

FOREWORD

BY

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INTRODUCTION

The global decline in coral reefs during the last decades has provoked the most serious concerns about these remarkable ecosystems. Were they owing to a single worldwide cause, like influenza, plague or HIV in humans, the focus of efforts to understand and remedy the situation would be clear. Instead, the causes of declines as well as the nature of reefs vary significantly from region to region and within regions. Thus the urgent need is to assess the condition of reefs regionally with directly comparable quantitative observations rather than anecdotal reports.

This volume contains the initial reports and their synthesis of a new approach to assessing the regional condition of coral reefs in the Western Atlantic Ocean developed under the Atlantic and Gulf Rapid Reef Assessment (AGRRA) program. It features rapid, multiscale assessments by teams of five-six trained observers for reefs of the Greater Caribbean, Gulf of Mexico and South Atlantic with the same method. Thus it becomes possible to assess many reefs spread over the entire region.

The AGRRA protocols are focused on three key functional and structural elements of reef ecosystems: stony corals, fish and algae. The long-term goal of this region-wide effort is to provide, for the first time, a database suitable for comparative evaluation of current reef condition. This approach is similar to that which public health officials would use to make a rapid health assessment of villagers in remote areas. Analysis of the assessments provides norms of condition for some 30 key parameters of reef condition, such as the species identity, sizes and partial mortality of reef-building corals and the biomass of ecologically and commercially significant reef fishes. As demonstrated in the Synthesis of this volume, these initial norms, which are like those of human health assessments (blood pressure, pulse, reflexes), can be used to compare individual reefs at different spatial scales: between reefs; groups of reefs; subregions; or for most of the 20 reef areas in this volume. Even these initial results offer valuable background information for selecting protected areas or perturbed reefs in need of monitoring.

While this volume was in preparation, additional AGRRA surveys have been carried out in several other major reef areas: Jamaica's northern and western coasts; Cuba's southern coast; the Caribbean reefs of Panamá and the Florida Keys. The

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completed regional assessment will expand and refine the initial regional interpretations presented in this volume, and produce an essential baseline with which to gauge future major changes disclosed by revisits.

SPECIAL VALUE OF THESE INITIAL RESULTS

Each of the assessments in this volume is based on data from multiple sites. The areas assessed extend from the northern Bahamas to the southernmost reefs of the Caribbean and from the windward Netherlands Antilles to the Gulf of Mexico. Some areas are of special interest because of significant anthropogenic impacts (e.g., Veracruz, México, Costa Rica and some Virgin Islands sites). Others are notable for the relative scarcity (apart from fishing) of direct human impacts (e.g., Andros in the Bahamas, Flower Garden Banks in the NW Gulf of Mexico and Los Roques, Venezuela); all are affected by adverse regional- and global-scale changes. The inclusion of the southernmost reefs in the Atlantic off Brazil extends the range of areas examined and adds a coral community and reef structure quite different from that of the Greater Caribbean. These assessments were accomplished owing to the major efforts of about a hundred reef observers and team leaders from eight different countries who volunteered to spend long days of arduous diving to collect the basic data.

The results of these first 20 AGRRA surveys demonstrate the promise of this approach for characterizing and comparing reef condition, for distinguishing between regional and local impacts, for recognizing the differences between acute and chronic stressor effects and for identifying candidate reef areas for protection or remediation. Some unanticipated but valuable dividends are the ancillary observations on the distribution of reefs, their general community structure, their geomorphology, and identification of localized threats to reefs. For example, the reef off Andros Island, some 217 km long, was so little known that our general characterization provides the most comprehensive information available on this second longest reef complex in the Western Atlantic.

Kramer (this volume) has contributed an extensive Synthesis of the separate reports. The regional means cited below are based on this standardized analysis of the initial AGRRA dataset.

Corals

Our results provide quantitative verification of the decline of elkhorn coral (*Acropora palmata*) on reefs crests in Los Roques and the Tobago Cays (St. Vincent). Furthermore, what had been dense arrays of *A. palmata* on reef crests off Providencia in the Turks and Caicos Islands and Grand Cayman (Ginsburg, personal observations) and off Abaco (Bahamas) are now largely standing dead skeletons. Living staghorn corals (*A. cervicornis*) were rare in all areas, including those in which they are known to have occurred historically. That some of the die-offs of sensitive acroporid corals occurred in relatively remote areas reinforces earlier demonstrations that the declines are regional not local (e.g., Aronson and Precht, 2001). Surprisingly, healthy thickets of living elkhorn predominated on the shallow (1-3 m) crest along the Andros (Bahamas) reef tract,

however, and signs of recovery and recruitment in localized areas elsewhere in the region are encouraging.

The averages for living stony coral cover of $18 \pm 10\%$ in shallow reefs (≤ 5 m) and $26 \pm 13\%$ in deeper reefs (10 ± 3 m), which are based on 17 of the assessments, cannot be used as representative of the whole region for at least three reasons: a wide range of percent cover was found within and among reef areas; the means are not adjusted for the relative sizes of the different reef areas; and shallow reefs are under-represented in most areas.

Partial mortality in stony corals represents the cumulative effects of diseases, overgrowth by algae and other epibionts, predation, bleaching, physical abrasion, etc. It can be subdivided by assessors on the basis of skeletal appearance into “recent” ($< \sim 1$ year) and “old” ($> \sim 1$ year) mortality. As with coral cover, the regional mean of recent mortality of 4% of colony surfaces for both shallow and deep sites masks significant subregional variations. Recent mortality was well above the regional mean off Andros and in the western Caribbean (Belize, Yucatán) as a result of the cumulative effects of bleaching and diseases associated with the 1998 ENSO-related warming. The most severely affected taxa were *Agaricia tenuifolia* and species of the *Montastraea annularis* complex. Outbreaks of diseases in *M. annularis* and *M. faveolata* were additionally noted off Curaçao, the Cayman Islands, Costa Rica and some of the Virgin Islands. Of special concern is the prevalence of diseases and bleaching-related mortality in the *M. annularis* complex, a major contributor to reef framework throughout the Greater Caribbean.

Algae and Fishes

Although much attention has been given to the current prominence of macroalgae on many wider Caribbean reefs, in terms of relative abundance, turf algae generally predominated in the AGRRA assessments. In deeper sites, however, elevated values for both macroalgal relative abundance and macroalgal index (a proxy for its biomass) were found throughout the Bahamas (Abaco, Andros and San Salvador) and in María la Gorda (Cuba).

Herbivores affect the types, abundance and biomass of algae found on reefs. Herbivorous fishes [surgeonfishes (acanthurids), parrotfishes (scarids) ≥ 5 cm, and the damselfish *Microspathodon chrysurus*] averaged $\sim 30/100$ m² overall on deeper sites in the 17 areas having comparable data. Their density was not related to the relative abundance and index values of macroalgae for the region as a whole. Moreover, the long-spined urchin (*Diadema antillarum*), formerly a key herbivore, was too scarce (regionally $< 3/100$ m²) to have any significant effect on algal distribution patterns.

The total density of reef-associated AGRRA fishes (primarily the “AGRRA herbivores” plus commercially important predators) was nearly twice as high in shallow ($85/100$ m²) as in deeper ($49/100$ m²) sites for the 17 assessments mentioned above. Large-sized parrotfishes, seen mostly in the southern Caribbean, were rare. The overall mean density of large-sized groupers (serranids) and snappers (lutjanids) averaged $< 1/100$ m². The scarcity of large fishes is an indication that, regardless of location, legal designation, or local fishing regulations, the entire region has been overharvested at least for these species.

Synopsis

Quantitative historical data with which to compare the present results are lacking for reefs in most of the assessed areas. Where prior information of some form exists, it is clear that only the relatively remote Flower Garden Banks have remained essentially unchanged in recent decades. Everywhere else (San Salvador in the Bahamas, Cayman Islands, Costa Rica, Los Roques, U.S. Virgin Islands, Yucatán) their condition has deteriorated.

Kramer (this volume) shows how 13 of the 30 individual norms of condition can be used to establish a preliminary biotic health index for the 17 deeper assessments having comparable data. The four considered "better" (above average) are two in offshore locations (Flower Garden Banks and Los Roques), and two that are adjacent to small human populations (Bonaire and the windward Netherlands Antilles). In contrast, the six that were grouped in the "worse" (below average) category include sites in two sparsely populated biosphere reserves (Sian Ka'an, México, and Guanahacabibes, Cuba), two of the Bahamian islands (Andros, Abaco), unprotected areas of the Yucatán, México, and Costa Rica's Cahuita National Park. Given these spatial patterns, no single type of threat, at any scale from localized anthropogenic inputs through regional overfishing and diseases to ENSO events and climate change, seems sufficient to explain the details of presumed or documented declines on reefs that have been assessed to date by the AGRRA protocols.

DEVELOPMENT OF THE AGRRA PROGRAM

The AGRRA program developed from insight afforded during the 1993 Colloquium and Forum on Global Aspects of Coral Reefs. This meeting, attended by some 120 scientists from 20 different countries, was an early attempt to consider the condition of reefs on a global scale. A major conclusion of the meeting highlighted the insufficiency of available information: "The database for evaluating the condition of the world's reefs is quite inadequate on all counts," (Ginsburg and Glynn, 1994).

This conclusion was especially relevant to reefs of the Western Atlantic and Gulf of Mexico. Despite the extensive research on this region's reefs beginning in the early 1900s, large areas had received little or no attention from reef scientists. [An exception is the ongoing international Caribbean Coastal Marine Productivity (CARICOMP) program, a pioneering effort to monitor reefs, sea grass communities and mangroves at a series of fixed localities around the region (Kjerfve, 1998).] However, it had already been clear for about a decade that reef-building corals, most notably the branching elkhorn and staghorn acroporid corals, were in serious decline at numerous sites in the Greater Caribbean. What was not clear in many areas was which other stony corals were affected.

An initial effort to develop a standard method of assessing reef condition was focused solely on the reef-building coral community and followed the approach of Juan Manuel Díaz and his colleagues (Díaz et al., 1995) to record partial mortality of stony corals. The results demonstrated that a census of corals by species, size, and partial mortality could be done rapidly and provide useful comparisons of the condition of patch reef corals in south Florida (Ginsburg et al., 1996; Ginsburg et al., 2001).

The idea of a region-wide survey of Caribbean reefs was first discussed informally at the 1996 Reef Symposium in Panamá. A major refocusing came later in 1996-1997 when Robert Steneck and Judy Lang proposed adding observations on algal functional groups, fish densities, herbivory, recruitment and the distinction between recent and old partial mortality, and then field-tested the protocols in three different geographic locations. Philip Kramer and Patricia Richards Kramer organized the first extensive field test of this expanded method in the Bahamas along the Andros reef tract in August 1997. It included quantitative fish assessments, following suggestions from Peter Sale, and roving diver surveys that were both conducted by Ken Marks.

The positive results of all these trial applications encouraged us to post the protocols on the Internet and organize an international workshop that was held in Miami in June 1998. Eighty-one scientists from 19 different countries of the Greater Caribbean, Brazil, Canada, the United Kingdom, Austria and the Philippines participated in the five-day session to review and refine the prototype AGRRA protocols and plan their region-wide application. All the participants contributed to the development of the final product through lengthy discussions of the methods and a field trip to test the proposed revisions. The product of this workshop was Version 2 of the AGRRA protocols (see Appendix One, this volume) and most of the reports in this volume were based on that version.

TRAINING AND APPLICATION OF THE PROTOCOL

It was evident from the field trials before and during the 1998 workshop that training was necessary to ensure the consistent application of the AGRRA protocols. Accordingly, Philip Kramer and Patricia Richards Kramer with Christy Pattengill-Semmens and Andrew Bruckner organized the first training workshop in Bonaire. Held in February 1999, for 11 participants, its success encouraged us to conduct a second workshop for reef scientists from Central America in Akumal, Quintana Roo in May, 1999. Philip Kramer, Patricia Richards Kramer, Andrew Bruckner and Elizabeth Fisher helped conduct this five-day bilingual session. The 25 participants came from México (13), Belize (5), Honduras (3), Cuba (2), Costa Rica (1) and Colombia (1).

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Contributors

Most the individual assessments reported in this volume required many long days of scuba diving and/or snorkeling, usually from small boats operating from shoreside bases, by participants who were all volunteers. Each assessment team consisted normally of six divers, four of whom made transects to evaluate corals and algae, and two who collected information on fish through belt transects and a roving diver census (for a description, see Appendix One, this volume). At the end of each day, team members then had to spend further hours transferring their results to a standard spreadsheet. Their commitment and hard work provided the basic data on which each report is based and for the Synthesis chapter. The leaders of these assessments naturally became the authors and coauthors of these reports. Their patience with, and responses to, the prolonged editorial and database construction process is much appreciated.

The Synthesis chapter was made possible only through the use of an Access database. A major effort was required to ensure the consistency of the data entered in the database. Philip Kramer spent days correcting the initial entries through correspondence with observers. We are fortunate indeed that Kenneth Marks set up and maintained the database in such a way that queries could be answered in short order. Assembling this regional database was only possible owing to the generous sharing of basic data by the team leaders.

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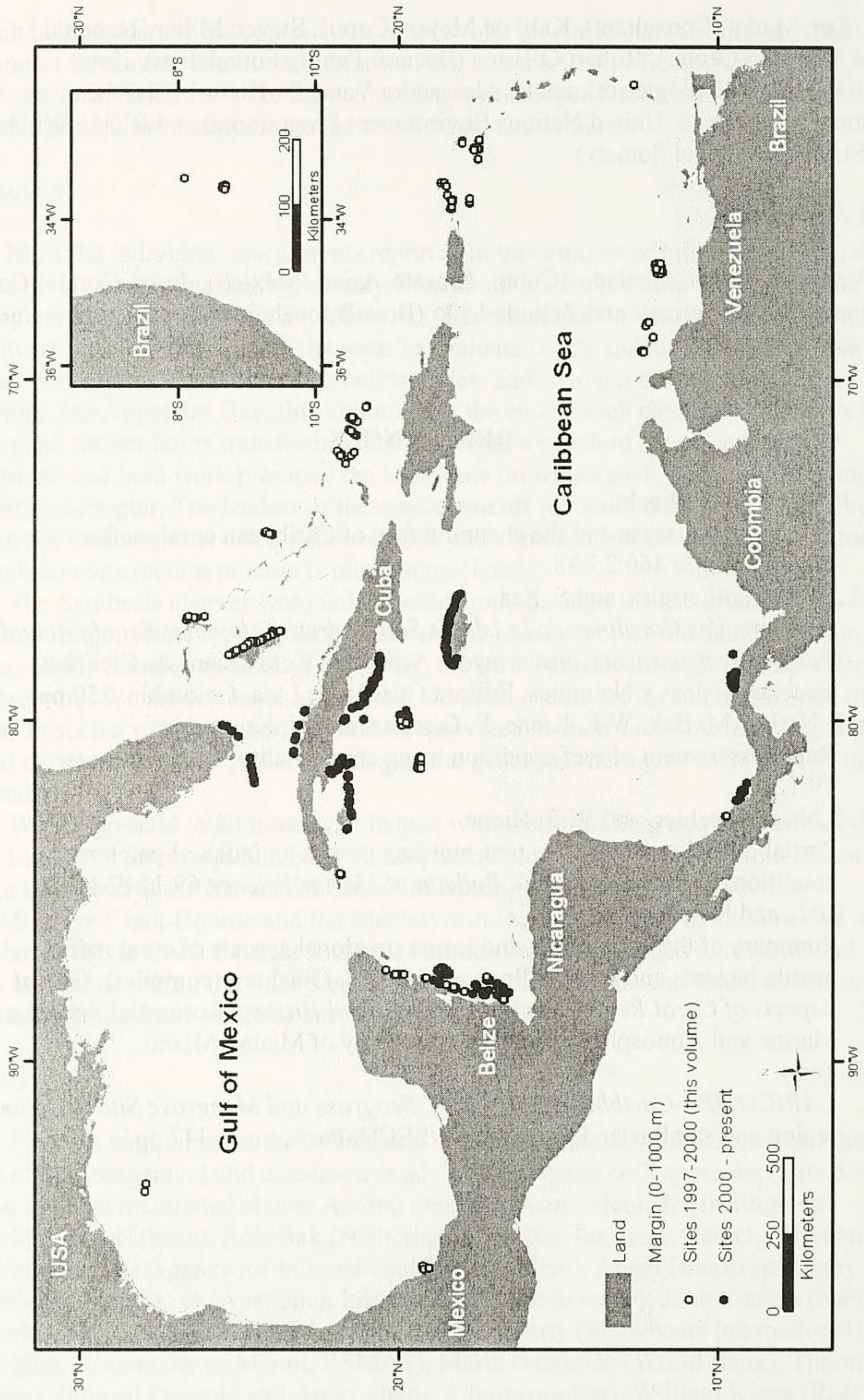


Plate 1. Location of all AGRRA sites assessed as of mid 2003.