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UNITED NATIONS
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EXPERT GROUP MEETING ON INDUSTRIAL GROWING AND PROCESSING OF MARINE ALGAE

Riga, USSR, 4-8 August 1986

Report*

prepared by

the UNIDO secretariat

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Contents

A. Introduction

Reflecting a growing concern that science and technology are being increasingly directed towards destructive ends, the United Nations General Assembly in December 1983 called upon the international community to take the necessary steps to ensure that "the results of scientific and technological progress are used exclusively for the benefit of mankind and for promoting and encouraging universal respect for human rights." The UNIDO International Forum on Technological Advances and Development in Tbilisi, USSR, in April 1983, expressed a similar concern and a call was made for "a new form of international co-operation involving a limited number of new and advanced technologies to meet particular needs of a clear and urgent character to the human community." The Forum called such technologies "Technologies for Humanity".

The idea underlying the concept of "Technologies for Humanity" is to establish a limited number of specific cases where research, development and dissemination would be carried out in the public domain and co-ordinated on a world-wide basis, so as to achieve substantial results in the shortest possible time. These results would be measured in terms of the number of people who would be beneficially affected and the relationship of the needs thus being met to their fundamental human right to a decent and meaningful existence. Such an endeavour will involve not only the mobilization of financial resources and scientific talents, but also the will and commitment of all countries, as well as the dedication and participation of the international scientific and technological community.

The comprehensive utilization of marine algae to produce human food and animal fodder, in agriculture, and in industry is considered as fitting very well into the concept of "Technologies for Humanity".

Annual world production of seaweed in 1984 was estimated by the FAO to be 3.6 million metric tonnes. Brown algae grown in temperate waters are largely used as a raw material for the alginate industry, whereas red algae grown in tropical waters are used as a raw material for the agar and carrageenan industries. Both brown and red algae are used for human food, particularly in the Far East.

The first-hand value of seaweeds in 1973 was estimated by FAO to be $765 million, with 95% of this figure attributable to the sale of edible algae in Japan, Korea and China. Seaweeds harvested for use by the phycocolloid (algal gum) industry accounted for only 3% of the first-hand value of seaweed products, even though this industry utilizes 50% (by weight) of harvested biomass.

Currently, seaweed culturing varies from the simple harvesting of wild populations, to the complex culturing of edible seaweeds practised in the Far East. Similarly, processing may vary from simple drying to the complex extractions practised in the alginate, agar and carrageenan industries. Increasingly the introduction of modern biotechnology offers possibilities for the improvement of seaweed strains. This field of interest was thus seen as a possible area where the merging of traditional and advanced technologies could benefit socially disadvantaged and malnourished people in the developing countries.

UNIDO therefore called together a group of experts to examine the current status of seaweed utilization (including cultivation and processing) and consider developments of this utilization which would benefit those in developing countries.

The group comprised (a) academic scientific researchers in algal cultivation and algal biotechnology (including genetic engineering), (b) experts on seaweed resources and those with a knowledge of the problems of seaweed culture in developing countries, (c) representatives from other international organizations concerned with the problem and (d) representatives from intimately involved industrial concerns.

B. Discussion Format

The meeting elected Dr. U. Horstmann as the Chairman and Dr. P. Robinson as Rapporteur.

Five papers were introduced for discussion and used as reference documents for the meeting, these were:

(i) "Industrial growing and harvesting of algae", Dr. Michanek;

(ii) "Utilization of algae for food, fodder and in agriculture", Dr. Robinson;

(iii) "Cultivation and processing of seaweeds", Drs. Blinova and Voronova;

(iv) "Utilization of marine algae as a raw material for industry, in particular for medical and pharmaceutical industries", Dr. Horstmann;

(v) "Application of biotechnology in algal mariculture", Dr. Wu.

Informal submissions by Mr. James (FAO) and Mr. Sanderson (Kelco Ltd.) were gratefully received.

C. Discussion

Incorporated within the brief of this group were specific objectives to formulate project concepts for consideration and implementation, and to formulate more general recommendations for the attention of interested parties. These objectives were met and relevant details are provided in Annex I and Section D respectively. This section summarizes the general discussions over the duration of the three-day meeting, from which the formulations arose.

The presentation of papers clearly affirmed the view that current usage of seaweeds for human consumption is largely restricted to the Far East, though the increased interest in vegetarian and macrobiotic diets in developed Western countries is bringing about a limited resurgence of interest in edible seaweeds in both Europe and North America. In many of the developing countries, however, seaweeds are not particularly exploited even where natural stocks exist. Throughout the three-day meeting various possibilities were considered for the direct use of edible seaweeds. Suggestions generally fell into three main categories (a) those to encourage populations to make better use of available local stocks, (b) suggestions to encourage utilization of local and non-local, raw and processed, seaweeds in particular for the supply

of iodine, vitamin A (which is rich in Porphyra), and (c) suggestions to encourage further development of seaweed consumption in the developed countries, thereby stimulating the need for further production (much of it by developing countries). Many comments were made over these matters, only some of which have been included. Further analysis of certain possibilities are included in Annex II.

The difficult problem of encouragement of the further use of natural stocks was considered, and it was admitted that, in many cases, populations would not eat such an alien food as seaweed even when malnourished and hungry. However, to elucidate areas where populations might accept such products it was suggested that palatability trials be carried out with algal products to assess areas where further work might be beneficial.

As regards the use of algae for medicinal purposes (making particular use of the iodine and vitamin A contents) it was realized that WHO is embarking on massive programmes of education and treatment with respect to goitre and night-blindness, and UNIDO/WHO co-operation was recommended. The advantage of seaweed-feeding over conventional (injection or tablet) therapy was thought to be the possibility of continued usage after the campaign had discontinued, i.e. seaweed utilization might become a regular part of the diet and thus prevent the diseases from re-emerging once the aid programme had ceased. Because of problems associated with seaweed palatability, however, it was considered that the most likely areas for the success of this programme would be those in which seaweeds had once been consumed regularly, but in which the practice had subsequently declined. A programme to revive old customs of seaweed utilization was therefore proposed for this purpose.

The use of seaweeds as sources of valuable pharmaceuticals was carefully considered. However, even though much research has been done in this respect, and various active compounds have been identified, as yet no seaweed pharmaceuticals have been produced commercially. The general feeling therefore was that UNIDO could currently play a valuable role in monitoring research into algal pharmaceuticals so that if a particular seaweed became valuable in this context, UNIDO could advise countries as to how to develop their seaweed industries in an appropriate fashion. This activity could perhaps be incorporated into the work of UNIDO's 'centres of excellence' (discussed later) or the International Centre for Genetic Engineering and Biotechnology.

It was also reasoned that the further demand for seaweed products in the developed countries would stimulate expansion of cultivation and industrial processing in developing countries. Realizing that the demand for seaweed products in the Pacific and Orient are already large, it was generally felt that a programme of product (i.e. seaweed) familiarization and promotion be carried out in the West to generate demand and stimulate new development. The fact that many edible seaweeds are red algae which grow best in the warm tropical water of many developing countries was appreciated in this respect. This programme was seen as combining well with that of developing novel algal products.

Regarding the phycocolloid industry, it became evident that extra demand for such colloids would lead to an immediate industrial response, and would increase employment in the developing countries where the raw material is gathered. This consumer-led stimulation of employment was considered an effective and sustainable technique for industrial development. The search for new applications for phycocolloids was therefore considered an immediate priority. The establishment of working parties comprising food technologists and industrialists (i.e. consumer and producer interests) was thought to be a useful first-step in such a programme.

It was also argued that, where social and economic conditions were favourable, processing of a final or semi-processed product could be carried out in the developing countries themselves. The group, however strongly endorsed the view that the prime objective was to establish fully competitive and self-sufficient industrial concerns in developing countries, rather than those which would soon collapse after withdrawal of UNIDO funding. It was realized that, in many cases, the supply of seaweed as a raw material was not the most major economic consideration, but that the supply of chemicals, available energy, efficient transportation, and a skilled and motivated workforce are at least (if not more) important to the continued success of such processing plants. However, one specific project - the local production of high grade agar for microbiological use in countries possessing the red algal resource and without the economic ability to import the product - is included as an example of what is possible.

The dependance of a viable seaweed processing industry on a well educated management and workforce was realized, and to stimulate the development of such a group in the populations of developing countries various strategies were discussed.

Direct training programmes were considered, and the integration of UNIDO's interest into the training programmes anticipated by FAO was thought to be a useful measure. The concept of establishing 'centres of excellence' was also discussed, as was the possibility of UNIDO (and other international organizations) contributing resources to such a venture. The necessity for at least two such centres was reasoned, one located in tropical and the other in temperate climes, so as to allow study and training related to all commercially valuable seaweed species. The establishment of 'reciprocal agreements' between academic and R&D institutions in developed and developing countries was also thought to be of value since such 'twinning' could lead to an efficient (i.e. cost effective) and rapid transferral of concepts and techniques, through the free exchange of ideas (and problems) and personnel between such countries. However, the mechanism to select appropriate 'twins' remains to be resolved, as does the funding for such co-operative ventures. Co-operative industrial ventures were also considered and it was reasoned that the resources of available coastline and labour in the developing countries, and the resources of new technology, skilled management and labour in the developed countries, could surely be combined to the mutual benefit of all parties. It was considered, therefore, that UNIDO may play a vital role in identifying areas of interest where the mutual benefit of developing and developed countries could be gained by co-operation. Such activities could, perhaps, be co-ordinated within the proposed 'centres of excellence'. The fact that such co-operative ventures would develop slowly and would demand careful and long-term planning before fruition was realized, and preliminary investigations into the suitability of all co-operative ventures was encouraged.

The rapid advances made in genetic engineering, and their applications to seaweed production and industrial processing were carefully considered. It was recognized that recombinant DNA technology has considerable potential for the development of new and useful seaweed varieties for subsequent cultivation. It was also recognized, however, that conventional plant

breeding programmes have proven successful in this context, and these may require only knowledge of a traditional cultivation and selection rather than the highly qualified academic demand of recombinant DNA technology. The general feelings of the group, therefore, were that UNIDO could provide a valuable role in monitoring seaweed culture problems and identifying areas to which recombinant DNA technology could be applied In this context, it would be desirable for some staff at the UNIDO International Centre for Genetic Engineering and Biotechnology to be interested both in eukaryotic molecular biology and phycology. The potential future interaction of such personnel with workers from any of the 'centres of excellence' or from other academic or R&D institutions in developing or developed countries was clearly recognized, and should be encouraged.

As the converse to gathering information concerning problems, the proposal to efficiently distribute information regarding advances in algal biotechnology was considered to be a useful complementary measure. The increase of relevant input into UNIDO's "Genetic Engineering and Biotechnology Monitor" being perhaps the simplest solution.

The need to establish a rational policy to prevent over exploitation of valuable seaweed resources was emphasized by various contributors throughout the meeting, and as a prerequisite the need for more careful evaluation of current seaweed resources was requested. The possibility of using remote (i.e. satellite) sensing for this purpose was detailed and it was generally considered that this technology would allow (a) identification of local upwellings, i.e. areas of high potential use for seaweed cultivation, and (b) any large areas of unexploited seaweed stocks. It was argued that such data would enable developing countries to make best use of their coastline for future development. The problem of satellite resolution was discussed and it was realized that high-resolution military satellites, though desirable, would be unlikely to be available. Resolution down to 35m is attainable, however, using available commercial satellites, and it was hoped that UNIDO could secure some co-operation from involved countries in supplying higher resolution satellite images for this purpose. Current FAO activities in remote sensing were also detailed, and it was suggested as a possibility that FAO (with UNIDO assistance) extend their remote sensing operations to specifically investigate seaweed populations. Further details of remote sensing are included in a specific project proposal.

The two new FAO publications (to be published 1987) on the biology of the economically important algae and the relevant processing techniques were detailed, and the necessity for these publications was unanimously appreciated to update older (1975-6) FAO works.

Concern was aired that much of the seaweed harvested for use by the food and colloid industry was not properly treated such that losses before consumption or processing could be high. An urge for research into seaweed biodeterioration was therefore made, and this could perhaps be a project carried out or co-ordinated by the proposed 'centres of excellence' and incorporated in training programmes.

Increasing the economic viability of small colloid plants in developing countries was also considered, and one proposal was to build into such plants a degree of flexibility so that they could process not only seaweed, but other marine and terrestrial material. Though a very desirable concept, the feasibility of this ideal was not clearly established - certainly alginate processing operations possess no versatility, but this interesting suggestion does merit further consideration.

The utilization of seaweeds as fertilizers was carefully considered and it was generally accepted that liquid preparations offered greatest potential for future exploitation, particularly if transportation was necessary. Whilst the feelings of some contributors were that such seaweed preparations were of high value, others preferred to see more testing so as to understand the effects of such additives before overall recommendation for usage. If, as is often claimed, the effects of such products are attributable to phytohormone (particularly cytokinin) content, their usage for seedling germination and development was considered to be of particular interest. At this stage of development, however, it was generally considered best if UNIDO encourage R&D in this field and encompass the area by including a working-party to review the situation (as has already been described and is described further in a specific project proposal).

As efficient converters of solar energy to chemical energy, seaweeds were proposed as a possible fuel source either for methanogenesis or combustion. It was generally considered that most value from such ventures

would be gained if they were restricted to village- or household-sized projects. It was accepted, however, that this was not a particular area of expertise amongst the contributors, and a call for the collation of relevant research, together with a preliminary study of feasibility was proposed.

Throughout, mention was made as to whether special areas be considered for intensive investigation. Though it was felt that all countries should generally be given equal encouragement to establish and develop seaweed culture and processing industries so that no individual member was in any way disadvantaged, it was also realized that certain areas (particularly Africa) would be unable to respond to such encouragement unless given further assistance. It was reasoned, therefore, that a further fact-finding programme should, if possible, be implemented to more clearly identify the problems of the industrial development of a seaweed industry in this region. Also palatability trials, etc. (outlined earlier) should be particularly vigorously applied in this region, to indicate the demand for seaweed products.

Whilst the meeting was specifically designed to consider macroalgal (seaweed) technology, it was also clear from discussion that there was considerable interest and expertise on microalgal culture and this area of interest was closely considered in relation to the needs of the developing countries. It was recognized that very large sums of money had already been invested in microalgae culture, with little overall success, yet it was felt that microalgae do offer considerable potential for alleviation of some of the problems of malnutrition in the developing countries. A useful compromise was made (and a specific project concept developed) to currently restrict study of microalgae to low-tech culture and industrial processing which could be run easily and successfully at the 'village level'.

The meeting finished with an agreement that much could and much should be done to expand seaweed culture and processing for the benefit of <u>all</u>. Some general recommendations were formulated and specific project concepts were forwarded for further evaluation. Further projects could certainly have been proposed if time and anticipated funding allowed, but the projects suggested present an integrated package of measures as a first step in the long-term objectives of the group and UNIDO.

D. Recommendations

The following general recommendations were formulated at the meeting for consideration and implementation.

1. Regarding the direct utilization of seaweed for human food, UNIDO should consider three main areas for development:

   (a) the use of seaweeds at the local level in developing countries;

   (b) the use of seaweeds for preventive medicinal effects (in for example goitre and night blindness programmes);

   (c) the use of seaweeds as high cost, sophisticated foodstuffs for the developed countries.

2. As sensible first-steps to implement the desires outlined in proposal 1 it is advised that programmes of palatability testing of edible algae, and new edible product evaluation be carried out.

3. For proposal 1(b) it is specifically advised that UNIDO co-operate with WHO in their planned goitre and night blindness campaigns. A more general recommendation, however is that over all dealings in the seaweed development programme, UNIDO should co-operate and if necessary combine its efforts with FAO, UNESCO, UNEP and other relevant international organizations and industrial concerns, so as to avoid duplication of effort and to ensure rapid and efficient transfer of relevant technology information and expertise to developing countries.

4. Since further development of the phycocolloid industry is restricted by market demand, it is recommended that UNIDO encourage (initially through a scheme of working parties) the investigation of new applications for phycocolloid products.

5. Combined with proposals 1(a), 1(c) and 4, it is clear that further utilization of seaweeds and seaweed-based products is limited, in many cases, by aesthetic objections. A proposed programme of product

promotion (stressing nutritional and medicinal value) is therefore recommended, particularly towards clearly established 'marketing responsive' populations and groups. It is anticipated that this will lead to an increased and sustained 'consumer-led' demand for seaweed products, and subsequently industrial expansion.

6. It is recommended that UNIDO establish at least two 'centres of excellence' in appropriate climatic regions for the study of temperate- and tropical-water algae of commercial importance. Centres would be expected to have an active research role, and run relevant training courses in technology development and transfer for visiting scientists and industrialists.

7. In order to establish areas of relevant academic ability in countries expanding their seaweed cultivation and/or processing capacities, it is recommended that UNIDO encourage co-operative agreements and joint ventures in academic and R&D institutions in developing and developed countries through a programme of 'twinning'.

8. It is recommended that UNIDO similarly encourage co-operative agreements and joint ventures between industrial and/or governmental bodies in developing and developed countries. It is recommended that UNIDO's initial role in this programme should be one of identifying areas where joint ventures could be carried out for mutual benefit.

9. It is recommended that UNIDO implements a programme of collation of seaweed culture and processing problems and assesses their suitability for solution by recombinant DNA biotechnology. It is envisaged that this action would be intimately involved with the staff of the UNIDO International Centre for Genetic Engineering and Biotechnology. It is also recommended, therefore, that mulecular phycology is represented amongst the interests of the centre's staff.

10. As a supplementary action to that outlined in proposal 9, it is recommended that UNIDO better emphasize details of research in algal biotechnology in its own publications, in particular in the "Genetic Engineering and Biotechnology Monitor".

11. It is recommended that UNIDO encourage the full co-operation of relevant countries in providing high-resolution satellite images for the assessment of areas of current and potential use for seaweed culture.

12. In connection with proposal 11, it is suggested that UNIDO act to mobilize international co-operation in efforts to study the extent and content of current seaweed stocks, and act to encourage an understanding of the effects of current (and proposed) harvesting on these natural populations.

13. In connection with proposal 12, it is suggested that UNIDO encourage those industries dependent on large quantities of seaweed as raw materials to investigate the long-term economic benefits of seaweed cultivation rather than depend upon the short-term gains of intensive exploitation of natural populations.

14. It is recommended that UNIDO should monitor and regularly review the R&D relevant to pharmaceuticals derived from seaweeds so that, if commercially valuable drugs are elucidated, UNIDO can recommend a logical course of action to the seaweed culture and processing industry.

15. It is recommended that UNIDO evaluate the R&D related to the usage of liquid seaweed extracts for fertilizer and implement a series of limited trials on crop plants utilized in developing countries. Co-operation with relevant industrial concerns is highly recommended.

16. It is recommended that UNIDO investigate and encourage the production of semi-processed products in the country of collection itself (where such products are technically feasible and economically advantageous) enabling producer countries to manufacture more valuable items. This general point of 'upgrading' the value of collected seaweeds is anticipated as an early project for the 'centres of excellence' (proposal 6).

17. It is suggested that UNIDO look more closely at the potential of seaweed for energy generation (methanogenesis and combustion) and incorporate such interest into a research proposal at the 'centres of excellence' (proposal 6) or integrate this into ongoing programmes which UNIDO or other international agencies are already carrying out.

18. It is stressed to UNIDO that microalgae should also be considered in all of the aforementioned proposals, since microalgal cultivation is ideally suited to the climates of numerous developing countries and is advantageous in that it is not dependent on areas of available coastline.

19. It is recommended to UNIDO that they encourage further forums for debate and discussion of these and associated problems and ideas, both individually and by collaboration with appropriate international agencies and academic societies.

20. It is recommended that, in all educational campaigns, UNIDO particularly emphasize the fortunate positions of many (tropical) developing countries in possessing valuable stocks of red seaweeds, which may be of use as food or as raw materials for the agar and carrageenan industry.

21. It is recommended that UNIDO encourage developing countries to consider the possibility of utilization of their seaweed resources in the preparation of their national, industrial, technological and agricultural plans and programmes.

22. Considering the restricted world markets for many algal products, it is recommended that developing countries should consider and, wherever practicable, implement policies programmes to encourage domestic consumption of seaweeds and seaweed products.

23. It is recommended that UNIDO consider, and further study, the existing technologies and techniques of upgrading the quality of seaweed based final and semi-final (semi-processed) products, in order to evaluate areas where extra profit could be generated in the industrial processing of seaweed products in developing countries.

24. It is recommended that UNIDO consider further the special problems and needs of the peoples of Africa. It is recommended that these countries be specifically included in all programmes of palatability testing, consumer education and product evaluation. It is also recommended that the feasibility of industrial development of a seaweed based industry in such areas be considered and encouraged.

ANNEX I

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ANNEX II

Project Proposals

Contained in this section are a group of specific proposals for consideration and implementation. This list is not exhaustive, but includes examples of plans for work to resolve many of the current difficulties of seaweed culture and processing ventures in the developing countries.

I. INCREASING THE USE OF SEAWEEDS FOR DIRECT HUMAN CONSUMPTION

1. Introduction

The benefit of seaweed resources may be derived either directly, through their local use as foodstuffs, or indirectly, through their sale. In the former case seaweeds can be regarded as important sources of protein, minerals and vitamins, whereas in the latter case their use is as a raw material for profitable industrial concerns.

2. Objective

The primary objective is to create economic benefits for coastal communities in impoverished areas through the development of their seaweed resources.

The principal secondary objective is to improve the nutritional state of coastal communities and, through the transport of seaweed products to inland communities, to improve the general health of such populations, particularly towards alleviating the problems of goitre and night blindness.

A further secondary objective is to encourage industrial development in the collection and processing of the raw materials.

3. Activities

(a) With regard to the established prophylactic and curative effects of seaweed iodine in cases of goitre, means should be studied towards making seaweed products available to goitre susceptible communities. Individual governments and WHO should be consulted and involved. The possibilities of such use for other micronutrient deficiency diseases such as night blindness (vitamin A deficiency), scurvy (vitamin C deficiency) should also be considered.

(b) In many developing countries, the adoption of seaweed for food will depend on the existing food habits within the society. The introduction of novel seaweed foods therefore requires careful product development, acceptability testing and consumer education. However, providing that both market evaluation and product promotion are effectively carried out, there certainly appear to be good opportunities for both traditional and novel edible seaweed products to contribute to the diet as palatable and nutritious foods. Areas where seaweeds were once regularly consumed, but in which the practice has since declined, seem to be promising areas for investigation in this respect, and this forms a separate proposal (number II).

(c) The rapidly developing and highly lucrative health food market in developed countries presents a potentially profitable market for the export of edible seaweeds from countries possessing the seaweed resources and the processing capacity. However, since such products are unfamiliar to such markets the necessary actions prior to commercialization are:

(i) product development and testing;

(ii) estimation of market size, product cost and subsequently economic return;

(iii) product promotion

An attraction of this proposal is that there are clear opportunities to generate capital investment in such ventures.

4. Inputs

A programme of considerable magnitude, developed over several phases, over a period of about five years, and involving the co-operation of a well respected national institute is envisaged. Three permanent international staff would be required to cover the areas of technology, economics and marketing. Other staff with more specific expertise could be employed as ad hoc consultants, and the national institution would be expected to devote a number of personnel to the project also. Necessary equipment for the task would include a pilot plant for production of trial products.

5. Institutions involved

Essential to the success of the project is the full co-operation and commitment of a food technology institute with extensive fisheries experience. Close co-operation with health services, community welfare groups, non-governmental organisations and local industry would also be necessary. The project would also probably benefit from its division into two or more sub-elements which could be carried out in institutes in various countries, thereby stimulating international collaboration over the central issues.

II. REVIVING ABANDONED CUSTOMS OF SEAWEED CONSUMPTION

1. Introduction

Regrettably, the introduction of new (Western) food habits into developing countries has, and still is, stimulating the abandonment of old customs of eating habits. In many cases traditions of seaweed consumption are only just remembered.

2. Objectives

To stimulate a greater awareness in old customs of seaweed consumption and re-establish practices. At the same time establishing markets in which new algal products might be more readily accepted.

3. Activities

The difficulty in discovering abandoned customs seems best approached at both the academic level, by social anthropologists and historians, and at the non-academic level (amongst the general population). Of particular use in the latter case may be the organization of a competition to find the 'best' or oldest seaweed recipe. (FAO has in the past also used this strategy to encourage interest amongst the general populace.) If sufficient interest is generated, UNIDO would then need to encourage the supply of seaweed raw materials and appropriate processing technology, if this did not automatically occur upon realization of demand.

4. Inputs

A reasonably low-cost programme over one to two years would be anticipated initially. Co-ordinated (worldwide) by permanent UNIDO staff, but probably best run in each country by health and/or food institutes. Requirements for funding for advertising, collection of information, assessment of the 'desirability' of recipes and 'prize-money' are clear, but these sums of money are not anticipated to be large.

5. Institutions involved

Probably best organized initially with one food and/or health institute collecting data from each country, with centralized UNIDO action to pass ideas from one country to another, and to establish areas where further work could be done in relation to proposal I.

III. DIVERSIFICATION OF THE UTILIZATION OF ALGAE AND THEIR DERIVATIVES

1. Introduction

Regarding the use of phycocolloids in particular, market expansion (and thus the expansion of collecting and processing operations in developing countries) is limited by current market size.

2. Objectives

To identify new markets for algal products and develop novel algal products for use, thereby generating new employment by raising world demand for seaweed products. It is thus anticipated that employment would be generated particularly in seaweed producing areas where underutilized handling and processing systems already exist.

3. Activities

To identify new markets and products, five expert groups will be formed to investigate the following five areas:

(a) preparation and marketing of edible seaweeds;

(b) utilization of seaweeds in agriculture, particularly towards the effects of liquid preparations as soil conditions and plant growth stimulators;

(c) development of new applications for agar;

(d) development of new applications for alginate;

(e) development of new applications for carrageenan.

4. Inputs

Each of the five groups would necessarily comprise three experts (preferably from R&D establishments). Additionally, UNIDO staff to 'steer' these groups would be useful. Groups would need to meet at least twice, first to generate new ideas, and a second time after several months of investigation to discuss the results.

UNIDO would be required to fund meetings, but since experts would come from involved industries it would be expected that most (if not all) of the required R&D would come from the industries themselves. UNIDO's overall position would thus be one of stimulation and co-ordination.

5. Institutions involved

R&D institutions of the relevant industries

IV. PRODUCTION OF MICROBIOLOGICAL GRADE AGAR

1. Introduction

Many developing countries with substantial resources of the red seaweeds Gelidium and Gracilaria suitable for agar production, spend considerable amounts of foreign exchange in importing agar for microbiological media. Such agar is essential to health services, food industries, export/import inspection agencies and others. These local red seaweeds are presently either used for the production of low-grade agar for use for example in desserts, or are exported. The seaweeds could, however, be manufactured into a higher grade product suitable for the uses outlined above.

2. Objective

To locally produce agar of microbiological grade in the developing countries with natural stocks of appropriate seaweeds.

3. Activities

(a) to review world trade in agar, and identify developing countries with large agar imports;

(b) to match countries with high import demand, available seaweed resources and sufficient general industrial ability;

(c) to develop a package of technology in terms of plant and operating procedures;

(d) assuming interest from developing countries, to provide necessary plant and training.

4. Inputs

UNIDO would be to devote permanent staff, or appoint a consultant (or both) to review the trade situation in high-grade agar and select appropriate developing countries for further evaluation.

The development of plant would be necessarily carried out by an industrial or academic institution.

Installatien of equipment, training, and a period of staff familiarization would be required, and several units would be envisaged as being the minimum required. A small team of engineers and consultants would thus be necessary during deployment, and a maintenance requirement would need consideration. The total project cost is estimated to be in the order of $700,000 - $1,000,000.

5. Institutions involved

Government institutions involved in fisheries technology, industrial development, trading standards, etc. could usefully be involved. Alternatively academic institutions with interests in these fields might participate. Local industry should also be involved in the programme.

V. ASSESSMENT OF THE APPLICATIONS OF BIOTECHNOLOGY TO SEAWEED CULTURE AND PROCESSING

1. Introduction

It is clear that biotechnology (i.e. recombinant DNA technology) is a potentially valuable tool for the modification of seaweed varieties. Historically, however, plant breeding programmes have been used towards this end (in China, for example) with considerable success. The situation is further complicated by the fact that in many cases it is not clear what modifications are actually necessary to the currently available seaweed varieties.

2. Objectives

To critically assess the role of recombinant DNA technology in the future modification of existing seaweed varieties of economic value.

3. Activities

To collect and collate information concerning the major problems encountered in seaweed culture and processing ventures, e.g. disease conditions and climatic tolerances. To initially evaluate problem and arrange for collection of varieties and evaluation of cultural conditions at problem sites. To consider recombinant DNA technology and traditional genetic breeding technologies as solutions to problems and advise as to institutions where work could be carried out.

4. Inputs

UNIDO would need to provide staff to co-ordinate the collection and retrieval of information, and would need to provide resources for experts to visit problem sites. Publication of the fact-finding exercise could also be a useful alternative so that experts could identify themselves and individually come to agreements over further measures with the appropriate seaweed ventures.

5. Institutions involved

Co-operation of local fisheries and academic institutions is vital to the success of this proposal, so that samples could be collected and analysed 'in the field'.

VI. REMOTE SENSING TO ESTABLISH AREAS MOST SUITABLE FOR SEAWEED CULTURE

1. Introduction

The choice of area for establishment of new seaweed culture ventures has historically been a rather random affair, without due attention being paid to the nutritional status of the waters themselves. Remote (i.e. satellite) sensing, however, now enables us to establish local upwellings where waters are likely to be rich in nutrients and therefore particularly suitable for utilization by seaweed cultivation ventures.

2. Objectives

To utilize available satellite technology to elucidate areas of upwellings for recommendation for utilization by seaweed cultivation ventures.

3. Activities

To use available images from the Coastal Far Colour Sensor, as well as those of the AVARR and T-M-system for analysis of the coastal areas of developing countries. As well as establishing those areas which would be of particular value for further development towards seaweed cultivation, these techniques should also allow any large areas of natural seaweed stocks to be identified, thereby allowing further exploitation as necessary.

4. Inputs

Satellite data, which has already been collected and is currently on magnetic tape, will have to be acquired ($10,000 - 50,000), processed ($50,000 - 100,000) and evaluated by one or two consultant experts.

5. Institutions involved

Co-operation with remote sensing agencies is necessary as is co-operation with international agencies. It should be investigated as to whether this proposal could be integrated into plans and activities of FAO.

Co-operation of developing countries should also be acquired so that key areas be identified so as to obviate the need to analyse images from the entire length of coast.

VII. ESTABLISHMENT OF A TRAINING PROGRAMME FOR MANAGEMENT/SCIENTISTS/WORKERS IN SEAWEED CULTIVATION AND PROCESSING OPERATIONS

1. Introduction

It is clear that the development of new seaweed based industries requires workers (at all levels) to be aware of the problems and potentials of seaweed culture. Within this context, hands-on experience of seaweed cultivation and processing technologies are vital to ensure that developing industries produce materials of acceptable quality within the world market, and are able to operate so as to be economically competitive.

2. Objectives

A training course to train personnel from developing countries aspects of seaweed culture and processing technology.

3. Activities

To be of any value, the location of the training course must reasonably simulate the anticipated environmental conditions in the developing countries from which the trainees come.

Training from expert staff (consultants or full time staff at an appropriate institution) would be required, using equipment either already available within the developing countries, or able to be constructed at little cost (and with little necessary importation). Both manual and cerebral aspects of the area should be considered, so that trainees could return to assess local conditions and respond in a flexible (not stereotyped) fashion.

4. Input

The staff required for such training programmes would probably be centred at a fisheries or academic institution or a 'centre of excellence'. Thus UNIDO would need to fund the running of courses including the travel and accommodation expenses of trainees and the staff costs for course duration.

However to achieve the best type of course a more long-term investment in an institution would seem likely and the UNIDO-funded 'centre of excellence' has much to recommend it.

5. Institutions involved

Depending on choice (as outlined in 4). Co-operation with FAO in their anticipated training programme is, however, strongly suggested over this matter.

VIII. MICROALGAL 'SALT' PRODUCTION

1. Introduction

Deficiency of vitamin A leads to a serious condition known as night-blindness which may manifest itself as both physical and mental retardation and, in many cases, total blindness. The problem is serious, and is endemic in many developing countries. Alleviation of this condition may be effected by the addition of B-carotene (provitamin A) to the diet.

2. Objectives

The increase in dietary provitamin A in selected area of developing countries through the culture of vitamin rich microalgae, simple processing, and distribution as an algal 'salt'.

3. Activities

As a first phase it is proposed that existing microalgae plants in for example Peru, India and Thailand should be used for small-scale pilot projects, for the growth of salt-tolerant Dunaliella species.

In a second phase small and relatively simple microalgae raceways (culture units) should be established in areas where vitamin A is most urgently needed.

In both phases it is the primary object to keep processing simple, and it is envisaged that this will involve simple evaporation of the culture medium to leave a 'salt' of dried (vitamin rich) Dunaliella together with salts which were present in the growth medium. The salt could then be distributed to necessary areas and used as an additive to the normal diet.

4. Inputs

The first phase will require one scientist and one technician to act as consultants, and will need 2-3 local personnel 'on-site' to monitor the day-to-day running of the pilot plant. A sum of some $50,000 would also be required for the refurbishing and upgrading of existing facilities, and for the provision of new devices.

The second phase would require $50,000 to $100,000 for the establishment of simple production plants and for maintenance costs, plus four personnel.

5. Institutions involved

In phase one, the established microalgae culture operations in Peru and/or India and/or Thailand would be involved.

In phase two, interested governments and their health agencies would be needed for effective operation.

Over the whole programme the collaboration of WHO would be needed, to ensure no duplication of effort and to co-ordinate target areas.

IX. ASSESSMENT OF POTENTIAL FOR FLEXIBILITY IN SEAWEED PROCESSING PLANTS

1. Introduction

Seaweed harvesting, like most others, is seasonal, thus seaweed processing plants must either import the raw material from other localities or close during certain times of year. In general, the former alternative is preferable for large industrial concerns, but for small plants in developing countries the latter alternative is the inevitable consequence.

2. Objective

To identify the scale of the problem as regards seasonality of operation of processing plants, and to consider the need for higher inherent flexibility in newly built plants.

3. Activities

(a) to collect and collate information relevant to seasonality of operation of small plants;

(b) as necessary, to set up a small working party comprising engineers and senior plant-managers to investigate the desirability and feasibility of increasing flexibility of operation, and to advise on further action to be taken either of specific or general nature.

4. Inputs

Initially UNIDO personnel to identify small plants, to identify problems, to collate problems and to identify members of a working party. Three to four consultants to meet, at least twice, in a working group and personnel at R&D or academic institutions to carry out prototype and pilot-plant trials, as necessary.

5. Institutions involved

Initially individual plants will be required to co-operate and identify their own problems. In developing more flexible plant material the co-operation of an engineering institution used to the problems of food processing would be necessary.

X. ENERGY FROM SEAWEED BIOMASS AND HOUSEHOLD WASTES BY HOUSEHOLD-SIZE FERMENTATION PLANTS

1. Introduction

Methanogenesis and combustion are both useful methods of producing available energy for use in cooking and in providing light. Methanogenesis is, however, of further use in that the digested product is of value as a soil conditioner and fertilizer. Many countries (India and China being prime examples) already have well developed 'biogas' programmes using household wastes.

2. Objective

To investigate the usefullness of seaweed additions to household waste for methanogenesis, and fertilizer value of the by-product.

3. Activities

Initially to collect and collate research in the field. Then, as necessary, to initiate R&D, involving setting up of a pilot-plant for study. Finally recommendations for the quantity of seaweed to be included in biogas plants.

4. Inputs

UNIDO personnel or co-operating academic staff/consultant to collect data and identify need for further study.

Pilot plant ($1000) to be operated and studied in a co-operating engineering institution or academic institution with strong biochemical engineering department.

5. Institutions involved

R&D or academic institution. Co-operation of relevant countries governments and regional/local organizers of biogas programmes. Any other international agencies who have (or have had) biogas implementation

programmes. Co-operation of the waste-water treatment industry (in developed countries) may be particularly useful, since they have much experience in methanogenesis.

XI. SEAWEED INFORMATION BANK

1. Introduction

Many of the problems encountered by industrialists and academics in developing countries have also been encountered, and solved elsewhere, and have been reported in published material. The problems of lack of access to this material is, however, the bottleneck' in this situation.

2. Objectives

It is proposed to set up a 'library' of literature relevant to the needs of the developing countries' seaweed processing industries.

3. Activities

Centralized UNIDO personnel will be required to provide the service, or this could be done in co-operation with the FAO Aquatic Science and Fisheries Abstracts (ASFA), and/or UNESCO. Consultants, with good knowledge of relevant literature, would supply reference lists and possibly annotated lists of papers.

4. Inputs

At least one UNIDO staff member to collect references and send it on to institutions requiring assistance. Continued support of consultant scientists to identify relevant information. Use of a computer storage/retrieval system if feasible.

5. Institutions involved

Costs could be reduced by co-operation of international industries or by the assistance and co-operation of a science reference library from a developed (probably English fluent) country. Translation services would be desirable but not essential if costs were to be kept down.

XII. IMPROVEMENT OF THE MASS CULTURE OF SEAWEEDS

1. Introduction

In countries of the tropical zones where a great number of seaweeds from natural stocks traditionally have been used for human consumption (e.g. Southeast Asia, East Africa), an increasing demand due to growing population and because of new ways of utilization (mainly animal fodder and raw material for phycocolloid production) cannot be met by harvesting from wild resources which in some cases have been overexploited already.

Improved mass culture of these seaweeds, as already successfully practised with a few tropical algal species (e.g. Eucheuma in the Philippines) together with the search for new species potential for mariculture would help to satisfy demand.

2. Objectives

The project aims at:

- the investigation of the biological and hydrographical background for mass culture of some specific tropical seaweeds already utilized and of high future demand;

- development and improvement of mass culture technologies of these seaweeds considering local potentials and socio-economic needs.

3. Activities

The study will focus on tropical algal species of the genera Gracilaria, Hypnea, Eucheuma and one Sargassum species and on their use for production of phycocolloids and animal fodder (Sargassum).

Following topics will be investigated in particular:

- Ecophysiological laboratory and field studies on environmental requirements for mass culture;

- Improvement of culture conditions for above-mentioned high quality seaweeds (Phycocolloid producers) by artificial fertilizing and strain selection;

- Quality control of the seaweeds for phycocolloid production.

4. Inputs

Duration of project: 2-3 years
Foreign experts: 1-2 persons
Local scientists: 3 persons
Local technical staff: 4 persons and labour US $ 60-80,000

5. Institutions involved

Tanzania:	University of Dar-es-Salaam
Philippines:	University San Carlos Cebu City
	University of the Philippines Los Banos
	Mindanao State University IIT