fragments can live for extended periods of time if kept in damp conditions (i.e., dive bags and stored gear). Coral researchers and restoration practitioners often work in close contact with the bottom, often more so than other types of divers on coral reefs, and it is this increased contact that raises their risk of serving as a vector for AIS.

b. Research/Collection Gear. Nets, holding bags, buckets, and other collection gear in direct contact with coral colonies pose the greatest risk, but can be easily controlled through required cleaning procedures or the documented use of new gear in certain areas.

c. Diving Platforms. Primary vector is through hull-fouling, anchoring systems, and ballast water. This is most serious with small skiffs and boats that may access shallow-water portions of the reef. Required prior cleaning procedures for anchoring systems, and proper control of waste water, ballast water, and bilge water while on site are important.

d. Movement of live specimens of coral or live rock from one site to another, or allowing live transport from collection site to nurseries (in-situ or ex-situ).

No live coral from commercial harbors, Pearl Harbor or Kaneohe Bay will be collected for Source Corals due to AIS concerns without extensive precautions written as permit conditions (including minimum one month quarantine in systems with UV sterilizer units on water discharges and daily documented inspection of specimens for AIS, predation, health and disease, minimum documented inspection both pre- and post-collection, and additional controls on the source corals to prevent spread of undetected AIS and disease).

3. Levels of Gear Cleaning

Level I Cleaning: Visual inspection and manual removal of unwanted materials (AIS, non-coral marine life, debris, etc.).

Level II Cleaning: Visual inspection followed by fifteen (15) minute freshwater soak and drying.

Level III Cleaning: Visual inspection followed by fifteen (15) minute soak in a diluted bleach freshwater solution (1 part bleach : 20 parts freshwater), followed by freshwater soak or rinse and drying.

4. Quarantine

A Quarantine Protocol should be a permit condition involved in evaluating and collecting source corals. See Appendix III Requirements for Facilities Holding Live Coral in Hawaii for specific recommendations on quarantine for collected live corals.

PERMITTING RECOMMENDATION: An AIS plan will be a condition of any coral collection activity.

G. Genetic Concerns Involved with Source Coral Collection

There are concerns about genetic changes to a native population brought about by the selective removal of conspecifics from the immediate area to use as source corals for elsewhere. Note that this concern is focused on genetic loss from the source area.

<u>PERMITTING RECOMMENDATION</u>: Requirement to only sub-sample genets within an approved coral collection area, along with required photo-documentation (and GPS) to assure that genetic diversity has not been overly depleted at a collection site.

H. Pollution and Water Quality Concerns

A Pollution and Water Quality Protocol should be a permit condition involved in evaluating and collecting source corals. Of specific concern should be a prevention of pollution and water quality impacts at the collection site and in the immediate vicinity of the source coral from the collection activities. Questions to consider regarding pollution and water quality might include:

1. Does the applicant propose using equipment or platforms from which to collect coral that pose any pollution or water quality concerns? Does the applicant have sufficient background in detecting and evaluating pollution and water quality effects to prevent contamination or release from their activities?

2. Are the source coral sites located within areas of high pollution and water quality concern?

3. At a minimum, inspection and documentation (including photos, see Appendix IV) of the applicant's gear and platforms should be conducted pre-collection activity.

I. Ecological Concerns about Source Coral Collection

Based on the species and amounts requested for collection, concerns for assessing any probable immediate or long-term ecological effects resulting from the proposed collection may include:

1. Will the removal or damage (example: through fragment or nubbin collection) of key individual coral colonies result in population effects or effect other components of the ecosystem?

2. Will the collection result in significant changes to trophic interactions at the source site?

3. Will the collection result in significant changes in shelter habitat for other marine species?

4. Will the collection significantly effect corallivores (specifically, endemic corallivores, such as certain species of butterflyfish) at the site?

In general, concepts such as the potential for ecological phase shifts should be evaluated prior to any approval for collection. This takes on greater significance relative to either the rarity of the targeted source coral or the size of the source colony targeted. **Unique[17] coral colonies should not be targeted as source colonies in general.**

PERMITTING RECOMMENDATION: Permit conditions should reflect the unique ecological and coral dynamics of a specific target or collection site.

J. Amenity and Economic Issues with Coral Collection

Amenity issues include changes imposed on an area that affect the way that people view the intrinsic value of that area. Prohibitions on take of large colonies, rare and unique colonies, and the number of specimens usually minimize this concern.

Economic impacts usually involve concerns about a negative influence on site tourism from loss of species or perceived damage at the source site, or changes to habitat and ecology at the collection site affecting both fisheries and tourism. In general, DAR encourages prohibitions on take of large, rare, or unique colonies, and minimizing overall number of take to minimize this concern.

K. Other Collection Concerns

1. Undeclared Use of Organisms

The 'take' of live coral and its intended use for specific restoration activities will be clearly indicated on the permit provided. However, the sharing of these samples with other investigators for activities not

[17] A unique coral colony is one which either by the rarity of the species, or the colony's form, size or specific location within a reef structure provides a distinctive or exceptional feature to an area.

specified in the original permit is a clear violation, and raises both resource management and legal concerns relating to transport-out-of-area, proprietary and bioprospecting uses, direct commercial uses, or non-permitted culturing or experimentation. Frequently a NRT permitting agency has to discern between an applicant's expressed purpose in conducting the proposed restoration and other intended uses that were not expressed in the permit application. Control over the number of samples taken, the state of the samples, their maintenance, and the disposition of samples can help minimize unauthorized use of regulated organisms. Strongly encourage the requirement for formal Chain of Custody for all corals, fragments, and progeny involved with a project.

In the best scenario, the rationale for collecting the live organisms and conducting the restoration activity should come from, and be directed by, DLNR as part of a long-range plan to address critical needs. This is rarely the case, and more often it is the applicant expressing their research interest or outside funding requirement as a perceived need for resource managers to the agency. In these cases, an analysis of the proposed activity's relationship to existing natural resource management priorities along with a detailed risk assessment of the proposed actions is needed (See Appendix VIII).

2. The Repetitive Actions of Coral Collection Itself Serving as Vectors for AIS, Disease, and Other Concerns

A number of jurisdictions are now strongly questioning whether to allow researchers to move from site to site within a region without verifying that their gear, boats and persons are not serving as a vector for disease or AIS transmission. While some researchers have stated this is not a viable vector concern (Williams & Miller 2005), other research efforts and NRT agencies have shown this to be a real concern as explained below. As an example, increasing interest has been paid to concerns regarding recreational divers, their gear, and their activities, serving as vectors for the spread of coral disease (Brownlee 2006). The Florida Keys National Marine Sanctuary (FKNMS) has quarantined, by way of a temporary rule, all entry by divers into two areas of the FKNMS due to a disease that was rapidly killing *Acropora cervicornis*. The federal government specifically stated that the measure was necessary "to protect healthy coral from human-caused contamination" (U.S. Federal Register 2003). Mexico recently closed two areas in Cozumel to diving and snorkeling for similar concerns. While this may be prudent under such circumstances, coral researchers (and by extension, coral restoration practitioners), who by their stated objective might be in direct and multiple contact with both diseased, AIS-impacted, and 'healthy' colonies in the area and beyond, pose the highest risk under such a scenario. Therefore, these **individuals should**

adhere to strict routines involving sampling 'clean to dirty' areas and gear decontamination protocols (Woodley *et al*. 2008). Strongly recommend level III cleaning for in-water gear used in such areas.

A number of permit conditions have been considered to address these specific concerns, but paramount to most natural resource impact concerns is verification (and documentation) that these practices are being implemented. To reduce concern, the NRT permitting agency might consider including a staff biologist or enforcement officer on those projects where significant or rare coral collection is to be conducted to ensure adherence to permitting conditions. At a minimum, such a permit condition should be listed as an option for the NRT agency, and perhaps should include cost recovery to the NRT for such expenses.

3. Type of Collection Gear Used

Agency concerns might be raised concerning an applicant's experience and proficiency in use of coral extraction tools as certain tools can cause extensive damage to both substrate (in Hawaii, most exposed hard marine substrate is fully protected as live rock and all submerged lands are regulated as conservation districts) and the remnant coral colony. In general, the smaller the extraction tool, the less the concern[18]. Tools such as underwater pneumatic drills and jackhammers, crowbars, large chisels and hammers, and surface-supplied extraction equipment all raise strong needs for controls on collateral damage to reef resources through the extraction activity. It is strongly recommended that collection only be done by experienced individuals who are familiar with the tools being used and who have either direct documented experience, or have undergone training from DAR or recognized organizations in collecting Hawaiian corals in a non-destructive (i.e. minimal collateral damage) manner.

4. Export of Live Coral for Use Elsewhere

Transport of corals, coral tissue, and disease cultures outside of a country tends to fall under national government controls, usually involving either customs enforcement or CITES. Practically, a range of NRT agencies may be involved in the regulation of shipments of live organisms or cultures. If the organisms or parts to be shipped represent non-living material, the regulation of shipments is probably controlled primarily through the customs enforcement or the country's CITES authority. The primary NRT agency with legal right of inspection needs to be directly involved with any permit conditions by another NRT regarding the exportation of samples and/or cultures out of the country.

[18] See Appendix VI for information on using small tools to collet coral pieces and colonies.

It is the general policy of the State of Hawaii to NOT allow live Hawaiian coral to be shipped out of State for any purpose (research, commercial, restoration, or otherwise).[19]

X. Issues Associated with Transport of Live Coral

Transport of live coral for restoration involves basically two types of transport to be regulated: movement away from the collection site, and movement towards an outplant site. If the movement from a collection site to an outplant site is done without any modification to the collected coral colony, the process is called **Translocation** (or sometimes referred to as **Transplantation**); direct transplantation of corals from one site to a different site has been strongly discouraged in Hawaii without extensive controls. In general, it has been State policy not to allow direct coral transplantation from a harbor to a natural reef due to AIS, heavy metal, pollution and possible disease concerns. Issues involved with transport include:

A. Concept of Health Documentation Prior to Transport

Health certificates or official inspections prior to moving live organisms from one area to another are required in some jurisdictions. Some jurisdictions have recently started to require veterinarians to issue such certificates, though few veterinarians have experience with the health dynamics of invertebrates, let alone cnidarians. In practice in Hawaii, certain public facilities, such as the Waikiki Aquarium, the Maui Ocean Center Aquarium, and the Hawaii Coral Restoration Nursery, have professional staff whose job is to evaluate coral health. Guidelines for evaluation of coral health in Hawaii are provided in Appendix V.

Other jurisdictions, as a matter of policy relative to genetic populations, AIS concerns, disease concerns, and social/economic concerns, allow limited to no movement of any live marine animals (including corals) from site to site.

In general, detailed risk assessments (Appendix VIII) should be conducted and properly evaluated prior to considering any translocation activities.

B. Diseases, Parasites and AIS

Corals because of their calcium carbonate structures, growth-form plasticity, large surface area, and internal coelenteron (water-filled cavities) offer numerous niches for growth of various microsymbionts that in new habitats could prove to be invasive or parasitic. As such, transport (and translocation) requires extensive pre-transport evaluation (and possible quarantine) and biosecurity care.

[19] Violations of State law that result in the attempt to transport Hawaiian coral outside of Hawaii may constitute a federal felony under the Lacey Act.

C. Genets

There are concerns about genetic changes in a native population brought about by the introduction of conspecifics from outside of the immediate area.

Consideration should be given to a species' natural method of genetic flow to minimize human intervention in natural evolutionary processes. For example, *Montipora* species broadcast gamete bundles which, after becoming larvae, can move relatively long distances before settling and growing into adult colonies and would be of less concern transplanting within an island then shorter distance larvae.

D. Handling of Coral Collections in Transit

1. Direct handling of coral specimens immediately post-collection and while in-transit often can cause long-term stress and should be minimized. Special care needs to be taken to ensure any handling is done by individuals whose hands are free of sunscreen, perfumes and other chemicals. Hands should be cleaned with freshwater and simple soap, rinsed and dried. Use of disposable nitrile gloves minimizes exposure to corals and vector issues involved in handling.

2. **Chemicals should not be used to treat corals in transit or immediately before outplanting.** Concerns exist about pharmaceuticals and other chemicals used to treat live organisms (or holding water) while in captivity being released into natural environments through the transit activities for the corals or their outplanting (See Appendix V)[20].

3. To help prevent breakage (and help temper temperature change) in delicate coral forms during transit, store sealed bags (containing seawater and corals) in volumes of water (sealed buckets or large tubs). For very delicate forms, wet corals should be contained in a protective wrap (example: bubble wrap) within their storage containers to minimize further fragmentation or damage during short distance transport.

E. Temperature

1. Water temperature at the source coral site should be recorded and taken into consideration when preparing corals for transport. Care should be taken to prevent water temperatures from heating during transit by ensuring water is changed out immediately before transit,

[20] It is illegal in Hawaii to have certain chemicals on-board small vessels or in the water that could be used for take of marine life.

particularly if coral colonies have been contained in the same holding receptacle for the duration of the source coral collection activity. While in transit, coral water temperature should be closely monitored and preventive measures should be enacted to prevent coral stress.

2. Transit receptacles should be shaded to prevent water temperatures from rising due to direct solar heating. This is especially important on boat decks and when transporting corals by truck.

3. The water volume in holding containers is directly proportional to the rate at which corals will heat up. Sealed bags can be placed within a water bath to help maintain transit temperatures. Do not place ice within a water bath containing corals to modify the temperature.

F. Water Quality

1. Care should be taken to ensure sufficient water quality is maintained during source coral transit by changing out transit water immediately before transit, particularly if coral colonies have been contained in the same holding receptacle for the duration of source coral collection.

2. During extended transit times, clean seawater may be flushed through transit containers to ensure the maintenance of ideal water quality parameters are maintained. Care should be taken to not greatly vary water temperature.

3. It is important to appropriately dispose of transit water following transit to reduce spread of AIS and disease from the source coral site to the nursery site.

4. Battery-powered air bubblers can be used sparingly during transit to help with evaporative cooling, maintaining oxygen levels and water movement in limited water volumes.

G. Agency Notification

The State of Hawaii often requires notification by a permit holder of pending transport of live coral between sites, islands, and out-of-State; this notification should be clearly specified in the permit. Notification is required by both State and Federal regulations when taking live animals aboard a plane. Notifications should include evidence of legal authority to transport the regulated live organisms. The notification should identify the individuals involved and the specific organisms involved (along with numbers, etc.), and reference to their specific permit number(s). At a minimum, two parties should be notified: the NRT permitting agency and the local associated enforcement agency(s). NRT notification enables proper record keeping, user group conflict avoidance, and helps the permittee to comply with permit conditions. Notification of the appropriate marine enforcement agency is strongly recommended from a compliance standpoint and also prevents a misplaced response by enforcement officers during permitted activities. In cases where crossing of jurisdictions is involved, multiple agencies and permits may be required.

PERMITTING RECOMMENDATION: Permit conditions should prohibit interisland movement of corals or translocation of corals without formal written approval. Permittee is to notify DAR prior to any pre-approved interisland transport or translocation in State waters. Interisland transport requires a copy of the approved permit to travel with the organisms and be available at any time for inspection by the carrier, enforcement agencies or DAR.

XI. Issues Associated with Holding and Maintaining Corals (Nurseries)

Most jurisdictions have strong concerns about the importation of cultures, corals, tissues or symbionts from areas where coral disease, AIS, or water quality issues are known to occur. In cases where the source corals are from outside the country, the import permit requirement is universal; **Hawaii, in general, does NOT allow the importation of live coral in any form from other countries or States.** This is not always sufficient to control the risks, and communication between NRT agencies responsible for coral reef impacts and the agencies responsible for importation permits can help reduce these risks.

Significant ecological risks exist when disease cultures, live corals, live tissues, and/or symbionts from outside an area are allowed to be maintained live in facilities that are in close proximity to reef areas without sufficient biological control procedures in place, regardless of taxonomic similarity or parity. To reduce these risks, communication between the primary NRT agency with legal right of inspection and the permit issuing agency should be clear regarding the holding of live samples, colonies, and/or cultures in captivity.

Live coral should be held at a legitimate marine lab or aquaculture facility within the State of Hawaii with inspection provisions written into the permit conditions. Special provisions and requirements need to be included depending upon whether the facility has open or closed water systems (or both).

Experience has shown that holding of live coral over time requires a significant level of professional care and a dedicated facility with clean seawater access. Corals need daily maintenance when held in land-based facilities; and water quality is of prime importance. When the goal is to re-introduce the coral back into the wild in some form, the investment in regards to documented professional care and a dedicated facility free of contamination becomes paramount.

XII. Issues Associated with Acclimatizing Corals for Re-Introduction.

Corals to be outplanted, if grown and maintained in ex-situ nursery conditions (or in-situ conditions different from the outplant site) must be slowly acclimated to natural outplant site conditions before reintroduction. This requires adjustment (slowly, over a period of weeks) of water quality parameters, lighting, temperature, turbidity, and water motion to mirror conditions at the outplant site.

XIII. Issues Associated with Preparation and Modification of a Restoration and/or Outplant Site

Outplanting corals require careful preparation of the outplant site, including site maps and documentation to show that the activity will minimize impacts to natural resources.

A. Spawning Periods

Restoration activities that may affect adjacent coral colonies should be curtailed immediately before, during, and for three days after, anticipated annual coral spawning events. DAR will determine these periods for the species in the immediate area of the activity and set-up corresponding inactivity windows for the restoration field work to take place.

PERMITTING RECOMMENDATION: Permit conditions should prohibit significant disturbance activities during the anticipated annual spawning periods for those major coral species present in and around the outplant site. In general, focus is on the periods around the full moon during April and May for *Pocillopora meandrina*, new moon during June, July and August for *Montipora*, and full moon during July and August for both *Porites* and *Fungia*.

B. Determining Habitat Outplant Dynamics at a Restoration Site

Coral reefs are complex systems made up of a suite of habitats, only a portion of which are actually corals. Outplanting of corals as part of a restoration activity requires analyzing the restoration habitat relative to the following:

1. Soft Substrates (Sand, Rubble)

With few exceptions, most Hawaiian coral species occur on hard substrates. Placing coral (even atop man-made structures) in sand and rubble habitats leaves corals exposed to harsh sediment movement conditions, where over time colonies can be scoured, smothered, or exposed to extended turbid conditions which can affect long-term survivability. Many soft substrate habitats will appear to be unused from a distance but actually may contain infaunal communities or *Halimeda* or native sea grass (*Halophila*) meadows.

There are two methods to anchor corals in soft substrate habitats:

a. Affixing an anchoring mechanism, like a corkscrew or duckbill stake, into the soft sediment. Concerns include movement over time and entanglement in the anchoring lines.

b. Placement of a large solid substrate object[21] atop the soft substrate. The solid substrate object needs to be heavy enough not to move with storm waves, strong currents, or be moved by human activity. Concerns may exist for AIS settlement on the exposed substrate object. Composition of large, solid substrate objects used must be evaluated relative to their breakdown rate in seawater or their ability to leach toxic or environmentally-harmful materials over time.

2. Hard Substrates

Outplant sites should not be atop or impinge other major live coral colonies. Most exposed hard substrate will constitute live rock under State law and require specific approvals for outplanting atop. In general, detailed site descriptions need to be evaluated in advance to determine the level of loss that may occur. Cleaning of the hard substrate surface can be accomplished with wire brushes and scrapers prior to affixing the colony structures to the hard substrate (see Appendix VII).

C. Determining Coral Outplant Dynamics at a Restoration Site

Given the documented slow natural coral growth rates in Hawaii and trophic dynamics associated with co-evolution amongst endemic reef species, efforts should be made to maintain historical species biodiversity at a restoration site.

1. Species Diversity

Species outplanted to a site should be the same as what currently occurs at the site or what historically has been documented at the site. Natural history differences in species distribution (depth, light, wave action, turbidity, etc.) should be followed. Documented restoration site assessments should be conducted prior to outplanting of coral to determine existing coral species, state of the corals, and sizes.

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[21] Placement of large objects onto State submerged lands may require both State and Federal permits.

2. Outplant Colony Size

In general, due to slow growth rates, larger size colony outplants provide higher confidence in survivability and greater ecological services and functions than smaller conspecifics and should be encouraged where practical. Advantages of outplanting large-sized (40 cm+) colonies:

a. Large corals provide far more ecological services and functions than small coral colonies, including greater shelter space for fish and invertebrates.

b. Large corals provide a significant size refuge against sedimentation, physical disturbance, predation, competition, disease, bleaching and pollution effects.

c. Large corals are more likely to be sexually reproductive.

d. Large corals provide greater protection against alien species inundation.

Issues of natural juvenile colony survival at the outplant site can help determine minimum desired colony outplant size.

3. Outplant Colony Growth Form

Growth form at the time of outplanting should be designed given unique site specifics such as level of wave action and water motion, diurnal light levels, and turbidity.

4. Proximity of Outplants

In Hawaii, outplanted corals should be spaced a minimum of 20 cm away from each other to minimize inter- and intra-specific competition between colonies in the near term[22].

D. Restoration Plan Approval

A detailed Restoration Plan will need to be submitted to the State for approval. Depending upon the situation and scale of the project, an applicant might also have to produce either a detailed Environmental Assessment (EA) or a Environmental Impact Statement (EIS). The Restoration Plan will need to detail how the field work or activity will be accomplished and include a discussion of any anticipated impacts (turbidity issues, clearing of live rock, etc.). The applicant should be concise but thorough in describing the various phases of the restoration activity along with the techniques and materials to be used in the field and the equipment/material to be used. If

[22] Based on slow (1 – 2 cm per year) average growth rate (Minton, 2013).

man-made materials are to be left in State waters, indicate precisely their composition and dimensions and numbers, and provide specific siting information.

Modification of Hawaii State Submerged Lands requires approval from the Board of Land and Natural Resources and may require other approvals from other agencies. For larger scale restoration projects, one or more of the following approved plans may be required:

1. Aquatic Invasive Species Plan

2. Chemical / Pollution Control Contingency Plan

3. Turbidity / Siltation Control Contingency Plan

In addition, there may be concerns about genetic or ecological changes to the native population brought about by the introduction of conspecifics from outside of the immediate area which would need to be addressed during the Restoration Plan approval process.

E. "Proof of Concept"

When confronted with proposed large collections or outplanting numbers and sizes, broad restoration site impact concerns, novel restoration protocols or activities, or high risk associated with proposed restoration activities, a demonstration project or "proof-of-concept" activity under controlled conditions requirement can provide an opportunity to work out problems with a restoration protocol. Such a requirement benefits the restoration applicant, the natural resource itself, and the State of Hawaii. Triggers for this approach might include: the size or scale of the proposed activity being uncomfortably large; availability of funds to complete the proposed work and permit conditions or any questions as to the feasibility of the methods or procedures proposed. **For projects that have never been successfully done before in Hawaii, small-scale Proof of Concept projects should be done in non-critical, safe environments such as microcosm tanks, non-critical generic areas, and sites where unforeseen negative impacts can quickly be contained and reversed.**

F. Use of Vessels, Large Equipment

Usually restoration activities require the use of small vessels and occasionally larger platforms to operate and conduct activities off of. These platforms themselves create a series of impact concerns due to their need to operate in close proximity to coral reefs.

1. Anytime a vessel or large equipment is used in close proximity to shallow coral reefs, a surface lookout or other forms of vigilance should be used to avoid contact with shallow living structures and protected animals such as monk seals and sea turtles. It is preferable that the area be thoroughly surveyed and documented prior to moving vessels or equipment in to do work.

2. Requirement for "Clean" Restoration Equipment, Vehicles, etc.

   Assurance of clean or decontaminated gear, vessels, and restoration equipment and supplies (specifically, structures to be placed underwater) is increasingly becoming a standard for coral disease work and involves NRT-approved standard operating procedures (SOPs) (Woodley *et al*. 2008). This same approach is also required for restoration work in Hawaii, and should involve pre-activity inspections of all in-water gear, vessels, and equipment to verify that they are "clean" of foreign, invasive or hazardous materials and organisms. Where cleaning is required, it is done to a NRT-acceptable standard (which may vary by jurisdiction), and is done in a location that poses no risk to Hawaii's regulated species or areas.

PERMITTING RECOMMENDATION: Permit conditions should require documentation that all in-water gear, supplies, dive gear and vessels to be used on-site for restoration activities has been cleaned and inspected for AIS and other health concerns. Furthermore, the permittee should certify that such cleaning and inspection was done both prior to initiation of active field restoration work, and outside of the targeted area either on land or in a pre-approved marine location.

3. On-Water Fueling of Vessels and Equipment

   Fueling of vessels shall be done at approved fueling facilities. On-water fueling of vessels and equipment shall only occur with proper spill control materials on-site.

4. Specific Platform Issues

   Platform issues need careful consideration when operating in Hawaiian coral reef waters as a result of increasing user overlap, concerns about AIS and pollution, and secondary impacts resulting from the use of the platform itself to conduct restoration activities. The issues include those associated with modes of transport into or out of the targeted restoration area (e.g., waterways, channels, moorings), and/or support structures from which in-water restoration operations can be staged (e.g., public docks, research vessels). To address these issues permitting questions may include:

a. Are there conflicts or impacts associated with the applicant's proposed platform use of public docks, waterways, channels or moorings?

b. Are there health and safety issues relative to the use of the applicant sharing the platform for use of transport or staging of gear, restoration supplies, biological samples, or chemicals?

The discharge of materials, by the platform while either on route to the reef restoration site or while on station, can pose serious impact concerns. Major types of discharge include grey water, black water, bilge and ballast discharges:

a. <u>Grey Water</u>.
Grey water discharges include those involving a release of wastewater (but not sewage), most often used for cleaning elements of the platform, its occupants, or for preparing samples, food or gear. Grey water poses risks because it frequently contains measurable amounts of hydrocarbons, fecal coliform bacteria, and other pollutants. On restoration platforms it may inadvertently contain traces of chemicals used or serve as a pathway for disease or invasive species introductions.

b. <u>Black Water</u>.
Black water discharges primarily represent human sewage and can be a significant source of disease, nutrients and chemical pollution.

c. <u>Bilge</u>.
Bilge discharge can release a variety of pollutants, oil, and AIS.

d. <u>Ballast Water</u>.
Ballast water discharge is most often seen with large vessels that carry cargo. Ballast water discharge can also release AIS.

Often such discharges are covered additionally by agencies other than the direct NRT involved in approving the restoration activity, and can be addressed in different ways. Some NRTs require permission from the other regulatory body regarding discharge, others include permit conditions to minimize it, and others require a trained and recognized Pollution Prevention Officer to be present and actively engaged aboard larger platforms.

Anchoring the staging and/or transport platform in a coral reef area raises concerns that are often overlooked during the permitting process. Asking whether the platform would anchor on or near the reef structure regardless of the restoration activity can provide guidance in the review process. If so, then the platform may be regulated through other means than the applicant's permit. Anchoring of platforms in some jurisdictions requires differentiation between large vessels that stay a considerable distance away from the shallow reef structure (but which can significantly damage deeper habitat with their larger anchors), and smaller skiffs which often go over reef structures and into lagoons or deeper reef flats.

a. Large research vessels, operating in close proximity to coral reefs, can increase the magnitude of damage caused from a variety of activities described above, in addition to physical damage caused if the vessel runs aground. Anchoring should be restricted to soft bottoms only, or if anchoring in close proximity to a reef, divers should be used to sight the anchor.

   Anchoring should be designed to slightly over-compensate the stabilization and holding needs of the platform in order to accommodate changes in current, wind, waves and platform operations. This is done primarily to prevent the platform shifting anchorage and damaging reef structures, and the movement of the anchor itself serving as a mechanism to directly damage reefs through its movement. Multiple anchors can be used to stabilize a platform from moving with current or wind changes; care needs to be used in anchor and chain placement on the bottom and concerns about increased entanglement risks based on multiple lines being in close proximity underwater.

b. Small skiffs often have the ability (due to the shallower water) to direct their anchoring away from reef substrate or hand-placing their anchors if required as a permit condition. However, impacts from the use of small craft atop or near reef structures include inadvertent hitting of the reef with their hulls while maneuvering and prop damage to structures.

Permit conditions should require minimum training and experience of vessel operators in regards to operating within shallow Hawaiian reef areas, mandatory use of GPS, and maintenance of GPS logs (or preferably a mandatory vessel monitoring system (VMS) required by the jurisdiction), and slow speed with a bow lookout while over shallow reef habitat can minimize the risks of these impacts.

Other activities associated with the use of restoration platforms include fishing, multiple research or restoration activities by different parties, and concurrent commercial activities.

5. Fishing activities off platforms often occur when restoration activities are done in remote areas with individuals fishing for food, but should be discouraged or prohibited in those areas where the general public is regulated against such activities.

6. Concerns about the synergistic or cumulative effects of multiple activities on the same restoration platform are significant and often occur with research or commercial vessels used. In general, each discrete restoration activity should be permitted separately; the use of "blanket permits" to cover a wide range of activities on coral reefs conducted by a wide range of researchers at a single institution leads to lack of accountability and difficulty in managing resource impacts. Commercial activities co-occurring on a platform used for restoration should be discouraged in ways that keep each as separately regulated activities.

   At the end of the permit period any structures, moorings, or vessel platforms from the targeted area which were brought in and used in support of the proposed restoration activity should be removed and be included as a permit condition. Documentation should be required to validate that this condition has been met. Any damage caused to the natural resource by the proposed restoration activity or its support platforms should also be documented and corrected. The requirement of GPS-synched photographs (along with date-time stamps) can serve as an inexpensive way of documenting pre-existing baseline conditions, durational impacts and post-removal return to baseline (see Appendix IV).

7. Minimizing Collateral Damage

Some in-water gear raise few, if any, permitting issues (small data loggers, water- and sediment-sampling devices that are not motorized or operated in a non-mechanical manner, non-permanent transect lines and quadrats), while other types of gear need to be limited both in number and application (sub-surface marker buoys, underwater stake markers). For coral restoration activities, certain gear may require strong limitations and conditions on use (e.g., hard substrate extractive and modification gear, chemical release gear, microcosm gear, caging equipment) due to its ability to cause significant impacts or ecological phase shifts; its ability to move about with moderate surge; or its likelihood to serve as settlement substrate for AIS.

8. Placing Objects on the Bottom

All objects should be lowered and/or placed on the bottom in a controlled manner. Where necessary, lift bags, winches, cranes or other equipment should be used to maintain control over the rate of descent and allow for precise placement or installation on the bottom. Operators of such equipment should have documentation as to required experience in its operation.

9. Presence of ESA-Listed Species

All significant in-water restoration work activities involving modification of substrate shall be immediately suspended if ESA-listed species enter the immediate area (i.e. within 50 m of an active work area). Examples of such species include marine mammals (including the Hawaiian Monk Seal) and sea turtles. Work activities are defined specifically as preparatory actions for restoration or the actual restoration activity itself.

10. Avoiding User Conflicts

User conflicts can arise between restoration activities and the public (e.g., fishing, recreational vessels), commercial enterprises (e.g., dive operators, tours), or other ongoing research activities (e.g., long-term monitoring efforts). Many jurisdictions do not want restoration activities to displace or create conflicts with their local and established users of the marine resources. Limiting the target area or specifically designating appropriate sites for conducting the proposed activities can help limit these concerns. Requiring GPS and photo documentation of all restoration field activities can also help later in discerning validity of impact complaints to existing user sites (see Appendix IV).

G. Avoiding Introduction of Non-native or Invasive Species

Often concerns related to aquatic invasive species (AIS) are directed at extraction activities associated with source corals for restoration. Frequently overlooked are the potentially serious issues related to the introduction of non-native species during the active restoration activity itself.

1. Vector Issues

Many jurisdictions in areas with high incidence of coral disease or AIS outbreaks recognize a variety of user groups as potential vectors for movement of disease and AIS around the region; fishers, recreational tourism and field researchers are among those of greatest concern. Permit applicants may underestimate a species' AIS risk by suggesting that the species already occurs in the area under concern[23]. The perception that the threat to other coral species is minimal, as the disease or AIS has not been seen associated with other species, also can underestimate the risk. For example, in remote areas, the direct interaction with possible novel vectors such as divers, their gear and restoration activities may pose previously undocumented risks to such areas by introductions into a naïve population. The definition and issue of accurate geographical range of target species and/or symbionts or pathogens frequently arises in permit reviews.

Applicants may mischaracterize a species' true range or that of its symbionts/pathogens. For example, while the State of Hawai'i includes the NWHI and the Main Hawaiian Islands, *Acropora* coral species are primarily only found in the NWHI. Arguments have been posed that the movement of *Acropora* from the NWHI into the Main Hawaiian Islands does not qualify as importing alien species; this argument disregards the natural geographic range of the species which does not normally extend into the Main Hawaiian Islands and therefore does pose a risk.

<u>PERMITTING RECOMMENDATION</u>: In general, movement of live marine organisms between Hawaiian islands should require advance notification and approval from the permitting NRT.

Several alternatives may help address NRT concerns. One alternative is a requirement for the NRT to determine, as part of the permitting process, that the benefits of the proposed restoration clearly and significantly outweigh the risk posed from accidental introduction of non-native organisms, symbionts, or pathogenic microbes into areas under the agency's jurisdiction. Risks can be assessed using a simplified Risk Assessment process (Appendix VIII). An alternative approach by some NRTs is to require the applicant to submit detailed plans to minimize potential threats of AIS introduction or movement.

2. Minimizing Range Expansion of AIS and Disease

"When studying disease, the highest priority in public health, environmental science or any other research discipline, is to prevent its spread into previously unaffected populations" (Hargrove 2008). While Hargrove was talking specifically about coral disease researchers, the same approach applies to the relatively new field of coral restoration. The definition of actual range of a target disease or AIS versus the proposed range of restoration activity where overlap can occur is critical from a NRT and risk management perspective.

[23] While this may be true, it may represent a completely different population and or associated symbiont/pathogen assemblage.

Lacking specific information regarding this range, a NRT should assume that proposed restoration activities pose a significant risk of expanding the disease or AIS range without permit conditions to minimize this risk.

3. Cleaning Gear

Visual inspection of all diving and collecting gear prior to cleaning to remove small visible fragments of live material which might be resistant to the chemical cleaning. Clean gear by soaking in dilute bleach (Note: 1:20 dilution of commercial bleach) or a commercial cleaner which contains quaternary ammonium compounds (such as Lysol® cleaner), for a minimum of ten minutes, rinsing in freshwater afterwards, and then drying completely (Marano-Briggs 2006). NOTE: Freshwater soaks and/or just air drying DO NOT, by themselves, control bacteria or many other microbe's viability completely (Brownlee 2006).

H. Chemical Effects

Coral restoration fieldwork may involve the use of chemicals. This elicits strong concerns about the potential impacts if even small amounts are released into the marine environment. Strong NRT controls are usually placed on applicants carrying chemicals into the field on their person, on their in-water gear, or in small skiffs. A different level of concern exists for chemicals carried on larger, formal research vessels or platforms. Permit conditions often detail requirements to neutralize chemicals and provide primary and secondary containments for chemicals on-board. Chemicals of concern include chemical preservatives (such as formalin or ethanol), chemicals used to prepare restoration materials, chemicals used to capture organisms, chemicals used to treat organisms, and chemical used to disinfect or clean gear.

PERMITTING RECOMMENDATION: General permit conditions should prohibit the use of any chemicals directly in the marine environment and their presence on vessels or other platforms conducting restoration activities.

I. Direct Ecological Effects

In general, endemic species at the receiving site are more likely to be at risk from restoration activities due to lack of predator-prey co-evolution and the potential of being out-competed by introduced species or new colonies of the same species containing different endosymbionts.

J. Cumulative, Synergistic or Secondary Effects

Frequently a restoration applicant will only address direct potential effects of their proposed restoration actions, without considering long-term effects after they are finished, or what they are leaving for the NRT to manage over time. Increasingly, jurisdictions conducting restoration are considering longer term and cumulative effects into their restoration permit reviews. In general, a NRT will likely look at the cumulative or synergistic effects of the applicant's proposed activities with other ongoing activities in the target area to reduce impacts to habitat, populations, or the ecosystem, as well as expected possible secondary impacts, and attempt to manage them with additional permit conditions.

XIV. Other Issues

A. Issues with Restoring Rare Coral Species

By definition, rare corals occur in such limited numbers that any restoration activities involving their disturbance should be done by restoration practitioners with extensive experience and a proven success rate. Actions should be phased in with full risk assessments of each phase (Appendix VIII).

The State of Hawaii has initiated a Memoranda of Agreement (MOA) with the Maui Ocean Center to serve along with the Hawaii Coral Restoration Nursery (CRN), as a Rare Coral Ark Facility. The purpose of the Rare Coral Arks is to provide within a well-established facility with full-time professional coral husbandry and aquarium systems management staff, care and maintenance of extremely rare Hawaiian coral species as an insurance policy against its loss or extirpation in the wild. Both facilities have over 50 species within their Ark programs.

B. Restoration Within Identified Sensitive Areas

In general, **restoration activities to corals at identified sensitive areas need to be overly cautious, and should meet the strictest levels of review and permitting conditions.** Rationales for each field action must be carefully established and convey both a unique and justified need, along with a strong expectation of benefit as described at the top of the document. Of all sites in Hawaii, restoration in sensitive areas should only be allowed following successful pilot projects conducted elsewhere. Examples of identified sensitive areas in the Hawaiian Archipelago:

1. Northwestern Hawaiian Islands
    - **a. Northwestern Hawaiian Islands State Refuge**

2. Kauai County
    - **a. Waters Immediately Surrounding Offshore Islets**

b. **Waters Surrounding Kaula Rock**
c. **Mana Barrier Reef Complex**

3. Oahu
   a. **MLCDs**
   b. **Paiko Lagoon**
   c. **Waters Immediately Surrounding Offshore Islets**

4. Maui County
   a. **Waters Immediately Surrounding Offshore Islets**
   b. **MLCDs**
   c. **Ahihi-Kinau Reserve**
   d. **Deep Reef Areas Between islands**
   e. **West Molokai Nearshore Area**
   f. **Kahikili**
   g. **Oluwalu to Macgregor Point**

5. Hawaii County
   a. **Waters Immediately Surrounding Offshore Islets**
   b. **MLCDs**
   c. **Puako**

C. Use of Bonds and Other Means for Restoration Projects

Some jurisdictions have explored the use of bonds for restoration activities that pose substantial impact risks to natural resources or that are untested technologies or actions. The funds recovered under the bond are used first for emergency restoration costs and secondarily to mitigate unexpected damages caused by the restoration effort itself. The bonds functions in two ways, first it helps ensure compliance on the part of the permittee, as there is a significant and immediate monetary forfeiture upon violation and it clearly shows the seriousness of the resource management agency in addressing unacceptable impacts from activity. The second advantage of a bond program is that it provides guaranteed funds from forfeited fees for cases needing immediate response or emergency restoration actions.

D. Weeds in Areas of High Biodiversity or High Endemism

Increasingly there's discussion about making certain coral species (usually ones that already express colonizing characteristics (i.e. fast growth, ability to settle in new environments, etc.)) more resistant to environmental change. While such a intervention strategy may be desirable at some future date or in certain geographical locations currently, they pose additional risk in a region such as Hawaii characterized by extremely slow natural coral growth and extremely high endemism. Additionally, endemic corals (as Keystone Species) often have a range of endemic reef species uniquely associated with them. Promotion of generic colonizing species over the wide range of less common endemic corals could result in significant phase shifts to our Hawaiian reef ecosystems. Secondary concerns might include enhancement of populations of native pest species due to such restoration. For example, in Florida the influx of coral outplants has led to an increase in corallivorous snails, whose predators are being fished out, leading to a cyclic problem for coral outplants.

E. Publication Concerns

Many NRT agencies will specifically request that certain compliance information be included in any publication relating to activities they permitted. Examples include listing the permit number and type used for the research; and acknowledgement of laws and rules related to the organism, area, or gear used. Some jurisdictions require (as a permit condition) a review and clearance of publications or findings or analyses prior to public release. These types of conditions provide control over misinformation regarding specifically regulated resources or areas.

On a different topic, as coral restoration science is a relatively new field, there are many people publishing how-to guides and best management practices which may be counter-productive in places such as Hawaii with exceptionally slow growth rates and high endemism, where the resource is strongly limited in nature, and where there are significant and wide-ranging pressures on the marine resource from other users. While the NRT does not have control over an author's views and opinions based on permitted actions, it does have a responsibility to the public it serves to correct misinformation that harms the public trust resource through its publication.

XV. Conclusions

Coral restoration is a relatively new field and an increasingly critical focus of study from both a regional and international resource management perspective, and one that needs to be continued and expanded at an alarmingly fast pace. Hawaii, by virtue of its extreme isolation, high endemism, and exceptionally slow natural growth rates, poses unique challenges to this new field in regards to methodology and protocols which may significantly differ from those commonly used elsewhere. The potential focus on multiple sites, extraction methods, field manipulations, and effects on vector ecology all have resource management implications relative to the proposed restoration that may be new, novel, or threatening to public trust resources. The recommendations listed and proposed strategies listed above offer a first synthesis of approaches towards minimizing significant risks in order to allow certain of these activities to progress to better benefit management of the resource. Ultimately, the most successful coral reef restoration permitting programs will be judged based not on the number of publications nor necessarily on the quality of the science conducted, but instead on these four basic principles (Note: Adapted from the State of Hawaii NWHI Refuge rules):

1. A “Do No Harm” requirement for setting permit conditions.

2. Use of a clearly defined precautionary approach in setting permit conditions, designed to minimize impacts from activities; especially where precedent or data is limited.

3. Transparency in the permitting review, including a public comment component.

4. Substantial penalties and public accountability of permit violators to minimize environmental damage and maximize compliance.

In the final analysis, it is the pursuance of the State’s constitutional mandate to protect and conserve its natural resources for the benefit of the people of the State of Hawaii that is of overriding concern, not the significance of the science proposed, nor the funding accepted, nor even the political pressure of those individuals or outside agencies or NGOs involved.

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Appendix I. State Laws, Rules and Regulations Governing Hawaii Corals, Live Rock and State Submerged Lands[24]

Coral & Live Rock Regulations

- Violations of State-issued Special Activity permits involving regulated marine organisms, marine habitats, or gear, may subject the Responsible Party (RP) to criminal and/or civil penalties under HRS §187A-12.5, 187A-13, & 188-70.

- All coral and live rock (any marine substrate with marine life visibly attached) are fully protected against any take or disturbance. HAR §13-95.

Hawaii Endangered Species Regulations

- Prohibits take, transport and commerce in species listed by the State of Hawaii as Endangered. Such species may be in addition to those listed by the Federal government under the Federal ESA. HRS §195D.

Invasive Species Regulations

- Rules and regulations to prevent the introduction and spread of non-indigenous aquatic species into State waters. HRS §187A-6.5, HAR §13-76.

- Regulations relating to intentionally importing prohibited or restricted articles into Hawaii. HRS §189-6.

Marine Protected Area and Marine Managed Area (MMA) Regulations

- Rules and regulations related to MPAs and MMAs in the Main Hawaiian Islands.
  - Big Island. HRS §188-34, HAR §13-29, §13-33, §13-35, §13-37, §13-47, §13-54, §13-55, §13-57, §13-58, §13-60.4, §13-63, §13-95-18.
  - Kahoolawe. HRS §6k; HAR §13-260.
  - Kauai & Niihau. HRS §188-22.5, §188-35, HAR §13-49, §13-50, §13-60.8, §13-64, §13-65.
  - Lanai. HAR §13-30, §13-53.
  - Maui. HAR §13-31, §13-32, §13-51, §13-60.7, §13-209, §13-244-32.
  - Molokai. HAR §13-56.
  - Oahu. HRS §188-22.8, §188-34, §188-35, §188-36, HAR §13-28, §13-34, §13-36, §13-48, §13-62, §13-125.

- Rules and regulations related to the Northwestern Hawaiian Islands Marine Refuge. HRS §188-37; HAR §13-60.5.

Submerged Lands Regulations

- HAR §13-5: Conservation Districts. All submerged lands within State waters are considered conservation district and covered under HAR §13-5. Placement or

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[24] HRS refers to Hawaii Revised Statutes (laws) and HAR refers to Hawaii Administrative Rules; both of these are the legal instruments used to regulate activities in Hawaii associated with natural resources.

erection of any material on lands, if it remains longer than 14 days, will require approval of the State. This would include scientific equipment, monitoring stakes, and most forms of coral restoration.

Water Quality Regulations

- HAR §11-55: Water Pollution Control. Administered by the State Department of Health, Clean Water Branch. Includes requirements for NPDES permits.

- HAR§11-200: Rules for Environmental Impact Statements.

Appendix II. International and Federal Treaties, Laws, Rules and Regulations Governing U.S. Coral Reefs and Importation of Coral Reef Products

International Regulations

Research Permits – Most countries require some sort of permit for conducting research activities in-country. Most jurisdictions have multiple levels of permitting, often through different agencies. There may be a cost for such permits.

Research Visas – A number of countries require specific visas for research-focused activities. Lack of the proper type of visa can result in fines, incarceration, deportation and confiscation of research samples, gear and equipment. Usually there is a fee for visas.

International Treaties

Convention on Biological Diversity (CBD) – 1993 (U.S. has not ratified this treaty yet). Sections of the treaty (Articles 8(g) and 8(h)) is directed at alien species or living modified organisms which may cause significant and harmful changes to a marine ecosystems, habitats or species through either intentional or unintentional introductions. Articles 4, 17.1 & 18.1 deal with transboundary movements of living modified organisms and biosafety considerations. This includes provisions related to transboundary movement of organisms relative to bioprospecting and biopiracy.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) – 1973 (U.S. ratified in 1974). All stony coral species and their products were listed in Appendix II in 1985; blue coral, organ pipe coral hydrozoan corals and black coral are also listed. Trade is allowed if the exporting country finds that the "take" does not pose a significant risk to the species in the wild or its ecosystem, and if accompanied by proper CITES permits. Each country has a management authority which issues such permits (in the U.S. that entity is the U.S. Fish & Wildlife Service).

Convention on Wetlands (RAMSAR Convention) – 1971 (U.S. ratified in 1986). The Ramsar Convention (so named from the site of its inception, Ramsar, Iran) provides a framework for international conservation of wetland habitats. Designated wetlands are often termed 'Ramsar Sites'. Each signatory country establishes a National Wetland Committee to guide that country's actions.

United Nations Convention on the Law of the Sea (UNCLOS) – 1994 (U.S. has not ratified this treaty yet). A section of the treaty (Act 196) is directed at species which may cause significant and harmful changes to a marine environment through either intentional or unintentional introductions.

International Convention for the Prevention of Pollution from Ships (MARPOL) – 1973, modified in 1978. The international treaty to control pollution of the sea, including dumping, oil and exhaust pollution. It covers dumping of materials from ships at sea. All ships flagged under signatory countries are covered, regardless of where they sail.

U.S. Federal Law, Rules and Regulations

Admissions Act – The Admissions Act of 1959 provided for admitting Hawaii into the Union and defined specifically what constituted the State of Hawaii. Section 2 of the Act specifically states that "The State of Hawaii shall consist of all the islands, together with their appurtenant reefs and territorial waters, included in the Territory of Hawaii on the date of enactment of this Act..." . The Admissions Act makes clear that all reefs (and thereby all corals attached or on these reefs) attached (appurtenant) to an emerged island in Hawaii (except Midway) belong to, and are under the administrative and legal control of, the State of Hawaii. This provision is clear and different from the broader, undefined definition of what constitutes State waters.

Clean Water Act (CWA) – The Clean Water Act of 1972 (sometimes called the Federal Water Pollution Control Act) protects surface waters in the United States from activities affecting water quality. The act is administered by the EPA. A primary function of the act is to stop pollutants from being discharged into U.S. waters; another section is focused on wetlands, which are viewed by the U.S. EPA as including coral reefs.

Endangered Species Act (ESA) – The Endangered Species Act of 1973 protects and conserves species that are listed as endangered or threatened. The act is administered by either the USFWS or NOAA. A number of coral species, (example: *Acropora palmata* and *A. cervicornis*), are listed, though none currently in Hawaii. In addition, restoration activities on reefs or other habitats which may affect critical habitat for other ESA species such as sea turtles, monk seals or other species may trigger ESA concerns. Note that the ESA's definition of harm as part of "take" includes habitat effects (upheld in the U.S. Supreme Court decision involving Babbitt v Sweet Home Chapter of Communities for a Great Oregon).

Executive Order 13089: Coral Reef Protection – Signed by President Clinton in 1998, this executive order mandates that all Federal Agencies use their resources and existing authorities to better protect and conserve the nation's coral reefs.

Fish & Wildlife Act (FWA) – The Fish and Wildlife Act of 1956 (16 U.S.C. §742) established a comprehensive national fish, shellfish, and wildlife resources policy, that coordinates federal actions and reviews, and directs a program of research activities related to both national and international fish and wildlife matters.

Lacey Act – The Lacey Act of 1900 (16 U.S.C. §3371-3378, 18 U.S.C. §42) prohibits trade in flora and fauna that have been illegally taken, possessed, received, transported, or sold. It is administered by the USFWS and NOAA, and may occur when such actions are taken in violation of state, federal, tribal or foreign laws or regulations.

Misdemeanor violations include up to $10,000 fine per violation or up to one year in jail. Felony violations include up to $20,000 fine per violation or up to five years in jail.

Magnuson-Stevens Fisheries Act - The Magnuson-Stevens Act of 1976 (16 U.S.C. §1801-1884) is the primary law governing the management and conservation of marine fisheries in the United States and establishing essential fish habitat. A series of Fishery Management Plans have been created around the U.S. that include corals under their management, including plans for U.S. Federal waters in the Gulf of Mexico, the Caribbean, and the Pacific.

National Environmental Policy Act (NEPA) – The National Environmental Policy Act of 1970(42 U.S.C. §4321 et seq.) establishes national policy and goals related to conservation of the nation’s natural resources. It establishes policies related to the need for and production of Environmental Assessments (EA) and Environmental Impact Assessments (EIS), and directs various federal agencies roles in review and production. It is primarily administered by the EPA.

National Marine Sanctuary Act (NMSA) – The National Marine Sanctuaries Act of 1972 (16 U.S.C §1431 et seq.) provides for regulation of activities within designated National Marine Sanctuaries, and provides for civil penalties of up to $130,000 per day per violation. It is administered by NOAA.

National Park Service Act (NPSA) - The National Park Service Organic Act of 1916 (16 U.S.C §1 et seq.), established the National Park Service and provides for regulation of activities within designated National Parks. It is administered by the National Park Service.

National Wildlife Refuge Act (NWRA) – The National Wildlie Refuge System Administration Act of 1966 (16 U.S.C. §668dd – 668ee et seq.) provides for regulation of activities within designated National Wildlife Refuges. It is administered by the USFWS. Public Law 100-653 (1988) allows for fines for violating the Act as provided for under the U.S. Code (sections 3571 – 3574), up to one year in jail, or both.

Rivers and Harbors Act – The Rivers and Harbors Act of 1899 (33 U.S.C. §403) in part regulates the release of matter of any kind and the placing of structures in the Nation’s navigable waters[25]. While much of its provisions are also covered by the CWA, this act remains independent and under the administration of the U.S. Army Corps of Engineers.

Sikes Act – The Sikes Act of 1960 (16 U.S.C. §670a-o) requires the Department of Defense to provide for conservation and restoration of fish and wildlife resources on lands

[25] Section 10 of the Act states that "All waters subject to the ebb and flow of the tide (tidal action) are navigable waters of the US".

(including submerged lands) under its control. Public Law 99-561, approved in 1986, (100 Stat. 3149) required Federal and State natural resource agencies be given priority in management of fish and wildlife activities on military reservations.

Appendix III. Requirements for Facilities Holding Live Coral in Hawaii

A. In-Situ Nurseries

1. In-situ nurseries are exemplified by coastal water costs and concerns, relatively lower labor costs, lower energy and supply costs, with tradeoffs in water parameter control and resultant coral growth rates.

2. **Siting of In-Water Nurseries**

   a. **Depth**
   Depends on potential wave, current and light dynamics at the site. In Hawaii, due to intense wave action, in-situ nurseries are best located in deeper water and/or in shallow waters protected from strong surge/wave action, tidal influences, high light levels, and human activities.

   b. **Water Quality**
   In-water nurseries should not be sited in areas that experience or are vulnerable to effects from excessive runoff or waste water inputs.

   c. **Overlapping User Groups**
   The specific site used for an in-situ nursery should minimize conflict with other marine users and specifically limit their influence on the water quality and other environmental dynamics of the nursery site. The nursery should be located in an area that is not frequently used for recreational or commercial activities (fishing, boating, snorkeling, etc.) where nursery corals or materials may be damaged or altered.

   Another consideration of placing nurseries into public areas is the potential for ecotourism effects. That said, this also increases concerns regarding the unlawful take of resources from a nursery for other uses, in the Caribbean, a number of in-situ coral nursery locations have reported repeated of corals from their in-water structures. For Hawaii, the balance needs to be on public use of Public Trust resources (State submerged lands) and concerns regarding displacement of existing user groups in regards to siting of in-water facilities.

   d. **Proximity to Healthy Reefs**
   Close proximity (i.e. within 10 meters) of healthy, living coral reef poses unreasonable risks to natural reef structures in Hawaii. Nursery structures may serve as substrates for disease, AIS and predators that could negatively impact the adjacent natural reef.

e. Inspection of In-Situ Nurseries

Facilities sited within State waters have to be available to inspection by the State of Hawaii NRT agencies. Inspections will focus on health of the corals maintained, the viability of the structures used relative to potential impacts on adjacent habitats, user conflicts within the area, and nursery operations concerns.

3. Materials Used

Because of strong seasonal wave action, currents and rules regarding the types of material that can be left in State waters for extended periods of time, detailed discussion between the restoration practitioner and the permitting NRT agencies must occur early on in the planning stages. In general, concerns about the materials used can be broken down into the following overall concerns:

a. Leaching and Other Chemical Concerns

Certain materials (concrete, PVC, other plastics) are known to leach chemicals over time. Of primary concern is the use of such materials for life stages of corals that may be the most susceptible to chemical effects (i.e. Larval settlement and microfragmented coral polyps).

b. Bioaccumulation

As algae and other organisms grow atop certain materials, grazers may scrape the material along with the organisms they are consuming and over time, bioaccumulate these materials internally. Other consumers may move these materials up through the food chain, where eventually they could affect humans. Soft metals and toxic materials such as lead should not be used.

c. Entanglement

Lines and cords used to suspend hanging nurseries and to anchor structures could pose entanglement risks for marine mammals and sea turtles.

d. Damage to Adjacent Habitat (Bulldozing)

If portions of the in-water nursery break loose, waves and currents could in turn move them into adjacent natural reef structures, causing damage.

4. Post-Collection Steps

a. Removal of AIS should be done immediately after collection, again immediately following transit and before being placed into the nursery, and checked regularly following introduction to the nursery setting.

b. Removal of excess rock and exposed skeleton with no living coral tissue (this will help minimize AIS, micropredators, and pollution issues).

c. Near-daily health, micropredator, and AIS checks.

5. Quarantine

Because quarantine for AIS and disease concerns is not practical in-situ, in-water nurseries should restrict the corals that they actively hold to those from the immediate area which have decreased AIS or disease concerns. Limited in-water assessment can be done for health concerns where frequent monitoring is possible. Alternatively, the use of an ex-situ quarantine system could address concerns regarding AIS and disease prior to transfer to the in-situ nursery site. Corals must be kept under quarantine until observed to be pest and disease free for a minimum of 30 days and follow the recommendations for ex-situ quarantine facilities shown below.

6. Holding of Organisms

a. Absolutely NO chemicals, antibiotics, nutrients, or genetically-modified organisms or food items can be used or placed in State waters without thorough review and written approval (in advance) by DLNR (and possibly additional State and Federal agencies).

b. Daily health and AIS checks done on all corals in the nursery is recommended. Minimum time frames should be established if daily care is not practical. The size of the in-water nursery should be scaled relative to its ability for daily maintenance and evaluation.

c. Frequent removal of algae, unwanted organisms, and sediment on coral and adjacent structural materials should be done.

d. Protocols should be followed to minimize impacts to the surrounding area during nursery maintenance. This specifically includes not allowing debris caused by cleaning activities to float onto adjacent reef habitats.

e. Prevent and minimize potential damages due to nursery structural failure (i.e. broken materials) by conducting frequent inspections and maintenance.

f. Recognize that by holding organisms on structures in deeper water (due to wave action, tides, currents, etc.), re-acclimation (to higher light levels, water motion, etc.) will need to occur prior to outplanting nursery-grown corals in shallower waters.

g. Disease outbreaks in a nursery are best controlled when spotted early through regular nursery checks. When corals experience any mortality due to disease, they should be removed from proximity to other healthy corals or from the nursery entirely.

h. Dead coral skeletons should be documented, then removed from the nursery and disposed of through proper channels. Piles of coral skeletons become hazardous rubble in areas with high wave action and inadvertent artificial reefs when in areas of low wave action. Note that dead coral in State waters is still fully protected by law.

7. Permittee Biosecurity Actions

All individuals working within the nursery and its holding facilities must practice appropriate biosecurity actions in regards to the facility and DAR's guidance to minimize transmission or exposure of AIS, disease, or micropredators. Often this involves mandatory inspection and cleaning of individuals and their gear both prior to, and immediately after, exposure to corals held in captivity.

Additionally, as in-situ nurseries are sited in areas open to the general public, additional controls may need to be required to minimize these same concerns for the general public and to evaluate the risks involved with holding corals under such circumstances.

8. Data Sharing / Reporting

Within in-situ nurseries, restoration practitioners have an obligation to report the health and survival of corals within their care. As such, permits should require quarterly or semi-annual reports of coral health within the nursery compiled from routine coral health and AIS checks, including overall coral mortality, presence of any AIS, and cause of any coral loss. In addition, this report should include any nursery maintenance including the addition or removal of any structures, disposal of any dead coral skeletons, or actions taken to combat disease or AIS within the nursery.

Permits should also stipulate a requirement for immediate notification of both DAR and the State of Hawaii Department of Health of any die-off or health issue affecting 20% or more of the corals maintained by the coral nursery.

B. Ex-Situ Nurseries (Including Existing Public Aquariums and Research Facilities)

1. Land-based nurseries are exemplified by high coastal land costs, high labor costs (including the need for professional aquaculture specialists with coral husbandry and aquarium systems background), high energy and supplies costs.

2. Siting of Land-Based Nurseries
Most land-based nurseries are located directly adjacent to the ocean with both saltwater intake and outfalls.

3. Water Sources
Different sources of seawater for a land-based nursery come with different advantages and disadvantages (all need to be as clean as possible, likely require the use of filtration, and will need a mechanism for appropriate and legal discharge):

a. Direct Seawater Intake
Advantage: Large volumes available, cost per volume is low. Mirrors ambient water temperatures.
Disadvantages: Concerns about water quality, pollution, nutrients, disease and AIS coming in with water. Mirrors ambient water temperatures. Cost of filtering and pumping.
Note: May require extensive filtration (sand filters, sock filters, activated carbon filters) and/or the use of UV sterilizers or ozone. Permits for intake(s) and outfalls will be required.

b. Saltwater Well
Advantage: Minimal pollution, disease and AIS concerns; water temperature tends to be a couple degrees cooler than ambient during the hottest times of year.
Disadvantages: High silicate levels and other minerals (which may cause diatom blooms). Cost of installation and pumping.

c. Artificial Seawater
Advantage: Minimal water quality, AIS, disease and pollution concerns. Ability to precisely control saltwater parameters.

Disadvantages: Limited to availability of salt mixes and holding tanks. Cost per volume is extremely high. Need large volumes of purified/distilled freshwater. Storage space required. Poor quality control of salt mix purity can be devastating to overall water quality.

The Hawaii Coral Restoration Nursery has all three water sources available and has used different combinations at different times of year. Note that all three water sources require a mechanism for disposal; most likely either an ocean outfall, injection wells or discharge to the sewage system. All discharge mechanisms require permits (possibly from multiple agencies). Water exiting the nursery setting may require sterilization through UV or other filtration to reduce introduction of AIS or disease.

4. **Seawater Disposal**

Seawater used to hold corals in a land-based nursery will need to be disposed of either continuously (flow-through system) or occasionally (closed system through partial or complete water changes). Disposal of used seawater usually occurs in Hawaii in one of three ways:

a. Seawater Outfall into Ocean
b. Ground Sump
c. Disposal into County Sewage System

Each of these mechanisms needs special permission and approvals from one or more county, State or federal agency. Care needs to be taken to treat seawater where necessary to remove concerns regarding AIS, bacteria, pollutants, nutrients, and/or chemical enhancements.

5. **Materials Used**

Maintaining corals in microcosm on land requires extensive equipment including, but not limited to, an assortment of tanks, water pumps, air pumps, chillers, skimmers, highly specialized lighting (and/or shading) equipment, and extensive and variable piping.

a. Need to use "aquarium-safe" materials to hold corals. Certain tank materials may leach (certain plastics, etc.) or not hold up to sunlight or lights used. Glass and plexiglass are frequently used; gel-coated fiberglass troughs also are commonly used. Only use "aquarium safe" sealants (most silicone sealants are not "aquarium safe", look for ones that are labeled as such) on aquariums and troughs.

b. Only use coral-safe glues (not all cyanoacrylates (super glues) are the same; use either medical grade or one labeled specifically for corals).

6. **Permittee Biosecurity Actions**
   All individuals working within the nursery and its holding facilities must practice appropriate biosecurity actions in regards to the facility and DAR's guidance to minimize transmission or exposure of AIS, disease, or micropredators. Often this involves mandatory inspection and cleaning of individuals and their gear both prior to, and immediately after, exposure to corals held in captivity.

7. **Quarantine**
   The use of an ex-situ quarantine system is recommended (and may be required) in order to prevent AIS and disease transfer to an outplant site. Corals must be kept under quarantine until observed to be pest- and disease-free for a minimum of 30 days. This may be accomplished by using closed or open systems, defined below:

   a. Closed Systems

   Defined as a self-contained recirculating static system. This often utilizes the following (but is not limited to): a filtration system, sufficient lighting, methods of temperature control, foam fractionation, along with water changes to maintain water quality. Waste water must also be sterilized prior to disposal.

   b. Open Systems

   Defined as a dynamic system with incoming and outgoing water. This requires a source of clean seawater (and/or extensive filtration of incoming seawater) and methods for appropriately discharging outgoing water, through the use of ultraviolet light sterilizer.

8. **Post-Collection Steps**
   a. Removal of AIS should be done immediately after collection, again immediately following transit and before being placed in quarantine, and checked for daily while in quarantine.

   b. Removal of excess rock and exposed skeleton with no living coral tissue (this will help minimize AIS, micropredators, and pollution issues).

   c. Daily health, micropredator, and AIS checks. If issues are found, the 30-day quarantine period restarts.

   d. Daily cleaning (i.e. removal of algae and detritus) of quarantine system

9. **Holding of Organisms**

   In both closed and open systems, the following guidelines are recommended:

a. System Requirements

   Water quality control mechanisms, temperature control, lighting, water movement.

b. Coral Husbandry Requirements

   Conduct daily coral health checks. Requires daily removal of algae, unwanted organisms, and detritus oon corals and adjacent materials.

c. Coral Feeding and/or Supplement Dosing (may be optional)

   Coral foods vary and often are broken down by polyp-size varieties. The CRN feeds corals a variety of both live (zooplankton and phytoplankton cultures that we grow) and processed (home-made recipes combining commercial coral foods and amino acids with frozen, feed-quality marine organisms, all blended together and re-frozen into feeding pucks which can be dissolved in filtered seawater at a later date for feeding) coral foods.

10. Coral Husbandry Requirements

Maintenance of live coral in land-based nurseries requires a high degree of professional labor. Staff need extensive experience in both coral husbandry and aquarium system maintenance. The level of experience required is proportional to the scale of the operation, the length of time corals need to be maintained in captivity, and the rarity of the corals maintained. In general, coral husbandry includes:

a. Knowledge of coral species and special considerations concerning Hawaiian coral species, including micropredators and health issues associated with specific coral species.

b. Practical working knowledge of coral biology <u>and</u> husbandry.

c. Practical working knowledge of aquarium systems at the scale of those used for the nursery.

d. Daily coral health and water quality checks.

e. Daily life support checks.

f. Daily removal of algae, unwanted organisms, and detritus on coral and adjacent materials.

g. Optional coral feeding and or dosing.

h. Continuous record keeping on all aspects above.

9. Inspection of Ex-Situ Nurseries

Facilities sited on land within the State of Hawaii which hold live coral will have as a condition of their permit the ability for the State NRT agencies to inspect the facility with prior notification. Inspections will focus on health of the corals maintained, AIS and disease concerns, the viability of the structures used relative to potential impacts on adjacent habitats, and nursery operations concerns.

10. Data Sharing / Reporting

To evaluate the success of allowed restoration, permits should require annual reports of coral health within the nursery compiled from routine coral health and AIS checks, including overall coral mortality, presence of any AIS, and cause of any coral loss. In addition, this report should include any nursery maintenance including the addition or removal of any structures, disposal of any dead coral skeletons, or actions taken to combat disease or AIS within the nursery.

Permits should also stipulate a requirement for immediate notification of both DAR and the State of Hawaii Department of Health of any die-off or health issue affecting 20% or more of the corals maintained by the permittee.

Appendix IV. Requirements for Photodocumentation and Chain-of-Custody[26]

A. What is Chain-of-Custody (CoC)?

In simplest terms, chain of custody is a chronological paper trail focused on documenting when, how, and by whom individual items of physical or electronic evidence—such as photos or harvested corals—were collected, handled, analyzed, transferred or otherwise controlled by a regulated body.

The CRN uses CoC to substantiate our collection and handling of corals, and also to track both the source fragments and any produced coral products emanating from the original source fragments. Such tracking is critical for permitting agencies, the general public, and the funders to have confidence both in the scale and success of the restoration activity.

B. Source Collection and Outplanting Photo-Documentation Protocol

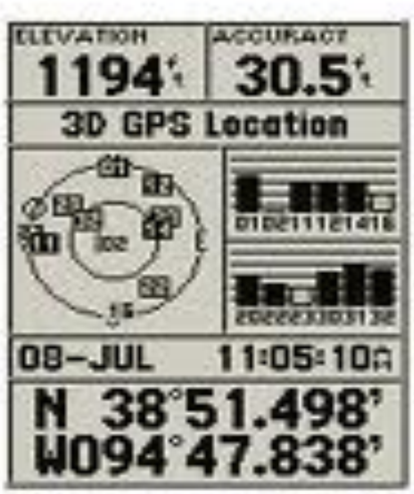
1. Prior to Entering Water (Camera Preparation):

a. Charged batteries in camera.
b. Set date-time stamp to current date and time.
c. Make sure location coordinates are accurate if camera has a built-in GPS feature.
d. Empty SD card in camera.
e. Have second back-up camera set-up same way.

2. At the Surface:

a. Very first photo is of external (boat or hand-held) GPS unit, set to a screen that shows location (latitude and longitude), date and time (and preferably the number of satellites the GPS is using).

[26] Modified after Gulko *et al*., 2008; and Gulko *et al*., 2012.



b. Photograph every diver and their data slates. Photograph to-be-used collection gear, supplies, and tools. Data slates should show date, time and location information.

c. Take multiple shots to create a 360 degree view of the surface to show surface site conditions.

3. In the Water/Underwater:

a. Photograph the depth displayed on a depth gauge or dive computer placed on the bottom substrate at each collection site.

b. Photograph one series of underwater shots 360 degrees in each general collection area to document underwater collection site conditions.

c. Photograph each undisturbed colony prior to collection including wide-angle (full scene) shot from multiple angles without scale bar in front.

d. Place scale bar in front of coral to be collected and leave untouched for remainder of shots. Photograph undisturbed colony with scale bar from multiple angles.

e. Photograph full coral colony (full body shot) from multiple angles.

f. Close-up photograph of any unique features prior to collection.

g. Photograph empty collection receptacle (bag, container) with unique identifier prior to collecting the coral. Extra care should be taken to ensure genets are kept separate from other genetics in order to maintain whole colonies are kept together.

h. Photograph (document) collection of colony or fragments, including photos of coral specimens being put into bags or containers underwater… photos should capture unique identifier label on each bag or container with the coral inside it.

i. Final shot for each underwater collection is of the scale marker, still in its original place, after specimen has been collected. This is done specifically to document any damage (or lack thereof) caused by the collection effort to the colony or adjacent habitat.

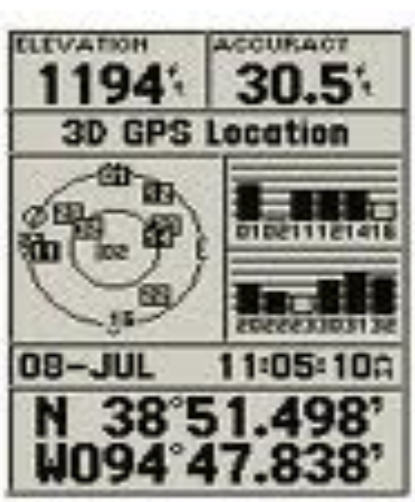
4. At the Surface, on Return to Boat or Shore:

a. Photo of each dive team member holding their filled-out data slates.

b. Individual photos of all collected corals (individual/group shots) in their labeled collection bag/containers, including their first and secondary transport receptacles.

c. Take multiple shots to create a 360^{o} degree view of the surface to document surface site conditions at the end of the collection dive.

d. Final photo is of the GPS unit, set to a screen that shows location (latitude and longitude), date and time (and preferably the number of satellites the GPS is using.



5. Afterwards, and as soon as possible, download photos onto two separate transferable media (i.e. USB drives, non-re-recordable CDs (one for transfer to the permitting agency, one for use in analysis and for databank), etc.). Label, sign and date media in some way as to uniquely identify it.

C. Chain-of-Custody for Collected Corals

1. Use of Databases to Track Corals, Fragments and Grow-out Modules.

All restoration projects should maintain a database that cross-references coral collections, through quarantine, fragmentation and microfragmentation, grow-out, outplanting, and translocation activities; along with photos, growth data, and health data. The Hawaii Coral Restoration Nursery uses Microsoft Access, but any database that allows for cross-referencing samples, species, locations and uses will do. It is critical that scheduled back-ups of a database are maintained and that the database is housed in an area that minimizes risks of system failure, loss or damage.

2. Unique Identifiers

Each collected coral should be given a unique identifier that represents the site and numerical order of the collections. The identifier should also be able to be used to trace back exactly who collected the coral, the date it was collected, GPS point, the size of the coral at the time of collection, its health state, and any photos or other documentation tied to the specific coral and its collection.

If, as is the case for the Hawaii Coral Restoration Nursery, the coral genet is assigned a permanent reference number upon being quarantined, the original number and the other information listed above should be tracked within the new number and the facilities' database. Each unique identifier shows the species collected (The CRN uses a three letter code, with the first capitalized letter representing the genus and the second two letters representing the species), the location site of collection (The CRN uses a three letter code for each location) and a three digit number representing the order of collection of that specimen for that species at that location (Example: 'Pda HAL 007', representing the 7^{th} genet colony of *Pocillopora damicornis* collected at Haleiwa Harbor (designated HAL)).

3. Isolating Genets

Corals collected should be isolated at the time of collection in sealable bags or containers (with each bag or container identified with a unique identifier as described above); this provides some assurance as to the genetic integrity of the sample which is important if the sample is to be used later or microfragmentated for grow-out.

4. Fragging and Microfragging Samples

When fragging or microfragging an isolated genet, the new frag would have the same unique identifier followed by a single letter to signify the generation of subsample (Example: 'Pda HAL 007 A' and 'Pda HAL 007 B', etc.).

5. Microfragging Onto Grow-out Modules

When fragments or microfragments are attached onto modules for outplanting, the original identifier is usually incorporated into a unique module number or sometimes a unique number for a set of modules to be outplanted together. At the Hawaii Coral Restoration Nursery, a highly visible (yellow) uniquely bar-coded and numbered plastic tag that matches the same number etched into the bottom of each module. These numbered tags correspond with the unique coral identifier assigned following collection.

D. Chain-of-Custody for Outplanted Corals

1. Use of Databases to Track Outplanted Corals.

All restoration projects should maintain a database that cross-references coral collection through quarantine, fragmentation and microfragmentation, grow-out, outplanting, and translocation activities; along with photos, growth data, and health data. The Hawaii Coral Restoration Nursery uses Microsoft Access, but any database that allows for cross-referencing samples, species, locations and uses will do. Critical that scheduled back-ups of a database are maintained and that the database is housed in an area that minimizes risks of system failure, loss or damage.

2. Outplanted Coral Identifiers

Care needs to be taken with identifiers used in the field to identify outplanted individual colonies, modules or groups of modules as the tags themselves can serve as a substrate for cyanobacteria or algae to grow on and stress the coral itself, or may become loose and damage nearby corals. As a result, we recommend placing the identifier tag slightly away from the outplanted coral(s), at a distance close enough to identify the coral, but far enough away to minimize damage (10 cm or more is usually adequate).

Appendix V. Guidelines for Evaluating Health Status of Live Corals

A. Health Assessment Prior to Collection

Observe and document coral colony for bleaching, tissue loss, excessive algal growth, excessive amount of AIS attached to colony. Corals expressing these impacts should not in most cases be collected unless specifically targeted within the permit or as necessary for emergency restoration.

Target corals will maintain full tissue coverage across the colony, will have normal coloration (varies by species), and minimal to no AIS.

Documentation should include the majority of the corals within the immediate vicinity of the targeted source coral, in addition to documentation of the source coral itself.

Unidentifiable organisms in direct contact (or immediately adjacent) to the targeted source coral should result in non-collection.

B. Health Assessment While in Quarantine

Observe and document coral for signs of stress (including but not limited to sudden tissue loss, continuous excessive mucus, bleaching, or sudden lightening of color due to sudden shift in temperature > ±5°F, etc.). Observation of tissue sloughing should be a cause for alarm.

Observe and document corals for signs of AIS and micropredators (including but not limited to coral tissue predation, presence of laid micropredator egg cases, presence of cyanobacteria or filamentous algae, coral tissue recession from other hydrozoan interactions, overgrowth of sponge/tunicates, etc.).

Observe and document coral fragments for healthy new growth along disturbed margins, normal coloration, and polyp extension where applicable, etc.

C. Health Assessment Post Quarantine / Pre-Microfragmentation

Observe and document coral for full tissue coverage across colony, growth along margins, normal coloration, and polyp extension.

D. Health Assessment Post-Acclimitization / Pre-Outplant

Observe and document coral for full tissue coverage across colony, growth along margins, normal coloration, and polyp extension.

Observe and document corals for lack of signs of AIS and micropredators (i.e. no cyanobacteria or filamentous algae, no sponge/tunicates, etc.).

Appendix VI. Guidelines for Collection of Live Corals

A. Pre-Collection

1. Document coral source site habitat (see Appendix IV) and confirm identity of target species before any collection occurs. Only sample from pre-approved (i.e. pre-approved species, sizes, location and form) locations.

B. Tools Used

1. Branching and Digiform[27] Forms
   The use of coral cutting shears and small chisels provide for precise cutting of fragments and nubbins. Care should be taken to sample from the periphery or the colony in a manner that minimizes non-targeted breaking of primary (and in some cases, secondary) branch stems.

2. Massive and Encrusting Forms
   Often slightly larger chisels and hammers or prybars are required to remove small colonies or fragments. Fragment removal should be targeted only on the periphery of a colony to minimize non-targeted breaking of the remaining portions of the colony.

3. Collected corals brought ashore can be processed to eliminate unnecessary materials and certain risks. The Hawaii Coral Restoration Nursery uses a Gryphon brand Aquasaw® to precisely cut fragments and nubbins to produce microfragments for restoration purposes after collection. The saw minimizes undesired fragmenting and can be used to remove un-needed non-living material that may harbor AIS or pollutants, particularly immediately following transit, before going into quarantine.

4. In-water collection gear should be cleaned by soaking in dilute bleach (Note: 1:20 dilution of commercial bleach) or a commercial cleaner which contains quaternary ammonium compounds (such as Lysol® cleaner), for a minimum of ten minutes, soaking and rinsing in freshwater afterwards, and then drying completely (Marano-Briggs 2006). NOTE: Freshwater soaks and/or just air drying DO NOT, by themselves, control bacteria or many other microbe's viability completely (Brownlee 2006).

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[27] Digiform corals in Hawaii are primarily represented by the endemic species *Porites compressa* (Finger Coral) and other similar species.

C. Collection, Documentation, and Chain-of-Custody

1. Collection activity should be photo-documented and follow an established chain of custody procedure (see Appendix IV).

2. All field fragmentation of coral colonies should be from the periphery of a colony, never the center.

3. Extra care should be taken to ensure genets are kept together and separate from other genets in order to maintain whole colonies are kept together.

4. If breakage of the sample occurs at the time of collection or during transport to the holding facility, surgical-quality superglue[28] (cyanacrylate) can be used to re-glue the pieces together to maintain the genet reliably against other coral samples during quarantine and/or grow-out.

D. Post-Collection Handling

1. As soon as possible, corals should be scrubbed of any non-coral marine life to avoid unintended introduction or transfer of species into any nursery setting. This can be accomplished with tooth brushes, straw cleaners, or other restoration tools.

2. Whenever possible, excess live rock should be removed using band saws, hammers and chisels, or other restoration techniques. Reduction of excess non-targeted living coral collected material can significantly reduce quarantine concerns.

3. If necessary, fragile and small corals can be mounted on unglazed ceramic tiles or coral plugs (variety of materials used) with surgical-grade super glue (cyanacrylate).

4. Immediately upon transfer into the nursery, practitioners should assign a unique identifier and take an intake photo for use in the nursery's database, including scale and a date/time stamp.

5. Handling should be minimized (i.e. number of people who handle a coral, how many times handled, how the coral is handled). Hands

[28] The Hawaii Coral Restoration Nursery uses a brand called IC-Gel, produced by BSI. The manufacturer also sells an accelerant specifically for coral that causes it to dry even faster. Surgical-quality superglues have been approved the for use on human tissues directly and cause minimal concerns with coral tissue.

should be clean (no chemical cleaners, sunscreen or perfumes) and/or clean gloves worn.

Appendix VII. Guidelines for Outplanting of Live Corals

In current practice, outplanting of corals overwhelmingly requires affixing them to the substrate in some manner. Corals should never be placed un-affixed on a substrate as wave action, storm surge and strong currents can turn corals and associated substrates into projectiles, becoming implements to damage other corals and reef structures. Even when affixed atop other structures, the structures need to be either over-weighted for the depth they are in (against occasional storm surge and waves) or otherwise anchored to the bottom. Dispersal of free-swimming coral larvae is not included in this section; however, settled coral larvae when placed into a restoration site constitute colonies of outplanted coral.

Though outplant mortality for small, fast-growing corals has been shown by one limited study to be reasonably similar for volunteers and restoration experts in another part of the world (Hesley 2017)[29], the situation in Hawaii is extremely different and Hawaiian corals that necessitate larger outplant size to survivie concurrently necessitate professional experience. Thus, outplanting of live corals at sizes larger than 20 cm in Hawaii should only be done by experienced and trained commercial divers or restoration practitioners, not volunteers. As with most of the other stages involving live coral, minimal handling by individuals should be done. Paramount to such operations is well-developed dive plans and safety contingencies.

A. Pre-Outplanting

Baseline surveys need to be done along with reef mapping of proposed outplant site(s) to determine suitable habitat for outplanted coral colonies. Documentation of appropriate substrate that is free is live coral and that minimizes impacts to high quality live rock must be done and approved for siting the specific outplanting of coral. This can be conducted through traditional benthic survey methods, or relevant photogrammetry. After completion both the restoration practitioner and DAR coral biologists should coordinate review of this data to assure that the habitat is suitable for the size, form, and type of coral to be outplanted.

B. Tools Used

The tools used to conduct restoration will vary dependent on the scale and means of the restoration effort. Care needs to be taken during planning as to OSHA standards as it relates to commercial diving activities versus

[29] "The mean partial tissue mortality of corals outplanted by volunteers after 1 month was 15.3% (SD = 35.7) compared to 17.8% (33.5) for corals outplanted by restoration experts. While differences in average tissue mortality were evident among reefs (Fig. 2), mortality values were not significantly different between user groups on any of the reefs restored." From the paper 'Citizen science benefits coral reef restoration activities' in the Journal for Nature Conservation.

research or work diving activities that might be conducted by academic or government agencies or NGOs. The types of tools used (or the sizes of corals outplanted) may default to require the use of commercial divers. Use of lift bags, cranes, pneumatic tools, and other mechanisms to conduct outplanting coral requires special training and planning relative to both the surface crew and the in-water divers.

Clean gear to be used in-water ahead of time by soaking in dilute bleach (Note: 1:20 dilution of commercial bleach) or a commercial cleaner which contains quaternary ammonium compounds (such as Lysol® cleaner), for a minimum of ten minutes, rinsing in freshwater afterwards, and then drying completely (Marano-Briggs 2006). NOTE: Freshwater soaks and/or just air drying DO NOT, by themselves, control bacteria or many other microbe's viability completely (Brownlee 2006).

In most cases, the use of explosives and chemicals underwater is expressly prohibited in Hawaii.

C. Attaching Corals to the Substrate

1. Soft Substrates

Any outplanting structure larger than 1 meter can constitute an artificial reef. Permissions and permitting may be required from both Federal and State entities.

Care needs to be taken to site the outplanted corals atop stable structures tall enough to avoid soft sediment resuspension, scouring, and turbidity issues.

2. Hard Substrates

In many places, corals can be affixed to hard substrates via either direct or indirect contact with the live coral itself. In direct contact scenarios, an epoxy is typically affixed to the coral and then onto cleaned live rock or other hard substrate. In these cases, use of coral-safe epoxy is paramount to the success of outplanting endeavors. Not all marine-safe epoxy is also coral-safe. The Hawaii Coral Restoration Nursery supports the use of a two-part marine epoxy called 'Splash Zone' (Z-SPAR A-788) for attachment of corals larger than 10 cm diameter to hard underwater substrates. The rationale for this is that this epoxy has been used for over 20 years by the Maui Ocean Center on Hawaiian coral colonies both within their tanks and at permitted outplant sites; a number of these epoxied corals in captivity have successfully reproduced suggesting minimal obvious reproductive effects when used properly. In the field, when used properly, this epoxy has held-up to the rigors of high energy shallow-water wave and surge dynamics commonly seen in Hawaiian waters.

For outplanting methods using an indirect attachment method, the coral is placed upon a secondary structure[30] that is then affixed to the hard substrate, commonly with epoxy (once again, preference is 'Splash Zone'). As Hawaiian corals are naturally slow-growing, any outplanting method that involves coral growth to permanently attach the coral to the substrate is highly discouraged, as these methods generally cause scour or displacement before coral growth can be achieved. Outplanting structures should be designed to achieve relatively low centers of gravity and reasonable belief that the structure will not be compromised within the Hawaiian reef ecosystem.

D. Discouraged Methods of Attaching Corals to the Substrate

A variety of methods which might be used elsewhere to attach corals to the substrate are discouraged or illegal for use by the State of Hawaii.

1. In Hawaii, the use of plastic cable ties, metal or plastic straps or stakes, or use of plastic or metal wire to affix corals to substrate is highly discouraged due to Clean Water Act (CWA) concerns.

2. Due to the caustic nature of many concrete mixtures, live small corals should never be placed directly into wet concrete. Additionally, curing the dried concrete modules for a couple weeks in freshwater will leach out most caustic elements prior to attaching small corals to the concrete.

3. Steel rebar poses risks in remote areas as steel can be used as a substrate for cyanobacterial blooms which can spread and affect nearby corals.

4. Use of dead coral or marine rubble may constitute live rock under Hawaii law and require permission for use.

5. Large structures with corals attached that have large amounts of open space pose a risk in Hawaii in certain reef habitats as they can serve as a substrate for invasive algae to take hold and overgrow the coral..

E. Documentation and Chain-of-Custody

Follow guidelines presented in **Appendix IV Requirements for Photodocumentation and Chain-of-Custody**.

F. Monitoring of Outplanted Corals

[30] Often unglazed ceramic tile or pre-cured concrete.

Monitoring outplanted corals is much like monitoring the results of heart surgery; intense monitoring during the period immediately after outplanting to gauge for infection, side effects, and stress is recommended. Monitoring eases after a couple weeks and eventually becomes annual or biannual. The concept is that if there is to be an effect related to the outplant itself or the incompatibility of the coral to the outplant site, it will express itself shortly after outplanting. After a couple weeks to a month, the outplant has likely altered it symbiotic community to match that of the surrounding community and is functioning similar to natural corals at the site.

1. Sample Monitoring Timeline

   (a) Year 1: Within two (2) days post-outplant.

   (b) Year 1: Then one week post-outplant.

   (c) Year 1: Then once a month, for Month 2 & 3 post-outplant.

   (d) Year1: Then half a year later.

   (e) Post-Year 1: Once a year or biannual.

2. Reference Site Selection

   It is important that restoration sites have relevant reference sites for comparison for long-term monitoring. In most cases (taking into account the scale of the restoration effort), reference sites should be as close to the restoration site as possible, but outside of the area of impact from the restoration effort. Note that this means the reference might be within the original impact event area that caused the need for restoration (in which case, the reference site(s) serves as a comparison of restoration against natural recovery), or it might be outside of the original area of impact and thereby serve as a comparison of altered habitat versus natural over time.

   Reference sites should strive to have the following characteristics:
   a. Same type of reef habitat
   b. Same depth
   c. Same water quality
   d. Same light and water motion regime

   Often it is recommended that reference sites be created along the same depth contour immediately adjacent to, but outside of, the restoration site, on either side of the restoration site, if possible.

Note that the term ‘outplant monitoring’ has multiple meanings in regards to restoration activities:

1. Monitoring of the health of the outplanted coral. . This monitoring reflects the successful ability of the practitioner to outplant the coral with minimal stress and resulting health impacts. This is relatively short-term monitoring and is the primary purpose of the monitoring during Months 1 – 6 post-outplant. This monitoring should include, but in no means is limited to:
   a. Presence and degree of outplant bleaching
   b. Presence and degree of outplant mortality
   c. Size of outplant
   d. Presence of any known coral disease
   e. Attributed corallivores
   f. Attributed aquatic invasive species
   g. Presence of competitors directly affecting coral health and growth
   h. Impacts of sedimentation
   i. Obvious breakage of coral colony or outplant structure

2. Monitoring of the overall effectiveness of the restoration effort itself. This is the long-term monitoring that compares and contrasts with the reference sites. This can be conducted through traditional benthic surveys or relevant photogrammetry techniques. Metrics to monitor include but in no means are limited to:
   a. Restored coral area (total area of outplanted coral colonies)
   b. Obvious impacts to restoration site post-outplant
   c. Overall outplant mortality

Reference sites for monitoring should be specifically identified at the same time that the specific site for restoration is identified. Baseline studies for both the restoration site and monitoring reference sites should be conducted at the same time.

Appendix VIII. Sample Risk Assessment for Sourcing Live Corals for a Restoration Project

A. Keawekapu Project

A number of years ago the State of Hawaii was conducting an artificial reef project off the island of Maui at a site called Keawekapu, and inadvertently dropped a number of large concrete artificial reef modules onto a live coral reef instead of onto the soft bottom substrate originally targeted. Through due diligence, the State fully investigated the incident, bringing an enforcement action against itself and held itself accountable. At the time, the State had determined that removing the modules may cause even more damage to the natural substrate, and so the decision was made to leave them in place and allow natural recovery to take place atop the modules (this was estimated to occur in 20 years). Ten years later, having determined that very little recovery had actually taken place (far below the estimated recovery rate), the State contracted an outside, independent body to fast-grow corals for attachment onto the concrete modules to help restore the impacted reef. The question that initially arose was where was the best source for corals for this project.

B. Possible Sources of Live Coral

Four possible sources for live coral were identified for this project: corals from the restoration site itself (preferably loose corals that had been damaged with the original event), coral from other natural coral reefs on that island, corals from other impacted sites on that island (corals of opportunity), and corals from harbors around that island. Recognizing that each option posed risks to be evaluated, the State ran a quick, back-of-the-envelope risk assessment on the available options.

C. Evaluation of Risk

To evaluate the risks, risk categories were created specific to the issue of sourcing coral:

1. Issues associated what may be on, in, or around the collected coral relative to the source site;

2. Issues associated with impacts to the source area resulting from coral collection;

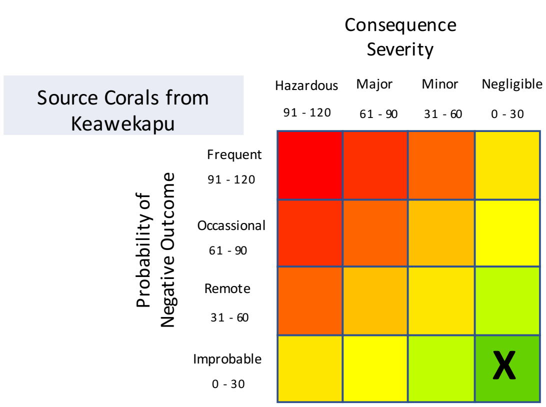
3. Issues associated with using the coral from specific source sites at the outplant site (Keawekapu)).

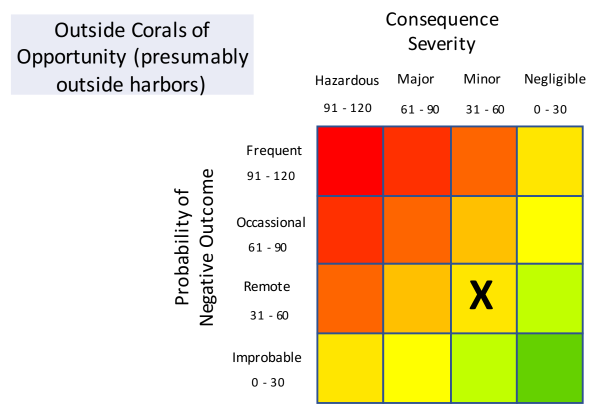
Various sub-categories were evaluated using a scale of 0 to 9 (with 0 being low effect and 9 being a very high effect). Furthermore, each subcategory at each possible source site was evaluated using this scale relative to both the <u>probability</u> of a negative occurrence, and the <u>severity</u> of such an occurrence if it did occur. Results were tabulated as shown below.

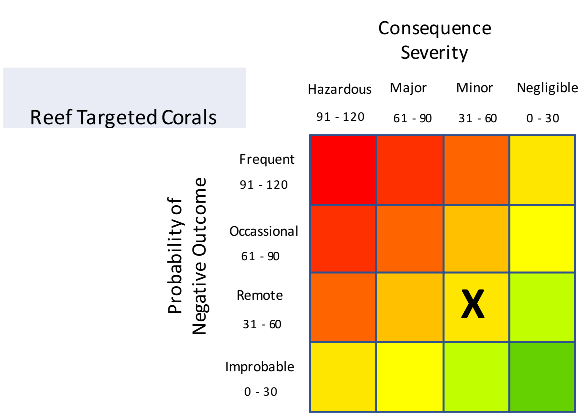
For each proposed source site, the probability and severity scores were summed and displayed in a standardized risk matrix using stoplight (red-yellow-green) colors to display overall risk associated with each proposed action.

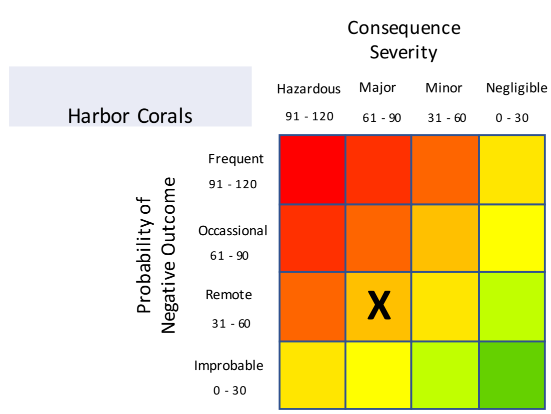
		CORAL SOURCE AREAS							
Risk Category		Keawekapu		Outside Corals of Opportunity (presumably		Harbor Corals		Reef Targeted Corals	
		Severity	Probability	Severity	Probability	Severity	Probability	Severity	Probability
Source Material Introduction	Invasive Macrospecies	1	1	5	3	6	6	4	2
	Disease (Bacterial, Viral)	1	0	5	3	6	**6**	<u>4</u>	2
	Heavy Metals	1	0	3	1	5	5	3	1
	Hazardous Chemical	1	0	3	1	5	5	3	1
	Nutrients	1	0	2	1	3	2	2	1
Negative Impact to Source Area	Source Corals	5	2	4	9	5	9	5	9
	Accidental AIS Introduction	6	2	5	2	5	1	6	2
	Decrease in Rugosity	1	1	2	2	3	**4**	4	4
	Decrease in Biodiversity	0	0	5	2	4	1	6	1
Negative Outplant Effects	Change Biodiversity	0	0	6	5	7	6	6	5
	Change Population Genetics	<u>0</u>	0	5	9	7	9	5	9
	Change Species Abundance Ratios	5	2	5	6	5	6	5	2
	Total: Scale of 0 - 120	22	8	50	44	61	60	53	39

D. Final Risk Matrices









The result shows the least risk for sourcing corals for this example would be from the Keawekapu site itself.