COMPARATIVE APPROACHES TO REEF MONITORING AND ASSESSMENT: AN OVERVIEW

Special Session Chaired by Kenyon C. Lindeman, Phillip A. Kramer and Jerald S. Ault

The session on Comparative Approaches to Coral Reef Monitoring and Assessment contained six papers, including many methodological approaches to reef assessment. This diversity underscores the critical roles of spatial, temporal, and phylogenetic scaling in sampling, a recurrent theme throughout the NCRI conference. In this overview, we initially focus on our session and then attempt to summarize several conference-wide themes relevant to reef monitoring and assessment with an emphasis on approaches that bridge the often differing perspectives of invertebrate and fish researchers.

This session contained three studies that monitored or assessed reef condition based on field studies, two that evaluated anthropogenic impacts to corals using other methods, and one on variations in growth parameters among morphotypes. Quibilan et al. used fixed video transects to detect changes in coral cover and substrate heterogeneity in several areas of the Philippines. They concluded that video transects have utility in detecting changes in cover, but require supplemental methods to identify species-scale patterns. Steneck and Lang reported on results of an Atlantic and Gulf Rapid Reef Assessment (AGRRA) of reefs from the Caribbean Yucatán. Their data allowed the identification of coral reef condition at multiple spatial scales before and after bleaching and hurricane disturbance events. Reigl and Kramer compared photo, line, video, and AGRRA methods among locations in the Red Sea, South Africa, Arabian Gulf, and the Bahamas. They concluded that given similar sampling constraints, the AGRRA method was most effective at quantifying the condition of reef communities. Swart et al. reported on sclerochronological techniques to identify past patterns of coral growth in the northern Florida Reef Tract. They assessed correlations between these data and possible negative effects of past causeway construction. Arias-Gonzalez used trophic information and biomass estimates from many sources to parameterize an ECOPATH model to preliminarily assess reef condition as estimated by fish production for unprotected or partially protected areas in Mexico. Thornton et al. used transplant experiments to compare growth parameters among coral morphotypes and identified several physiological mechanisms that may underlie depth-stratified distribution patterns.

These studies illustrated two common differences among many assessment methods: (1) the spatial and temporal scales of study, and (2) the availability of consistent habitat classification tools. Too fine a scale of observation can make a system or parameter too variable to be predictable, whereas too large a spatial or temporal scale can reduce the detection of variability (Levin, 1992). In the case of reefs, the majority of studies have focused on relatively small scales (<10 yrs, <100 km). To accurately gauge natural disturbances and human impacts, larger-scale (>10 yrs, >100 km) baseline data can be more useful (Done, 1997). Since multiple sublethal and lethal stressors can impact reefs (e.g., Hughes and Connell, 1999) and effects may cascade through system components in unanticipated manners, idealized assessments will consist of coordinated studies of primary reef components (e.g., corals, water quality, algae, fishes) and their linkages to best predict the processes that most influence present and future reef conditions.

Inconsistent or undefined use of terms and lack of standard classification systems for reef habitats can also constrain comparative habitat studies (Mumby and Harborn, 1999). Since vast amounts of reef areas have never been mapped, initial efforts at classification often depend on those surveying an area for the first time. The result is often variable emphasis on certain abiotic and biotic parameters according to the perspectives of the study. Many approaches have focused on either of two basic habitat categories: (a) water-column characteristics or (b) structural bottom-types. Since organism use of similar structural habitats can vary across insular or continental shelves, spatial frameworks that combine both fine-scale habitat structure and larger-scale physiographic zones across the shelf (e.g., as opposing axes of area-specific matrices) can be logical, informative, and comparable among regions.

Coral and fish workers have often used different approaches to assess reef habitats utilized by both groups. These differences often derive from the divergent attributes of the organisms, particularly the capacity for movement. After settlement, even territorial or cryptic fishes are more mobile than coral species. In addition, some fishes undergo cross-shelf ontogenetic migrations that include the use of multiple structures and depths. Coral research often focuses on fine-scale patterns by intensive examinations of quadrats or line transects that often cover only several square meters of area. While the number of replicate quadrats or transects for a given reef is often high, the number of reefs assessed is often very low. Notable exceptions to this include Hughes et al. (in press) and Kramer et al. (1999). Fish assessments often involve long transects with distances of 15–100 m, or stationary counts with diameters to 14 m. Emphasis is often on assessing many reefs, as well as replicating counts within the same reef. Parameters emphasized within surveys typically differ as well. For example, invertebrate work often focuses on fine-scale measures of rugosity, light penetration, and percent cover at the species-scale. Fish surveys have often employed basic habitat categories (e.g., fore-reef, deep-reef) with some measures of water chemistry (e.g., temperature and salinity). Fish surveys can include percent cover estimates, but usually at coarser scales than coral surveys. There are important exceptions to these generalizations, but we suggest there is a need to further integrate these approaches.

Methods that better unify benthic and fish perspectives are beginning to emerge. Rapid assessment programs such as AGRRA can generate quantitative habitat information for both invertebrates and fish at the same sites. This approach is advantageous for linking data sets since a common scale of sampling is undertaken and habitat definitions are more uniform. The evaluation of reef condition can be based on deviations from 'normal' values (where 'normal' can be defined by data means or other parameters). This approach allows for the sampling of many reefs to resolve large-scale patterns across 10–1000 km distances missed by smaller-scale studies (e.g., Kramer et al., 1999). In addition, many new tools for habitat assessment are becoming available. For example, with new GIS technologies, integrations of multiple databases, and advances in population modeling, both habitat and fish distributions can be addressed in spatially explicit manners by habitat-affinity indices and habitat-suitability modeling (Monaco et al., 1998; Rubec et al., 1999). In addition, bioenergetic models using growth potential as a proxy for habitat use can predict production rates of differing habitats (Brandt and Hartman, 1993; Ault et al., 1999).

The momentum to better link benthic and fish perspectives of habitat assessment is not driven only by researchers. Managers must increasingly make decisions that ultimately influence many interconnected reef habitats and fishery species. Diverse human activities such as oil spills, ship groundings, the many stressors derived from coastal construction activities (e.g., Lindeman and Snyder, 1999), and fishing gear can have indirect or direct effects on reef habitats supporting fishes. The need to better unify coastal habitat management with fishery management has been accelerated in the United States by new legislation to identify and protect essential fish habitat (EFH). This has increased focus on comprehensive mapping of both reef habitats and fish distributions, the valuation of differing habitats for managed species, more detailed characterizations of stressors and potential sublethal effects, and the use of enhanced predictive tools for decision making. In addition to EFH initiatives, many researchers and managers now suggest that traditional management tools are not maintaining sustainable stocks, and fishery reserves, closed to any catch, are necessary (Roberts et al., 1995). The conservation of biodiversity and the interconnected habitats that support ontogenetic migrations of fishery species are fundamental to reserve design. Therefore, increased attention to reef habitat assessment is also occurring in association with fishery reserve initiatives around the globe.

Given the current context in which reef habitat assessments are conducted, the following points may have immediate relevance:

- Increased methodological integration of coral and fish assessments will enhance biological understanding within both realms.
- Hardbottom habitats, octocorals, sabellariid worms, and a number of other structural features contribute to reef composition besides living corals. Assessment tools are needed which detail ahermatypic reef structures, as well as hermatypic.
- Increased efforts to inventory both degraded and natural reef areas are needed.
- Many new technologies are available for in situ, surface, or high-altitude data collection. Coupled with advances in data processing and visualization, these new technologies and their hybrids can greatly increase both descriptive and analytic capabilities of reef biologists.
- Management evaluation of multiple stressors, cumulative effects, and policy alternatives can be aided by increased use of risk assessment and decision-support procedures.
- Long-term temporal and spatial studies on the scales of decades and kilometers are needed to better understand natural variability and to gauge the human effects upon reefs. This need is recognized by researchers but requires long-term institutional support that is often absent.

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