Genetic rescue has been shown to increase population fitness by introducing adaptive genetic variants, which can counteract the negative effects of inbreeding and genetic drift. However, it is essential to carefully plan these interventions to avoid maladaptation, where introduced genes may not be suited to the local environment. Studies have highlighted the importance of considering both short-term and long-term outcomes of genetic interventions, as well as the potential for maladaptation, to optimize conservation strategies (Derry et al., 2019). By balancing these factors, assisted gene flow and genetic rescue can effectively support the recovery and sustainability of threatened reptile populations.

5.3 Adaptive management strategies

Adaptive management strategies are dynamic approaches that incorporate ongoing monitoring and feedback to adjust conservation actions based on new information and changing conditions. These strategies are particularly important in the face of rapid environmental changes and uncertainties. By integrating ecological and evolutionary principles, adaptive management can enhance the effectiveness of conservation efforts for reptiles. For instance, the use of genomic tools to monitor adaptive genetic variation can inform management decisions and help identify conservation units that require specific interventions (Flanagan et al., 2017).

Adaptive management also involves the integration of in-situ and ex-situ conservation efforts. By combining data from both settings, conservationists can develop comprehensive management plans that address the needs of species across their entire life cycle. This approach has been successfully implemented in zoo-based conservation programs, where data on reproductive ecology and life history traits are used to inform both captive breeding and wild population management (Blais et al., 2022). By continuously evaluating and adjusting strategies, adaptive management ensures that conservation actions remain effective and responsive to new challenges.

5.4 Ex-situ conservation and captive breeding programs

Ex-situ conservation and captive breeding programs play a vital role in preserving reptile biodiversity, especially for species that are extinct in the wild or face imminent extinction. These programs provide a controlled environment where species can be bred and studied, offering insights into their reproductive ecology and behavior. For example, captive breeding of the narrow-headed gartersnake has revealed important aspects of its reproductive biology, which can inform both ex-situ and in-situ conservation efforts (Blais et al., 2022).

Assisted reproductive technologies (ART) are increasingly being used in ex-situ conservation to enhance genetic diversity and overcome reproductive challenges. Techniques such as artificial insemination, gamete storage, and genome resource banking can capture and preserve genetic material from select individuals, facilitating genetic rescue and reintroduction efforts (Perry and Mitchell, 2021). These technologies are crucial for maintaining genetic diversity and adaptive potential in captive populations, ensuring their long-term viability and success in reintroduction programs.

6 Case Analysis: Integrating Ecology and Evolution in the Conservation of the Galápagos Marine Iguana

6.1 Species background and evolutionary significance

The Galápagos marine iguana (*Amblyrhynchus cristatus*) is a unique species, being the only extant marine lizard in the world. This species is endemic to the Galápagos Archipelago and has evolved remarkable adaptations that allow it to thrive in both terrestrial and marine environments. These adaptations include specialized feeding behaviors, primarily consuming algae from the rocky seafloor, and unique morphological traits such as modified snout configurations and increased muscle attachments in the skull, which distinguish it from other iguanids (Paparella and Caldwell, 2021).

The evolutionary history of the marine iguana is complex, involving incipient speciation and hybridization events. Genetic studies reveal strong population structures between islands, with evidence of both within-island speciation and between-island hybridization, which may enhance the species' evolutionary potential by integrating local adaptations into a common gene pool (Quezada and Steinfartz, 2015).