MANAGEMENT STRATEGIES FOR SUSTAINABLE EXPLOITATION OF RED ALGAE, *Gracilaria* sp, AN AGAROPHYTE FROM CIENFUEGOS BAY, CUBA

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ABSTRACT

Gracilaria sp is reported as one of the most abundant seaweeds in Cienfuegos Bay (22 ^{0}, 02' N Lat. and 80^0, 27' W. Long.), being also the most studied species because of the wide potential use in the territory, and its ecological function in this ecosystem. However, it is necessary to fill the significant knowledge gaps before commencing the commercial exploitation of this resource. The main purpose of this paper is to propose an integrated management plan for the sustainable exploitation of this species, which includes avoidance and/or minimization of negative impacts on the bay as a whole. The plan provides an integrated process in three phases, encompassing development, research and management, and flowing to the acquisition of new biological data, information about the integration with other "stakeholders", and an increasing knowledge of the environmental problems, according to the results of the Environmental Impact Assessment as an important planning tool in the decision-making process. The flexibility and adaptability of the Management Plan allows looking beyond the actual trends and environmental policies in Cuba to be assured of the success of this plan. It also brings the possibility to be applied methodologically to other species and bays in the country, and in other Caribbean areas, dealing the same issue.

Key Words: macroalgae; sustainable exploitation; management plan; integrated coastal zone management; *Gracilaria* sp.; ASW, Cuba.

RESUMEN

Gracilaria sp. es reportada una de las macroalgas más abundantes de la Bahía de Cienfuegos (22 ^{0}, 02' Norte Lat. and 80^0, 27' Oeste. Long.), siendo también la más estudiada debido al amplio potencial de uso en el territorio, y su función ecológica en el ecosistema. Sin embargo, es necesario llenar significantes lagunas del conocimiento antes de comenzar la explotación comercial de este recurso. El principal próposito de este trabajo es proponer un plan de manejo integrado para la explotación sostenible de esta especie, el cual evita y/o minimiza impactos negativos sobre la bahía como un todo. El plan brinda un proceso integrado en tres fases que incluye desarrollo, investigación y manejo, y fluye por adquisición de nuevas datos biológicos, información acerca de la integración con otros "stakeholders" y un creciente conocimiento de los problemas ambientales, según los resultados de la Evaluación de Impacto Ambiental como un importante instrumento de planificación en los procesos de toma de decisiones. La flexibilidad y aadaptabilidad del plan permite ir mas allá de los procedimientos standards y políticas ambientales actuales que tiene el país para asegurar el éxito del plan. Este también brinda la posibilidad de ser aplicado metodológicamente a otras especies y bahías del país, y áreas del Caribe, tratando el mismo asunto.

Palabras claves: macroalgas; explotación sostenible; plan de manejo; manejo integrado de zonas costeras; *Gracilaria* sp; ASW, Cuba.

Each coastal area needs a particular management plan depending on its economic, social and biophysical characteristics (Cicin-Sain & Knecht, 1998). According to Pringle (1986), the management plan development is a complex task involving: 1- coordination between resources development studies and stock assessment science; 2- the marriage of data generated by biologists, sociologists, and economists; 3- resource management plan development; and 4- regulation.

Any strategies for exploiting seaweeds around the world must consider all the interactions of many factors related to them in order to minimize impacts on target species and its associated community. As well, this new activity (Integrating seaweeds) needs to maintain a harmonious relationship among traditional and non- traditional

activities, it must acquire and use the best possible information for management decisions, and incorporate government policy interests into the program (Sharp, 1981; Alveal *et al.*, 1995).

The development of a management plan for seaweed activity in the coastal zone of Cienfuegos Bay, Cuba, has the possibility of becoming successful, especially for the government interest in developing a management plan for the entire bay because of the economic and social importance of this ecosystem (Fig. 1), besides other interests that always accompany the exploitation of seaweeds such as the economic, social and ecological value of seaweeds in this area. In addition to that, this resource is one of the most abundant natural resources in this bay, and also is the most studied (Fig. 2).

Although, the environmental management practices has not been sufficiently adequate to achieve the goals of sustainable development, many efforts has been made in this sense, which bring favourable conditions for the seaweed case, once they have never been exploited. The use and development of this resource has been only restricted to studies (Morales, 1994; Castellanos *et al.*, 1998, 1999; Leon *et al.* 2000) for knowing its potential exploitation, so an effective management plan could be applied.

Taking into account that it is necessary to exploit seaweeds of sustainable manner, the paper has two objectives, as follows:

- To undertake a thoroughly review of all the existing information on seaweed from Cienfuegos, with particular emphasis on *Gracilaria sp.*
- To propose pilot seaweed management plan as a first step for achieving the sustainable exploitation of seaweed in Cienfuegos Bay in the future.

There are several favourable conditions that may help to develop this plan, which it can be related as strengths:

Strengths that may help to develop this management plan:

- The growing concern from the government to protect the coastal zone.
- The presence of institutions like a new Centre of Environmental Studies of Cienfuegos, Provincial Environmental Agency and Cienfuegos University. Moreover, there is a Program of Marine Management Education in the country that may contribute with the national expertise in this area.
- There is an environmental education plan that is currently being developed on behalf of the government making campaigns for environmental protection. This creates a base for the development of any kind of plan.
- A legal framework "The Environmental Law (1997)" that provides the basis for management and the provision for future changes. The "Technical-Jurisdictional Regulations for the Sustained Use of the Bay" (1994) approved by the Provincial Government in Cienfuegos.
- There is basic biological information on *Gracilaria sp* from Cienfuegos Bay to built a harvest plan (Leon *et al.* 2000).
- There is basic chemical information and industrial test of use (Castellanos *et al.* 1998, 1999; Chaviano *et al.*, 1994).
- There is a community around the coastal zone where the natural beds are, that can participate in co-management activity.
- The interest of the provincial government in developing a management plan of seaweeds in Cienfuegos Bay because many benefits will be coming from the seaweed exploitation such as: increased number of employment opportunities, promotion of commercial activities, integration the seaweed activities with other user and uses of the Cienfuegos Bay..

Nevertheless there are other conditions that are unfavourable for this management plan that constitute weaknesses.

Weaknesses that must be considered to propose the plan:

- The existence of traditional top-down decision making and planning processes for the development of the country as well as the allocation of resources. Although there is now a tendency to allow horizontal decision making.

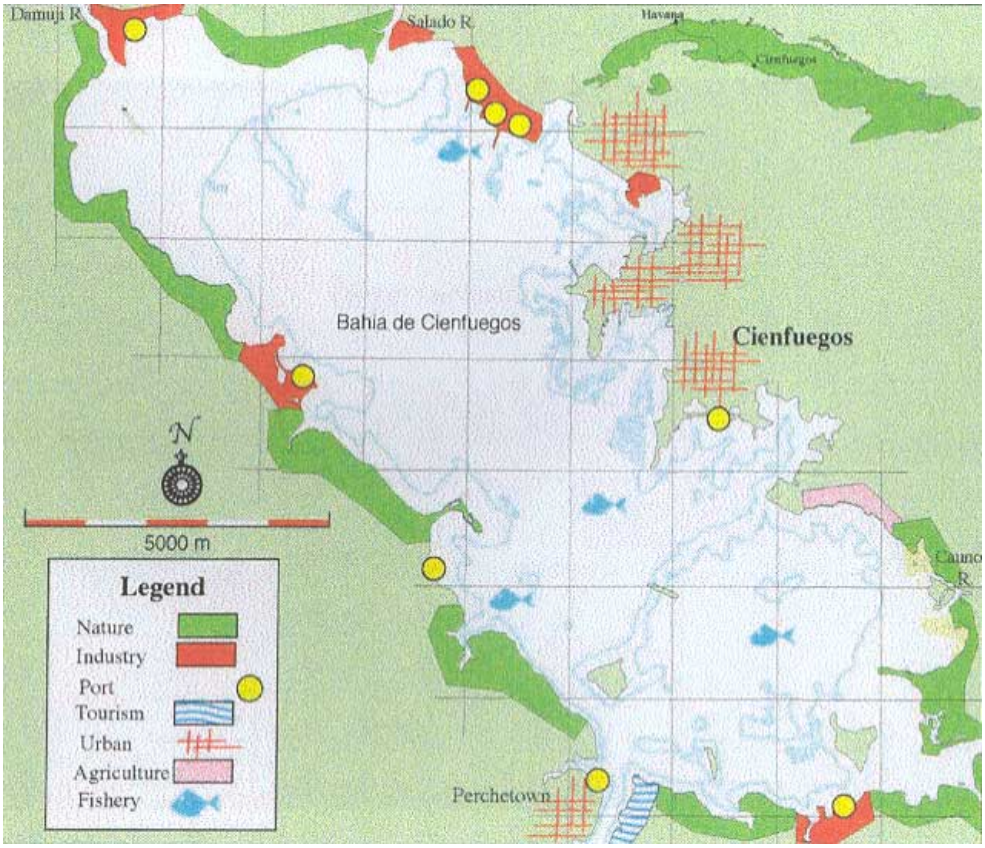

Fig. 1. Cienfuegos Bay with the major development influences.

- Although there are new pieces of environmental legislation, there still persist problems with enforcement. This will cause problems when the time comes to implement the Management Plan.

- The sewage and industrial waste treatment constitute an issue of major concern in Cienfuegos Bay and the pollutants can affect or are affecting the environmental quality of the water and bottom and hence the life and quality of seaweeds.

- Although, there is a tendency to the integration, actually there is a poor cooperation among users, which provoke an absence of environmental thinking among the developers. There is an insufficient cooperation and integration among industries and the institutions responsible for environmental protection.

- Another problem is the lack of environmental conscience among the local residents who may interfere with the application of the Management Plan.

- Sometimes the economic thinking is opposed to environmental policy and thinking.

- Something very important and that is considered as weakness is the knowledge gaps in the biological information on seaweeds. These include:

1. Information about reproductive process of *Gracilaria sp* from Cienfuegos Bay such as the germination rates, congenity of spores, rate of growth of germling, sources of mortality for germling and transport distances of spores.

2. Information is required on the role of seaweeds as a habitat structure in the Bay.

3. Studies of impacts on habitat are at present missing from the information base.

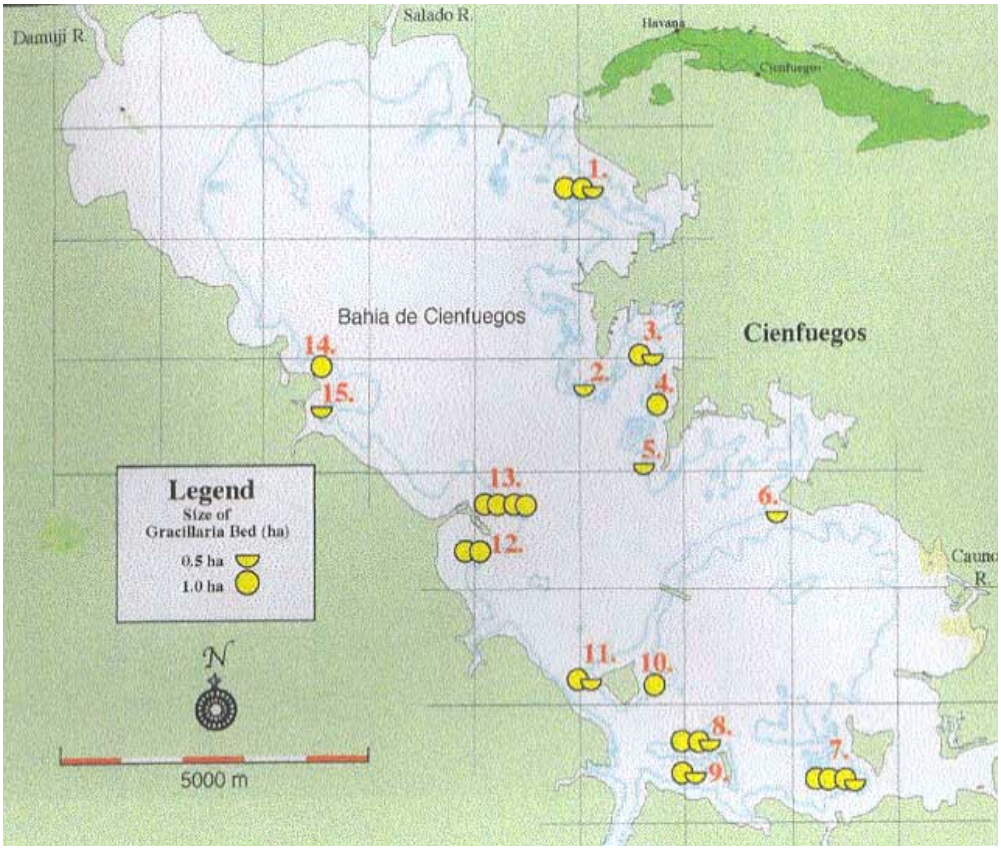

Fig. 2. The distribution and area of *Gracilaria* sp. Beds in Cienfuegos Bay.

4. Also it is necessary to know the impact of enhancement of benthic habitat by the aquaculture of seaweeds.

5. Conflicts with the existing fisheries. The illegal non-commercial shrimp fishing (dragging) is made on these natural beds, which can damage the population of seaweeds. Although the commercial fishing is far from natural beds, the gear conflict can occur because of the movement of the sediments, which smother seaweeds.

Jurisdictional Issues and Problems:

Although the marine resources are considered "common property" inside our jurisdiction, the Organ of the Central Administration of the State is the owner as stated by the Constitution of the Republic of Cuba. The responsibility is shared with several Ministries that have interest in the sea or coastal zone such as: Ministry of Fisheries (MIP), Ministry of Tourism (MINTUR), Ministry of Transport (MITRANS), Ministry of Agriculture (MINAGRI) and Ministry of Science, Technology and Environment (CITMA). Nevertheless, all Ministries must follow the policy designed by CITMA as rector of the environment. In this sense each ministry or agency, according to CITMA policy, must adapt this to their interests establishing their own regulations. Therefore, the proposal of Seaweed Management Plan would be approved once each party details its responsibilities under which the harvest must be conducted in an integrated process.

Taking into account that exploiting and processing seaweeds is a new activity for Cuba including Cienfuegos Province, and besides, there are the knowledge gaps to make a correct management plan of seaweeds, it is necessary to propose a "Pilot Scale" harvest and development. This will allow a precautionary approach to the development of this activity and will allow continuing the research and assessment of possible impacts with the intention of being sure of a long-term conservation and sustainability of the resource. Economic viability would also be assessed in the pilot phase, so that,

if the development is successful, the market will require more biomass. Therefore seaweed culture should be developed at the pilot scale in parallel to determine the best approach for the future. After assessing these results, it will be necessary to expand the harvest to the remainder of natural beds and increase the scale of culture. A new environmental impact assessment will be required for decision-making by the management commission whether to continue, cease or expand from the pilot scale and the conditions around this decision.

Proposal of Research Management Plan:

We have created a flow chart that describes the processes and structure for research development and management of *Gracilaria sp*. It is evident in this flow chart how, who and what must be done to reach the goals (Fig. 3). There are three phases in this process.

Phase I

A *Gracilaria* Management Group (GMG) will have the responsibility of proposing the development of pilot harvesting and aquaculture plan reviewing and integrating all the information about biological, physical, chemical, environmental and socio-economic aspects. It will address knowledge gaps with a research plan. This document is a proposal that will be reviewed and fine-tuned with relevant details within the GMP. GMP will propose practical implication of the plan including the necessary regulations. They will also review all the results from the Research Program and Environmental Impact Assessment (EIA).

In addition, GMG will allocate the environmental and fishing licences to exploit *Gracilaria sp* in Cienfuegos. Finally, all the information from this group will be integrated into the ICZM for the Bay, incorporating the criteria of stakeholders (direct and indirect users of both the seaweeds and Cienfuegos Bay). The decision to apply a Pilot Plan will be taken by the Commission For Integrated Coastal Zone in Cienfuegos (Fig. 3).

Phase II

This phase will proceed if there is a positive answer from the ICZM Commission in Cienfuegos. If the answer is negative the GMG will redevelop the plan in reference to the problems described by the ICZM. Otherwise the GMG will set a pilot harvest plan as a precautionary approach to management,

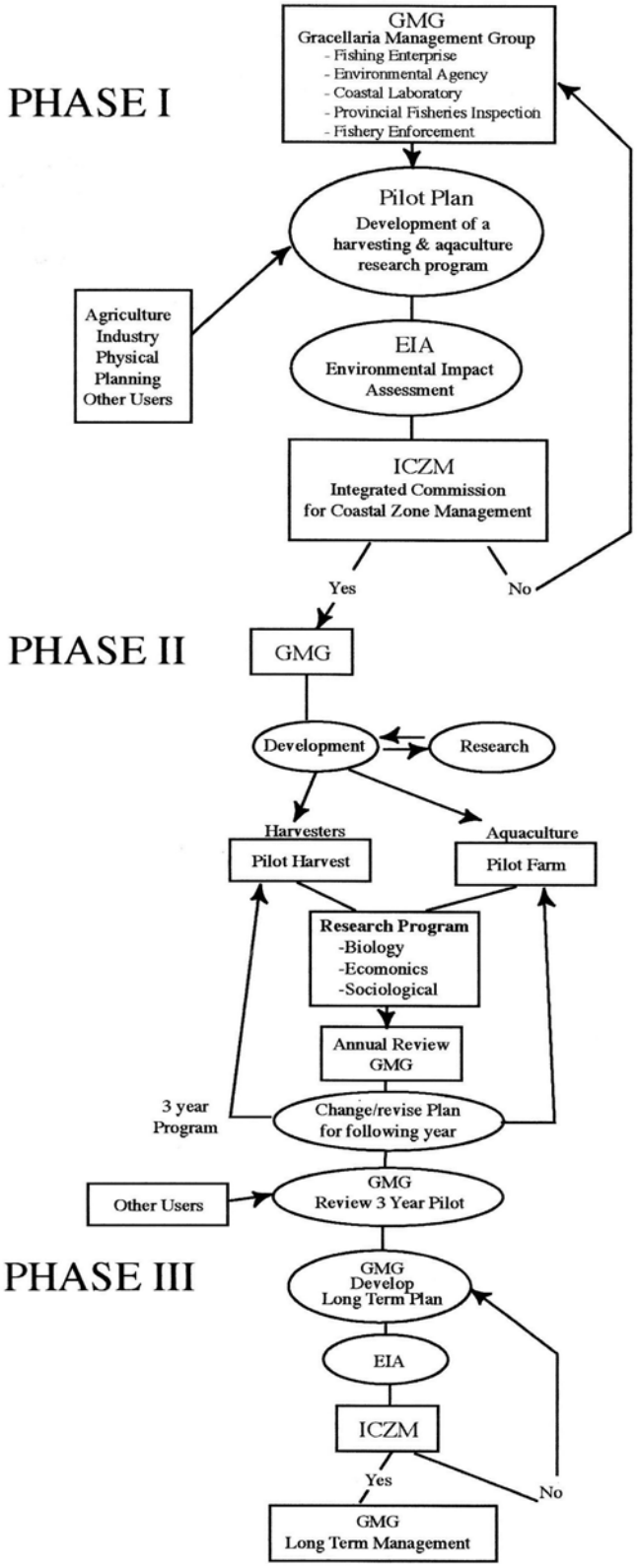

Fig. 3. A flow-chart of the three phases of *Gracilaria* sp. management in Cienfuegos Bay.

what area would be harvested, the frequency of re-harvest, type of harvest technology and period of harvest. The design of the pilot farm is not a set component of the plan. However the design will determine the size and location of the farm. The GMG will provide a farm manual to the aquaculture group, which will describe the dimensions of farm, substrate, individual weight of seeds, distance between each seed, period of harvest of seaweed from culture. The GMG will provide the outline of a research program that will gather information on both knowledge gaps identified in the review of existing information as well as the needed monitoring data for both the harvest and aquaculture of *Gracilaria.*sp. The research program will include biological, economic, and sociological aspects and in general identify the environmental impacts of both natural harvest and aquaculture. The *Gracilaria* Management Group will carry this research out over 3 years of the pilot stage. Each year the data will be reviewed by the GMG to modify the harvest plan and pilot farm project. At the end of this period there will be general overview of the biology, economics and management that again will include stakeholders and key agencies. This review will be as used as the basis for a long-term management plan.

Pilot Harvest Plan

In this plan is defined the location, area of harvesting, exploitation rates, size limitations, period of harvest, method, license conditions and research / monitoring. The pilot harvest provides an opportunity to fill knowledge gaps and priority will be given to: Recovery of biomass following harvest, reproductive capacity and relationship to recruitment of germlings in harvested and unharvested patches, changes in population structure and dynamic in harvested and unharvested patches, composition and abundance of associated biota in harvested and unharvested patches, catch per unit effort of harvesters and the relationship to standing crop and economic return and the integration with other users including assessment of conflict.

Pilot Farm Research and Management

The concept of this pilot farm is to provide an economically viable unit while information is gained on productivity, technology, economics and environmental impact. The farm is located at the site of a research project and is in a region good water quality and circulation. Its size is set in the plan to allow for a practical level of funding relative to the potential benefits (Morales,1994) (Fig. 4).

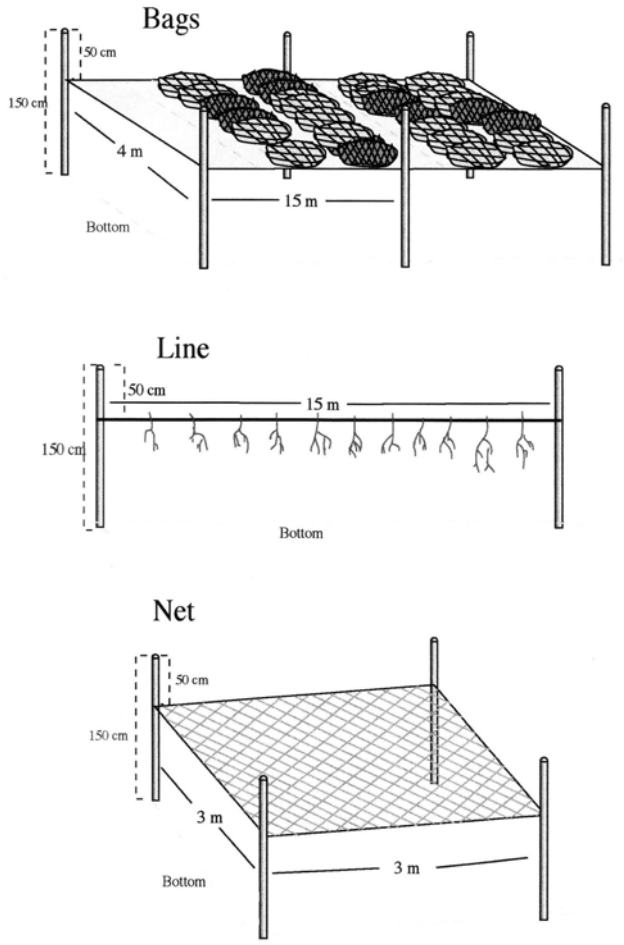

Fig. 4. Different grow-out techniques used in the pilot farm of *Gracilaria* sp. In Cienfuegos Bay.

Activities such as Post- harvest, Research/ Monitoring, Number of Workers and other requirements are taken into account in this plan. It is reviewed annually by the GMG and if changes are needed these are implemented in the following years plan. Otherwise the plan is repeated. At the end of the 3 years period the entire program is reviewed as well as the input of other user groups affected by the plan.

Phase III

The GMG will formulate a long-term plan that may involve expansion of the harvest and farming of *Gracilaria sp* based on the science and economic

review. This new plan will be put into the EIA process and their information provided for consideration by the ICZM. If the answer is no the plan will be revised and resubmitted. The long-term plan will also include a strategy to continue research on knowledge gaps particularly those that require sustained study. The precautionary approach will be maintained in this expansion and supported by the data from the 3 years pilot research and development program.

The third phase will begin following the EIA and the decision of the ICZM on both pilot plans: harvest and farm. If there is any change, the pilot plans must reviewed and new proposals must be done. The EIA information will be analysed by the Commission of ICZM to approve or not the long-term management in which the *Gracilaria sp* Management Group will keep research program, monitoring, surveying and enforcing the regulations for achieving the sustainable exploitation of seaweeds in Cienfuegos Bay. Through this flow is evident that the principle of Precautionary Approach has been applied and there is active integration with other users

Co-management Involvement

The co-management approach would be likely to be applied in some ways in these small coastal communities that are experiencing the development .The Reina community in Cienfuegos City is one of the most optimum communities to apply co-management. Although the local participation in decision- making process is not perfect, this community is divided in three Popular Councils in which some agreements can be taken in relation to the interest of the community. Many other reasons support the selection of this area to develop a co-management approach: This place t is near the natural bed of "Los Prácticos" and its inhabitants have traditional fishing experiences. In addition, they have social problems such as unemployment, prostitution for being near to the main port in Cienfuegos City, illegal-fishing activities like shrimps, etc, which affects the natural beds. Therefore, more education in general sense and development of incentives is much needed in this area. Other important reason is that the group researching seaweeds is located within this area, so that good relationships could be achieved between researchers and community.

CONCLUSIONS

With the purpose of achieving a sustainable exploitation of seaweeds in Cienfuegos Bay, Cuba, we used a bibliographic review in order to know the experiences of Integrated Coastal Zone Management (ICZM) in other part of the world, including the role of seaweeds. The review provided the basis for understanding of the actual trends and environmental policies in Cuba and more specifically in Cienfuegos Province. The management agencies and structure (the institutions role and responsibilities), and also jurisdictional issues and problems are broached in this paper too. In addition, specific information, mainly assessment studies regarding *Gracilaria sp* in Cienfuegos Bay have been described and used in the development of a management plan. EIA is used as a method to analyse the positive and negative effects of an activity or project on the environment and it is a key controlling part of the proposal plan as main result in this proposal.

Another important result achieved is the development of a phased in process that flows from increasing knowledge. It must be followed to integrate seaweed exploitation within the framework of an Integrated Coastal Zone Management Plan. This strategy is divided in three phases, which will depend on the answers from the Environmental Impact Assessment in different stage of the plan and finally of the decision-making process done by Commission for the Integrated Coastal Zone Management of Cienfuegos Bay.

It is clear that in the face of significant knowledge gaps such as: organizational, biological, technological and socio-economic, a very interactive and adaptive management plan is needed for *Gracilaria sp.* Such plan can utilize new data, deal with issues of integration with stakeholders and respond to environmental issues. The flexibility and adaptability of this management plan, in the context of reality in Cuba today, allow to go beyond the normal framework to be assured of the success of this plan within industrial development, because it enters in areas of environment, economy and sociology.

RECOMMENDATIONS:

- To form the *Gracilaria* Management Group in Cienfuegos Province with the responsibilities defined in this proposal.

- To build the necessary logistical, research and institutional structure to apply the Seaweed Management Plan in the territory.

- To establish within the legal framework of an ICZM some specific regulations to exploit seaweeds as this is a new fishing activity in our country.

- To base the harvesting plan on an adaptive and flexible strategy relating to environmental conditions such as the meteorological variations within the harvesting season as it affects standing crops.

- To implement an active educative and consultative program that mixes the usual top down policy in decision-making with bottom up grassroots initiatives taking advantages of government structures such as "Popular Council" in the communities.

- The environmental education must include and be directed towards all sectors of economic and political development beginning with all levels of government representation, including also the community.

- To improve the relationship between harvesters of Reina community and researchers from the Environmental Study Center of Cienfuegos.

- To encourage the Provincial Agency of CITMA as the prime agency for the environment in the territory to increase and improve the inter-sectoral approaches that facilitate the precautionary approach.

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