

A Habitat Mapping Program: The Basis for a Caribbean Coastal Zone Information System

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ABSTRACT

The interface between land and sea, however geographically defined, is the coastal zone. The coastal zone encompasses a multitude of activities and resources, the management of which overlap numerous national jurisdictions. A prerequisite for coastal zone management is access to appropriate data and information; therefore, intergovernmental and interdepartmental cooperation and compatibility regarding coastal database building and mapping are essential for coastal zone management. The coastal zones of the Caribbean are exposed increasingly to a wide variety of physical, biological, and chemical stresses, thus threatening the orderly development and management of its resources. The stresses originate from land-use activities in the coastal watersheds such as agriculture and forestry; from the communities and industries concentrated along the coasts; from commercial activities in the nearshore and offshore such as shipping, dredging, resource exploitation, and hydrocarbon and mineral extraction; and from broader-scale phenomena such as global warming, sea level rise, shoreline erosion, and long-range transport of air pollutants. These stresses have resulted in major coastal zone problems: pollution of coastal waters (from land-based sources); loss of vital fish and wildlife habitat; and conflicting coastal uses (*e.g.*, aquaculture/traditional fisheries/recreation). This paper describes the result of a study sponsored by the International Centre for Ocean Development, namely Study to Evaluate the Need for a Habitat Mapping Program (October 21, 1990). The study was undertaken by the authors with the assistance of the Centre for Resource Management and Environmental Studies, University of West Indies, Barbados. The report strongly supports the need for a regional habitat mapping program as an important component of a comprehensive Caribbean Coastal Zone Information System (CCZIS). A proposed workshop to develop an action plan for the implementation of a CCZIS is described as a possible adjunct to the GCFI Conference in Merida, Mexico.

KEY WORDS: Habitat Mapping, Coastal zone Resources Information systems, Caribbean.

INTRODUCTION

In 1989 the authors, representing the Champlain Institute, undertook a study to evaluate the need for a Caribbean Habitat Mapping Program. Scientific support was provided by the faculty of the Centre for Resource Management and Environmental Studies (CERMES) of the University of West Indies. The study was sponsored by the International Centre for Ocean Development (ICOD) of Halifax, Nova Scotia, Canada; the Centre's mandate included ocean resource development in the Caribbean. This agency was recently disbanded by the Canadian federal government; its responsibilities and programs have been assumed by the Canadian International Development Agency (CIDA) which is currently selecting private sector companies/consortia to manage some of the programs initiated by ICOD.

The ICOD-sponsored study, described in this paper, complements several of the projects and programs with which ICOD was associated, including:

- establishment of the Organization of Eastern Caribbean States (OECS) Fisheries Unit in St. Vincent;
- financial support of CERMES, UWI Barbados;
- financial support of the Marine Science Centre, UWI Jamaica;
- sponsorship of the Caribbean study on Marine Science Education and Research (Garrett *et al.*, 1990);
- sponsorship of the Interpretation Plan for Barbados Marine Reserves (Olsen, 1990);
- sponsorship of the Marine Fish Habitat in the Eastern Caribbean Study (Hunte and Lark, 1990); and
- execution of the CARICOM/CIDA Fisheries Resource Assessment and Management Program (CFRAMP).

STUDY RATIONALE

The economic welfare of a nation or region is directly dependent on the resources available to it and on the ability of the people to use these resources to their benefit. The coastal zone is of critical importance to the economies of Caribbean nations. For geographic, socio-economic, and demographic reasons, the resources of many Caribbean nations are inextricably associated with the coastal zone, the interface between land and sea. In many instances Caribbean nations can be classified as "coastal zone" in their entirety because of their small size, surrounding sea, and the intimate interrelationship between the terrestrial and marine environments.

The coastal zones of the Caribbean are exposed increasingly to a wide variety of physical, biological, and chemical stresses, thus threatening the orderly development and management of their resources. The stresses originate from numerous sources including land-use activities in the coastal watersheds, such as agriculture and forestry; from the communities and industries

concentrated along the coasts: from commercial activities in the nearshore and offshore, such as shipping, dredging, resource exploitation, and hydrocarbon and mineral extraction; and from broader-scale phenomena such as global warming, sea level rise, shoreline erosion, and long-range transport of air pollutants. These stresses have resulted in major coastal zone problems: pollution of coastal waters; loss of vital fish and wildlife habitats; and conflicting coastal usage.

Conflicts within the coastal zone, for example between tourism and fishery activities, are exerting serious pressure on traditional fisheries. A Caribbean Habitat Mapping Program and associated coastal information systems would identify the conflicting resource uses and provide a knowledge base to assist with their resolution. Also the Mapping Program would highlight the critical role played by the users of specific coastal resources, the logical backward linkages to proper land use planning, and the forward linkages to relevant legislation and enforcement designed to protect, conserve, and manage coastal resources. In addition, the compilation of maps at national and site-specific scales will facilitate community participation in resource management, a key issue, particularly in the rural coastal villages of the Caribbean.

The complexity of Caribbean fisheries and the management of Caribbean coastal resources in general have been reviewed extensively, including Mahon *et al.*, 1985; Chakalall, 1989; the CIDA sponsored Caribbean Environmental Program Strategy; and the Caribbean Environment Program/UNEP Technical Report No. 2, Regional Overview of Environmental Problems and Priorities Affecting the Coastal and Marine Resources of the Wider Caribbean (1989).

The requirement for an inventory of Caribbean resources, in particular fisheries, their distribution and associated habitat has been extensively documented and is considered to be a high priority. The dynamic nature of these resources and the effect of exploitation and development dictate an equally dynamic system of inventory update and resource and habitat mapping to ensure the availability of up-to-date information for resource managers. These requirements necessitate the implementation of a Coastal and Ocean Information Network (COIN) for Caribbean Marine resource management (Butler and LeBlanc, 1989).

The identification and delineation of habitats are key components of stock assessment and fishery resource management in general. However, these activities cannot be considered in isolation as the status of habitats is dependent on the multiplicity of activities taking place in the coastal zone. The ICOD-sponsored Hunte and Lark report(1990) emphasizes the importance of protecting, conserving, and mapping coastal habitats, which are primarily composed of coral reefs, seagrass beds, and mangroves. The report clearly identifies the environmental, and socio-economic importance of habitat identification and management to the economies of Caribbean nations.

Mapping is the most effective technique for the portrayal of complex socio-economic, physical, environmental, and resource data. Habitat mapping as a component of a coastal zone information system must be a dynamic and ongoing process. This process can be facilitated by the introduction of automation such as desktop mapping, Geographic Information Systems (GIS), and remote sensing technologies (Butler *et al.*, 1986; Butler *et al.*, 1988). But mapping produced by manual methods alone continues to be a valuable management tool; it can be digitized at a later date if appropriately geographically-referenced and if automation is subsequently introduced.

STUDY LOGISTICS AND FORMAT

The authors, in collaboration with Drs. M. Henry, L. Ishmael, and R. Mahon from CERMES, visited seven Caribbean Nations, namely, Jamaica, Belize, Antigua, St. Lucia, St. Vincent, Trinidad, and Barbados during a two week period in April, 1990. Personnel from national, regional, and international organizations were consulted during this field mission. Time and financial constraints precluded a comprehensive coverage of all Commonwealth Caribbean nations; however, the selected countries, we believe, provided an accurate reflection of the Region as a whole.

STUDY CONCLUSIONS

The study team concluded that a Caribbean Habitat Mapping Program should be implemented as an essential resource management tool. Also it should be considered as the first phase of an incremental process to develop a comprehensive coastal zone information system as a basis for coastal zone management. This, however, will require a long-term political and financial commitment.

The Caribbean Habitat Mapping Program also must complement the CARICOM/CIDA/ICOD Fishery Resource Assessment and Management Program (CFRAMP) and the CIDA-sponsored Natural Resources Database Project. The Mapping Program should also be coordinated with the Environmental Resource Management Project (ENCORE) sponsored by USAID.

STUDY RECOMMENDATIONS

The recommendations are taken verbatim from the original Caribbean Habitat Mapping Program study report which was submitted to ICOD in October, 1990. Since that time the report has been circulated to the personnel who participated in the study. As a result of subsequent discussions, including those taking place informally at the ICOD-sponsored International Ocean Forum held in Halifax, Nova Scotia, November 1991, the recommended format for an

initial Habitat Mapping Workshop was further refined. A proposed Workshop outline concludes this paper following a review of the original study recommendations.

It should be noted that some of the agencies associated with the original study have assumed different mandates, such as CERMES, or no longer exist such as ICOD. Other agencies and organizations, however, can fulfill these tasks and responsibilities.

The recommendations of the 1989 ICOD study are as follows:

1. A series of political, management and technical challenges must be addressed to ensure the successful implementation of the Caribbean Habitat Mapping Program:

- Adequate and reliable databases;
- Sufficient staff to dedicate to projects;
- Trained personnel for thematic map compilation, design and production;
- Interdepartmental cooperation and communication;
- Regional cooperation;
- Political support;
- Appreciation of problems associated with automation;
- Adequate funding;
- Program coordination;
- Adequate facilities; and
- Hands-on counterpart advice and training.

2. A focused counterpart training program is a critical prerequisite for the successful implementation of the Caribbean Habitat Mapping Program, in terms of deliverables and the acquisition of mapping/GIS/remote sensing skills by each country. The subsequent utilization of trained personnel and acquired equipment following the completion of the Caribbean Habitat Mapping Program must also be taken into consideration. When the training programs are being planned, a clear distinction must be made between the level of expertise required to become **power users** of the technologies (mapping/GIS/remote sensing) and that required by the resource managers to communicate effectively with the specialists and to appreciate the benefits and constraints of these technologies. On the basis of their observations, the authors believe that Trinidad and Tobago has the combination of personnel, skills, and organizations necessary to undertake its national Habitat Mapping Program utilizing manual mapping techniques. Jamaica, Barbados, and Belize may also have that capability. St. Lucia and St. Vincent will require some assistance to undertake their national Program. Antigua, and we suspect the other countries of the Commonwealth Caribbean (excluding those mentioned above), will require significant scientific and technical assistance. With an increase in the degree of automation, complexity of equipment and associated skill requirements, the level of training,

supervision, and funding will inevitably increase and regional production centres (e.g., Trinidad and Tobago) may be justified because of the funding, training, scheduling and logistic challenges.

3. The number and categories of parameters to be mapped in addition to habitat types will be dependent on geographic location and the availability of data, personnel, and financial resources. The linkage and interdependence of many of the parameters must be stressed, for example, between topography, land uses, resource users, planning legislation/enforcement, and cumulative impact on marine resource quality. Steep topography, deforestation, erosion, increasing use of pesticides, herbicides, and fertilizers, the use of rivers as repositories for solid waste and raw sewage, all have immediate and profound effects on the marine environment in the form of diminished water quality and reef stress. These factors in turn exert negative impacts on the capability of resources to sustain economic pursuits in the fishery, tourism and recreational sectors.

The categories of parameters which should be considered for mapping include:

a) Living Resources - Coastal, Coastal/Marine and Marine: Areal extent and nature of (substrate type, species type, biomass, e.g., standing crop, etc.) mangroves, coastal wetlands, estuarine marshes, seagrasses and reefs, demersal and pelagic fisheries.

b) Non-Living Resources: Sandy beaches and other coastal substrates including rocky and sandy areas, bathymetry, geomorphology, sediment types (composition and grain size), sediment transport.

c) Oceanography: Coastal currents, upwelling, wave climate, physico-chemical features of coastal and shelf water (temperature, salinity, etc.), primary productivity.

d) Environmental Characteristics: Pollution (nutrients, microbiology, pesticides, BOD, turbidity, petroleum products, solid waste, etc.).

e) Land Use and Settlement: Housing infrastructure, industry (including fisheries and tourism), population density, etc.

For a more detailed list of parameters, refer to Appendix 1.

4. The Caribbean Habitat Mapping Program, when fully implemented, should consist of map series at three levels of detail which can be undertaken sequentially or concurrently, depending on national and regional priorities:

Regional Habitat Mapping, e.g., 1:500, 000 (small-scale, overview). This can be used to sensitize readers to the importance of habitats to regional resource management and to lever funds for subsequent phases.

National Habitat Mapping, e.g., 1:50, 000 (medium scale), which is suitable for national resource management. This information can also be generalized for regional habitat mapping updates.

Site-specific Habitat Mapping, e.g., 1:5,000 (large-scale). The selection of sites to be mapped will depend on their relative ecological and economic

importance. This information can be generalized for updating both the regional and national habitat mapping series.

5. The authors recommend that ICOD fund the first phase in the implementation of the Caribbean Habitat Mapping Program. The first phase should consist of the following:

- Sponsorship of a Regional Caribbean Habitat Mapping Workshop;
- Sponsorship of participation by CERMES in the Program; Sponsorship of production of the Regional Habitat Mapping Series;
- Sponsorship of a pilot National Habitat Mapping Workshop in Trinidad and Tobago;
- Sponsorship of production of a pilot series of national and site-specific habitat maps for Trinidad and Tobago.

6. Because of the multi-national complexity of the Caribbean Region and the multi-sectoral requirements of habitat mapping, program management and coordination will be of paramount importance; although there are a number of Caribbean-based agencies and institutions with regional mandates, only CERMES would appear to have the required combination of attributes to carry out this responsibility. The necessary attributes include scientific credibility, multi-disciplinary expertise, program management skills, regional infrastructure and support, and a universally accepted regional mandate. Further, as its name implies, a prime objective of CERMES is the development of sustainable resource management strategies, with the coastal zone as an obvious focus. It should also be noted that CERMES, as a regional educational institution of the University of the West Indies, would be committed to the dissemination throughout the Caribbean of scientific, technological, and management expertise gained from the Program.

To implement the first phase of the Caribbean Habitat Mapping Program, the authors identify the following actions for consideration by ICOD:

1. It is recommended that ICOD sponsor, organize and chair a Regional Caribbean Habitat Mapping Workshop to address the concept and applications of habitat mapping and to present the conclusions of this report. The Workshop would review the report's recommendations and endorse an implementation strategy, including mapping guidelines and management and coordination responsibilities, for approval in principle by national governments and regional authorities. Participants invited by ICOD to attend the Workshop should include representatives from relevant national and regional governments and international organizations. This Workshop would complement those planned for the CARICOM/CIDA/ICOD Fishery Resource Assessment and Management Program. CERMES should provide Secretariat support to the Workshop and, based on Workshop deliberations, be responsible for the preparation of a detailed proposal and work plan for the Regional Caribbean Habitat Map Series.

This proposal and workplan should be submitted to ICOD for funding consideration.

Following confirmation of further funding for the first phase of a regional Caribbean Habitat Mapping Program by ICOD:

2. It is recommended that CERMES organize briefing sessions regarding the Caribbean Habitat Mapping Program for senior national and regional government personnel. Because of the Program's requirements for interdepartmental and regional cooperation, political support and appreciation at the highest level (*e.g.*, ministerial) will be necessary.

3. It is recommended that CERMES employ additional staff as required for the implementation, coordination and management of the first phase of the Habitat Mapping Program. A mapping/GIS/remote sensing expert should be employed to assist and advise all phases of the Program and could be responsible for training specified nationals and CARICOM and OECS personnel, who should receive introductory mapping/GIS/remote sensing training to ensure regional and national coordination and communication.

4. It is recommended that CERMES initiate and subsequently manage and coordinate the production of the regional map series of the Caribbean Habitat Mapping Program. If necessary the production of the maps can be subcontracted to other regional or national institutions.

5. It is recommended that ICOD sponsor and organize a pilot National Caribbean Habitat Mapping Workshop in Trinidad and Tobago under the chairmanship of CERMES. Participants invited by ICOD should include those personnel identified as potential members of the Trinidad and Tobago National Interdepartmental Committee (refer to Recommendation 6). This Workshop would identify geographic areas for mapping as a pilot project at national and site-specific scales. It would also identify national implementation strategies and organizational and personnel responsibilities. Deliverables and timetables would be agreed upon and documented.

6. It is recommended that Trinidad and Tobago establish a National Interdepartmental Committee to facilitate the production of the pilot national and site-specific maps of the Habitat Mapping Program. The Committee should be composed of senior departmental and NGO personnel, chaired by a representative of CERMES, and with a representative from the Fisheries Division acting as the coordinator/secretariat. Members of the National Interdepartmental Committee should be encouraged to attend mapping/GIS/remote sensing familiarization workshops to facilitate communication with technical support staff and the National Working Group (refer to Recommendation 7); the workshops should be organized by CERMES. The National Interdepartmental Committee should be responsible, with support and advice from CERMES, for the preparation of a proposal to secure funds from appropriate agencies to complete the national and site-specific maps series

for Trinidad and Tobago. The recommended tasks and responsibilities of this Committee are outlined in Appendix 2.

7. It is recommended that Trinidad and Tobago establish a National Working Group to produce the pilot national and site-specific maps of the Habitat Mapping Program. The Working Group would be answerable to the National Interdepartmental Committee. The recommended tasks and responsibilities of this Working Group are outlined in Appendix 3.

8. It is recommended that CERMES undertake a comprehensive review of extant and planned mapping/GIS/remote sensing installations and facilities in the Caribbean, in anticipation of some degree of automation regarding data collection and analyses.

9. It is recommended that a desktop mapping system such as GeoAXSES or INFOCUS be established on a pilot basis at CERMES (UWI Barbados) for evaluation and for demonstration purposes. Desktop mapping software is PC-based, relatively inexpensive (500 to 3000 Cdn dollars) and easy to operate and use. It also provides a valuable introduction to full GIS functionality and implementation when that is required.

10. It is recommended that CERMES, in collaboration with the appropriate units of CARICOM and OECS and in the context of such studies as IDRC's A Regional Information System Strategy for the Caribbean for the Year 2000 (1989), review and document the longer term requirements and implications of coastal zone information systems within the Caribbean. The Inland Waters, Coastal and Ocean Information Network (ICOIN), being implemented in Canada, may serve as an example.

11. It is recommended that CERMES be responsible for liaison with all regional donor or implementation agencies (*e.g.*, WECAFC, OAS, etc.) to ensure cooperation and minimize duplication with a regard to the Habitat Mapping Program and subsequent coastal zone management initiatives.

12. It is recommended that CERMES act as a repository for all Caribbean coastal zone documentation, including mapping.

13. It is recommended that, based on the experience of the Trinidad and Tobago pilot project, other countries participating in the Caribbean Habitat Mapping Program organize National Workshops, National Interdepartmental Committees and National Working Groups. Funding for these activities and the production of the subsequent national and site-specific habitat map series should be sought from appropriate national sources and international funding agencies. Following a review of progress to date and the utility of this program, ICOD should consider further funding support for these activities.

THE NEXT STEP

Following submission of the Caribbean Habitat Mapping Program study

report to ICOD and subsequent discussions both in the Caribbean and in Canada, it was proposed that a workshop or series of workshops be held in the Caribbean Region to develop the details of an Action Plan to implement a Caribbean Habitat Mapping Program. This Program would form the foundation of an eventual Coastal and Ocean Information Network (COIN), a prerequisite for resource management.

Workshop participants, to be invited by the sponsoring agencies, would include representatives from relevant national and regional governments, NGO's and international organizations. An appropriate Workshop Agenda should include at least the following items:

1. Introduction, Background and Workshop Objectives
2. Summary of Current and Proposed Caribbean Coastal Zone Projects and Programs
3. Review of ICOD sponsored Study to Evaluate the Need for a Caribbean Habitat Mapping Program
4. Concept and Applications of Habitat Mapping
Manual Procedures and Techniques
Automated Procedures and Techniques, *e.g.*, desktop mapping, Geographic Information Systems and remote sensing
5. Review of Draft Proposal to Implement a Caribbean Habitat Mapping Program
6. Review of Funding Options
7. Development of an Action Plan, including:
 - Management and Coordination Responsibilities
 - Counterpart Training
 - Schedules
 - Deliverables
 - Follow-up Activities.

Finally, the all-important sponsors may include one, a combination, or all of the following:

Canadian International Development Agency (CIDA);
University of West Indies (UWI);
Caribbean Environmental Health Institute (CEHI);
Caribbean Natural Resources Institute (CANARI);
United Nations Environment Program (UNEP);
Institute of Marine Affairs (IMA);
Caribbean Community (CARICOM);
Organization of Eastern Caribbean States (OECS)

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Appendix 1. Habitat and coastal zone mapping parameters.

The following is a partial listing of the parameters that could be addressed in the Caribbean Habitat Mapping Program and subsequent coastal resource management and information system. The mapping and information system should be designed to identify, consolidate and display information on the resources of the region, related developments and the impact of these developments on the resources.

1) Physical and Environmental Features:

- a) bathymetry
- b) currents (surface, bottom)
- c) water temperature
- d) salinity
- e) tidal range
- f) turbidity
- g) chlorophyll
- h) sediment transport
- i) stratification
- j) meteorological characteristics
- k) near-shore geomorphology
- l) coastal morphology (*e.g.*, cliffs, beaches, wetlands, etc.)
- m) rivers and estuaries

2) Habitat by Type, Location and Condition:

- a) coral reefs
- b) coral rubble
- c) sand
- d) mangroves
- e) seagrass

3) Critical Habitats by Location (known and presumed):

- a) lobster nursery areas
- b) turtle beaches
- c) seabird areas
- d) estuarine spawning areas
- e) marine reserves and parks
- f) aquaculture sites

4) Species by Distribution, Spawning Grounds, Fishing Grounds and Seasons:

- a) reef fish
- b) lobster
- c) conch
- d) turtles
- e) flying fish and other small pelagics (plus baitfish)
- f) tunas
- g) other large pelagics (*e.g.*, rainbow runners, kingfish and billfish)

Appendix 1. Continued.

5) Types of Fishing by Species, Season, Boat and Gear Type:

- a) troll fishing
- b) hand lining
- c) fish traps
- d) seining (purse and shore)
- e) foreign fishing vessel sightings (by country), distinguishing vessels of adjacent countries from distant water fleets
- f) sport fishing N.B. Areas fished by nationals, which are outside their area of national jurisdiction, should be indicated.

6) Other Marine Activities:

- a) location and size of fishermen's communities
- b) location and size of fishing ports
- c) number (part-time and full-time) of fishermen
- d) number and size of boats and gear types
- e) principal handling and trans-shipment points and harbours
- f) shipping routes
- g) main sources of domestic and industrial pollution
- h) identification of Ciguatera zones
- i) sand mining

7) Administrative and Socio-Economic Considerations:

- a) reliance of communities on fishing activity
- b) tourism facilities and development areas
- c) marine parks and conservation areas
- d) government subsidies
- e) EEZ and political boundaries
- f) cooperatives
- g) fish consumption
- h) inter island trade and fishing agreements
- i) demographics and population movements

8) General Land Use:

- a) agricultural
- b) forestry
- c) industrial
- d) tourism
- e) recreational
- f) sewage effluent (outfalls, treatment plants, industrial, etc).

Appendix 2. Tasks and responsibilities of the national interdepartmental committees.

It is recommended that the National Interdepartmental Committees be responsible for the following tasks:

- 1) Identification, consensus building and documentation of project objectives;
- 2) Identification of dedicated production team (National Working Group - refer to Appendix 3) and facilities;
- 3) Review of training requirements, including the identification of trainees, training facilities, and instructors, etc.;
- 4) Identification and documentation of user needs;
- 5) Identification and documentation regarding products to address user needs, e.g., traditional manually-produced maps;
- 6) automated GIS-based information systems, or a combination of both (5 and 6);
- 7) Identification of procedures and personnel to ensure continuing communication and cooperation between the users and the producers of the map series and/or information system;
- 8) Identification of locations to be mapped at large-scale site specific levels and the establishment of mapping priorities;
- 9) Implementation of a data and information gathering program to fill the "gaps" identified by the Working Group.

Techniques for acquiring this information are outlined in Section 7 of FAO Fisheries Technical Paper 274, *Marine Resource Mapping: an Introductory Manual* (Butler *et al.*, 1986);

Dissemination of the map/information products, and the concurrent establishment of sensitization and training workshops for potential users.

Appendix 3. Tasks and responsibilities of the national working groups.

It is recommended that the National Working Groups be assigned the following tasks:

- 1) Identification of information requirements;
- 2) Identification of information and data sources;
- 3) Assessment of information/data availability, coverage, quality and adequacy;
- 4) Collection of extant information/data;
- 5) Identification and communication of information/data "gaps" to the National Interdepartmental Committee for resolution;
- 6) Collation and compilation of working manuscripts for review by the National Interdepartmental Committee;
- 7) Production of sample product(s) for field testing and verification by operational personnel;
- 8) Production of maps and/or information system.

The above process is detailed in FAO Fisheries Technical Papers No. 274 and No. 295 (Butler *et al.*, 1986 and 1988 respectively). If deemed appropriate, some of the tasks assigned to the National Working Group could be carried out by a regional production center.