

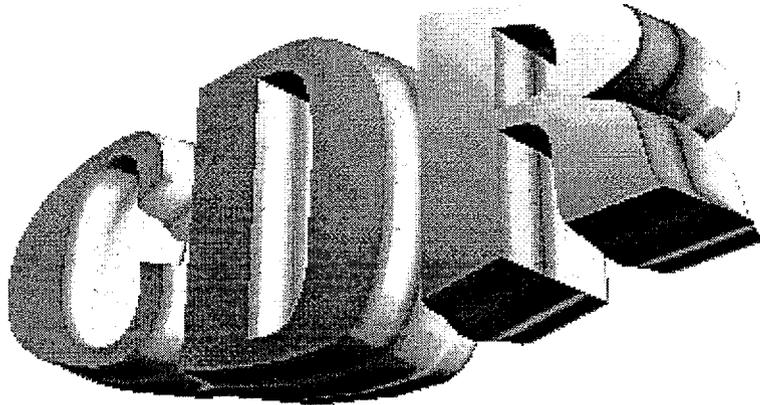
PD ABO-497

97570



*American Embassy
Tel Aviv, Israel*

1997



Grant Agreement

*Israel Oceanographic & Limnological Research (Israel) &
University of Costa Rica (Costa Rica)*

TA-MOU-97-C14-015



U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR GLOBAL PROGRAMS, FIELD SUPPORT & RESEARCH
CENTER FOR ECONOMIC GROWTH
Washington, D.C.

Copy No. 3 of 8



Embassy of the United States of America

*American Embassy
Tel Aviv, Israel*

April 23, 1998

Mr. Eyal Erez
Director of Administration
National Institute of Oceanography
POB 8030, Tel Shikmona
Haifa 31080
Israel

SUBJECT: Grant No. TA-MOU-97-C14-015

Dear Mr. Erez:

Pursuant to the authority contained in the Foreign Assistance Act of 1961, as amended, the Federal Grant and Cooperative Agreement Act of 1977, and the Interagency Agreement between the Agency For International Development and the U.S. Department of State of December 15, 1997, as amended, the U.S. Embassy/Tel Aviv (hereinafter referred to as "*Embassy*" or "*Grantor*") hereby grants to Israel Oceanographic & Limnological Research (hereinafter referred to as "*IOLR*" or "*Grantee*") the sum of two hundred thousand U.S. dollars (\$200,000) to provide support for a research program entitled "**Costa Rican Coral Reefs Under Siltation Stress: Assessment, Restoration & Management**" as more fully described in Attachment 2, entitled "Program Description", and the Grantee's proposal, as revised, which is made a part of the Grant and incorporated herein by reference.

This Grant is effective and obligation is made as of the date of this letter and shall apply to commitments made by the Grantee in furtherance of program objectives during the period beginning *May 1, 1998* and ending on or before *April 30, 2003*. The Grantee is allowed to incur pre-award costs 90 calendar days prior to award date.

This Grant is made to the Grantee on condition that the funds will be administered in accordance with the terms and conditions as set forth in Attachment 1, entitled "Schedule", Attachment 2, entitled "Program Description", Attachment 3, entitled "Payment Forms", Attachment 4, entitled "Performance Report - Guidelines", and Attachment 5, entitled "Mandatory and Required as Applicable Standard Provisions", which have all been agreed to by your organization.

In order to comply with regulations applicable to this Grant, it is essential that all documentation provided as attachments to this letter be thoroughly reviewed. The Grantee is responsible for full understanding of, and compliance with, all applicable regulations. However, in some cases, information set forth in the attached is subject to interpretation and warrants specific guidance. Such additional information is set forth below.

I. SUBGRANTS

Grants are being awarded to Prime institutions to work in collaboration with Sub institutions. Notwithstanding actual billing and payment procedures, the full Grant amount and research activity is formally attributed to the prime, or Israeli institution in this case. The only legal relationship the U.S. Government has is with the prime institution.

Provided with this Grant Agreement is a copy of a draft, sample format for your use in establishing a legal, binding relationship with the Sub or Developing Country (DC) Institution you intend to collaborate with. It is essentially identical to the award document made by the U.S. Government and complies with applicable regulations.

If the Grantee chooses to use its own format, care should be taken to ensure that required regulations have been applied. Subgrants may only be awarded to responsible institutions which possess the potential ability to perform successfully.

Since your institution will be held accountable for the grant in its entirety, it is important that the Subrecipient institution be held accountable by your institution. In this manner, the prime protects itself from unnecessary risk of disallowed costs.

However, in no case can a U.S. Government responsibility be claimed, construed, or inferred from the use of this or other Subgrant agreement by the Grantee.

II. AUDITS

In order to receive advance payments, all institutions (prime and sub) must have had a current audit performed by an independent external CPA firm in accordance with applicable regulations (i.e., those pertaining to the country where the institution is located as well as Government Auditing Standards developed by the Comptroller General of the United States). Any adverse findings contained in such audits, as determined by the Grant Officer or his designee, must have been adequately resolved. In the event an audit has not been performed recently, the Grantor (U.S. Government in the case of the prime, prime in the case of the sub) may elect to perform a limited financial review, conducted at the discretion of the Grantor, prior to authorizing advance payments. In this case, the Recipient of the advance must agree to comply with all future audit requirements.

III. STANDARD PROVISIONS

All Mandatory and Required as Applicable Standard Provisions indicated to be applicable in later sections of this Grant should be reviewed, understood, and adhered to. However, the following are considered to be most frequently applied to this program:

A. Revision of Grant Budget

In many cases, specific Grant Officer approval for budget changes is not required (if the need for a change is identified, the Grantee should refer specifically to the provision to determine whether or not Grant Officer approval is required). However, there may be other changes that should be discussed with the Project Officer, or his designee, to ensure continued agreement on the direction of the program. The Grantee should consider factors such as impact and reasonableness in determining which non-mandated changes should be brought to the attention of the Embassy. In no case will a change be approved which is contrary or detrimental to the original or detrimental to the objectives of the project as technically approved by the science review panel.

B. Air Travel and Transportation

Project Officer approval is required on all international travel. All air travel and shipments are to be made on U.S. flag air carriers when available. Exceptions to the requirement may be made if a U.S. flag air carrier cannot provide the foreign air transportation needed, or if use of such service will not accomplish the U.S. Government's mission (see circumstances outlined in the provision for specific allowable exceptions). Economic considerations do not override this provision. In the event U.S. flag carrier service is deemed to be unavailable, the Grantee must prepare and retain for audit purposes, a certificate of unavailability.

C. Procurement of Goods and Services

The Grantee must ensure high standards with respect to procurement. When possible, procurement should be competed to the maximum extent practicable. Technical needs should be determined, and all other factors being equal, purchase should be made at the lowest price available. Contracts meeting applicable thresholds should include appropriate legal remedies in case the subcontractor fails to perform. Wherever possible, the Grantee should use U.S. and small business sources.

D. Eligibility Rules for Goods and Services

The Grantee (and its Sub) may not purchase the following using U.S. Government funds: military equipment, surveillance equipment; police or other law enforcement commodities or services; abortion equipment or services; luxury goods or gambling equipment; or weather modification equipment.

The Grantee may not purchase from any source listed on the List of Parties Excluded from Federal Awards. To this end, the Grantee may rely on a self-certification provided by the supplier, unless there is any knowledge by the Grantee that the certification should not be accepted.

Specific prior, written approval from the Grant Officer is required prior to purchase of the following: agricultural commodities; motor vehicles; pharmaceuticals; pesticides; rubber compounding chemicals and plasticizers; used equipment; U.S. Government-owned excess property; or fertilizer. In the event the Grantee outlined a specific need for any of these goods in its proposal, and provided full disclosure of the reason, source, method of selecting the source, price comparisons, and other pertinent information, the Grantee may assume that approval of such specific goods is provided through award of this document. Any changes to requirements outlined in the proposal must be submitted for review and approval.

Also, attached is a partial list of authorized countries for acquisition of goods and services. In general, the order of preference is (1) U.S.; (2) Cooperating Country (i.e., country of location for prime and sub); (3) selected free world countries (see Code 941 countries, attached); and (4) special free world countries (Code 935, attached). These rules apply to source (place of purchase), origin (place of manufacture) and nationality (of supplier). When the Grantee uses other than U.S., documentation must be retained for audit purposes which indicates one of the following conditions: (1) procurement was of an emergency nature; (2) higher preference sources' prices are at least 50% higher; (3) impelling local political considerations preclude consideration of higher preference sources; (4) item is only available from the intended source; or (5) procurement from the identified source best promotes the objectives of the U.S. Foreign Assistance program.

IV. GRANT ADMINISTRATION AND CLOSEOUT

A. Responsibilities and Authority

1. Only the Grant Officer has the authority to modify the terms and conditions of this Grant. The Grantee must exercise care in considering various situations. In general, if any portion of the Grant must be changed to reflect the Grantee's intentions, the Grant Officer should be so notified, in writing with a copy to the Project Officer, or his designee. This correspondence should outline the change needed, the reason, and the impact (technical and financial), and should request approval to make such change.
2. The Project Officer, or his designee, is the Embassy's contact point for all issues not addressed to the Grant Officer. This includes, but is not limited to, technical clarifications, certain budget changes, voucher tracking, etc.

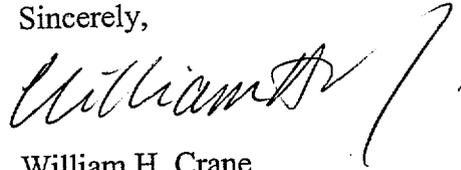
B. Closeout Procedures

1. The following definitions shall apply for the purpose of this section:
 - a. **Closeout:** The closeout of a Grant is the process by which the Embassy determines that all applicable administrative actions and all required work of the Grant have been completed by the Grantee and the Embassy.
 - b. **Date of Completion:** The date of completion is the date on which all work under the grant is actually completed, or the date on the award document, or any supplement or amendment thereto, on which the Embassy sponsorship ends.
 - c. **Estimated Completion Date:** The date contained in the Grant which is anticipated to be the "Date of Completion". This date may be modified to reflect delays or other reasonable circumstances which warrant extension of the time period. Requests for such revisions should comply with the above IV.A.1. requirements for Grant Officer approval, and should be submitted sufficiently (not less than 120 days) in advance of the estimated completion date contained in the Grant to permit evaluation and action prior to that time.
 - d. **Disallowed Costs:** Disallowed costs are those charges to a Grant that the Grant Officer determines to be unallowable, in accordance with the applicable Federal cost principles or other conditions contained in the Grant.

2. The following outlines specific requirements which must be met prior to initiation of the closeout process:
 - a. Upon request, the Embassy shall make prompt payments to a Grantee for allowable reimbursable costs under the Grant being closed out.
 - b. The Grantee shall immediately refund any balance of unobligated (unencumbered) cash that the Embassy has advanced or paid and that is not authorized to be retained by the Grantee for use in other Grants.
 - c. The Embassy shall obtain from the Grantee within 90 calendar days after the date of completion of the Grant, all financial, performance, and other reports required as the condition of the Grant. The Embassy may at its discretion grant extensions when requested by the Grantee.
 - d. When authorized by the Grant, the Embassy shall make a settlement for any upward or downward adjustments, to the Embassy's share of costs after these reports are received.
 - e. The Grantee shall account for any property acquired with funds provided herein or received from the U.S. Government, as discussed in Attachment One, Schedule.
 - f. In the event a final audit has not been performed prior to the closeout of the Grant, the Embassy shall retain the right to recover an appropriate amount after fully considering the recommendations on questioned costs resulting from the final audit.

Please sign all copies of this letter to acknowledge receipt of this Grant. Keep two copies for your files and one for the Principal Investigator, and return the **original** and all remaining copies to this office.

Sincerely,



William H. Crane
Grant Officer
American Embassy, Tel Aviv

Attachments:

No.	Title	Page
ONE	Schedule	9
TWO	Program Description	21
THREE	Payment Forms	31
FOUR	Performance Reports - Guidelines	39
FIVE	Mandatory Standard Provisions	49
	& Required as Applicable Standard Provisions	55

ACKNOWLEDGED:

DATE: _____

INSTITUTION: ISRAEL OCEANOGRAPHIC & LIMNOLOGICAL RESEARCH

AUTHORIZED INDIVIDUAL: _____ EYAL EREZ א״ל ערז

DEPUTY DIRECTOR GENERAL סמנכ״ל

SIGNATURE: Eyal TITLE: _____

PRINCIPAL INVESTIGATOR: Dr. Baruch Rinkevich DATE: May 5th, 98

SIGNATURE:  TITLE: DR. B RINKEVICH

FISCAL DATA:

Proposal No.: C14-015
 Appropriation No.: 19-80113
 Obligation No.: 4437814015
 Allotment No.: 4437
 Function Code: 8550
 Object Code: 4220
 Amount Obligated: \$ 200,000
 Total Estimated Amount: \$ 200,000
 Project Office: U.S. Embassy Tel Aviv, ECON/AID
 Voucher Paying Office: RAMC/PARIS

NUMERICAL LIST OF CURRENT AID GEOGRAPHIC CODESCode 935:

SPECIAL FREE WORLD

Any area or country in the Free World* including the cooperating country itself.

Code 941:

SELECTED FREE WORLD

Any independent country in the Free World*, excluding the cooperative country itself and the following:

Europe		Others	
Albania	Lithuania	Angola	Kyrgyzstan
Andorra	Luxemburg	Australia	Mongolia
Armenia	Macedonia**	Bahamas	New Zealand
Austria	Malta	Bahrain	Qatar
Azerbaijan	Moldova	Canada	Saudi Arabia
Belgium	Monaco	Cyprus	Singapore
Bosnia and Herzegovina	Montenegro**	Gabon	South Africa
Bulgaria	Netherlands	Hong Kong	Taiwan**
Belarus	Norway	Iceland	Turkmenistan
Croatia	Poland	Japan	United Arab Emirates
Czech Republic	Portugal	Kazakhstan	Uzbekistan
Denmark	Russia	Kuwait	
Estonia	San Marino		
Finland	Serbia**		
France	Slovak Republic		
Georgia	Slovenia		
Germany	Spain		
Greece	Sweden		
Hungary	Switzerland		
Ireland	Ukraine		
Italy	United Kingdom		
Latvia	Vatican City		
Liechtenstein			

* "Free World" excludes the following areas or countries:

Afghanistan, Cambodia, Cuba, Iran, Iraq, Laos, Libya, North Korea, People's Republic of China, Syria, and Viet Nam.

** Has the status of a "geopolitical entity", rather than an independent country.

Attachment One

SCHEDULE

A. Purpose of Grant

The purpose of this Grant is to provide support for the proposal entitled "**Costa Rican Coral Reefs Under Siltation Stress: Assessment, Restoration & Management**", which is hereby incorporated by reference. This proposal was revised on *April 23, 1998*. All changes reflected in subsequent revisions are applicable to this Grant award.

B. Period of Grant

The effective date of this Grant is the date of the Grant Letter. The estimated completion date is *April 30, 2003*.

Funds obligated herein are available for program expenditures during the period *May 1, 1998*, through *April 30, 2003*.

C. Amount of Grant and Payment

1. The American Embassy, Tel Aviv, hereby obligates the amount of **\$200,000** for the purposes of this Grant.
2. Payment shall be made to the Grantee in accordance with the procedures as set forth in Attachment Four (4), Required as Applicable Standard Provision No. One, entitled "Payment - PERIODIC ADVANCE".
3. All financial reports required by this provision shall be identified by the Grant No. and the CDR Proposal No., and shall be submitted to:

**Office Of The Science Counselor
U.S. Embassy
71 Hayarkon Street
Tel Aviv 63903
Israel**

D. Grant Budget

The following is the budget for this Grant which includes local cost financing items, if authorized. Revisions to this Budget shall be made in accordance with the Mandatory Standard Provision of this Grant entitled "Revision of Grant Budget". Within the total estimated amount of this Grant, the Grantee may adjust the line items as may be reasonably necessary for the performance of the Grant program. Such changes require coordination with the Project Officer.

Element	Estimated Amount	
	I O L R	C O S T A R I C A
Salaries	\$40,000	\$30,000
Diving Equipment	\$0	\$4,000
Materials	\$8,400	\$3,500
Travel - Int'l	\$25,000	\$13,000
Travel - Dom	\$5,000	\$31,300
Bench Fees	\$12,000	\$0
ODC	\$0	\$6,000
Indirect Costs	<u>\$13,600</u>	<u>\$8,200</u>
Sub-Total	\$104,000	\$96,000
Total	\$200,000	

In no event may the Grantee expend any amount above the obligated amount or the total estimated amount of this Grant, whichever is less. The U.S. Government is under no obligation to reimburse the Grantee for an amount in excess of the obligated amount.

E. Grant Participants:

Principal Investigator	Costa Rica	Project Officer
Dr. Baruch Rinkevich National Institute of Oceanography POB 8030, Tel Shikmona Haifa 31080 Israel	Dr. J.Cortés CIMAR University of Costa Rica San José Costa Rica	Mr. William Crane Science Counselor American Embassy Tel Aviv Israel

F. Reporting and Evaluation

Reports, the Principal Investigator's responsibility, must be sufficiently detailed to substantiate the findings and to permit a scientific evaluation of the research. Overseas collaborators shall be given fair credit for their participation in the research and a chance to review and comment on the Final Report before it is submitted. The principal investigator will share a draft of the Final Report with the Project Officer and AID/G/EG for comments prior to the formal submission.

Distribution of specific reports is outlined in individual report specifications, below.

All references to AID/G/EG shall mean: U.S. Agency for International Development; Bureau for Global Programs, Field Support and Research; Center for Economic Growth; Room 2.11; Washington, D.C. 20523-2110.

All references to AID/PPC/CDIE shall mean: PPC/CDIE/DI, U.S. Agency for International Development, Room 6.07 -154, RRB, Washington, DC 20523-6701.

1. Performance Reports: Required every six months. (A short semi-annual report and a substantive annual report). The principal investigator will submit reports stating what has been accomplished to date and detailing project management issues. A Financial Status Report will be attached to each report. Reports are due within sixty (60) days after the end of each six-month period. Four copies of each report are to be submitted to AID/G/EG; one copy to the Project Officer; and one copy to the USAID mission in the country of the collaborator.
2. Final Performance Report: Within ninety (90) days after the estimated completion date of the Grant, the principal investigator will submit this report to the same recipients in the same quantities as specified above.

Publication of results in scientific journals is encouraged. Additional guidance on report preparation is given in the "Interim Guidelines on Projects", available from AID/G/EG.

Financial reports shall be in accordance with the applicable payment provision.

G. Special Provisions

1. While in the country of collaborating institutions, the Grantee will keep the USAID field mission generally apprised of their work, but will not request administrative support except for the usual in-country introductions as may be appropriate. The Grantee will abide by Mission and host government regulations and customs as they apply to other AID supported in-country activity.

2. The principal and co-principal investigators of the Grantee and its primary sub-grantee, and essential scientific staff which were identified as critical to the success of the program prior to award of this Grant will not be changed without the prior written approval of the Project Officer.
3. Mandatory and Required as Applicable Standard Provisions for Non-U.S. Non-governmental Grantees are set forth as Attachment 5 to this Grant.

4. Overhead Costs

As part of the application process, the Grantee has agreed to absorb all indirect costs associated with this program in excess of the following which was agreed upon:

Overhead may be charged to this grant at a rate not to exceed fifteen percent (15%) and ten percent (10%) of the Total Direct Costs for Israel and Costa Rica respectively. This rate is considered fixed for the life of the Grant. If actual costs to the institutions are less than this ceiling rates, the Embassy shall only be requested to fund at the actual cost rates.

5. The title to all property acquired under this Grant will vest in the Grantee in accordance with applicable regulations contained herein. Property purchased for use by the collaborating institution shall vest in that institution. In light of the objectives of institutionalization within collaborating institution countries, equipment purchased for this use shall remain the property of that institution. Property titled to the Grantee shall be identified upon completion and disposition will be agreed upon. In general, the U.S. Government anticipates the transfer of this equipment to the Grantee if a valid continuation research activity is envisioned, particularly another under this CDR Program.
6. Compliance with Federal Guidelines and Regulatory Procedures:
 - a. The Grantee will implement this research activity in accordance with all relevant guidelines for U.S. Government funded research such as:
 - (1) The National Institutes of Health (NIH) guidelines for the ethical treatment of human subjects;
 - (2) Guidelines for the handling of radioactive materials;
 - (3) NIH and USDA guidelines for the handling of pathogenic microorganisms;

(4)
USDA-APHIS procedures for animal and plant health inspection;

(5)
NIH Guidelines for Research Involving Recombinant DNA Molecules;

(6)
Procedures issued by the USDA, EPA, or other appropriate federal agency, regarding testing of genetically engineered organisms;

(7)
State Department's and AID's environmental procedures; and

(8)
Such other Federal guidelines and procedures as may apply during the course of research.

- b. All existing comparable guidelines of the host country in which the research is actually located must be followed also.
- c. Reports submitted under this activity to U.S. Embassy/Tel Aviv and AID/G/EG will address the cited regulatory issues. All modifications of protocols affecting these regulatory concerns must be reported. The investigators are responsible for reporting any difficulties encountered in implementing these protocols.

7. Laboratory Safety and Hazard Containment:

Research will be conducted following the protocols described in the Grantee's proposal, as revised, which insure the safety of persons involved in the research. All research shall be conducted following procedures issued by the U.S. Government and those issued by the government of the host country for the containment of these hazards.

If the protocols involving laboratory safety and hazard containment are revised, they must be re-reviewed by the investigator's institutional review committee(s) that approved the original protocol, and the Project Officer and AID/G/EG must be informed in writing before the revised protocols are used. The revised procedures must be consonant with the guidelines of the country in which the laboratory is located and of the United States. Copies of the approval of the revised protocols by the investigator's institutional review committee(s) should also be provided the Project Officer and AID/G/EG.

Similarly, the research will be conducted in the facilities described in the Grantee's proposal, as revised. If the research is moved to new facilities, or the facilities are modified in such a way to affect safety or hazard containment, a description of the new facilities must be provided to the Project Officer and AID/G/EG before the research is effected. Any applicable institutional reviews of the facilities must be repeated, and the re-certification must be provided to the Project Officer and AID/G/EG.

8. Humane Treatment of Experimental Animals:

a. Principles for the Treatment of Vertebrates: The Grantee will adhere to the following principles for the utilization, care and transportation of vertebrate animals used in testing, research and training. For guidance throughout these principles, reference is made to the Guide for the Care and Use of Laboratory Animals prepared by the Institute of Laboratory Animal Resources, National Research Council.

(1)

Procedures involving animals should be designed and performed with due consideration of their relevance to human or animal health, the advancement of knowledge, or the good of society.

(2)

The animals selected for a procedure should be an appropriate species and quality and the minimum number required to obtain valid results. Methods such as mathematical models, computer simulation and in vitro biological systems should be considered.

(3)

Proper use of animals, including the avoidance or minimization of discomfort, distress, and pain when consistent with sound scientific practices, is imperative. Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals.

(4)

Procedures with animals that may cause more than momentary or slight pain or distress should be performed with appropriate sedation, analgesia, anesthesia. Surgical or other painful procedures should not be performed on unanesthetized animals paralyzed by chemical agents.

(5)

Animals that would otherwise suffer severe or chronic pain or distress that cannot be relieved should be painlessly killed at the end of the procedure, or, if appropriate, during the procedure.

(6)

The living conditions of animals should be appropriate for their species and contribute to their health and comfort. Normally the housing, feeding, and care of all animals used for biomedical purposes must be directed by a veterinarian or other scientist trained and experienced in the proper care, handling, and use of the species being maintained or studied. In any case, veterinary care shall be provided as indicated.

(7)

Investigators and other personnel shall be appropriately qualified and experienced for conducting procedures on living animals. Adequate arrangements shall be made for their in-service training, including the proper and humane care and use of laboratory animals.

(8)

Where exceptions are required in relation to the provisions of these principles, the decisions should not rest with the investigators directly concerned, but should be made, with due regard to U.S. and host country regulations, by an appropriate review group such as an institutional animal research committee. Such exception should not be made solely for the purpose of teaching or demonstration.

- b. **Applicable Regulations:** The transportation, care and use of animals should be in accordance with the U.S. Animal Welfare Act (7 U.S.C. 2131 et. seq.) and other applicable U.S. Federal laws, guidelines, and policies. All research shall be conducted following procedures issued by the government of the host country for the humane treatment of experimental animals.
- c. **Compliance with Reviewed Protocols:** Research will be conducted following the protocols described in the Grantee's proposal, as revised, which insure the humane treatment of experimental animals.
- d. **Revision of Protocols:** If any protocol involving the experimental animals is revised, it must be re-reviewed by the investigator's institutional review committee(s) that approved the original protocol, and the Project Officer and AID/G/EG must be informed in writing before the revised protocol is used. The revised procedure must be consonant with the guidelines of the country in which the animals are affected, and of the United States. Copies of the approval of the revised protocol by the investigator's institutional review committee(s) should also be provided the Project Officer and AID/G/EG.
- e. **Facilities for Animals:** The animals will be maintained in the facilities described in the Grantee's proposal, as revised. All animals shall be provided facilities satisfying the requirements specified by the U.S. Government and those issued by the government of the host country for the humane treatment

of experimental animals. If the animals are moved to new facilities or the facilities are modified in such a way to affect the animals, a description of the new facilities must be provided to the Project Officer and AID/G/EG before the change is effected. Any applicable institutional reviews of the facilities must be repeated, and the re-certification should be provided to the Project Officer and AID/G/EG.

9. Human Subjects

Research will be conducted following the protocols described in the Grantee's proposal, as revised, which insures the well-being and informed consent of human subjects. It will also be conducted in accordance with the applicable procedures issued by the U.S. Government to insure ethical treatment of human subjects, and by those issued by the government of the host country in which the human subjects are to be involved.

If any protocol involving human subjects is revised, it must be re-reviewed by the investigator's institutional ethical review committee, and the Project Officer and AID/G/EG must be informed in writing before the revised protocol is used. The revised procedures must be consonant with the guidelines of the host country and of the United States. If the patient's informed consent form is revised, a copy of the new form must be submitted to both the Project Officer and AID/G/EG. A copy of the approval of the revised form by the investigator's institutional ethical review committee must also be provided to the Project Officer and AID/G/EG.

In addition and prior to commencement of any experimentation involving human subjects, the Grantee shall make a judgment and communicate the same to AID/G/EG as to whether the regulations, procedures or facilities of the country in question are adequate to ensure the safety and free and informed consent of the human subjects. In the event such judgment is that they are not, the Grantee, the Project Officer, and AID/G/EG will consult and agree on the protocol to be applied to insure the safety and free, informed consent of the subjects.

10. Containment and Safe Disposal of Animal or Plant Pathogens or Pests

Research will be conducted following the protocols described in the Grantee's proposal, as revised, which insure the containment and safe disposal of animal or plant pathogens. All research shall be conducted following procedures issued by the U.S. Government and those issued by the government of the host country for the containment of these pathogens or pests.

If any protocol is revised, it must be re-reviewed by the investigator's institutional review committee(s) that approved the original protocol, and the Project Officer and AID/G/EG must be informed in writing before the revised protocols are used. The revised procedures must be consonant with the guidelines of the country in which the laboratory is located and of the United States. Copies of the approval of the revised

protocols by the investigator's institutional review committees should also be provided to the Project Officer and AID/G/EG.

Similarly, the research will be conducted in the facilities described in the Grantee's proposal, as revised. If the research is moved to new facilities or the facilities are modified in such a way to affect safety or hazard containment, a description of the new facilities should be repeated, and the re-certification should be provided to the Project Officer and AID/G/EG.

11. International Shipment of Organisms, Biologicals, or Controlled Materials or Equipment Procedures for the international shipment of these materials must be in accordance with those approved in the permits cited in the Grantee's proposal, as revised. All such shipments shall be in compliance with International Import/Export Regulations for all countries to and from which regulated items are shipped. If the shipment procedures are varied from those specified for permits, permits for the revised procedures must be provided to the Project Officer and AID/G/EG before shipping commences.

12. Recombinant DNA

- a. Research will be conducted following the protocols described in the Grantee's proposal, as revised, which ensure the containment of recombinant organisms. If any such protocol is revised, it must be re-reviewed by the investigator's institutional review committee(s) that approved the original protocol, and the Project Officer and AID/G/EG must be informed in writing before the revised protocol is used. Copies of the approval of the revised protocol by the investigator's institutional review committees should also be provided to the Project Officer and AID/G/EG.

Similarly, the research will be conducted in the facilities described in the Grantee's proposal, as revised. If the research is moved to new facilities, or the facilities are modified in such a way to affect safety or containment, a description of the new facilities must be provided to the Project Officer and AID/G/EG before the research is effected. Any applicable institutional reviews of the facilities should be repeated, and the re-certification should be provided to the Project Officer and AID/G/EG.

- b. Notwithstanding the above:

- (1)

The Grantee and its subgrantees may not commence testing in any foreign location until written approval for testing is obtained from the Project Officer, AID/G/EG and the government of the country where testing is planned. Testing shall be conducted in accordance with all applicable regulations of that country.

(2)

In addition, however, and prior to commencement of any such testing, the Grantee shall make a judgement and communicate the same to the Project Officer and AID/G/EG as to whether the regulation, procedures or facilities of the country in question are adequate to ensure testing in an environmentally sound manner. In the event such judgement is that they are not, the Grantee, the Project Officer, and AID/G/EG will consult and agree on the conditions to be applied to the testing which will have such environmental effect.

(3)

Reports submitted under this activity to the Project Officer and AID/G/EG will address regulatory issues as above related to the activity.

13. Endangered Species

Research will be conducted following the protocols described in the Grantee's proposal, as revised, which insure the protection of endangered species. All research shall be conducted following procedures issued by the U.S. Government and those issued by the government of the host country for the protection of endangered species.

If any protocol involving these species is revised, it must be re-reviewed by the investigator's institutional review committee(s) that approved the original protocol, and the Project Officer and AID/G/EG must be informed in writing before the revised protocols are used. The revised procedures must be consonant with the guidelines of the country in which the species are to be affected, and of the United States. Copies of the approval of the revised protocol by the investigator's institutional review committees should also be provided the Project Officer and AID/G/EG.

In addition, however, and prior to commencement of any such activity which may affect an endangered species, the Grantee shall make a judgment and communicate the same to the Project Officer and AID/G/EG as to whether the regulations, procedures, or facilities of the country in question are adequate to ensure the protection of those species. In the event such judgment is that they are not, the Grantee, the Project Officer, and AID/G/EG will consult and agree on the conditions to be applied to the activity which will protect that species.

14. Environmental Hazards

Research will be conducted following the protocols described in the Grantee's proposal, as revised, which insure that there are no unacceptable environmental

hazards incident to the research. All research shall be conducted following AID and U.S. Department of State environmental guidelines and those issued by the government of the host country.

If any protocol involving environmental hazards is revised, it must be re-reviewed by the investigator's institutional review committee(s) that approved the original protocol, and the Project Officer and AID/G/EG must be informed in writing before the revised protocol is used. The revised procedure must be consonant with the guidelines of the country in which the research is located and of the United States. Copies of the approval of the revised protocol by the investigator's institutional review committee(s) must also be provided to the Project Officer and AID/G/EG.

In addition, however, and prior to commencement of any such activity which may create an environmental hazard, the Grantee shall make a judgment and communicate the same to the Project Officer and AID/G/EG as to whether the regulations, procedures or facilities of the country in question are adequate to ensure the protection of the environment. In the event such judgment is that they are not, the Grantee and the Project Officer and AID/G/EG will consult and agree on the conditions to be applied to the activity which will ensure environmental protection.

15. Intellectual Property Rights

Intellectual property rights stemming from the activities supported under this Grant will be apportioned as described in the Grantee's proposal, as amended. If the participants choose to modify that apportionment, the revised apportionment must be submitted to the Project Officer and AID/G/EG for approval before it takes effect.

Attachment Two

PROGRAM DESCRIPTION
(Technical Work Plan - excerpts)

TECHNICAL WORK PLAN

The proposed study is planned to be conducted for a period of four years, through the following four main routes:

1. Long term determination of suspended and re-suspended sediments in the studied areas.
2. Evaluation of siltation stress on the population and colony levels.
 - a) Long term monitoring photostation surveys.
 - b) Histopathological studies.
 - c) Reproduction under siltation stress - a field study.
 - d) In situ growth rates and patterns of growth as influenced by sedimentation.
3. Restoration of sediment-stressed coral reef and denuded areas by:
 - a) Coral fragments
 - b) The use of sexual recruits both by transplantation of gravid colonies to denuded areas and by newly metamorphosed larvae collected and settled in the laboratory.
4. Training of Costa Rican scientists in reef management, histology and histopathology of corals.

C 1. Suspended and re suspended sediments - a field survey

Field stations will be established in both sides of Costa Rica: in Parque Nacional Cahuita (the Caribbean Sea) and Golfo Dulce (Pacific Ocean). Both areas are heavily stressed by siltation Cortes and Murillo, 1485a; Cortes and Risk 1985; Cortes, 1990). All field studies and observations listed below (parts C3, C4, respectively) will be done in these field stations (see detailed area description, part C2). Therefore it is necessary to determine, in a long-term study, the annual fluctuation of the suspended and resuspended sediments. Both values will give the "whole picture" of the siltation stress, since the suspended sediments that laid on the bottom, but resuspended into the water column as a result of wave actions, currents, storms, reef walkers, etc., are potentially very dangerous to the corals (Cortes and Risk, 1985; Neil, 1990) It is also very important to evaluate the height above the substrate to which the resuspended sediments are moved. For example, in an earlier study done within Parque Nacional Cahuita, Cortes and Risk (1985), have recorded variable values of $20-1179 \text{ mg cm}^{-2} \text{ day}^{-1}$ at 25cm, and $14-666 \text{ mg cm}^{-2} \text{ day}^{-1}$ at 75cm. These data are also very important in planning transplantation of coral fragments and/or recruits.

To measure sediment resuspension, we will use sediment traps as constructed by Cortes and Risk (1985), plastic cylinders with an opening area of 21.2 cm^2 Sediment traps will be set in triangular arrays at 25, 50, 75 and 100 cm above substrate in the chosen stations at each locality. Traps will be put once a month for 2 days for a period of 3 years. Contents of collected traps will be washed through preweighed filters ($0.45\mu\text{m}$) rinsed with distilled water, poisoned by sodium azide (10^{-3}M), dried and weighed. The weighed filters will be acidified(1M HCl) to remove calcium carbonate sediments, dried and reweighed. This procedure will provide us with the relative contribution of terrigenous sediments to the resuspension particles.

Background values of suspended particulate matters will be taken once a month from surface waters, by sampling 1 liter. Water samples will be poisoned by sodium azide, filtered through preweighed filters, dried and reweighed.

C 2. Description offield stations

Both of the selected zones, Golfo Dulce in the Pacific coast and Cahuita National Park on the

Caribbean coast, are, on the one hand, the most heavily stressed areas by siltation, and on the other hand represent zones which show sufficient variation with regard to sedimentation. Since both areas contained live flourishing reefs, partially dead and completely dead reefs, all comparisons can be made within the same selected area without being involved in comparisons of areas with significantly different environmental conditions.

Golfo Dulce in the southern Pacific coast of Costa Rica is about 50 km long and 10-15 km wide (covering an area of ca. 680 km²). It is an enclosed embayment of tectonic origin located in one of the wettest regions of Costa Rica, with 4 major rivers (Fig. A) which carry an enormous amount of terrigenous sediments (as a result of soil erosion, dredging for gold mining, deforestation, cultivation of bananas in the river basin areas, and more; Cortés, 1990). Field observations have indicated that water circulation in the gulf is similar during both ebbing and flooding tides, and the water flow has counterclockwise directionality (Fig. A). This water flow moves along areas of pristine reefs (nos. 1,2 in Fig. A), partly dead reefs (no. 3 in Fig. A) or destroyed reefs (nos. 4, 5 in Fig. A). In this area we will establish 5 working field stations in which the work and studies described in sections C1, C3 and C4 will be carried out: the field surveys for suspended and resuspended sediments, the study on the stress enforced by siltation on the colony and population levels (photostation surveys, histopathological changes, reproductive activities of corals, growth rates) and the studies on rehabilitation of stressed reefs (the use of sexual and asexual recruits). For a detailed description of Golfo Dulce including reef descriptions, anthropogenic disturbances, sediments and aerial figures of selected areas, see Cortés (1990).

Cahuita National Park is the most significant coral development on the Caribbean coast of Costa Rica (Hands et al., 1993). This coral reef shows low live coral coverage and species diversity and large average colony diameters. The amounts of suspended and resuspended particulate matter were found to be very high, and a large amount of terrigenous material was usually trapped inside the long, massive corals (Cortés and Risk, 1985). A detailed study on the area has shown that coral growth rates are low and are significantly inversely correlated with sediment resuspension rates (Cortés and Risk, 1985). Like other coral reef areas, the coral reef along Cahuita National Park is not evenly distributed or developed, having areas of more pristine reefs and others largely affected by the siltation stress. For example, the reef to the north has well developed buttresses, but the live coral coverage is very low. The highest live coral coverage occurs near Puerto Vargas. In this area, tides are predominantly diurnal with a mean range of only 0.5-0.4 m. Swell breaking over the outer reef generates powerful flushing currents, to different directions, forming a variation in local environmental conditions. As a result, the lagoon water carries, on the average, up to three times as much suspended particulate matter as does the outer crest (Cortés and Risk, 1985). Three field stations (1-3, Fig. B) will be established in the reefs at Parque Nacional Cahuita. As in Golfo Dulce, these 3 field stations will be used for the study described in sections C1, C3 and C4. A detailed description of this area can be found in Cortés and Risk (1985), Hands et al. (1993) and literature cited.

Both studied locations (Golfo Dulce and Cahuita National Park) are relatively restricted, and each one of them has different habitats which are under relatively similar general environmental conditions (such as storms, sunlight hours, water temperature, etc.). On the other hand, each studied location shows significant variation with regard to sedimentation load and siltation stress: some of the sites within each location are the most pristine habitats along the coasts of Costa Rica, others are almost completely devastated by the impact of sedimentation. This ensures that the results obtained in the proposed research will be correctly evaluated with sedimentation stress and not resulting from non-related causes.

C:3. Siltation stress - Studies on the population and colony levels

There are at least 16 sets of different characteristics for monitoring coral responses to siltation stress (Peters and Pilson, 1985; Rogers, 1990). Out of these parameters we have chosen four characteristics, one on the population level and three on the colony level. The rationale for choosing these characteristics was the relatively simple methodology involved and the potential significant data which may be accumulated by using these parameters on the long term. Parameters which give

results within a very short period of time (such as differences in biochemical composition, follow-up methods of radioactive labeled compounds, etc.) were not chosen, although some of them may be adapted later on for a follow-up study. The Population level - A long term study of monitoring photostations is planned to be conducted in both areas of interest. To quantify the overall influence of stressors (such as siltation stress) on the population level, there is a need for long term observations in a specific area of interest. It is true that changes as a result of chronic stress (not by extreme phenomena such as hurricanes, rapid sea level changes, etc.) may be manifested in a way that can be detected by current methodology only after a long period of time, sometimes 10 years or more (Hughes and Jackson, 1985; Done, 1992b). In order to follow changes as a result of siltation stress, we propose to start (in the first stage of research, a three years follow-up study is planned) a long term study on the community structure of Costa Rican coral reefs. This is the first such research in sedimentation stressed coral reefs.

There are several methods of monitoring a specific reef site. We have chosen the technique of photostation surveys, a technique which gave significant results (for example: Porter and Meier, 1992), and in some aspects is superior to the plotless and transect methods (Loya, 1978), especially for measuring specific colony growth rates, growth patterns, fission, fusion, and coral mortality.

Several quadrat photostations (of 2x2 m each) will be set up in each of the studied reefs in the same area where the sedimentation traps will be set. The number of photostations will be determined in accordance with the relative variability of the live coverage area. Photographs will be taken every 4 months with underwater camera (Nikonos V with a 28 mm underwater lens). Each quadrat will be divided into 16 smaller quadrats (0.5x0.5 m). Therefore 16 photographs are required to document each 4 mt photostation (2 stations can be photographed by a single 36 frame film). Each photostation will be permanently marked by 4 stainless steel stakes cemented by underwater epoxy glue to the substrate. Each survey will be performed by using black and white negative films, and repeated with color slide films for a backup set of information. Photographs will be analyzed by planimeter, attached to a desk-top computer.

The colony level - We plan to monitor in a long term study: 1) histopathological changes in coral tissue by using light microscopy on histological preparates; 2) reproductive activity of large colonies as studied by histological sections, and by laboratory in situ collections of planulae larvae; 3. growth rates, by using vital staining of the skeleton. All samples will be taken in the same areas of monitoring sediment loads.

The most common species will be studied in detail. In Golfo Dulce, the study will be concentrated on *Pocillopora damicornis*, *Pocillopora uarians*, *Psammocora stellata* and *Porites loData*. In Cahuita National Park we will study *Porites astreoides*, *Acropora palmata*, *Siderastrea siderea*, *Monastrea cavernosa*, and *Agaricia agaricites*.

Very limited data is available regarding reproductive activities, seasonality, and other aspects of the reproductive biology and ecology of Costa Rican corals. Although much effort has been

given to the Caribbean corals, in general (Srmant, 1986, 1991; Chornesky and Peters, 1987; Richmond and Hunter, 1990; Soong, 1991; Gittings et al., 1992; Johnson, 1992; and literature therein for earlier studies) the results that regional and annual variations in reproductive seasons exist between different parts of the Caribbean (Soong, 1991; Szmant, 1991; Johnson, 1992) emphasize the need for a detailed study on Costa Rican corals for their reproductive activities. In the Pacific side, information on coral reproduction has recently been available (Glynn et al., 1991; in press), However, this study was carried out on reefs not stressed by sedimentation (Isla del Cane in Costa Rica). These results will serve as an additional background for comparisons with the reproductive activities of corals from the silted reefs of Golfo Dulce. Although most of the study on the reproductive activities of corals will be concentrated on the above 9 oornmon species, all efforts will be given to add as much information to the reproductive activity of other coral species, to increase our understandi ng of coral reef biology in this area.

Only a few studies have incorporated histological examinations to reveal histopathological responses of cnidarians to sedimentation stress (Schumacher, 1979; Peters and Pilson, 1988; Peters and Yevich, 1989). These studies have recorded a loss of mucus secretory cells and nematocysts from the epidermis, which were not replaced, probably because energy reserves for cell replenishment were adversely affected (Peters and Yevich, 1989), the appearance of microparasites and more. Live coral specimens will be fixed by 4% neutralized formaldehyde solution for 24-48 hour, then washed in several changes of 70% ethanol before storing in 75% ethanol. Coral branches and samples will be decalcified (Rinkevich and Loya, 1979) and embedded in plastic blocks (JB4). Tissues will be sectioned at 2 um by ultramicrotome and stained with hemotoxylin and eosin. Additional sections from each specimen will be stained with Heidenhain's aniline blue method for revealing connective tissues, periodic acid schiff reaction (PAS) with alcian blue for mucus secretory cells, Heidenhain's iron hematoxylin for microparasites, chromic acid and osmium tetroxide method for lipid, and more. Specimens from stressed areas will be compared with samples taken from a relatively non-stressed site. Some of the histopathological studies will be taken in the laboratory at Haifa, israel, where all the facilities for histological protocols are available.

The reproductive activities of the above selected common coral species will be followed by studying JB-4 sections stained with the hematoxylin-eosin method. Samples of coral species will be taken every month in the first year of the experiments. Thereafter, samples will be taken in accordance with the reproductive season of each species. Tissue sections from heavily stressed areas will be compared with samples taken from non-stressed areas for: onset of reproduction, the average amounts of gonadsipolyp, changes in sexuality, percentage of sterile colonies, changes in the length of reproductive seasons and reproductive activities as measured by the number of produced eggs/larvae per coral head. The studied species will also be the main target for the active restoration phase of the proposed study, where larvae and coral fragments will be transplanted to different parts of the reef.

As in the histopathological study, the histological preparations and examinations will be conducted primarily in the laboratory in Haifa.

In situ growth patterns and rates will be performed by Vital staining the coral skeletons with Aiazarin Red S solution (Lamberts, 1974). The study will be done mainly on those species where reproductive activities and histopathological patterns will be revealed. The results of this study will be compared with the data obtained on growth rates of 8 species of scleractinians from Caio

island in the Costa Rican eastern Pacific (GurmBn and Cortés, 1989b). Living corals subjected to the alizarin (sodium-sulphalizarinate) dye dissolved in sea water (10-15 mg/l < 24h) incorporate the dye into their newly formed skeletons. The color remains in the skeleton as a permanent reddish line, indicating where calcification occurred during the experiment. Alizarin is very simple to use and does not require the sophisticated apparatus used for radioisotope protocols. Corals of different species will be stained by closing them within transparent plastic bags for 24 hours. These specimens will be sacrificed 1 year thereafter. The growth rates and changes in the shapes of the colonies will be compared between control and heavily stressed sites.

C 4. **Rehabilitation of stressed reefs**

This innovative approach of "gardening" stressed reef areas will be performed by using both sexual recruits and asexual recruits:

The use of sexual recruits - While the use of asexual recruits (transplantation of branches or colony fragments) may be used as an immediate and efficient methodology for rapid rehabilitation of denuded reef areas (see below), "gardening" the reefs via sexual recruits, although -a much slower process, has all the long term benefits of a proved method for increasing the genetic variability and heterogeneity of coral species. In areas where environmental conditions support sexual reproduction of corals, and suitable substrate is available, transplantation, for example, of gravid adult colonies into a denuded area may result in the highest return of effort (Richmond and Hunter, 1990). Moreover, detailed knowledge of the natural history of reef corals (including their reproductive patterns and seasonality,

larval behavior and settlement) is not only central to understanding ecological and evolutionary patterns and processes but is also required for successful management of stressed reef ecosystems (Johnson, 1992). Another advantage of using the sexual recruits is the case where sources of coral larvae may be found away from the denuded reefs, and there is great concern for a significant reduction in the coral genetic variability. One of the most striking examples is Cocos Island (Isla del Coco, Costa Rican Pacific Ocean) which is located approximately 500 km southwest to Costa Rican coasts. In 1982/1983, the reefs were adversely affected by the El Niño warming event, which resulted 5 years later in dramatic coral mortalities at all depths (1-24 m), bringing the live coral cover to a minimal density of 2.6-3.5% only (Guzman and Cortés, 1992). Because coastal reefs in Central and South America are down-current from Cocos Island, the nearest sources for coral larvae recruitment may be at least 6,500 km away (summarized in Guzman and Cortés, 1992).

Therefore, if long-distance dispersal is not feasible, the reefs have to be self-seeded (sensu Sammarco and Andrews, 1988). It was clearly stated that 'with reef degradation and destruction occurring on a global scale, an application of the reproductive data is in the area of reef recovery, since areas of reefs which have been denuded may be re-seeded (Richmond and Bunter, 1990). The stable, warm water conditions of Costa Rican seas provide a unique opportunity to study and practice this approach in detail. For example, in contrast to other coral reefs in the eastern Pacific, coral species in Costa Rica, such as *Pocillopora damicornis* and *P. elegans* (among the most important reef building taxa there), reproduce most actively, and up to 90% of all colonies contained gametes, year round (Glynn et al., 1991). Consequently, numerous pocilloporid recruits have been observed at some sites in Costa Rica (Glynn et al., 1991).

The detailed study on coral reproduction is depicted in section C3. For the use of sexual recruits, we will adapt two work strategies which will complement each other and will increase the

chances for successful application of this approach, the use of sexual recruits: (1) in situ transplantation of gravid colonies to denuded areas. (2) transplantation of newly metamorphosed coral colonies which were collected and settled in the laboratory, under the most protected conditions, to ensure high rates of metamorphosis.

Transplantation of gravid colonies (as was suggested by Richmond and Gunter, 1990) will be done under water in the most careful way to minimize any harm to the colonies. Gravid colonies at the peak of their reproductive season, just before shedding their gonads or planula-larvae, will be carefully detached from their substrates by using hammer and chisel and transplanted to denuded areas in containers with sea water or, if possible, by carrying them underwater for shorter distances. This method will allow the swimming coral larvae to be introduced into new areas in the reefs where previously, as a result of local water movement, currents, tides and/or highly stressed areas, the planula could not cross sites to settle in the denuded reef habitats. As such, the transplanted gravid colonies will be attached to different localities in the reefs: the fore and back reefs including the shallow reef tables. These colonies will be attached to the substrates by underwater epoxy resin, a fast and non-toxic glue. This study in the first year will concentrate on evaluating the possible success of this approach. For that purpose, a group of several (up to 10) gravid colonies ("reproductive seed") will be introduced into a denuded area. The area around this "reproductive seed" will be monitored regularly by SCUBA diving once every 3 months, 500 m on each side, to find new recruits. Control areas in both places (Parque Nacional Cahuita in the Caribbean Sea and Golfo Dulce in the Pacific Ocean) will be carefully selected. These areas will represent the same environmental conditions as the studied sites, but are found not only away from the studied sites but also in a position where currents from the studied areas with the "reproductive seeds" do not flow towards them. The control sites will be monitored in the same way. The first coral species to be studied will be *Pocillopora damicornis* in Golfo Dulce and *Porites aspreoides* in Parque Nacional Cahuita. These species were chosen because of their long reproductive season (Szmant, 1986; Glynn et al., 1991) and their fast growth rates (Guzman and Cortés, 1989b), allowing rapid detection of new growing recruits. It is the aim of this study to establish the potential of this approach. If this strategy of rehabilitation of denuded reefs will be found solid, then more coral species will be studied and a long-term experimental protocol will be carefully developed. This approach is a longterm one but from the ecological point of view has all the benefits of producing coral reef communities characterized by a high genetic variability.

Transplantation of newly metamorphosed coral colonies collected and settled in the laboratory - The major benefit of this approach is based on our experience that under laboratory conditions, many of the larvae settle and metamorphose, and the survival of very young coral individuals exceeds that of successful settlement in the field (unpublished). Coral colonies at the peak of their reproductive activity will be carefully transferred to the laboratory and put into aquaria just for the period necessary for the collection of reproductive products. Fertilized eggs, just shed from coral heads, and young swimming coral larvae will be collected in the laboratory from gravid colonies and allowed to settle and metamorphose on artificial objects (such as plastic substrates) or on natural substrates (pieces of coral skeletons, mollusc shells, etc.). Established new colonies will be transferred to the field and glued to the natural substrates by underwater epoxy glue. Survival and growth rates will be followed by photography and measuring the sizes of the recruits. In the Caribbean reefs planulae may be collected from the following species: the four *Agaricia* species, *Favia fragum*, *Manicina areolata*, *Isophyllia sinuosa*, *Mycetophyllia ferox*, two *Porites* species, and *Siderastrea radians* (Richmond and Gunter, 1990 and the literature therein). In the Pacific coast of Costa Rica, planulae of *Porites panamensis* and *Pocillopora* spp. may be collected (Smith, 1991, pers. obs.). Larvae of other species such as *Pocillopora damicornis* and *Tubastrea aurea*

(Richmond and Flunter, 1990) must be present but have not been observed or collected (Glynn et al., 1991, in press).

The use of asexual recruits By selecting coral species that were common, fast growing and easily attached to the substrate, Maragns (1974) has demonstrated the feasibility of coral transplants to rehabilitate a damaged reef in Hawaii, This approach was further used by other scientists, and more interestingly, good shortterm survival was recorded in corals transplanted over large localities From Florida reefs to reefs off the Texas coast (Fucik et al., 1984). Recently, a preliminary restoration experiment was carried out in two different shallow reef habitats along the Costa Rican coral reefs.

These experiments revealed that 80% of coral fragments, imported from a nearby reef and transplanted onto dead reef frameworks, survived after 3 years. These fragments also increased the number of living corals in the denuded reefs by 41-115% (Guzman, 1993).

Since the approach of transplanting coral fragments has already been practiced on a small scale by several scientists for many years and gave good results, we will start with a larger scale of transplantation using more species of corals. Easily fragmented species (usually branching corals, but also massive forms) will be subcloned to three size groups ranging from small branches (or ramets), medium size (several branches), to large coral fragments. The fragments will be planted in different habitats along the reef(the lagoon, the fore reef, the reef table and the back reef). We have already found (unpublished) that holding these coral fragments by plastic clips preglued to concrete plates reduced mortality and ensured rapid regeneration. As in the above experiments, the survival of branches planted in different sites and their regenerative capacities will be followed and documented by a two-monthly observation protocol. We will concentrate within the framework of this study in at least 7 species known to reproduce naturally by fragmentation: *Acropora palmata*, *A. ceruicornis*, *Madracis mirabilis*, *Porites furcata*, *Montastrea annularis* (from the Caribbean) and from the eastern Pacific: *Pocilloporum damicornis*, *Porites lobata* and *Pavona clavus* (literature cited in Highsmith, 1982; Guzmán and Cortés, 1989a; Guzman, 1991). Successful results of coral transplants on a Pacific reef of Costa Rica were published by Guzman (1991, 1993). This study further the direct effects of sedimentation on fragment survival and growth rates, a control reef (undisturbed or less disturbed by sedimentation) will be chosen in both oceans bordering Costa Rica. From each studied coral species, 50 coral heads will be subcloned, 25 transplanted into a heavily impacted reef, while the other 25 colonies will be subcloned for the control reefs. Only large colonies will be sampled, and therefore several hundreds of branches/fragments will be transplanted into the different habitats. All the fragments will be attached to the substrates in an upright position, away from other coral colonies, to reduce the possibility of intra- and inter specific competition. Conclusions will be drawn following the first phase of 3 years.

Both sexual and asexual recruits will also be tested for their survivorship and growth patterns/rates with their distance from the substrate (in accordance with the sediment traps which are situated 25,50,75, and 100 cm above the bottom). Recruits will be cemented into the reef or artificial objects with underwater epoxy glue. The statistical analysis of growth rates in areas affected by sedimentation will be compared to the control branches/colonies growing in areas affected by other environmental variables (dry vs rainy seasons, water temperature, sunlight hours), according to Guzman and Cortés (1989b). This will allow us to find the best choice of fragment size for each studied coral species and to evaluate the amount of work needed (manpower, feasibility of rehabilitating large denuded areas, etc.) to fulfill the future goals of the research. The main purpose of the present phase of the first 3 years is to find the best conditions where both types of recruits (sexual and asexual) will maximize their survivorship. The results obtained after the

3 year study will be used for an active program of restoration parts of heavily stressed reefs where no recruits are recorded (Cortés and Risk, 1985).

C 5. Training of Costa Rican scientists

During the 3 years of the proposed study, at least 3 Costa Rican or other Central American scientists (either graduated students or field technicians, not yet determined) are expected to visit Israel and to be trained in: 1. Coral reef management in the Coral Nature Reserve at Eilat, 2. Coral histological and histopathological studies and techniques in the National Institute of Oceanography, Haifa. Each scientist is expected to stay for at least several months to one year. This training will not only be relevant to this project but will enhance the research capability of Costa Rica and other Central American countries.

The coral nature reserve in Eilat has recently been stressed by elevated particle suspension in the water as a result of human activities (tourists, SCUBA divers, snorkelers, etc.) which raise the sediment from the bottom to the water column and harm coral colonies, as well as from recent floods which increase water column turbidity and buried parts of the reefs under fine, slurry muds.

The problem of "reef under mud" *sensu* Cortés and Murillo (1985a) has become a principal problem in the Red Sea coral reefs as well. We have recently started a project which aims to evaluate the effects of sedimentation and tried to develop protocols for reef rehabilitation, similar to what is presented in this AID-CDR proposal. Because of the smaller scale and the very defined studies, the coral reef at Eilat may serve as a "field laboratory" in which Costa Rican scientists may study the details of the work without being involved in a large-scale study. Therefore, all the components of the proposed study which involve coral sampling, transplantation, handling, larvae collection, vital staining, planula settling, evaluating the amount of sediments, underwater work, etc., will be done together with the Israeli partners, students from the laboratory at Haifa, and the PI.

The work in Eilat will also be conducted together with the people of the Nature Reserve Authorities, headed by the chief marine scientist, who deal in day-to-day problems of management, problems of pollution, collection of animals, tourism and more. Additionally, during the stay in Eilat, a small project dealing with the effect of reef walkers on sediment resuspension (*sensu* Neil 1990) will be undertaken. Therefore the work in Eilat will cover all aspects of reef management and field studies mentioned here. In Haifa, a laboratory study will cover all the aspects of histology, histopathology, and histochemistry of corals using our facilities for paraffin and plastic metacrylate (JB-4) sections. The histological training is a very important component of the proposed research. It will allow the Costa Rican scientists to establish a modern laboratory in Costa Rica working on several aspects of coral biology and ecology such as reproductive activities, infestation of parasites, the general "state of health" of the coral tissues sampled from different localities, and more. In Haifa, the training procedure will be undertaken by a qualified graduate student, a very skilled technician, and the Israeli PI.