GALAPAGOS CORAL CONSERVATION AND MANAGEMENT PLAN

SECURING THE GALAPAGOS CORALS' SURVIVAL

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HOW TO CITE THIS PUBLICATION

Galapagos National Park Directorate (GNPD), Charles Darwin Foundation (CDF), Universidad San Francisco de Quito (USFQ), Jocotoco Foundation, Nova Southeastern University (NSU), California State University, Monterey Bay (CSUMB), Conservando Galápagos (CG), Technion — Israel Institute of Technology (Technion), Nazca Institute of Marine Research (Nazca), University of North Carolina at Chapel Hill (UNC), Brown University (BU), Conservation International Colombia (CI-C), Conservation International Ecuador (CI-E), Pontificia Universidad Javeriana Cali (PUJC), Galapagos Reef Revival (GRR), University of Miami (UM), Smithsonian Tropical Research Institute (STRI), and Bar-Ilan University (BIU). (2025). Galapagos Coral Conservation and Management Plan (GCCMP). Puerto Ayora, Galápagos, Ecuador.

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EXECUTIVE SUMMARY

The Galapagos Coral Conservation and Management Plan (GCCMP) is the outcome of a participatory and collaborative process involving key stakeholders, including scientists, conservation experts, and representatives from governmental and non-governmental organizations. The process of building this document included different phases: a review of available literature, preliminary meetings among organizing committee members, and a workshop held in February 2023 in Puerto Ayora.

The primary objective of the GCCMP is to promote the protection, recovery and persistence of corals in the Galapagos Archipelago, through the implementation of the management plan by 2030 that will articulate lasting research and prioritized management actions. This plan recognizes the crucial importance of corals for marine ecosystems, coastal protection, tourism, fisheries and scientific research in Galapagos.

The GCCMP is structured around three main components:

1. Monitoring and Direct Threats: Establish a scientific baseline of information on the distribution, composition, and health status of corals, with the objective of identifying the main threats they face, including global warming, extreme climate events, diseases, ocean acidification and deoxygenation, as well as developing strategies for their mitigation.

2. Resilience, Resistance, Genetics, and Modelling: Focus on understanding the basic biology of Galapagos corals and developing predictive models of coral persistence to anticipate possible responses to environmental and climatic changes.

3. Restoration and Other Management Interventions: Design, establish and implement a comprehensive strategy for the coral restoration in priority areas, addressing pressures from invasive species and other anthropogenic impacts.

Additionally, the success of the GCCMP relies on sustained, progressive efforts, a well-coordinated working group, active community involvement, and consideration of socio-economic factors. Key knowledge gaps have been identified, and a proposed budget outlines the costs of implementation. This includes available funding for ongoing projects as well as new initiatives

In summary, the GCCMP represents a joint commitment to protect and conserve this important marine ecosystem, with the aim of ensuring its continuity, sustaining related ecosystem goods, processes and services, and contributing to the environmental and socio-economic health of the archipelago.


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ACKNOWLEDGEMENTS AND CREDITS

The GCCMP is the result of a participatory process, which included a review of available literature, preliminary meetings among organizing committee members, and a workshop held in Puerto Ayora in February 2023. The ideas proposed in this plan were discussed and agreed upon at the workshop and collectively belong to all its participants. This plan would not be possible without the set of ideas and expertise of all those who participated in this process and who are recognized in alphabetical order below.

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The planning, coordination, and recording of workshop contents and discussions, as well as the systematization of the results in this plan, were carried out by the organizers and facilitators.

The Galapagos National Park Directorate (GNPD) acknowledges and thanks the Galapagos Conservancy (GC), Fondo de Especies Invasoras para Galapagos (FEIG, for its Spanish acronym), Fundación Jocotoco, Charles Darwin Foundation (CDF), Galapagos Science Center from Universidad San Francisco de Quito (GSC-USFQ), Bezos Earth Fund and Re: Wild, who provided the funds for the workshop and the publication of this document.

Figure 1: Participants of the Galapagos Coral Conservation and Management Plan workshop at the dock of the Charles Darwin Research Station. ©Rashid Cruz/CDF

GALAPAGOS CORAL CONSERVATION AND MANAGEMENT PLAN
Ensuring the survival of Galapagos corals - **2025**

INTRODUCTION

Corals are fundamental to the health of the oceans. Not only are they diverse habitats, but they also protect coasts from erosion and are crucial for marine biodiversity. Additionally, coral reefs generate income through tourism and offer scientific research opportunities. Taking care of them is key to maintaining the health of the marine ecosystem.

The decline of corals in all the world's oceans has mobilized efforts in public policy, conservation, management, research, and education since the major events affecting coral reefs were recognized, linked to extreme oceanic events (El Niño Southern Oscillation, ENSO), anthropogenic impacts (tourism, fishing, pollution), and climate change effects such as, ocean acidification. Although coral reefs in tropical waters are more internationally known (Australia, Indonesia, the Caribbean, the Red Sea), coral communities in more temperate and deep waters have intrigued the scientific community for decades and are as relevant in the eyes of science and conservation as the tropical ones.

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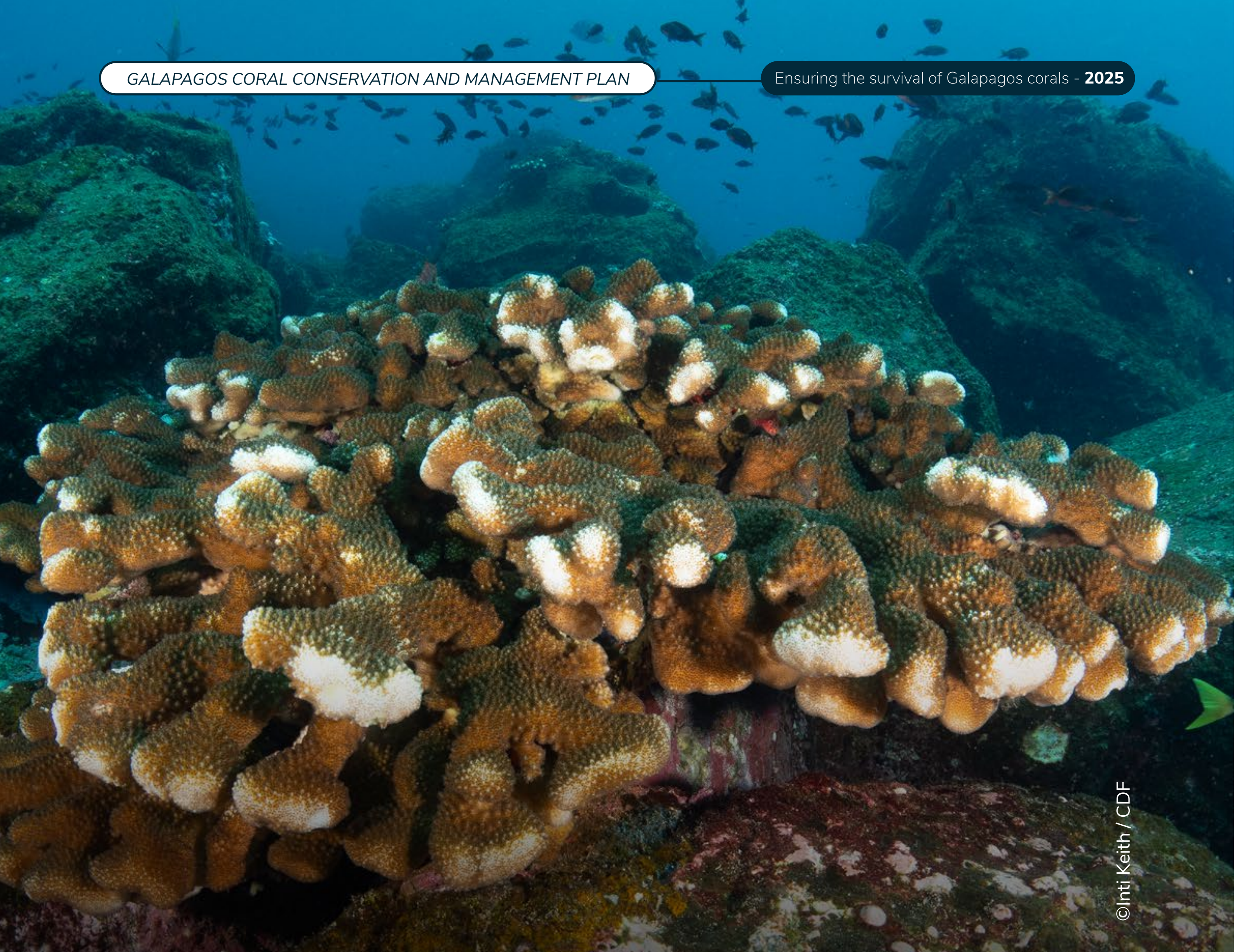

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The Galapagos Islands represent unique conditions that resemble a natural laboratory for the study of corals due to their equatorial location and the variability of currents and upwelling conditions. Corals are a vital component of the marine ecosystems in the Galapagos, with studies spanning decades to understand their resilience and environmental interactions. Early documentation in 1954 by Hancock recorded the uplifting of coral communities (*Pavona clavus*, *Pocillopora damicornis*, and *Porites lobata*) by six meters in Bahía Urbina (west of Isabela), highlighting the impact of geological activity on coral habitats. In the 1970s and 1980s, pioneering research by Jerry Wellington and Peter W. Glynn provided valuable insights into paleoclimates and oceanic conditions. However, the archipelago's coral reefs suffered severe losses due to the 1982/83 ENSO event, which led to a 97% coral mortality rate, followed by another strong ENSO event in 1997/98 that further hindered recovery and caused local extinctions.

Today, Wellington Reef at Darwin Island remains the last shallow structural reef in the Galapagos **(Glynn et al., 2018; Keith et al., 2022)**, It is mainly composed of warm-water corals, specifically *Porites lobata*, whose structures can reach sizes of two to four meters in height, along with several colonies of the genera *Pavona* and *Pocillopora.* In Galapagos, a total of 26 species of hermatypic corals with photosynthetic endosymbionts in the family Symbiodiniaceae have been recorded **(Glynn et al., 2018)**. The absence of structural reefs was not always the case; at one time, there were 17 structural coral reefs scattered across various islands **(Figure 1)**, some over 500 years old. The recent discovery of extensive reefs at 400-600 meters depth fringing seamounts has expanded knowledge of deep-sea coral habitats, underscoring their ecological importance and resilience. Ongoing research and conservation efforts are crucial to protecting these fragile ecosystems against the increasing threats of climate change.

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Regulatory Framework

The protection and conservation of Galapagos reefs and coral communities are referenced in national and insular regulations: (a) Ministerial Agreement 067, issued on June 8, 2016, by the Ministry of Environment: Establishing protection and conservation measures for Ecuador's reefs and coral communities; (b) The 2014 Galapagos Protected Areas Management Plan; and (c) The Ramsar International Convention, as coral reefs are considered Marine Wetlands. Under this framework, Ecuador is part of the Regional Initiative for the Integral Management and Sustainable Use of Mangrove and Coral Ecosystems, which was approved by the Ramsar Standing Committee (SC40) in May 2009.

1. Ministerial Agreement 067 (2016) establishes, among other points: (a) The need to generate an official georeferenced map of the country's main reefs and coral zones, indicating their conservation status and sensitivity. To this end, agreements can be made with educational institutions and non-governmental organizations (Art. 4); (b) Tourism and diving operators, duly authorized by the relevant authorities, will promote good environmental practices in their activities, inside and outside protected areas. Diving and snorkelling guides will include advice related to improving neutral buoyancy in their pre-dive briefing to avoid affecting the rocky bottom or corals; visitors will also be warned not to touch or remove anything from the environment (Art. 10); (c) Fishing practices are completely prohibited within the coral protection zones and rocky shallows, as established in the current Fisheries Law (Art. 13); (d) The Ministry of Environment, through the Undersecretariat for Marine and Coastal Management and the Undersecretariat for Climate Change, must incorporate in their policies and strategies, adaptation and mitigation measures to the effects of climate change to ensure the effective protection of reefs and coral ecosystems, participatively.

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The Ministry of Environment, through the Undersecretariat for Marine and Coastal Management, will implement and promote the necessary research to generate relevant and updated information for decision-making and the creation of policies and strategies to address climate change; it will also be responsible for disseminating existing and generated information for environmental awareness, prevention, and protection (Art. 14); (e) The Ministry of Environment, through the Undersecretariat for Marine and Coastal Management, the Protected Areas Administrations, and the Provincial Directorates, is responsible for monitoring the state of the country's reefs and coral zones according to their capabilities; for this, they must establish participatory monitoring protocols for the protection and evaluation of coral zone health, in coordination and alliance with appropriate institutions, non-governmental organizations, and the academic sector. The purpose of these protocols is the standardization of methodologies for correct technical analysis, to generate information that allows the Ministry of Environment to implement or adjust actions inside or outside protected areas for the prevention of reef and coral zone deterioration, in addition to promote their protection and conservation (Art. 16); and (f) The promotion of scientific research projects with academic entities and NGOs (Art. 17). Articles 18 and 19 emphasize the importance of socialization and education to all community sectors, including tourists, in coordination with the Ministry of Tourism. Sanctions are established based on the Forestry Law and the Organic Integral Penal Code and are regulated through the Organic Environmental Code as the legislative instrument.

2. Galapagos Protected Areas Management Plan (2014) recognizes the subtidal zone as one of the main inshore ecosystems, including rocky bottoms and vertical walls, coral reefs, and sandy bottoms, and cites 10 coral species listed in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) in 2013. It also cites Objective 1 of "Manage the conservation of the Galapagos ecosystems and their insular and marine biodiversity to maintain their capacity to generate services."; Objective 4 of "Dynamizing participatory and inclusive social processes to foster good living and a responsible Galapagos culture with the environment"; Objective 5 of "Increasing and Integrating interdisciplinary scientific-technical knowledge, applied to the management of the interaction between ecosystems and the socio-economic and cultural systems of the Galapagos Province in a context of Global Change"; and Objective 6 of "Promoting national and international cooperation for the conservation of Galapagos ecosystems and biodiversity, according to the priorities established by the Ecuadorian State in the Galapagos Special Regime Territorial Planning and Sustainable Development Plan". All these objectives are framed in the work carried out in the workshop and the results presented here.


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3. Ramsar International Convention (2009): The convention's guidelines emphasize the sustainable management of mangroves and coral reefs, recognizing their ecological importance and the need to protect them from threats such as pollution, overfishing, and climate change.

The regulatory framework outlined in the previous section validates the GCCMP as a decision-making tool for management related to research, fishing, tourism, and conservation. Once approved by the GNPD, it can be used as a key document for coordinating activities that comply with the Protected Areas Management Plan and Ministerial Agreement 067.

4. Convention on International Trade in Endangered Species (CITES): This convention plays a crucial role in the conservation of corals by regulating their international trade. Several coral species found in the Galapagos are included in Appendix II of CITES (2013), which mandates that any trade must be controlled to prevent overexploitation. Exporting or trading these species requires strict permits and compliance with sustainability guidelines to ensure their protection. In Ecuador, the Galapagos National Park Directorate (GNPD) and other authorities are responsible for enforcing CITES regulations, preventing illegal trade, and ensuring proper management of coral resources.

History of Corals in Galapagos

The Galapagos Archipelago is home to 300 species of the phylum Cnidaria. There are 88 accepted coral species, 71 natives, 16 endemic, and 1 cryptogenic **(CDF, 2024)**. These figures are still conservative, with new cold-water coral species being identified through recent deep-ocean explorations and collections post 2015. Within this phylum are the hermatypic corals, i.e., reef-forming corals, with a total of 26 species, 12 of the genera *Pocillopora*, 5 *Pavona*, 2 *Psammocora*, 2 *Cycloseris*, 2 *Madracis*, and 1 each for the genera *Porites*, *Gardineroseris*, *Leptoseris*. Although 12 *Pocillopora* coral species **(CDF, 2024)** have been identified morphologically, however, genetic species delimitation in this group has not been fully resolved. For several decades, studies and research have been conducted on coral reefs in Galapagos, mainly to understand how natural events like El Niño – Southern Oscillation (ENSO) have impacted the health of these important ecosystems.

The literature review on studies of hermatypic corals, summarized in a digital database, covered 64 publications including papers, theses, reviews, checklists, Google Scholar searches, and targeted Google searches. The documentation covers eight studied genera of hermatypic corals, 10 scientific disciplines, and includes more than 60 authors. Most publications are related to coral ecology, population dynamics, and El Niño events, including past ones in the form of paleoclimate. Studies have been conducted on 15 of the Galapagos islands. Floreana had the most published studies, followed by Santa Cruz, Isabela, and Darwin. Lastly, the genera *Pocillopora* and *Pavona* have been the most studied genus in Galapagos.

Many authors of the reviewed publications make recommendations for management actions or conservation plans, for example: no-anchor zones, tourism management, biosecurity protocols, and the development of Early Detection and Rapid Response protocols. We note that knowledge generated on key topics is lacking, for example: (i) study of invasive species dispersion, (ii) climate change-induced impacts, refuge habitat and biological response, (iii) population connectivity and (iv) social perspective studies on people's views about corals.

Current Status and Threats

Of the 17 documented inshore coral reefs in Galapagos before 1982, only one functional reef—Wellington Reef at Darwin Island—remains today (2025), along with a few scattered coral communities (Glynn et al., 2018). This dramatic decline highlights the vulnerability of coral ecosystems in the archipelago. However, the GCCMP aims to protect and foster the recovery of all coral species in the region, not only the reef-building hermatypic corals but also solitary ahermatypic corals, black corals (*Antipatharians*), soft corals (*Octocorals*), cold-water corals, and other lesser-known species. By broadening conservation efforts beyond reef structures alone, this program ensures that the entire coral biodiversity of the Galapagos is preserved.

The remaining corals in the Galapagos face multiple environmental and anthropogenic threats, many of which have intensified due to climate change and human activity. These include:

- Temperature stress (hot and cold, gradual and rapid inversions, rate of change).
- Global warming.
- Diseases.
- Lack of recruitment.
- Ocean acidification.
- Marine invasive species (for example *Caulerpa*).
- Pollution.

While some threats, like global warming and ocean acidification, require global-scale intervention, the GCCMP prioritizes localized threats that can be actively managed to improve coral resilience in the Galapagos. Efforts include monitoring temperature variations, managing invasive species, reducing pollution, restoring coral populations, and promoting sustainable marine practices. Through these targeted actions, the program aims to safeguard existing coral communities, encourage natural recovery, and ensure that Galapagos corals continue to play a crucial role in the marine ecosystem.

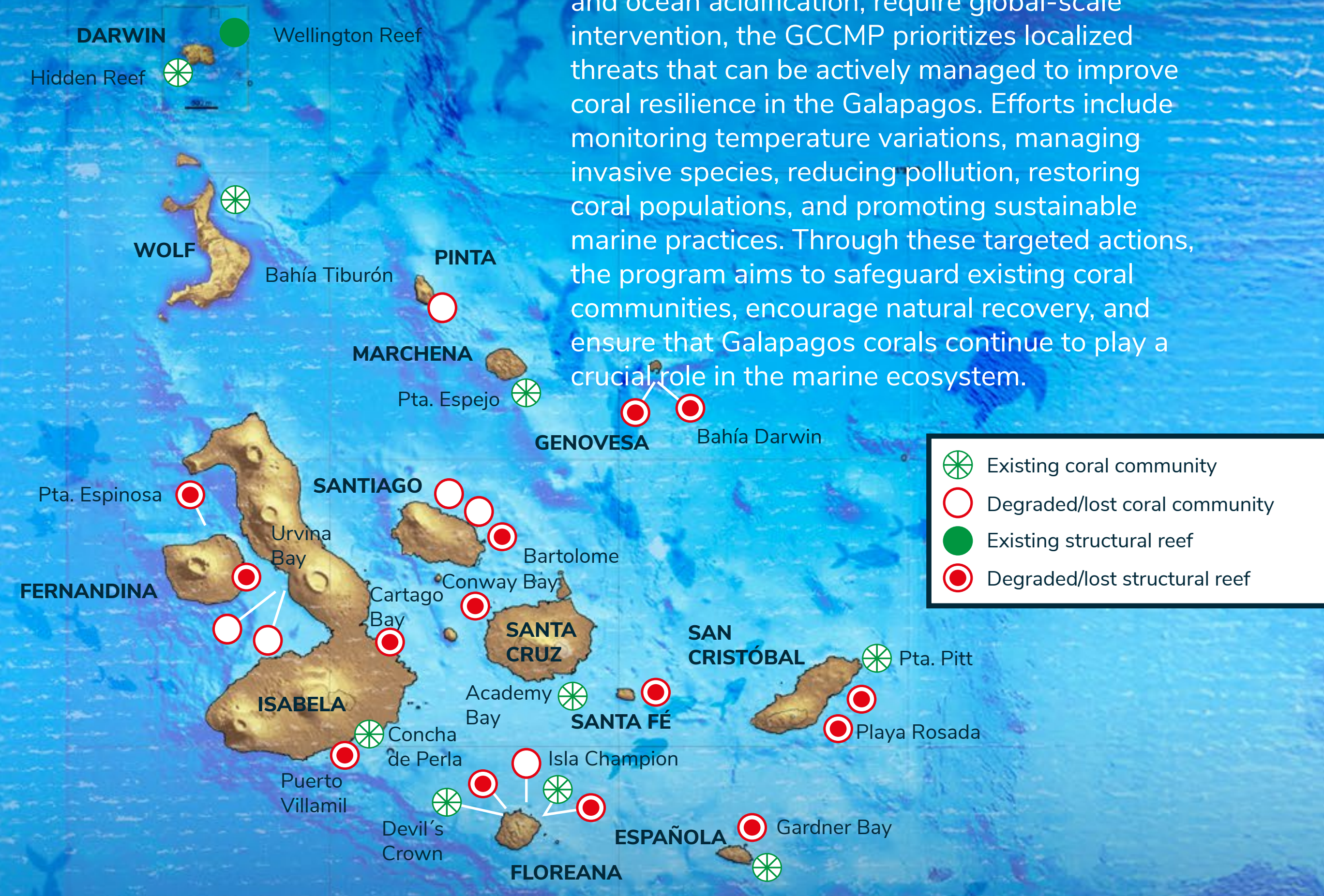

Figure 1: Location and conditions of inshore coral reefs and coral communities in the Galapagos Islands post El Niño 1982-1983 (Glynn et al., 2018).

VISION AND GENERAL OBJECTIVE

Vision

The corals of Galapagos maintain their ability to generate ecosystem services.

General Objective

By 2030, coordinated research and prioritized management interventions will secure the recovery and persistence of Galapagos corals.

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Scope

The GCCMP maintains a general focus on the collective corals of Galapagos, with activities primarily applied within the Galapagos Marine Reserve (GMR), although potential expansion to Hermandad Marine Reserve has been considered. Marine Protected Areas (MPAs) are recognized as important distribution areas for cold-water corals, and the importance of maintaining a regional perspective due to connectivity with other coral areas in the Eastern Tropical Pacific (ETP) is acknowledged. This includes the coastal zone of mainland Ecuador, Cocos Island in Costa Rica, Gorgona and Malpelo Islands in Colombia, Coiba Island in Panama, among others. The vision and general objective of the GCCMP are based on the benefits that healthy coral communities can provide in environmental, marine ecosystem function, food security, carbon sequestration, carbon cycling, and economic contexts (including tourism). The GCCMP is a response to the observed degradation of corals and reefs, over time.

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COMPONENTS, STRATEGIES, PRIORITY MANAGEMENT AND CONSERVATION ACTIVITIES

The work carried out during the three-day workshop, based on the knowledge acquired in Galapagos and at the regional level on corals, ongoing projects and initiatives in Galapagos, and knowledge sharing among experts, allowed for the definition of three components for the Action Plan: Monitoring and direct threat detection and impact mitigation; Resilience, resistance, genetics, and modelling; and Restoration and other management interventions.

Knowledge gaps were identified in two ways: some affect all three components, while others are specific to each component. The most urgent gaps, which impact multiple areas, are prioritized under the first component: **Monitoring and direct threat detection and impact mitigation.**

In total, **nine strategies** (Table 1) were identified across the three components mentioned above, covering research, management, community science, among others. Each strategy involves collaborative work between various entities, for which leaders/responsible parties have been identified. This is to work collaboratively and achieve the vision and objectives to conserve the corals of Galapagos, becoming a global reference for coral protection and conservation initiatives. We emphasize that coordinated and complementary efforts are a transversal and priority characteristic of the GCCMP. The information generated and gathered within each component serves as input and feedback for the work developed in the other components.

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Key Initiatives

1. Ongoing Projects:

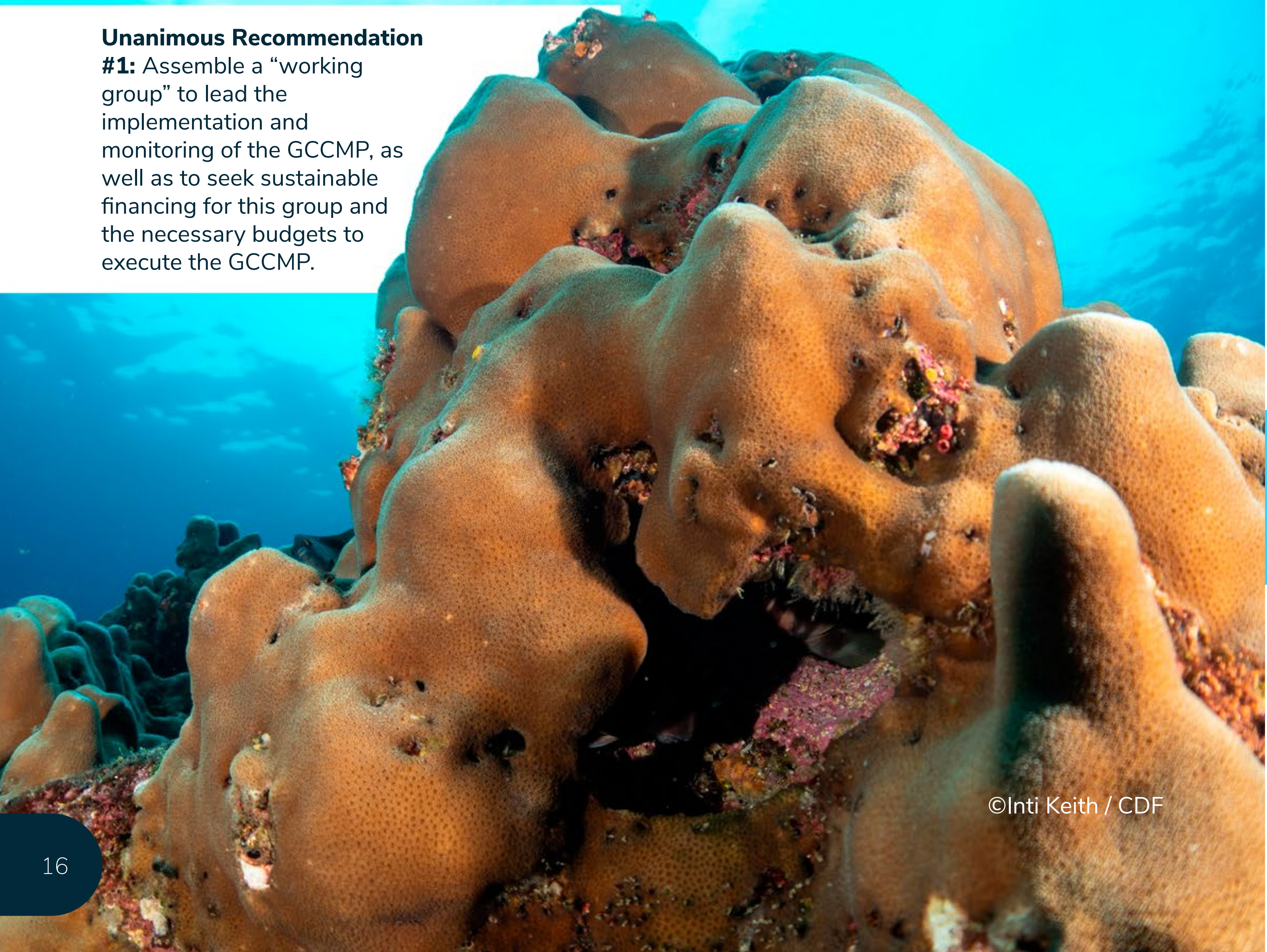
- Two coral restoration projects: Punta Estrada, Santa Cruz Island (GNPD); La Calera, Isabela (GRR-USFQ).
- Determination of the identification of symbionts and microbiomes inhabiting the corals of Galapagos (CSU Monterey Bay, CSUMB; USFQ; University of Miami, UM; CDF; Smithsonian Institution, SI).
- Coral Identification Guide (GNPD, 2023)
- Project mapping the variation in the physiological response of corals to thermal stress (CSUMB; USFQ).
- Update on the status of hermatypic corals of the GMR (GNPD; CDF).
- Use of photogrammetry to assess the health status of coral communities over the long term (GNPD; CDF).

2. Working Group and Sustainable Financing for the GCCMP

Unanimous Recommendation #1: Assemble a "working group" to lead the implementation and monitoring of the GCCMP, as well as to seek sustainable financing for this group and the necessary budgets to execute the GCCMP.

2.1 Responsibilities of the Working Group:

- Identify a person in charge to centralize information, convene meetings, systematize commitments, follow up, and communicate promptly about news and possible funding.
- Explore, together with the person in charge, emerging financing mechanisms; for example, networking at ocean conferences, specific calls for corals, and opportunities in Galapagos such as the Galapagos Marine Reserve Fund (FIAS) and the Galapagos Life Fund.
- Avoid duplication of efforts, streamline the process of obtaining permits, align work with regional plans and management plans, and stay up to date with advances in elements of the GCCMP that already have funding.



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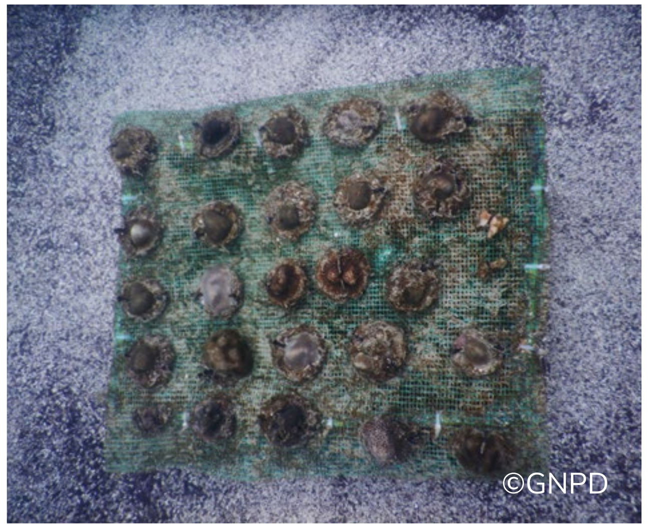

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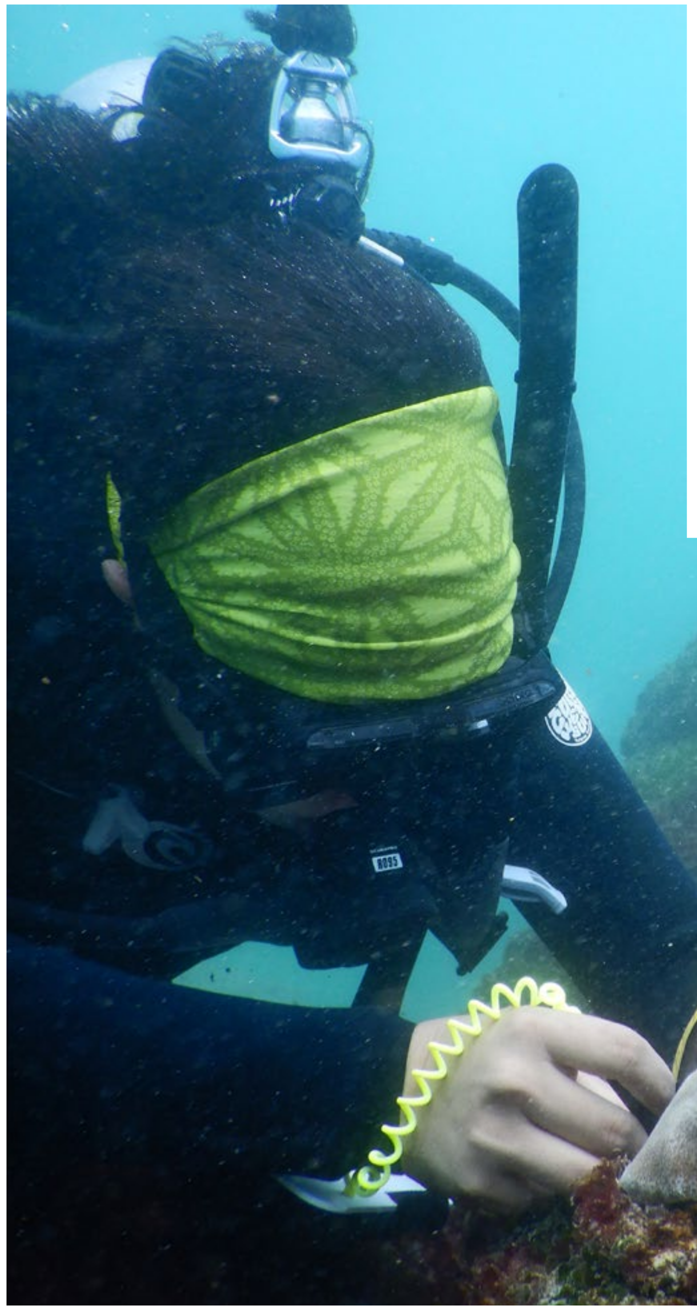

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3. Socioeconomic Engagement

Unanimous Recommendation #2: Integrate **science, community engagement, and socioeconomic aspects** into the research, management, protection, and restoration of corals.

3.1 Examples of actions to consider:

- Establish a line of communication, awareness, and updating of relevant information. This could take the form of social media groups, communication, and dissemination for guides, scientists, conservationists, educators, and community members.
- Invite and involve strategic partners in the execution of certain GCCMP components: (a) Education Sector - Galapagos Agreement for Education, Contextualized Curriculum of Galapagos; (b) Guides Sector through guide associations; (c) Boat Sector through representation of their unions; (d) Diving and snorkelling sector - agencies and operators; (e) Fishing sector.
- Generally, increase information dissemination to broader audiences that may be interested in coral and conservation topics, both locally and internationally. News of coral discoveries and hydrothermal vents generated significant excitement among the local, national, and international populations.

Knowledge Gaps and Priorities

In this first instance, it is emphasized that there are many knowledge gaps on the topic of Galapagos corals, many of which are shared between the three identified work components and are vital for building predictive models of coral populations, as well as for preparing restoration projects, management, and threat prevention. The products linked to these knowledge gaps are covered in Component A, with two activities and one strategy. The following section summarizes the main knowledge gaps:

- Basic biology of Galapagos corals
- Spatial distribution of coral species, genetic diversity, environmental tolerances, adaptive capacity to climate change, and remaining populations.
- Measurements of environmental conditions: physical, chemical, and oceanographic.
- Studies on sexual reproduction (spawning, recruitment, metapopulation dynamics, larval dispersal, currents, source-sink dynamics) and characterization of life cycle stages (spawning to recruitment).
- Measurements of disease and bleaching prevalence

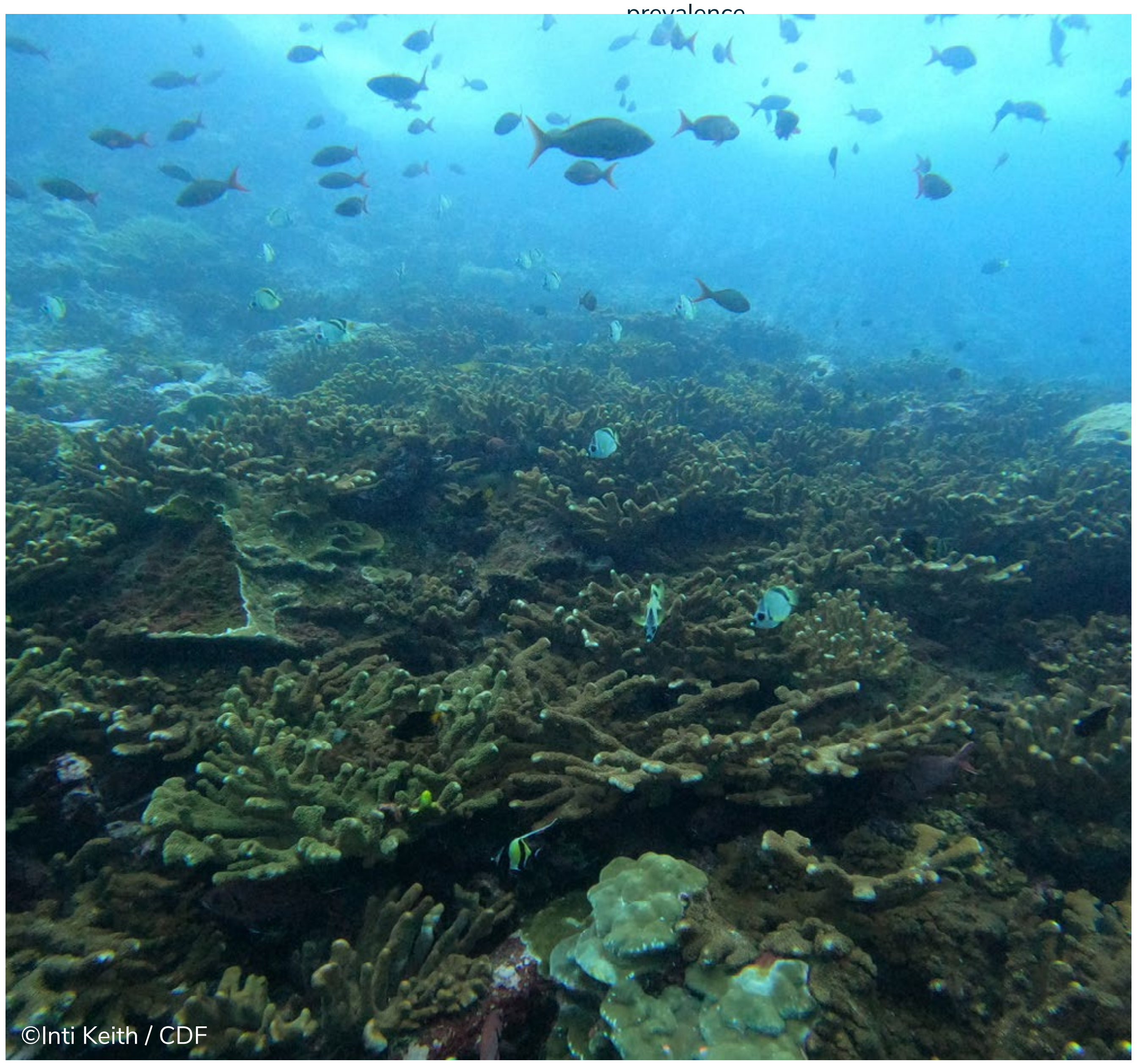

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Table 1: Galapagos Coral Management and Conservation Plan: Components, Strategies, and Activities

Component 1: MONITORING AND DIRECT MITIGATION OF DIRECT THREATS					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**GNPD & co-leaders**
Activity 1. Creation of Corals of Galapagos Geodatabase & Atlas	Generation of a baseline with the organization of available information.				CDF
Activity 2. Survey methodologies standardization	Research protocols and methodologies & indicators definition				CDF, USFQ
Strategy 1. Addressing relevant knowledge gaps.	Exploratory trips to areas without information, testing of methodologies, identification of possible critical sites (key, vulnerable, high risk, priority).				CDF, USFQ
		Physiochemical conditions (T, pH and aragonite, nutrients, currents, salinity, upwelling, bathymetry). Field Trips x 3 Years			CDF
		Coral status and threat surveys. Field Trips x 3 Years			USFQ, BIU
Strategy 2. Establishment of a continuous ecological monitoring.	Updated baseline of conditions of coral communities				CDF, USFQ, BIU, STRI
	Sheets documenting the impacts of invasive species on coral communities				CDF, USFQ
		Monitoring and data analyses			CDF, USFQ
Strategy 3. Community Science.	Platform where guides, tourists, and other community members can contribute information (it needs to be defined who receives, filters, and analyzes it.	Media campaign focused on raising awareness and disseminating progress.	Media campaign focused on results achieved.		USFQ, CDF

Component 2: RESILIENCE, RESISTANCE, GENETICS AND MODELLING

	Year 1	Year 2	Year 3	Year 4	GNPD & co-leaders
Strategy 4. Understanding the basic biology of Galapagos Corals.	Monitoring and characterization of coral diseases				USFQ, UM, CDF
		Characterization of resilience mechanisms: (i) genetics / epigenetics; (ii) acclimatization, ecological and physiological; iii) symbiont communities			BIU, UM, STRI, CSUMB, USFQ, CDF
			Determination of hybridization potential and the viability of hybrids.		UM
Strategy 5. Mapping the status and vulnerability of populations to predict future high- and low-risk regions for corals.	Determine the geographical distribution of the host and symbiont genotypic diversity.				CSUMB, USFQ
			Integrate this information and perform spatial analyses.		BIU, CSUMB, USFQ
			Quantify coral patch dynamics		STRI, USFQ
	Spatial Variation in Coral Diversity and Reef Complexity in the Galapagos using photogrammetry				CDF


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	Year 1	Year 2	Year 3	Year 4	GNPD & co-leaders
Strategy 6. Development of population models to anticipate possible responses to ongoing environmental and climatic changes, as well as to active interventions.	Measurements of relevant vital rates (growth, mortality, recruitment, reproductive mode, timing of spawning, fecundity)				STRI, CSUMB, CDF, USFQ
		Quantification the variation of intraspecific vital rates, including trade-offs (e.g. does increased thermal tolerance mean reduced growth)			CSUMB, USFQ
		Quantification of genetic connectivity and population dynamics.			USFQ
			Estimation of larval dispersal using oceanographic modelling.		USFQ, CDF
			Evaluation of efficacy of human interventions (assisted gene flow, nurseries).		BIU, CSUMB, USFQ
			Measurements of the dependency of vital rates on environmental conditions.		USFQ
				Integration of all information to construct models.	STRI


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Component 3: RESTORATION AND OTHER MANAGEMENT INTERVENTIONS						
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**GNPD & co-leaders**
Strategy 7. Coral Restoration	Monitoring of restoration pilot projects					BIU, CSUMB, USFQ, GRR, CDF
	Definition of criteria that will allow prioritize restoration sites					BIU, USFQ
	Establishment of tested materials and methodologies for restoration in the GMR.					BIU, USFQ
		Standardization of necessary parameters for the monitoring of restoration areas.				BIU, CSUMB, USFQ, CDF
		Establishment of monitoring methods and success evaluation.				BIU, USFQ, CDF
		Development and implementation of the coral reef restoration strategy in the Galapagos Marine Reserve (GMR) by the Galapagos National Park Directorate (GNPD)				USFQ, GRR, CDF
			Long-term monitoring of restored coral areas			USFQ, GRR, CDF
				Exploration of recollection techniques of gametes and other methodologies to promote sexual reproduction.		BIU, USFQ, GRR
				Upscaling by applying restoration techniques in prioritized sites.		BIU, USFQ, GRR
Strategy 8. Management of invasive species to accelerate the recovery of coralline areas.	Monitoring of the impacts of invasive species on coral communities.	Determination of action to reduce the generated stress in coral communities by invasive species.			Upscaling of mitigation methodologies.	CDF
Strategy 9. Other anthropogenic effects.	Anthropogenic impacts identified and mapped in relation to coral habitats and communities.	Communication, awareness, and engagement of stakeholders.	Legal framework for increased protection and regulation of harmful activities.			BIU, CDF

BUDGET

Approved and/or Upcoming Projects

- **The New Evolutionary Challenge for the Galapagos Program**
  The Program is funded by the Green Climate Fund (GCF), with CAF serving as the implementing agency, in coordination with the Ministry of Environment and Energy (MAE) and the Governing Council of Galapagos. WWF, together with the Galapagos National Park Directorate (GNPD), serves as the executing agency.
- **Galapagos Life Fund,** upcoming opportunities for surplus projects related to Control and Monitoring and Surveillance of both Marine Reserves.
- **Blue Planet Fund, small grants ($200-300K) up to ($3M).**
- **KFW – administered for FEIG, co-executor Jocotoco**. 3 years to start. Coral status update focused on species affecting them. Based on establishing management measures.
- **Re:Wild**, Coral restoration in Galapagos. Fund managed by Fundación Jocotoco, with 8 months of funding, concluded in June 2023. Future stages still pending.
- **CDF-GNPD Deep-Ocean Program. Deep-Ocean and mesophotic baseline, including cold water coral associations over a 5 initial year program** 2023-2028 ($7M total) between ETP research partners (CDF, STRI, INVEMAR, University Costa Rica/ FAICO).

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CONCLUSIONS

The GCCMP is the result of a collective and collaborative effort involving various actors from the scientific community, governmental and non-governmental organizations, as well as local and international experts. This document represents a significant milestone in our efforts to protect, preserve, and recover key species of the Galapagos marine ecosystems with the shared intention that ongoing and future research and conservation efforts support the testing and upscaling of coral conservation methods for broader geographic applications. The complexity of this group of invertebrates, due to their genetic diversity, the habitats they occupy, their adaptative capacity, signs of resilience, vulnerability to multiple anthropogenic impacts, and their restoration potential, makes this work an inspiration and highlights the interdisciplinarity and collaboration necessary to achieve the set objectives.

We sincerely thank all participants who contributed their experience, knowledge, and dedication during the development of the GCCMP. Your commitment and collaboration were essential for its development and are crucial for its successful implementation in the coming years.

We are committed to working together to ensure that the proposed strategies and activities are effectively carried out, with the aim of fostering the recovery and persistence of Galapagos corals for the future. With the continued support of our institutions and allies, we are confident that we can achieve the overall goal of this plan, in line with the vision that the corals can maintain their ecosystem service-generating capacity in the Galapagos.


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GALAPAGOS CORAL CONSERVATION AND MANAGEMENT PLAN
Ensuring the survival of Galapagos corals - 2025

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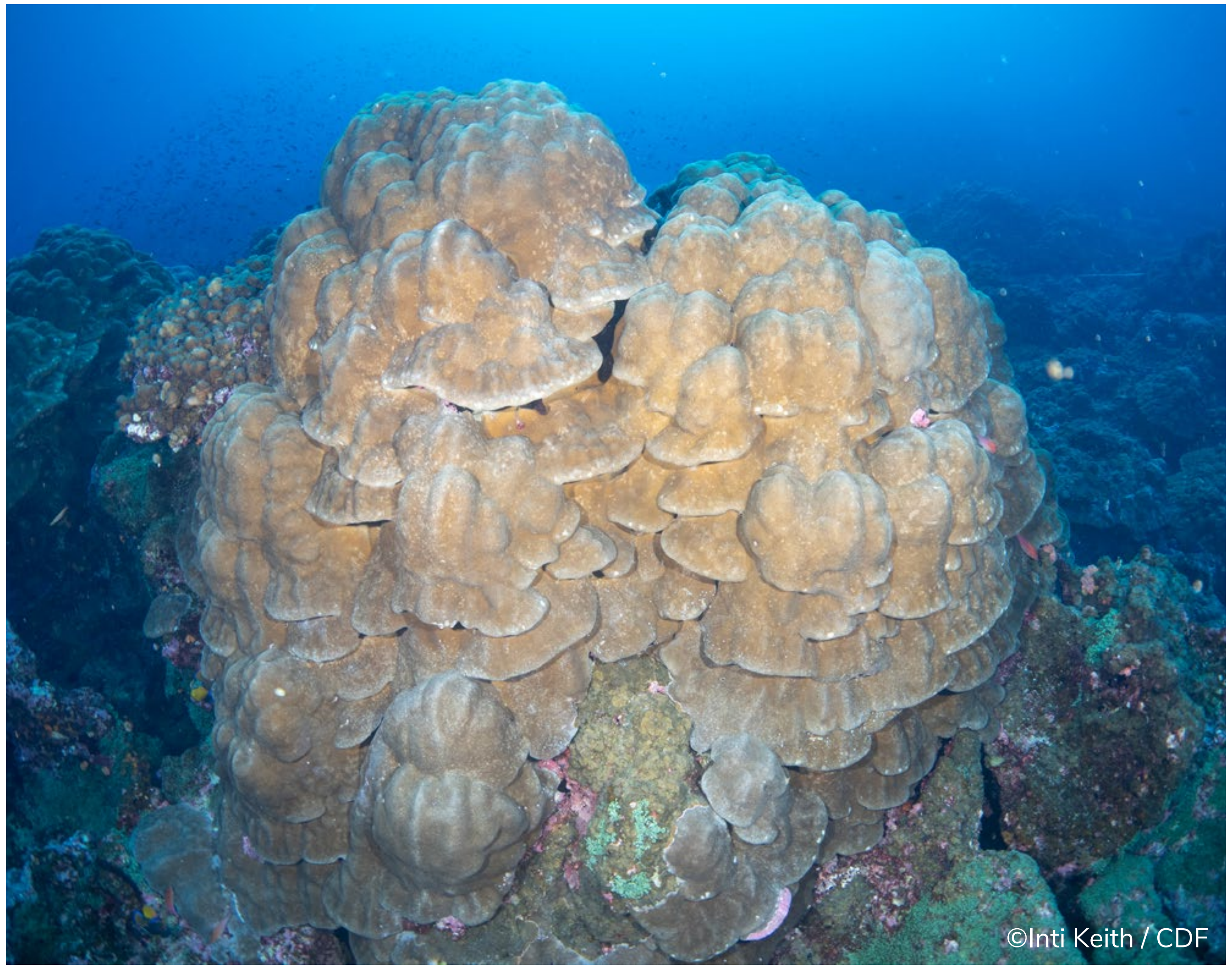
GLOSSARY

Source: "Los arrecifes de Coral. Manual para Estudiantes" 2016. https://issuu.com/seagrantpr/docs/manual-para-estudiantes-arrecifes-de-coral/41

Adaptive capacity: The ability of coral holobionts to respond and adjust to environmental stress, via processes including genetic adaptation, shifts in symbiont communities, and physiological acclimatization.
Acclimatization: The physiological process of becoming accustomed to a new environmental condition.
Anthropogenic: Resulting from human activities.
Asexual Reproduction: A type of reproduction that does not involve male and female gametes as it does not require specialized structures or cells, where a single organism produces one or more identical individuals, all with the same genetic information. In corals, this occurs through budding and fragmentation.
Atoll: Coral reefs with a circular or oval shape surrounding a lagoon, growing around submerged volcanoes that were formerly islands. Most of these reefs are found in the Pacific Ocean and the Indian Ocean.
Barrier Reef: A type of coral reef that borders the coast and is separated from it by a generally deep area of water known as a lagoon. It extends parallel to and at a great distance from the coast.
Bleaching: An event in the reef, induced by stress, where the coral expels its zooxanthellae and loses its distinctive color, becoming transparent and exposing the white color of its calcium carbonate skeleton.
Budding: A protrusion that forms on a parent organism. That bud then separates and grows into a new individual (this process occurs during budding).
Budding: A type of asexual reproduction in which a new polyp develops as a bud (protrusion) from a parent polyp.
Chitin: A substance insoluble in water found in some invertebrates to provide support and rigidity.
Climate Change: Modification or variation of the climate either globally or regionally compared to its historical climate.
Cnidarians: A phylum of exclusively aquatic organisms with radial symmetry, two tissue layers, and a mouth surrounded by tentacles with stinging cells known as cnidocytes. Anemones, jellyfish, and corals belong to this phylum.
Cnidocytes: Specialized cells unique to Cnidarians, containing a stinging apparatus known as a nematocyst. These are used for defense and capturing prey. These cells are abundant in the tentacles and mouth.
Complex Protein: Proteins that, in addition to amino acids in their molecular structure, contain other elements, such as phosphorus, sulphur, or carbohydrates.
Coral Colony: A colony is a group of identical polyps that remain connected. During the development and growth of hard coral colonies, calcium carbonate is secreted to form an external skeleton.
Coral Fragmentation: A type of asexual reproduction where pieces of a coral colony break off and can grow into a new colony.
Coral Polyp: One of the structural types in cnidarians, sessile in habit. The polyp's body is tubular or cylindrical, with a mouth and tentacles at the top, while the opposite end is fixed to the substrate.
Coral Spawning: A natural phenomenon occurring only at night, involving coral colonies and species that release their male and female gametes simultaneously into the water column.
Erosion: The displacement of soil or land due to elements such as wind, wave action, rain, and/or human activities.
Essential Habitats: Environments necessary for feeding, growth, and reproduction of certain species.
Euphotic Zone: The region in aquatic systems where sunlight penetrates. The depth of this zone is variable and depends on water turbidity.
Exoskeleton: An external skeleton that provides support and protection in some animals.
Fertilization: The process in which a male reproductive cell (sperm) and a female reproductive cell (egg) join to form a new organism.
Fisheries-Interest Species: Species targeted for fishing.
Fishing Ban: An indefinite or temporary prohibition on fishing established to protect the reproduction of certain fish species.
Fishing: The capture and extraction of fish and shellfish from aquatic environments.
Fringing Reef: One of the types of coral reefs characterized by a flat submerged platform, sometimes forming a lagoon, that grows directly from the shore into the sea. It is the most common type of coral reef in the Caribbean.
Gametes: Cells involved in sexual reproduction. They have a single copy of each chromosome (haploid). In many animals, these are known as eggs and sperm. When they unite, they form an organism with two copies of each chromosome (diploid), like humans.
Gastrovascular Cavity: The main area of the coral responsible for digesting food and transporting nutrients throughout the body of organisms like Cnidarians.
Genetic Diversity: The amount of genetic variation

present in a population or community. Greater genetic diversity increases the likelihood that species will adapt to environmental changes.
Genetic Exchange: A process involving the combination of genes during sexual reproduction. This produces genetic variation (differences in hereditary traits) in a population.
Genotype: The genetic identity of an organism that includes the specific genes inherited from both parents, which, along with environmental influences, determine its physical appearance (phenotype).
Global Warming: A prolonged increase in the average temperature of the Earth's atmosphere and oceans due to the increase of greenhouse gases, which causes the heat entering the Earth to become trapped, leading to a rise in the planet's temperature.
Gorgonin: A complex protein that constitutes the horny skeleton of gorgonians (flexible corals).
Greenhouse Gases: Gases present in the atmosphere, such as carbon dioxide (CO2) and methane (CH4), that absorb part of the energy from solar radiation and consequently cause an increase in the planet's temperature.
Habitat: A place or space that provides all the conditions necessary for an organism to live, reproduce, and perform all its functions.
Herbivores: Organisms that feed on plants and algae.
Hermatypic Corals: Corals that have symbiotic relationships with zooxanthellae, produce calcium carbonate exoskeletons, and can form reefs.
Horny Corals: A type of coral with a skeleton hardened by a flexible material (gorgonin) and calcareous spicules. Also known as gorgonians.
Horny Tissue: Hard, fibrous tissue that forms hard structures such as the horns of some animals, hooves, hair, and nails. Its main component is chitin.
Invertebrates: Animals that lack or do not develop a backbone. They make up 95% of the Animalia kingdom and include corals, jellyfish, lobsters, clams, crabs, sea urchins, etc.
Ion: An atom or group of atoms charged electrically due to the loss or gain of electrons.
Mesophotic Corals: Hermatypic corals found at depths of 100 meters (300 feet) or more.
Metamorphosis: The developmental process in larvae before reaching adulthood or sexual maturity. During this process, organisms undergo structural and physiological changes.
Mutualism: A type of relationship in which two or more organisms of different species benefit from each other. For example, corals receive sugars and other organic components from zooxanthellae, while the zooxanthellae receive carbon dioxide, nutrients, and protection from the coral polyp.
Nematocysts: Organs with tubular threads that can discharge and paralyze other animals with their venom. These specialized structures are found within cnidocytes.
Ocean Acidification: The decrease in ocean pH due to the absorption of atmospheric CO2. The increase in atmospheric CO2 causes rises in ocean CO2, creating imbalances between different forms of dissolved inorganic carbon in seawater. The decrease in pH causes organisms with calcium carbonate exoskeletons, such as corals, crustaceans, and coralline algae, to reduce their calcification rates.
Octocorals: Also known as flexible or horny corals, they are a group of corals with eight tentacles per polyp. This group includes sea fans, sea plumes, and sea whips.
Overfishing: Excessive fishing that removes more organisms than appropriate and reduces the number of individuals in a population so dramatically that it cannot reproduce sufficiently to survive.
Patch Reef: A type of coral reef that grows in small clusters and is isolated from the coast.
Pharynx: A tubular structure extending from the mouth to beyond the middle of the gastrovascular cavity. Its function is to facilitate water circulation through this cavity.
Photosynthesis: A process that uses sunlight, water, nutrients, plant chlorophyll, and carbon dioxide to produce food and oxygen.
Planktonic Organisms: Generally microscopic organisms that live floating in marine or freshwater environments (with limited movement capability).
Planula: A type of planktonic larva in cnidarians.
Protein: A chemical substance composed of structured chains of amino acids (substances with a carboxyl group and an amino group) linked by chemical bonds. They contain carbon, oxygen, nitrogen, and hydrogen. All proteins in living beings are composed of 20 amino acids.
Reef Crest: The upper edge of the coral reef, which is shallow. It receives the direct impact of wave action.
Reef Front: The zone of the reef facing the open sea. It extends from a level near the surface to greater depths and may have a gentle to steep slope.
Reef Lagoon: A body of water formed between the shore and the reef. Generally calm waters that may vary in depth.
Restoration: Assist in the recovery of a degraded ecosystem or habitat to restore its values and services
Reproductive Aggregations: Events where adult fish migrate to a specific area to gather for a short period of time to reproduce.
Runoff: Rainwater flowing over sloped land surfaces into aquatic environments. This water carries sediments and may contain agricultural waste (e.g., nutrients, pesticides) harmful to aquatic organisms. Runoff is greater when it passes over impermeable surfaces like sidewalks, streets, and roofs, preventing natural infiltration that occurs, for example, in soil.
Scleractinian Corals: A type of coral with a skeleton hardened by calcium carbonate.
Scleractinians: Colonial organisms characterized

by the secretion of an external calcareous skeleton, responsible for reef formation. Most inhabit tropical reefs and house zooxanthellae.
Seafloor: The bottom of the sea.
Sessile: An organism attached to substrates or other surfaces and unable to move from place to place.
Sexual Maturity: The age or stage at which an organism gains the ability to reproduce.
Sexual Reproduction: A type of reproduction involving male and female gametes.
Species Extinction: The disappearance of all members of a species.
Spicules: Needle-like or similar structures that are part of the skeletons of flexible or horny corals and sponges.
Stinging Nettle: Common name for plants of the genus Urtica, characterized by stinging hairs that release an acidic substance causing intense itching and irritation on the skin when touched or brushed against.
Sustainable Fishing: A type of fishing that extracts an appropriate number of individuals of the right size from a population, allowing it to remain sufficiently numerous to survive, reproduce, and continue to be exploited for many years.
Symbiotic Relationship: Refers to the close and prolonged association between two or more organisms of different species, where the organisms do not necessarily benefit from each other. Symbiosis includes mutualism (both organisms benefit), commensalism (one organism benefits while the other is neither helped nor harmed), and parasitism (one organism benefits while the other is harmed).
Tentacles: Flexible extremities or appendages of an animal located around the mouth of invertebrates, used for grabbing food, movement, and defense.
Top Predators: Animals that hunt other living animals for food and survival and are not preyed upon by other animals; they are at the top of the food chain.
Zooplankton: Microscopic planktonic animals that are at the mercy of currents and whose swimming abilities are insufficient to move independently of the currents. Many animal groups are found in zooplankton, either as adults or in various developmental stages.
Zooxanthellae: Microscopic single-celled algae living within the tissues of some marine invertebrates. Most are dinoflagellates belonging to the genus Symbiodinium.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APPENDIX 1: SWOT for Large Scale Restoration Processes

STRENGTHS	OPPORTUNITIES
• GNPD leads the process • Involvement of key actors • Existing funding • Existing Literature • Installed capacities • Galapagos Special Law	• New funding • High potential involvement of several sectors (scientific, touristic, fishermen and academia)
WEAKNESSES	**THREATS**
• Territory/available personnel • Social appropriation of knowledge • Zoning Process in revision • Lack of knowledge of different actors	• Anthropogenic pressures • Invasive Species • Economic interests • Climate change / local impacts / natural

APPENDIX 2: Example of a draft of medium and large-scale restoration plan (to be developed further)

TIMELINE

Phase 1: Monitor 4 Pilots (monitoring program 0-18 months)

- Baseline monitoring (what is there) of the specific location (in each pilot): Month 0-6 months
- Chose the coral species and methods (gardening + restoration): Month 0-6
- Decide on the criteria for prioritizing and site selection: Month 0-6
- Manufacture and install nurseries and other restoration components (AR – 3D components, size, shape, materials): month 2-6
- Monitoring through 3 months natural succession biofilm development (eDNA): month 6-9
- Monitor and adaptive management evaluation for the 4 pilots: month 6 – 18
- Site active restoration with nursery fragments: month 9-10
- Evaluation for identifying threats and weaknesses for scaling projections (based on SWOT): month 17-18
- Local community program and stakeholder involvement /strategy/preparation/education: month 0-60

Phase 2 (pilot scale up 18-36 months): upscale 2 big projects $2.5 million – $3.5 million

- Decide on the criteria to scale up: month 18-42
- Implement escalation methods to reach medium phase restoration goals.
- Monitor and adaptive management evaluation for restoration phase

- Continue monitoring the other 2 pilots: month 18-42
- Install after manufacturing the 2 locations scale up: month 22-30
- Monitor 2 locations for 1 year: month 18-30
- Local community involvement in restoration activities and diversifying local economy. (restoration, nursery construction, gardening, manufacturing in 3D printing/monitoring/ surveillance): month 22-42

Phase 3 (scale up 36-60 months): upscale 10-12 places, tourist restoration $3.5 - $4.5 million

- Continue monitoring the 2 locations scale up: month 30-60
- Choose at least 2 locations for scale up:
- Manufacture and install new location
- Tourism program/strategy
- Manufacture and install at least 4 other locations
- Monitoring and surveillance and ecological biodiversity services

	0-3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
1	■	■																		
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18																		■	■	■

Site Selection Criteria

- History brief
- Coral communities that are getting better, Restoration potential
- Feasibility: Easy-to-go place, cheap to maintain, constant monitoring
- Different microclimates and conditions for the coral nursery sites but similar to each implementation areas
- Ecosystem services
- Representativeness of bioregions
- Relevance to the established goals
- Disturbance exposition
- Coral resilience capacity
- Thermal and present and future disturbance
- Restoration capacity


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