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PERSPECTIVE

A user's guide to coral reef restoration terminologies

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Abstract Global coral reef restoration efforts continue to diversify in approach, location, and socio-ecological context. In parallel, vocabulary has evolved such that practitioners, scientists, policy makers, communicators, and investors must navigate an increasingly confusing set of terms that are inconsistently defined. Precision around terms and definitions is an important attribute underpinning the rate and extent with which restoration can scale. However, in contrast with more established ecological restoration fields, coral reef restoration lacks a formal lexicon for its core approaches and processes. Here we synthesize, distill, and clarify a core lexicon proposed for coral reef restoration. We navigate readers systematically through terms used for various coral reef restoration approaches, project planning and intent, process workflows, and biological material. We also consider vague terms commonly used that present challenges to singularly define. While we expect this proposed lexicon to continue to evolve, we offer an important first step toward more integrated communications around coral reef restoration.

Keywords Coral reef restoration · Terminology · Reef recovery · Restoration goals · Coral propagation · Ecological restoration

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Introduction

Efforts to restore coral reefs are accelerating worldwide as local and global anthropogenic pressures continue to erode coral reef ecosystems (Edwards et al. 2024). Management strategies increasingly incorporate stewardship-led restoration activities (e.g., Hein et al. 2020; Shaver et al. 2020; Suggett et al. 2023) that are often coupled to research and development portfolios spanning fundamental science and engineering (e.g., Bay et al. 2023; Voolstra et al. 2021) to recover degraded reef sites. In parallel, financing and commercialization mechanisms to support and scale these restoration activities have diversified (Suggett et al. 2023) and the number of restoration projects around the world has rapidly grown. While reef restoration activities continue to expand in approach, location, socio-ecological context, and expertise (e.g., Boström-Einarsson et al. 2020; Hein et al. 2020, 2021; Suggett et al. 2023; Peixoto et al. 2024), the vocabulary now used to describe restoration activities and practices has evolved to the point where new (and not-so-new) to-the-field practitioners, scientists, policy makers, communicators, and investors must navigate an increasingly confusing set of terms that are not consistently defined, i.e., a poorly defined lexicon.

Robust communication of restoration intent and process is central for several fundamental reasons: (1) Scalability of restoration rests—in part—upon effective networks of practice that are built upon a solid foundation of communication and knowledge exchange (e.g., the Coral Restoration Consortium); (2) Precision around definitions is needed for clarity in regards to restoration intent and purpose (Suggett et al. 2024); and (3) Consistent terms or definitions enable reconciliation of disparate data sets needed to improve practice (Goergen et al. 2020) and create certainty for investors in what they actually fund and can expect in terms of returns. As such, the growth of restoration as a field and as a practice is—at least in part—constrained by a lack of common lexicon. Restoration of terrestrial ecosystems has developed and employed standard terms and definitions (e.g., SERA 2021) of core processes central to delivering effective restoration outcomes (Gann et al. 2019) as well as the spectrum of associated restoration activities (Gann et al. 2019; Gerwing et al. 2023). While key attributes of reef restoration have presented specific lexicons (e.g., management—Shaver et al. 2022; monitoring—Goergen et al. 2020; financing—Suggett et al. 2023), coral reef restoration is yet to embrace a formal set of terms and definitions for its core activities and processes.

Here we present a "user's guide" to reef restoration terms and definitions, focusing on the language that is common and fundamental to reef restoration activities and processes. While many of these terms will seem familiar to those already deeply embedded in reef restoration, our intent is to synthesize, distill, and—on occasion—clarify our lexicon to improve communication as our community continues to grow. In doing so, this guide can act as a framework that helps project managers build their own more nuanced context-specific glossaries. Importantly, we recognize that ecological restoration projects often have benefits that far outweigh ecological processes alone (e.g., cultural heritage, economic value; Peixoto et al. 2024); however, here, we focus on the terminology associated solely with the ecological aspects of restoration. We recognize many terms considered in this guide carry standard definitions (e.g., Oxford English Dictionary). However, how these terms are applied within a reef restoration context warrants more precise definitions. Reef restoration is a relatively young field (e.g., Boström-Einarsson et al. 2020; Edwards et al. 2024), and we fully expect that this lexicon will evolve over time. Our guide covers terms in four categories: (1) restoration methodology, (2) factors underpinning the delivery of project outcomes, (3) core process for restoration workflows, and (4) coral material used for restoration. We conclude with a final section that considers vague terminology commonly used in reef restoration, but which presents a challenge to define. Each of these categories is supported by a separate terms and definitions table.

Defining the intended approach to achieve reef recovery

Coral reef restoration is currently defined as any active ecosystem repair-based approaches that aim to recover reefs according to set goals (sensu Hein et al. 2021; Suggett et al. 2024). This terminology has been broadly adopted to include actions that span biological-, ecological-, and/or structural (e.g., engineering)-based interventions, as well as those that reduce stress (e.g., shading and cooling) or add resilience (e.g., assisted evolution-based approaches) (Hein et al. 2021). Using "coral reef restoration" as a blanket term has been useful to rapidly build a community of research and practice around reef recovery-based approaches; however, singular terms also carry the potential to mislead. Restoration as an endeavor represents a subset of activities (Gerwing et al. 2023) that each carry very specific definitions (Table 1). If not used correctly, terms can create confusion among managers, decision makers, governance authorities, external stakeholders, or investors. For example, most projects may have intentions to deliver "ecosystem restoration"—the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (Gerwing et al. 2023, Table 1)—but may unintentionally communicate their approach around "reef engineering" or "coral gardening." Fundamental project restrictions (e.g., permitting, financing) may constrain project activities to "reef regeneration" or "reef rehabilitation" (Edwards et al. 2024) but regardless communicate a perception of "ecosystem restoration." Such confusion in terms has already resulted in narratives that question the credibility and/or feasibility of restorative approaches, e.g., Hughes et al. (2023) synonymizing restoration ecology experiments with ecological restoration (see Suggett et al. 2024).

Most restoration activities currently undertaken aspire to meaningfully improve ecological condition and process, fundamentally encompassing many social factors that are directly and indirectly connected to reef ecological condition (Peixoto et al. 2024); however, the scope, scale, and approach of any given restoration activity may predispose what is achievable. More specific terms for how restoration activities can aid reef recovery are easily adapted from those already employed for other restoration fields along the "restoration continuum" (sensu Gann et al. 2019) (Table 1, Fig. 1); as such, activities may overlap along this continuum (Gerwing et al. 2023) and so projects may identify with different activities as they mature over time (Gann et al. 2019; Gerwin et al. 2023). Ideally, activities should be conducted within a socio-ecological goal-based context to more

Table 1 Glossary for activities to achieve coral community or reef ecosystem recovery—expanding upon Edwards (2010); Edwards et al. (2024); Hein et al (2021) and Rinkevich (2006) by adapting from wider ecological restoration resources (Gann et al. 2019; Gerwing et al. 2023, SERA 2021)

SER Category	Term	Synonyms	Definition	Use
Overarching Term	Coral reef restoration	Coral reef ecosystem restoration; reef restoration	Assisting to improve the ecological state of a coral reef ecosystem that has been degraded (damaged or destroyed)	3041
Ecological Restoration	Coral restoration	Coral reef enhancement; *Often synonymized with coral reef restoration (or coral gardening) where ecological recovery metrics are the goal.* Technically covers “intra-ecosystem restoration”	Assisting to improve the ecological state of a coral reef ecosystem that has been degraded, damaged or destroyed by focusing specifically on recovering corals (as the primary framework builders of coral reefs)	2009
Ecological Restoration	Coral gardening	Coral husbandry, coral farming (see Table 3), coral restoration, reef gardening	Care of a reef area via growing, planting coral and/or active management (pruning, cutting, predator removal etc.), including manipulation of species compositions. Often synonymized with coral husbandry and/or coral restoration	533
Ecological restoration	Reef ecological reconstruction	Rewilding, Restocking, Population “kick-starting,” ranching	Reintroduction of reef biota (entirely or near entirely)—often carrying a disproportionately high impact on ecosystem diversity stability—that cannot re-colonize within desired timeframes, even after other interventions. Likely a factor required for more “holistic” ecological restoration	10*
Rehabilitation	Reef engineering	Reefscaping, seascaping; reef ecological engineering	Changing the appearance or function of the reef through the addition of fauna, flora and/or structure (including artificial substrate addition or habitat modification) to meet a desired outcome (e.g., enhanced esthetics for tourism, increased biodiversity)	332*
Rehabilitation	Reef rehabilitation; reef repair	Reef ecosystem rehabilitation	Actions that seek to reinstate a desired level of coral reef ecosystem functioning where the goal is renewed and ongoing provision of ecosystem services (i.e., direct and indirect contributions of ecosystems to human wellbeing) rather than the biodiversity and integrity of a designated native reference ecosystem	222*
Remediation	Reef remediation		Management activity, such as the removal or detoxification of contaminates (e.g., ship grounding) or excess nutrients, that aims to remove sources of degradation (Gann et al. 2019)	24**
Reduced impacts	Reef regeneration	Recolonization; proactive reef restoration; passive recovery	Natural (unassisted) improvement to ecological state primarily for low to intermediate disturbance or degradation. Includes removing, e.g., by designating via Marine Protected Areas. Can be facilitated via active removal of ecological impediments (e.g., invasive species, pests, and predators)	83*

Terms and their synonyms are listed where the term is considered in order of most common use in the literature to date. Terms are grouped according to Society for Ecological Restoration (SER) categories, which are presented systematically as (1) “Overarching” term of coral reef restoration, (ii) Ecological restoration, (iii) Rehabilitation, (iv) Remediation, and finally (v) as Reduced Impact. All terms were subject to a Web of Science search (7th August 2024) to quantify “use” of each term and associated synonyms (i.e., number of articles using terms) in the literature either (a) as is, (b) *where “AND restoration” was added, or (c) **where “AND restoration AND reef” was added. “Synonyms” refers to terms used in consistent manners according to the stated definition

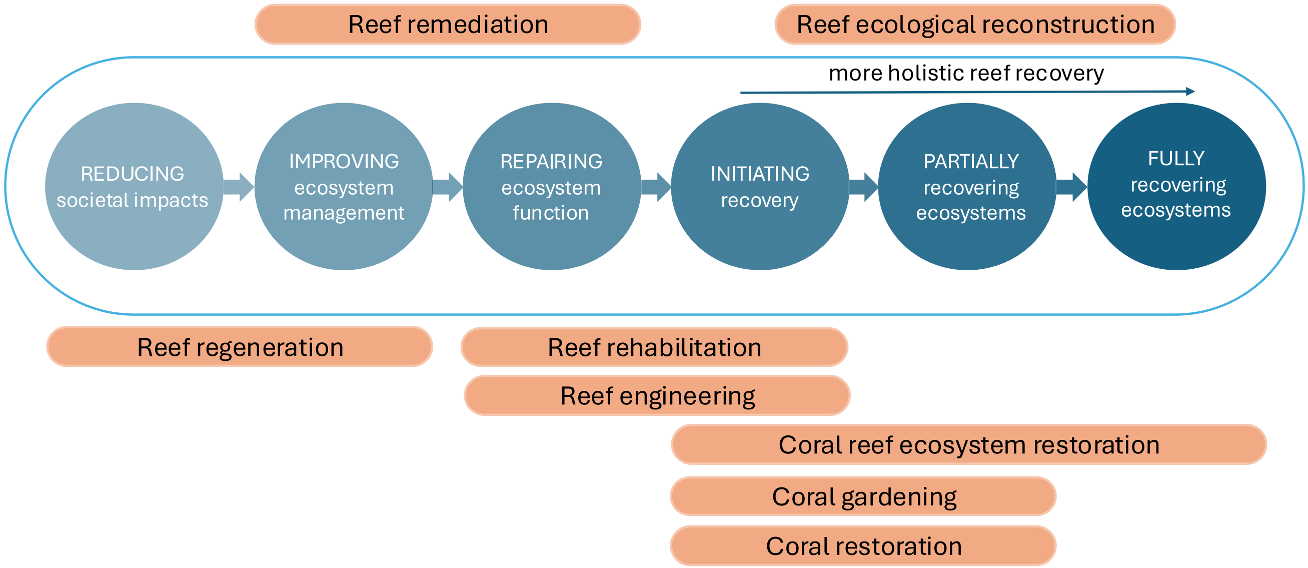

Fig. 1 Categories of coral reef restoration terms. All terms are adopted or adapted as per Table 1 and mapped to the "continuum of restoration" (image center re-drawn from Gann et al. 2019), including mapping modified from Gann et al. (2019); Gerwing et al. (2023)

precisely define where they operate (Gerwin et al. 2023) on the spectrum of reef repair. Fundamental to Table 1 (Fig. 1) is defining "coral reef ecosystem" as the collection of organisms that interact with each other and the physical environment, including the formation and modification of coral reef structure. Also—as per Gann et al. (2019)—defining "degraded," "damage," or "destroyed" as "a level of deleterious human impact to ecosystems results in the loss of biodiversity and simplification or disruption in their composition, structure, and functioning and generally leads to a reduction in the flow of ecosystem services," "acute and obvious deleterious impact on an ecosystem," and "when degradation or damage removes all macroscopic life, and commonly ruins the physical environment of an ecosystem," respectively. We acknowledge that the terminologies in Table 1 are expansive and therefore divide Table 1 into terms based on their position within the restoration continuum, in line with Gerwing et al. (2023). Within the restoration terminology, only "reef regeneration" fulfills *proactive* approaches while all others are considered *re-active* (sensu Hein et al. 2021).

An important case specific to the language of reef restoration activities is the term "coral gardening." It was introduced as a somewhat colloquial term to encompass the practicalities of growing and planting coral (and its subsequent active management, which by extension may be termed "reef gardening") (Table 1)—while it remains used in scientific literature (Table 1), it serves as an important means to communicate increasingly complex restoration activity to the public and hence critical social benefits (Peixoto et a. 2024). However, the interpretation of this term can often be aligned to a stricter definition of gardening that is not ecological restoration guided by fundamental scientific principles; indeed, the more advanced field of terrestrial restoration is not interchangeably referred to as gardening. Use of the term coral gardening therefore also opens an opportunity to question the rigor of ecological restoration efforts for reefs. Our recommendation in navigating the terminologies of reef restoration is to observe caution and encourage efforts to be self-critical and as accurate as possible in communicating their activities. Referring to the "decision tree" of Gerwing et al. (2023) is a useful means of resolving the nature of activity for any given stage of restoration project maturity or capacity. Table 1 provides the means to clarify the terms for different approaches, while Fig. 1 contextualizes where these terms occur (and overlap) on the "restoration continuum."

Defining the factors central to delivery of reef recovery

Defining the conditions required for implementing reef recovery

Any intention to implement restoration activities starts with setting clear socio-ecological goals and development of underlying targets and objectives (Table 2). Robust operational planning and an effective monitoring strategy are required to track performance that governs perceptions of reef restoration activity "success' (Goergen et al. 2020). Key to performance tracking is expanding focus beyond the intended restoration site to include both "reference" and "control" sites (detailed in Gann et al. 2019) (Table 2).

Table 2 Glossary for overarching coral reef restoration planning and strategy—adapted from Gann et al. (2019); Gerwing et al. (2023); SERA (2021); Shaver et al. (2020); Goergen et al. (2020); Pascoe et al. (2024)—details and examples given here are specific to coral reef restoration, but more expansive terms and definitions can be found in these original sources, including where uncertainties in precise definitions still exist

Stage	Term	Definition	Example or reef context
Program planning	Goal	Desired future (ecological, social) conditions	"We will improve coral cover and biodiversity," "enhanced community participation to reef restoration activities," etc.
	Objective	Changes and immediate metrics (ecological, social) needed to achieve the target and goals	"We will grow 5,000 corals to plant 50,000 fragments per year using in situ nurseries"*
	Target	Metrics (ecological, social) intended marking the end for the restoration project—reported for specific metrics or attributes	"Coral cover will be increased by 15%," "100,000 corals will be planted," "10,000 visitors per year to nursery" etc.
	Success (*antonym* = failure)	Whether—and extent to which—goals, targets, objectives (etc.) have been achieved	
Operational planning	Historical baseline	Description of the ecosystem (ecological, social) as some predefined time earlier than that of the monitoring baseline	Time-specific reef ecosystem condition, with known contexts of anthropogenic pressures at—or prior to—description
	Monitoring baseline	Description of the ecosystem state (ecological, social) at the onset of intervention	Time-specific reef ecosystem condition against which further change can be compared
	Control site	Location used that is unamended and serves as a *negative control* to assess effectiveness of restoration	Reef site that shares the same condition as that marked for restoration but is not impacted by the restoration actions (e.g., "spillover" effects if too close)
	Reference ecosystem (site)	Ecosystem identified as the target condition for restoration. Often a "non-degraded" version of the system, represented by an extant site (or a model built around inherent variability of conditions). May not represent the historical (or native) condition	Reef site that exemplifies expected reef ecology, diversity, function, and successional state and what the restoration practice aims to achieve (may be in the form of a *positive control*)
	Restoration site	Location chosen for restorative action (not to be confused with the area ultimately ecologically recovered within this site; see also Table 5)	Restoration is conducted at *x* reef (where restoration activity is confined to a specific area size of *x*; co-ordinates *x*, *y*)
	Native ecosystem (site, condition, species)	Representative site, condition, species known to have evolved locally (or recently modified from natural- or human-induced changes to environmental conditions, but excluding invasive and/or non-native species)	Representative present day reef site for the locality based on long-term knowledge (and historically where invasive species have long been introduced)
	Reef recovery	Ecosystem state following pro- and re-active and repair-based activities—may be full, i.e., all key ecosystem attributes closely resemble those of the reference model, or otherwise partial	

Terms shown are the most fundamental for each stage.*See Table 5 for terms around coral units

However, selection of the goals and associated reference (and control) sites are first contingent upon *the* critical question for recovery: *what is the desired ecological outcome?*

Ecological restoration should aspire to recover to native conditions, where a native ecosystem is “An ecosystem comprising organisms known to have evolved locally or have recently migrated from neighboring localities due to changing environmental conditions including climate change.” (see Table 2; Gann et al. 2019). Coral reefs are exceptionally ecologically and biogeochemically complex systems, and therefore, model native systems may be needed to capture inherent variability across nearby reference sites (Gerwing et al. 2023). Activities that aim for recovery goals outside of native conditions—i.e., aim for non-native recovery—will restrict projects to “reclamation” (and are not covered here). Similarly, projects that focus on recovery of specific ecosystem services—and hence in effect a specific ecological state (Hein et al. 2021; Suggett et al. 2023)—will again restrict projects to “rehabilitation” (see Edwards et al. 2024), for example, where the goal is to safeguard tourism value by improving reef esthetics. Regardless, an important consideration facing many coral reef restoration projects may be to develop a reference model representing greater ecological resilience to future forecasted environmental conditions. Understanding local reef ecosystems that span both historical conditions and resilience to specific forms of complex stressors (e.g., forecasted climate change impacts) is critical in guiding the restoration strategy and ultimate feasibility. Developing suitable frameworks based around desired outcomes for restoration of reefs is the same as for any other ecosystem (Gann et al. 2019), dialing in significant resourcing requirements beyond recovery actions themselves, and so must be planned and budgeted for from the outset.

Defining the processes employed to achieve reef recovery

Core processes form the framework for common “reef restoration workflows” (sensu Hein et al. 2020, Edwards et al. 2024), specifically, coral propagation using either in-water (in situ) or land-based (ex situ) nurseries and subsequent coral planting, the latter of which may involve substrate preparation steps such as removal of space competitors (e.g., macroalgae, farming damselfish) and predators (e.g., *Drupella* snails) or substrate stabilization and addition (Table 3). Collectively, the common restoration workflow describes the core practice of coral restoration (or gardening) via both pro- and re-active restoration (Hein et al. 2021) and “biological support to accelerate natural reef recovery” (Bay et al. 2019) (Table 1), with the respective key terms and definitions in Table 3. Of these processes, coral propagation has particularly drawn a diversity of synonymized terms, ranging from coral husbandry to mariculture (Table 3). While silviculture has been applied to describe coral propagation, it originated for trees, woodlands and forests and likely best avoided to minimize confusion among the already wide synonym base.

One specific coral propagation approach, “micro-fragmentation” is becoming increasingly popular (e.g., Page et al. 2018, Mostrales et al. 2022) but as a term carries an important nuance in its use and hence definition, specifically, where “micro-fragmenting” describes the process of generating very small units (or "micro-fragments") of biological material under the notion that growth accumulates faster for smaller units (Page et al. 2018). In contrast, “micro-fragmentation” more commonly describes the close planting of micro-fragments in a cluster to enable faster reskinning, fusion or grafting (e.g., accelerate areal coverage and/or larger colony reformation) (Morales et al. 2022). The two terms may be unintentionally used inter-changeably, but refer to very different process and outcomes (and hence may ultimately benefit in future from better distinction as terms themselves).

A critical requirement across the common restoration workflow is effective monitoring of the processes to improve practice as well as measure outcomes relative to restoration goals. Monitoring for restoration is an expansive topic spanning data capture, analysis, reporting, and stewardship that has been evaluated in detail recently and we refer readers to this resource (Goergen et al. 2020). However, we also recognize the need to rapidly advance critical areas including data capture, analysis, storage, and accessibility, which warrants dedicated and detailed consideration beyond current works.

Several terms describing the core processes for reef restoration have become common for practitioners and scientists, where many of the synonyms reflect interchange between colloquial and conventional terms (or potential mistranslations cemented into the vernacular). However, the detailed approaches and tools used to deliver these processes are expansive. Such detail has created a spectrum of specific terms and definitions covered elsewhere, e.g., for attachment materials (Suggett et al. 2020) or substrate stabilization approaches (Ceccarelli et al. 2020). Similarly, experimental interventions that are still in research and development phases aimed at accelerating the effectiveness of these core processes (e.g., Voolstra et al. 2021) have their own nomenclatures that are covered in depth elsewhere, for example, assisted evolution (van Oppen et al. 2015), including genetic management (Bay et al. 2023), and probiotics (Peixoto et al. 2021).

Defining biological units of coral material (and associated processes) across the coral reproductive life cycle

Coral propagation methods have advanced breeding via both asexual and sexual reproduction modes (Lewis et al. 2022;

Table 3 Glossary of terms and definitions for processes central to reef restoration activities—including definitions adapted from Edwards (2010); Bay et al. (2019); Edwards et al. (2024); Randall et al. (2020); SERA (2021); Whitman et al. (2024); Rinkevich (2006)

Term	Synonyms	Definition
Attachment		Securing coral fragment (or larval settlement device) to the substrate using physical or chemical means—typically as a "fixative." *Note it also describes natural re-fusion of coral fragments to the reef substrate once placed (e.g., wedged)*
Attachment device	Planting device; attachment system; see also, settlement device	An object crafted or modified specifically to promote attachment of coral to reef substrate
Asexual propagation	Clonal propagation; fragmentation; cutting	Detachment (via natural physical or human action) of one or more polyps from a coral colony to cultivate new colonies
Biofouling		Cover of surfaces by organisms that can have a negative effect on structure integrity or intended purpose (e.g., competing for space on coral nurseries)
Caching	Holding;Staging	Temporary storage of coral stock in a specific location (often on nursery structures)
Co-culture		Simultaneous propagation of coral with that of another organism group intentionally chosen (e.g., herbivorous snails, urchins)
Coral nursery		An area (or building) that contains structures/aquaria/tanks used to hold, grow, and therefore supply corals for later planting onto reefs
Coral nursery structure		An object constructed from several parts designed to cultivate (or cache) corals
Coral plug	Coral base; cookie; puck; tile	Physical object on which coral is secured for propagation and/or planting (and may often carry device specific names). *Plug may infer male or female connectivity*
Coral husbandry	Silviculture; coral propagation; coral farming; coral culturing; coral cultivation; coral mariculture; coral aquaculture	Breeding of corals (typically colonies but also solitary coral polyps)—often (but not always) to enhance growth yields and returns—including asexual and sexual reproduction modes. Can be either in situ (off or in shore) or ex situ (on shore) and is the marine branch of aquaculture, *noting that coral aquaculture is sometimes used but is not correct*. When ex situ can be in specialized marine aquaria (raceways, etc.) to replicate optimum growth conditions in a controlled environment
Coral (larval) seeding		Dispersion of coral (larvae) on a reef, typically as free-living larvae, or as larval settlers or coral fragments attached to a "settlement device"
Grafting	Fusion	Attachment of one coral biological unit to another that results in active growth of both units (where grafted units can be isogeneic = genetically identical tissue = *fusion*; allogeneic = genetic variants of the same species = *chimera*; or Xenogeneic = different species or genera)
Macroalgae removal	Seaweeding; biocontrol	Actions to reduce abundance of macroalgae to relieve competition for space for coral recruitment and growth
Micro-fragmentation	fusion; re-skin	Close placement of small, asexually propagated, ramets for faster initial growth and to more rapidly yield larger colony by grafting with neighboring fragments. Used to rapidly resheet substrates including dead coral. *Often synonymized with micro-fragmenting*
Micro-fragmenting		Creation and propagation of "small" biological units (i.e., micro-fragment; see Table 5) asexually under the notion that growth accumulates faster for smaller units (more rapid generation of biomass)

Table 3 (continued)

Term	Synonyms	Definition
Mono- (poly-) culture		Propagation of one (more than one) coral genet in a specific location. Polyculture can commonly refer to simultaneous propagation of more than one coral species in the same nursery
Planting	Outplanting	Active attachment of coral material to reef substrate. Outplanting is commonly used for material that has been generated from a nursery/caching phase
Predator (or space competitor) removal	Biocontrol; culling; corallivore removal; pest control	Actions to reduce abundance or activity of coral predators (e.g.*Drupella/ Coralliophila* snails, fireworms or crown-of-thorn starfish *Ancanstaste*r spp.) or non-algal competitors (e.g., Palythoa, farming damselfish)
Pruning		Cutting process to remove unhealthy or unwanted material (e.g., controlling disease)
Re-sheeting	Re-skinning; fusion	Applying new coral tissue to substrate, which is typically on coral that has died, but the skeleton is still intact
Settlement device	Larval settlement device	A substrate specifically designed and engineered—architecture and materials—to attract, house and/or protect coral larvae as they establish into juvenile coral
Sexual propagation	Breeding	Coral propagation through fertilization of eggs and sperm
Substrate addition	Artificial reef; substrate introduction	Placement of units of consolidated materials (natural or "artificial") onto the reef to increase area available for colonization
Substrate preparation	Substrate cleaning	Modification of substrate to be more conducive to coral planting and/or attachment (e.g., biofilm removal)
Substrate stabilization	Substrate consolidation	Securing substrate of relatively low consolidation (e.g., rubble) using either physical or chemical means to bind and be more resistant to physical disturbance
Wedging	Jamming	Firmly securing loose coral or settlement devices into natural reef openings by means only of human physical force

"Synonyms" refers to terms used in consistent manners according to the stated definition

Randall et al. 2020; Banaszak et al. 2023) to generate material across various coral life stages. In the case of scleractinian corals used for restoration, the word coral typically refers to a collection—or colony—of genetically identical polyps housed in corallites (but see Tables 4, 5), which can undergo "fragmentation" (Table 3) to yield replicates of the genetic (or clonal) line. This process is termed asexual reproduction when it occurs naturally (e.g., when a colony branch is sheared off by physical action such as storms), although it should be noted that asexual propagation may also occur within colony via "intra- or extra-tentacular budding." However, exploiting this life history strategy for restoration is known as asexual propagation (Table 3). While some coral species are solitary polyps as adults (i.e., not colonies), they are currently not actively targeted for restoration. Sexual propagation methods are diverse for broadcast spawning and brooding biologies (Table 4), and span fertilization of gametes, subsequent embryogenesis to competent reef living larvae, and then settlement of larvae back to the reef and metamorphosis to a new coral (Randall et al. 2020; Banaszak et al. 2023). Here we define basic units of coral biological material used with various sexual and asexual propagation techniques in Table 4. More detailed terminology necessary to describe specific sexual propagation methodologies may be found elsewhere, notably genetic management (and associated terms describing population units, e.g., hybrid, chimera) (Bay et al. 2019; 2023).

Hard-to-define terms within coral reef restoration language

Several terms in coral restoration are difficult to define without specifying local context and practices—such terms are often used loosely and/or interchangeably, leaving use open to interpretation. Confusion is particularly inevitable where vague terms are used as qualitative descriptors rather than quantifiable metrics within databases holding information for programs (i) operating according to multiple coral cultivation approaches or (ii) attempting to reconcile data from across other programs employing different cultivation approaches. For example, the term "propagule" can be used to describe both coral biological material and coral life stage (Table 5).

Table 4 Glossary of key terms and definitions describing coral material (and associated life cycle processes) used for restoration activities—adapted from Edwards (2010); Edwards et al. (2024); Randall et al. (2020); Goergen et al. (2020); SERA (2021); Banaszak et al. (2023)

Term	Synonyms	Definition
Brooding		Internal fertilization and embryogenesis within the tissue of a coral colony, before release of competent larvae
Colony	See Table 5	Coral resulting from the asexual growth of contiguous polyps derived from a single founder event (either a fertilized egg or asexual fragment). *Usually used to describe larger and more visible corals, but see* Table 5. Conventional definition for colony (biological unit of coral consisting of two or more genetically identical polyps) does not account for genetic mosaicism that could arise from carry branch-specific mutations as colonies age/increase in size
Coral holobiont	Coral	Collective of the coral cnidarian host and its associated community assemblages of prokaryotic and eukaryotic microbes living within the tissues, mucus, and skeleton (zooxanthellae, bacteria, archaea, viruses, endolithic algae, etc.)
Donor	Source; broodstock; parent; mother	Origin of coral material—can refer to either the organism and location. *Similarly, can apply to the entire organism (donor colony) or partial colony (donor fragment), see* Table 5
Gamete bundles	Spawn; larval bundles	Package (secreted by a mucus layer) containing many eggs and sperm for efficient transportation prior to fertilization
Gametes	Gametocytes	Haploid reproductive cells (oocytes, female; spermatocytes, male)
Genet	Parent; colony (see Table 5), lineage	Genetically distinct colonies within a population, and the product of planula settlement and subsequent development (Heyward & Collins 1985). *Lineage may sometimes refer to an unproven or assumed discrete genotype*
Genotype	Genetic variant	Alleles (sequence of nucleotides) carried in a particular gene or gene location. *Commonly used as an identifier of unique individuals among a population*
Larvae	Planulae; propagule (see Table 5), offspring	Microscopic—often planktonic—free-living stage representing latter embryogenesis for fertilized eggs
Morphotype		A phenotype referring to the morphology and architecture of coral growth, typically categorized into idealized forms (e.g., branching, massive, plating, etc.)
Opportunity coral	Coral (fragment) of opportunity	Coral harvested from the reef that has detached (e.g., storms, anthropogenic activity) and is unlikely to survive without intervention. Often a target for nursery material
Phenotype		Observable characteristics specified for a coral biological unit (e.g., color, growth rate, heat tolerance) that are the result of interactions of the genotype and environment
Ramet	(see Table 5), genetic clone; replicate; offspring	Colonies arising from fragmentation of a genet (Heyward & Collins 1985)
Re-attachment	Anchoring; attachment; overgrowth	Biological process whereby tissue of an—as yet unattached—coral grows onto the substrate and begins to calcify to create a solid connection. *Not to be confused with process-based securing (including gluing, wedging, tying* etc.*) and re-sheeting as per* Table 3
Recipient site	Sink	Destination site for new coral material generated (e.g., nursery, reef, etc.). *Note that "sink" is the antonym of source (donor), but use is typically reserved for describing natural connectivity*
Recruitment		Production, supply, introduction, and/or development of a new generation of individuals onto substrates—applies to sexual or asexual derived donor material
Rescue coral	Opportunity coral; at-risk coral	Coral identified at risk of loss from external pressures (e.g., construction) and purposely removed to be relocated or harvested for propagation
Settlement site		Substrate location "selected" by larvae to metamorphose into coral and attach
Spawn, spawning	Broadcast spawning	Release of eggs and sperm, including egg and sperm bundles, during a fertilization event

Table 4 (continued)

Term	Synonyms	Definition
Spawn slick		Formation of high concentration (often of multiple species) of positively buoyant fertilizing eggs and embryos on the water surface under calm conditions

"Synonyms" refers to terms used in consistent manners according to the stated definition

Table 5 Examples of factors common to reef restorative activities and decision-making that carry many terms often used interchangeably across projects and/or without being specifically defined

Concept	Terms	Challenges in usage
Biological unit of coral material	Fragment; partial-fragment; micro-fragment; colony; nubbin; branch; coral; isolate	Terms are used to describe any portion of coral material (harvested—and lack any standardization needed to understand contribution to restoring coral populations (e.g., size versus whether reproductively competent). Need to always be supported with quantitative definition—see Edwards (2010)
Biological unit of propagated material	Propagule; offspring; nursery (or outplant) colony	Terms for newly propagated coral irrespective of reproduction mode (asexual and sexual propagation). The intended definition for use of term should always be specified
Exceptionally resilient or stress tolerant corals, reefs	Super-coral; super-reef	Use is highly context dependent—topic covered in detail in Camp et al. (2018) with a contextualization framework
Improvement in biological fitness	Acclimation; acclimatization; adaptation	Terms often used interchangeably without defining genotypic versus phenotypic changes—detailed in Edmunds & Gates (2008) for appropriate usage
Movement of coral from one location to another	Transplant; translocate; direct transplant; relocation	Intentional transportation from one location to another. Differentiation therefore requires knowledge of dispersal for any given population and environmental conditions, and hence movement distance should always be specified as part of the movement term and definition; terms exist for "assisted migration" where population dispersion distances are known (National Academies of Sciences, Engineering, and Medicine 2019)
Spatial footprint of restoration activity	Site; location; area; reefscape; reef	Terms used interchangeably to describe where any action in support of delivery of coral community or reef ecosystem recovery (Table 1) is conducted but should always be specific. A key source of ambiguity is in the specific area being recovered through planting versus the broader area of all restoration actions (donor sites, nurseries, reef extent etc.)

Challenges are outlined as to why definitions are not always provided along with recommendations to ensure local use is contextualized (and preferably quantified objectively). Adapted from various sources where listed in the Table

Describing a biological unit of coral material presents perhaps the biggest challenge. Practitioners and scientists interchangeably refer to coral material as a "nubbin," "branch" or "fragment" (among other terms) as ramets from a genet of coral. The term "nubbin" is synonymous with "fragment" (see Edmunds et al. 2022), and previous works have proposed nubbins to range from several cm in length to a mere 0.25 cm^2 (and where "large nubbins" are 3–10 cm long fragments) (e.g., Shafir et al. 2006). Both nubbin and fragment have been used for all coral morphologies and hence large(r) units may also constitute branches. Terminology for "micro-fragments" (see Table 3 for "micro-fragmenting" *vs*. "micro-fragmentation") defines "small" (note, not necessarily "micro") as 1 cm^2 (Page et al. 2018) or < 5

cm^2 (e.g., Mostrales et al. 2022). These examples show that terminologies and definitions are inconsistent but that quantitative qualifiers are always provided. Precision in defining coral biological units (i.e., specifying size, number of polyps, etc.) is a fundamental prerequisite to minimize uncertainty in understanding exactly what has been cultivated and planted, and in turn in quantifying restoration outcomes (e.g., number of coral units grown or planted). All terms describing coral biological unit(s) for restoration purposes technically represent a coral colony (see Table 4); however, how each unit ultimately contributes to coral reef processes depends on size, shape, and fitness, including reproductive maturity, for any given biological unit (see Edwards 2010; Edmunds et al. 2022). Similar inconsistencies exist across coral morphological terms and in how coral species are locally identified and differentiated; however, the same principle applies—context-specific definitions should always be provided.

Other ambiguous terms may be commonly used in the description of reference sites or donor material that is considered superior (i.e., "super-coral," "super-reef") and/or have greater capacity to be tolerant or resilient to change (adapted, acclimated, etc.). However, these terms are rarely based on specific contextual definitions but rather by empirical observations of how well coral has persisted under environmental change and/or related to public perception—the term "super" can be interpreted in any number of ways (see Camp et al. 2018). Similarly, moving material across locations may be described by ambiguous terms, but whether this occurs within or outside of the bounds of natural population dispersion (and hence is transplanted within or translocated between) is rarely verified—The National Academies of Sciences, Engineering, and Medicine (2019) has proposed a series of terms for assisted migration where population dispersal distances are known. In all such cases, we do not suggest such ambiguous terms be abandoned. Instead, it is essential that users always (a) state their specific intended definitions and (b) ensure alignment of these defined terms within program planning (i.e., goals, objectives and targets). Defined use should be supported by quantifiable descriptors until a framework to better standardize ambiguous terms for more effective collective use can be achieved.

Summary

Formalizing terms and definitions relating to coral reef restoration activities is critical to galvanize the ongoing acceleration of research and action toward reef recovery. Our proposed "user's guide'" is a step toward creating a common core lexicon that can be used by reef restoration practitioners, scientists, managers, policy makers, and communicators. We recognize the need to revisit this lexicon periodically as this diverse community and its practices continue to grow. Furthermore, applying the core framework proposed here to local contexts, languages, and project-specific attributes is a logical next step in supporting this further evolution of our reef restoration lexicon as a community.

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