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INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY
A Three-Volume Study

by

Judith Kildow
Principal Investigator

Massachusetts Institute of Technology

Cambridge, Massachusetts 02139

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Volume I

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Table of Contents

	Page
Volume I	
Foreword	1
Introduction	5
"International Transfer of Marine Technology: The Transfer Process and International Organizations" by David A. Kay	13
"The Role of Communication in the International Transfer of Marine Technology" by John Ball, Vinod K. Dar, and Marcia Levis	41
Volume II	
"Training and Technical Assistance in Marine Science: A Viable Transfer Product" by David A. Ross and Leah J. Smith	1
"Marine Mineral Resources" by Herbert D. Drechsler and Malcolm T. Wane	47
"Maritime Transportation Systems" by Henry S. Marcus	81
"Fishing and the Fishing Industry: An Account with Comments on Overseas Technology Transfer" by John Liston and Lynwood Smith	143
Volume III	
"Proposals for a United States Program in International Marine Cooperation" by Vinod K. Dar, Stephen Gibbs, Judith Kildow, Marcia Levis, and Lina Newhouse	1

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Foreword

This report is a response to the 1973 amendment to the National Sea Grant College and Program Act, and has been sponsored by the National Sea Grant Office. Through this amendment, Congress authorized and mandated that a study be done to determine more effective means for the United States to share marine science and technology with other nations. Recognizing the complex and interdisciplinary nature of the problem, the grant recipients at the Massachusetts Institute of Technology gathered together on several occasions a group of more than 30 experts representing academia, business and government to discuss the range of possibilities and limitations for improving the effectiveness of United States activities in international marine science and technology programs. These same experts authored and critiqued special studies in areas that required immediate attention. Three types of papers resulted, and appear in these volumes: 1) studies of socio-politico-economic aspects; 2) studies of scientific and technical aspects; and 3) a proposal for a hypothetical United States program in international marine science and technology sharing with an accompanying country case study of Mexico as a possible participant.

Thus, this report contains both conceptual and practical guides to assist the Federal Government in establishing more effective means for sharing marine science and technology with other nations.

A more basic problem was addressed in this study and should be noted here. While the legislation alluded to the needs of developing nations, and while the primary focus of this study is on those nations, the group of experts who participated in this effort made it very clear that the United States should take every opportunity to call upon the expertise of all nations in establishing such a program; that the United States does not have a monopoly on marine science and technology capabilities and should therefore look to other nations who also have advanced knowledge. Thus, industrialized as well as less developed nations could share in such programs and ultimately receive mutual benefit from them, establishing an environment of truly sharing rather than repeating the often ineffective attempts at unilateral assistance.

The report appears in three volumes. Volume I begins with a brief introduction that provides background information on the complexities of the range of issues covered in the study. Its purpose is to weave the diverse problems of foreign assistance, resource shortages, and Law of the Sea negotiations into a coherent set of issues for the reader. It is followed by a review and assessment of past and current foreign assistance programs. This paper points out the paucity of marine-related programs as opposed to land-based ones, and concludes that most programs to date have been ineffective. The second paper discusses a most important, but oft overlooked component for success -- communication and information transfer. This study identifies and evaluates the various communication channels in any international program, and uses the "Gatekeeper Theory" to explain how more effective means of communication can be achieved.

Volume II includes studies of the scientific and technical aspects of the problem. The first paper addresses the problem of scientific research and is written by an oceanographer and an economist who describe the few international cooperative programs that have already taken place in the marine area. They delineate the fields of oceanographic study, indicating areas where mutual benefit could be derived if research were carried out jointly by United States scientists and those from foreign developing lands.

The remaining papers in this volume address the technical and economic aspects. Taking several different marine industries, such as fishing and hard minerals, each author gives a detailed description of the industry, from research needs to marketing. Then, with an understanding of what the industry is about, the reader is informed of the infrastructure necessary to participate and enter the industry, stressing particularly, the paucity of resources available to developing nations, but suggesting possible alternatives for them.

Finally, incorporating the key ideas from Volumes I and II, Volume III confronts the mandate directly. The first paper is an actual proposal for a United States program in international marine cooperation, including substantive as well as administrative recommendations. It is followed by a country case study of Mexico. The authors describe the country's marine activities, assess the potential areas for cooperation with the United States, point out problem areas, and ultimately suggest why Mexico might be a good first candidate for participation in a new U.S. program.

Acknowledgments

The editor of these volumes and director of this study wishes to thank all those who participated for their prompt and valuable contributions. She also wishes to express her appreciation to Dr. Ayala-Castanaras and other members of the Mexican Government and scientific community for their assistance in making the Mexican Case Study possible.

Special thanks are also due Dr. Robert Abel, former Director of the National Sea Grant Program and his Associate Director, Mr. Robert Wildman, for their wholehearted support for this undertaking and their prompt assistance in helping the participants obtain information necessary to complete the study.

Finally, the director wishes to thank the Administration of MIT for its co-operation in making it possible to carry out such a complicated and unusual study.

Introduction

After several decades as recipients of foreign assistance with questionable results, and as producers of many of the world's land resources, more than a hundred nations, who describe themselves as "disadvantaged" have grasped the opportunity afforded them via the Law of the Sea negotiations to change concepts and practices in the development and allocation systems for resources from the seas. The seemingly limited nature of the earth's land resources and the possibility of only tenuous access to these resources in the future have spurred interest in the potentials of the oceans.

Notions of resources shortages -- ideological or real -- have provoked national policy inquiries on a global scale. Each nation has been compelled recently either from within or from external influence to examine its position with regard to its resource needs, and the current and potential implications for its economy. The formation of OPEC and the oil embargo that followed have only acted to catalyze this inquiry, which has broadened to include a multitude of other important resources, living and nonliving. Changes in the international system as well as advances in science and technology have exacerbated the problem of competition for the resources.

The Law of the Sea Conference, a set of meetings that has been taking place unofficially and officially since 1968, has provided an effective forum for discussion and negotiations regarding ocean resources as well as other ocean issues. While a potpourri of issues ranging from keeping open strategic straits to permitting freedom of oceanic research has received much attention, the issue that finally surfaced from the 100 or more other issues was resources -- who owns them, who can develop them, and who can distribute them. Scientific research in the oceans also is tied to this issue.

In retrospect, it appears that the "Third World"* nations saw the oceans as an effective vehicle through which to assert their influence and ideas. Their fears that some land resources were in short supply and that major technological advances enabled people in the industrialized world to exploit the ocean resources probably helped stimulate the oceans debate.

While rapidly developing marine food, mineral and energy technologies offer broadened opportunities, many Third World nations fear that these technologies will be used to their detriment. Because much of the technology, skills and

* Also referred to as the Group of 77, but numbering over 100 nations.

capital to use them resides in the industrialized world, these less developed nations claim that if they don't act, they will be bypassed by this new source of resource wealth and possibly even harmed by such resource developments that could cut into their own markets and weaken their already fragile economies.

Their concerns focus on international waters as well as coastal waters. Most nations agree that continental shelf resources belong to coastal states, and many new states are anxious to claim their newly acquired resources. The 200 mile fishing zone, also generally accepted by most nations, will provide yet another source of revenue and protein for states whose economies are weak. However, many nations states do not even have the capability to find out what resources they may own, and must depend upon the more industrialized countries to help them to find out -- whose scientists and engineers have the necessary training, equipment and money. Some questions are still unanswered. Who will have acess to data on marine resources? Who will be able to understand and use the data? And how can the information be used equitably for the development and utilization of global resources?

While scientists have been collecting resource-related information about foreign waters while on distant water cruises for more than 20 years, they have operated independtly most of the time. Usually, their information disclosures have been informal -- colleague to colleague -- except in publications, which often appear long after the research has been completed. And, scientists have not always published all of their information due to time and costs. Thus, a problem exists for representatives of foreign nations who want timely access to information collected in their waters. The proprietary nature of information also presents some problems. On the one hand, most ocean scientists represent public universities where policy dictates that information be in the public domain. Yet the governments of some nations prefer or even demand that information about their coastal lands be kept proprietary for economic and military reasons.

There is, however, a much larger problem. Even if the scientist resolves the problem of availability of information, there is not always a trained person with whom to share the information. Thus, many developing nations are asking for assistance in training some of their people, as part of the agreement to permit foreign scientists in their waters. Other nations hire companies or scientists from other universities to do the training or the work itself. When they do hire people to develop the resources, once they know the resources are there, proprietary information becomes very important for negotiating purposes.

The Law of the Sea meetings have clarified understanding of the international climate within which international cooperation must be fostered. The developing nations have made it clear that they are not interested in sporadic, informal efforts to cooperate in marine resource development. Many realize the importance, in the short run, of protecting their marine resources, and want to train their nationals and foster the growth of their marine institutions to maximize use of these resources. Some immediately want to seek technical and scientific expertise that will enable them to build up appropriate educational scientific systems, interpret data and assure some control over their resources in the future.

The need for cooperation grows as 200 mile zones come into effect. One estimate is that approximately 37 percent of the ocean space is within these resource zones. Officials from many of the coastal states wish to exploit and manage the resources of these zones, but without the manpower, capital, or equipment to do this, many coastal nations will have to forego this opportunity for many years.

Some generalizations can be drawn at this point.

Foreign scientists from industrialized nations need to compromise with representatives from developing nations in order to continue to do their research within 200 miles.

Developing nations have at least two options:

1. They can attempt to get foreign assistance to train their own people to develop resources;
2. they can hire others to develop the resources for them.

Both options require some understanding of the information, but to differing degrees.

Some valuable resources also exist in international waters. Jurisdiction over this territory remains controversial and may be unresolved for some time to come. Here, a 1968 United Nations Resolution claiming the resources of the deep ocean for the Heritage of Mankind has been interpreted in two ways. On the one hand, the Group of 77 claims it means the resources belong to no one unless everyone agrees to ground rules for development. On the other hand, many industrialized nations interpret this resolution to mean that the resources are there for anyone to take. A primary purpose of the Committee I negotiations of the Law of the Sea Conference is to arrive at a compromise solution over this issue.

Manganese nodules are the resource at issue, and there is little agreement over the management, development and utilization of this resource. Private industry in the United States, primarily, but also in other Western nations and Japan, has developed the technology to exploit and develop this resource. Yet, just because these resources are now available, the other nations, who do not have the technology, money, or skills to participate are demanding that these companies in some way share this potential wealth with them, in order to gain access to this resource.

While these industries believe that they are allowed to exploit the resource, they are unable to get the necessary financing from lending institutions because they have no assurance that their ventures will succeed in such an uncertain international political environment. International regulation governing exploitation of manganese nodules is nonexistent, and these corporations cannot obtain a license from any authority to show that their claims are legal. Until that happens, the banks appear uninterested in their plight. How can a corporation, which must answer to its stockholders, share a technology that requires almost unprecedented investment, with other nations, before any part of the investment is returned? It can't. Then, what can it do? It can agree to share revenues, when they begin to come in, and it can agree to share mine sites that it has explored with some international authority; and it can, but not happily, agree to control production of certain minerals to avoid cutting into already existing markets. In fact, the U.S. position has reflected all of these offers. And yet, the developing nations are not willing to accept a treaty and there is no compromise in sight. Sharing marine technology, particularly that which is in the forefront of its field, is almost impossible in a private enterprise system. There is no easy solution.

This case illuminates the problem of foreign technical assistance. It can act as a guide to any program the United States may initiate in the near future. Sharing of marine science and technology with other nations is best carried out under the following conditions:

1. If the technology is sophisticated and expensive and owned by a private corporation, it should be left to the private corporation to negotiate any sharing that will take place, so that it can be assured of some

benefit accruing from the agreement.

2. The Federal Government should only offer assistance when there is obvious benefit to be derived from such assistance by those who will be involved in giving the help. That is, if marine scientists must share time and facilities on their cruises, they should be reimbursed financially or otherwise by those receiving their assistance.
3. The Federal Government should only offer assistance in areas where it has jurisdiction and does not interfere with private enterprise.

Of course these are not steadfast rules and need not be adhered to blindly. The purpose for listing them here is to note that if they are not followed, great difficulties will follow in any attempts to coordinate the remaining sectors of the United States government to assure support for positions.

Of course, other ocean uses than resources interest the negotiating nations in the Law of the Sea meetings. Ocean transportation systems -- shipping and shipbuilding and port development -- all represent huge industries. Is it possible for a developing nation to share in the benefits of these industries? As international trade increases, trade routes will change and new ports will be necessary. As new types of ships that handle cargo more efficiently enter the seas, new ports will have to be built or old ones modified. As life changes throughout the world -- as island transportation systems become more popular, as coastal transportation systems are recognized as more efficient means to transport large quantities of people or cargo -- new types of ships will have to be built. These and many other types of opportunities stand out for the future, offering possibilities for newcomers in these industries.

There are also some critical military issues that must concern the United States and other major maritime powers. While the more industrialized nations certainly hold the trump cards on issues regarding technology, they find it differcult to play them when raw material vulnerabilities and military necessities confront them every day. Thus, the Group of 77 demands for assistance to equalize the resource situation and the international economic system in general have found some sympathetic listeners who may attempt to satisfy some of their demands in return for compromise on other issues.

In the case of marine science, many of the Third World nations clearly recognize the problem of using information even if foreign scientists share data with them. Many of these countries need people to educate scientists in their own countries; they need equipment for training and applications of the training. Some had not really considered turning to the oceans for economic growth, so they need time to evaluate their needs and then integrate them into the economic plans for their countries, if indeed they have any. Of course, this is a simplified description of what has transpired over the past several years, but it demonstrates the complex issues of technology sharing.

Once the Third World Bloc called for assistance in return for compromise on other issues, it was no simple matter for the nations who were in a position to lend assistance to determine how to go about it. United States officials met behind closed doors for months before they made a decision to promise officially some type of assistance to these more disadvantaged nations. Finally, July 20, 1973, U.S. Ambassador Donald L. McKernan presented the offical U.S. position on the issue of scientific research and technical assistance before Subcommittee III of the Committee on the Peaceful Uses of the Seabed and the Ocean Floor Beyond the Limits of National Jurisdiction.

Agreeing that "all nations benefit from scientific research in the sea," he said, "methods must be developed to assist all nations in obtaining the technical knowledge necessary to profit more directly from scientific research." He suggested a two stage process for accomplishing this transfer of scientific knowledge:

1. "Developing countries should receive assistance in interpreting data about marine areas of concern to them in a manner that is relevant to their interests."
2. "Means must be devised to provide the technical capability for all countries not only to interpret the data for themselves but also to actually engage in scientific research in the marine environment."*

Thus, the United States made an unmistakable commitment to the developing nations, as an attempt to save some freedom for American scientists to carry out their research in foreign waters.

Once the United States made this commitment, it was necessary to demonstrate its sincerity. Anticipating the need for such proof, marine scientists had been

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* Statement by Ambassador Donald L. McKernan, before the Committee on the Peaceful Uses of the Seabed and the Ocean Floor Beyond the Limits of National Jurisdiction, Subcommittee III, July 20, 1973.

working behind the scenes in Congress, and persuaded a key senator to introduce legislation which would begin some action. On July 10, 1973, Congress amended the National Sea Grant College and Program Act of 1966. "The Secretary of Commerce was authorized and directed to undertake through the National Sea Grant College Program, a study of the means of sharing through cooperative programs with other nations, the results of marine research useful in the exploration, development, conservation, and management of marine resources." To carry out this mandate, the Congress authorized the sum of $200,000.*

The history of the legislation indicates that it was prompted by a fear that, in the future, U.S. research scientists would have less and less access to foreign waters. The legislation states that,

> "The developing countries, without the ability to use the results of marine exploration and research, have become increasingly suspicious of and unreceptive to free and unrestricted ocean research off their shores. This threat to continued freedom of scientific inquiry in ocean waters led the United States, at a meeting of the United Nations Seabed Committee in 1972, to promise an effort to share the results of research and marine technology, so that developing countries could share in the benefits of freedom of scientific study of the oceans." **

The study concludes with recommendations to the U.S. Congress for the United States to begin an International Sea Grant Program. Gradually the Federal Government incorporated some of those recommendations into legislation in 1976 with recommendations for a small international Sea Grant effort. The foreign assistance legislation for the same year included the National Sea Grant Program as one of the offices responsible for foreign aid programs.

Meanwhile, the Intergovernmental Oceanographic Commission established a group of regional meetings under the auspices of its subgroup TEMA, which met during 1975 to determine the needs of the developing nations in marine science and technology, and the possibilities for assistance from those nations willing and able to help. A key problem with these meetings, was the inability of the United States to offer any monetary assistance through UNESCO. Legislation passed by the U.S. Congress prohibited U.S. contributions to UNESCO because of its exclusion of Israel from its activities, and the IOC TEMA group was a part of UNESCO. Thus, the United States could only attend these meetings and listen,

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* This study was sponsored by that grant.
** Public Law 93-73, 93rd Congress, H.R. 5452, July 10, 1973

making no offers, only suggestions.*

If the United States is about to embark upon a new type of technical assistance program in the marine area, now is the time to examine past programs and results so that repetition of mistakes can be avoided as much as possible. This study attempts to do just that. The papers that follow provide a broad range of perspectives on the problems and possibilities for a marine science and technology sharing program with other nations, and should provide a reliable guide for government decision-makers.

Yet another area needs immediate attention to assure the success of a new U.S. attempt -- U.S. ocean policies and activities. According to former Secretary of Commerce Elliot L. Richardson, "The growth of oceans policies and programs in the past five years has been organic, spreading out to meet perceived needs rather than as a part of a considered plan. We should once again assess which programs should be interrelated and which should not." ** According to Congressman John B. Breaux, Chairman of the Oceanography Subcommittee of the House Merchant Marine and Fisheries Committee, "we find that from even a conservative estimate, marine science activities and oceanic affairs are still being coordinated by 21 organizations in six separate departments and five agencies. Such a scatter-shot approach at formulating and carrying out policy has got to create much overlapping and confusion at best." ***

Thus, it would seem that two basic ingredients are necessary for a new program to begin on the right track: 1) a reassessment of past U.S. foreign assistance activities, and 2) a reassessment of past U.S. domestic oceanic activities and policies. This study attempts to do the first. It does not do the second.

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* In early 1977, the U.S. Congress finally authorized the U.S. contribution to UNESCO.

** Oversight Hearings, Oceanography Subcommittee of the House Merchant Marine and Fisheries Committee, September, 1976.

*** IBID.

INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY:
THE TRANSFER PROCESS AND INTERNATIONAL ORGANIZATIONS

by

David A. Kay

Projects Director
American Society for International Law

TABLE OF CONTENTS

		Page
I.	Definitions and Concepts	15
II..	Description and Typology of Technology Transfer Programs of International Organizations	16
	Model I, Training and Fellowship Programs	17
	Model II, Information Dissemination and Advisory Program	19
	Model III, Research Programs	23
	Model IV, Direct Tranfer of Technology	28
III.	International Organizations and Marine Science	32
IV..	International Organizations and the Transfer Process	34

INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY:
THE TRANSFER PROCESS AND INTERNATIONAL ORGANIZATIONS

I. Definitions and Concepts

Science and technology and particularly the issues surrounding the transfer of technology to developing states have become major concerns of international organizations during the last decade. Within the United Nations system, the vehicle for this new concern has been the work of the United Nations Advisory Committee on the Application of Science and Technology to Development, and is symbolized by its publication in 1971 of a World Plan of Action for the Application of Science and Technology to Development. It is accepted within the United Nations that multilateral action for the accelerated transfer of technology to developing states should occupy a strategic place in the efforts of international organizations to attack the problems of economic underdevelopment. The provisions of both the International Development Strategy for the Second United Nations Development Decade and the Program of Action on the Establishment of a New International Economic Order emphasize the necessity of expanded international action to accelerate the transfer of technology to developing countries.

This paper describes and evalutes the approaches and mechanisms used by international organizations in their efforts to transfer technology. While the ultimate concern of this paper is to provide some guidance as to the type of issues that might arise and the choices open to policymakers if the United States were to decide to broaden the scope of the National Sea Grant Program to marine technology transfer at the international level, the paper does not restrict itself to analyzing the experience of international organizations in transferring marine technology.

The author gratefully acknowledges the assistances provided by Cathryn Dickert in the preparation of this paper.

The reason for this is that in the total concern of international organizations with technology transfer, the transfer of marine technology ranks rather low, and there is no a priori reason for believing that the lessons and models developed in other areas are not relevant to marine affairs.

The following sections of this paper will first lay out a typology for classifying international organization programs in technology transfer and then briefly describe the activity of the United Nations system and terms of this typology. The paper then turns to an analysis of international organizations and the transfer of marine technology. Finally we will turn to the implications of the existing international organization efforts for future efforts at international technology transfer of marine science.

In identifying technology transfer efforts, this paper has adopted Harvey Brooks' definition of what constitutes technology transfer. Brooks has written that, "Wherever systematic rational knowledge developed by one group or institution is embodied in a way of doing things by other institutions or groups, we have technology transfer." [1] Thus the transfer of technology concerns not just the transfer of research but also education, information, production facilities and management systems. It is the role of international organizations in this broader transfer process that is examined here.

II. Description and Typology of Technology Transfer Programs of International Organizations

In analyzing the operational activities of intergovernmental organizations over the last 15 years, one can easily identify as a major program focus activities concerned with the transfer of technology. In general,

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[1] Harvey Brooks, National Science Policy and Technology Transfer, National Science Foundation.

this program focus has been directed toward the issue of how one accelerates the transfer of technology from developed to developing countries. Multilateral action to accelerate technology transfer has been generally viewed as one instrument that should be used to attack the problem of persistent low levels of economic development.[1]

The broad scope of multilateral programs designed to transfer technology can be separated into four types of activities:

(1) Training and fellowship programs
(2) Information dissemination programs
(3) Research programs
(4) Direct transfer programs

For the purpose of analysis, each of these types of activities can be conceived of as a model or mechanism for the transfer of technology. In this section of the paper, I will outline the major dimensions of how each of these mechanisms operates and will also describe the program activities of international organizations that fall in each area.

Model I, Training and Fellowship Programs

The earliest efforts of international organizations that can be clearly labeled as directed toward technology transfer were training and fellowship programs. In terms of budget size, these mechanisms still represent the dominant element in the activities of international organizations. For example, in 1971 the International Labor Organization (ILO) spent $37.9 million on technical assistance activities out of a total budget of $71.5 million. Technical assistance activities accounted for 75 percent of the Food and Agriculture Organization (FAO) total expenditures in 1971. While the ILO and the FAO are the leading United Nations specialized agencies in terms of percent of budget expenditures on training and fellowship programs, this type of activity ranks as a major program activity of all of them. Even in the case of the World Bank, in fiscal 1973, of loans and credits

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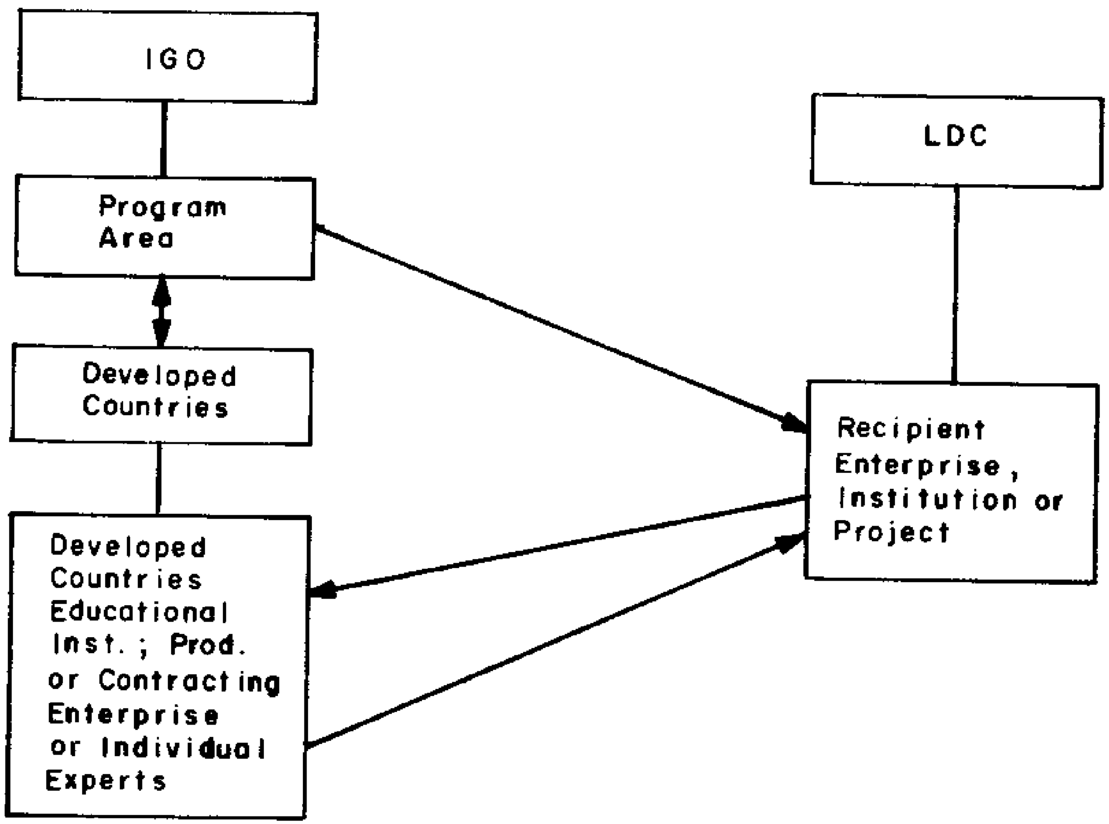
1 A major example of this mode of thinking can be found in World Plan of Action for the Application of Science and Technology to Development, prepared by the Advisory Committee on the Application of Science and Technology to Development for the Second United Nations Development Decade, United Nations, New York, 1971.

CHART I

MODEL I Training and Fellowships



totaling $2,218 billion, $62 million was provided specifically for training and fellowship type activities.

Chart 1 schematically represents the general relationships that are found in the training and fellowship activities of international organizations. One indication of the diversity of activities covered by the training and fellowship activity represented in this chart is the activity of the UN Development Program in 1973.

The UNDP Report of the Administrator for 1973 indicates that for UNDP project expenditures by sector, agriculture leads the projects funded with about 28 percent of the value of such activities, industry follows with 16 percent, transportation and communications with 13 percent, 10 percent economic and social policy planning, while projects in education and science and technology each have 8 percent.

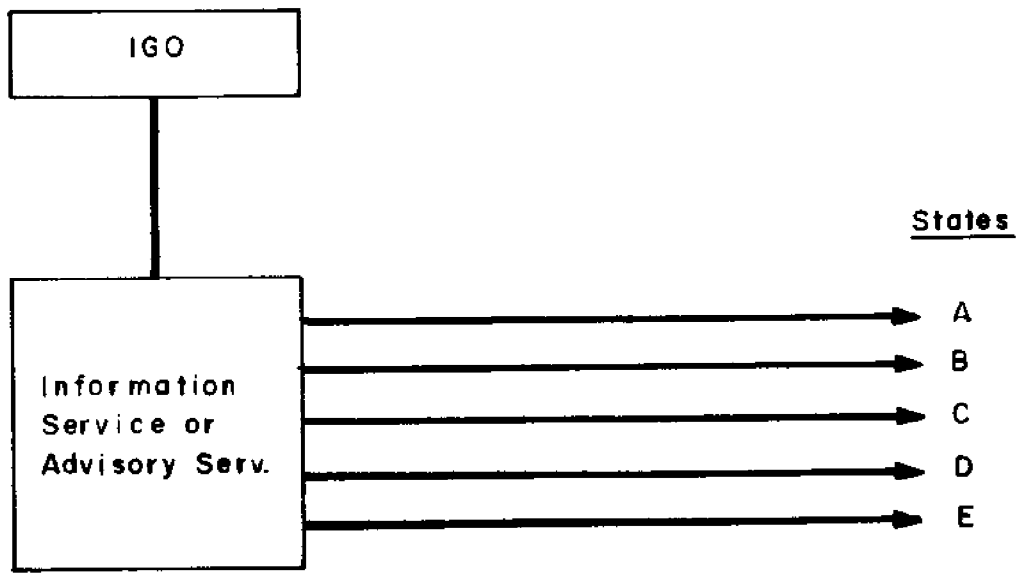
In 1973 the United Nations system had approximately 8,000 experts in the field on technical assistance activities. FAO, with almost 3,000, had the largest number of such experts. Geographically, United Nations experts were distributed as follows: Africa 29 percent; Europe, Mediterranean, Middle East 25 percent; Asia and the Far East 22 percent; and Latin America 22 percent. In 1973 there were 35 developing states to which more than 100 experts were assigned. Algeria, Indonesia, Iran and Nigeria each had more than 200. A total of 148 states had United Nations experts during 1973. More than 5,000 fellowships were awarded in 1973 under the UNDP training program. There were 1,117 fellowships awarded to Africa; 1,238 to Asia and the Far East; 1,867 to Europe, Mediterranean, and the Middle East; and 929 to Latin America. More than half of the fellowship recipients chose in 1973 to study in five countries, the Federal Republic of Germany, France, Italy, the United Kingdom and the United States.

Model II, Information Dissemination and Advisory Program

It has been generally accepted by international organizations that a major mechanism for assisting in the transfer of technology should be in-

CHART 2

MODEL II Information Service; Advisor Services; Publications



formation and advisory services capable of making available to the developing countries the latest research findings. This assumption was a major theme of the United Nations Conference on Science and Technology for the Benefit of the Less Developed Areas held in 1963, and subsequently became an accepted program element of the Advisory Committee on the Application of Science and Technology to Development (ACASTD) established by the United Nations on the recommendation of the conference. Information and advisory services and avdisory services rank with training and fellowship programs as the most commonly available technology transfer mechanism in the United Nations system.

Chart 2 provides a schematic diagram of the two most frequently found models of information and advisory services in the United Nations system. The International Labor Organization is typical of the general information service operated by United Nations agencies. In 1969, it established an Integrated Scientific Information Service to record in machine-readable form all new aquisitions, including journal articles, research reports and monographs, catalogued in the ILO library. Each item recorded contains a full bibliographical description and a subject abstract. As of 1974, approximately 60,000 abstracts had been entered into the system. Printed indexes are prepared by computer and distributed to research institutes, libraries, government agencies, and employers and workers organizations. A thesaurus has been prepared to permit interchange of machine-readable data among more than 20 agencies active in the field of development assistance. The ILO also issues six times a year more extensive abstracts in the technical training field. These abstacts (CIRF Abstracts) summarize published information on ideas, programs, experience and experiments in the training of operative personnel, supervisors and technical staff in all sectors of the economy. In Geneva, the ILO operates a large documentation service as part of the International Safety Centre (CIS). This service includes (a) the distribution of cards containing abstracts in three languages at the rate of 3,000 abstracts per year; (b) publications of the monthly bulletin Occupational Safety and Health Abstracts in three languages; (c) the distribution of photostats and microfilms through national centers; and (d) the issuing of bibliographies covering subjects relating to occupational safety and health and the provision of information in response to requests for information concerning occupational safety and health.

UNESCO is organizing an ambitious world science information system known as UNISIST. This system is the outgrowth of a collaborative effort begun in 1966 by UNESCO and the International Council of Scientific Unions (ICSU). UNISIST hopes to serve as a flexible network of information sources in the fields of science, engineering and technology. In establishing UNISIST, the objectives were outlined for its initial phase: (1) Better tools to link existing systems (for example, standardization of bibliographic descriptions both in traditional and digital forms); (2) Strengthening of institutions in the information transfer process, such as libraries, information analysis centers and abstracting, indexing and translating services; (3) Development of human resources (particularly scientists, editors and documentalists) needed to plan and operate future information networks; (4) Assistance to developing countries to help them lay the minimum bases for science information systems. In cooperation with the French government, the International Serials Data Center (ISDC) was established in 1973 as the first major operating component of UNISIST. The objectives of the ISDC system are to: develop and maintain an international register of serial publications containing all the necessary information for the identification of the serials; define and promote the use of a standard code (International Standard Serial Number -- ISSN) for the unique identification of each serial; facilitate retrieval of scientific and technical information in serials; make available this information to all countries, organizations or individual users; establish a network of communications between libraries, secondary information services, publishers of serial literature and international organizations; promote international standards for bibliographic description, communication formats, and information exchange in the area of serial publications.

In terms of technology transfer, one of the most interesting aspects of this Model II type activity is the advisory service function. UNESCO, for example, maintains an advisory service designed to assist its members in establishing organizational and institutional structures to facilitate the formation of national science and technological policy. Through this advisory service by the end of 1973, UNESCO had responded to requests from more than 50 states concerning the possible establishment of science policy structures. The advisory service responded to these requests with technical assistance, advisory missions, fellowships and information on the experience of other states in science policy. By the end of 1973 more than 40 of these states created national science and technology policy councils.

The United Nations Industrial Development Organization (UNIDO) maintains an advisory service in Vienna. In addition to serving as a general question and answer service on matters of industrial development, the UNIDO advisory service assists states, on request, with the selection and purchase of industrial equipment.

All of the United Nations programs surveyed maintain publication programs, often quite extensive, that serve to disseminate information in their program areas. However, none of these information programs has been subjected to a detailed survey of their effectiveness and one suspects that Sir Robert Jackson's general evaluation "that the developing countries aren't getting as good a technical assistance service as they should... ."[1] also applies to the information programs.

Model III, Research Programs

While a large number of the United Nations programs surveyed have ongoing research programs that relate to technology transfer, this tends to mask large differences in the type, size and extent of research being undertaken. At one extreme are the very modest research efforts of the regional economic commissions that examine, for example, the potential

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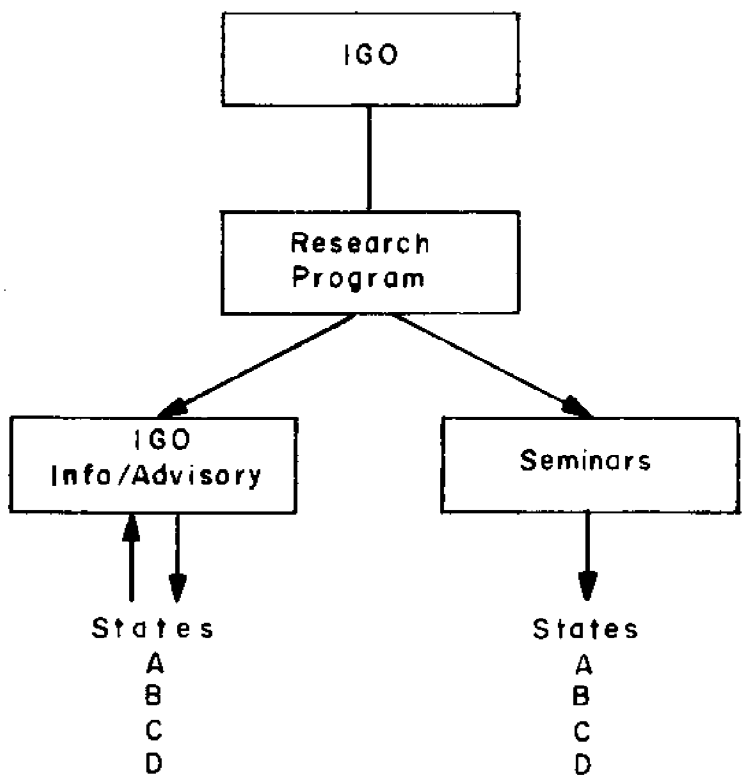
1 Sir Robert Jackson, A Study of the Capacity of the United Nations Development System, Volume I (United Nations, 1969), p. iv.

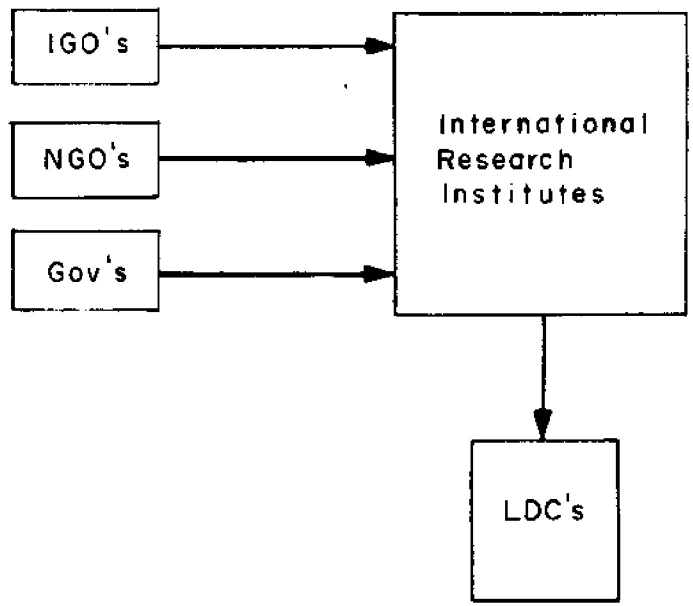
CHART 3

MODEL III Research

Alternative A



Alternative B



for the development of the man-made fiber industry in a region. On the other extreme are the si able research efforts carried on by FAO, UNDP and IBRD in the agricultural field.

Typical of the modest to medium scale research efforts on technology transfer and one that falls, as do most such programs, into the general pattern of Alternative A of Model III is the research program of UNITAR. In 1967 UNITAR decided to concentrate its research program in the field of technology transfer on two areas, a methodology for case studies in developing countries and a series of sectoral studies that would examine the experience of transferring specific industrial technologies.

The methodology was published in 1968 (E/4597, October 1968) and suggested guide lines for studying transfer arrangement, the nature of the transfer, the channel used, forms of contractual relationships, supplier's position and the evaluation of the transfer process. The sectoral studies that were subsequently undertaken attempted to describe and analyze the conditions and circumstances that governed the transfer of technology in specific fields. The sectoral studies rested on the assumption that experience varied with the industry concerned and that it would be therefore useful to cover some of the more significant sectors. Among the sectors covered to date have been pharmaceuticals, automobiles, petrochemicals and electronic components. To complement the sectoral studies, UNITAR has also carried out four other studies: (1) the experience of Japan as an exporter of technology to developing countries; (2) an analysis of the experience of the Philippines and Mexico in the choice and adaptation of industrial technology; (3) the experience of multinational firms with operations in developing countries; and (4) the experience of the Soviet Union in the transfer of technology to the developing countries. UNITAR has used these studies as the basis for a series of regional seminars as well as making them available through its regular publication program.

While the UNITAR research program represents in general the typical type of "in house" research conducted by international organizations, other examples do exist. In many ways, the most important such example is the one that is shown as Alternative B in the chart of Model III. In

1971 on the initiative of the World Bank, the Consultative Group on International Agricultural Research was founded. The main purpose of the Consultative Group is to give financial support to international agricultural research institutes for the purpose of increasing the quantity and improving the quality of food production in developing countries.

The composition of the Consultative Group is a rare example of blending the international organizations, states and nonstates into a common framework. Its 29 members include the World Bank as chairman, FAO and UNDP as cosponsors. The other members include 13 states (Australia, Belgium, Canada, Denmark, France, Germany, Japan, Netherlands, Norway, Sweden, Switzerland, United Kingdom and the United States); three regional development banks (African, Asian and Inter-American Development Banks); the Commission of the European Communities; three private foundations (Ford, Rockefeller and Kellogg Foundation); and the International Development Research Centre, an independent Canadian organization. In addition the five major developing regions of the world participate in the Consultative Group through representatives selected by the membership of FAO. The current representatives are: Argentina and Brazil (Latin-America); Morocco and Nigeria (Africa); Philippines and Thailand (Asia); Egypt and Pakistan (Middle East); Israel and Romania (Southern and Eastern Europe).

The members of the Consultative Group are presently supporting six existing international centers already in operation -- the International Maize and Wheat Improvememt Center (Centro Internacional de Mejoramiento de Maiz y Trigo, or CIMMYT), based in Mexico; the International Rice Research Institute (IRRI), based in the Philippines; the International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical, or CIAT), based in Colombia; the International Institute for Tropical Agriculture (IITA), based in Nigeria; the International Potato Center (Centro Internacional de Papa, or CIP) based in Peru; and the recently established International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), based in India.

The Consultative Group, through its African Livestock Subcommittee, also has been proceeding with the establishment of an International Laboratory for Research on Animal Diseases (ILRAD) recently inaugurated in Kenya, and with a comprehensive research activity for animal production and health -- theInternational Livestock Center for Africa (ILCA) -- now being established in Ethiopia.

The Consultative Group also approved the establishment of an International Board for Plant Genetics Resources designed to support and coordinate the creation of a network of plant gene collections in order to conserve characteristics which may be of value in breeding plants with higher yields, better food value or greater resistance to pests and diseases. The Board, although established within the framework of the Consultative Group, would operate in particularly close cooperation with FAO, where it will have its headquarters, and which will provide the Board Secretariat. To the extent possible, the Board will utilize existing international, regional, and national genetic resource centers and research institutes for the establishment, maintenance and utilization of the necessary genetic resource collections.

In addition, the group endorsed in principle a coordinated program of rice trials to be carried out by the West African Rice Development Association (WARDA), and instructed the group's secretariat to explore the availability of funds for that program.

In formulating the decisions concerning the programs of existing centers and on new undertakings, the group had the advice of its Technical Advisory Committee (TAC), consisting of 13 experts drawn from both the less developed and the developed countries. The terms of reference of TAC are to:

(i) advise the Consultative Group on the main gaps and priorities in agricultural research related to the problems of the developing countries, both in the technical and socio-economic fields, based on a continuing review of existing national, regional and international research activities;

(ii) recommend to the Consultative Group feasibility studies designed to explore in depth how best to organize and conduct agricultural research on priority problems, particularly those calling for international or regional effort;

(iv) advise the Consultative Group on the effectiveness of specific existing international research programs; and

(v) in other ways encourage the creation of an international network of research institutions and the effective interchange of information among them.

The Consultative Group raised $15 million in 1972, $25 million in 1973 and $33 million in 1974 for agricultural research.

Two of the research institutions, the International Rice Research Institute and the Wheat and Maize Improvement Center, being supported by the Consultative Group, are responsible for the developments that led to the "green revolution" through greatly increased food production from new varieties of wheat and rice. Both of these institutes provide examples of very high quality research being conducted within an international setting and subsequently leading to a substantial transfer of technology to developing countries.

While the agricultural research institutes are the most fully developed example of Alternative B type research programs, they are not the sole example. The International Foundation for Science was established in 1974 in Stockholm with an initial grant of $180,000 from the Swedish government and $40,000 from the Royal Society of Canada. These funds will be used during the first year of the Foundation's operation to support research on fish breeding in ponds or lagoons; microbiology of nitrogen fixation for soya beans, pulses and green legumes; and isolation and investigation of natural products for use as pharmaceuticals. The foundation grew out of a suggestion of a Pugwash meeting and a 1970 meeting of 16 national academies of science. It is expected that by 1976-77 funds from government agencies and foundations will provide an annual operating budget of approximately $3 million.[1]

Model IV, Direct Transfer of Technology

In this fourth model, the international organization provides for

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[1] New Scientists, Vol. 62, no. 899, 23 May 1974, pp. 496-497.

the direct transfer of a technology from a developed to a developing country. The mechanism for transfer is a loan or a grant that will allow the developing state to import the technology for incorporation into its development projects.

In the United Nations system, this form of technology transfer is largely the domain of the World Bank Group.[1] Between 1946 and the end of 1973 the World Bank has lent $2.9 billion to 29 African states, $6 billion to 15 Asian states and $6.5 billion to 22 Western Hemisphere states. As can be seen in the table below, loans have been made for electric power, roads, railways, ports, natural gas pipelines, telecommunications, agriculture, industry, water supply, education, family planning and industrial imports.

Sectoral Breakdown of Total IBRD Lending, 30 June, 1973

Purposes	Bank Loans US $ Million
Agriculture	2,064.4
Education	507.8
Electric Power	5,748.7
Industry	3,263.0
Nonproject	1,458.1
Population	26.5
Telecommunications	527.7
Tourism	66.0
Transportation	6,049.0
Water Supply and Sewage	557.9
Urbanization	21.4
Total	20,335.5

For a review of the project descriptions of the World Bank Group's leading activities, refer to the World Bank and International Development Association Annual Reports, 1972 to 1975, for a description of World Bank and IDA Lending by Sector.

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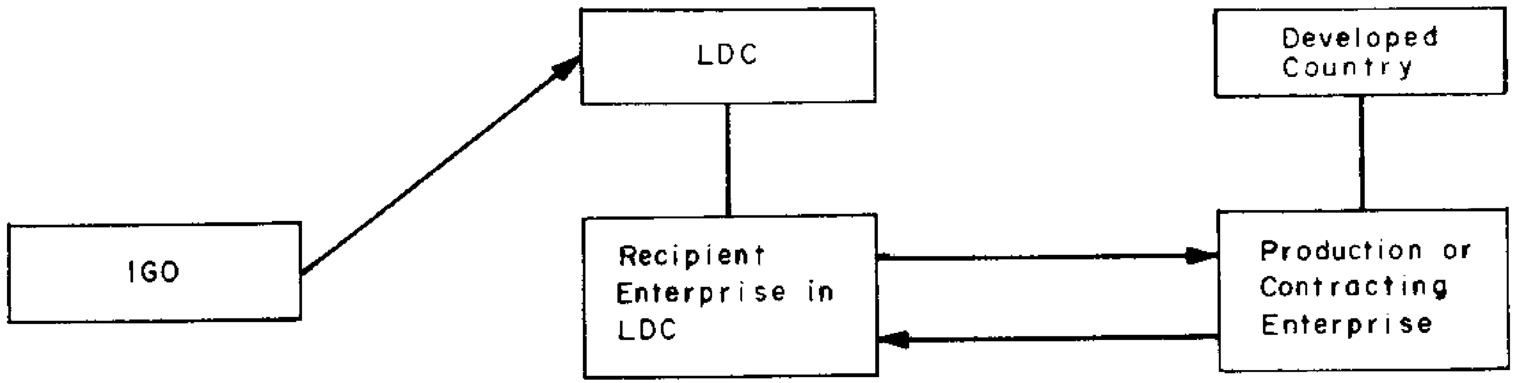
[1] The World Bank Group is composed of the International Bank for Reconstruction and Development, established in 1946, the International Finance Corporation, founded 1956, and the International Development Association, founded in 1960.

CHART 4

MODEL IV Direct Transfer of Technology



In general, the World Bank will grant loans only for specific projects. These projects must be judged by the World Bank to be technically and economically sound and of high priority for the economic development of the country. In addition to its concern with merits of the proposed project, the bank is required by its rules to ascertain that there is reasonable assurance that the loan can be repaid without placing an undue burden on the state's economy and that the borrower cannot obtain financing for the project on reasonable terms from other sources. Because the Bank raises most of the money it lends through its own borrowing from investors who buy its obligation in the world's capital markets, it is particularly sensitive to insuring the soundness of its investment. The Bank is limited in making loans to governments of lender states or to public or private organizations that can obtain the guarantee of the member government in whose territory the project to be financed is to be located.

Projects proposed for Bank financing generally are generated from five sources: (1) a direct proposal from a state to the Bank requesting funding for a project; (2) a Bank mission supervising an earlier project may suggest a follow-on project; (3) the Bank may send a special mission to a region specifically to identify suitable projects; (4) a Bank resident representative or mission may identify a needed project or, a project may be identified through the work of other United Nations agencies such as UNDP or UNIDO. In evaluating proposals, the Bank looks at the following aspects of a project:

1) Economic, including the demand for the goods or services the project will provide, the extent to which the project will employ domestic resources (including labor) which would otherwise be unutilized, the balance of payments effects of the project, and the relative merits of different ways of producing the goods and services required. A comparative analysis is made of the likely economic costs and benefits.

2) Technical, including examination of the detailed plans for the project's construction and operation, the location, scale, layout and design of the project, the types of process and equipment to be used, the timing of the project, and the availability of factors of production and of technical staff. Cost estimates are also examined in detail, and provision for general cost increases and contingency allowances are checked.

3) Institutional, managerial and organizational, including the availability and/or training of qualified local management, the possible need for providing outside management or advice in the early stages of the project, the project's staff structure, and the freedom of management from undue external pressures.

4) Procurement and commercial, including all arrangements for buying and selling, both of the materials needed during the implementation of the project, and of the inputs required and output expected after its completion. The Bank normally requires international competitive bidding for project construction and equipment.

5) Financial, including assessment of the funds needed during project implementation and their source, and of the project's operation costs, revenues and prospective liquidity after completion. The Bank usually provides only a part of the whole of the foreign exchange component of a project's total cost; arrangements for the provision of the remaining finance are examined. [1]

Among the international organizations examined in this paper, the World Bank stands alone in the attention it gives to detailed supervision and evaluation of its projects once they are underway. The Bank controls disbursements of funds throughout the life of the project, checks the specifications of goods supplies and supervises the awarding of contracts, periodically sends missions to monitor the progress of each project, and conducts a full-scale evaluation of each completed project. This concern with effectiveness coupled with its financial where-with-all to directly transfer technology makes the Bank, probably, the most effective instrument of technology transfer in the United Nations system.

III. International Organizations and Marine Science

In the preceding section, an analysis was made of the efforts over the last 15 years of the United Nations system in the field of technology transfer. As a total proportion of the efforts of the UN system that can be labeled technology transfer, the transfer of marine technology ranks rather low. For example, out of approximately $4 billion worth of projects approved by the World Bank in 1972 and 1973, only $441.75 million can be identified as related to the transfer of marine technology.

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[1] Questions and Answers, World Bank and IDA, (Washington, IBRD, January 1974), pp. 11-12

For a general overview of the efforts of the United Nations system in marine technology, please refer to "UN and the Sea," UNITAR News, Volume 6, No. 1, 1974, pp. 8-15.

In terms of dollars spent on technology transfer, the three principal United Nations specialized agencies involved with marine sciences are UNESCO, FAO, WMO, and IMCO.

Since 1960, UNESCO's main involvement with marine science has been its Intergovernmental Oceanographic Commission (IOC). The IOC was established in that year to promote scientific investigations of the oceans to learn more about the nature and resources of the oceans. IOC has principally served as a promoter of the collection and dissemination of oceanographic data and as a facilitator of coordination between governments and intergovernmental and nongovernmental organizations. It has served as a coordinator of several international expeditions and more than 200 scientific cruises. IOC created working groups that have been responsible for developing and implementing the plans for projects such as the International Indian Ocean Expedition; the International Cooperative Investigation of Tropical Atlantic; Cooperative Study of Kuroshio; Cooperative Study of Caribbean; and the Cooperative Study of the Mediterranean.

Although hopes have been periodically expressed by some governments that the IOC would become the focal point of United Nations activity in the marine field, this has not happened, and it now seems unreasonable to expect it to develop this role. While this is not the place for a full-scale evaluation of IOC, there does appear to be general agreement within the United Nations system, as well as among concerned outside analysts, that there is little reason to expect the IOC to play a greatly expanded role in marine affairs.[1]

FAO's involvement in marine science has been principally in the field of fisheries. In the fisheries area, its operations fall largely into either the training and fellowship category of Model I or the information dissemination category of Model 2. The FAO is the executing agent responsible

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[1] For more on the IOC, see: Daniel S. Cheever, "The Role of International Organization in Development of Marine Resources," International Organization (Summer, 1968); Edward Wenk, Jr., The Politics of the Ocean (Seattle, Washington, University of Washington Press, 1972); Margaret E. Galey, The IOC: Its Capacity to Implement the IDOE (Unpublished Ph.D. dissertation, University of Pennsylvania, 1970).

for the training and fellowship projects of UNDP that relate to fisheries. It also collects and publishes regional and global fisheries statistics and registeries of marine science and training institutions. The marine activities of the World Meteorological Organization (WMO) are focused on efforts to understand the interaction between ocean and atmosphere and its impact on weather. These activities fall into the categories of Model II, information dissemination, and Model III, research of the typology used in this paper.

The fourth United Nations specialized agency with a major involvement with marine affairs is IMCO. Since its creation in 1948, IMCO has served as an advisory and coordinating agency designed to assist governments on the technical aspects of ocean transportation. Its major role in the transfer of marine technology has been to collect and disseminate information along the lines of Model II. However, recently as a result of the efforts of developing states, IMCO has begun to play a larger role as an executor of UNDP projects designed to train and assist states in developing the capabilities in ocean and coastwise shipping.

This very brief survey of the efforts of the United Nations system in the transfer of marine technology, is not designed to be a full inventory or evaluation of the activities of the United Nations system in this field. Such a survey and evaluation should in fact be made if it is decided to inernationalize the Sea Grant Program. While marine transfer projects have not composed a predominant part of any United Nations agency program, except IOC, it is hoped that this survey gives an indication of the activities undertaken.

IV. International Organizations and the Transfer Process

Largely in response to the demands of the developing states, the United Nations system has increased the resources devoted to technology transfer. Most of these resources are funneled through either the training and fellowship type programs characteristic of UNDP activities of through the direct transfer programs that are characteristic of the World Bank Group's lending activities.

In looking at the activities of the United Nations system in this area, one can find a developed repertoire of channels for technology transfer. These have been laid out in this paper in terms of four models:

(1) Training and fellowship programs

(2) Information dissemination programs

(3) Research programs

(4) Direct transfer programs

These four models represent the existing capabilities of the United Nations system to assist in technology transfer. While much more research needs to be done on the effectiveness of these programs as agents of technology transfer, it appears that the most successful programs have been the research activities of the agricultural research institutes and the direct transfer activities of the World Bank Group.[1] While more research needs to be done on this issue, one distinguishing characteristic of the Bank's activities is its strong commitment to programs from the beginning project identification stage until the conclusion of a project. Of all the programs reviewed in this paper, only the activities of the Bank demonstrate any clear concern with assessing the impact of its projects and in using that assessment in formulating future projects. Also, the Bank, in its constituent legislations and in its funding operations stands apart from the rest of the United Nations system and is less subject to the political vicissitudes that sweep the system. It seems to be particularly significant that the Bank's dependence on raising funds on the open money market enforces a disciplined concern for the contributions that its projects make to the economy of borrowers. The argument would run that if Bank projects do not contribute to economic capacity of borrowers they will find it difficult to repay their loans to the Bank, which would in turn find it difficult to meet its existing obligations or to borrow new funds on the open money market.

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1 The most searching criticism to date of the training and fellowship that characterize UNDP activities can be found in the Jackson Report, A Study of the Capacity of the United Nations Development System, (UN Document DP/5, 2 vols. 1969).

While international programs designed to transfer technology have increased in size and variety during the last 15 years, we should recognize the limitations in these programs, particularly as they relate to the possibility of an expanded marine transfer program. These limitations fall into four principal areas. The first relates to structural weakness in the United Nations system. Such structural weaknesses include a less developed country domination and orientation that permeates almost every aspect of the system. The less developed countries have demonstrated a clear preference for resource transfers over less spectacular scientific investigations and nonproject transfers of resources that allow the country to decide on the use of the funds over more closely evaluated project funding. In general, the less developed states have also demonstrated a much lower evaluation of the importance of marine science than that held by many developed states. Another structural weakness of the United Nations system with regard to marine transfer relates to the state of suspended animation that the system finds itself in pending the outcome of the Law of the Seas negotiations. All United Nations efforts in this area have become focused on these negotiations and no new initiatives are likely within the system until it is seen what kind of regime emerges from the negotiations. Structurally the United Nations system has not, on the whole, demonstrated great creativity in encompassing nonstate actors in its programs. This is a particularly serious weakness in an area such as marine science where the activities of the scientific, educational and multinational business community play such an important role. A final major structural weakness of the United Nations system as agents of technology transfer is the inherent weakness of the management system of international organizations. With the exception of the World Bank Group, the prevailing model of organization in the United Nations is a triple division between an international conference composed of all members and responsible for establishing overall policy; a council, composed of a selected group of members and responsible for more direct review of operations; and a secretariat, recruited internationally usually according to geographic guidelines and responsible for the day-to-day administration of the organization. With very few exceptions this organizational structure has shown itself to be ill-equipped for managing operational programs. Objective are seldom clearly established nor consistently maintained; programs are infrequently related to stated objectives; and effectiveness and competence are seldom the criteria relevant to program or staff selection or evaluation.

A second principal limitation of the United Nations system with regard to technology transfer relates to the performance of the international secretariat. At the present it cannot be assumed that the international secretariat of the United Nations system has either the quality or influence required for a greatly expanded program in marine sciences although there are "islands" of technical quality and efficiency.

Unless the quality of the personnel and the effectiveness of the institutions engaged in these new programs are clearly respected by governments, the scientific community and other international organizations, there is little hope that an expanded marine transfer function would have a major impact. It is doubtful that such a level of quality can be developed without substantial institutional change, including a direct challenge to many of the hallowed canons of international secretariats, such as the concepts of career civil service and geographic representation of staff. In very few areas of the United Nations system has effective performance been the standard against which bureaucratic form and organization have been tested. New patterns and altered forms of existing organizational patterns will surely be needed if international machinery of recognized quality and influence is to develop in this area.

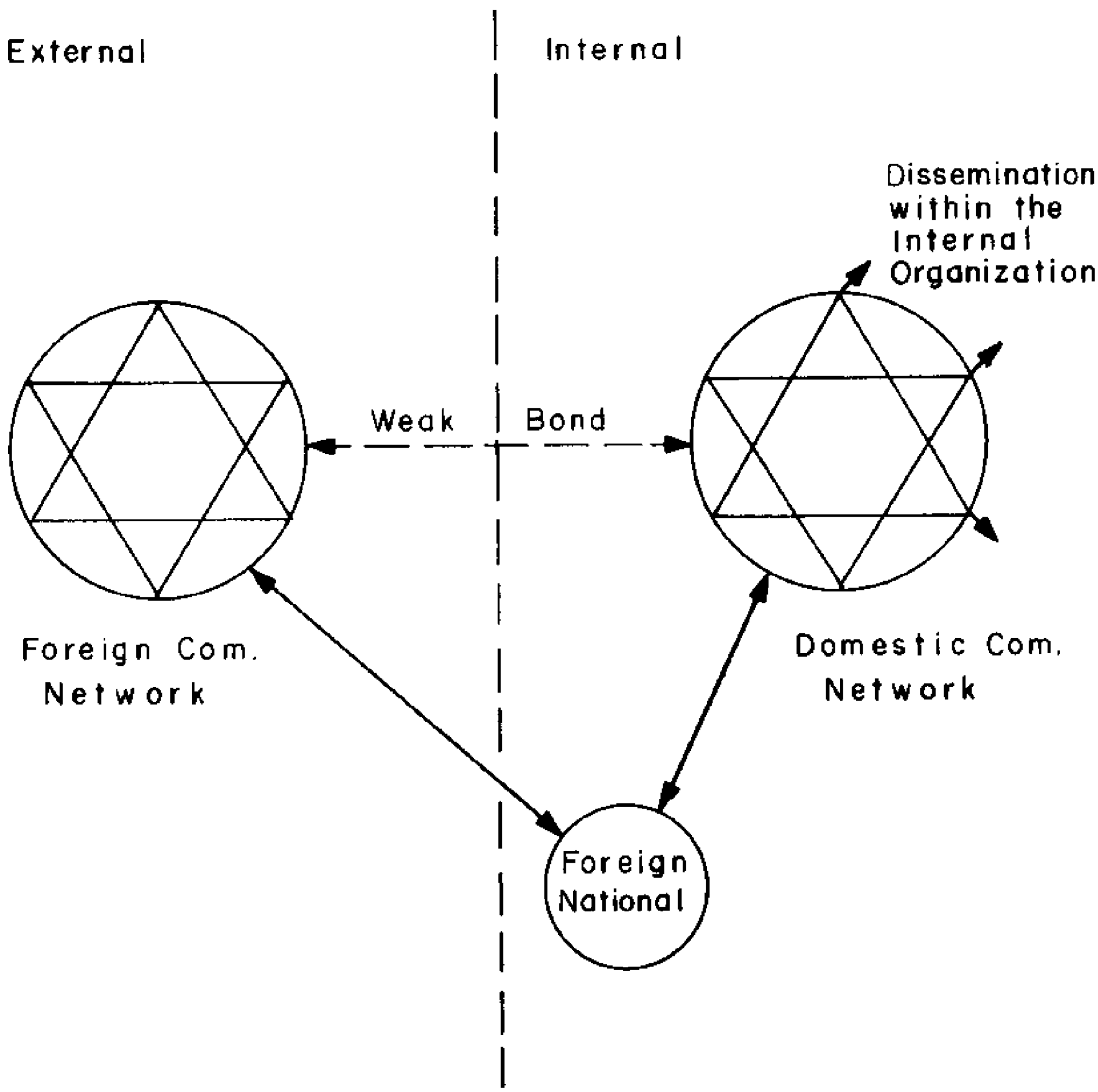
A third limitation of the United Nations system with regard to marine technology transfer relates to the legislative competence of the existing organs of the United Nations involved in marine affairs. Although it was hoped that the IOC would develop as a center of marine activity within the United Nations, this was not the case. Basically IOC, being a subsidiary body of one of the specilized agenies -- UNESCO, was legislatively unable to assert a predominant role over other specialized agencies. This lack of a central coordinating and planning capacity for marine affairs has led to duplication and made serious evaluation of the effectiveness of existing United Nations marine programs almost impossible. Unless the Law of the Sea negotiations create such a body with the legislative competence to assert its authority in the system, one can expect the marine activities of the United Nations system to remain fragmented.

A final limitation on a greatly expanded United Nations role in marine technology transfer is the poor track record of many existing programs of the United Nations system. The general performance of the United Nations system today, notwithstanding its effectiveness in some areas, leads to considerable skepticism that it provides an adequate base for expansion in responsibility without substantial modification. A host of new United Nations programs has been created in the last 20 years, including the United Nations Development Program, the IOC, the United Nations Conference on Trade and Development, and the United Nations Environment Program, without being able to achieve their stated objectives. United Nations performance has been particularly weak in creating effective mechanisms for managing operational programs. This is not just a question of the capabilities of international secretariats but more fundamentally a question of the willingness of governments to encourage the needed evolution and expansion of the functions and authority of the United Nations system in directions that constrain their own freedom of action.

In considering how an international Sea Grant Program might operate, one should face realistically the advantages and limitations of using existing international institutions. The United Nations system, at present, offers the best and only real opportunity for providing an institutional base with global participation. In areas of marine transfer, for example, large-scale oceanographic investigations, where global participation and legitimacy is required, the United Nations system may be the most suitable device. In other areas it may be desirable to coordinate bilateral or regional programs with existing activities of the United Nations system. A model for such coordination could be found in the Aid-India Consortium, where the bilateral national foreign aid programs are coordinated with the efforts of international lending agencies, such as the World Bank. Additionally, it may be necessary to build some new institutions outside the United Nations, especially in areas requiring high technical efficiency, with limited membership and patterns of control and influence quite different from those which prevail in most United Nations bodies.

Finally, it should be clear that this paper only opens subjects for investigations, subjects that have far too long been ignored by academics, governments and international organizations. Four such subjects deserve especially high priority for future work. First, is the entire question of the effectiveness and/or impact of a program of an international organization. The effectiveness/impact nexus is one that appears to have been consciously ignored by most international organizations that conduct technology transfer programs. We need to know much more about the definitional and measurement properties of effectiveness/impact and of the characteristics of programs and organizations that are effective or ineffective. Secondly, we need more investigation of the new phonomena of international research such as that illustrated by the agricultural research institutes. We know very little of even a descriptive nature about the dynamics of such research and nothing of an analytical nature of such research. A third area that calls for more research is the dynamics of mixed management systems that include substantial elements of unilateral, bilateral, regional and global responsibilities. In areas such as the environment and marine affairs, "policy space" is developing that includes government and nongovernmental actors at various levels of aggregation. Yet we know very little of the dynamics of the management of complex "policy space," except that it does not fit our prevailing typologies. For example, we need to concern ourselves with identifying the best available management tools to operate a Sea Grant Program that might include a well developed national program, a set of twined institutions across national boundaries, a regional research program and cooperation with ongoing United Nations activities. Also, much more research is needed on mapping the complex network of nongovernmental activity that already exists in the marine field, measuring its contribution to technology transfer and examining its potential contribution to an expanded Sea Grant Program.

FIGURE 1


External
Internal
Dissemination within the Internal Organization
Weak
Bond
Foreign Com. Network
Domestic Com. Network
Foreign National

The foreign national (as shown in Figure 1), a person who has been trained in the external environment and normally resides there, communicates between groups and in effect, performs the roles of a liaison between the two environments. This person need not be a foreigner; he could originally be a member of the organization or community designated "internal environment" who went to a community, organization or foreign country (designated as the external environment) for training and decided to remain in the external environment. Alternatively, the foreign national could be a member of a community, organization or country that comprises the source of information (the external environment) who decided to work in the user community or organization (the internal environment). As a result of this association with people in both environments, the foreign national is able to perform the role of a liaison between those groups who are users of information and those who are sources of this information or expertise.

The characteristics of the foreign national must meet certain requirements. This person, besides being an expert in the field of science or technology to be shared, should be willing to place strong emphasis on locating and properly communicating with the appropriate people in the country being entered. The foreign national could very well be a person from an environment outside the host country, but perhaps a great deal more might be accomplished if this were not the case. If a member from the host country, who has been trained and is a resident abroad, were to be sent back to his or her own country, the benefits could possibly be two-fold. One, the cultural and political barriers would take far less time to penetrate because this person would know the proper procedure necessary to obtain cooperation. Second, by encouraging people from less developed countries who have been educated and are utilizing and sharing their talents in a foreign nation to return home, the so-called "brain drain" could, in certain serious cases, be somewhat alleviated.

There is one aspect of training these people in the host country and then having them return to their native country that should not be overlooked. Although the people spending time abroad are more innovative about the use of ideas and methods once back at home, there is a possible tendency for people spending more than one year abroad to be less aggressive in the introduction of change.[3]

THE ROLE OF COMMUNICATION IN THE INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY

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TABLE OF CONTENTS

		Page
I.	ACTORS IN THE COMMUNICATION PROCESS	44
	Actors Within an Organization	44
	Audiences	50
II.	PROCESS OF CREATING AN INTERNATIONAL TRANSFER PROGRAM	51
	Needs of Identification	51
	Initial Contacts	51
	Project Life Cycle	53
	Problems of Present Mechanisms	54
	International Transfer Model	56
III.	COMMUNICATION CHANNELS	60
IV.	THE EXTENSION SYSTEM CONCEPT	65
V.	RECOMMENDATIONS	67
	Extension Strategy	67
	Program Management Recommendations	70
	FOOTNOTES	72

The relevance of communication to international technology cooperation and sharing endeavors needs formal recognition from the earliest stages of program initiation.

Cross-cultural communication is neither easy nor instantaneous. It is fraught with the dangers of misunderstanding that stem from differing value systems. It is highly dependent on the development of human skills in creating an awareness that these differences exist and must be overcome. While the process may be long and demanding, eventually it can be rewarding.

International cooperative mechanisms ultimately depend on the existence of a communication system that is responsive to needs, facilitates information flow, and aids in feedback and follow-up activities. The creation of a comprehensive international marine information system would help maximize the benefits that would result from more efficient generation and application of marine information.

A systematic evaluation of the process of communication, including patterns, channels, and message content, comprise a theoretical framework based on the obvious needs of clarity in global communication. Understanding these elements may be useful in developing enduring communication bonds and alleviating some of the problems that have contributed to the failure of past programs.

The aspects of communication that need to be explored in recommending an information transfer system include: 1) the actors involved in the communication process; 2) the process of creating an international transfer program; 3) the problems that plague existing mechanisms; 4) communication channels, and 5) the extension system concept. An analysis of these areas has led to the formulation of an international transfer and flow model. Finally, recommendations designed to facilitate the implementation of such a model will be suggested.

I. ACTORS IN THE COMMUNICATION PROCESS

Because communication must be between people rather than organizations, inadequate emphasis of identifying, selecting and employing the right personnel and means of information transmission can contribute to the failure of many programs of ostensibly sound structure and reasonable content. Various actors, each serving specific functions to aid in the process, comprise a communication system. The following is a discussion of these people and the roles they perform.

Actors Within an Organization

A concept that could be useful in developing communication stems from a process widely employed in an informal sense, but seldom given conscious recognition. It is known as the "gatekeeper concept." A formal definition of this concept states that "the gatekeeper mediates between his or her organizational colleagues and the world outside and effectively couples the organization to outside activity."[1]

Figure 1 illustrates the basic concept of the gatekeeper. The internal environment constitutes the organization, area or community in which information is needed. The external environment constitutes the total pool of knowledge and expertise outside the organization. People, material and information flow across the two environments. The external and internal environments do not necessarily refer to separate countries. They could well be used in regard to users (the internal environment) and sources of information (the external environment) in the same country.

Empirical evidence shows that certain individuals in an organization or community perform the role of "communication stars," that is, people who are frequently turned to for advice, formal or informal leadership, and technical information. Further, these communication stars form a close network of communication (both formal and informal) within the organization. Information acquired by one member tends to diffuse to the other members of the organization and strong communication bonds become established.[2] The stars within the circles represent the gatekeeper communication networks of the internal and external environments.

The foreign national needs to be a part of the communication network in the organizational community of the country which is sharing the science and technology. The person linking the two environments would be constantly acquiring, processing, generating, and disseminating relevant information from the external communication network.[4] Then it is essential for the person to become a part of the internal communication network for any successful communication to take place. In this way, the information received by the foreign national may be transmitted to the recipient country and that person may optimally, as a result of becoming a part of the internal communication network, be able to send information back to the members in the donor country who form the relevant scientific community.

A final comment regarding Figure 1 alludes to the weak bond between the external and internal environment. This bond exists as a result of trips and/or work done by members of one environment in another environment.

Figure 2 is a further elaboration of the gatekeeper network and its relationship to other members of the organization. Information acquired by the gatekeepers tends to circulate through the gatekeeper network and diffuse outwards to non-network members.[5]

Member 6, for instance, would acquire information from gatekeeper 3 who obtained it from gatekeeper 1. It may be that gatekeeper 1 was initially responsible for introducing the knowledge to the organization.

Figure 3 serves both to put the gate keeper in a new perspective and introduce two more important concepts--those of the liaison and the isolate.[6] In this perspective, the gatekeeper is placed in the framework of the total organization, which could be governmental, industrial, scientific, academic, rural or district level community. There are different areas or departments within any organization, each having different functions and methods of operation and communication. Therefore, the gatekeeper needs to be placed in this interdepartmental perspective in order to ascertain how relevant information flows in and out of these differing areas of the organization.

When interdepartmental information flows are observed, it is found that gatekeepers do not tend to communicate across departments. The majority of the members of an organization are, by and large, average performers, and it is these members who perform the liaison function of carrying information across departmental boundaries. Going to work together or meeting during a

FIGURE 2 Internal Gatekeeper Network

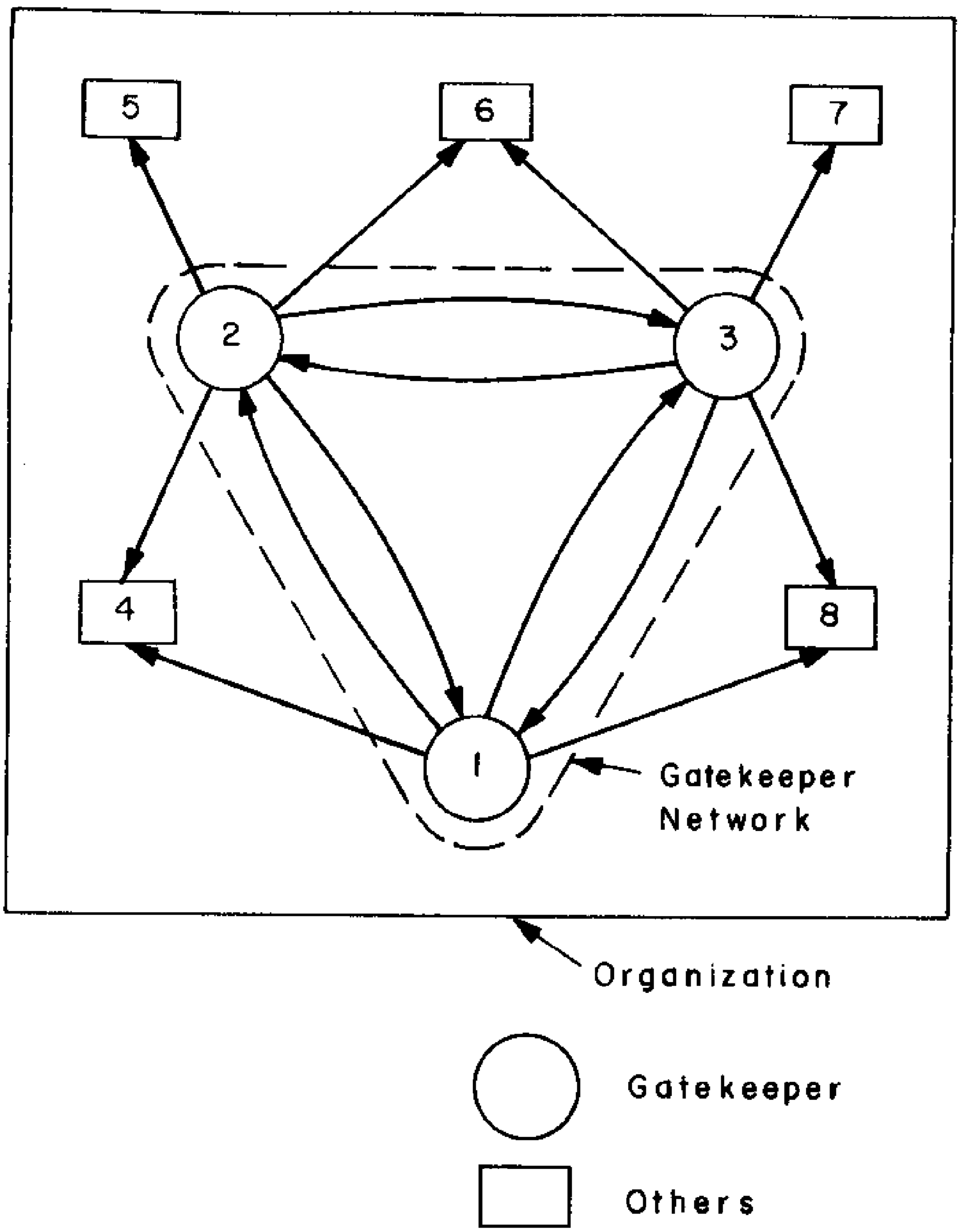
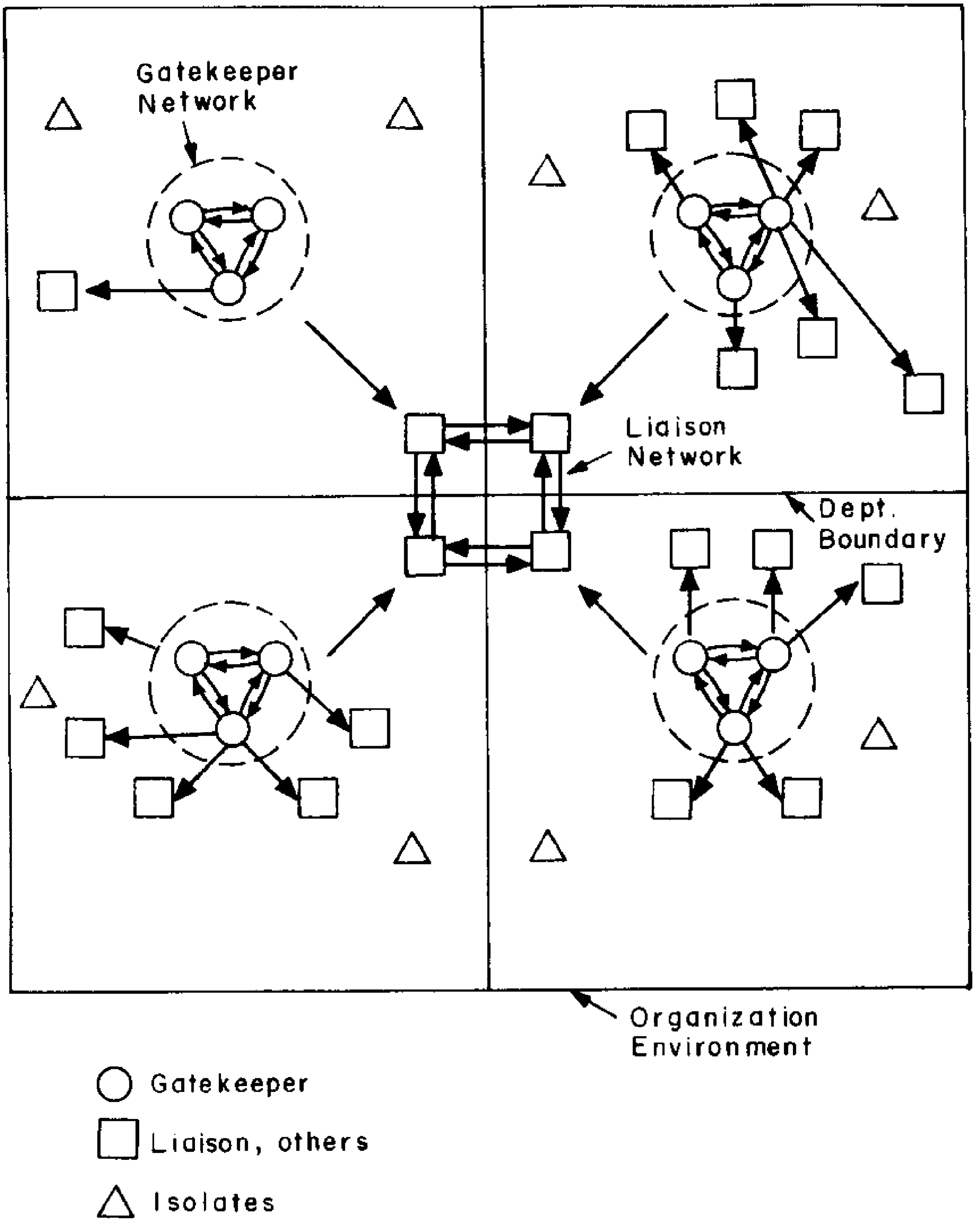


FIGURE 3 Interdepartmental Gatekeeper Network



Gatekeeper - exceptional worker
Liaison -average- communication between departments
Isolate - poor performers

coffee break are just two ways in which this is brought about.

It has been found that the informal communication patterns of the liaisons are constantly changing. They may be established through the creation of the interdepartmental task force teams. Upon completion of the assignment, when the people return to their own departments, their contact with members of other departments does not cease, and therefore, a liaison exists. But, it has been shown that the strength of the communication between these people diminishes over time. Thus, the role of the liaison is constantly shifting.[7]

The isolate completes the performance spectrum. While the gatekeeper is generally an outstanding worker, the output by the isolate is by and large, visibly poor, relative to the performance of colleagues.

Once the process is understood, the first question generally posed is, how does one identify the key people within an organization? Table 1 presents a list of characteristics normally attributed to the key people in any organization.[8]

TABLE 1

IDENTIFYING THE KEY PEOPLE

Characteristics:

1. Read far more, 'hard literature'

2. Broader ranging and longer term relationships with technologists outside their organization

3. Important direct contributor to the organization technical goals

4. Produce significantly greater number of papers and more likely to be among those cited when a chief engineer or chief scientist is asked to name key people

5. High proportion of first line supervisors and second line supervisors

6. Personal characteristics:

    a. Feel accomplishment from helping others
    b. Less emphasis on congenial people
    c. More emphasis on competent people
    d. Preferred to map broad features of a problem
    e. Felt accomplishment when doing innovative work
    f. Lesser feeling of accomplishment from meeting or exceeding standards
    g. Scored no higher than colleagues in creative ability tests
    h. More formal education (more Ph.D.s)

7. Their primary motive for helping people is not that they feel it will help them get ahead in the organization. It is possible that helping colleagues provides them with a measure of job satisfaction.

8. High in innovation, productiveness, and usefulness

9. History of being able to influence others in organization

10. Seem to work better under time pressure

Audiences

Audiences may be classified in any number of ways. One that is useful for the purposes of this paper is to classify them according to their familiarity with general and specific marine information and technology. At one end of the classification, one might find audiences that completely lack even the barest rudiments of the topics at hand. Lacking any frame of reference, these audiences would find it almost impossible to assimilate any new ideas. At the other extreme are audiences that are so familiar with the subject that communication is almost useless. Whether one is dealing with marine industry, government officials, international groups, educators, or the general public, most situations fall between the two extremes.

When viewed in terms of broad global perspectives, the audiences may be classified as follows:

1. Private citizens groups
2. Commercial activities and trade associations
3. Government planning and management agencies
4. Educational institutions
5. Research establishments
6. International organizations
7. Extension and communication programs and personnel themselves
8. Combination of two or more of the above

Narrowing the perspective to that of a project orientation, the audience titles change. The audiences become more functional. The functions of a manager, scientist, technologist and worker begin to play important roles in the project implementation. The success of a project depends to a large extent on the adequate flow of information. Everyone associated with the formation of the project -- the scientist, the manager, and the technologist -- needs to communicate with each other and with the outside experts by means of any or all available channels. However, all audiences do not need to communicate with each other to the same extent and frequency. While the manager must communicate extensively with all audiences, there appears to be no real reason why the scientist and worker need to communicate. This is because information to the worker will come from the technologist, the external change agent, and the manager. One of the main problems of communication is that of attaining a thorough understanding of the intended audience and of sending the best information with the proper communication methods and the right transfer agents.

II. PROCESS OF CREATING AN INTERNATIONAL TRANSFER PROGRAM

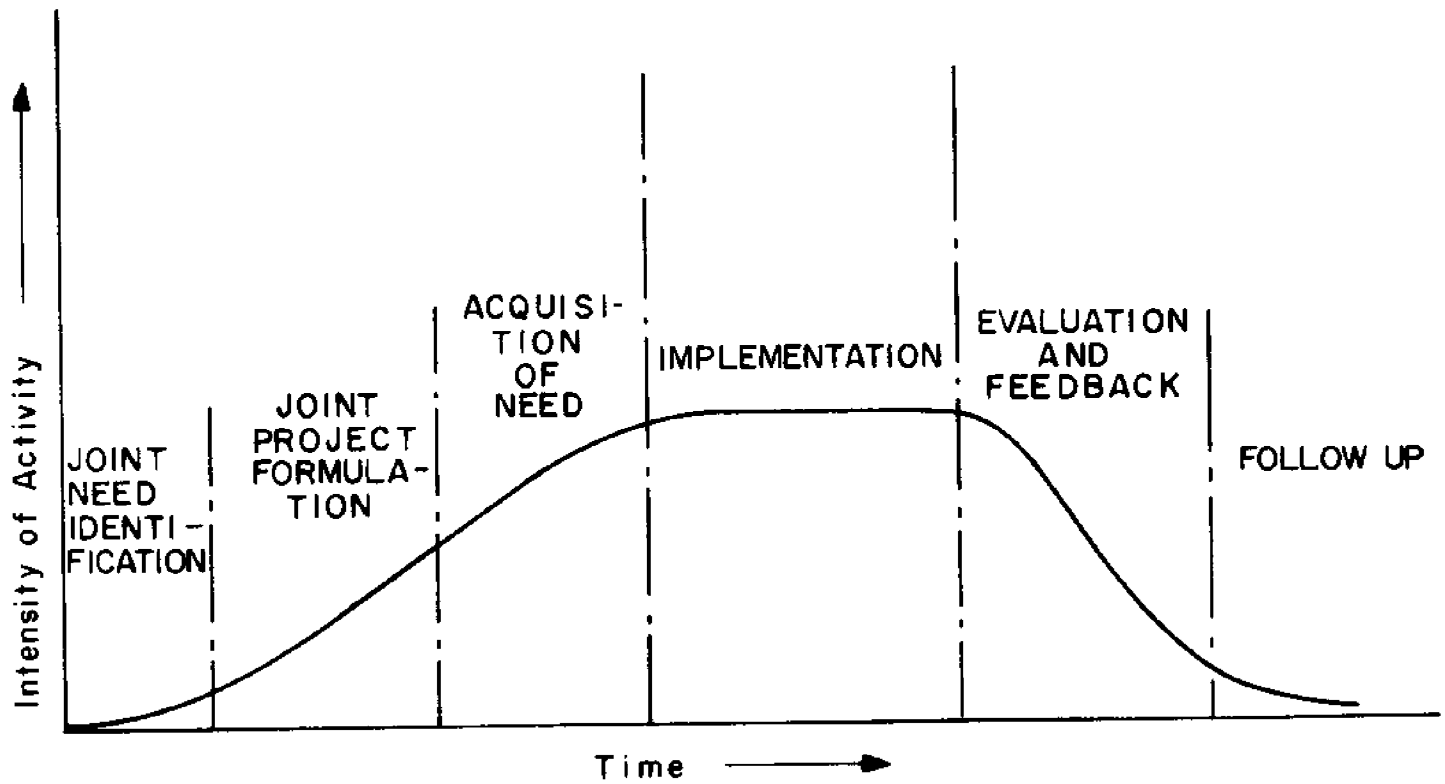
Needs of Identification

The term "technology transfer" has a three-stage history. The first stage was that the United States would go into an underdeveloped country, tell them what they needed, and institute these "benefits" within the country. The second stage initiated a joint identification of needs between the host country and the United States and then the solutions were forced upon them. The third stage incorporates joint identification of needs, joint research into possible solutions, and joint work on program establishment, follow-up and evaluation.

Initial Contacts

An important point in the process is the initial contact with appropriate governmental and local officials. Change and change agents represent a potentially disruptive force in the status quo irrespective of the area of activity. They must have the sanction of local officials if they are to operate at all effectively. It is important for an approved, but nevertheless new program, to gain public acceptance. The first concern is to gain an entry into the community and this process is considerably aided by local contacts. It is also aided by intensive efforts to learn local languages and/or dialects, to understand and respect local customs, culture, and traditions. In the setting where there is an absolute scarcity of adequately trained personnel, the successful program hastens to train and transfer the responsibility to local people as quickly as is feasible. This is accomplished through on-site training and more formal education programs. Therefore, the extensive use of highly trained outside specialists tends to typify an information or technology transfer program impacting an underdeveloped country more than it does a situation where there is some general familiarity with the subject matter.

FIGURE 4 Project Life Cycle



Project Life Cycle

Seven vital stages are necessary in order for any project, regardless of the area or complexity involved, to be completely effective. See Figure 4. These steps constitute the project life cycle and can be categorized in terms of: 1) joint need identification; 2) project formulation; 3) acquisition of relevant resources; 4) implementation; 5) evaluation; 6) feedback; 7) follow-up. Extensive external monitoring is also important. This monitoring would primarily take place during the last four steps of the process and would entail having a person or a group of people observe, regulate, and control the activities of the project to a certain extent.

Although the first four steps are generally an integral part of all projects, it is not uncommon for a worhtwhile project to conclude with no emphasis or regard being placed on the importance of evaluation, feedback and follow-up.

Objective evaluation tests how far the project succeeded in accomplishing the assigned objective without placing any sort of value judgment on the objectives themselves.[9] But this puts a constraint on the process of determining the effectiveness of the project. It assumes that the ex-ante evaluation, in which the needs of the recipient are determined at the onset of the project, were accurate and that these needs have not shifted over time. Permanent evaluation and follow-up, a process of involving continuous and progressive reformation and adaptation, is extremely relevant.[10]

How the relationship between the objectives of the project and the needs of the recipients correlate is ascertained through feedback procedures. This is accomplished through communication with those involved in every aspect. It is crucially important not to exclude those affected by secondary impacts of the project results, i.e., workers losing jobs as a consequence of technologically advanced equipment, thereby increasing the local unemployment rate.

Upon completion of the evaluation and feedback stages, the project may be considered complete in the minds of the implementors and backers. However, without follow-up, there is no way to discover if the project is deteriorating, the causes,or the corrective actions needed to prevent further deterioration. Periodic cnecks and planned interventions can be extremely beneficial in keeping a vital project alive and functioning. Important concepts arising from involvement may be acquired and transferred to future projects of the same nature. The follow-up stage may sensitize coordinators as to what should be emphasized or avoided in initiating future activities.

It should be stressed strongly, that while the stages of evaluation, feedback, and follow-up are conceptually separable, they should not be segregated in practice. Follow-up implies that the processes of evaluation and feedback are in operation. All of these elements are imperative for an overall effective project.

Problems of Present Mechanisms

Major problems in international transfer mechanisms typical of almost any effort are:[11]

1. Little assessment of audience needs
2. Access largely limited to program elites, scholars, and international agency personnel
3. Little targeting of information
4. Little systematic feedback about services
5. Lack of effective promotion of services
6. No mechanisms to transmit information on needs back to the ultimate producers of information
7. Inadequate transformation of information
8. Dominance of scholarly approaches
9. Very limited link between international or regional agencies and local informational units
10. Single medium orientation
11. Virtually no coordination among international information agencies

Extension programs are often also plagued with several other inadequacies:[12]

12. Interdepartmental conflicts and local agency rivalries
13. The dual image agents have of their roles and functions. While they are aware of the longer term benefits accruing from extension methods, they are often tempted to use executive methods to secure quick results. Executive methods imply a decision-making process which ignores the involvement of the people working beneath the initiator; in this case having no

involvement by the local community. Bureaucratic pressure to attain targets can deter the use of slow but more useful demonstration and extension methods.

14. Guidance in human skills necessary for interpersonal communication is often not available. An assessment of the individual backgrounds of agents and training suitable to the specific needs, is generally not undertaken

15. It is also observed that a failure to provide the field agent promptly with adequate supplies, technical support and back up action results in the agent's loss of credibility. Fettered by the lack of support, the agent cannot pursue the communication process to its completion. The audience tends to lose faith in the agent and in the innovations that are being promoted.

16. There are definite costs associated with the acquisition in information and technical know-how, some explicit and some implicit. The design and functioning of an information system must be conditioned by isolating mechanisms, the implicit costs. These might include time, culture, space, public and private priorities, inadequate communication channels, technical sophistication and relative user concentration. Developing and operating a small information system can be an expensive proposition, an explicit cost.

Fragmented efforts may duplicate similar activities of other extension programs and information systems. The problem is one of making the output serve the specific needs of a user while at the same time spreading the system costs over many other system users. An international marine sharing program can be valuable in alleviating this problem.

In addition to these problems, there are several factors that account for the gap between perception and implementation of programs:

1. The audience may be unable to relate the additional information it acquires to its felt needs.
2. The content and mode of the communication may be such that it does not convince a constituency of the advantages of the innovation (viewed in terms of efficiency, economy and ease of mastery and tolerable risk), of its cultural compatibility.
3. Feasibility and of the audience may have an unfavorable image of the source of communication; a distrust of the agency or agent from where it originates.

4. The language, idiom and style of communication may be such that an idea is partially conveyed.
5. The structural features of the audience can retard the promotion of new ideas. Powerful vested interests often attempt to monopolize the benefits of innovations.
6. The audience may have an unhappy memory of similar innovations in the community which would make it cautious and suspicious of trying the innovation again.
7. The information being transmitted could be beyond the absorptive capacity of the audience.

International Transfer Model

Many of the faults of the present mechanisms delineated in the previous section are due to blockages in the flow of information. Ronald Havelock, at the Center for Research on Utilization of Scientific Knowledge (CRUSK), has developed an information flow model that is of considerable value in thinking through the delivery and feedback processes. Functions are as follows:

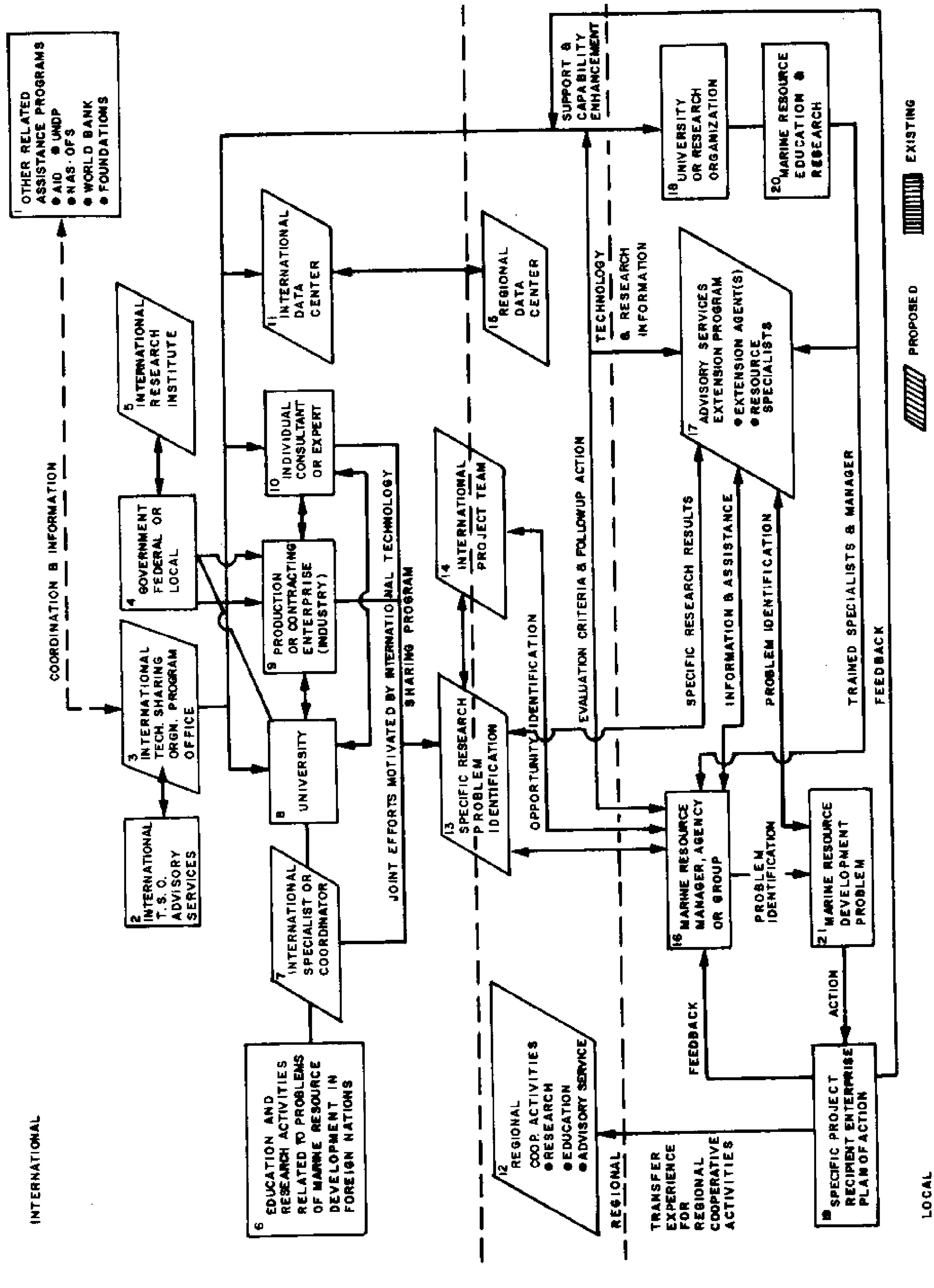
1. Acquisition: Number and type of sources, quantity, and form in which material is received.
2. Screening: Judging, selection and rejection based on quality, relevance, form, etc.
3. Cataloging: Indexing, abstracting, coding.
4. Storage: Microfilming, computerizing, centralization, cumulative indexing, reproduction capability for indexes, abstracts, documents, whole files.
5. Transforming for Users: Translating, summarizing, integrating, interpretive writing, packaging; generalized, targetted, individualized transformations.
6. User Access: In-person, mail, telephone; searching - manual - computer (on-line, batch); key words, Thesaurus descriptor, citation-output - titles, abstracts, whole documents.
7. Dissemination: Publishing, advertising the service, seminars and workshops, media presentations.
8. Assistance to Users: Consulting, guiding, or training in interpretation, application or problem-solving.

9. Communication from Users on: (a) needs (including need surveys), (b) reactions to information received, (c) reactions to the service.
10. Analysis, interpretation and prediction of user needs. (With or without #9).
11. Feedback on R&D Producers and Knowledge Sources either as new guidelines for input or assessments of user needs.

Theoretically, people will communicate once cultural, language, and political barriers are penetrated, but, in specific cases, this may not always be the case. For instance, in Latin America, studies have found that change agents tend to communicate most with persons of similar status and least with persons of lower status than themselves.[13] This makes one realize that even though the proper people within the country are identified, the communication between the change agent and the host country may be ineffective. Also, "our failure to establish and pursue specific purposes in acquiring and consuming information may have negative consequences of a specific purpose for communication to others." [14] Once the key people have been contacted, it is of paramount importance in a joint technology sharing program that the highest priority should be the identification of needs and tentative plans of action. The implication here is that program objectives should be unambiguously delineated before any action is initiated. The mere establishment of communication channels does not mean people are communicating. Instant relaying of long distance messages and fast transport of different peoples does not mean communication is taking place.[15]

In order to insure that the impact of the projects is not transitional, some type of institutional or organizational arrangements must be established as an integral part of the projects. Without this commitment, and an automatic process for the creation and transmission of innovations, the long term growth will probably be negligible.[16]

It is because of this that new channels of communication must be established, new methods introduced, and a network of decentralized institutions must be formed. It is precisely this need that led to the creation of the model on page 58. A thorough explanation of the model and its relationship to the communication model will be provided in order to focus on the valid application of communication. It is, in very broad terms, a model of a proposed International Technology Sharing Program.


INTERNATIONAL
REGIONAL
LOCAL
1 OTHER RELATED ASSISTANCE PROGRAMS ● AID ● UNDP ● NAS-OFS ● WORLD BANK ● FOUNDATIONS
COORDINATION & INFORMATION
2 INTERNATIONAL T.S.O. ADVISORY SERVICES
3 INTERNATIONAL TECH. SHARING ORGN. PROGRAM OFFICE
4 GOVERNMENT FEDERAL OR LOCAL
5 INTERNATIONAL RESEARCH INSTITUTE
6 EDUCATION AND RESEARCH ACTIVITIES RELATED TO PROBLEMS OF MARINE RESOURCE DEVELOPMENT IN FOREIGN NATIONS
7 INTERNATIONAL SPECIALIST OR COORDINATOR
8 UNIVERSITY
9 PRODUCTION OR CONTRACTING ENTERPRISE (INDUSTRY)
10 INDIVIDUAL CONSULTANT OR EXPERT
11 INTERNATIONAL DATA CENTER
JOINT EFFORTS MOTIVATED BY INTERNATIONAL TECHNOLOGY SHARING PROGRAM
12 REGIONAL COOP. ACTIVITIES ● RESEARCH ● EDUCATION ● ADVISORY SERVICE
13 SPECIFIC RESEARCH PROBLEM IDENTIFICATION
14 INTERNATIONAL PROJECT TEAM
15 REGIONAL DATA CENTER
OPPORTUNITY IDENTIFICATION
EVALUATION CRITERIA & FOLLOWUP ACTION
SUPPORT & CAPABILITY ENHANCEMENT
TECHNOLOGY & RESEARCH INFORMATION
16 MARINE RESOURCE MANAGER, AGENCY OR GROUP
17 ADVISORY SERVICES EXTENSION PROGRAM ● EXTENSION AGENT(S) ● RESOURCE SPECIALISTS
18 UNIVERSITY OR RESEARCH ORGANIZATION
19 SPECIFIC PROJECT RECIPIENT ENTERPRISE PLAN OF ACTION
20 MARINE RESOURCE EDUCATION & RESEARCH
21 MARINE RESOURCE DEVELOPMENT PROBLEM
SPECIFIC RESEARCH RESULTS
INFORMATION & ASSISTANCE
PROBLEM IDENTIFICATION
TRAINED SPECIALISTS & MANAGER
FEEDBACK
ACTION
TRANSFER EXPERIENCE FOR REGIONAL COOPERATIVE ACTIVITIES
PROPOSED
EXISTING

A problem that creates a gap between awareness and acceptance of innovation in underdeveloped nations is that there may be an unsuccessful history of similar innovation in the community. This may arouse a sense of caution and suspicion among the members of constituent community.[17]

The model of a proposed international sharing program is divided by the dotted lines into three sections: international, regional and local. The solid lines connecting boxes represent direct communication paths. Communication relates to the flow of information from the international level to the regional and local levels, and also within the local level itself.

The foreign national, discussed in the section on Actors Within an Organization, could be a member of the advisory services extension program (box 17). This person must also be a part of the communication network of the external environment, meaning that the person must be a representative from either the university (box 8), an international specialist or coordinator (box 7), a production or contracting enterprise (box 9), or an individual consultant or expert (box 10).

Specific problem identification (box 13), can be achieved in one of two ways. First, it could be identified by the resource manager, agency or group (box 16) with information and assistance being obtained from the extension agent (box 17), local university or research organizations (box 20). This may be adequate to formulate a solution, create a specific project plan of action and carry through the project. Second, the problem could be identified through the joint cooperation between the resource manager, agency or group (box 16) and the international project team (box 14). This team would be made up of members of both the donor and recipient countries working not only on problem identification, but perhaps on a new opportunity identification. Following this stage the specific project plan of action would take place.

Once problems are identified, solutions could be formulated on one of three levels. Hopefully, most could be accomplished strictly at the local level as a means of creating a sense of self-sufficiency within the host country. But if adequate information is not available for the solution through the assistance of the local advisory service, the university, or the resource and education institute, the help must be obtained from either the regional or international level. It is because of this need that a regional (box 15) and international (box 11) data center is proposed as one way of solving the problem. In this way, the "foreign national" could go to these centers and obtain the needed information.

Within the region, attention should be given to the following activities for the purpose of transferring and sharing information and experience:

1. Building the regional and trans-regional organizations that will be the nuclei through which the information and technology program can be operated.
2. Identifying problems and opportunities for regional and transregional sharing of marine information and technology.
3. Investigating the communication systems and information sources for their applicability, accessibility, and economies of scale. Additional functions at the regional level will include activities like translation, interpretation, and integration of information.

Having completed the international flow model, attention now is directed towards mechanisms within the system to facilitate the information transfer.

III. COMMUNICATION CHANNELS

Communication channels linking audiences, sources of expertise and end users are an integral part of the transfer process.

Communication paths among the following segments of the community appear necessary:[18]

1. Political sector and bureaucracy
2. Planner and political decision maker
3. Planner and units of production
4. Different departments and agencies of the government
5. Planner and research agencies
6. Different levels of administration
7. General administrator and technicians
8. Modernizers and the rest of society
9. Overseas consultants/advisors and local counterparts
10. Donor and recipient nations

These links comprise the communication flows among the change agent, the "politicians," "managers," "scientists," "technologists," and "workers."

Communication channels need to be analyzed and established with a framework that acknowledges communication must make itself heard or seen against competition. This implies repetition or use of multiple channels.[19] They must be able to respond to the following questions:[20]

1. What is the best mix, for a given purpose and a given time, of mass communication with interpersonal communication?
2. What is the best distribution of resources so that communication can be made to flow where it is needed?

Table 3 lists and explains some communication and information channels that scientists and technologists employ. Workers, for example, could be better reached through channels like public radio and television, posters, and puppet shows.

In order to discern which information channel would be the most appropriate for a particular type of audience, i.e., scientist, manager, technician, or worker, a matrix such as found in Table 4 could be of some use.[21]

There are four areas of evaluation of the information source -- accessibility, ease of use, technical quality, and frequency of use. These four areas are given some sort of weighting appropriate for a particular project. For instance, accessibility may be more desirable than technical quality so it may receive a weighting of 60 percent, while the other three might receive weightings of 20 percent, 10 percent, and 10 percent respectively. The last column is used for a weighted average to determine the overall importance of the 18 channels of information. This ranking is not appropriate for every situation. For each audience, and for each project within the same audience, new criteria for ranking must be developed according to specific needs.

It does appear though that accessibility is the overriding determinant in channel selection and that even an apparent exception to this can be understood in terms of a secondary effect, the use of one information channel to make another more accessible.[22] What can be termed a channel evaluation filter is pictured in Figure 5a. This shows how information is generally obtained by an audience, and the relative importance assigned to each criteria. Figure 5b illustrates the information flowing from various communication channels, through a channel evaluation filter, and finally to its ultimate recipient.

TABLE 3*

Information Channels

Literature:	books, professional, technical and trade journals and other publicly accessible written material.
Vendors:	representatives of, or documentation generated by suppliers or potential suppliers of design components.
Customer:	representatives of, or documentation generated by the government agency for which the project is performed.
External sources:	sources outside the organization which do not fall into any of the above three categories. These include paid and unpaid consultants and representatives of government agencies other than the customer agency.
Technical staff:	engineers and scientists in the organization are not assigned directly to the project under consideration.
Research:	any other project performed previously or simultaneously in the organization regardless of its source of funding. This includes any unpublished documentation not publicly available, and summarizing past research and development activities.
Group discussion:	ideas which are formulated as the result of discussion among the <u>immediate</u> project group.
Experimentation:	ideas which are the result of test or experiment or mathematical simulation with no immediate input of information from any other source.

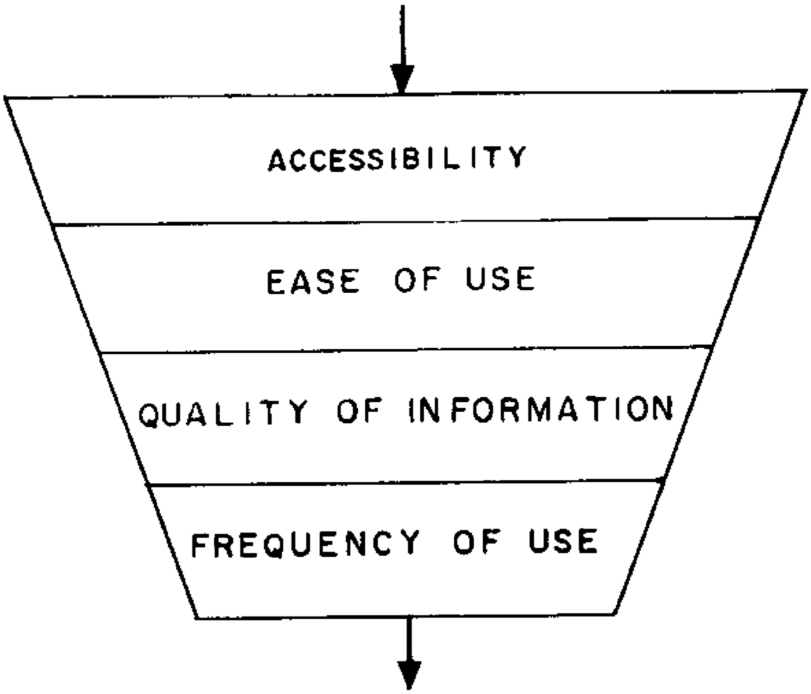
* From Thomas J. Allen's Ph.D. thesis, pp. 2-7.

TABLE 4

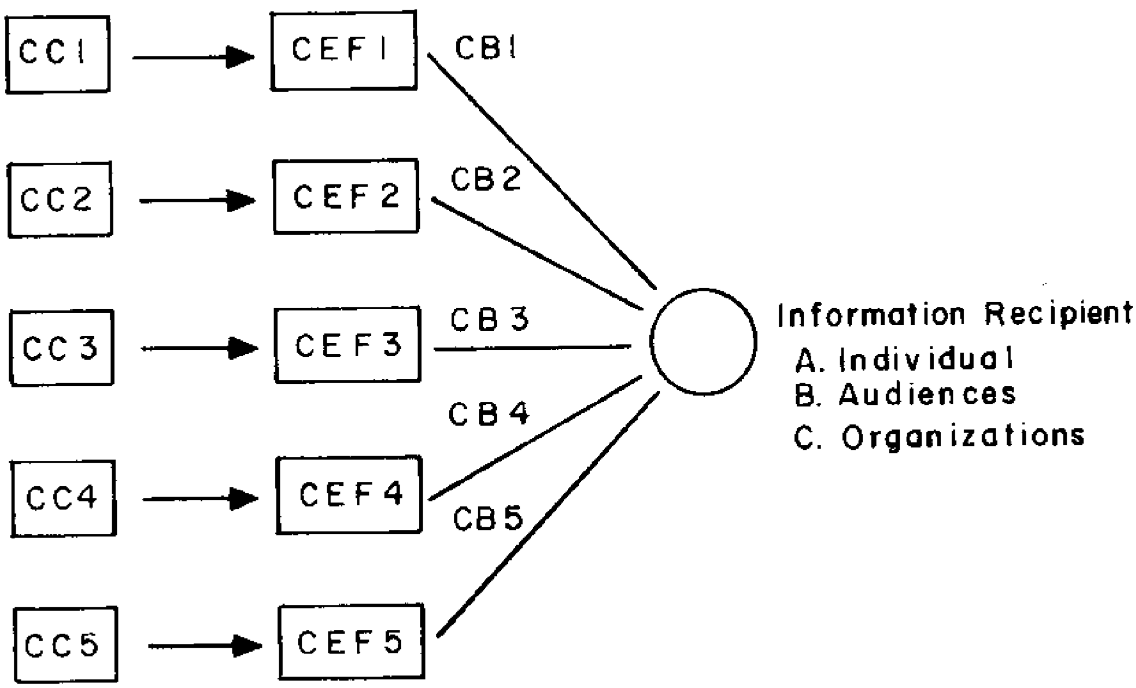
Channel Evaluation Matrix

CRITERION / CHANNEL	ACCESSIBILITY	EASE OF USE	TECHNICAL QUALITY	FREQUENCY OF USE	WEIGHTED AVERAGE RANKING
Literature					
Vendors					
Customers					
External Sources					
Technical Staff					
Research					
Group Discussion					
Experimentation					
Newspapers					
Radio/T.V.					
Posters					
Puppet Shows					
Bazaars					
Coffee Houses					
Mime/Dance					
Extension Agent					
Leaflets					
Audio Visual Displays					

FIGURE 5 Channel Evaluation Filter



A



CC - Communication Channel
CEF - Channel Evaluation Filter
CB - Communication Bond

B

IV. THE EXTENSION SYSTEM CONCEPT

Another premise of this paper is that a local marine extension system is a vital link in the process of international transfer. While there are many on-going arrangements that already are involved in transfer processes of one sort or another, the local extension system has the structure and capability to reach diverse groups of people and perform the varied tasks involved in relating the information appropriate to each group.

Especially useful in defining the traditional extension role is the list of characteristics of the Cooperative Extension Service. This list, which defines a very workable system, is given below:

It is educational in program content and methodology, not regulatory or financial. This is attached directly to the public university system rather than to state government.

It provides informal, noncredit education conducted primarily beyond the formal classroom, and for all ages.

It helps people solve problems and take advantage of opportunities through education.

It features the objective presentation and analysis of factual information for decision making by the people themselves. It is typically research-based with communication among research, extension, and resident-teaching functions of the state university system, and also with the resources of the United States Department of Agriculture and other agencies, public or private.

It functions through local offices which are semi-autonomous units accessible to and subject to influence by local residents.

It involves cooperative but not necessarily equal sharing of financial support among federal, state, and county or local levels.

It is practical, problem-centered and situation based. Extension education starts with helping people to identify and understand their needs and problems and to use new technology or information in solving them.

The funding and administrative relationships permit educational programs directed at broad national purposes, yet serving specific local needs with priorities determined locally.

The effectiveness of the extension agent, the communication channels and the information transmitted, is often diminished by a variety of factors. These range from suspicions within traditionally oriented communities of new ideas to inadequate perceptions by the change agents of the needs and problems of their constituents.

The change agent often performs a dual role, that of securing the adoption of new ideas and that of attempting to hinder the diffusion and spread of certain innovations from other sources that may compete with or supersede ideas sponsored by the agent.[23] It becomes important to realize this dual influence of the change agent in an extension program. Adding complexity to the role of the agent are class distinctions that are particularly endemic to developing societies though not confined to them. There is a real possibility that the lower classes, whose need for information and innovative ideas is the greatest, may be largely ignored.

Status differences may also exist between the agent and the people with whom he is dealing. Where this disparity becomes wide, an effective barrier to communication may be created. The agent is often a member of the middle or upper class, and therefore, tends to gravitate towards these people.

Suspicion of foreign agents is only one of the problems. The problem of "reentry"[24] into the social system faced by local people who have temporarily left their community for further training, compounds the hazards with which an extension system must contend. A guard against the tendency to train local change agents beyond a certain level of sophistication must exist. Some studies have found that in developing nations, agents with only a high school education were more successful in villages than those with a college education.[25] However, it should be borne in mind, that training programs must include establishment of links between these agents and governmental and institutional representatives. One way in which this may be accomplished is through involvement of all these people in the actual training process. Apparently, the high school educated agents were better able to maintain linkages with the local community members.

In developing countries traditional information means are expanding to include the functions of information translation, interpretation, and application. However, where potential users are unaware and unable to seek out information there remains a large area that can only be served by extension systems or advisory programs of one sort or another. On the other hand, the emerging extension systems often find the traditional information systems inadequate to properly provide information for specialized needs. The response has been to try to establish their own narrow information systems.

The point to be made here is that the weakest link in a complex information and technology transfer system is likely to be the extension process.

If the foreign national of the model is to be used as an extension agent, it is necessary to overcome language, cultural, and other similar differences. Not surprisingly, the success or failure of these efforts often times is directly related to chance and the backgrounds of the persons involved. A necessary ingredient is professional training and competence.

It is not the purpose of an International Technology and Information Sharing Program to enter a country, set up an extension service, and attempt to compete with any form of existing extension service, or advisory agency. On the contrary, the intent is to help the country, and if this can be accomplished most efficiently by coordinating efforts and meshing into existing agencies, then this should be the preferred method of operation. By working in conjunction with these other agencies, existing ties may be utilized in order to gain easy acceptance. A thorough investigation should be made in regard to these existing organizations to insure against associations that have negative connotations in the minds of the villagers, and to insure against upsetting already established organizational, institutional and personal bonds.

V. RECOMMENDATIONS

The following recommendations begin with those specifically related to an extension strategy. Incorporating these with the recommendations based on communication aspects and program design, a framework for an operational international technology sharing system begins to emerge.

Extension Strategy

1. The program of change that an agency or extension agent has in mind should be tailored to mesh with cultural values and past experiences. The norms of a social system have a significant effect on the diffusion of ideas. A change agent should seek to create an atmosphere in which the people are more receptive to new ideas, thereby reducing the perceived risk surrounding innovations. While sounding reasonable, this would have great practical difficulties. Cross-cultural extension agents often possess values different from their audience. Unless an awareness of audience value systems exists, the agent is likely to meet with only limited success.

2. Both the recipients and the change agent must perceive a need for an innovation before it can be successfully introduced. In addition, perceived benefits must exceed perceived costs. "An induced technological change will succeed to a degree proportionate to the extent to which the (client system) who feels a need for it, are brought into this planning and execution, and feel it to be their own."[25]

3. Extension agents ought to be more concerned with enhancing the competence of their audience in evaluating new ideas and processing new information than with merely promoting innovations per se. An example of this would be a technical training program which enables the people to judge for themselves the merits of a particular technology.

4. Extension agents should focus their efforts upon opinion leaders and gatekeepers in the preliminary stages of information dissemination and technology diffusion.

5. An attempt to anticipate the social consequences of introducing new methods and technology ought to be made. Local power structures and patterns within the society can easily be threatened or disrupted if the extension program is insensitive to local mores. An elite class which perceives a threat to its position or status can become a formidable obstacle in the communication system. Conversely, programs that merely reinforce the entrenched interests of an elite and serve to widen disparities among privileged and underprivileged classes of people in the community should also be avoided since the entire extension system could acquire an unfavorable image.

6. An agent should not begin with programs that require a great deal of support.

7. In the context of technical cooperation, communication has to aim at more than the transmitting information and creating awareness. It should also promote execution and adoption of techniques and methods.

8. A communication system needs to incorporate provisions for multi-channel flow of information since many developing communities distrust a new idea if it comes from only one source; unless multiple channels are available by which to corroborate the facts, the information may be received with

suspicion and be rejected.[27] The system should also utilize traditional means of social communication--the bazaar, the coffee house, the bar, the tea house, the country fair, the puppet show, and others -- which continue to be influential long after newspapers, broadcasts and other media methods became available.[28] The specific channels employed must be tailored to the individual needs of those with whom work is being done.

9. A way of identifying communication patterns within the community with an orientation towards understanding communication gaps in the flow of information is suggested. Once the gaps are identified, attention can be focused on developing both formal and informal links to facilitate information flow, establish new patterns and strengthen existing ones. Personal interviews using a comprehensive questionnaire would serve as a suitable technique for obtaining relevant information.

The Inter-Organizational Communication Matrix shown on page 65 should cover all the actors within any environment under consideration. Organizations, both temporary, such as annual conferences, and permanent, such as universities, are listed along the rows and columns of the matrix. Communication within the organization is termed internal and denoted by an I. Efficient communication systems within the organization are denoted IS for internal strong, and poor communication systems denoted IW for internal weak. It is recognized that IS and IW form extremes and classification into either category may be difficult. The need for an intermediate category IM (internal medium) is obvious. The cut-off points for determining the ranges within a category, on some scale, should be established prior to conducting the study. Inter-Organizational links are classified as X or formal and Y or informal. The matrix is then filled in according to the nature of the link. Gaps in the matrix then serve to focus attention on areas where inadequate or very little communication exists. The completed matrix also provides an indication of which inter-organizational links, formal or informal, need to be strengthened. Finally, it permits the decomposition of the matrix into a smaller model which clearly shows the informal organization within the community.

In the example shown below, 1, 2, 3, 4 are four hypothetical organizations. Organization 4 is clearly somewhat of an isolate whereas 2 and 1 are closely linked. The need for an operational communication system that fosters the sort of links that exist between 1 and 2 becomes apparent. Further, the relationships between 1 and 2 could be explored in greater detail to obtain insights into how the entire community may be linked by an XY configuration. Of course, a certain amount of judgment is needed to determine the strength of the organization bond before it can qualify for an X or Y linkage rating and empirical methodologies should not be difficult to find.

	1	2	3	4
1	IS	XY	X	
2	XY	IW	Y	X
3	X	Y	IS	
4		X		IW

Program Management Recommendations

10. Initiate contacts with people in the marine community. Inform them of the intention of the program to establish an initial working relationship.

11. Visit each country assessing marine resources, problems, management potentials, communication links, information needs, resource people, educational and research establishments, and the like.

12. Determine the weak points in the intra-country extension and communication systems and make strengthening these a first order of priority.

13. Identify and improve the problem-identification and feedback mechanisms and the means of addressing problems for local and/or regional attention.

14. Take advantage of opportunities for using transfers (involving no new products or technology) as they arise.

15. The international technology sharing program in the marine sciences.

should be university based. The establishment of bilateral arrangements between the United States and universities in developing countries is suggested.

16. The programs should be oriented towards software and developing human skills.

17. The objectives of the programs should be such that they make a material contribution to institution building, which increases domestic competence, i.e., a visiting professor who has the expertise to expand the level of competence in a given area at a university.

18. Steps should be taken to establish a regional or international data bank as proposed by the model on page 53.

19. Programs should be instituted through binational project teams made up of representatives from the participating nations. These teams need not be part of a formal structure. People within both the communities could be designated members of the team without any physical relocation taking place.

20. A program should be initiated to promote closer institutional communication in order to facilitate information flow and help avoid duplication of research.

21. Training abroad should be encouraged because it increases an awareness as to the location of available sources of foreign expertise, and broadens the range of formal and informal contacts which facilitate access to these sources of information and competence.

22. Programs should be designed to incorporate a method of evaluation, feedback and follow-up to insure relevant objectives are met.

FOOTNOTES

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Volume II

INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY

A Three-Volume Study

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TRAINING AND TECHNICAL ASSISTANCE IN MARINE SCIENCE:

A VIABLE TRANSFER PRODUCT

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TABLE OF CONTENTS

		Page
ABSTRACT		3
INTRODUCTION		4
I.	MARINE SCIENCE	5
	Training in Oceanography	8
	Research Equipment Used in the Marine Sciences	9
	Chemical Oceanography	10
	Biological Oceanography	11
	Physical Oceanography	12
	Marine Geology and Geophysics	13
	Basic Versus Applied Research	14
II.	VIEWS AND EXPERIENCES OF AMERICAN OCEANOGRAPHERS TOWARDS TECHNICAL ASSISTANCE	15
	Interest of Marine Scientists in Cooperative Programs	20
	Types of Cooperative Marine Science Programs	23
	Mechanisms of Scientific Contact	28
	Difficulties in Technical Assistance	28
	Overall Interest of U.S. Scientists	29
III.	VIEWS OF SCIENTISTS FROM DEVELOPING COUNTRIES	30
	Types of Programs Desired	30
	Research Fields of Interest	32
	Other Ideas on Technical Assistance	33
IV.	RECONCILING THE VIEWS OF MARINE SCIENTISTS FROM DEVELOPED AND DEVELOPING COUNTRIES	34
	Past Programs - Success and Failures	35
	Establishing Criteria of Success	36
	Mechanisms for Technical Assistance	37a
SUMMARY AND RECOMMENDATIONS		38
ACKNOWLEDGMENTS		45

ABSTRACT

Marine science is presented as a possible transfer product for training and technical assistance programs with developing countries. To develop this point we present the major research interests, techniques and instruments of the various branches of marine science and show how some could be used in a transfer program. To ascertain past experience and present interest in cooperative projects with foreign scientists we sent a questionnaire to over 100 U.S. marine scientists. The U.S. scientists showed a high level of interest in cooperative marine science programs and over two-thirds had participated in some type of international marine science program. many of which involved marine technical assistance. The respondents suggested many problem areas in such programs, particularly inadequate funding, variations in scientific backround among participants, cultural and language problems, and government bureaucracy. The experiences and criticisms of some marine scientists from developing countries are also reviewed and compared to the views of U.S. scientists. The foreign scientists noted as problems insufficient opportunity to participate in the planning of the programs, inadequate length of programs, and difficulties with funding and government support. We suggest several mechanisms to expand and improve the effectiveness of educational and technical assistance programs in the marine sciences with developing countries. Based on our study we feel that there is considerable interest among U.S. marine scientists in having training and technical assistance marine science programs with foreign countries. Furthur developments await funding and leadership.

INTRODUCTION

The oceans cover close to 72 percent of the earth and about 100 countries border it. Its influence upon the economics and living conditions of the remaining 28 percent of the world is immense. For many countries the oceans are, or could be, a major source of food and/or of mineral wealth. Most of the shipment of trade is by the sea. Much of the world's industrial and human waste eventually ends up in the ocean. In many countries a large percentage of the population lives near the sea and uses it for recreational and other purposes. The conflicts over and opportunities for the use of the sea have been increasing at a considerable rate, and several of the developing countries are anxious to develop marine science capabilities.

Many developing countries are suspicious of the use of the ocean by developed countries, and see this as just another example of resource exploitation by the richer countries. Recognizing this, it has been suggested that a program of oceanographic technology transfer be established[1] to allow the developing countries to share realistically in the opportunities of the ocean. We propose here that training and technical assistance in marine science be considered as one of these technology transfer products. We shall describe the work and equipment used by oceanographers and present results of a survey investigating international marine science cooperative programs.

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[1] Ambassador McKernan, in a statement to Subcommittee III of the UN Seabed Committee in August 1972, indicated that the U.S. in principle was committed to providing technical assistance in marine science to developing countries.

I. MARINE SCIENCE

A basic understanding of the ocean involves the description of the characteristics of the water of the oceans as well as the interaction of this water with the overlying atmosphere, the underlying rock and sediments, and the animal and plant life that it contains. The study of the ocean thus requires many different scientific inputs. Traditionally, marine science was taken to refer to oceanography, which was divided into five main subdivisions: physical oceanography, biological oceanography, marine geology and geophysics, chemical oceanography, and ocean engineering. More recently it has been recognized that the basic scientific information obtained from the ocean also affects man's immediate welfare. This has led to the involvement of fields such as law, economics, international affairs, political science, decision-theory, management, diplomacy, and even anthropology in the marine science arena.

Many definitions have been given for the term "oceanography." The simplest and perhaps most appropriate one was given by H. B. Bigelow in 1931, when he defined oceanography as "the application of all science to the phenomena of the ocean[2]" Bigelow recognized the importance of the interactions within the ocean. For example, the wind blowing on the ocean surface has a major effect upon the biology and chemistry of the ocean and indeed can even influence the sediments buried on the ocean floor. Thus, to properly evaluate the ocean, it is often necessary to have an understanding or appreciation of all the different subdivisions of oceanography. A brief discussion of the main interests of the scientists working in different subdivisions follows, but it should be noted that the dividing lines are really artificial and not rigid.

The chemical oceanographer is mainly concerned with chemical reactions that occur at the air-sea interface, with biological reactions and with those reactions that occur on or below the sea floor. Chemical oceanographers are also interested in the distribution of the elements in the sea and their source and travel paths through the ocean. This often requires a study of

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[2] H. B. Bigelow, Oceanography: Its Scope, Problems, and Economic Importance (Houghton Mifflin, Boston, 1931).

the composition of the sea water as well as knowledge of the chemistry of marine sediments and of the organisms living within the ocean. By the use of radioactive isotopes, the chemical oceanographer has recently been able to introduce time into his studies and thus can calculate the rate of mixing processes within the ocean. More recently, some chemical oceanographers have been concerned with the effects and distribution of human and industrial waste products in the ocean. Their data have been important for evaluating the pollution of the ocean. Those scientists more interested in the chemistry of the sediments on the sea floor or more specific deposits such as manganese nodules are generally called geochemists.

The marine geologist, sometimes called geological oceanographer, is mainly interested in the topography, structure, and sediments of the continental margin and ocean basin. Some marine geologists specialize in the coastal zone and are especially concerned with mechanisms of sediment transport, beach development, and erosion processes. Others have specialized in studies of the continental margin, i.e. the continental shelf, continental slope, and continental rise. More recently, efforts have been made to use geophysical techniques to further the theory of sea-floor spreading, a concept that explains most of the major features of the earth's crust as due to the moving apart and collision of plates, or portions of the crust. In this regard, the marine geologist and marine geophysicist have very similar interests and it is sometimes difficult to distinguish between the two.

The marine geophysicist, or geophysical oceanographer, is generally concerned with the deeper structure of the earth's crust. His main tools are measurements of the earth's gravity, using gravimeters; the magnetic field, using magnetometers; and seismic measurements, using acoustical or electrical energy transmitted directly into the ocean. The energy is reflected or refracted from different layers within the earth's crust and the time and quality of the returning signals can be used to work out models of the structure of the area. These types of studies are called seismic reflection or refraction. The techniques used by the marine geologists and geophysicists can also be used to find structures favorable for oil and gas deposits.

The biological oceanographer is principally interested in the occurrence and distribution of life within the ocean. This includes ascertaining areas of high biological productivity, the mechanisms that control this productivity, and the distribution of nutrients and other elements important to plant and animal growth in the ocean. The actual rate of production of organic material can be measured using radioactive isotopes or other techniques. These oceanographers are also concerned with the transfer and flow of energy throughout the food chain and, more recently, how the introduction of man-made wastes has influenced the food chain.

There is another group of marine biological scientists whose efforts are mainly in fishery or marine food products. Their studies emphasize fish behavior, taxonomy, physiology, ecology, and population dynamics as well as management and statistical evaluations of the fishery resources.

Recently, biological and chemical oceanographers have attempted to control and monitor the development and growth of marine organisms, creating the rapidly expanding field of aquaculture.

The physical oceanographer is mainly interested in the physical properties of the sea including air-sea interactions. These physical properties include the development of waves and currents by winds, the transmission and exchange of the heat received by the ocean, the distribution of physical properties of the water such as temperature and salinity, and the transmission of light and sound within the sea. Studies can be purely theoretical, using models, or at sea, using buoys or ships. Results from these data can be used for prediction of weather and oceanographic conditions. In the past, physical oceanography has probably been the most isolated of all the subdivisions of oceanography. However, with the increased refinement of measuring techniques and better understanding of the chemical and biological processes in the ocean, a new and more fruitful interaction is occurring between the physical oceanographer and oceanographers of other disciplines.

The ocean engineer is concerned in part with the technical instruments and equipment used in oceanographic research. This field is actually more important than it may first appear, since many of the major advances in marine sciences have resulted from technological breakthroughs such as seismic reflection techniques and improved methods of sampling and measurement. More recent developments have been the fully automated data systems that can be left at sea for months or longer, buoys or instrument packages that can transmit the data directly to the laboratory, submersibles, and the GLOMAR CHALLENGER, a ship which has the ability to drill in most of the deep waters of the ocean. Data processing and analysis have also been improved by more widespread use of computers, both on ship and at research centers.

Another group of ocean engineers is more concerned with ways of using the ocean. These engineers may work in the coastal environment, where they evaluate and develop methods to prevent coastal erosion and harbor siltation, or on the deeper parts of the shelf, where offshore terminals and mining operations may take place. Ocean engineers also design harbors, breakwaters, and other marine facilities.

Training in Oceanography

Most practising oceanographers in the United States have received their training in one of two principal ways. In the past, the most common method was to obtain basic training and specialize in one of the physical or biological sciences, and then sometime during one's career to become interested in the marine application of that specialty. For example, a geologist studying ancient coral reefs may have become interested in carrying this study furthur to look at present-day examples. Thus, many of our present-day oceanographers did not have training in marine sciences, *per se*, but rather became interested in marine problems at a later stage of their career. The resulting communication problems have led to fragmentation and occasionally to relative isolation of a particular group.

Currently, most practising oceanographers are trained in marine science. These scientists usually graduated from the larger oceanographic institutions which offer advance training in the field of oceanography. They are generally exposed to all the major subdivisions of oceanography and their thesis research may have overlapped two or more subdivisions. Most new marine scientists, regardless of how they became oceanographers, have had some training in the various subdivisions of oceanography. Because some areas of oceanography are changing rapidly in response to concerns such as environmental degradation, it is extremely important that an oceanographer interested in related problems have at least a modest background in biology, chemistry, physics, and geology.

It does not follow that foreign oceanographers should be trained in the same manner as the U.S. oceanographers. One method not commonly used but with considerable potential here or in other countries would be to retrain scientists from other fields to do oceanographic work. Such training could both serve as an outlet for those fields where supply of scientists exceeds demand and produce marine scientists in relatively short periods of time.

Research Equipment Used in the Marine Sciences

For most marine scientists the basic piece of equipment is the research vessel. This can be a very sophisticated 150 meter long research vessel or a 3 meter rowboat, depending upon the job to be performed. Choosing the appropriate ship for the job is most important. Large research vessels capable of working in the deep ocean probably are required only by those countries already well developed in marine sciences. These ships, besides having the capacity for extended trips, must have considerable storage space to carry equipment used for different programs in the course of the expedition. Such vessels and the types of basic research they do are frequently beyond the present needs and interests of the developing marine countries. Probably more immediate returns would accrue to less-developed countries if they put their oceanographic efforts into that area immediately adjacent to their coasts and emphasized practical and applied research rather than basic research. Some specific suggestions will be presented in the following sections. It would be impractical and uneconomical to use a large research vessel for nearshore, estuary, or coastal zone studies. More appropriate vessels for coastal zone research would be in the 10-30 meter range, occasionally larger depending upon offshore weather conditions and the width of the continental margin.

A research vessel that would range several miles off the coast should be equipped with two major pieces of equipment. The first is some system of navigation. If within sight of land and the coastal areas are well mapped, sextants are adequate. Vessels working close to shore could also use dead reckoning and visual navigation. Radar is usually good out to a distance of 20 or 40 miles. Farther from land, Loran systems can be used, but these require land-based field stations. Other, more sophisticated navigational systems can be rented or obtained, usually at considerable cost, if they are necessary. Sophisticated navigational aids are generally not necessary for most conventional offshore research. However, in the case of resource development or emplacement of instruments on the sea floor, they may be imperative. The second piece of equipment that should be on board research vessels is an echo-sounding instrument to ascertain water depth. Besides the obvious safety value, knowing water depth is important for lowering instruments and charting the area.

Other general types of research equipment include permanently fixed buoys which contain instruments for long-term monitoring of temperature, currents or other marine parameters. Within the suite of instruments that are typical of each of the different subdivisions of oceanography, there are several that have applications in all fields. These include underwater cameras, satellites, underwater television, and side-looking sonar. The latter two are rather exotic pieces of equipment and have only specialized use. However, underwater cameras can be very useful, especially for evaluation of some marine deposits, estimates of bottom living organisms or searches for old buried wrecks.

Satellites can also be important instruments for oceanographic research: they can be used, with the appropriate electronics equipment, for navigation and can transmit weather information to ships at sea. Recently, satellites have been launched which can measure sea surface temperature, detect sea-water color changes (which may be an indication of biological or polluting activities) and photograph the ocean. These photographs can be helpful in understanding how storms form, how waves are generated and travel, and how the coastlines are modified by such waves. The basic instruments of the different disciplines of oceanography are described below.

Chemical Oceanography

Since the main objective of chemical oceanographers is to understand the chemistry of sea water, they must obtain a sample of sea water and then use some technique or device that will measure a certain element, or characteristic compound, within the water sample. The sampling device should be able to obtain a sufficient amount of water for analysis, it should be easy to locate as to depth or any other water property, and it should not contaminate the sample. Probably the simplest and most reliable water sampling device is the Nansen bottle, which contains two accurate thermometers, one of which is protected against the pressure effect of sea water and one that is not. This device is also a basic piece of equipment for the physical oceanographer. The recorded temperature differences between these tow thermometers (the water temperature is recorded when the Nansen bottle is inverted at the time of sample collection) can be used to calculate the depth at which the water sample was obtained. These devices are relatively cheap, very dependable, and are commonly used throughout the scientific community. The thermomemters can be calibrated fairly easily. Larger samples of water can be obtained by other common devices such as Niskin bottles that are commercially available and reasonable in price. If high purity samples are necessary, sampling devices can be of stainless steel or covered with teflon.

Recently some very sophisticated sampling devices have been developed that can be triggered electronically from the ship and keyed to a particular property of the water column. These properties are measured electronically. Such devices generally are far beyond the need of most developing countries and are utilized only in deep-sea work where differences in water properties are so small that extremely accurate sampling becomes important.

After a sample of water is collected, numerous chemical techniques can be used for analysis. Chemical analyses can be made using standard titration techniques or more advanced methods such as flame photometry, spectrofluorometric analysis, electrical conductivity, mass spectrometry, X-ray and atomic absorption. Measurements of the basic properties of sea water can be made using relatively simple and cheap equipment requiring minimal training. Fortunately, these properties, which include salinity, oxygen content, and nutrient content (generally nitrogen, phosphorus, and silica), are also those properties which will be of most use to developing countries interested in exploitation of living resources in their waters. Determinations of pollutants usually require more sophisticated measurements, especially because they are generally present in small amounts.

Salinity can be determined by using an electronic device that measures the conductivity of the sea water and compares it to a standard; this relatively simple electronic device is commercially available. The measurement can be done at sea or the sample can be stored for later analysis. Oxygen and nutrient measurements are also fairly simple, although some have to be made at sea or soon after sample collection. A study of the distribution of nutrients and oxygen could show areas of high or low biological productivity.

Biological Oceanography

The biological oceanographer is interested in sampling the population of the sea and understanding why it occurs where it does and what are the important oceanographic factors that influence it. For small organisms, such as plankton, a net with a small mesh size (commonly called a plankton net), which can be towed through the water, is most appropriate. This device will not catch larger organisms and fish, for which a larger net or sampler is necessary. Bottom dredges can also be used to obtain samples of the fauna living in or on the bottom. All these devices are generally quite simple, easy to use and repair, and can be constructed locally. Fishermen can use sonic devices to locate schools of fish; fairly reliable units are commercially available, but training in their use is necessary.

More sophisticated equipment can be used by biological oceanographers to measure the environmental and ecological properties of the sea water in relation to their effects on the organisms. In this instance, they will generally use instruments also used by the chemical oceanographer. Measurements of temperature, salinity, nutrient-content, and light penetration are generally of immediate importance to the biological oceanographer.

Many countries will be concerned with the quantity of biological resources off their coast, where they are located, and the rate at which they can be exploited. These questions are not easily answered and usually require the collection of routine oceanographic data, such as nutrient distribution and fish and plankton samples, over a period of several years. The biological resources of the ocean are only part of a larger food chain, which includes solar energy, photosynthesis, and many levels of plants and animals. This food chain can be very sensitive to environmental changes and over-exploitation. Besides, natural environmental changes can also result in changes in the biological population and in resource composition.

A new field - aquaculture - is an attempt to duplicate or even improve on nature in breeding fishery products in the coastal zones. This system has both limitations and advantages. One advantage is the greater ease in harvesting the product grown in an aquaculture system. Another is the possibility for greatly expanded production which might not be possible in the wild. Disadvantages include the necessity of acquiring basic knowledge and technology to develop such a system, high initial costs, large numbers of unknown variables, and possible adverse social and economic effects on existing fisheries.

Physical Oceanography

The physical oceanographer is generally interested in measuring the important physical properties of sea water, which include temperature, salinity, and density, and using this data to ascertain large or small-scale water changes or movement. Temperature measurements are usually made by accurate thermometers on Nansen bottles, by bathythermographs (BT) (simple devices that can be lowered from the side of a moving ship and will etch a temperature versus depth graph on a piece of glass) or by more sophisticated devices including expendable BT's and electronic devices that are abundant in the United States and have been made available to interested countries. These devices produce quick, routine measurements and the data can be compiled by relatively untrained personnel.

Currents, both their direction and speed, can be measured either directly or indirectly. One direct method is simply to note ship drift or to put bottles or drift cards into the water and record where and when they are recovered. Drogues, or subsurface floats, can be used to delineate deeper currents. Electronic devices such as buoys with current meters can be left in the water for a period of time to measure the long-term effects of currents. However, these devices usually involve sophisticated electronics that may be beyond the capabilities of some developing countries.

Some specific problems such as wave erosion in the nearshore zone, harbor design, and delineation of areas of strong vertical mixing involve input of physical oceanographic data as well as data from the other oceanographic subdivisions. Many such problems are especially relevant to developing countries. This further emphasizes the need of developing countries either for broadly-trained scientists or for a range of specialists in all fields.

Marine Geology and Geophysics

The most common instrument of the marine geologist is a device for sampling the sediment or rock on the sea floor. On sandy areas, a grab sampler is generally used; this is a fairly cheap and simple device that only obtains a surface sample. If subsurface samples are required from a sandy area, a vibrocorer device is needed. These are fairly expensive, complex, and require a ship of 10 meters length or more. This type of device would be needed to survey a potential sand and gravel or heavy mineral deposit. In muddy or silty sediments, piston or gravity coring devices can be used to obtain subsurface material. Both these devices, although heavy, are relatively simple and easy to maintain and use.

The marine geologist and marine geophysicist share several electronic devices. One is the echo-sounder, which is mainly used to measure water depth. Depending upon the sound frequency used, subbottom returns to more than 100 meters can sometimes be obtained. Echo-sounders can be an especially powerful tool for evaluation of potential mineral deposits. These devices can also be used to detect fish in the water column. Although an echo-sounder can be complex, the devices can be run without too much technological sophistication, provided that appropriate spare parts are available and the machines are properly installed.

Another instrument shared by both fields is the continuous seismic profiler (a common name for many devices). This device puts considerably more energy into the water, using gas discharge or electrical spark, than an echo-sounder and in this way subbottom reflections from several kilometers can be obtained. This device is especially useful in the delineation of potential oil and gas basins and requires a high degree of technology for its operation and maintenance. Essentially similar information can be obtained by seismic reflection methods which use explosives. These techniques can cause environmental damage, but fortunately are not as commonly used as in the past.

The marine geophysicist has some sophisticated tools which require advanced technology. Gravimeters measure the earth's gravitational field but require a very sophisticated navigation system, and magnetometers measure the earth's magnetic field. The deep structure of the ocean crust can also be studied using seismic reflection and refraction techniques. These involve fairly complicated instrumentation and sometimes more than one vessel. In most instances, these instruments would be beyond the technical ability of developing countries.

Basic Versus Applied Research

The preceding paragraphs have briefly mentioned some of the more important instruments and techniques used in basic oceanographic research. However, the same pieces of equipment would commonly be needed for many applied research programs within the nearshore waters of a developing country's coast. In many instances, the differences between basic and applied research will be minimal. For example, any exploration for mineral resources will require a bathymetric chart of the area, bottom samples, and an understanding of the important sedimentary processes. Oil and gas exploration should start with a general understanding of the geological structure of the area under consideration. Fisheries exploitation will be helped by knowledge of the distribution of nutrients and the different organisms as well as of the general characteristics of the water. These are all subjects of major interest to scientists involved in basic research. Once this background information is obtained, more detailed studies can be made to pinpoint areas of mineral or biological potential.

In any case, many oceanographically less developed countries will have difficulties in obtaining, maintaining, and analyzing results from such instruments regardless of their application to basic or applied research. As a first step, a group of people from the country should be trained in the basic marine sciences and in the collection of oceanographic data. Another group should be trained as technicians. These people could be scientists technicians already trained in other fields who are interested in marine problems. The initial training should be broad enough so that the new scientists could handle most kinds of oceanographic research, or at least know the basic principles. Unfortunately, most countries have only a limited number of marine scientists and these generally are marine biologists, with relatively small numbers of marine geologists, geophysicists, coastal engineers, and technicians. These latter groups are especially important in applied work. The relatively small number of marine scientists in individual countries can be seen in Table 1, which shows the active scientific manpower in countries having the most marine scientists. The table indicates that about 80 percent of the coastal states have fewer than 50 marine scientists. The number of marine research laboratories may be exaggerated, but the number of actual personnel is probably more important. These data only serve to further illustrate that U.S. scientists and institutions can be extremely helpful to these countries by developing cooperative research and educational programs. Because of the general lack of trained personnel, the latter probably provide the best immediate opportunity for technology transfer.

II. VIEWS AND EXPERIENCES OF AMERICAN OCEANOGRAPHERS TOWARDS TECHNICAL ASSISTANCE

Throughout the United States many marine scientists have participated in programs with foreign scientists or countries. These programs range from collaboration on small projects to joint institutional programs. Some projects just involve education, others involve technical assistance, and still others are limited to participation in each other's cruises. SOme of these programs are judged to be very successful while others are unqualified failures. It is important to understand how these programs have developed, what have been

TABLE 1

MANPOWER AND INSTITUTIONAL CAPABILITIES IN DIFFERENT NATIONS

Country*	Number of Marine Scientists	Number of Research Institutions and University Laboratories
United States	1,350	250
United Kingdom	680	116
Japan	550	164
U.S.S.R.	500	53
Canada	360	17
West Germany	224	34
Australia	181	37
India	168	25
Brazil	140	18
France	120	43
Norway	94	21
Netherlands	77	21
Yugoslavia	74	20
Mexico	74	35
South Africa	59	12
Philippines	55	21
Korea	51	15
Peru	50	7
Argentina	41	17

* Of the 99 marine nations, only the first 19, in terms of number of scientists, are shown.

Source: S. Z. Quasim, "Development of Marine Science Capabilities in Different Regions of the World" in Bologna Conference Report, 1973.

the mechanisms of communication between the various scientists, how such programs can be improved, and what are the pitfalls. The answers to these questions must also be viewed in the light of changing international conditions for ownership and freedom of scientific research within the ocean.

To obtain a response to the above questions from the U.S. scientific community, we distributed a questionnaire (see Appendix I). We realize that our questionnaire did not reach all people who are interested in international marine technology transfer. Nor do we suggest that the response is a statistically representative sample of the U.S. marine scientific community. However, we feel that some of the points made may be indicative of the general feelings of the U.S. marine scientists. The questionnaire was distributed to approximately 100 people, selected from a list of Sea Grant investigators and from other oceanographers with especially heavy representation from the Woods Hole Oceanographic Institution. We requested that people pass copies of the questionnaire to colleagues they thought might be interested in the study. We received 91 responses, which suggests a response rate of at least 70 percent, although we cannot be sure of the exact percentage. This is a very high percentage compared to general responses to questionnaires and with regard to the fact that we requested answers within three weeks. For comparison, a questionnaire distributed by the State Department in 1973[3] to about 1,450 marine scientists received 399 responses (or 27 percent). Table 2 shows the affiliation of the respondents to our questionnaire and Table 3 shows their general scientific specialties.

Since the response does not represent a perfect sample of the marine scientific community, appropriate caution should be used in extrapolation of these results. However, the large and generally positive response to our questionnaire does indicate an interest on the part of the U.S. marine science community in international marine science technical assistance and education programs. The high response rate probably also reflects the concern of U.S. oceanographers about how the Law of the Sea Conference could affect their oceanic research.

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3 C. H. Check, "Law of the Sea: Effects of Varying Coastal State Controls on Marine Research," Ocean Development and International Law Journal (Summer, 1973), p. 209-219.

TABLE 2

AFFILIATION OF SCIENTIFIC RESPONDENTS
TO INTERNATIONAL MARINE TECHNOLOGY QUESTIONNAIRE

University of Connecticut	1
Duke University	2
Fletcher School of Law and Diplomacy (Tufts University)	1
Florida State University	1
University of South Florida	1
U. S. Geological Survey	2
Harvard University	1
University of Hawaii	10
Institute of Marine Resources (University of California)	1
Louisiana State University	1
Lehigh University	1
South Maine Vocational Technical Institute	1
Marine Science Consortium (Millersville, Pennsylvania)	1
Massachusetts Institute of Technology	4
Middlebury College (Vermont)	1
University of Miami	4
Mississippi State University	1
Northeastern University	1
National Oceanic and Atmospheric Administration (NOAA)	1
North Carolina State University	1
Oregon State University	2
Scripps Institution of Oceanography	1
Smithsonian Institution	1
Stevens Institute of Technology	1
University of South Carolina	1
University of Rhode Island	2
University of Southern California	1
Texas A&M University	1
State of California Resources Agency	1
Virginia Institute of Marine Science	7
University of Washington	12
Woods Hole Oceanographic Institution	23
West Indies Laboratory (U.S. Virgin Islands)	1
TOTAL	91

TABLE 3

GENERAL MARINE SCIENCE SPECIALTY OF RESPONDENTS TO QUESTIONNAIRE

Biological Oceanography	25
Fisheries	12
Chemical Oceanography and Geochemistry	4
Marine Geology and Geophysics	26
Physical Oceanography	4
Ocean Engineering and Other Fields of Engineering	13
Administration	7
TOTAL	91

Interest of Marine Scientists in Cooperative Programs

Our first question asked about participation in cooperative marine science programs (including research, education, advising, and data, instrument, or faculty exchange) with a foreign country or foreign scientists over the past five years, the type of program and funding sources. Based on the 91 responses: 63 respondent (69 percent) had one or more cooperative marine science programs, 20 (22 percent) did not have a program but were interested in or were in the process of developing one, and eight (9 percent) were not interested in foreign programs. Thus, a total of 91 percent of the respondents were interested in, have, or have had cooperative marine science programs involving foreign scientists.

Cheek[4] noted a somewhat similar response when asking how scientists would respond to various restrictions on research by coastal states. Most were willing to take foreign scientists to sea or even to participate in some sort of training program. However, scientists objected to giving up jurisdiction over samples and publication rights, or altering the research plans.

The major oceanographic institutions have generally made an effort to take foreign scientists to sea, especially in work done in foreign coastal waters. Table 4 shows the foreign scientist participation for year 1973 on UNOLS (University-National Oceanographic Laboratory System) ships. Although 200 scientists from 36 countries appear to represent a considerable effort, the number of foreign scientists is really fairly small and heavily biased. For example, most of the participants were from countries that are considered to be well developed in the marine sciences. A detailed study of the composition of the scientific party of ships from the Woods Hole Oceanographic Institution, which generally takes considerable numbers of foreign scientists compared to other U.S. oceanographic institutions, showed that foreign scientists everaged about 5 percent of the total scientific personnel for the period 1967-1973.[5] In many instances, the availability of travel funds and knowledge of interested participants could have resulted in a considerable increase in foreign scientist participation. However, taking foreign scientist

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4 ibid., p. 209-219

5 D.A. Ross, "Cooperative Research Programs at Woods Hole Oceanographic Institution," in C. Morse (ed.), Ocean Policy Committee Conference on U.S. Marine Scientific Assistance (in press).

TABLE 4

FOREIGN SCIENTISTS PARTICIPATING ON UNOLS SHIPS
1973

Ship	Foreign Scientists
Scripps Institution of Oceanography	
AGASSIZ	Mexico 19, Switzerland 1
MELVILLE	Norway 1, Brazil 1
OCONOSTOTA	Germany 1, Mexico 2
WASHINGTON	Canada 1, Japan 5, United Kingdom 1
ALPHA HELIX	United Kingdom 2, Australia 7, Canada 4, U.S.S.R. 2, Japan 4
GLOMAR CHALLENGER	New Zealand 8, Canada 2, Australia 4, Hungary 1, Denmark 1, United Kingdom 2, Malaysia 1, Japan 4, Switzerland 2, France 1, Germany 1, India 1
TOTAL: 16 countries, 79 scientists	
Lamont-Doherty Geological Observatory	
CONRAD	Brazil 7, Argentina 5
VEMA	Norway 1, France 1
TOTAL: 4 countries, 14 scientists	
Duke University Marine Laboratory	
EASTWARD	West Indies 26
TOTAL: 1 country, 26 scientists	
University of Miami, RSMAS	
CALANUS	Mexico 1
GILLISS	Italy 3
ISELIN	Netherlands 1
ORCA	Scotland 1, Sweden 3
TOTAL: 5 countries, 9 scientists	
Oregon State University	
CAYUSE	Germany 2
YAQUINA	Sweden 1, Ireland 1
TOTAL: 3 countries, 4 scientists	
University of Rhode Island	
TRIDENT	France 1, United Kingdom 1
TOTAL: 2 countries, 2 scientists	
Texas A&M University	
ALAMINOS	Mexico
TOTAL: 1 country, 1 scientist	
University of Washington	
THOMPSON	Japan 1, Mexico 3, Spain 5, Canada 1, France 2
TOTAL: 5 countries, 12 scientists	
Woods Hole Oceanographic Institution	
KNORR	Germany 3, United Kingdom 1, France 1, Italy 1
ATLANTIS II	Norway 1, Portugal 4, Brazil 3, Taiwan 2, Israel 1, United Kingdom 2, France 1, Spain 1, Germany 2, Senegal 1, Ghana 7, Congo 1, Guatemala 1, Jamaica 1

COUNTRIES

Argentina - 5
Australia - 11
Brazil - 11
Canada - 11
Chile - 1
Colombia - 1
Congo - 1
Denmark - 1
Ecuador - 3
France - 7
Germany - 9
Ghana - 7
Guatemala - 1
Hungary - 1
India - 1
Ireland - 1
Israel - 1
Italy - 4
Jamaica - 1
Japan - 14
Malaysia - 1
Mexico - 32
Netherlands - 1
New Zealand - 8
Norway - 3
Peru - 1
Portugal - 4
Scotland - 1
Senegal - 1
Spain - 6
Sweden - 4
Switzerland - 3
Taiwan - 2
United Kingdom - 10
U.S.S.R. - 5
West Indies - 26

TOTALS:
36 Countries
200 Scientists

Table 4 (cont.)

CHAIN - Canada 3, U.S.S.R. 3,
United Kingdom 1

TOTAL: 17 countries, 41 scientists

University of Hawaii

KANA KEOKI - Colombia 1, Chile 1, Peru 1,
Ecuador 3

TOTAL: 4 countries, 6 scientists

University of Southern California

VELERO IV - Mexico 6

TOTAL: 1 country, 6 scientists

to sea may not constitute a very serious element of a technical assistance program. Technical assistance in the form of joint cruises is most effective if the person is well-trained and realistically takes part in the research program.

Types of Cooperative Marine Science Programs

A total of 94 individual projects involving foreign marine scientists were cited by the U.S. scientists surveyed. The general classification of the programs, which obviously varied considerably in depth and intensity of effort, is given in Table 5. Some programs involved more than one type of assistance, for example a specific fisheries management education program coupled with technical assistance to the fishing industry. In these cases the predominant effort was cited. Joint research projects, including joint cruises, accounted for almost half the activities cited by U.S. scientists. Next most frequently cited (19 percent) were educational programs, often representating extensive long-term cooperative arrangements between two or more universities. Technical training and assistance (14 percent) and advisory and development programs (11 percent) ranked next, followed by data exchange (7 percent).

Foreign countries in these programs were about evenly divided between the countries that have developed marine science capabilities and those that do not. The regional distribution of participating countries is given in Table 6. Since numerically there are fewer countries developed in the marine sciences, this distribution suggests a tendency to work more with countries that have at least a modest level of marine science capability. The preference for developed countries is probably motivated by factors such as ease of making contacts with scientists from these countries and a greater awareness within the country of the value of marine projects. The disproportionately large share of programs with developed countries suggests that some incentives may be necessary to induce U.S. scientists to work with countries that are considerably less developed in the marine sciences.

The funding for these programs came from a large array of agencies and organizations (Table 7). Most of the programs required more than one sponsor, and many respondents noted that financial problems were one of the big limitations of their program.

TABLE 5

CLASSIFICATION OF PROJECTS INVOLVING
FOREIGN MARINE SCIENTISTS CITED BY
RESPONDENTS TO QUESTIONNAIRE

Type of Program	Number of Programs	Percentage of Total
Education	18	19%
Joint Research (Joint Cruises)	45 (14)	48% (15%)
Advisory Services & Development Programs	11	12%
Technical Training and Assistance	13	14%
Data Exchange	7	7%
TOTAL	94	100%

NOTE: This table differs from that in the original Sea Grant report. A different classification system has been used, resulting in 94 individual programs rather than the 75 reported in the Sea Grant table.

TABLE 6

REGIONAL DISTRIBUTION OF FOREIGN COUNTRIES
PARTICIPATING IN PROJECTS CITED BY
RESPONDENTS TO QUESTIONNAIRE

Region	Number of Projects	Percentage of Total
Africa	6	6%
Asia and the Far East	10	11%
Europe and USSR	23	24%
Latin America	20	21%
Oceania and Canada	9	10%
Other Mediterranean and the Middle East	10	11%
More than one region	16	17%
TOTAL	94	100%

TABLE 7

FUNDING SOURCES FOR PROJECTS CITED BY RESPONDENTS TO QUESTIONNAIRE

Agency for International Development

American Petroleum Institute

Atomic Energy Commission

Economic Commission for Asia and the Far East

Environmental Protection Agency

Ford Foundation

Foreign and American Universities

Foreign Governments

Fulbright Fellowships

International Decade of Ocean Exploration

National Oceanic and Atmospheric Administration

National Oceanographic Data Center

National Science Foundation

Office of Economic Opportunity

Office of Naval Research

Oil Companies

Organization of American States

"Out of own pocket"

Rockefeller Foundation

Sea Grant

Seed Program - part of AID

Smithsonian Foreign Currency Program

State Agencies

Table 7 (cont.)

United Nations Development Program

United Nations Educational, Scientific, and Cultural Organization

United States Geological Survey

World Health Organization

Essentially all the respondents thought that their program was successful; most had resulted in joint publications and some benefit to the foreign country. The degree of success is difficult to evaluate, because many of the programs were initiated by U.S. scientists in pursuit of their own interests. However, some noted that their programs could have been better and suggested mechanisms for improvement which will be discussed later. Encouragingly, most programs had foreign scientific participation in the actual planning of the program.

We asked the marine scientists what instruments and techniques they thought would be most useful to developing marine countries. Most suggested basic and simple pieces of equipment that would be dependable and require little technological training to operate. Several included sophisticated equipment mainly related to their specialty. Some of the equipment suggested, especially the geophysical surveying instruments, probably requires a higher level of technological training and maintenance than is presently available in many of the developing countries.

In a similar vein, we also asked what types of research U.S. scientists thought would be of value to developing countries. Numerous programs were suggested, but they generally had one main theme: programs that could discover, understand, and develop the marine resources, either biological or mineral, of the developing country. These included basic geological and geophysical studies to map, sample, and ascertain the structure of the countries' continental margin, in order to discover areas of hydrocarbon or other mineral potential. Also mentioned were coastal and estuary studies to control beach erosion.

Research concerning the quality and quantity of biological resources, as well as technology to detect and monitor their changes, and responses to pollution or other changes of the environment were frequently mentioned as being important to developing countries. Included within the development of biological resources were aquaculture studies, measurement of biological properties of the water column, and determination of areas of upwelling. A more detailed discussion of potential programs is given in the last section of this paper.

Mechanisms of Scientific Contact

In an attempt to ascertain how such cooperative programs develop, we asked how contacts were made with foreign scientists, what kind of difficulties had been experienced in dealing with scientists and organizations from foreign countries and, finally, how countries could judge which programs would be beneficial to them.

Most contacts between U.S. and foreign scientists resulted from personal contact at international conferences, through participation in committees, or by actual visits to foreign countries. Less frequently, contacts have been made by visits of foreigners to the United States and by exchange of letters. Even fewer contacts were made through a former student or by joint participation on a research cruise. Several individuals noted that it was best to avoid official agencies such as the State Department in establishing contacts. It appeared obvious from the responses that possibilities of contact and program development would be increased if funds for travel to international conferences or foreign research and educational centers were easier to obtain.

Difficulties in Technical Assistance

Among the difficulties noted in attempting to transfer technology to scientists from developing countries, funding, languages, and lack of adequate training among the scientists of the foreign country were most often mentioned. Less commonly mentioned were bureaucratic problems, institution rivalries, mistrust of the foreign country toward Americans, foreign scientists considering the work to be below their dignity, difficulty of communicating by mail, the manana syndrome, and lack of instruments and technologies. Most scientists felt that if funding were adequate and foreign scientists were sufficiently well-trained, many of the other difficulties would become minor. This view may be somewhat naive since several other elements such as national commitment and a definite plan would be needed for a successful long-term program. A program's success also depends on the experience and determination of the American scientist. Many of the failures could almost have been predicted - either because the program was overly ambitious or ill-defined, or resources were inadequate to carry it out.

Our query concerning how countries less developed in the marine scienc could judge which programs would be most beneficial to them was difficult t answer, and many scientists did not. Among the positive responses, the following seven were most commonly made:

1) Establish an international scientific advisory board (oceanographers and social scientists with foreign experience) who can consult on regional or local problems.
2) Have individual foreign scientists visit the country.
3) Hire consultants.
4) Improve education of their own scientists.
5) Make decisions based on best economic return for dollars invested.
6) Listen to local scientists.
7) Determine priorities after analyzing own resources.

Among the negative responses (which were considerably fewer than the positive ones) were that they can't judge or that we shouldn't advise others since we haven't done such a good job with our own marine problems.

Overall Interest of U.S. Scientists

In general, U.S. scientists expressed a high degree of interest in programs involving international technical assistance and transfer of marine technology, and over two-thirds of the respondents had already participated in such programs. The success of the various education, joint research, and other programs varied widely, but with few exceptions scientists wanted to continue existing programs or participate in future ones.

Funding for these programs came from many sources, but inadequate funding was one of the most common complaints about difficulties in past programs. Increased funding, along with more careful project preparation (planning of objectives and background training for scientists and technicians of the developing country), would greatly improve the benefits derived from joint research and educational programs by both sides.

The types of research and instruments which U.S. scientists thought would be useful to countries developing their science capabilities were, again, varied. More emphasis was placed on applied research and simple instruments than on very basic research and complex instruments. The areas of interest for future projects involving technology transfer will be compared with the interests expressed by scientists from the developing countries in the next two sections.

Altogether, the interests of the U.S. scientists as expressed in the responses to our questionnaire reveal a range of experience and enthusiastic concern with programs of education, technical assistance, and marine technology transfer which suggests expansion of such programs in the future. With information from the scientists of oceanographically less developed countries, we will be able to make some tentative suggestions to improve the effectiveness of future programs.

III. VIEWS OF SCIENTISTS FROM DEVELOPING COUNTRIES

Scientists from the developing coastal states are generally eager to expand the capabilities of their countries in the marine sciences. Attitudes toward programs that transfer technology from the developed nations vary, but most of the scientists who participated in the Marine Science Workshop on this subject, held in Bologna, Italy by the Johns Hopkins University, 15-19 October 1973, expressed interest in some type of program.[6] These scientists did not necessarily reflect the views of their governments. Opinions varied on which subjects within the marine sciences would be of most immediate interest - from basic collection of physical and geological oceanography data to applied research on fisheries.

Attitudes expressed at the Bologna conference and by other foreign scientists about the types of programs desired and the areas of particular interest will be reviewed in this section. The following section will compare the views of the scientists from developing countries with those from the United States.

Types of Programs Desired

The types of programs desired, as expressed at the Bologna Workshop, varied considerably from country to country, but a general preference emerged for programs that were long-lasting and were carried out in the developing country. Within individual developing countries, scientists felt it was important to increase attention to the marine sciences and to integrate marine science needs into the overall development plans. Syed M. Haq of Pakistan[7] suggested one mechanism to bring this about: to coordinate agencies representing a number of interested research organizations within each country at a national level by the government to promote marine research

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[6] Ann Hollick (ed.), Report of the Marine Science Workshop held by the Johns Hopkins University, Bologna, Italy, 15-19 October 1973.

[7] ibid., p. 55-56.

activities. He also mentioned the importance of close links between universities and marine research organizations and the need for strong financial support from the government.

Regional cooperation among the developing countries was also mentioned by a number of scientists including Diop of Senegal and Ayala-Castanares of Mexico.[8] Such programs encompass shared data collection, increased utilization of scarce trained manpower and equipment. Not only regional research centers but also bilateral agreements between universities within a region were suggested both for training and research. The importance of long-term commitment to such programs and of strengthening existing institutions was stressed by all.

Programs involving the participation of scientists or institutions from developed countries include participation of individuals, bilateral arrangements between institutions, multilateral projects, and programs with international aid institutions such as UN agencies. Bologna participants such as Haq and Vanucci, from Mexico, felt that much could be learned from individual scientists from developed countries, and that their participation in training and education programs was especially important.[9] However, these foreign scientists should come to the developing country to provide appropriate training to both scientists and technicians and to help formulate on-going programs of research and training adapted to local needs. In addition, promising young scientists from developing countries could be sent to study marine sciences in foreign institutions. The exchange of students and teachers could take place either as a bilateral agreement between universities or under the auspices of international organizations such as UNESCO or OAS.

Research programs are the other major type of program with joint participation by scientists from developed and developing countries. Some joint research efforts take place through international programs in fields such as exploration, mapping of the ocean floor, data collection in various fields. Participation by developing countries in such projects was urged with three desired results: to arouse interest in the marine sciences, to increase the available data in various areas, and to lead to future programs with other

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[8] <u>ibid</u>., p. 46, 66-71.

[9] <u>ibid</u>., p. 56, 38-39.

individual countries.

Greater participation in research cruises of foreign vessels in a developing country's coastal waters or resource zone was also urged. Scientists wish to avoid last-minute invitations to come aboard a ship simply to enable that ship to obtain a permit to do research in coastal waters. Instead, they would like to participate in such cruises from the planning stage on through the cruise itself, subsequent laboratory work and publication of results. In other words, scientists from developing countries want to participate as equals in joint cruises and investigations.

At the same time, the need within developing countries to develop adequate background to utilize effectively foreign assistance of all kinds was stressed. Some past programs of technology transfer, through education and joint research, have failed partly because of the inability of the developing country's scientific and political system to absorb the program.

Sanchez Cortes, president of the Colombian Commission of Oceanography, has also mentioned the problem of technology transfer at a level unsuitable for the scientists or equipment available in the country.[10] He also stressed the importance of full participation by the developing country in all phases of a project before the training cruise itself and the failures that could result if needs were not correctly formulated by the scientists of the developing country.

Thus, many different kinds of programs involving technical assistance are desired by scientists in the developing countries. They recognize the importance of developing basic marine science capabilities within their own country in order to prepare for full participation in joint programs which will further enhance their national and regional abilities to train young scientists and conduct research.

Research Fields of Interest

Scientists at the Bologna Workshop expressed interest in most fields of oceanography. Fisheries research was mentioned most often, but topics such as intensive world-wide data collection, effects of pollution on the sea, marine geophysical studies, fluctuations of sea levels, and so forth were also considered.

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[10] Capitan de Fragata Jaime Sanchez Cortes, private communication, 5 June 1974.

A consistent preference was expressed for projects that would improve management and utilization of marine living and nonliving resources for economic and social development. Such projects have the dual advantage of increasing the likelihood of government support for marine science and improving the economic situation of the country.

Fisheries were the primary living resource suggested to be better utilized. Investigations mentioned included chemical and physical ocean characteristics affecting distribution of species and harvesting techniques; biotic characteristics of the food chain, population dynamics, and effects of pollution. The need for long-term planning and sustained effort in devising fishery management were also mentioned.

Aquaculture was also mentioned frequently. Most of the extensive aquaculture in the world is practised in developing countries, especially in Asia, but other countries also hope to develop their capabilities to increase protein availability and perhaps simultaneously to use potential pollutants such as domestic sewage and power-plant heat to increase yields.

Nonliving resources that could be exploited include oil and natural gas, manganese nodules, phosphorite nodules, and other minerals. Better use of existing resources includes the protection of the marine environment for recreational purposes against the hazards of pollution and obtaining a better understanding of oceanographic parameters to improve marine construction, including harbors and boats. The potential earnings could represent substantial increases in needed foreign exchange.

Other areas of research interest included long-range weather forecasting (particularly vital for drought-stricken regions in India and Africa), obtaining additional water supplies for domestic, industrial, and agricultural use, and forecasting changes in the movement of the oceans and their biotic resources.

Clearly, a wide range of oceanographic research areas are of interest to scientists in the developing countries, although the greatest emphasis is on fields such as fisheries which have a short-term economic payoff.

Other Ideas on Technical Assistance

The scientists who participated in the Bologna conference also expressed some other ideas to aid the transfer of marine technology. Personal scientist-to-scientist contacts were cited as particularly useful in setting up mutual assistance projects because such contacts can often avoid the delays and problems which arise in government-to-government negotiations. Increased contact between senior scientists and foreign graduate students was also urged to upgrade thesis research and to increase circulation of literature and research reports. Similarities in national situations could be exploited and language barriers avoided by increased utilization of regional expertise and by development of regional programs generally.

In terms of acceptability of various kinds of technical assistance programs, the most important elements seem to be (1) full consideration and active consultation with scientific representatives of the developing country at all stages of the program and (2) a sufficiently long-term commitment to the program to establish it on a viable basis after the assistance program <u>per se</u> has ended. Complaints of failures of past programs could be traced to these elements plus insufficient funding, unnecessary administrative and bureaucratic complexity, inadequate absorptive capacity within the less developed country's scientific and political system, or lack of coordination between programs.

In general, then, scientists from the developing countries are interested in a wide variety of programs to develop expertise in many aspects of the marine sciences. Although criticisms of past programs abound, attitudes toward future programs are generally optimistic. Scientists feel that increased research and educational efforts in the marine sciences within their countries and regions can be sucessfully coordinated with bilateral and international programs of education and research to improve the abilities of developing countries to exploit their marine resources and to contribute to the world's store of knowledge about the marine sciences. Technical assistance is implicit in all the programs mentioned and clearly has a vital role in enabling the developing countries to attain their goals in the marine sciences.

IV. RECONCILING THE VIEWS OF MARINE SCIENTISTS FROM DEVELOPED AND DEVELOPING COUNTRIES

The past experiences in international transfer of marine technical assistance for scientists from developed and developing countries have been varied. The views of U.S. oceanographers and foreign scientists have been explored in some detail in previous sections. Here we shall explore areas which indicate confluence and conflicts of interest for the two groups of scientists. As a first step, we shall attempt to assess reasons for success and failure of past programs.

Past Programs - Successes and Failures

Past programs or projects of technical assistance have failed, in the view of scientists from developed and developing countries, for several reasons. The difficulties most frequently encountered by U.S. scientists involved in international technical assistance have been insufficient funds and inadequate scientific and technical background of local scientists. Problems with government bureaucracies, both U.S. and foreign, and lack of government commitment or local political conflicts were also mentioned by many U.S. scientists. Other problems were language and cultural barriers to communication, conceptual shortcomings, and difficulty in establishing contact with scientific counterparts in the developing country. Clearly, different approaches to the government and scientific community will be needed for different countries. A few scientists responding to the survey had encountered no difficulties at all in their programs of technology transfer.

Scientists from oceanographically less-developed countries cited many of the same difficulties as U.S. scientists. Again, particular emphasis was placed on scarcity of funds and inadequate background preparation or ability to absorb the technology within the developing country's scientific and political system. They also mentioned similar problems with government bureaucracy and administrative complexities. However, those on the receiving rather than the transferring side of the technology transfer process did have a number of comments different from those of the U.S. scientists. Prime among these perceptions was the feeling that representatives of the developing countries were given insufficient opportunity to participate in the planning and execution of these programs. In addition, imprecise definition of objectives for the specific programs and the lack of coordination among programs within a nation or a region were criticized. Many programs were considered too short to be effective. Successful programs, on the other hand, were generally characterized by the scientists from developing countries as long-term, usually education-oriented. Some were exchange programs between universities for students and faculty. Others included a series of regional training programs in Latin America sponsored by UNESCO.

United States scientists who had participated in programs of technical assistance felt that the programs were successful in almost every case. Clearly the U.S. scientists were speaking from their own point of view; a few were doubtful about any significant long-term benefits to the developing countries they had worked with. U.S. scientists' experiences have already been discussed in a previous section, but it is worth mentioning again that these programs included exchange of students and faculty, research cruises, advisory services, planning of overall marine program development, training of technicians, and data collection. Since many of the projects resulted in publications co-authored by scientists from less-developed countries, one may presume at least some degree of success.

Establishing Criteria of Success

The scientists from the developing countries seem to have more doubts about the benefits derived from past programs than do the U.S. scientists. Partly, the differing opinions may stem from the lack of overlap in experience between the two groups. The two groups obviously represent only a small portion of the total population of marine scientists from developed and developing countries. We hope that they are reasonably representative, but there is no way to guarantee that they are. More important, the views of the two groups may represent a real divergence in criteria for success of a given project. A project that fulfills the objectives of the U.S. scientist may not fulfill the objectives of the cooperating scientist from a developing country. Moreover, the objectives of the scientist from the developing country may not coincide with the needs of his country as perceived by government officials and administrators of overall science development programs. For example, a joint research cruise might seek to establish the distribution of certain rare chemical elements in the coastal waters of a developing country. Finding the distribution of these elements might precisely satisfy the research objectives of the U.S. scientist. The scientist from the developing country might regard the research as worthwhile for its own sake but perhaps of less interest than a study of major chemical elements over a wider area of ocean near his country. The government officials of the developing country might consider the entire project a waste of time because they are really interested in expanding aquaculture or exploring for petroleum deposits in the offshore area.

Thus, it is difficult to set up criteria of success that will satisfy all parties concerned in a project involving international technical assistance. However, the following points do seem relevant in most cases:

- The project should last long enough to ensure that the benefit of the project will continue after the formal technical assistance aspects have ended. This applies particularly to technician training or setting up formal education programs.
- The scientists of the developing country should be included from the earliest planning stages of the program. Their insights into the needs and social-political-economic realities of their own country will enhance the likelihood of success in the long run.
- Even on short research cruises, participation of the developing country scientists should be as comprehensive as possible - a second point of view from someone with local knowledge and experience should improve the design of experiments as well as the viability of any training in new technology which takes place as a corollary of the research.
- Programs involving developing countries and international agencies, multinational research or training projects, and bilateral projects with foreign scientists or institutions should be coordinated through the country's existing programs in the marine sciences. Duplication of effort will be avoided, and areas of particular need can be more easily identified.
- When scientific equipment is involved in the transfer of technology, it should be adapted to the needs of the developing country. It should not be too expensive or difficult to operate, and adequate provision should be made for repairs and replacement of parts. Not only must technicians and scientists be able to use the equipment properly, but also someone should be able to maintain and repair the equipment as necessary.

If these conditions are met, a program of international marine technology assistance will have a much improved chance of success. Success in most cases could be interpreted as the developing country's acquiring the capability to conduct its own marine research and training programs. Virtually all areas of oceanography are of interest to some scientists in both developed and developing countries. One problem in designing a project of education, cooperative research, or other programs involving technology transfer, is to find a reasonable match of scientific personnel on both sides.

The areas of oceanography which have higest priority in the developing countries are generally those related to resource exploitation, including fisheries. This does not by any means imply that scientists from developing countries are interested only in "applied" research. On the contrary, many of the basic parameters that must be explored in assessing a potential fishery or evaluating a potential for expansion of an existing fishery are established in the course of "basic" research. Thus, the desire of developing countries for applied research need not conflict with the interest of U.S. scientists in basic research.

Mechanisms for Technical Assistance

Educational programs for students and scientists are highest on the list of priorities for the developing countries. Such educational programs, often also incorporating the buildup of equipment and facilities, are regarded as necessary to ensure adequate consideration of the marine sciences in overall development programs and to enable the country to take advantage of national resources that can be exploited. Scientists from the United States who have participated in cooperative educational programs have been very enthusiastic on the whole. The interests of developed and developing countries seem likely to converge in educational marine science programs. The problems in this area are most likely to be obtaining adequate funding, setting a sufficiently long time frame and adjusting the kind of training to the conditions in a specific country. When educational institutions and scientists from the two countries (or from the developing country and an international agency) work closely together, with the cooperation of governments and funding agencies, it is possible to overcome these problems. To reiterate, any potential conflict of interest in educational programs can be avoided by careful planning.

Several additional mechanisms for international technical assistance have been suggested by scientists from both the United States and developing countries. One is to expand the exchange of scientific information through increased circulation of journals, reprints, and documents, establishment of regional data centers, and expansion of advisory services from developed country scientists on thesis research by graduate students in developing countries.

Another mechanism would be to hold symposia on marine subjects with developing countries and provide some travel money for scientists from surrounding areas to participate. This could give impetus to the development of regional goals and to the establishment of institutions to help achieve them. International groups of specialists could be created to advise on scientific programs and instrumentation standards. These groups could be established under the auspices of an international agency to serve the needs specified by the developing countries. A clearinghouse of publications in the United States advising on the opportunities and research interests within foreign countries could aid in increasing scientific cooperation.

All these mechanisms would serve the additional purpose of expanding scientist-to-scientist contacts, urged by many scientists who have been involved in past programs of marine technology transfer. Increased funding for attendance of international conferences has been suggested by many scientists as another way to expand personal contacts. Scientists from developing countries and the United States feel that programs growing out of personal contacts have a much better chance for success than programs initiated at the government level.

SUMMARY ANL RECOMMENDATIONS

Programs for the transfer of marine science and technology offer exciting opportunities for marine scientists of both developed and developing countries. A survey of 91 U.S. marine scientists showed that over two-thirds actually had participated in some type of international marine science program, many of which involved marine technical assistance to other countries. Their experiences, along with those of scientists from developing countries, show that programs can succeed if certain potential problem areas which have led to failure in the past can be avoided. Chief among the reasons given by U.S. scientists for past failures were inadequate funding and insufficient scientific background of the foreign scientists. Other problems were language and cultural barriers and difficulties with government bureaucracies. Scientists from the developing countries cited insufficient opportunity to participate in planning the programs, inadequate length of programs, and difficulties with funding and government support.

Many problems could be ameliorated by a central organization for foreign marine science programs. Such an organization, perhaps a U.S. government agency, could help to coordinate various research and training projects and perhaps serve as custodian for specialized equipment, as in a library. Most important, the organization could bring interested scientists and institutions from both sides together for programs of mutual interest. In some instances, scientists or marine policy personnel could take special leave from their own institutions to work temporarily with the new organization.

A number of suggestions can also be made to overcome particular difficulties which have beset past programs. The effectiveness and benefits of programs of marine technology transfer would be improved by increased availability of funds and closer cooperation between the scientists of participating countries on planning and follow-up. Inadequate scientific background of some participants could be at least partially overcome by a training program well integrated into the overall project. The training program could include participation in a cruise, visits to an institution or laboratory, a visiting lecture series, and a course taught by a group of marine scientists spending a period of time in the developing country. The group-teaching approach could lead to a successful marine science program if enough dedicated scientists were willing to spend sufficient time in the foreign country.

Such teaching programs might require an adjustment of our reward systems within U.S. institutions, because the individual scientists involved would have to commit a period of time away from their research. Many research and educational programs would be more successful if they were done together rather than as two different projects. For example, a group of scientists could first visit a country to teach and develop research programs based on local problems, then a U.S. oceanographic ship could visit the area to study a problem of joint interest.

Although most oceanographic institutions take foreign scientists to sea, this avenue of contact could be developed further. Increased funding for travel and perhaps a listing of foreign scientists and students who would be interested in going to sea could improve foreign participation in cruises.

Training centers for foreign students could be established in this country. One such program has been established at Duke University Marine Laboratory where an eight-week interdisciplinary program has been taught. Twenty or so participants from various countries spend eight weeks at their laboratory in classes and working on individual research projects. The National Oceanographic Data Center also has had several programs in which various aspects of data handling processes were taught to foreign technicians. The training in Washington was followed by a four-week visit to the Woods Hole Oceanographic Institution for lectures on various subjects in oceanography. Both programs also included some experience aboard a research vessel. Some difficulties arose in these programs because participants were from different countries and had variable scientific backgrounds. Training programs might be more effective if participants were selected from a few countries with common background. In addition, at least part of the program could be carried out within the foreign country, concentrating on a research problem of immediate interest to the participants. Perhaps they could bring the "problem" with them. The training of foreign scientists should emphasize the importance of their future roles as educators within their country.

The education of local scientists by training programs should, if possible, also reach administrators and politicians. The better they understand the benefits and shortcomings of marine science, the easier should be the development of marine science training and research institutions within the country. A program to train marine science administrators is presently being considered by the Intergovernmental Oceanographic Commission.

The choice of what type of marine science program a foreign country should develop is difficult, and the issue of advice from outside institutions or individuals is particularly sensitive. However, a scientific advisory board, composed of experienced oceanographers and social scientists, could be of assistance if requested by a country. Outside consultants or visits by foreign scientists could also help, but a parochial viewpoint should be avoided at all times. Each country probably should be treated differently, because besides basic differences in scientific ability, resources, and interests, different sociological and economic pressures will generally require different approaches and methods of program implementation within the various countries. For these reasons, regional research institutions or large-scale regional cooperative programs should be created only if each participant has its contributions clearly defined. Clearly, each country's representatives should be attuned to the country's needs. Cooperative programs between countries developed in marine science have occurred fairly frequently (e.g. Deep Sea Drilling Project, FAMOUS), but these generally have concerned areas of basic science or are conducted in areas of the ocean outside the territorial waters or resource zones claimed by the participants.

Most developing countries appear to be mainly interested in applied research, or research that shows an economic return as soon as possible. Conversely, many U.S. marine scientists are primarily interested in basic research. This divergence of interests need not create conflicts, since most resource studies require a substantial amount of basic scientific material as a foundation. For example, delineation of mineral resources requires bathymetry and sediment sampling, which in many cases a marine geologist interested in basic research would also want to do. Thus, research interests among scientists of developing countries and developed countries can in many instances be compatible.

Based on our questionnaire, personal contacts, and experience, we have compiled a list of potential marine science research projects, instruments, and techniques that could be part of a technical assistance program (Table 8). This list is not comprehensive but is meant to show some of the opportunities for marine technical assistance. Many items on the list fall within the activities of organizations such as Sea Grant in the United States or the major research objectives of large research institutions in the United States. If we have correctly interpreted the interests of scientists from developing countries in marine science, it seems that programs of marine education and technical assistance await only funding and leadership.

TABLE 8

POTENTIAL RESEARCH PROJECTS, INSTRUMENTS, AND TECHNIQUES FOR INCLUSION IN PROGRAMS TRANSFERRING MARINE SCIENCE TECHNOLOGY TO DEVELOPING COUNTRIES.

Biological Oceanography and Biological Resources

Research on quantity and quality of marine biological resources.

Fishery analysis, population dynamics, and planning research.

Equipment for assessment and location of fish by acoustical equipment.

Mariculture and aquaculture research, techniques, and equipment.

Fish processing research - FPC.

Programs for measurement of nutrient content, organic content, standing crop, species composition, phytoplankton growth, and food chain dynamics.

Studies of primary and secondary production.

Water resource and water quality studies.

Reference collection of endemic organisms.

Physical Oceanography

Coastal circulation and harbor studies.

Nansen bottles, thermometers, salinometers, and equipment for associated chemistry and standard hydrographic measurements.

Mechanical bathythermographs, drift bottles, bottom drifters, and drogues.

Coastal tidal gauges, current and wave meters.

Monitoring of weather, precipitation, and evaporation; and equipment for measuring basic meteorological variables.

Determination of areas of upwelling.

Vertical structure of water column.

Currents and nearshore circulation.

Marine Geology and Geophysics

General bathymetric and sediment mapping.

Sand and gravel, phosphate, manganese nodules, and heavy mineral

Table 8 (cont.)
page 2

Marine Geology and Geophysics (cont.)

exploration.

Sediment sampling devices including snappers, corers, and dredges; in certain circumstances, vibrocorers.

Echo-sounders, continuous seismic profiling systems, and for shallow work - multichannel systems.

Magnetometers and gravimeters.

Shallow and deep structure of the continental margin.

Delineation of basins having oil and gas potential.

Aerial photographic shoreline surveys.

Coastal, shoreline, and estuarine studies including estimates of erosion and deposition.

Chemical Oceanography

Base-line measurements of the chemical composition of nearshore waters.

Methods of pollution detection and prevention.

Influence of waste disposal and pollutants on marine life.

Fate of pollutants in the marine environment.

Heavy metal content of nearshore waters and bottom sediments.

Simple equipment for chemical and biochemical techniques and measurements.

Ocean Engineering

Flood control studies.

Harbor design and situation studies.

Possibilities for tidal energy.

Sites for offshore terminals and other facilities.

Wave barriers and breakwaters.

Development of marine recreational areas.

General

Ship, computer, navigation system, and laboratory equipment such as microscopes, etc.

Well-trained scientists and understanding administrators.

Table 8 (cont.)
page 3

General (cont.)

Teaching programs both at the MS and Ph.D. levels in oceanography and marine technology within the foreign country.

Training programs to develop marine-related expertise of scientists trained in other disciplines.

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MARINE MINERAL RESOURCES

A Review and Critique of the Present State of Knowledge and Art of Marine Mining Technology

by

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Statement of Purpose

The objective of this report is to present an account of the present state of the knowledge and art of marine mining and its associated technologies. Analysis and comments are included to assist the U.S. Sea Grant Program in deciding on its involvement with international institutions in research and support of technological transfer to less-developed countries. The report does not deal with petroleum, gas and sulfur resources, but concentrates on what may be termed "hard rock minerals."

Table of Contents

		Page
I.	Introduction	51
II.	The Nature of the Mineral Industry	51
III.	Needs of the Developing Nations	52
IV.	The Oceans as a Mineral Source	53
	A. The Marine Environment	53
	B. Physical Oceanography	54
	C. Marine Chemistry	55
	D. Marine Geology	56
V.	Marine Mineral Resources	59
	A. Dissolved Deposits	60
	B. Unconsolidated Deposits	60
	C. Consolidated Deposits	63
VI.	The Mining Problem	63
	A. Prospecting and Exploration	63
	B. Feasibility Studies	69
	C. Exploitation	71
VII.	Typical Structure of the Mining Industry	76
VIII.	Items of Transferable Knowledge	78
IX.	Recommendations	79
	References	80

I. Introduction

The world population uses mineral resources at an ever increasing rate. Land areas are being extensively and vigorously explored and mineral resources are being found. The oceans, both near the continental land masses and at the abyssal depths, are not fully utilized as exploration sites and exploitation locations. However, groups in many countries such as the United States United Kingdom, Finland, Japan, Indonesia, Malaysia and others are currently exploiting the fringes of the oceans. Minerals being mined include ilmenite, rutile, cassiterite, iron sands, lime shells, and sand and gravel. In the rock beneath the seabed at the continental margins, minerals such as coal and sulfur are being recovered; and in the seawater itself, salt, magnesium and bromine are obtained. The sea, therefore, is a huge potential source of minerals.

This report identifies the uniqueness of mineral exploitation and indicates which minerals may be recovered from the ocean in the near future, possibly within 30 years. The needs of many developing countries in terms of mineral wealth will be discussed, followed by description of the details of marine mining procedures. The final section of the critique examines the structure of the minerals industry and indicates which items of technology and knowledge may be transferable to nontechnically-oriented economies. The final section includes recommendations.

II. The Nature of the Mineral Industry

The demand for most minerals is a derived demand. That is, the demand for a mineral comes from the demand for other goods. This demand is not similar to the demand for fish which is a direct consumer good. Suppose a plumber wishes to solder a pipe. He has a demand for solder. The solder contains metals such as lead and tin. The plumber's demand for solder eventually creates a demand for tin eventually creates a demand for cassiterite, which is the mineral from which tin is obtained. Eventually the cassiterite is mined in the near offshore portions of Indonesia or Malaysia.

Another feature of the mineral industry is related to the concept of scarcity of resources, which is an economic rather than a physical concept. When individuals speak of the exhaustion of mineral resources, they commonly think in terms of physical quantities. In reality the earth is composed of all types of minerals and physical exhaustion is not a prime concern. The real concern of scarcity of resources is related to the exhaustion of high quality resources leaving only the poor qualities for future generations. Here again, one must recognize that throughout the thousands of years that minerals have been used, the highest quality resources have always been exhausted. In the United States, the grade of copper being mined during the past one hundred years has dropped from about 12 percent copper to the current average grade of 0.6 percent copper. Fortunately, the reserves of copper minerals in this period of time have increased at a greater rate than the decrease in copper grade. By reserves, we mean that portion of the mineral mass in the earth which is exploitable under current social, political, economic and technological conditions. The tonnage of minerals in the reserve has tended to increase geometrically as the grade has dropped arithmetically. We see no substantive reason why this process should not continue. Of course, as the grade of mineral being mined decreases, the geographical locations for mining increase. There are few high grade spots on the earth, but there are many low grade locations containing valuable minerals.

III. Needs of Developing Nations

Any analysis of an international technology transfer program should discuss the needs of the less-developed countries both in terms of what we think they need and what they want. First, developing nations need minerals for internal development to provide for industrial growth such as metal fabrication plants, and in agriculture, using sea-based minerals for fertilizer. Other internal needs include development of a skilled labor force and the spread of technical knowledge. The less-industrialized countries must train engineers and technicians.

The spread of scientific knowledge is useful, but only to a few individuals. When scientific knowledge is translated into practical works the information becomes available to all the people in the country through linkage effects. The leaders of the developing nations, the so-called "Third World," have repeatedly mentioned that they want both scientific and technical information transfers.

Second, developing nations need minerals for external use, that is, for export to obtain hard currencies. In this case the developing nations are generally indifferent to the export commodity. They obviously prefer to join a monopoly-type industry rather than a competitive industry which is subject to severe fluctuations in mineral prices.

In recent years the growth and use of monopoly power of the Organization of Petroleum Exporting Countries (OPEC) in unilaterally quadrupling the price of crude oil to gain enormous quantities of foreign exchange is quite evident. In tin, much of which comes from the oceans, the International Tin Council has maintained a cartel agreement attempting to control tin output and price for close to 50 years.

Persons responsible for the transfer of scientific and engineering technology to the less-developed countries should recognize the dual motives of these nations concerning mineral affairs, i.e., internal and external use.

IV. The Oceans as a Mineral Source

The subject of marine mining is extremely broad and complex and contains many facets of terrestrial mining. The uniqueness of marine mining derives from the physical environment in which the mining activity must take place. The overburden superimposed on the ore deposits is liquid instead of solid and only under special circumstances can it be removed to reach the ore. Hence mining activities must be designed to cope with this condition and a fundamental understanding of the marine environment is essential for successful operations.

A. The Marine Environment

The marine environment is a complex natural phenomenon long studied but still little understood. The marine miner must learn to live with this environment, to work with it instead of against it, to learn never to ignore it. A mechanic placing a tool on the deck finds it lost overboard because of a sudden pitch of the ship, or the cook must make unending amounts of sandwiches because weather conditions permit little else.

For our purposes, the marine environment may be categorized into three broad groups: Physical Oceanography, Chemistry of the Seas, and Marine Geology. Each of these subjects relates to the economic mineral potential of the seas and oceans and is recognized as a complex discipline in itself. With respect to less-developed countries, education in these disciplines is a necessity for the simple communication of the fundamentals involved in economic marine mining.

B. Physical Oceanograpy

Physical oceanography is concerned with determining various parameters needed to describe the behavior of the liquid ocean. The fundamental parameters are 1) spatial position, 2) temperature and 3) salinity. Other important parameters such as density, pressure, water particle velocity and light transmittance may be measured, but are in part related to the fundamental parameters. Spatial position is determined by knowing the coordinates of latitude, longitude and depth, and for marine mining activities this must be done with accuracy and precision.

The spatial position of the marine mine is important because it provides protection for the public interests and the miners interest. Within the miner's "claim", he may be licensed to pursue a given line of mining activity. Outside of these boundaries others may have priorities or claims to be protected. In general, the mineralization within the claim boundaries will be nonuniform and the development of a feasible mining plan will be based on the position of the high and low grade areas that must be located with great precision.

The fundamental parameters of temperature and salinity are relatively easy to measure.

Temperature measurements are made with various devices of increasing sophistication. Temperature profiles in the ocean show three zones:

1) A surface zone of higher temperature, essentially isotherm due to surface mixing in the layer.
2) A transition zone connecting the surface zone to the deep zone.
3) A deep zone of lowest temperature, essentially isotherm due to its isolation from heat sources and mixing phenomena.

Salinity measurements are made by determining the electrical conductivity of the water. Salinity profiles of the ocean resemble temperature profiles, but are more unstable due to higher salinity water at the surface overlying lower salinity water at depth.

Pressure in the oceans is a function of depth and density and density is a function of temperature and salinity. Optical properties are a function of salinity and temperature, and acoustical properties are a function of temperature and pressure. Optical and acoustical properties are particcularly important, for the means of underwater communication with personnel of remote controlled equipment relies on light or acoustical transmission.

Tides, ocean currents, waves and circulation phenomena relate to the dynamics of the oceans. Major currents such as the Gulf Stream, Japan current and the Peru current carry the effects of underwater mining activities around the world, often depositing unwanted debris on someone else's doorstep. Deep circulation patterns exist in the oceans where essential cold water from the two poles flows toward the equator, creating a polar character in the deep and bottom waters of the world oceans.

The movement of the ocean waters is dependent on the amount of heat absorbed from the sun, the earth's rotation and sun-moon tidal effects. There are three major regions: 1) a surface region where wind-driven forces predominate; 2) an intermediate zone where rotational forces predominate; and 3) a lower region where frictional drag predominates. Near shore the zones coalesce. The prediction of tides and wave phenomena to be expected throughout the life of a marine mining venture is essential to the design of equipment and operations.

In particular one should know the extreme conditions with respect to tide and wave phenomena so that adequate planning and safeguards may be undertaken to protect the lives and limbs of personnel and to prevent equipment and method destruction. Location of anchorage, drift of vessels and equipment about the mining site, shearing forces on pump lines are just a few of the problems associated with the dynamic character of the oceans. Beach deposits may be mined by protecting the operation from the sea by constructing dikes. Offshore mining with dredges will be effected by tide and wave action. In general, specialists, or consultants, are required by mining companies to provide the necessary detailed information, and less-developed countries may not have the critical mass of work available to support groups providing such specialized knowledge.

C. Marine Chemistry

Seawater may be the most complex solution that technology is likely to encounter. Some 77 elements, including atmospheric gases, have been detected in seawater, and it is highly likely that more exist. The chemistry of the ocean is determined in the main by nine major dissolved components.

The major cations are sodium, magnesium, calcium, potassium and strontium. Anions include chloride, sulfate, bicarbonate and bromide. All other dissolved constituents total less than one percent of the total weight of dissolved materials. A number of chemicals or chemical compounds may be recovered from seawater.

An understanding of marine chemistry is essential if one desires to exploit the dissolved materials as an orebody. The effects of localized changes in marine chemistry on aquatic life are well documented and will not be touched on further. However, it should be noted that this is a source of concern in the less-developed countries.

D. Marine Geology

Marine geology may be grouped into 1) marine physiographic provinces, 2) marine rocks and 3) marine mineral resources.

Marine physiographic provinces are: 1) the continental shelf, 2) the continental slope, 3) the deep sea and 4) trenches. A more complete description is given in the accompanying table on the following page.

The basic marine rock types are sediments and igneous rocks. A grossly reduced classification of sediments is:

Pelagic deposits: sediments that were originally within 200 meters of the ocean surface and arrived at the bottom by settling through the ocean

a. Oozes - skeletal remains greater than 30 percent
    1. Calcium carbonate ooze
    2. Siliceous ooze
b. Red clay - skeletal remains less than 30 percent, quartz, feldspar, mica, clay minerals, manganese nodules, etc.

Terrigenous deposits: sediments derived from land and carried to site of deposition by currents

a. Organic muds
    1. Calcium carbonate mud and sand
    2. Siliceous mud and sand
b. Inorganic muds
    1. Clay
    2. Silt and sand
    3. Volcanic muds and sand

TABLE 20-7 Marine Physiographic Provinces

	Depth, M	Relief	Seismicity	Sediment/Rock Type
Continental shelf.............	0-200	Flat	—	Continental sands, gravels, muds, bed-rock continental sediments
Continental slope.............	200-3,000	5^{o} slope	—	—
Continental margin or rise....	2,500-4,000	Smooth slope up to 1^{o}	—	Continental-derived muds, small percentage of sands lenses
Abyssal plains................	Deeper than 3,000	Flat, generally featureless	—	Deep-sea oozes and clays
Abyssal hills.................	Deeper than 3,000	Rolling topography; generally less than 100 fathoms relief; features lobate oriented	—	Deep-sea oozes and clays
Ridge-rise system.............	—	Ridge, rugged; rise, smooth	High shallow focus	Bedrock basaltic
Fracture zones................	—	Rugged-elongate orientation of ridges and troughs	Generally aseismic	Bedrock basaltic
Trenches......................	Deeper than 6,000	—	High intermediate to deep focus	Bedrock basaltic; some areas ultra mafic
Sea-mount provinces	Various	Submarine volcanoes, generally individual conical; some with flatter tops called guyots	Aseismic except if active	Bedrock basaltic

TABLE 20-11 Principal Minerals of the Deep Sea

Authigenic	Pyroclastic	Biotic	Terrigenous	Diagenetic	Extra-Terrestrial
Phillipsite-hormotone	Pyroxene	Aragonite	Kaolinite	Phillipsite-hormotone	Nickel-iron spherules
1 Md mica	Plagioclase	Calcite	Biotic	Montmorillonoid	Olivine-pyroxene-chondrules
Opaline silica	Labradorite-oligoclase	Opaline silica	Chlorite	Nontronite	
Francolite	Orthoclase	Celestite	High Ab feldspars	1 M mica	
Celesto-barite	Microcline		Quartz	Orthoclase	
Gypsum	Sanidine			Dolomite	
Anhydrite	Volcanic glass			Maghemite	
Sphalerite				Mixed layer clays	
Goethite				Palagonite	
Fe oxides					
Magnetic Fe oxides					
MnO_2					
Manganites					

Source: SME Mining Engineers Handbook, Ivan Given, ed., New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, 1973) pp. 20-115.

Submarine Deposits: sediments that were never exposed to the atmosphere

a. Detrital - erosion of sea floor and submarine volcanic activity mixed with pelagic deposits

b. Chemical - authigenic formation on the sea floor

1. Clays
2. Manganese nodules
3. Phosphate nodules

Terrigenous deposits are found adjacent to land areas and deposited on the shallow shelf. Pelagic deposits are almost exclusively deep sea areas with little terrigenous contribution. Oozes form in regions where the rate of production of dead biological specimens exceeds the rate of solution. Siliceous oozes are relatively insoluble and occur where siliceous organisms have a high productivity. Inorganic clays are found in deep water. Chemical deposits are limited to areas of very low pelagic or terrigenous activity or where chemical precipitation is enhanced by localized conditions. Ferromanganese oxide deposits are found as nodules and crusts in deep water associated with red clay. Phosphorite deposits occur as nodules or muds in regions of upwelling of deep phosphorus-rich water. Metalliferous muds usually rich in iron oxides, zinc sulfide and other trace metals are associated with the hot salty brines occurring in certain closed basins in the Red Sea.

The most common igneous rock on the sea floor is basalt--a fine grained, dark, heavy volcanic rock. In general, as one proceeds through the physiographic provinces from the continental shelf to the deep sea, the sea floor rock changes from a granitic basement rock to a basaltic basement rock. Except near the continents where continental erosion products are plentiful, the sediment cover over the basement rocks may be less than a kilometer thick or may be nonexistent. Near geologically active ocean ridges and plate boundaries other rock types and minerals may be found.

V. Marine Mineral Resources

Marine mineral resources may be categorized as 1) dissolved deposits, 2) unconsolidated deposits and 3) consolidated deposits contained in the bedrock. The geologic and physiographic provinces of the seas have a considerable bearing on the formation of marine mineral resources. It should be made quite clear that the transfer of a resource which is a potentially exploitable deposit to a mineral researve or an orebody category requires the evaluation of many factors, not least of which is discovery. Only a small part of the seabed has been explored and most of the presently known resources are only conjectural by location. Hence assistance in the form of marine mineral resource search in the territorial waters of the less-developed countries is a most desirable area of concentration.

A. Dissolved Deposits

The dissolved mineral content of the seas forms a tremendous resource, but very little of it lends itself to economic exploitation. Only six of the 60 better known elements are commercially extractable. The accompanying table computed by McIlhenny and Ballard gives the estimated concentration, production and value of dissolved minerals from a seawater treatment plant handling 660 billion gallons per year. The values shown are based on the assumptions that the cost of production from the plant would be zero and that output would not be great enough to cause reduction of the then market price. Most of the minerals shown in the table would have a negative value after consideration of these two factors. The principal mineral commodities produced from seawater are salt, magnesium, fresh water and bromine.

B. Unconsolidated Deposits

Unconsolidated deposits may be mined by dredging methods, and in general do not differ from placer type deposits found on land. Continental shelf deposits contain minerals of low specific gravity and low unit value, such as sand and gravel, to minerals of high specific gravity and high unit value, such as gold. As might be expected in sand and gravel placers, these minerals make up the bulk of the deposit, 50 to 100 percent. However, in gold and diamond placers, these minerals are in miniscule amounts, measured in parts per million. The assessment of the economics and methods of exploitation of these different placers are important considerations and are unique to the deposits in question.

On the Continental Slope from the 200 meter to the 3,500 meter depth range two authigenic mineral resources are found: phosphorite deposits in the form of mud and crusts and nodules and metalliferous mids.

In the deep seas from 3,500 meters to 6,000 meters the most important

TABLE 20-16—Classification of Marine Mineral Resources

	Marine Mineral Deposits			
	Unconsolidated			
Dissolved	Continental Shelf, 0–200 M	Continental Slope, 200–3,500 M	Deep Sea, 3,500–6,000 M	Consolidated
Seawater: Fresh water Metals and salts of: Magnesium Sodium Calcium Bromine Potassium Sulphur Strontium Boron Uranium Other elements *Metalliferous Brines:* Concentrations of: Zinc Copper Lead Silver	*Nonmetallics:* Sand and gravel Lime sands and shells Silica sand Semiprecious stones Industrial sands Phosphorite Aragonite Glauconite *Heavy Minerals:* Magnetite Ilmenite Rutile Monazite Chromite Zircon Cassiterite *Rare & Precious Minerals:* Diamonds Platinum Gold Native copper	*Authigenics:* Phosphorite Ferromanganese oxides and assoc. minerals Metalliferous mud with: Zinc Copper Lead Silver	*Authigenics:* Ferromanganese nodules and assoc. Cobalt Nickel Copper *Sediments:* Red clays Calcareous ooze Siliceous ooze	*Disseminated, massive, vein, tabular, or stratified deposits of:* Coal Ironstone Limestone Sulfur Tin Gold Metallic sulfides Metallic salts Hydrocarbons

TABLE 20-18—Amount and Value of Products From a Seawater Factory Handling 660 Billion Gal of Water per Year*

Material Obtained**	Factory Production, 1,000 Tpy	Selling Price, $ per Ton	Product Value, $1,000 per Yr	1961 U.S. Consumption 1,000 Tpy	Ratio of Fact. Production to Consumption	Estimated Land Reserves at 1961 Rates of Consumption	
						U.S., Yr	World,† Yr
NaCl	76,360	10	763,000	26,100	2.9	+1,000	+1,000
Magnesium	45	705	31,700	45	1.0	+1,000	+1,000
Mg compounds	5,923	53	314,000	680	5.3	+1,000	+1,000
Sulfur	2,450	24	58,800	6,000	0.4	25	NA‡
$CaSO_4$	6,105	4	24,400	10,000	0.6	NA	NA
KCl	2,062	31	64,000	1,880	0.6	100	5,000
Br	184	430	79,000	85	2.2	+1,000	+1,000
$SrSO_4$	76	66	5,000	5	15	400	NA
Borax	113	44	5,000	100	1.1	200	NA
HF	3.8	320	1,200	330	0.01	30	50
LiOH	3.4	1,080	3,240	NA	NA	NA	NA
Iodine	0.14	2,200	300	1.3	0.11	NA	NA
MoO_3	0.041	3,200	132	15	3×10^{-3}	150	100
Selenium	0.011	11,500	127	0.5	0.02	100	NA
U_3O_8	0.007	16,000	112	26	3×10^{-4}	10	30
V_2O_5	0.014	2,700	39	6.7	0.002	NA	NA
$BaSO_4$	0.24	160	38	820	2×10^{-4}	80	NA
Silver	0.0008	35,000	28	5.5	1×10^{-4}	6	20
Gold	0.00002	1×10^6	20	NA	NA	NA	NA
Tin	0.008	2,240	18	40	2×10^{-4}	NA	NA
Phosphates	0.22	70	15	6,100	3×10^{-5}	1,000	1,000
Aluminum	0.03	450	13	2,300	1×10^{-5}	7	120
Zinc	0.05	230	12	460	1×10^{-4}	35	30
Nickel	0.006	1,580	10	180	3×10^{-5}	3	40
Copper	0.008	620	5	1,230	1×10^{-5}	30	35
TiO_2	0.0047	540	3	570	1×10^{-5}	40	110
ThO_2	0.0002	11,000	2	0.1	2×10^{-3}	1,000	NA
Cadmium	0.0004	3,600	1.5	5	8×10^{-5}	6	40
As_2O_3	0.0074	100	0.7	26	3×10^{-4}	100	NA
Cobalt	0.0002	3,040	0.6	5	4×10^{-5}	8	100
Antimony	0.0006	650	0.4	13	5×10^{-5}	3	100
MnO_2	0.005	50	0.3	1,000	5×10^{-6}	NA	35

* After McIlhenny and Ballard, 1963.
** Listed in form of dominant selling compound. Consumption statistics include other forms also.
† Assuming present level of extraction technology. +1,000 indicates material extracted from sea.
‡ NA = not sufficient data available to calculate statistic.

marine mineral resource is the manganese nodule. These nodules contain nickel, copper, cobalt, manganese and other elements of current interest. Many private and state companies are currently involved in developing the technology of exploiting these resources. Nodule resources are found in all the oceans, with the highest quality nodules located in the Pacific Ocean in an equatorial bank several thousand miles long by a few hundred miles wide. There is no mining of these nodules currently being done. However, several private groups claim the ability to mine and to produce metal commercially.

C. Consolidated Deposits

Apart from authigenic mineral crusts, there are no known hard-rock mineral deposits of minerals that are unique to the marine environment. Since the basement rocks underlying the continents extend in diminished form into the continental shelf regions, there is reason to postulate that hard-rock mineral deposits similar to those found on land may exist in the continental shelf areas. Coal, lead, zinc, copper, tin and gold have been exploited in the basement rocks in the continental shelf. Mining is by standard underground methods.

In trenches and adjacent areas and in the abyssal plains and hills the bed rock is mainly basalt and related rocks overlain by sediments of varying thickness. These regions may be considered as favorable locations for hard-rock mineral deposits on a local basis. Bed rock fracture zones and faults probably serve as structural control.

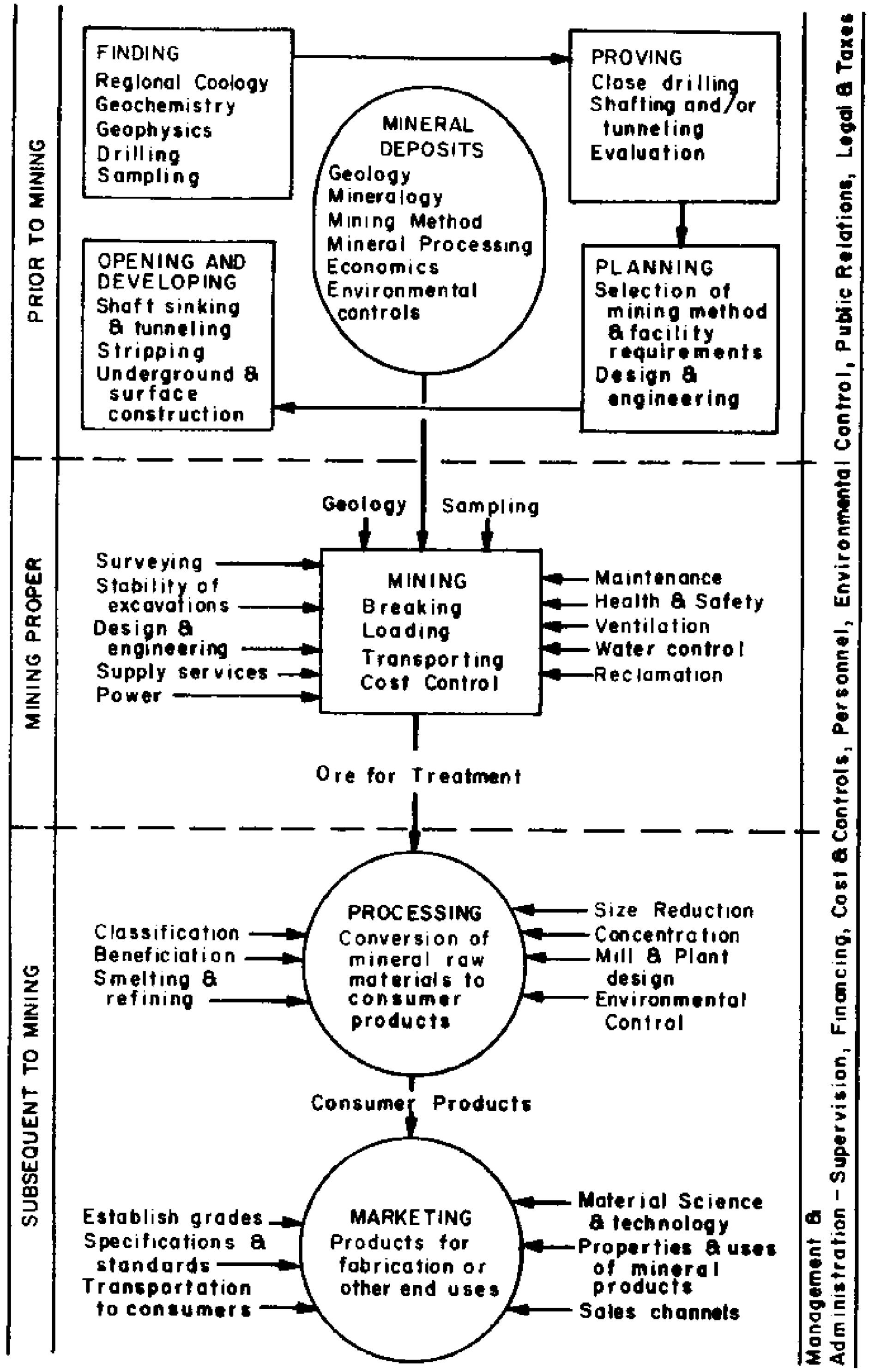
VI. The Mining Problem

For many years, offshore mining has been practised in continental shelf areas in water to a depth of 200 feet. With the discovery of the extension of oil and gas fields into the continental shelf regions, there has been a dramatic increase in well drilling and associated techniques for the recovery of these minerals as well as sulfur. Hence a considerable amount of expertise, knowledge and information is available for assisting the less-developed countries in the near shore regions of their territorial waters.

A. Prospecting and Exploration

The subject of prospecting and exploration is one of major emphasis in marine mineral affairs. Figure 1, following, provides in schematic form the

DEFINITIONS OF MINING TERMS



definitions of mining terms. This sketch indicates the steps of exploration, development and mining, and mineral processing. The words "search" and "find" explain the objectives of the two activities because in many instances similar equipment is used. The marine environment is both a help and hindrance to prospecting and exploration; it helps in the application of geophysical tools but hinders in the sampling and evaluation stages. In the past ten years many valuable papers have been written on the tools and techniques used in marine prospecting and exploration. In addition, there are numerous ongoing or recently completed surveys. Hence it is evident that the less-developed countries can learn much from these sources.

Briefly, finding and proving in the oceans is characterized by five activities: mapping, geophysical sensing, sampling, characterization and evaluation. The distinction between what is prospecting and what is exploration is unclear, and depends on the unique character of the deposit and area being investigated.

The marine miner faces unique difficulties when he wants to locate accurately, survey and map the mine site. Numerous types of charts and maps are required depending on the location of the site, i.e., inland bays or harbors, deep seas, or on the shelf. Topographic maps, charts of foreign waters, oceanographic data, rivers, harbors and navigable water maps are but a few of those required. In addition, a base map of the mine site is needed.

The primary base map is a bathymetric chart showing bottom topography. The grid spacing for a bathymetric survey should probably be no more than 1/4 mile, depending on the size of the target area. Where tectonics and morphology are involved in the control of mineral deposition, tight-grid high resolution surveying is required. There are a large number of systems and techniques used for bathymetric mapping problems and the less-developed countries may obtain aid or training from commercial sources.

All major methods of geophysical sensing for mineral deposits have been tried in the marine environment or are being researched. Echo sounders developed in World War II for submarine detection have been extensively used for bottom surveying and for the search for marine placer deposits of heavy minerals. The return signals show a recognizable section of the sub-bottom revealing shallow layers of sediments, bed rock, faults and other features.

The methods of geophysical sensing or physical sampling are the only known methods of searching for and finding ore deposits. A gravimeter is a

TABLE 20-56—Data on Standard-Type Dredges

	Dragline	Clamshell	Bucket-Line	Hydraulic Cutter	Air-Lift	Hydro-Jet
System classification	Mechanical repetitive	Mechanical repetitive	Mechanical continuous	Hydraulic continuous	Hydraulic continuous	Hydraulic continuous
Some Operating Restraints:						
Environmental	Washing of load		Ladder motion where rigid ladder is employed		Transverse motion of flexible riser	
Deposit characteristics	Medium-hard to loose granular		Hard to medium-hard rock		Loose granular material	
Depth of water, ft	Undefined	300+	160	100	Undefined	300+
Mechanical	Hoisting rate, weight of rope		Weight and bulk of ladder		Friction in pipe, other unknown hydraulic effects	
*A Range of Operating Parameters.**						
Depths	0–100	30–250	30–150	30–150	60–200	30–250
Rated capacity (normal)	1–5 cu yd	5–10 cu yd	2–18 cu ft	10–30 in.	6–24 in.	10–24 in.
Hp	70–500	2,500–5,000	500–3,600	400–8,000 pump, 75–2,500 cutter	70–5,000	300–6,000
Throughput, soft	Very variable	240–500 cu yd/hr	40,000–350,000 cu yd/mo	250–4,500 50–2,000 cu yd/hr 10.9–19.6	Very variable	Similar to hydraulic may increase
Operating costs	50¢/cu yd	4.4–28.3/cu yd	3.4–62.4/cu yd	15,000–100,000/mo	NK	NK
Capital costs	Low	Low	High	225–275 $/hp	Medium	Medium

* Ranges given are not exclusive.

Source: <u>SME Mining Engineers Handbook</u>, Ivan Given, ed., New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, 1973) pp. 20-115.

tool used in geophysical sensing. Gravity surveys indicate local variation in the direction and intensity at the earth's gravitational field. These changes are the result of structural or mineralogical changes in the earth's crust. Thus the gravity survey may locate faults, dikes, concentrations of some minerals, salt domes, and other geological features.

The interpretation of the results of gravity survey requires precise knowledge of topographic conditions and expertise on the part of the operator. The strength of influence of the earth's gravity is related to the distance the sensing equipment is from the interesting geological feature. Techniques have been developed to provide a stable base for the equipment to reduce wave action interference.

Another geophysical technique used in mineral exploration is with magnetometric equipment. Here the sensing is done by measuring alterations in the earth's magnetic field. Many changes in the earth's magnetic field can be traced to mineral concentrations. This technique is much less sensitive to changes in topography and much work is done using aircraft and boats. Magnetometer marine surveys are quite common and are used for both mineral exploration and locating metallic objects lost in the sea.

The subject of sampling, sampling methodology and sampling devices is of critical importance to the potential marine miner. The output of the search activity is the locating of a region containing a potential marine mineral resource. One now must determine if the marine mineral resource can become an orebody. The first step in this procedure is physical sampling of the mineralized mass.

The mining engineers place orebodies into three classes depending upon the reliability of the sampling methods and procedures. A proved orebody is one in which the tonnage and grade, mineral concentration, can be computed from the results of a detailed sampling program. The sites for inspection, sampling and measurement are so closely spaced and the geologic character is so well defined that the size, shape and mineral character are well established. The stated tonnage and grade should be within specified limits, usually plus or minus 20 percent. Probable and possible orebodies fall far short of these requirements and remain of speculative character. Subjective judgment usually plays a large role in evaluating probable and possible orebodies.

Numerous tools, specialized equipment and techniques are available for sampling marine mineral deposits. The simplest sampling technique is to grab a sample from the bottom. This can be done with a drag sampler, which is a flat-bottomed bucket. This device is towed by a ship and dragged along the seabed. It is not selective but the system works and samples have been retrieved from the deepest portions of the oceans with this tool. Fairly elaborate dredge samplers have been designed to recover sand, pebbles, loose rock, and to break small pieces of rock from the bottom. Some dredge samplers can recover more than one ton of material at a time. The difficulty with this type sampler is the slowness of the recovery system and the imprecision in picking the sample.

In an effort to increase the precision of the location in picking a sample, the "clam shell" type sampler has been developed. This machine, or a variation of it, has parting sections which are open as the bucket reaches the bottom. The shell halves or claws close either through a signal from the surface or by spring action upon contact with the bottom. This sampler can be more easily positioned using a television camera on the tool to show the engineers on the surface where the sampler has settled. These devices sample on the top ten inches of the ocean bottom, which in most instances is sufficient. This is because most minerals which are mined in the oceans lie within the top few inches of the ocean bottom.

A more complex, but more precise system of sampling the sediments is to use a device which removes a core from the bottom. This core provides physical material in its exact order as it was deposited on the bottom over eons of time. This is a good tool for geological investigations and prospecting sediments or bottom rocks, but does not give satisfactory information on phosphate or nickel nodules which lie on the surface of the seabed.

The coring device is a weighted pipe with a sharp cutting edge on the bottom end. The pipe is lowered from the ship and allowed to free fall from the vessel to impale itself on the bottom ooze or mud. On some tools, mechanical devices help force the cutting edge through the sediments. The Russian geologists claim that they have recovered a core 115 feet long from clay-like sediments. (A. D. Little report, p. 32).

B. Feasibility Studies

The characterization and evaluation stages of the prospecting and exploration effort involve the integration of all the knowledge pertaining to the potential mine site into feasible operating schemes. Oceanographic data, chemical data, geological data, prospecting and exploration data, mining methods data and the economics of the mining industry must be interwoven into a feasible scheme for exploiting the mine site. Essentially, one tries to operate a "paper mine" in order to determine the cash-generating character of a given method of mine operation. Since every phase of the data input into the proposed scheme of operation is uncertain the outcome of operating the "paper mine" can be stated only in probabilistic terms. Risks are involved in marine mining and also in terrestrial mining. The entire objective of the exploration effort is to reduce the uncertainty associated with the input data and thereby provide the necessary data for risk quantification.

The exploration phase culminates in a major feasibility study which evaluates all pertinent factors and gives results usually in the form of an economic cost-benefit analysis. The report gives the private or state investor all necessary data needed to permit a decision to seek financing for the project. The normal sequence of steps in a successful exploration campaign, prior to exploration, is to first find the deposit, second to obtain funds for investment, and third, to design and construct the operating plant. The time required for finding a deposit is difficult to estimate. However, some evidence obtained by the U.S. Bureau of Mines indicates that most copper deposits now being developed were found 40 to 80 years before initial development. A thorough exploration program may easily use five to ten years in the geological evaluation of a deposit. The time needed to acquire funds for investment in mining properties often takes two or more years. Major mining investments exceed several hundred million dollars. No one group usually wants to hold the entire risk of a mining venture. The time is used to obtain funds from several investing groups. The feasibility study is the major document which is used to convince investors to put money into the project.

A feasibility study summarizes all knowledge of the geographic and geologic environment, and the potential mine and refining operating system.

Data on ore reserves is combined with estimates of capital and operating cost for all components of the mining system. Estimates of long run price must also be made.

Most often the estimates of highest reliability are the capital and operating costs. This occurs because a history of operating and capital cost have been developed from existing mining properties. In some cases this would also be the same in ocean mining. Existing costs are known in near offshore dredge mining systems for gold or tin. In cases where no history exists, as in the case of nodule mining, costs usually are developed after evaluation of pilot plant results.

The pilot plant is a small scale mining and processing plant. If a proposed mine would operate at 5,000 to 10,000 tons per day, the pilot plant would be designed to operate at about 100 tons per day. The technological "bugs" would, hopefully, be removed in the pilot plant stage while acceptable cost estimates may also be developed.

An estimate of the income received by the mine is obtained either by acquiring a guaranteed price from a buyer, as in the case of iron ore, or by estimating the real future price over the relevant range of time interest of the mining property. If 15 percent internal rate of return is acceptable then the relevant life of the mining property is about 20 years after inception of production. Therefore, if the time for acquisition of funds, design and construction, and exploitation period of 20 years are considered, the price forecast should include a time horizon of about 25 years. An obviously impossible task.

Long run price forecasts can be estimated by two different methods. The first is an econometric model which develops a regression trend line based on historic data such as price output and inventories. This model assumes two primary weaknesses and is not used by the major mining firms. The first assumption is that the samples of data from many periods of time are representative of all periods of time in which the data are derived. This assumptio is not considered valid because real economic and human psychological factors change from year to year. The second key assumption is the statistical stability of the samples from the past into the future. Discovery of new mines, oil embargos, wars, depletion and technology change, are outside of the stability assumption, but, of course, these are the factors which directly affect future long run price.

The major mining firms utilize a recordian model of the world industry to develop long run price estimates. In the scheme, cost evaluations of all major world mines are made and plotted to estimate the amount of output available at any specific price. This simultaneously gives an estimate of long run price which is the minimum average cost of production of the most marginal producer. Knowing the cost of production of competitive mines also enables the prospective entrepreneur to know how competitive the new venture will be.

The feasibility report gives results in financial terms such as internal rate of return, average annual rate of return, net present value, pay back period, and other similar criteria. If the report shows a viable project, and if the finances can be obtained, the plant is constructed and exploration begins.

C. Exploitation

There are economic mining operations in each of the three marine mineral resource areas: dissolved, unconsolidated and consolidated.

Four elements or mineral suites are commercially obtained from seawater: sodium, magnesium, calcium and bromine. Salt evaporates are the most important compounds, but fresh water is a growing vital product.

A cubic mile of seawater contains 4,500,000 tons of magnesium. In the economic recovery of magnesium from seawater, lime sludge obtained from roasting or calcining oyster shells is fed slowly into tanks containing seawater. The chemical exchange between the lime and the seawater precipitates magnesium oxide. The crude magnesium oxide is collected and treated with hydrochloric acid to form magnesium chloride which is dried, then electrically treated in molten condition to give magnesium metal and reconstituted hydrochloric acid.

In bromine recovery from the oceans, the seawater is made slightly acid with sulfuric acid, then treated with chlorine which displaces the bromine from the water. Bromine is mixed with air and steam and removed from the water which is returned to the ocean. Bromine is removed from the air using sodium carbonate (soda ash) to give a bromide-bromate compound. This product is treated with sulfuric acid which releases the bromine into the air from which it is condensed to form liquid bromine.

Numerous dredging operations are actively exploiting such diverse prodduct as diamonds, gold, heavy mineral sands, iron sands, tin sands, lime sands and ordinary sand and gravel. The most important of all these commodities is sand and gravel, since 65 to 70 percent of the value of world production from marine unconsolidated deposits is derived from dredging sand and gravel.

Underground mining of offshore deposits has been carried out for many years. Coal, iron, limestone, potash and tin ores are the most significant items being produced. Underground mining beneath the sea floor will become more feasible as future advances in technology solve numerous technical and environmental problems.

The economics of the exploitation of marine mineral deposits are related to the same factors as a land based mine. The product must compete in the marketplace with other sources of supply. Much knowledge and experience in exploiting the three marine mineral resource areas is available within mining corporations involved in marine mining. Complete "turn-key" systems are available to the less-developed countries as well as engineering, technical training and education in any part of the system.

Methods for exploiting unconsolidated deposits are of great interest. These are deposits amenable to dredging. As with a land based mine, the choice of a specific system depends on the geometry of the deposit, nature and depth of overburden, relation of ore mineral to bed rock and bottom topography, economic, political and operational restraints. The table on page 70 gives data on standard-type dredges.

In evaluating a mining dredge one must be careful to differentiate between a dredge for moving material and a mining dredge. The mining dredge not only picks up the material from the sea bottom but also contains crushing, screening and also processing equipment. In the case of a dredge to produce sand and gravel, the processing equipment might only be screening equipment whose function is to size the material. The end product for sand and gravel dredges is cleaned sand-sized material ready for concrete or other similar use.

A dredge for recovery of gold in a placer deposit is more elaborate. The usual quantity of gold found in a beach placer deposit is less than 1/4 ounce per ton of material. The mining dredge contains machinery for removing the placer material from the seabed and a complex chemical plant. The common method for recovering the gold is to screen the material by casting away large boulders. The finer remaining sand and gravel is processed in a gravity separation plant or a chemical plant where the gold is dissolved in cyanide and later precipitated using zinc metal.

Several types of dredges are being used to exploit offshore minerals and two primary types are being considered for use in mining nodules.

Draglines and clamshells - this piece of dredging equipment is generally not limited in mining by depth of water. This system essentially is quite similar to the grope sampling devices described earlier. An extension of this concept has been proposed by Miro and Matsuda for mining deep sea nodules. Their system is a series of buckets on a continuous line and would be applicable to depths beyond 12,000 feet.

At the Aokom Tin Mining Company in Thailand, a grope bucket dredge, converted from an oil tanker, was used for mining tin near Tongah Harbor. The sea depth varies from 60 to 80 feet, with a maximum range of tide of 10 feet. The tin deposit is in unconsolidated sands covered by three to five feet of mud, sand, and shells. The thickness of the tin bed varies from four to 70 feet. The dredge used two to four cubic yard buckets for dredging. Kanjana-varit provider of the information, indicates that dredge movement was controlled by six mooring lines. A series of pits was excavated with one grab alternating with the other grab. Total recovery of the deposit could not have been great because only portions of the deposit were removed through the pit method. Changes in tidal currents also created difficulties in controlling dredge position. Much ground was missed and some was re-excavated.

Tough clay beds were difficult to dredge. The grabs could not cut into the hard ground. Large chunks of clay material which were excavated blocked the screening plant, reducing operating time. The normal operating time of this dredge was only 69 percent of the total available time. The entire operation was so inefficient that eventually grab dredge operations were stopped and superseded by a bucket dredge.

The advantages of the grab dredge were its capacity to work at greater depth in soft ground and to reduce lost working time as a result of inclement weather. However, as the following table shows, the grab dredge was highly inefficient compared to the bucket-ladder dredge.

For more details of various operating mining dredges, the reader is directed to the SME Mining Engineers Handbook, 1973, American Institute of Mining, Metallurgical, and Petroleum Engineers.

Corporative Data for 1962,

Grab Dredge and Bucket-Ladder Dredge

	GRAB DREDGE		BUCKET LADDER DREDGE	
	Production Cu. Yds.	Expenses cents per Cu. Yd.	Production per Cu. Yds.	Expenses cents per Cu. Yd.
January	81,090	21.6	160,000	25.8
February	66,131	28.1	150,000	28.1
March	86,730	24.0	166,000	28.1
April	68,130	31.3	99,000	49.6
May	71,855	34.2	153,000	26.6
June	67,410	40.6	185,000	22.6
July	69,360	42.5	176,000	18.2
August	72,740	39.6	172,000	27.9
September	74,670	38.2	148,000	24.9
October	96,980	31.6	136,000	24.0
November	97,870	32.4	155,000	30.4
December	96,800	32.2	190,000	25.7
Average per month	79,147	33.2	157,500	25.4

Total horsepower, 2526, average monthly throughout, 31.3 cu. yd. per month per hp.

Total horsepower 1397, average month throughout per unit, 112.8 cu. yd. per month per hp.

Source: SME Mining Engineers Handbook, Vol. 2, Ivan Given, ed. (New York: American Institute of Mining, Metallurgical, and Petroleum Engineers, 1973), pp. 20-134.

Nodule mining is still only at the conceptual or early pilot plant stage. Nodules have been recovered from about 2,500 feet of water using an air lift dredging system and from 12,000 feet using a continuous bucket line dredge. In both cases technical feasibility was shown but more technical work will be necessary to improve the mechanical systems and verify the cost of operation. An airlift is an air-hydraulic hoisting method. The dredge pipe extends An airlift is an air-hydraulic hoisting method. The dredge pipe extends from the surface ship to the seabed pipe could be 18,000 feet long). Air is injected at the bottom of the pipe, which is at the sea bottom, to produce a density differential. The air-water mixture flows up in the pipe, causing a substantial suction at the pipe entrance. Nodules, sand and other material on the bottom are drawn into the pipe and rise to the surface. There are many technical problems associated with the system the air expands greatly as it rises through the pipe, and there are corrosion and maintenance problems. Undoubtedly some form of hydraulic lifting or air lifting system will be used if nodule mining occurs. The following sketch indicates the current concepts of deep ocean mining systems.

Source: "Deep Ocean Floor Nodule Mining - First Generation Techniques are Here," Mining Engineering, April 1975, pg. 47.

In this process, the Pacific Ocean nodules are crushed, dried, and treated with hydrochloric acid gas at 500°C to release the chlorine, which reacts with the nodules to produce soluble metal compounds. These products are leached with steam. The insoluble product containing primarily iron oxides is released as waste.

The leach liquor is treated in a solvent extraction process to strip copper, nickel, cobalt and manganese, which are converted to metal through electolysis. This system has been tested in a small pilot plant but not tried in a large testing plant. The chloride process uses a highly corrosive reagent which requires the use of elaborate handling procedures. Most metallurgical plants which involving considerable chemical, pyrometallurgical or electrolytic processes, cost in excess of $100 million. If a chemical plant were constructed to produce fertilizer materials from seabed deposits, the cost would be many tens of millions of dollars.

VII. Typical Structure of the Mining Industry

The mining industry is usually subdivided into elements such as the copper industry, diamond industry or fertilizer industry. Each of these industries is usually composed of a few giant public or private firms which produce the bulk of the products. For instance, the governments of Zambia, Chile, Peru and Zaire control and produce almost 40 percent of the world copper supply, and if only export trade is considered, control more than 50 percent of the world copper supply. This situation is the same in almost all other sectors of the total mineral economy. In general, these huge mining companies, with assets more than one billion dollars, were financed and built with private capital and later nationalized or expropriated.

The various industries tend to have an oligopolistic appearance, but often looks are deceiving. For instance, the copper industry has relatively few producers, but the industry is considered a competitive industry over the long run, which is in excess of four years (the investment cycle). The same applies to the lead and zinc industry. There are some exceptions, as in the diamond industry or molybdenum industry which are controlled by one or two producers. The reason for the oligopolistic appearance is that each mine is unique and has a unique cost per unit of metal. The long run price is at the cost of production of the worst mine. If the price were higher than the cost of the worst mine, exploration would commence and new ore-bodies would be found. This is an important concept. There is no industry risk of finding new mineralized zones. Some of these discovered mineralized zones will have a production cost lower than the worst producer and will eventually be brought to production. The seabed minerals will be constantly in competition for markets and will be profitable only if production cost is lower than the worst mines in the world. In the case where profit in the mine itself is impossible or of no consequence, as for mines in socialist countries, the revenue to pay the wages and buy supplies is often provided by the government. Many mines are operated by governments in an effort to aid in import substitution or to help the general economy in some other manner. This is not a new concept in mining; the U.S. government has subsidized the U.S. mining industry since 1926. It should be expected that seabed mines may also be subsidized by some government either as import substitution or to protect the source of supply of valuable minerals as a national security concern.

Mining is a capital intensive business. Current estimates of the investment cost of a deep water mining system range from \$20 million to \$300 million. A one million dry ton per year system gives estimates which range from \$130 million to \$240 million. The current estimate for the capital cost of a nickel mine and supporting plant is in excess of \$250 million. Most modern mining plants including a mine, mill and smelter usually have investment costs in excess of \$200 million. These figures become important as a comparison to the fishing industry where one million dollars will buy a lot of equipment. In mining, \$10 million will only pay for the exploration cost of one major deposit; many more millions of dollars are needed to build the plant.

Mining industry know-how can be placed in four categories: exploration, mining, concentration, and chemical or pyrometallurgy. Each specialty requires a specific type of knowledge, and knowledge of one specialty is not transferable to other specialties. Many phases of a mining complex require experience gained only over time and through visiting many other mining properties. Fortunately, quite a lot of information is freely transferred between companies throughout the world.

Below are listed the typical job titles for various specialties in ocean mining and processing.

Exploration

Geologists	Sailors	Mining engineers
Geophysicists	Cooks	Metallurgical engineers
Mechanics	Laborers	Sample splitters
Electronics technicians	Clerks	Electricians
Chemists		

Mining

Dredge captains	Chemists	Warehousemen
Mining engineers	Clerks	Purchasing agents
Geologists	Laborers	Accountants
Mechanics	Electricians	Safety engineers

Concentration

Concentrator superintendents	Laborers	Metallurgists
Crushing plant operators	Clerks	Mechanics
Screening plant operators	Chemists	Foremen

Chemical or Pyrometallurgy

Foremen	Clerks	Electricians
Chemists	Mechanics	Laborers
Metallurgists	Chemists	

VIII. Items of Transferable Knowledge

It is well to consider the possible items of know-how that can be transferred. First, there is the know-how of learning what lies on the ocean bottoms adjacent to each recipient country. This information is valuable even if no minable minerals exist in these waters. Much of this knowledge is scientific, but there is also engineering knowledge that can be transferred during the exploration process. This practical know-how would be useful to developing nations even if the search for minerals proved fruitless. However, if the search showed that minerals of value existed, the remaining portions of know-how which could be transferred, over long periods of time, include design of the mine and the mining equipment, and design of concentrator and smelter if such a down stream plant were required. There are also possibilities of transferring operating know-how in the case of a successful venture.

It is recognized that this discussion carries far beyond work only relating to the oceans. However, mineral finds and later mineral production do not produce usable goods. How to transfer across borders to produce consumable goods should be considered.

IX. Recommendations

The Sea Grant Program has possibilities of transferring great amounts of know-how to developing nations. In the case of minerals, this transfer of information would flow considerably "down stream" from the sea itself. The information would relate to design and construction of mining plants, mine operation and marketing of the products. Along with this technical know-how there would be a continual need to provide financial and business know-how. The overall recommendation is that a project to transfer know-how should proceed, but only if the full aspects of what is entailed in developing a producing mine are accepted. If a transfer program goes only so far as to show some developing nations that valuable minerals do exist within their national boundaries, this does not help the nation to produce the wealth from the sea; the program could really be considered a failure. It is comparable to teasing a child with a lollipop and then taking it away once the child has had a single taste. Such behavior could result in severe tantrums.

The following recommendations are made on the basis that the program would push forward to the entire conclusion. The program should provide know-how to:

1. Explore the seabed, including scientific, technical, mechanical and hard equipment help.
2. Evaluate the results of the exploration program. This includes geological and mining engineering assistance plus all related ancillary help.
3. Finance the venture.
4. Design and construct the plant.
5. Operate the plant.
6. Market the resultant products.

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MARITIME TRANSPORTATION SYSTEMS

by

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TABLE OF CONTENTS

		Page
I.	INTRODUCTION	83
	A. General Comments Concerning Onshore Facilities and Ancillary Services	83
	B. General Comments on Personnel and Skills	84
	C. Ocean Transportation Systems	85
II.	GENERAL CARGO SYSTEMS	85
	A. Break-Bulk Cargo Vessels	88
	B. Unitized Cargo Carriers	89
	C. Onshore Facilities	92
	D. Economic Aspects of Unitized Cargo	104
	E. Conclusions Concerning General Cargo Systems	116
III.	BULK COMMODITY SYSTEMS	116
	A. Bulk Carriers	118
	B. Terminal Facilities for Liquid Bulk Carriers	123
	C. Unloading Equipment	129
	D. Loading Equipment	130
IV.	OTHER TYPES OF CARGO VESSELS	130
V.	THE WATERBORNE MOVEMENT OF PASSENGERS	131
	A. Ferry Services	133
	B. Hydrofoils and Hovercraft	135
VI.	RECREATIONAL CRAFT	135
VII.	CONCLUSIONS ON VESSELS AND TERMINALS	135
VIII.	ESTABLISHING OR EXPANDING A NATIONAL MERCHANT MARINE	137
	A. U.N. Code of Conduct for Liner Conferences	138
	B. Government Subsidies	141
IX.	POTENTIAL ROLE OF AN INTERNATIONAL SEA GRANT PROGRAM	142

I. INTRODUCTION

This report will describe marine transportation systems as they exist today. Specifically, these descriptions will try to answer the following question:

> What must country "x" have and/or develop in order to ship goods "y" by commercial marine transportation?

In order to ship or receive various types of cargoes, a country must be able to make use of a marine transportation system which would include vessels, port facilities, support equipment, and personnel. This report will briefly describe the different types of marine transportation systems which are appropriate for various types of cargoes. The types of cargoes discussed will include general cargo, bulk commodities, passengers, and other specialized goods. A wide variety of vessels will be considered; however, note that neither military nor fishing vessels will be considered.

The discussions will not be site specific; nevertheless, the comments will refer to a spectrum of conditions applying to nations ranging from underdeveloped to highly developed. A discussion of personnel, skills, and ancillary facilities and services will be included to show which types of marine transportation systems will be out of the reach of underdeveloped nations. No attempt will be made to define detailed skills or give detailed descriptions of types of ancillary facilities -- the discussion will simply give the reader the knowledge of which types of skills and machinery are easily accessible to all nations and which are not.

The types of advantages and disadvantages associated with having a country ship goods on a national flag merchant marine will be briefly discussed. The type of governmental subsidies will be mentioned. Finally, a potential international role for Sea Grants in the area of marine transportation systems will be discussed. Since this report will only touch briefly upon many of the facets of marine transportation systems, further references will be included in the footnotes for the reader desiring more details.

A. General Comments Concerning Facilities and Ancillary Services

In this section we shall make a few comments on the general types of onshore facilities and ancillary services one would expect to find at most ports. This general description will serve as a base for further discussions when analyzing different types of vessels. The general factors described here require no unusual skills and are not absolutely mandatory at every single port. They are in no way so specialized that their absence would greatly constrain a port from operating.

When one enters a port, one expects to see the appropriate aids to navigation in the area and piloting services where required. There would be facilities for customs officials, police, fire, and port administration personnel.[1] Ancillary services functioning at the port normally include fuel, supplies, food, water, electricity, telephone, marine insurance, and banking services. Each port typically would have access to some combination of personnel and facilities for ship and engine repair. (Note that shipbuilding and ship repair will not be discussed in this report because they are being handled in a separate study.)

As we proceed, we shall assume that all ports will contain the basic facilities and services described above. Consequently, we shall only comment to show differences from those mentioned.

B. General Comments on Personnel and Skills

The general facilities and ancillary services described above will need appropriate personnel. The skills for the functions are self explanatory and will not be described here. Likewise, all ships require personnel with basic skills in navigation, cargo storage and handling, and engine operation and maintenance. These basic skills, common to all vessels, will not be described in detail. However, when specific systems are described, any unique skills required, both aboard ship and on shore, will be discussed.

It should be noted that, in general, an older ship will be less complex technically than a brand new vessel. A developing nation, viewing this situation, should consider that technical complexity, in the shape of automated control systems, may simply be a substitute for expensive labor in countries with higher wages, rather than a necessary ingredient of operational efficiency. Moreover, the more technically complex a vessel, the higher the probability that the skills of foreign nationals will need to be employed to operate it (at least in the initial period).

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1 For more details on the role of port administrators, refer to Port Administration and Legislation Handbook, United Nations, New York, 1969, and Port Problems in Developing Countries, by Bohdan Nagorski, published by the International Association of Ports and Harbors, Tokyo, Japan, 1972.

A United Nations report states:

> In a country where labour costs are lower, total costs are likely to be lower with the less-advanced type of vessels which can be bought second-hand at ten years of age, or even younger, for under one-half of the cost of a new vessel. On the other hand, modern, technically advanced propulsive systems are generally more efficient than older, simpler systems and, hence, more economic irrespective of the level of wage rates. In considering whether to adopt the most advanced type of ship, the developing country needs to consider separately those aspects of technical complexity which yield absolutely more efficient operations and those which are adopted only as a substitute for high-cost labour in developed economies.[2]

The comments of technical complexity of vessels applies to all types of ships, and particularly to their power plants. The complexity of a marine nuclear or gas turbine power plant would make it impossible for a developing nation to employ its citizens to fully man these types of vessels. Since the general discussion of power plants and technical complexity applies to all vessels, further discussion will omit this point and only describe specific features of particular ships as they relate to additional required skills in this area.

C. Ocean Transportation Systems

Exhibit 1 gives a pictorial evolution of merchant ship design from 1920-1969, while Exhibit 2 shows the composition of the world fleet in 1970. We will now look at general cargo and bulk commodity systems and see the different types on vessels and port facilities required.

II. General Cargo Systems

General cargo vessels provide either liner or tramp services. A liner runs on a published schedule on a particular route receiving cargo from anyone. Typically, the cargo on a liner will consist of the goods of a large number of shippers, each with a relatively small shipment. On the other hand, a tramp will sail only when it has arranged a large shipment of goods which may be from a single shipper. The routes and sailing frequencies of

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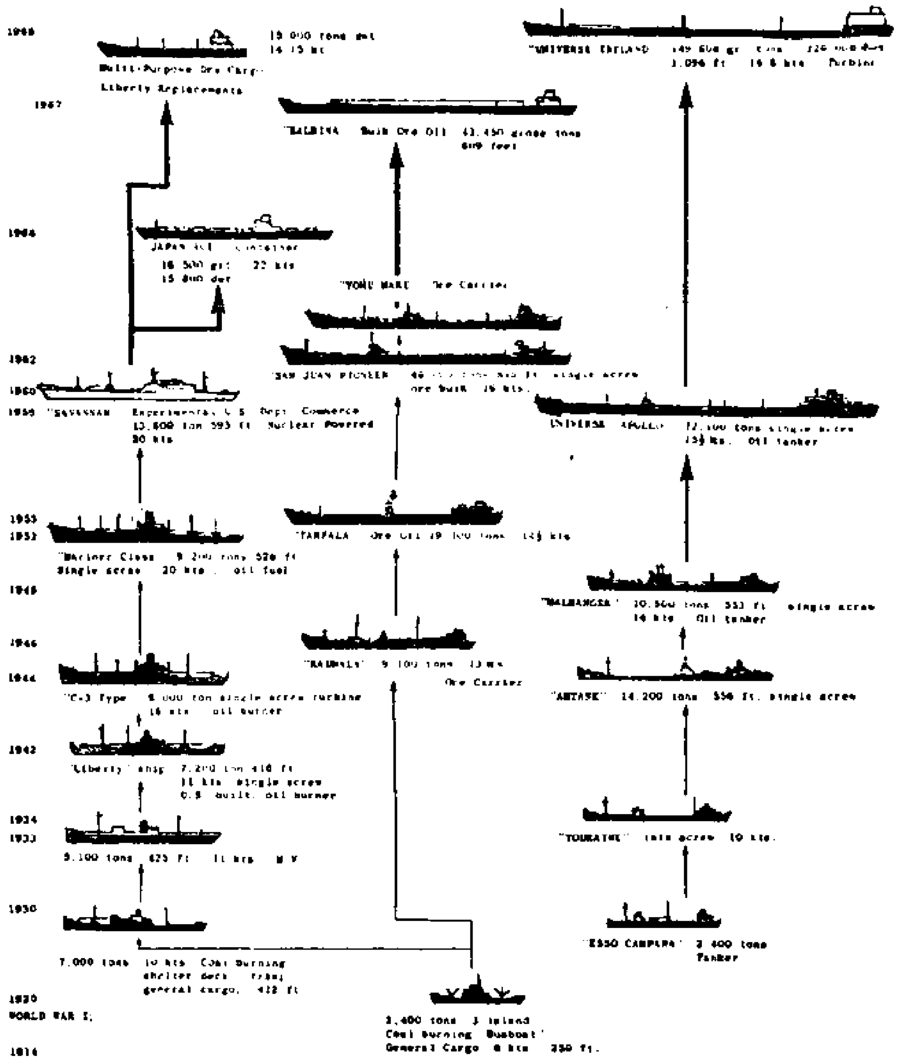
[2] Establishment or Expansion of Merchant Marines in Developing Countries, United Nations, New York, 1968, TD/26/Rev. 1.

Exhibit 1

. Evolution of Merchant Ship Design: Typical Ship Types, 1920-1969.



Source: International Sea Transport: The Years Ahead, S.A. Lawrence, Lexington Books, 1972, p.2.

Exhibit 2

Composition of the World Merchant Fleet, Dec. 31, 1970.[a]

Total	World Merchant Fleet (Ships 1000 grt. & over) No.	Grt.	Dwt.	Portion of the Fleet Typically Employed in: Short-Sea Service (less than 5000 dwt) No.	Grt.	Dwt.	Transoceanic Service (more than 5000 dwt.) No.	Grt.	Dwt.
1. Combination, freight and passenger ships	895	7484	4398	331	884	541	564	6600	3857
2. Freighters, all types	11899	67816	92347	5558	15000	21381	6341	52816	70966
3. Dry bulk carriers	2954	47201	77174	571	1568	2251	2383	45633	74923
4. Tankers	4232	88893	153070	955	2127	2977	3277	86766	150093
Total	19980	211397	326988	7416	19626	27152	12564	191771	299836

Freighter Classifications	(ships 1000 grt. & over) No.	Grt.	Dwt.
General purpose liner & tramp	10180	57300	80300
Refrigerated	901	4700	4900
Containerships, full	199	2287	2408
Containships, partial	123	867	1139
Roll-on, roll-off	38	339	360
Barge carriers	3	100	106
Timber & newsprint	377	1740	2420
Other speical types	78	530	620
Total	11899	67816	92347

Bulk Carrier Classifications	(ships 1000 grt. & over) No.	Grt.	Dwt.
General purpose	1894	29820	48500
Ore carriers	395	6300	10400
Ore/oil & OBO	196	7500	12600
Colliers	295	1400	2100
Car carriers	21	320	535
Other specialized types	153	1861	3040
Total	2954	47201	77174

Tanker Classifications	(ships 1000 grt. & over) No.	Grt.	Dwt.
General purpose	3860	86100	149600
LNG/LPG	172	1500	1300
Chemical	113	600	900
Other specialized types	87	693	1270
Total	4232	88893	153070

[a]Includes U.S. Reserve Fleet (786 vessels at 5,750 grt. and 6,970 dwt.)

Source: U.S. Maritime Administration.

tramps are totally determined by the needs of a relatively small number of shippers, each with a large amount of cargo.

Liner operators are generally organized into conferences, a type of rate-making cartel.[3] Since the rates are fixed by the conferences, the liners must compete mainly on services such as speed and sailing frequency, rather than tariffs.

A. Break-Bulk Cargo Vessels

As can be seen from Exhibit 2, the majority of freighters in the world are general purpose liner and tramp vessels. These vessels go by a variety of names -- general purpose, conventional general cargo and break-bulk cargo being the most common. As the names imply, this type of freighter has been the most prevalent historically and it can carry a wide variety of cargoes which normally are loaded in break-bulk form rather than unitized on pallets or in containers or barges. Most break-bulk cargo vessels carry between 5,000 and 15,000 tons of cargo. In terms of physical size, they present little problem to developed ports at present and show little sign of doing so in the future. The American Association of Port Authorities states:[4]

> Break-bulk vessels will have to maintain a relatively wide operational flexibility in and out of many, and often less developed and more restricted world ports. This will be a major curb on size trends.
>
> Typically, therefore, the break-bulk general cargo vessel of the future will probably be no longer than 700 feet, 90 feet or less in width, and will draw from 30 to 35 feet of water when fully loaded. These vessels should pose no serious problems in terms of harbor capabilities, but where some improvements might be needed, they should be relatively minor in scope, location and cost.

Conventional break-bulk cargo vessels carry their own cranes so they are truly self-sufficient. An old conventional pier and 20 to 30 feet of water is all that is needed for docking. In fact, a conventional break-bulk

---

3 For more information on conferences refer to International Shipping Cartels by Daniel Marx, Jr., Princeton University Press, Princeton, New Jersey, 1953, and The Economic Value of the United States Merchant Marine, by Allen R. Ferguson, Eugene M. Lerner, John S. McGee, Walter Y. Oi, Leonard A. Rapping, and Stephen P. Sobotka, Transportation Center at Northwestern University, Evanstown, Illinois, 1961.

4 Port Planning Design and Construction, by Standing Committee IV, Construction and Maintenance, American Association of Port Authorities, Washington, D.C., 1973.

ship could anchor in a harbor and unload (at a very slow rate) small amounts of cargo into samll lighters or barges if necessary, without using formal docking facilities. Skilled personnel on the vessel would handle the shipboard cranes. On the shore, the facilities can again be primitive. While a warehouse is normally expected to protect and store cargo, it is not essential. Likewise, while mechanized fork lift trucks would be expected to facilitate cargo handling on shore, manpowered carts or two wheel "hand trucks" can be used. In addition, a primitive inland transportation network is all that is actually required, although a more sophisticated transportation system would, of course, aid the distribution of cargo. No unusual skills are essential to operate a conventional general cargo system.

Although we have mentioned that the supporting facilities for a conventional break-bulk cargo vessel can be quite primitive, a modern efficient terminal could be as sophisticated as described in Exhibit 3. A typical layout of a general cargo berth as developed at Port Newark, New Jersey, is shown in Exhibit 4.

B. Unitized Cargo Carriers

The trend from break-bulk cargo to unitized cargo vessels resulted from the desire to reduce the time and cost associated with loading and unloading operations in port. This objective was fulfilled by going from the basic labor-intensive system of break-bulk cargo to more capital-intensive unitized cargo systems. By unitizing cargo with pallets, containers, and barges, the vessel operations in each system became more capital intensive and more productive.

Pallet ships are specially designed to handle all cargo on wooden pallets. A palletized cargo system has lower capital costs than other unitized cargo systems. The International Organization for Standardization has issued recommendations for standard sizes of flat pallets for through-transit of goods as described in Exhibit 5.

Exhibit 3

Suggested Principal Dimensions for General Cargo Terminals

1. BERTH LENGTHS
   Wharves - 750 foot multiples
   Piers – 850 feet

2. APRON WIDTHS

APRON WIDTHS	No R.R. Tracks	One R.R. Track	Two R.R. Tracks
Wharves & Piers	30 feet	30 feet	38.5 feet

3. CLEAR STACKING HEIGHT – SHEDS . . . . 20 ft.

4. GROSS TRANSIT SHED SPACE – per berth – 50,000 to 120,000 square feet.

5. INTERIOR COLUMN SPACING . . . . 40 ft. min.

Source: Port Planning Design and Construction, American Association of Port Authorities Washington, D.C., 1973, p. 164.

Exhibit 4

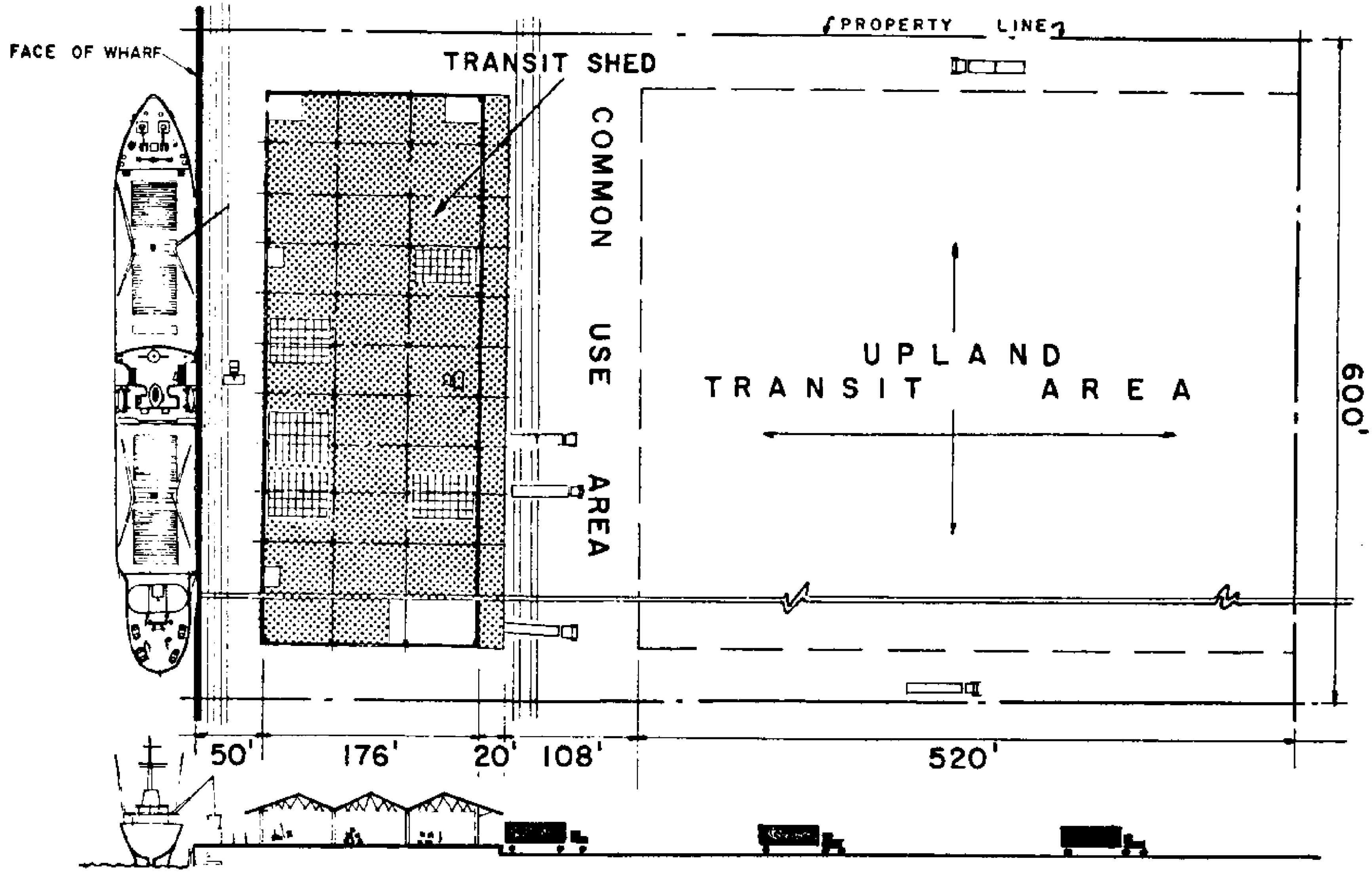


Figure A. General Plan and Section of a typical general cargo berth at Port Newark, New Jersey.

Source: Port Planning Design and Construction, AAPA, Washington, D.C., 1973, p. 166.

Exhibit 5
Standard Recommended Sizes of Flat Pallets

Inches
32 x 48
40 x 48
32 x 40
48 x 64
48 x 72

Source: Containers, Pallets and Other Unitized Methods for the Intermodal Movement of Freight: Application to Developing Countries, United Nations, New York, 1970, p. 11.

The late sixties saw the container revolution in full swing, and it continues, at a reduced pace, today. Containers come in many different sizes, the standard dimensions presented in Exhibit 6. A typical container ship is shown in Exhibit 7. By storing all cargo in containers the turn-around time of the ship in port is greatly reduced, greatly increasing ship productivity. Roll-on, roll-off ships are a special type of container ship where the chassis are left with the containers so that they can be driven on and off the ship.

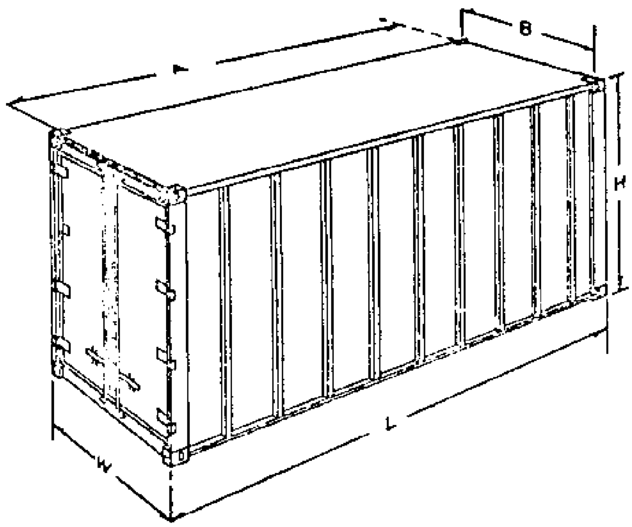
The most recent major entries into the unitized cargo trade are the barge-carrying vessels, known as the LASH (Lighter Aboard Ship) and the Sea-Barge Clipper or SEABEE. The purpose of the barge-carrying ships is similar to those of the container ships, except the containers are replaced by barges which are handled either by shipboard cranes or elevators. (Barge-carrying vessels may also carry containers in cellular holds or in the barges.) The success in increased productivity of modern unitized cargo vessels is shown in Exhibit 8. Typical cargo handling rates for the various types of general cargo vessels resulting in high productivity are shown in Exhibit 9.

C. Onshore Facilities

The sizes of the unitized cargo vessels present no major new physical constraints on the water portion of the harbor since the vessels are not much larger than conventional break-bulk cargo ships. Exhibits 10 and 11 show dimensions of typical container and barge-carrying vessels, respectively. However, the shore side facilities of certain unitized cargo carriers create severe challenges for ports. While many types of shipboard cargo cranes are commonly used as shown in Exhibit 12, the most efficient type of cargo handling equipment when comparing conventional general cargo, palletized, and container vessels is the shore based container crane as shown in Exhibit 13.

Exhibit 6

INTERNATIONAL STANDARDS FOR CONTAINERS



Normal length (feet)	L	W	H	A	B
40	40′0″ +0 −⅜	8′0″ +0 −3/16	8′0″ +0 −3/16	39′4¼″ +0 −½	7′5″ +⅛ −3/16
30	29′11¼″ +0 −⅜	8′0″ +0 −3/16	8′0″ +0 −3/16	29′3¼″ +0 −¼	7′5″ +⅛ −3/16
20	19′10½″ +0 −¼	8′0″ +0 −3/16	8′0″ +0 −3/16	19′2½″ +0 −⅛	7′5″ +⅛ −3/16
10	9′9¾″ +0 −3/16	8′0″ +0 −3/16	8′0″ +0 −3/16	9′1¾″ +0 −5/16	7′5″ +⅛ −3/16

SOURCE: "Containerisation—1966 and Beyond", *Traffic Management*, vol. 5, No. 2 (Chicago, 1966), p. 49.

Exhibit 7

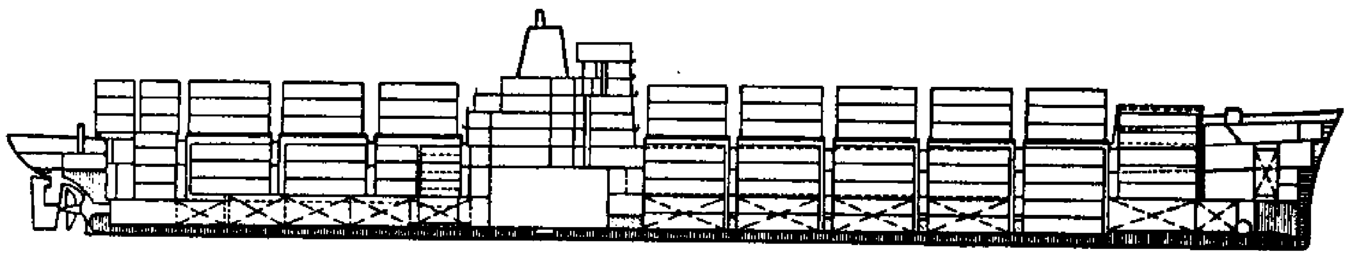


FIGURE 8-5. COMBINATION 20-FT. AND 40-FT. CONTAINERSHIP WITH MIDSHIP SUPERSTRUCTURE (SOURCE: AMERICAN MAIL LINE).

Source: Container Systems, Eric Rath, John Wiley & Sons, 1973, p. 214.

Exhibit 8

ESTIMATED TRENDS IN CAPABILITY PER SHIP

	Year Entered Service	Vessel Capacity (meas. tons[a])	Daily Mileage Capability	Assumed Days At Sea/Yr.	Annual Production Capability (billion ton-mi.) (2) x (3) x (4)
Break-bulk ships					
C2	1939-42	12,000	372	200	0.89
C3 (old)	1939-42	16,300	396	190	1.23
C '-S-66a	1966	17,780	480	185	1.58
Converted Containerships					
Sea-Land	1955	15,800	384	265	1.61
Am. Exp.	1966	23,200	504	259	3.03
U.S.L.	1968	23,200	480	259	2.88
New Containerships					
ACL	1969	21,200	588	261	3.25
Seatrain	1971	48,000	600	239	6.88
Can. Pacific	1971	17,500	480	264	2.22
Dart	1971	38,900	552	246	5.28
Sea-Land	1972	48,600	792	238	9.16
Barge Carriers					
LASH	1970	25,600	540	278	3.84
See Bee	1971	30,200	485	275	4.03

(a) Allowing for broken stowage, and assuming 25 measurement-tons per 20-ft. container.

Source: "The Third World At Sea," John L. Eyre, Defense Transportation Journal, March - April 1974, p. 48.

Exhibit 9

	Long tons per gang- or crane-hour
Break-bulk handling	15
Pallet system	60
Container system	200
Barge system	1,400*

* This is the rate of discharge of the mother ship and is relevant to the turn-round time of that vessel. However, discharge rate for the barge depends on the type of cargo carried. It is likely that the average rate of discharge from the barge would be higher than 15 tons per gang-hour when break-bulk cargo is carried. This is because the cycle time of shore cranes in discharging one sling or one unit of cargo is shorter than that of ship's gear, while easy access to the hold through wide hatches and a shorter distance between hold and wharf would increase the rate of cargo handling.

Source: Unitization of Cargo, United Nations, New York, 1970, TD/B/C.4/75.

Exhibit 10

Line	Vessel Characteristics			
	Length (in feet)	Width (in feet)	Draft (in feet)	Speed (in knots)
Atlantic Container Lines	646/695	86/92	29/28	22/25
American Export Isbrandsen Lines	610	78	27	20
Farrell Lines	668	90	33	22
Matson Navigation	719	95	31	23
Moore-McCormack Lines	620	90	31	25
United States Lines	700	90	28	25
Transamerican Trailer Transport	700	92	28	26
Sea Land Service	944	105	34	33

Source: Port Planning Design and Construction, AAPA, Washington, D.C., 1973, p. 8.

Exhibit 11

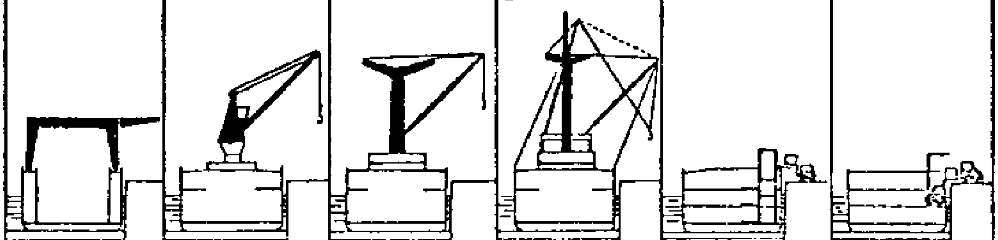
Ship and Lighter Characteristics

	Lash	Seabee
Length, feet	820, 860, 893	875
Breadth, feet	100, 106, 107	106
Draft, feet	36 to 40	37
Capacity, cu. ft.	1,309,238 up	1,500,000
Lighters Only	73 to 89	38
Containers, combination	49 lighters, 334 containers or 34 lighters, 700 containers	For deck load of 160-40 ft. containers add 300,000 cu.ft.
Hoist size, tons	500	2,000
Container Crane	35 tons on board	--
Lighters, Length	61' 6"	97' 7"
Width	31' 2"	35' 0"
Height	13' 0"	15' 9"
Capacity	19,562 Bale Cu. ft. 415 short tons	37,400 cu. ft. 850 tons

Source: Port Planning Design and Construction, AAPA, Washington, D.C., 1973, p. 184.

Exhibit 12

COMPARISON OF WORKING CAPACITIES AND COSTS OF COMMONLY USED TYPES OF CARGO GEAR

Type of gear	Gantry crane	Revolving crane	Swinging crane	Conventional gear	Pallet elevator	Side port
						
Hoisting capacity (safe working load)[a] (long tons)	20	5	15	7.5[b]	2	-
Working capacity[c] (tons per hour)	500	120	200	75	150	150
Price per unit installed (dollars)	350 000	35 000	35 000	16 800	70 000	20 000
$\frac{\text{Working capacity}}{\text{price}} \cdot 1\,000$	1.43	3.43	5.71	4.48	2.14	7.50

NOTE: 1 long ton = 1,016 kilogrammes.
[a] Typical values for the respectives types of gear.
[b] Based on 75 per cent of full load each time and on cycle time close to the minimum possible.
[c] Derricks with a 7.5-ton safe working load should normally take only 3 tons in union purchase.

Source: Coastal Shipping, Feeder and Ferry Services, United Nations, New York, 1970, p. 31.

In the container ship system, as well as with the other types of unitized cargoes, the ship is a capital intensive piece of equipment which must work in conjunction with capital-intensive shore facilities as shown diagrammatically in Exhibit 14. The types of shore-based equipment can vary widely as shown in the different container terminal systems in Exhibit 15.[5]

Container terminals called Terminal A and B, are described in Exhibit 16. Terminal A stores its containers on chassis and requires 131 acres. Terminal B stores its containers on the ground piled two and three high and requires 92 acres. The design of a container terminal and its supporting equipment will vary greatly depending on various factors including the size of ships handled and the frequency of arrivals. An example of traffic flow through a container terminal is shown in Exhibit 17.

A less developed country desiring to obtain a container terminal facility will generally find it easier to hire an international engineering firm to perform or help with the detailed design and construction of such a terminal. Since a less developed country would probably only be interested in a small number of container terminals, it would not be necessary for the nation to develop internally any skills not already possessed necessary for such a project. Likewise, in the construction of support vehicles and equipment within the terminal, it would be easier for the country to import foreign-built products rather than to attempt to manufacture a small number of these products.

The skills required in a container terminal will vary with its design; however, two types of key skilled personnel are needed, the container crane operators and yard mechanics to repair the cranes and other equipment. The larger more sophisticated terminals use computerized container control systems with all the skills attendant to computer system operations.

A key factor of the container system is that a developed inland transportation network must exist. Only when a door-to-door delivery can be made from an origin in one country to a destination in the other -- without opening the container can the true economies of containerization be realized.

[5] For more details on the structure and equipment of container terminals, the reader is referred to Physical Requirements of Transport Systems for Large Freight Containers, United Nations, New York, 1973, ST/ECA/170.

Exhibit 13

COMPARISON OF CAPACITIES, MANNING AND COSTS OF SHIP-MOUNTED AND SHORE-MOUNTED CARGO GEAR
(Costs per long ton in dollars)

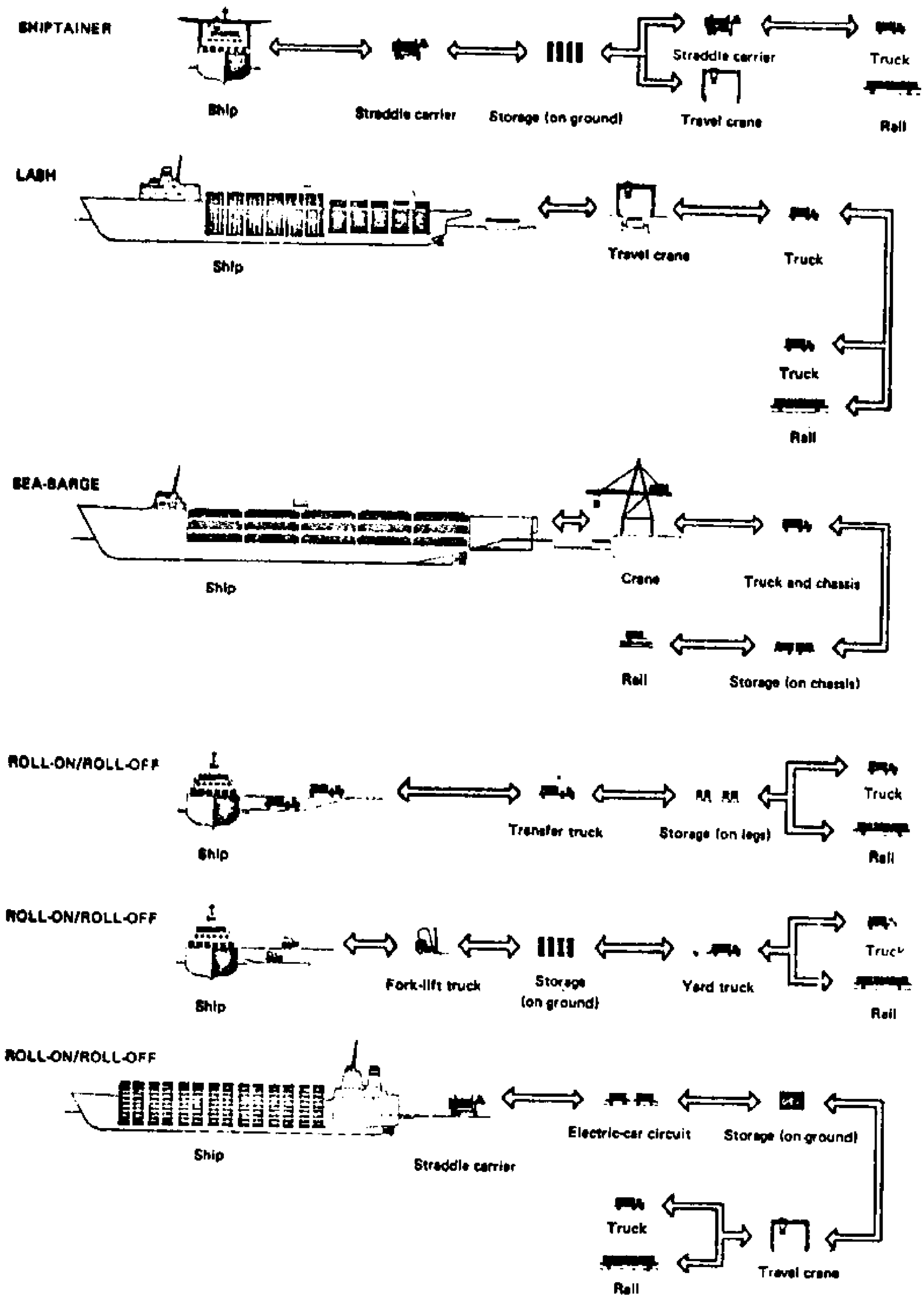
			CONVENTIONAL		PALLETIZED				CONTAINER	
			1 shore crane	10 pairs of derricks	1 shore crane	10 pairs of derricks	8 revolving cranes	2 pallet elevators and 3 side doors	1 shore crane	2 gantry cranes
A	Initial price		140 000	175 000	140 000	175 000	280 000	200 000	800 000	900 000
B	Capacity (long tons per hour)		15	150	40	400	400	300	200	400
C	Long tons handled per annum	D x B	30 000	140 000	80 000	140 000	140 000	140 000	580 000	560 000
D	Hours in use per annum	C/B	2 000	930	2 000	350	350	465	2 900	1 400
	Number of operators and signal-men		2	20	2	20	8[a]	0	1	2
	Hourly pay (per operator)		3.5	3.0	3.5	3.0	3.0	-	4.0	4.0
G	Total operator cost per hour	E x F	7.0	60.0	7.0	60.0	24.0	0	4.0	8.0
H	Total operator cost per annum	G x D	14 000	56 000	14 000	21 000	8 400	-	11 600	11 200
I	Depreciation and interest per annum	0.15 A	21 000	26 200	21 000	26 200	42 000	30 000	120 000	135 000
J	Power, maintenance, etc.		3 000	15 000	6 000	15 000	15 000	10 000	20 000	30 000
K	Total cost per annum	H+I+J	38 000	97 200	41 000	62 200	65 400	40 000	151 600	176 200
L	Total cost per long ton	K/C	1.27	0.69	0.51	0.44	0.47	0.29	0.26	0.32

NOTE: 1 long ton = 100 cubic feet. Calculation for shore cranes based on a fixed number of working hours per annum; basis for ship's gear is carrying capacity and round-trip time.
[a] With portable remote control; signal-men not required.

Source: Coastal Shipping, Feeder and Ferry Services, United Nations, New York, 1970, p. 32.

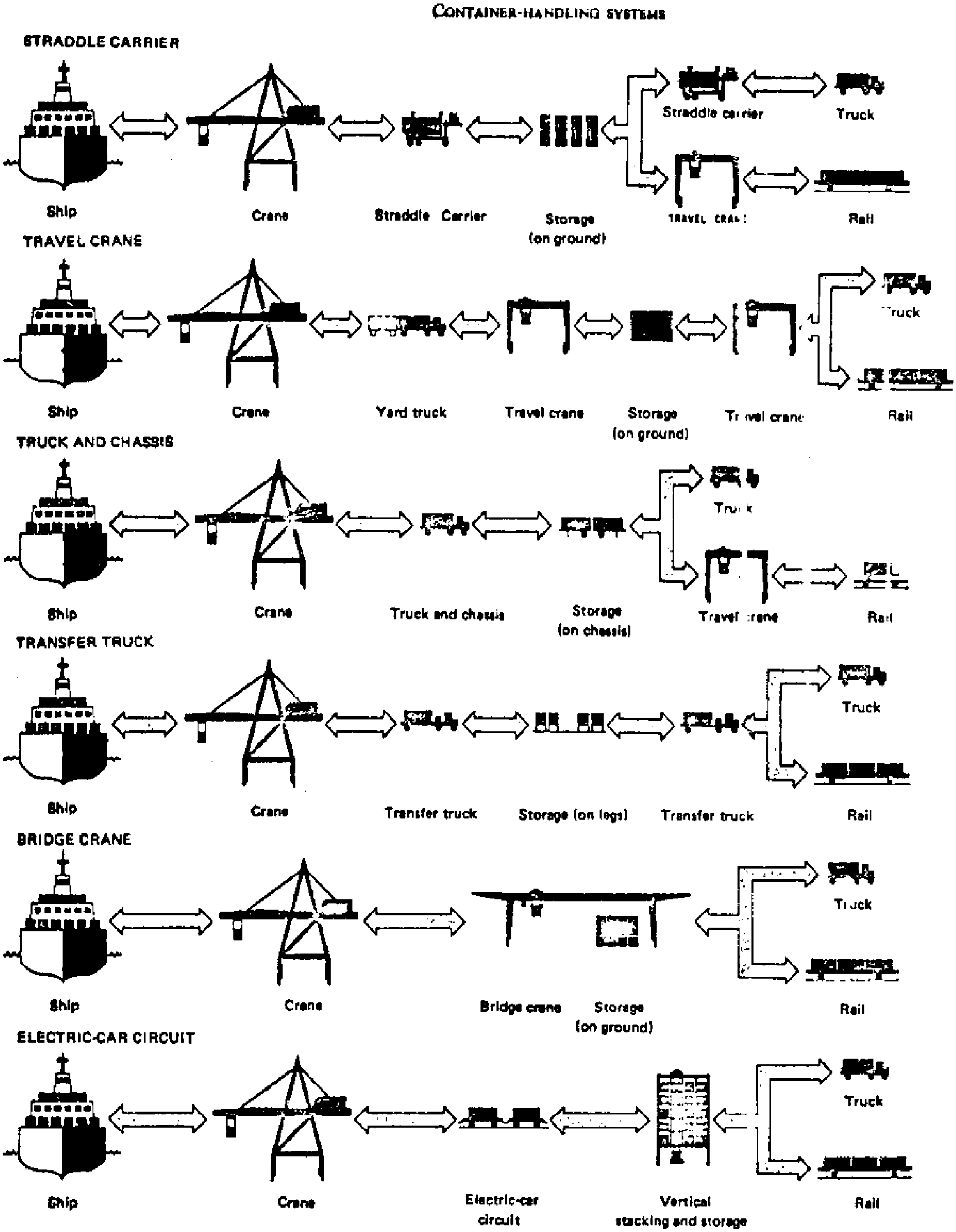
Exhibit 14

SHIP'S ROLE IN INTERMODAL CONTAINER TRANSFER



SOURCE: B. N. Hoffmaster and C. A. Neidergard, "Containerization: international-intermodal-integrated", paper submitted to the Organization of American States .Third Inter-American Ports and Harbour Conference, Viña del Mar, Chile, 15-24 November 1968.

Exhibit 15



SOURCE: B. N. Hoffmaster and C. A. Neidergard, "Containerization: international-intermodal-int grated", paper submitted to the Organization of American States, Third Inter-American Ports and Harbour Conference, Viña del Mar Chile, 15-24 November 1968.

Exhibit 16

Characteristics of Container Terminals
On Chassis System

Terminal A at Elizabeth has 3,140 feet of berthing space, and is considered to be four berths of 800 feet each. Cargo is being handled at the rate of 3,600,000 long tons per year, or approximately 900,000 long tons per berth. The containers are all one size, of the large variety, and average 16 long tons per container. Operation of this terminal is based on handling containers on chassis at all times, and ships load and discharge simultaneously. The terminal operator has complete control over the ships, the trucks, the stuffing and stripping and the handling. The tonnage is 33% foreign (North Atlantic) and 67% domestic. An average of 10% of the total containers transported are stripped or stuffed at the terminal.

The terminal occupies 131 acres of land, divided as follows:

Marshalling Containers	73 acres
Stuffing & Stripping Sheds	32 acres
Administrative Office & Employee Parking	11 acres
Operational space alongside ship	5 acres
Reefer, garage, gate, etc.	10 acres
Total	131 acres

Off Chassis System

Terminal B has 1920 feet of berthing space, and is considered to be 2 berths of 960 feet, although three vessels have occasionally docked at one time. Cargo is being handled at the rate of 1,630,000 long tons per year or about 816,000 long tons per berth. The containers are a mixture of small and large containers with 51,000 containers of 20-foot length and 63,000 containers of 40-foot length. The 20-foot containers average 12 long tons, and the 40-footers average 16 long tons.

The terminal is operated by a terminal operator, and is utilized by four different steamship lines. The operator has no direct control over the ships or the trucks. The cargo is all foreign, and all of the inbound cargo is subject to Customs inspection.

The operation of this terminal is performed by straddle carriers, with about half of the containers stacked two and three high. An average of 40% of the boxes are stripped or stuffed at the terminal.

The terminal occupies 92 acres of land divided as follows:

Marshalling Containers	49 acres
Stuffing and Stripping	37 acres
Administrative Office & Employee Parking	(Located off property)
Operational space alongside ship	3 acres
Reefer, garage, gate, etc.	3 acres
Total	92 acres

Exhibit 17

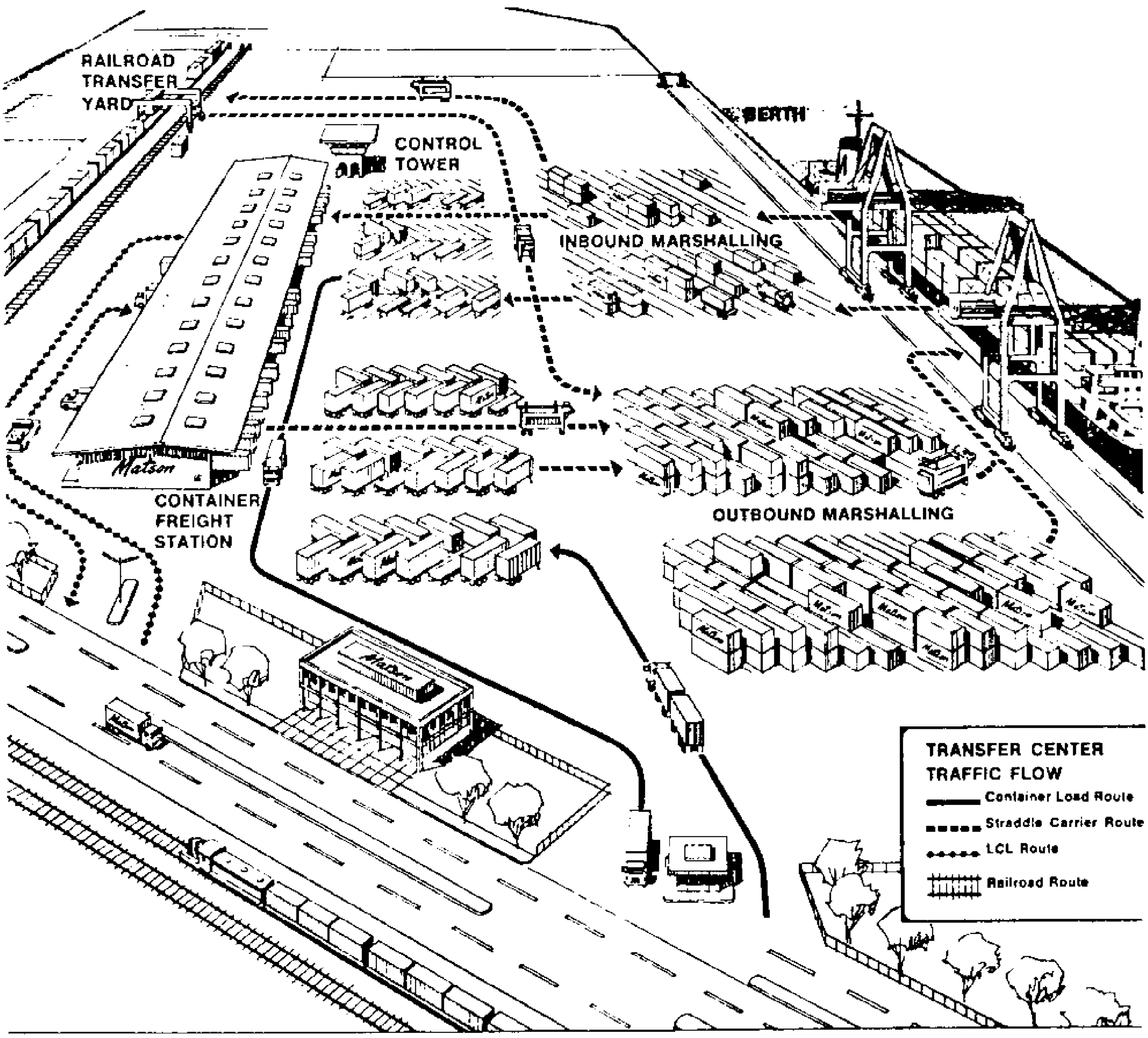


Figure 15. Example of a Containership Terminal and traffic flow. The drawing illustrates how the flow of containers is organized in a Matson transfer center. The arrows show how Less-Than-Container-Load cargo moves to the Container Freight Station first and comes out of the Container Freight Station last. Full container shipments go direct to the Container Yard. The rest of the movement within the transfer center is handled by straddle trucks and gantry cranes.

Source: <u>Port Planning Design and Construction</u>, AAPA, Washington, D. C. 1973, p. 83.

Barge-carrying vessels, theoretically, can operate without any specialized shoreside facilities. The ship can simply moor outside a congested harbor, unload its barges into the water where they are met by tugboats, load other barges received from tugboats, and be on its way. The tugboats will either bring the barges to nearby general cargo terminals to be unloaded or possibly move the barges through an inland waterway network. Note that to operate the barge-carrying vessels at their best, terminal areas must have an adequate number of tugboats and trained personnel. While terminals for barge-carrying ships can be quite primitive, major terminals are more extensive as shown by the artists rendition and general plan for the LASH terminal in San Francisco, California, in Exhibits 18 and 19, respectively.

D. Economic Aspects of Unitized Cargo

In order to determine the type of vessel which will give the lowest overall cost from origin to destination for a shipment between two countries, we must analyze the economics of the ocean transportation, the cargo handling facilities, and the inland transportation movements. An economic example is presented here from the United Nations Publication, Utilization of Cargo.

Note from Exhibits 20 and 21 that as we compare the conventional ship, the pallet ship, the container ship, and the barge-carrying vessel, the ships become more expensive and more productive. The vessels range in cost from $3 million to $13 million, while the amount of freight space per ship per year ranges from 147,142 to 825,000 cubic meters. Exhibits 22 and 23 show a breakdown of capital and operating costs for the four types of vessels.

By calculating capital and operating costs as a percentage of total costs as shown in Exhibit 24, we can easily see the extent to which the more productive, expensive ships become more capital intensive in their overall operations. The capital cost of the barge-carrying vessel makes up 60.7 percent of the total costs compared to only 37.7 percent for the conventional break-bulk cargo vessel. Because the productivity of the unitized cargo vessels tied, in large part, to their quick port turn around time, the longer the voyage the smaller will be the relative advantage of the unitized cargo vessel, as shown in Exhibit 25. On a 5,000 mile voyage

Exhibit 18

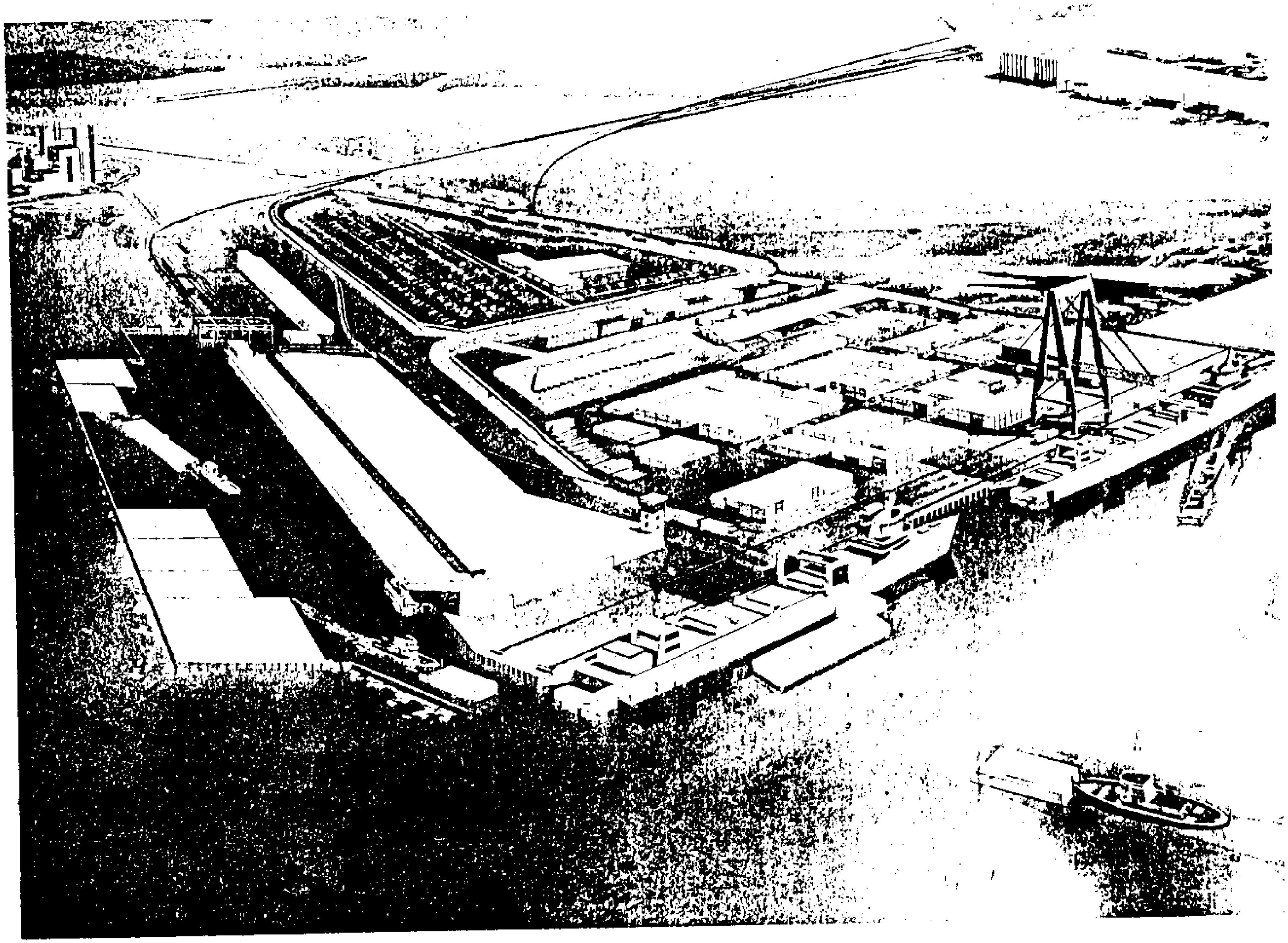


Figure 2. Artist's rendering of LASH terminal in San Francisco, California.
Source: Port Planning Design and Construction, AAPA, Washington, D.C., 1973, p 188.

Exhibit 19

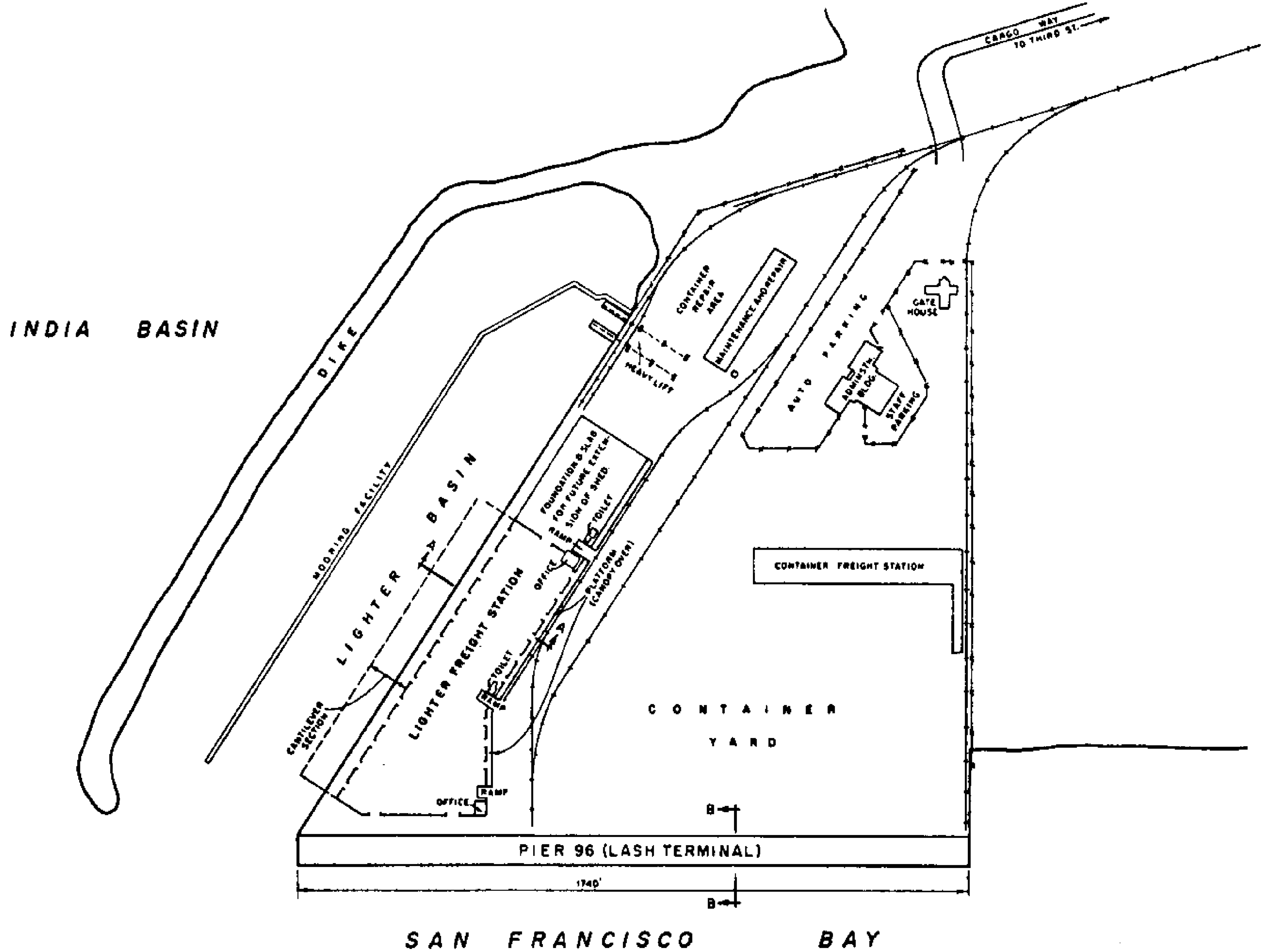


Figure 3. General plan of LASH Terminal in San Francisco, California.

Source: Port Planning Design and Construction, AAPA, Washington, D.C., 1973, p. 189.

Exhibit 20

Data relating to the hypothetical ships and routes used for cost comparisons

Item/Type→ ↓	*Conventional ship*	*Pallet ship*	*Container ship*	*Barge-carrying vessel (LASH)*
(a) *Particulars of ships:*				
Deadweight tons (1,000 kg)	11,000	11,000	15,000	43,000
Bale capacity [a]				
per container or barge (M³)	—	—	32	564
number of containers or barges loadable	—	—	700	73
per ship (M³)	15,000	14,200	22,400	41,200
Speed (knots)	16.0	16.0	22.0	18.5
Main engine	Sulzer 6RD68 7,200 SHP	Sulzer 6RD68 7,200 SHP	Sulzer 8RND105 28,000 SHP	Sulzer 9RND90 26,000 SHP
Bunker consumption (1,000 kg)				
in port	2.5	2.5	4.0	3.0
at sea	25.5	25.5	80.0	72.0
Cargo gear	5 hatches 8 cranes	3 pallet elevators 2 side doors	1 container crane ashore	1 ship-mounted gantry crane
Number of crew	36	30	30	30
Building cost ($1,000)				
per ship	3,000	3,500	6,500	13,000
per container/barge	—	—	1.5	35
(b) *Particulars of routes:*				
Distance of round voyage (sea miles)	10,000	10,000	10,000	10,000
Number of calling ports per round voyage	6	6	4	4
Broken stowage factor [b]	1.45	1.60	1.10	1.25
Cargo handling productivity [c]	30 M³ per gang hour	120 M³ (60 units) per pallet elevator or side port per hour	20 containers (20-foot) per hour	4 barges per hour

Source: The particulars and performances of each model ship are estimated on the basis of actual figures relating to existing vessels of similar types as far as available. Data on each cost item are estimated by the UNCTAD secretariat based on data collected from various sources, including published studies and personal contacts with operators.

[a] Bale capacity is the total number of cubic metres or feet available for the stowage of bales or other packaged cargo.

[b] Broken stowage factor means ratio of measurement tons of occupied ship space against the total measurement tons of the loaded cargo.

[c] Estimated from various statistics in terms of long tons on the assumption that the density of cargo is 0.5 long ton per cubic metre.

Exhibit 21

Carrying capacity and voyage duration

Item/Type→ ↓		*Conventional ship*	*Pallet ship*	*Container ship*	*Barge-carrying vessel (LASH)*
Bale capacity per ship	(1)	15,000 M³	14,200 M³	22,400 M³	41,200 M³
Broken stowage factor	(2)	1.45	1.60	1.10 [a]	1.25
Freight ton capacity per ship (1) ÷ (2)	(3)	10,300 M³	8,900 M³	20,400 M³ (700 cont.)	33,000 M³ (73 barges)
Cargo handling capacity per ship per hour	(4)	240 M³ (30 M³ × 8 gangs)	600 M³ (120 M³ × 5 gangs)	20 cont.	4 barges
Net time for loading/discharge per round voyage (3) ÷ (4) × 4	(5)	172 h.	59 h.	140 h.	73 h.
Hours' work per day	(6)	10 h.	10 h.	20 h.	15 h.
Total time for loading/discharge per round voyage (5) ÷ (6)	(7)	18 days	6 days	7 days	5 days
Allowance on port time [b]	(8)	5 days	3 days	2 days	1 day
Total time in port per ship per round voyage (7) + (8)	(9)	23 days	9 days	9 days	6 days
Sailing time per round voyage	(10)	26 days	26 days	19 days	22 days
Duration of round voyage (9) + (10)	(11)	49 days (7 weeks)	35 days (5 weeks)	28 days (4 weeks)	28 days (4 weeks)
Number of ships required for weekly service	(12)	7	5	4	4
Number of round voyages per ship per year [50 weeks ÷ (12)]	(13)	7.1	10.0	12.5	12.5
Total freight ton capacity per year per fleet (3) × 2 × 50	(14)	1,030,000 M³	890,000 M³	2,040,000 M³	3,300,000 M³

Source: see Exhibit 20

[a] Based on conferences' regulations which require a minimum of 90 per cent utilization of the inside cubic capacity of the containers.

[b] Allowance on port time covers time spent on mooring, gang shortage, unforeseen delays, etc.

Exhibit 22

Estimates of capital cost per freight ton of one cubic metre

(in $1,000)

Item/Type → ↓		Conventional ship	Pallet ship	Container ship	Barge-carrying vessel (LASH)
Building cost per ship [a]	(1)	3,000	3,500	6,500	13,000
Number of ships in service	(2)	7	5	4	4
Total investments in ships (1) × (2)	(3)	21,000	17,500	26,000	52,000
Total number of containers/barges	(4)	—	—	700 × 4 ships × 2.5 sets = 7,000	73 × 4 ships × 2 sets = 584
Total investment in barges/containers	(5)	—	—	10,500 (at 1.5 per container)	20,440 (at 35.0 per barge)
Annual capital costs on investments [b]					
Ships (3) × $\frac{1}{8.8513}$	(6)	2,370	1,980	2,940	5,880
Container (5) × $\frac{1}{4.8684}$	(7)	—	—	2,160	—
Barge (5) × $\frac{1}{8.8513}$	(8)	—	—	—	2,310
Total capital cost per year, per fleet (6) + (7) + (8)		2,370	1,980	5,100	8,190
Capital cost per freight ton of one cubic metre		$2.30	$2.22	$2.50	$2.48

Source: Calculations by the UNCTAD secretariat based on data given in Exhibits 20 & 21

[a] Estimated on basis of 1968 market price.

[b] Equal annual amortization with interest at 8 per cent compounded annually over the next 16 years in the case of ships and barges, 10 per cent and 7 years in the case of containers.

Exhibit 23

Estimates of operational cost per freight ton of one cubic metre

(in $1,000)

Item/Type → ↓	Conventional ship	Pallet ship	Container ship	Barge-carrying vessel (LASH)
Crew cost [a] per fleet	1,764	1,050	840	840
Maintenance, insurance and stores (3) of table 7 × 2%	420	350	520	1,040
Maintenance and insurance of container/barge	—	—	—	—
Container (5) of table 7 × 4%			420	
Barge (5) of table 7 × 2%				409
Fuel expenses [b]	605	565	1,240	1,281
Port charges [c]	550	399	335	458
Administration expenses [d]	585	446	1,680	1,272
Total operational cost per year per fleet	3,924	2,810	5,035	5,300
Operational cost per freight ton of one cubic metre	$3.81	$3.16	$2.47	$1.61

Source: See Exhibit 22.

[a] Crew cost is assumed as $7,000 per year per man.

[b] Fuel expenses are calculated on the basis of the bunkering price at Singapore as of the end of March 1970, e.g. marine diesel oil at $28.00, a bunker fuel oil at $15.50.

[c] Port charges are assumed as follows: $200 per day per 10,000 cwt, $1,000 per calling.

[d] Administration expenses are assumed as 10 per cent of the annual capital cost and the other operational costs in the cases of conventional ship, pallet ship and barge-carrying vessels, and 20 per cent in the case of container ships.

Exhibit 24

Structure of space cost per freight ton of one cubic metre

(percentages)

Item/Type→ ↓	Conventional ship	Pallet ship	Container ship	Barge-carrying vessel (LASH)
Capital cost on investments				
Ships	37.7	41.3	29.0	43.6
Container	—	—	21.3	—
Barge	—	—	—	17.1
Total capital cost	(37.7)	(41.3)	(50.3)	(60.7)
Operational cost				
Crew cost	28.0	22.0	8.3	6.2
Maintenance, insurance and stores (ships, containers and barges)	6.7	7.3	9.3	10.7
Fuel expenses	9.6	11.8	12.2	9.6
Port charges	8.7	8.3	3.3	3.4
Administration expenses	9.3	9.3	16.6	9.4
Total operational cost	(62.3)	(58.7)	(49.7)	(39.3)
TOTAL	100.0	100.0	100.0	100.0

Source: See Exhibits 22 and 23.

Exhibit 25

Total space costs in relation to distance

($ per freight ton of one cubic metre)

Distance (miles)	Conventional ship	Pallet ship	Container ship	Barge-carrying vessel
5,000	4.50	3.47	3.25	2.50
10,000	6.11	5.38	4.97	4.09
20,000	9.35	9.20	8.43	7.28

the conventional vessel has as cost of $4.50 per cubic meter of cargo space or 80 percent more than the $2.50 figure for the barge-carrying vessel. On a 20,000 mile voyage the conventional ship has a cost of $9.35 per cubic meter of cargo space, only 28 percent more than the $7.28 figure for the barge-carrying vessel.

The total origin to destination costs will also depend on the inland transportation network available. If cargo is brought down to the dock or quay in break-bulk form, stuffed into a container, then unloaded or stripped from the container and delivered in break-bulk form to its final destination, we lose much of the potential value of the containership relative to the conventional break-bulk cargo in such a quay-to-quay movement. If the container is loaded at the origin, but unloaded at the quay in the country of destination, this door-to-quay movement retains more, but not all of the potential containership value. Only in the door-to-door shipment, where the container is loaded once at the origin and unloaded once at the final destination, can we benefit from the total potential value of containerization. Exhibit 26 shows that while the unitized cargo systems are normally more economical than the conventional break-bulk system, the type of system which is most economical will vary with the degree of development (ability to make door-to-door and door-to-quay shipments) and the cost of labor. The savings in cost per unit of space of the various unitized cargo systems over the conventional break-bulk system is shown in Exhibit 27. The load factor of the ships will affect the capital-intensive unitized cargo systems more than the conventional break-bulk cargo system, as shown in Exhibit 28.

Generally rising labor costs will favor the capital-intensive vessels over the conventional ships. Exhibit 29 presents a prediction that in ten years the difference in cost per unit of space between the unitized-cargo vessels and the break-bulk ship will be significantly increased. For example, the difference in total cost per cubic meter of cargo space of $12.24 between the conventional ship at $23.11 and the containership at $10.87 will increase in ten years to $28.43 between the conventional vessel at $42.86 and the containership at $14.43. Finally, it should be pointed out that there are economies of scale in the size of both the unitized cargo carriers and the terminals. Exhibit 30 shows how unit costs decrease as the size of containerships and the volume of cargo through container terminals increase -- all operating at capacity conditions.

Exhibit 26

Estimates of cargo handling charges per freight ton of one cubic metre

(in dollars)

Range of unitized transport	*Trades/Type of ship and cargo →* ↓	*Conventional ship*	*Pallet ship*	*Container ship*	*LASH*	
		Break-bulk cargo	*Palletized cargo*	*Containerized cargo*	*Break-bulk cargo*	*Palletized cargo*
Door-to-door [a]	Developed countries					
	highest-cost (a)	15.00	4.00	3.00	10.00	4.00
	lowest-cost (b)	4.00	2.00	1.50	2.70	2.00
	Developing countries					
	highest-cost (c)	6.00	4.00	3.00	4.00	4.00
	lowest-cost (d)	2.00	2.00	1.50	1.40	2.00
	Combination of:					
	(a) + (c) ... (A)	21.00	8.00	6.00	14.00	8.00
	(a) + (d) ... (B)	17.00	6.00	4.50	11.40	6.00
	(b) + (d) ... (C)	6.00	4.00	3.00	4.10	4.00
Door-to-quay [b]	Developed countries					
	highest-cost (a)	15.00	4.00	3.00	10.00	4.00
	lowest-cost (b)	4.00	2.00	1.50	2.70	2.00
	Developing countries					
	highest-cost (c)	6.00	8.00	7.00	4.00	8.00
	lowest-cost (d)	2.00	3.40	2.90	1.40	3.40
	Combination of:					
	(a) + (c) ... (A)	21.00	12.00	10.00	14.00	12.00
	(a) + (d) ... (B)	17.00	7.40	5.90	11.40	7.40
	(b) + (d) ... (C)	6.00	5.40	4.40	4.10	5.40
Quay-to-quay [c]	Developed countries					
	highest-cost (a)	15.00	14.00	13.00	10.00	14.00
	lowest-cost (b)	4.00	4.70	4.20	2.70	4.70
	Developing countries					
	highest-cost (c)	6.00	8.00	7.00	4.00	8.00
	lowest-cost (d)	2.00	3.40	2.90	1.40	3.40
	Combination of:					
	(a) + (c) ... (A)	21.00	22.00	20.00	14.00	22.00
	(a) + (d) ... (B)	17.00	17.40	15.90	11.40	17.40
	(b) + (d) ... (C)	6.00	8.10	7.10	4.10	8.10

Source: (i) Break-bulk cargo: cargo handling charges in developed countries are estimated on the basis of information from operators and *Report on selected commodity unit costs for oceanborne shipments via common carriers (berth liners)* by United States Department of Commerce. Since the data in the report were based on 1964 cost experience, 20 per cent was added to reflect an increase of cost between 1964 and 1969. (ii) Palletized and containerized cargo: stevedoring and terminal charges in developed countries are estimated on the basis of information from operators. The relevant charges in developing countries are assumed to be the same as those of developed countries. Stuffing/unstuffing and palletizing/depalletizing charges are assumed as two-thirds of stevedoring and terminal charges on break-bulk cargo by conventional ship. (iii) LASH: handling charges for break-bulk cargo, including towing charge, are assumed as two-thirds of those for carriage by conventional ship, while those for palletized cargo are assumed as same as for carriage by pallet ship.

[a] Cargo handling charges comprise stevedoring and terminal charges excluding wharfage.

[b] Door of developed countries and quay of developing countries are assumed. Cargo handling charges in developed countries comprise stevedoring and terminal charges excluding wharfage, and in developing countries charges are added for stuffing/unstuffing containers or palletizing/depalletizing cargo.

[c] Cargo handling charges comprise stevedoring and terminal charges excluding wharfage, and charges for stuffing/unstuffing containers or palletizing/depalletizing cargo.

Exhibit 27

Saving in cargo handling and space costs of unitized transport over break-bulk by conventional ships, per freight ton of one cubic metre

(in dollars)

Range of unitized transport	*Type of ship and cargo →* / *Trade* [a] ↓	*Pallet ship* — *Palletized cargo*	*Container ship* — *Containerized cargo*	*LASH* — *Break-bulk cargo*	*LASH* — *Palletized cargo*
Door-to-door	A	13.70	16.10	9.00	15.00
	B	11.70	13.60	7.60	13.00
	C	2.70	4.10	3.90	4.00
Door-to-quay	A	9.70	12.10	9.00	11.00
	B	10.30	12.20	7.60	11.60
	C	1.30	2.70	3.90	2.60
Quay-to-quay	A	−0.30	2.10	9.00	1.00
	B	0.30	2.20	7.60	1.60
	C	−1.40	0.70	3.90	−0.10

Source: Space cost savings as indicated in paragraph 77 (rounded to nearest 10 cents) added to cargo handling savings calculated from Exhibit 26

[a] Trades are denoted as follows: (A) Trade between highest-cost developed and highest-cost developing countries; (B) Trade between highest-cost developed countries and lowest-cost developing countries; (C) Trade between lowest-cost developed countries and lowest-cost developing countries.

Exhibit 28

Comparison of shipping cost per freight ton of one cubic metre

(in dollars)

Space utilization (per cent)	*Range of unitized transport*	*Conventional ship* — *Break-bulk cargo* (A)	(B)	(C)	*Pallet ship* — *Palletized cargo* (A)	(B)	(C)	*Container ship* — *Containerized cargo* (A)	(B)	(C)	*LASH* — *Break-bulk cargo* (A)	(B)	(C)	*LASH* — *Palletized cargo* (A)	(B)	(C)
100	Door-to-door	27.11	23.11	12.11	13.38	11.38	9.38	10.97	9.47	7.97	18.09	15.49	8.19	12.09	10.09	8.09
	Door-to-quay	27.11	23.11	12.11	17.38	12.78	10.78	14.97	10.87	9.37	18.09	15.49	8.19	16.09	11.49	9.49
	Quay-to-quay	27.11	23.11	12.11	27.38	22.78	13.48	24.97	20.87	12.07	18.09	15.49	8.19	26.09	21.49	12.19
50	Door-to-door	33.20	29.20	18.20	18.80	16.80	14.80	15.90	14.40	12.90	22.20	19.60	12.30	16.20	14.20	12.20
	Door-to-quay	33.20	29.20	18.20	22.80	18.20	16.20	19.90	15.80	14.30	22.20	19.60	12.30	20.20	15.60	13.60
	Quay-to-quay	33.20	29.20	18.20	32.80	28.20	18.90	29.90	25.80	17.00	22.20	19.60	12.30	30.20	25.60	16.30

(Column header: *Type of vessel, unitization and trades* [a] →)

Source: Annex II, tables X and XI.

[a] Trades are denoted as follows: (A) Trade between the highest-cost developed and highest-cost developing countries; (B) Trade between the highest-cost developed countries and the lowest-cost developing countries; (C) Trade between the lowest-cost developed countries and the lowest-cost developing countries.

Exhibit 29

Comparison of estimated future costs by type of vessel

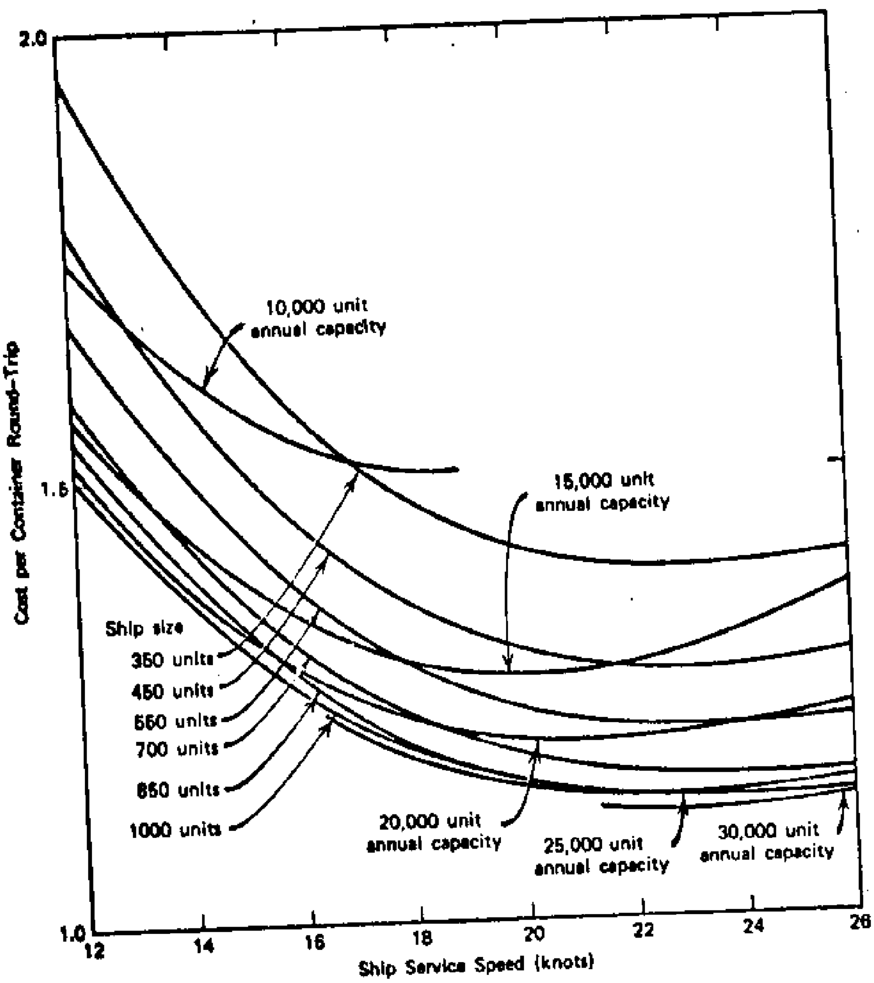
(in $ per freight ton of one cubic metre)

Type of vessel	Costs per cubic metre	Current	Ten years from now	Assumed growth rates (average per year) (%)
Conventional ship	Capital cost	2.30	2.30	0.0
	Operational cost	3.81	6.56	crew cost 10.0; other costs 5.0
	Cargo handling cost	17.00	34.00	10.0
	Total	23.11	42.86	8.5
Pallet ship	Capital cost	2.22	2.22	0.0
	Operational cost	3.16	5.30	crew cost 10.0; other costs 5.0
	Cargo handling cost	7.40	11.10	5.0
	Total	12.78	18.62	4.6
Container ship	Capital cost	2.50	2.50	0.0
	Operational cost	2.47	3.96	crew cost 10.0; other costs 5.0
	Cargo handling cost	5.90	7.97	3.5
	Total	10.87	14.43	3.3
LASH vessel	Capital cost	2.48	2.48	0.0
	Operational cost	1.61	2.54	crew cost 10.0; other costs 5.0
	Cargo handling cost (palletized cargo)	7.40	11.10	5.0
	Total	11.49	16.12	4.0

Source: Estimates by the UNCTAD secretariat.

NOTE: Cargo handling costs are based on door (of developed countries with highest costs) to quay (of developing countries with lowest costs).

Exhibit 30



COST PER CONTAINER-ROUND-TRIP VERSUS SHIP SIZE AND SPEED, AND ANNUAL THROUGHPUT

Source: U.S. Government Publication, *The Impact of Containerization on the U.S. Economy*, 1970.

E. Conclusions Concerning General Cargo System

We have now studied the various types of general cargo systems. While we have not in this study identified the type of system optimal for each trade route in the world, we can see the advantages of unitized-cargo systems. The travel time saved with unitized cargo vessels is particularly important to high value cargoes. The best choice for any trade route will depend on the availability of capital and port facilities, value of cargo, volume, directional balance of containerizable cargo, extent of inland waterways, inland transportation network, and cost of labor. These factors will obviously vary when we consider different countries with different degrees of development. Exhibit 31 briefly summarizes many aspects of the evaluation process.

III. Bulk Commodity Systems

Compared to general cargo liner vessels, bulk carriers provide quite a different type of service. The great majority of bulk carriers operate under medium or long term charters. Bulk carrier owners compete for these charters on the basis of overall cost to the charterer rather than such liner service characteristics as speed. A bulk carrier could easily spend many years carrying only one commodity on a specific route for a particular shipper.

A small percentage of the total bulk carrier fleet is involved in what is known as the "spot" market. Here, in a classical example of perfect competition, owners and potential charterers bargain for the use of tankers for a single voyage. The rates associated with such extremely short term chartering fluctuate widely depending on the overall industry supply-demand situation. Consequently, while the opportunity for high profits exists in the spot market, so does the risk of financial failure.[7]

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[6] For the reader desiring more information on the economic aspects of the evaluation process, we recommend Containers, Pallets, or LASH, the Economist Intelligence Unit Ltd., 1973.

[7] For more information on the tanker charter market, the reader is referred to The Theory of Oil Tankship Rates, by Zenon S. Zannetos, M.I.T. Press, Cambridge, Mass., 1966.

Exhibit 31

Evaluation of Service Systems for Liner Cargoes.

Systems Alternatives	*Factors Affecting Choice*	*Likely Outcomes*
Variables which may be controlled by the transport operator in organizing a transoceanic service	Variables associated with the particular market in which the firm operates which affect significantly the economics of systems choice.	The pattern of choices which may be observed in surveying the more successful operations.
1. Vessel characteristics size speed hold design, stowage factor, etc.	1. Cargo characteristics homogeneity and volume physical characteristics (size, durability, etc.) value origins and destinations	1. Container Systems when high volume of high value cargoes. Competitive pressures for investment. High port and ship labor costs with good inland transport links. Greater distances requiring larger ships higher speeds.
2. Cargo handling systems container pallet roll-on, roll-off conventional	2. Port characteristics longshore labor costs work practices and hours hazard of delay terminal facilities: cranes warehousing, lay-out	2. Pallet Systems when less opportunity to concentrate cargo loading and discharge. Imbalanced trade. Little emphasis on inland transport link.
3. Cargo consolidation and packaging strategy port or inland consolidation center by shipowner, shipper, or freight forwarder	3. Voyage characteristics distance weather ship operating costs	3. Conventional Systems when low port cost port congestion. Cheap cargoes. Long voyages. High cost of money and institutional barriers.
4. Connecting transportation rail truck ship pipeline barge	4. Customer preference	4. Mixed Systems when low cargo throughout. Many ports of call. Mixed cargoes and conditions enroute.
5. Ocean service frequency no. of ports		

Source: International Sea Transport: The Years Ahead, S.A. Lawrence, Lexington Books, 1972, p. 165.

A. Bulk Carriers

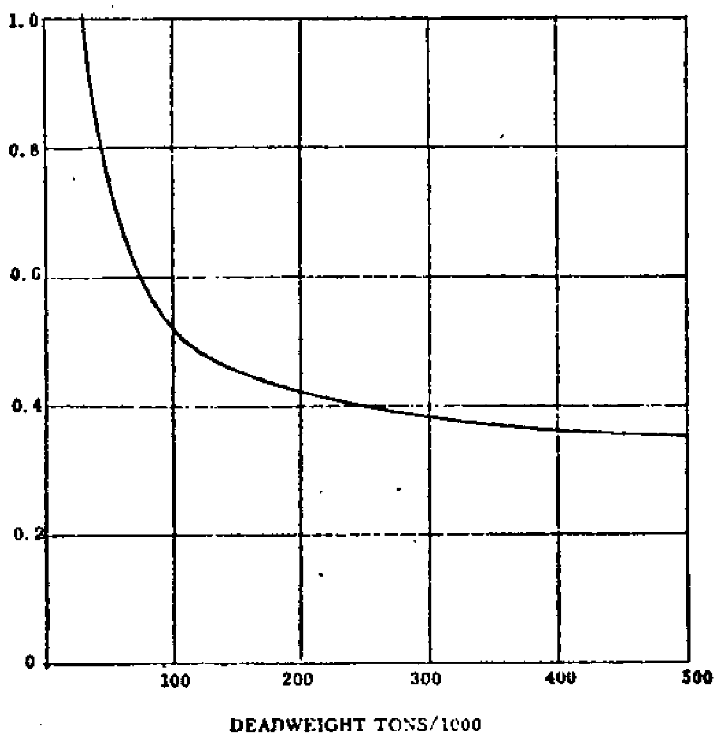
Referring back to Exhibit 2, we see that the great majority of tonnage in the world consists of bulk commodity carriers, both dry and liquid. Of the bulk carriers, the greatest portion of tonnage is made up of oil tankers.

The economic aspects of determining the best type of ship for a dedicated service or a specific trade route is considerably easier to evaluate for a bulk carrier than for a general cargo carrier. In our earlier analysis, the general cargo vessels carried a wide variety of cargoes from many different shippers. The prospective shipowner had to be concerned whether the cargo could fit into a container or whether the container could move inland. The prospective tanker owner does not have these problems. He is essentially concerned only with oil which can be easily pumped so cargo handling requires only pumps instead of more expensive, more labor intensive equipment, and inland transportation can be accomplished by pipeline in most cases. However, elaborate storage tank farms and pipeline networks may be needed to efficiently handle and store the oil.

The economic aspects of choosing tanker size for a long term charter on a specific trade route are relatively straightforward because of the economies of scale in tanker operation. Exhibit 32 shows how the cost per ton of oil decreases with an increase in tanker size. If we include mileage in our calculations as in Exhibit 33, we can see how greatly the cost per ton is reduced by using larger tankers on long voyages, such as the Persian Gulf to U.S. routes. The economies of scale apply in both the construction cost and the operating costs. Even in the loading and unloading operations the larger tankers operate at considerably faster rates than the smaller tankers, as shown in Exhibit 34.

In general, the optimal size for a tanker is the largest size physically able to use the port facilities on its given trade route. However, we find that most ports are greatly restricted in the size of tankers they can accept; for example only a few ports in the U.S. can receive a fully loaded tanker of 100,000 dwt because of the draft of the large vessels. Exhibit 35 shows how the draft of the tanker increases with the size of the vessel. The largest ship now in service, the 477,000 dwt Globtik Tokyo, draws 92 feet of water, quite an increase from the 16,600 dwt T-2 tanker workhorse of World War II, which required only 30 feet of water (see Exhibit 36).

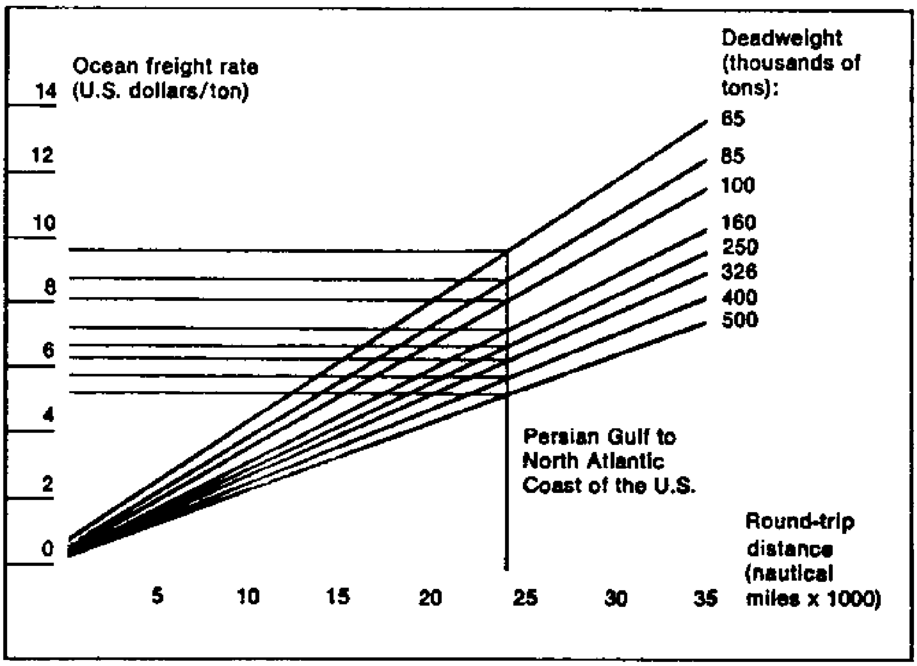
Exhibit 32



Typical relative cost of transportation per ton of cargo as a function of tanker size

Source: "Evaluation of the Potential of Combinations Carriers for Transporting U.S. Oil Imports," Edward V. Lewis, John Binkley, and Robert Zubaly, Marine Technology, April, 1974, p. 136.

Exhibit 33



Source: Offshore Terminal System Concepts, Soros Associates, New York, 1972.

Exhibit 34

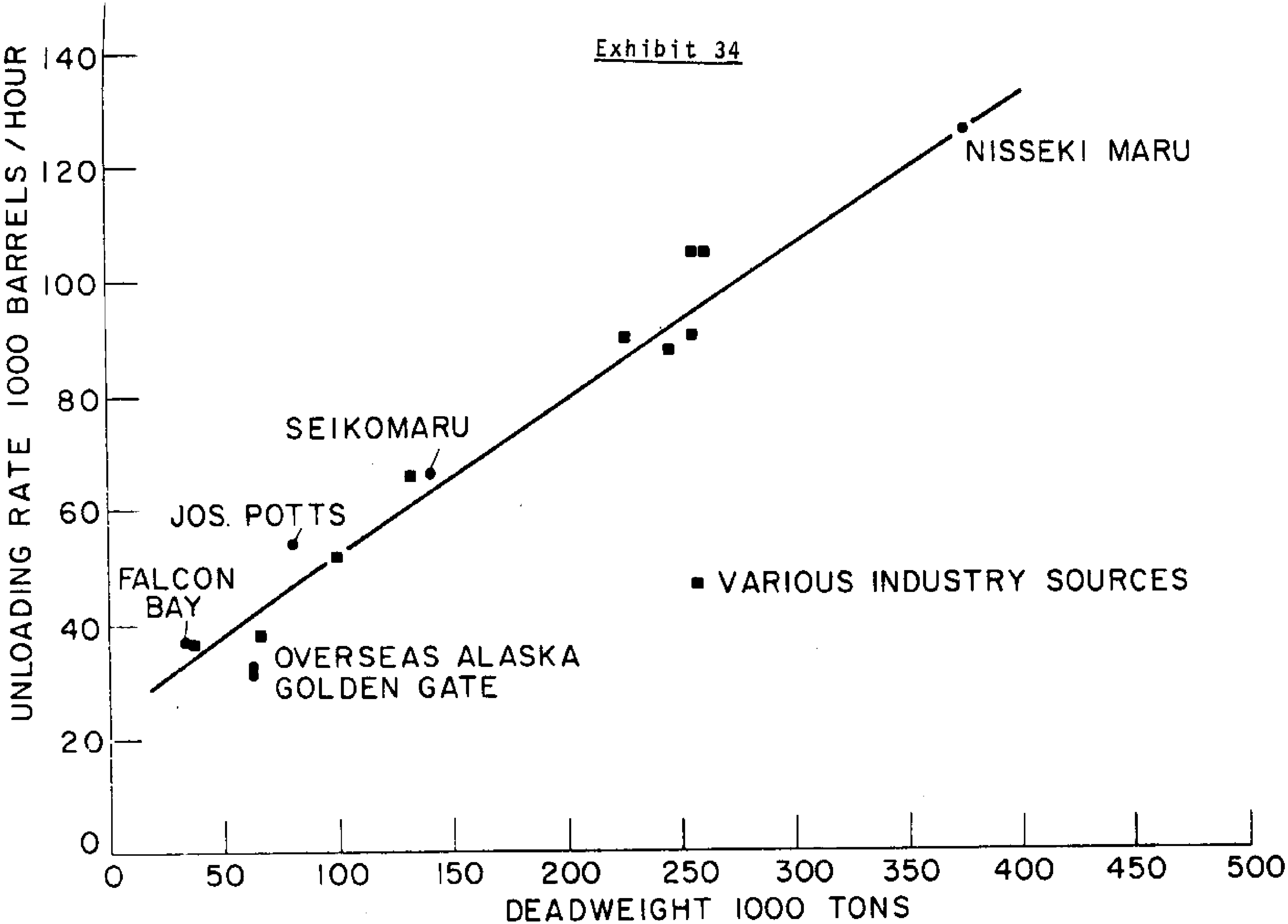
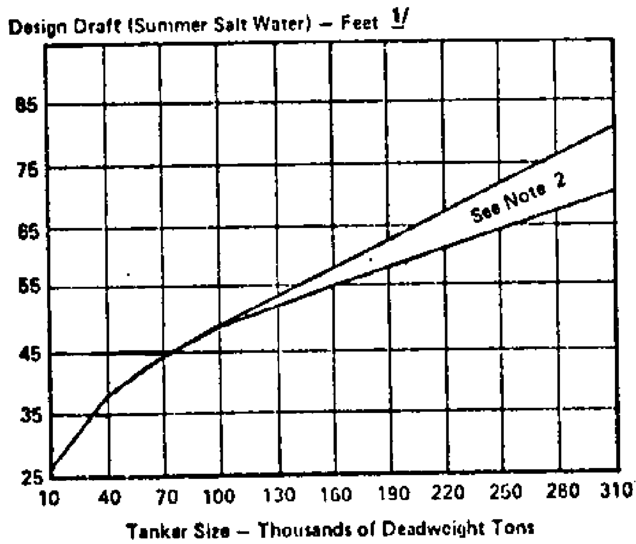


FIGURE I.2.5 LOADING & UNLOADING RATE

Source: The Georges Bank Petroleum Study, Volume I., Offshore Oil Task Group, Massachusetts Institute of Technology, 1973.

Exhibit 35

RELATIONSHIP BETWEEN DEADWEIGHT
SIZE AND VESSEL DRAFT



NOTE:

1. For Safety purposes required channel depths must generally be 5 to 10 feet greater than the maximum draft of vessels using the channel.
2. Beyond 100,000 dwt data available indicates a range of possible drafts depending upon the design characteristics of the vessels involved.

Source: The Economics of Deepwater Terminals, Maritime Administration, 1972, p. 17.

B. Terminal Facilities for Liquid Bulk Carriers

While T-2 tankers could simply dock at an oil pier in most any harbor and pump their cargo into storage tanks, the supertankers, due to their need for deepwater and maneuvering room, are quite restricted in where they can dock. With the exception of a few inshore terminals with deepwater, most large tankers now use offshore facilities. A conventional buoy mooring facility, shown in Exhibit 37, is commonly used with vessels less than 100,000 dwt. Exhibit 38 shows the single buoy mooring facility, commonly used with vessels over 100,000 dwt. There are more than 100 offshore mooring systems now in operation. Exhibit 39 diagrams an offshore artificial island complex; a major drawback with this type of system is the high initial cost. There are many possible variations on the offshore systems shown here. The exact choice for a particular location will depend on the depth of water, distance from shore, surrounding area, weather conditions, environmental impact of various systems, and of course the initial construction costs and operating costs involved with different systems. Considering all these factors normally leads to the choice of a single buoy mooring for an offshore terminal system for oil tankers.[8]

Note that the huge investment in supertankers and their terminals requires skilled personnel to operate and maintain the sophisticated equipment both on the ship as well as on the shore. We should point out that storage tanks and/or refineries that often accompany superports need not be located on the shore. Pipelines permit their location to be many miles inland. Developing countries with raw materials to export usually have little difficulty in finding skilled personnel in the form of employees of multinational companies which are eager to handle the oil or other resources.

The transportation systems accompanying the movement of dry bulk commodities such as coal, grains, and ores, are similar in many ways to the marine systems for oil. The degree of skilled personnel is in most cases similar to that for large oil systems. The economies of scale are similar as shown by Exhibit 40 for ore. While the sizes of dry bulk carriers have increased greatly in the past decade or two, they have not approached the

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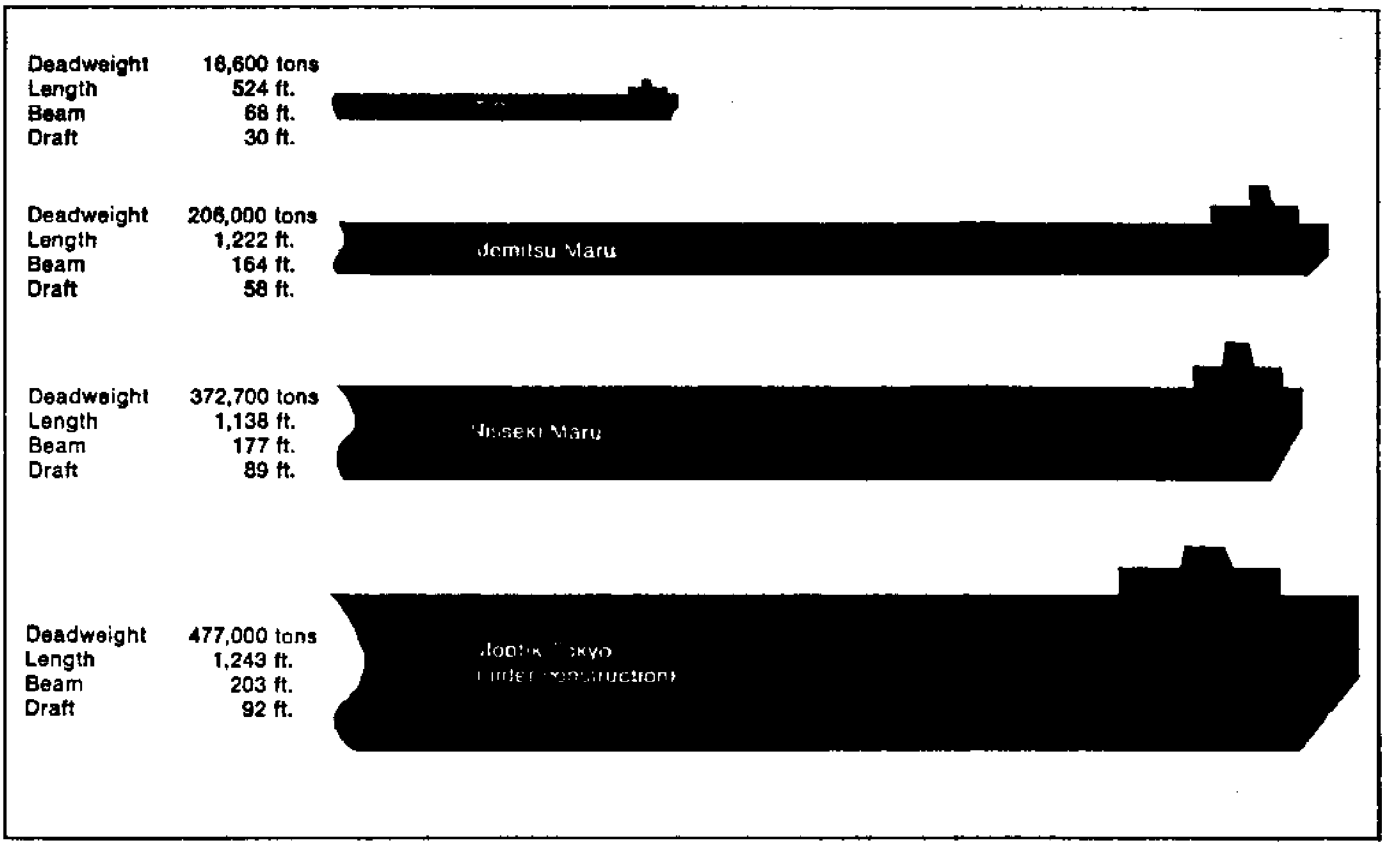
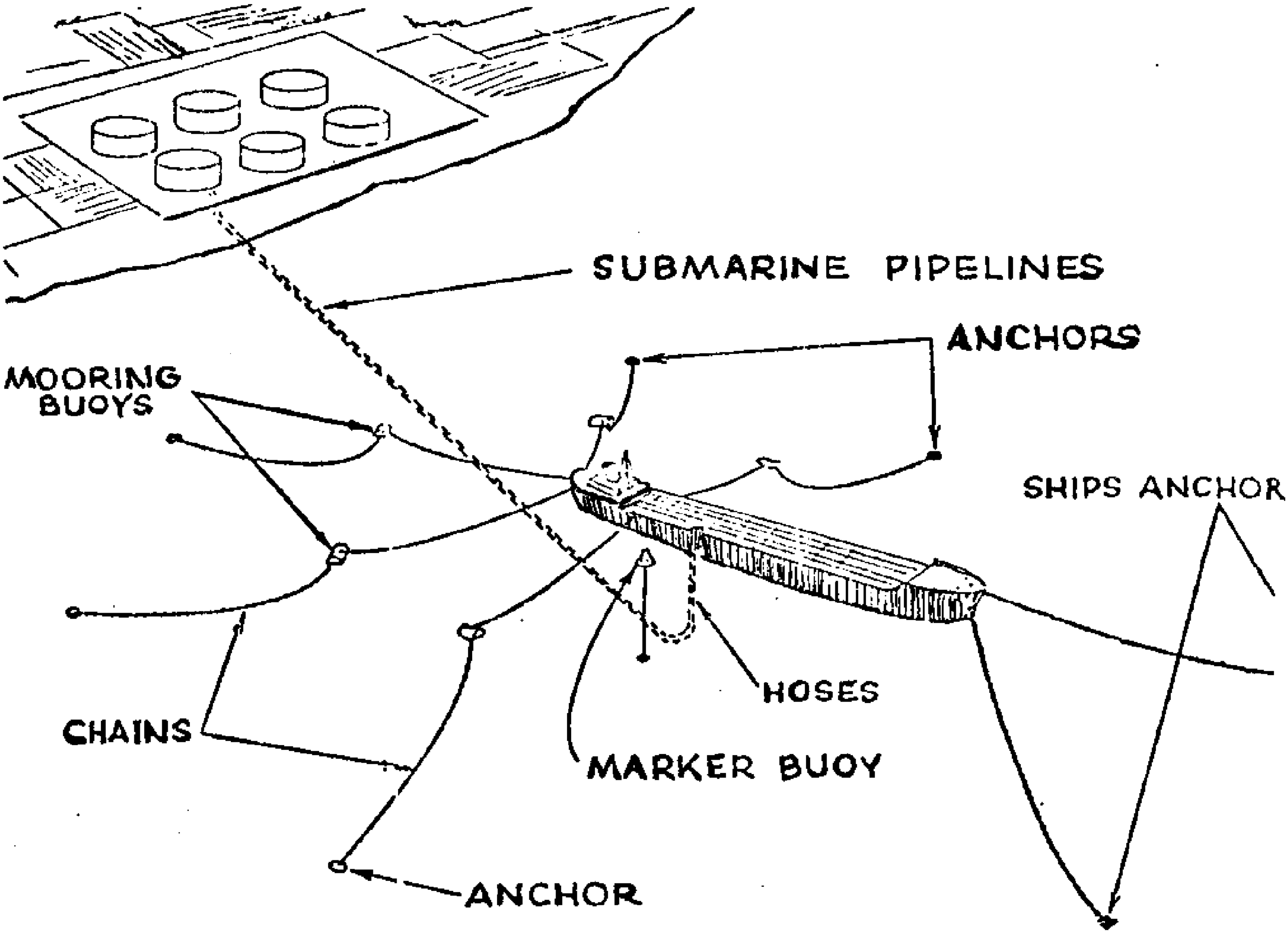
8 For more information on offshore terminals, refer to U.S. Deepwater Port Study, by Nathan Associates, 1972, and Offshore Terminal System Concepts, by Soros Associates, 1972.

Exhibit 36



Source: "The U.S. Superport Controversy," Henry S. Marcus, Technology Review, March/April 1973.

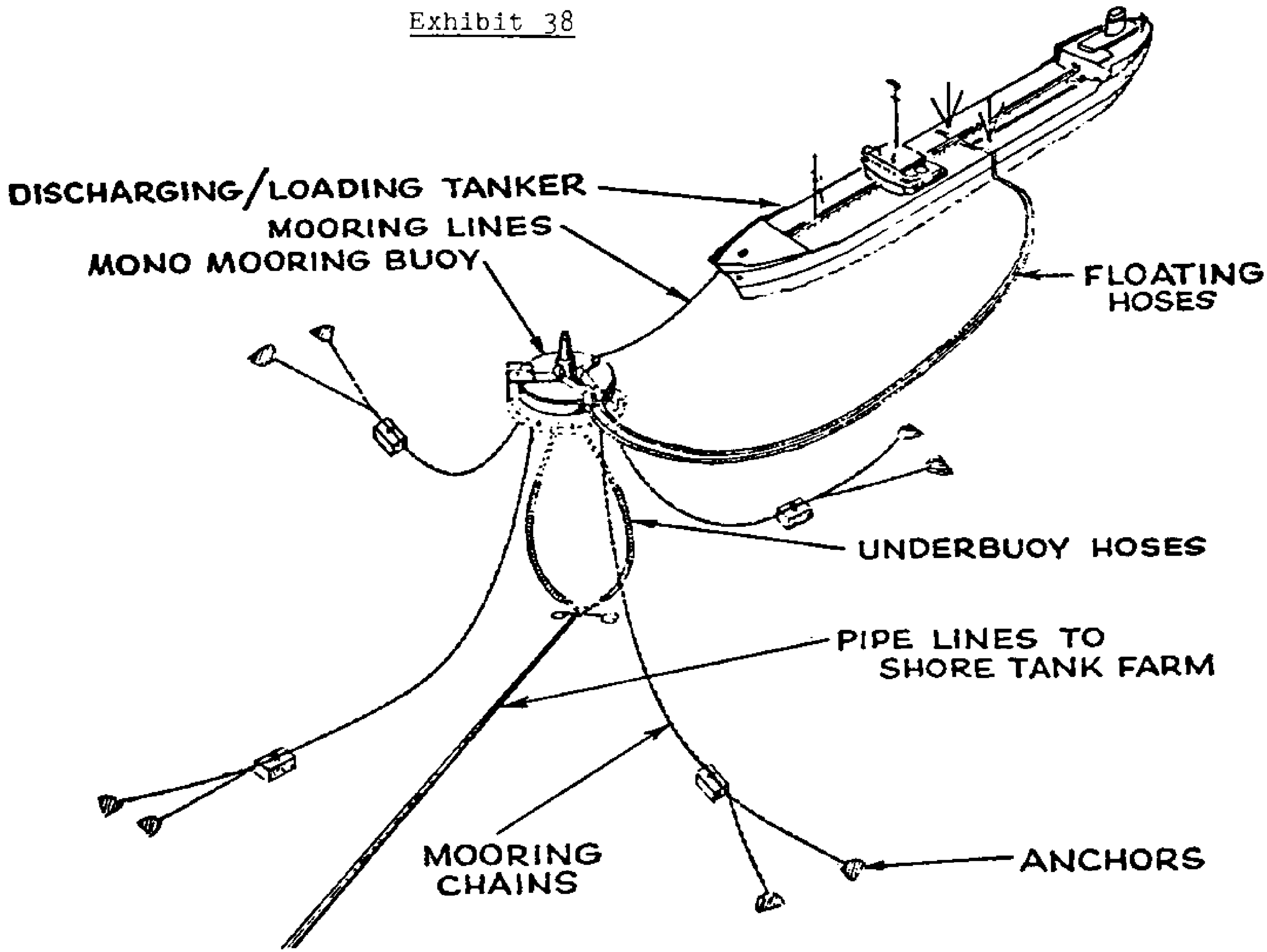
Exhibit 37



Conventional Buoy Mooring.

Source: Volume I, Draft Environmental Impact Statement, Maritime Administration Tanker Construction Program, N.T.I.S. Report No. EIS 730392 D, 1973, p. IV-205.

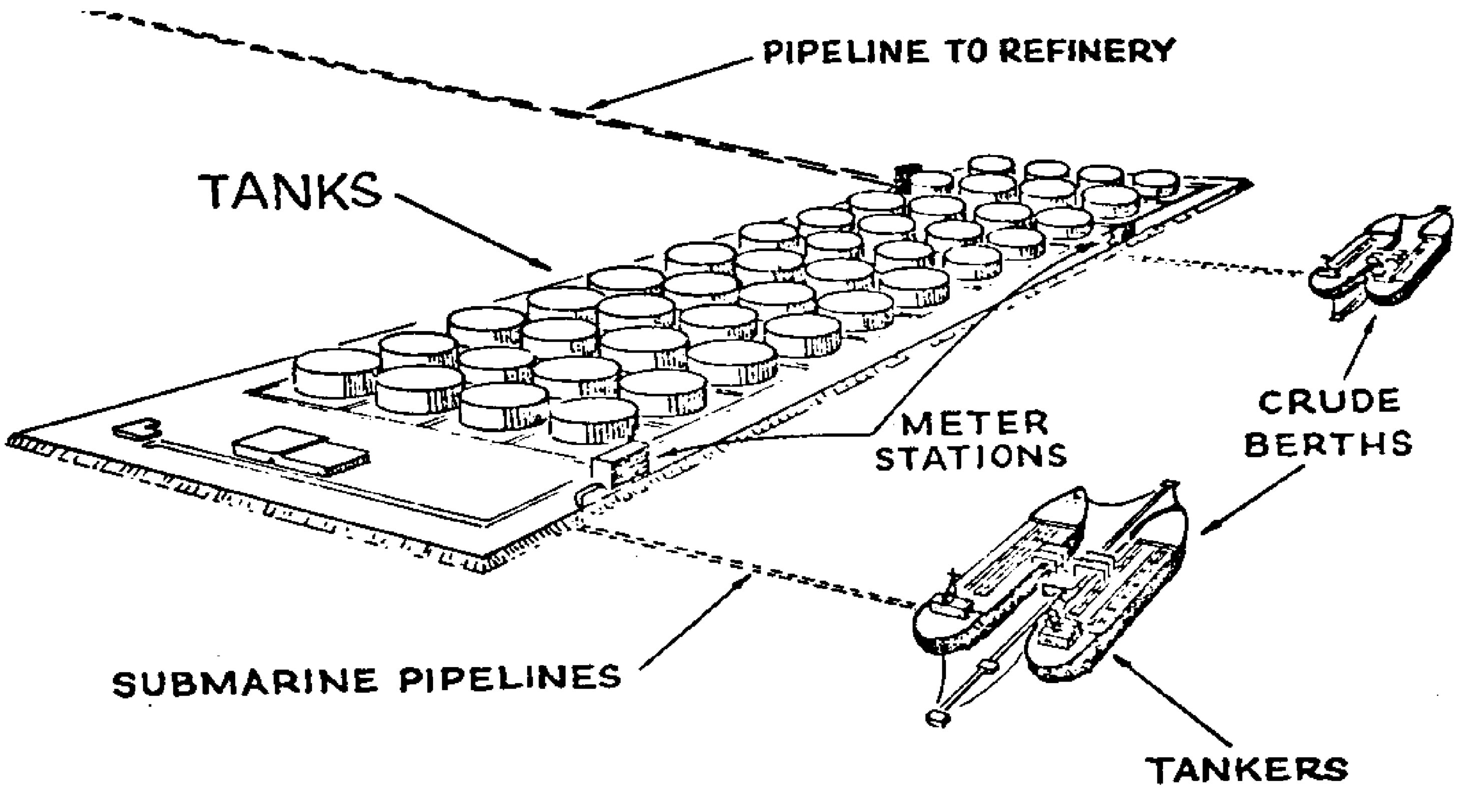
Exhibit 38



Single Buoy Mooring Facility.

Source: Volume I, Draft Environmental Impact Statement, Maritime Administration Tanker Construction Program, NTIS Report No. EIS 730 392 D, 1973, p. IV-207.

Exhibit 39

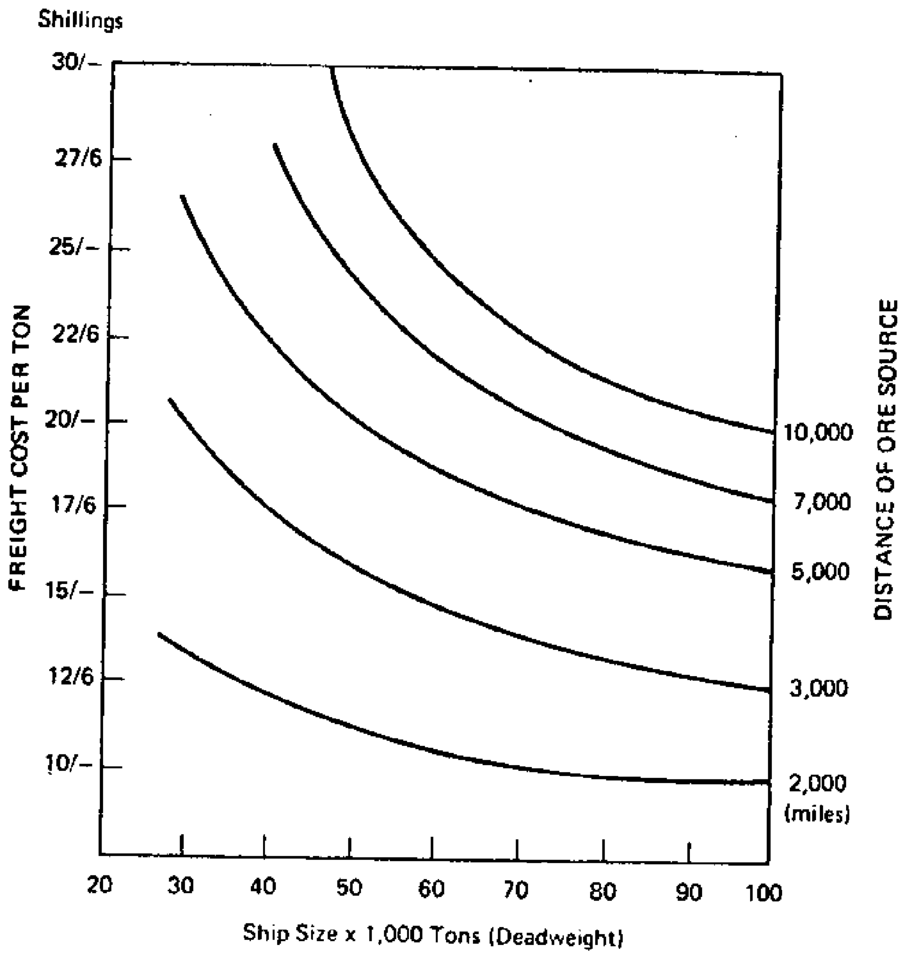


An Artificial Island Complex

Source: Volume I, Draft Environmental Impact Statement, Maritime Administration Tanker Construction Program, N.T.I.S. Report No. EIS 730392 D, p. IV-210

Exhibit 40

Shipment Cost Related to Ship Size and Distance of Ore Source.



Source: W.G. Meredith and C. Wordsworth, "Size of Ore Carriers for the new Port Talbot Harbour," *Journal of the Iron and Steel Institute*, 204 (November 1966), p. 1077.

size of supertankers. Dry bulk carriers in the 100,000 to 250,000 dwt range are considered to be very large. Most smaller dry bulk carriers use onshore terminals. However, the larger dry bulk carriers may use offshore island or fixed platform terminals where the cargo may be transferred to shore by conveyor belt, aerial tramways, or smaller vessels. It should be noted that dry bulk commodities also are moved on occasion by pipeline in a slurry form. A less developed country devising these types of high technology cargo handling systems would rely on an international engineering firm specializing in this area for detailed design and construction.

A major difference between dry bulk and liquid bulk systems is the cargo handling and storage facilities. While oil simply uses pumps and storage tanks, dry bulk utilizes considerably more varied equipment. As one would expect, the unloading rate of dry bulk commodities is considerably slower than that of oil.

C. Unloading Equipment

The following brief descriptions are given for unloading equipment at onshore dry bulk commodity terminals:[9]

a. Grab bucket -- In this system, an open clamshell bucket removes the material from the hold of the ship and deposits it ashore.

b. Marine leg -- This is essentially a continuous bucket elevator that can be suspended in a hold and adjusted for different elevations.

c. Drag conveyor -- This type of conveyor system uses spaced drag devices called flights mounted on a chain running in an enclosed housing.

d. Pneumatic -- The material is suspended in air and transported in the airstream.

e. Self-unloading vessels -- Some vessels have built-in unloading equipment that delivers the material to a fixed discharge point.

f. Slurry -- There have been several installations, particularly with iron ore, where the material is suspended in a fluid and transported from the ship hydraulically.

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[9] For more information on dry bulk handling equipment, refer to Port Planning Design and Construction, AAPA, 1973.

g. Miscellaneous -- There are other methods for specific commodities, such as electromagnets for scrap iron and steel.

D. Loading Equipment

The following brief descriptions are given for loading equipment at onshore dry bulk commodity terminals:

a. Belt conveyors -- This system is probably the most commonly used method of loading a ship or barge.

b. Direct spouting -- In this system, quite a common method, especially in grain shipment, the cargo is directly loaded by spouts from a high gallery

c. Pneumatic loading -- The loading is done with the material suspended in an airstream.

d. Self-loading vessels -- In a reversal of the unloading process, the material is generally delivered to one point on the vessel and the equipment aboard distributes it to the various holds.

e. Miscellaneous -- There are various other methods for particular commodities, such as electromagnets for scrap iron.

The choice of a loading or unloading system will depend on the particular situation -- the specific commodity, the volume, the cost involved, the loading rate desired, etc.

Many types of storage facilities may be used for bulk commodities: silos, domes, rectangular storage buildings, and open storage. In addition, inland transportation may take place in rail cars, trucks, barges or pipelines, depending on the specific circumstances.

IV. Other Types of Cargo Vessels

While we have briefly discussed general cargo vessels and bulk carriers, there are many specialized cases we have not described. In the general cargo area we did not discuss the many types of semi-container ships which carry some break-bulk cargo and some containers, or small feeder containerships which would carry containers between small ports and major container ports. In the bulk area, we did not discuss tug-barge combinations or specialized carriers, such as for lumber, automobiles, scrap iron, liquefied natural gas, liquefied petroleum gas, or chemical carriers. (Specialized vessels may provide a valuable economic opportunity for a nation with unique natural resources.) In addition, we did not describe the combination bulk carriers such as ore-bulk-oil carriers or oil-ore vessels. Although these many types of vessels each possess unique factors, the discussion of the major areas should give the reader the overall knowledge he needs pertinent to this report, so that we will make no further attempt to give a more detailed discussion of these matters.

In a similar manner, although our discussion has been aimed at trans-ocean commerce, we feel the major points of any domestic, coastal, or inland waterway cargo system have been covered. Cargo vessels used in these trades will be similar to transocean ships except normally smaller. The inland waterways will generally use tugboats and barges, such as in the LASH lightering system, although a tugboat may push an extensive flotilla of barges in certain parts of inland waterways.

The development of a domestic inland waterways fleet may prove extremely valuable to a less developed nation without extensive surface transportation networks. It should be pointed out that even in a highly developed country like the United States, barges and shallow draft freighters plying inland waterways carry 16 percent of the nation's domestic commerce.[10] We will now leave the cargo area and discuss the waterborne movement of passengers.

V. THE WATERBORNE MOVEMENT OF PASSENGERS

The era of the huge transatlantic passenger vessel has passed, laid to rest by the jet airplane. Cruise ships of smaller size have replaced the old giants. Of the twenty-five passenger ships that were regularly calling at the Port of New York in early 1973, the smallest were approximately 500 feet in length; the largest proportion were in the 600 to 700 feet range, and the largest was the *France* at 1,035 feet.

Exhibit 41 shows the general plan of a passenger terminal in Miami, Florida, which caters mainly to cruise vessels. The obvious characteristics, in contrast to a cargo terminal, are the parking lots, and the enclosed

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[10] *Big Load Afloat*, a publication of the American Waterways Operators, Inc., Washington, D.C., 1973, p. 2.

Exhibit 41

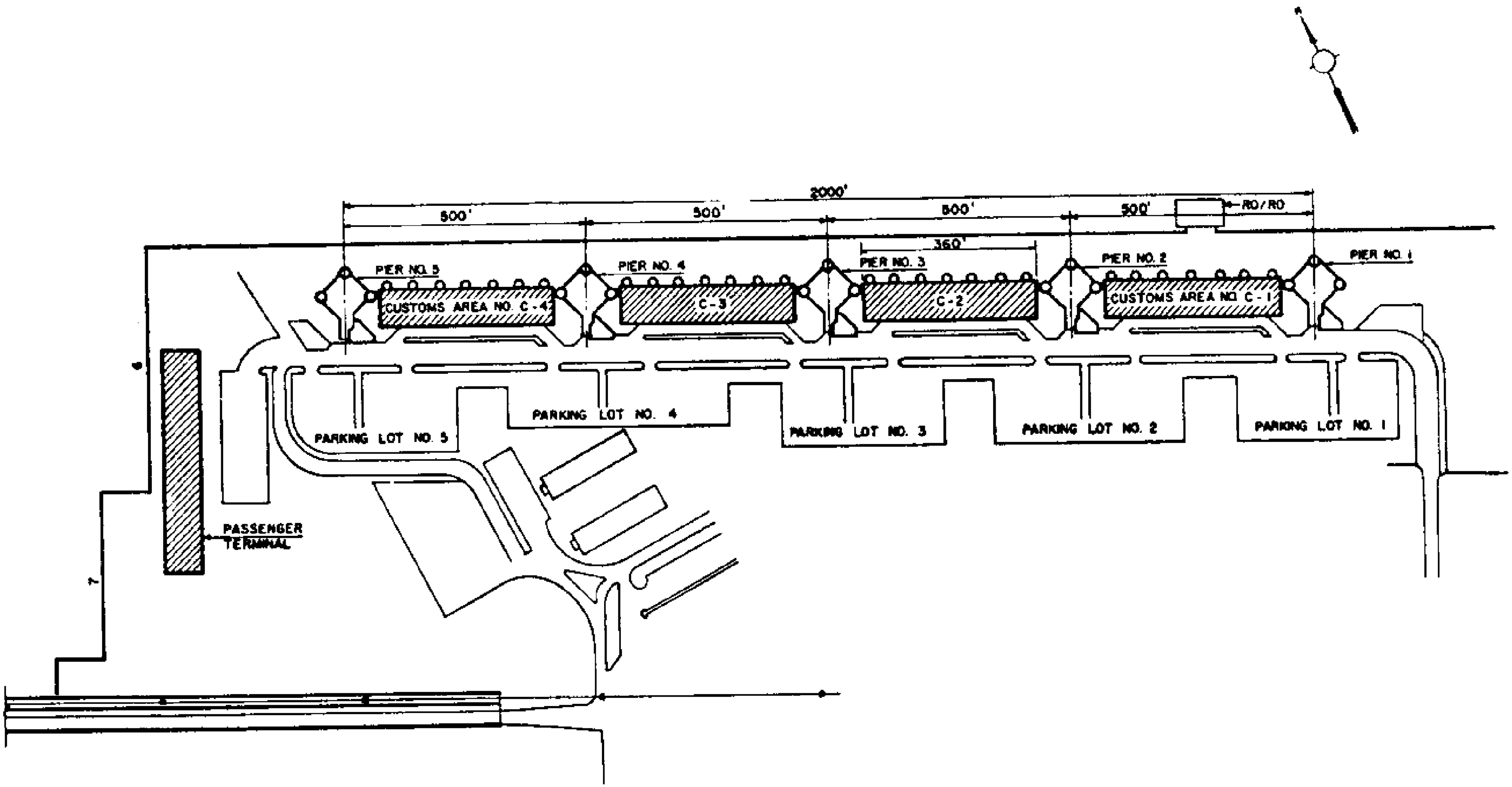

Figure 2. General Plan of Marine Passenger Terminal, Miami, Florida.

Source: Port Planning Design and Construction, AAPA, Washington, D.C. 1973, p. 247.

passenger and customs areas. While large amounts of baggage and supplies must be loaded aboard these vessels, this presents no problem in terms of equipment or personnel.

A. Ferry Services[11]

Where the traffic potential is sufficiently important to feed a ferry service, the types of ferry to be considered would normally be a combined passenger and car ferry or a cargo ferry. In either case, the cars or cargo would roll on and off. For one to three hour crossings, a combined passenger car/cargo ferry, of the roll-through type with loading ramps in bow and stern, would frequently be used. In this type of ferry, the vessel loads through a stern gate in one port and discharges through the bow gate in the other port. In this manner, all vehicles can drive through without any maneuvers or loss of time. The passenger accommodations are not luxurious in such a vessel, and there are no sleeping facilities. Overnight ferry services, with appropriate sleeping accommodations, exist in many parts of the world, but to a lesser extent than the more common ferries making shorter voyages.

In addition to the ferryboat design where the vessel has one propeller and is designed to facilitate driving on board at the stern and driving off at the bow, ferries can also be designed with one propeller and rudder at each end, so that driving on and off the ferry can be done in both directions. This latter design is called a double symmetrical ferry, and it can shuttle between two terminals without ever turning around.

A study by the UN suggests that double symmetrical ferries should be operated on stage lengths as presented in Exhibit 42. Exhibit 43 provides an evaluation between the two ferry designs as a function of capacity and stage length. Ferry terminals represent no special problems relative to the other types of terminal facilities already discussed, nor do the personnel required aboard ship or on shore.

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11 For additional information on ferry services, the reader is referred to Coastal Shipping, Feeder, and Ferry Services, United Nations, New York, 1970.

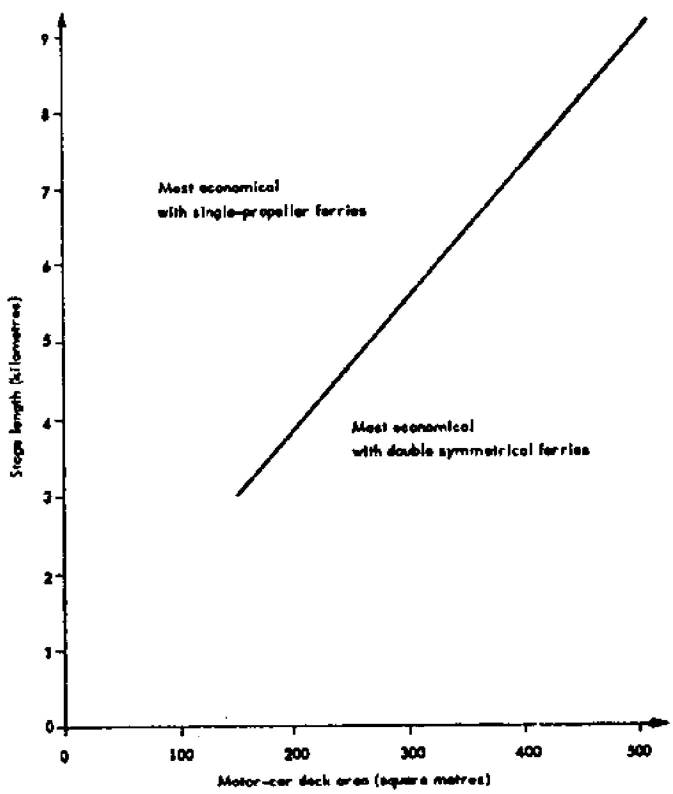
Exhibit 42

Number of motor-car units	Ferry capacity: Dimensions of motor-car deck (length × width) Metres	Feet	For stage lengths of less than: Kilometres	Nautical miles
8 - 10	19.5 × 7.5	63 × 25	3	1.6
18 - 20	29.0 × 9.5	95 × 31	5	2.7
24 - 28	38.0 × 9.5	125 × 31	7	3.8
38 - 42	47.5 × 10.6	156 × 35	9	4.9

Source: Coastal Shipping, Feeder and Ferry Services, United Nations, N.Y., 1970, p.77.

Exhibit 43

CHOICE OF TYPE OF FERRY AS A FUNCTION OF CAPACITY AND STAGE LENGTH



Source: Coastal Shipping, Feeder and Ferry Services, U.N., N.Y., 1970, p. 77.

B. Hydrofoils and Hovercraft

Two of the more glamorous types of passenger vessel are the hydrofoil and hovercraft, with stated cruising speeds between 30 and 60 knots. Exhibits 44 and 45 give data on the capacity, speed, construction cost, and operating costs for such vessels. It is difficult to choose between the vessel types, because of the general controversy between the manufactureres concerning the seaworthiness and reliability of the vessels as well as the operating and maintenance costs. It should be noted that both types of high-speed craft require specially trained personnel to operate and maintain their sophisticated equipment.

VI. RECREATIONAL CRAFT

Recreational craft can vary from canoes to luxury yachts. While terminal areas for recreational craft represent no problem technically, the actual types of facility will vary widely depending on income level of users, availability of sheltered harbors. The minimum in facilities would be an anchorage area with a few mooring buoys. A more elegant arrangement would be a marina facility with hundreds of private ships, each with shoreside fresh water and electricity. The only unusual skills required would possibly be in the repair of engines or boats. The only types of unusual equipment would be for transporting boats in and out of the water using marine railways or various crane arrangements.

VII. CONCLUSIONS ON VESSELS AND TERMINALS

We have seen in the bulk commodity trades, that a nation would want to use the most economical vessels which would generally be the largest ships able to use its facilities (and the facilities of the ports on the other end of the voyages). For developing nations without the skill to build or operate ships and terminals, these capital goods and personnel can be imported. In time, citizens can learn to operate the terminal facilities. (We will discuss the operation of the vessels with citizens later.)

In the area of general cargo, we realized that again a nation could import whatever vessels, terminal equipment and personnel it desired. However, the choice of the optimal ship was complex and dependent on such

Exhibit 44

APPROXIMATE CONSTRUCTION COSTS FOR VARIOUS TYPES OF HYDROFOIL BOATS AND HOVERCRAFT, 1969
(*Thousands of dollars*)

Type of vessel	*Capacity (seats)*	*Cruising speed (knots)*	*Price*
Hydrofoil boats			
PT 20	70	32	290
PT 50	100	34	500
PT 150	250	34	1,600
Hovercraft			
SR.N5	19	60	230
SR.N6	38	50	310
BH.7	140	55 - 60	1,150
SR.N4	600	60	4,500
HM.2	60	35	200

Source: Coastal Shipping, Feeder and Ferry Services, U.N. N.Y., 1970, p. 84.

Exhibit 45

APPROXIMATE OPERATING COSTS FOR VARIOUS TYPES OF HYDROFOIL BOATS AND HOVERCRAFT, 1969
(*Thousands of dollars*)

Cost	*Hydrofoil boats*			*Hovercraft*		
	PT 20	*PT 50*	*PT 150*	*SR.N6*	*SR.N4*	*HM.2*
Depreciations [a]	30	51	160	31	460	20
Interest [b]	9	16	48	10	135	45
Insurance [c]	6	10	36	9	190	45
Crew [d]	35	47	75	23	57	35
Fuel and oil [e]	18	36	100	36	36	18
Maintenance [e]	18	30	50	135	500	15
Operating costs per annum . .	115	190	469	244	1,702	96
Dollars per hour	43	76	170	100	670	3
Cents per passenger/kilometre [f].	1.1	1.35	1.0	3.6	1.3	1.05

NOTE: Utilization is assumed to be 2,500 hours per annum.

[a] Ten years of initial cost, less spares.

[b] Based on rate of 6 per cent of half initial cost.

[c] For hydrofoil boats, 2 per cent of initial cost; for HM.2, 3 per cent; for other hovercraft, 4 per cent.

[d] Two watches per day; no spare crew.

[e] Based on operational experience.

[f] Based on average speed over 40 nautical miles and number of passengers in a purely passenger version.

Source: Coastal Shipping, Feeder and Ferry Services, U.N., 1970, p. 86.

factors as the inland transportation network and the cost of labor. Again, a nation could train its citizens to take over the terminal operations in due time.

In the areas of passenger craft and recreational craft, there were no unusual terminal requirements and a nation should be able to train its citizens to take over such terminals operations with little trouble. While many types of passenger craft are available, it must be noted that high-speed craft such as hydrofoils and hovercraft will require specially trained personnel for their operation and maintenance.

The hardware for most any marine transportation system can be purchased by any nation, if it does not manufacture these products internally. In general, terminal facilities in any country can eventually be manned by that nation's citizens with proper training. In the next section, we will discuss whether a nation should establish or expand its own merchant marine rather than using foreign-flag vessels.

VIII. ESTABLISHING OR EXPANDING A NATIONAL MERCHANT MARINE

For the following reasons a nation, especially a developing one, may desire to establish or expand its merchant marine:[12]

(a) National security, including the prevention of disruptions of commercial services during hostilities (as well as the logistical ability to support a military effort)

(b) Reduction of economic dependence on foreign-flag vessels

(c) Influencing conference decisions (in the liner trades)

(d) Economic integration within a geographically scattered country

(e) Promoting exports

(f) Diversifying employment by putting citizens aboard vessels

(g) Balance of payments

(h) National prestige

While the reasons above would appear to provide ample motives for establishing or expanding a national merchant marine, some persons feel, as

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12 For further information on any of these topics the reader is referred to Establishment or Expansion of Merchant Marine in Developing Countries, United Nations, New York, 1968.

shown in the statement below, that it may be a mistake for a developing nation to establish a national merchant marine if it wants to influence a conference system to lower rates and receive better services.

> ...perhaps the most important observation is that one way not to alter the conference system is the establishment of a state-owned domestic flag liner fleet. This has been the favorite tactic of the developing nation. Such companies generally join the conference from the outset in order to have a "voice" in conference affairs or join quickly thereafter following a period of unprofitable operation outside the conference. The problem is that a single, new line can expect to have little effect on rates in a conference in which rate changes typically require a three-quarters or more majority, if such a line wanted to. More importantly the domestic flag line rarely shows any real inclination to fight for lower rates. Typically, it is a high cost operator, often losing money at prevailing rates. From the point of view of the people operating the line, the problem becomes one of operating at minimum visible public subsidy which dictates higher not lower rates. Thus, the state-owned line becomes a protagonist of the conference system and high rates, a protagonist who has special access to governmental bodies concerned with conference ratemaking. The state-owned line becomes the conference's 'voice' in governmental deliberations concerning the conference.[13]

A. UN Code of Conduct for Liner Conferences

From Exhibit 46, we can see that the merchant marines of developing countries make up an extremely small percentage of the world fleet and that this percentage has, in fact, decreased since 1965. The objectives of the developing nations were shown recently, when they actively supported (and succeeded in) the adoption of the United Nations Code of Conduct for Liner Conferences. This code calls for 80 percent of the liner cargo between two countries to be shared equally by the two nations involved, with the remaining 20 percent left for third nation carriers. The code has not been properly ratified to become effective. However, the repercussions from such a code could have great impacts on the merchant marines of developing nations because of the present structure of the conference system.[14] Since the bulk commodity trades do not use conferences and operate in essentially the classical economic supply/demand situation, a developing nation inefficiently

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13 Taken from Conference Ratemaking and the West Coast of South America, by J. W. Devanney, III, V. M. Livanos, and R. J. Stewart, M.I.T., 1972, p. 79 (a footnote from the quotation has been omitted.)

14 For more information refer to "The Liner Conference Convention: Launching An International Regulatory Regime," Law and Policy in International Business, The International Journal of Georgetown University Law Center, Spring 1974, Volume 6, Number 2.

Exhibit 46

WORLD TONNAGE DISTRIBUTION (grt)
By Flag of Registration
1955, 1965, 1969, 1970
(Mid-Year Figures)

FLAGS OF REGISTRATION (Groups of Countries)	SHARES OF WORLD TONNAGE % 1955	1965	1969	1970
WORLD TOTAL	100.0	100.0	100.0	100.0
Developed-market-economy countries (excluding Southern Europe)	74.2	61.8	58.6	57.0
Liberia, Panama	10.1	15.0	17.9	17.9
Southern Europe	4.9	8.0	7.7	8.6
Socialist countries of Eastern Europe and Asia	4.2	7.4	9.0	8.9
Developing countries, total	6.6	7.8	7.6	7.6
of which: in Africa	0.3	0.4	0.6	0.6
in Asia	2.2	4.3	4.4	4.4
in Latin America and the Caribbean	4.1	3.1	2.6	2.6

Source: "The Third World At Sea," by John L. Eyre, Defense Transportation Journal, March - April 1974, p. 47.

running a bulk carrier will have great difficulty finding employment for its vessel at the going market rate. However, since conferences essentially fix prices and control liner trade routes, if a developing country could simply establish itself in the conference with a 40 percent market share, there would be no problem finding employment for the vessels. Note that this does not mean that their liners could necessarily operate at a profit at the going market rate.

Whether any nation will be able to successfully establish an economically viable national merchant marine depends on the structure of its own economy, particularly the volume of its overseas trade and the extent to which it can meet the needs of shipping for capital equipment and operating inputs from its own resources. (Note that vessels can be either leased or purchased.) Whether this would represent the most economical use of its resources compared with other investment possibilities depends on where its comparative advantage lies at present as well as in the future.

If a nation decides to establish or expand its merchant marine, it must decide what type of vessels it wants and whether to acquire new or second-hand vessels. There are advantages and disadvantages for a developing nation associated with each choice and they are briefly summarized below.

a. Dry Bulk Carriers: Capital intensive and therefore poor at creating employment, very risky if operated on the voyage or short-term charter market, while long-term time charters or contracts may be difficult to secure unless there is a domestic user. However, if regular employment can be secured, they have favorable balance of payment effects.

b. Cargo Liners: Good for employment creation, once accepted into conference can count on receiving cargo, impact on conference questionable (without the ratification of the new U.N. Liner Code). If bought second-hand, may be a cheap way to entry and gaining experience. New ships have high capital/output ratio. Not as good for balance of payments as the bulk carriers.

c. Passenger Liners: Second-hand ships can be bought relatively inexpensively, due to decline of transocean passenger demand and are very long-lived, many ships in service being over 30 years of age. May be useful for countries with high tourist potential. High employment-creating effects, much of it relatively unskilled.

d. Tankers - Large: The same as for bulk carriers; long term charters or contracts essential. (Oil producing countries can find a ready market in delivering their oil to foreign countries.)

e. Tankers - Small and Medium Sized: Can be bought second-hand. Less capital intensive than large tankers.

f. Tramps: These break-bulk cargo vessels find easy entry into voyage charter and short-term time charter markets. If bought second-hand, have a relatively short earning life which reduces risk; relatively cheap, good for employment creation, favorable balance-of-payments effects if domestic repair facilities available; unsophisticated engines and equipment do not require highly specialized personnel to operate, but difficult to finance and may have long periods of lay-up or ballast voyages.

B. Government Subsidies

In order to help establish or expand national merchant marines, countries may wish to use subsidies. The most direct type of subsidies are simply payments to the shipowner to lower his costs of ship construction and/or operation. Other forms of assistance are low interest loans, accelerated depreciation write-offs, tax exempt or tax-deferred funds for profits to be used in ship construction or repair, government guarantee of mortgages, and preferential port charges for national flag vessels. Still other forms of subsidies do not directly involve financial payments but simply exclude foreign-flag carriers from certain cargoes or trade routes (such as laws), thereby insuring cargo for national-flag vessels. Governments can also aid their merchant marines by establishing and maintaining government-sponsored facilities to train sea-going personnel, by providing special medical benefits for seamen, and by sponsoring special marine-related research in universities and elsewhere.[15]

Using subsidies to aid a national merchant marine can be effective. However, if other countries retaliate, the effect of the assistance granted by the first country is reduced, although the advantage can be regained by increasing the subsidy. Each nation can apparently gain at the expense of

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[15] For more information of the type of subsidies used, the reader is referred to Maritime Subsidies, U.S. Maritime Administration, 1971.

other nations by increasing subsidies, although all become worse off in the process. Only those that give the greatest amount of assistance or discriminate the most effectively may finally benefit; moreover, the benefit may only be relative and not absolute.

IX. POTENTIAL ROLE OF AN INTERNATIONAL SEA GRANT PROGRAM

An International Sea Grant Program has the potential for playing an important role in aiding less developed countries with their marine transportation systems. Such a program could assist a country in making feasibility studies looking at such things as appropriate types of port facilities, trade route cargo projections, overall national port planning, merchant marine establishment or expansion, and appropriate choice of vessels. It should be noted that the United Nations, the U.S. State Department, and private consulting companies do various amounts of work in these areas.

An International Sea Grant Program may also be able to play a valuable role in the area of education through such means as curriculum development and training programs. Sea Grants could assist less developed countries in setting up merchant marine academies for training sea-going personnel and programs for training personnel for port administration and port operations. The political implications of having the U.S. aid the establishment or expansion of a foreign merchant marine deserve further attention. However, the desire to increase goodwill with oil producing countries that wish to develop tanker fleets and less developed countries that support the U.N. Code of Conduct for Liner Conferences (or wish to form bilateral agreements for the division of cargo with the U.S.) would seem to alleviate any potential problems in this area. While more research is definitely needed before specifying the optimal role for an International Sea Grant Program concerning marine transportation systems, it appears feasible that such an International Sea Grant Program would make a valuable contribution in this area.

FISHING AND THE FISHING INDUSTRY

An Account with Comments on Overseas Technology Transfer

by

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FISHING AND THE FISHING INDUSTRY

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	Page
I. GENERAL INTRODUCTION	149
II. THE FISHING SECTOR	150
A. The General Situation of the World Fisheries	150
B. Fisheries and Agriculture	152
C. Fish Stocks	153
1. Types of Animals Fished	153
2. Regional Distribution of Fish Stocks and Fishing Effort	154
D. Aquaculture	156
E. Effects of Fishing on Stocks	157
F. Fishing Technology	158
1. Overview	158
2. Fishing Gear	158
a. Stationary or Drifting Nets	160
b. Encircling Nets	160
c. Scooping Nets	160
d. Fish Detection	160
G. Fishing Boats and Fishing Operations	162
1. Overview	162
2. Artisanal Fishing	163
3. Middle Sized Boat Fisheries	165
4. Distant Water Large Boat Fisheries	166
5. Problems and Potential for Technology Transfer in Artisanal Fisheries	166
6. Peru and Thailand: A Comparative Case Study	168
H. Recreational Fisheries	172
III. THE PROCESSING SECTOR	172
A. On Board Ship	172
B. Off-Loading and Sale	173
C. Fresh Fish and Shellfish	174
D. Further Processing	175
1. Freezing	175
2. Canning	177

	Page
3. Curing	178
4. Newer Processes	179
E. Fish Meal and Oil	180
F. Structure of the Industry	182
G. Fish Consumption and Acceptance	186
IV. TECHNOLOGY TRANSFER	187
A. General Considerations	187
B. Program Planning and Development	190
C. Project Suggestions	191
D. A Note on Aggregated Technology Transfer	192
V. BIBLIOGRAPHY	201

INDEX OF TABLES

		Page
Table 1	Estimated Fish Yield by Animal Group	194
Table 2	Potential Fish Resources and Actual Catch	195
Table 3	Selected Examples of Aquacultural Yields Arranged by Ascending Intensity or Complexity of Culture Methods	196
Table 4	General Production Levels of Various Fishing Practices	197
Table 5	Some Comparisons Between the Fisheries of Peru and Thailand	198
Table 6	Top 13 Countries by Fish Catch, 1972	199
Table 7	Nominal Catches by Weight and Value for Selected Countries	200

ABSTRACT

World fish resources, fishing methods, and processing operations in the seafood industry are described. The fishery situation in developing countries (LDC's) is discussed, with particular reference to artisanal and other local fisheries, and examples are cited to illustrate the structure of the industry. Technology transfer from developed countries to LDC's is discussed and recommendations presented for future technology transfer programs. It is concluded that an integrated complex of small projects with defined, attainable objectives and immediate impact on income and food supply of the LDC populations is likely to be more successful than large-scale programs with little immediate payoff. A case study of fisheries in two developing countries, Thailand and Peru, and tabulation of statistical data on catches, value of catch, and unit value of fish species groups for selected countries, with a discussion of the significance of the data, are presented.

I. Introduction

In recent years, the world fisheries have landed about 70 million tons of fish and shellfish. This represents a substantial contribution to world food needs, particularly as it provides high-grade animal protein to parts of the world in which the availability of land-raised animals is relatively small or too expensive for general consumption. The potential for increasing the world catch is less than was previously thought, but a doubling of the present total landings seems possible according to current projections of total stocks. However, the very uneven level of technology throughout the world fishing industry (including activities not truly industrial in scope) results in great losses of edible fish and shellfish. Spoilage, poor processing methods, and inefficient handling procedures limit utilization of fish stocks, particularly in the artisanal fisheries which, on a manpower and distribution basis, dominate the world picture. Moreover, very large quantities of fish (close to 35 percent of the total catch) are used to produce fish meal for animal feed, thereby depriving human populations of direct food benefits and greatly reducing the efficiency of protein utilization in human terms (i.e. there is only about a 10 percent or less return of protein to humans of protein from fish through consumption of animals fed fish meal).

The restraints on increased fish production and seafood supply to the consumer are many and complex, involving economic, sociological, political, and legal factors, as well as technology. These restraints operate in an interrelated manner that frequently requires simultaneous removal of obstacles in a number of discipline areas to provide for their effective relief. Thus, technology development may be frustrated by legal restrictions on catching or processing methods, that are designed to protect a particular social group or to meet a defined political situation. The common resource nature of most fish and shellfish stocks has limited development of fisheries along the familiar lines of agriculture, the other main food producing industry. The absence of assured ownership rights has stifled sustained efforts by entrepreneurs and has restricted investment in particular fishing operations. Another difference from agriculture is that in most cases, the fisherman has no control over his "crop" but must depend on the bounty of nature, both for its availability and its condition. Aquaculture, which makes a comparatively small contribution (5-8 percent) to the world fish supply, is an exception to this. A third important factor is that fish perish. Land animals can be killed at the point of processing or distribution, and spoilage is dealt with easily. Fish, on the other hand, die where captured and must be transported to distribution and processing locations, often over long distances and under very difficult conditions.

II. THE FISHING SECTOR

A. The General Picture of the World's Fisheries

Fishing and aquaculture in a variety of forms date back to at least 1000 B.C., but today's fishing industry is mostly a product of the industrial revolution. Data on total catches is available only as far back as about 1900 for a few of the more advanced fishing countries, and worldwide data collecting began only in 1950 with the establishment of the UN's Food and Agriculture Organization. Thus, the dependable data base is relatively small.

With the beginning of FAO statistics, the world fish catch was just over 20 million metric tons (MMT) and had risen to about 69 MMT in 1970. This is an annual rate of increase of about 6.6 percent or about twice the rate of increase of terrestrial food production (Royce, 1972). While this is a significant contribution toward improving the world's protein supply, this does not mean that the availability of fish as food for people has increased to that degree.

One of the dramatic increases in fish production has been the explosive expansion of the Peruvian anchovy fishery from nothing in the late 1950's to 12.3 MMT in 1970. The entire catch went for production of oil and fish meal for nonhuman consumption. Thus, about one-third of the world's fish production goes into industrial products, often as supplementary components of animal food.

Second, the increase in catch is not evenly distributed over oceans or nations. Generally the northern temperate seas have seen the greatest sustained increases in fish production, and the tropical and southern seas the least. Production has centered in the northern, temperate, industrialized countries and not in the tropical, developing, or southern hemisphere countries. The latter, of course, are where protein deficiency is presently most acute. Third, the steadily climbing world averages are composed of individual fisheries whose records are by no means consistent. Fishing is still a high-risk business. Thus, when predictions are made about the maximum potential yield of the world fisheries (which vary from 50 MMT to over 1,000 MMT, with most around 100 MMT), they usually include exploitation of new species, which may require new technology and may face considerable product resistance by the intended consumers. Thus, much of the potential for improved supplies of fish for human consumption may depend on detailed analysis of and assistance to individual, local fisheries rather than any global scheme.

Finally, recent events, which do not show up in the FAO statistics, may have major effects on the future yield of ocean fish. First, a number of the major traditional fisheries - Atlantic cod, Pacific salmon, tuna, Alaska king crab, California sardine, to name a few examples - have reached a peak of production or have even suffered drastic declines, probably as a result of overfishing. This may cause economic and food supply hardships on the one hand, but may also speed up the acceptance of new, presently unexploited species as traditional species become less available or more expensive. The possibility of overfishing a given fish population has been greatly increased by the recent development and expansion of distant water fishing fleets, particularly by Russia and Japan, capable of fishing and processing fish at a rapid rate anywhere in the world. These fleets can capture fish faster than data can be obtained and analyzed for making management decisions to prevent overfishing. Partly in response to this kind of short-term, intensive "pulse-fishing," there is great impetus, particularly in less-developed countries, to establish a 200-mile fisheries or resource jurisdiction zone off their coasts. Some have done this unilaterally for a number of years.

When these 200-mile limits are put into effect, there will be a considerable period of turmoil for those nations fishing in what had previously been international waters. This and recent inflation of protein prices may drastically alter the composition of the whole fishing industry by changing the entire pattern of investment desirability. This, in turn, may increase the desirability of aquaculture industries, whose products have been often relatively high priced, but now may become more competitive as other fishery products become more expensive. Thus, in the next few years, many segments of the fishing industry and non-fishing industries can be expected to interact in a variety of only partially predictable fashions and at an accelerated rate.

B. Fisheries and Agriculture

Agriculture and fisheries share several features as producers of (protein) food, but there are also significant differences. Both suffer from the unpredictability of weather, the farmer directly, and the fisherman to the extent that solar input drives the ocean currents and influences primary productivity and fish distribution. Weather often may limit fishing operations, especially with smaller fishing vessels. Both industries produce protein and both have changed and become partly intertwined in recent years. Agriculture's staple crops have always been the starchy cereals which can be converted into protein only by feeding them to animals.

Fish protein has always been considered a high quality protein, because it has certain amino acids essential to human nutrition but not supplied by plant proteins.

The two industries intertwine at the point where livestock foods are being supplemented with protein, either from fish meal or soybeans. Availability of either one affects the other, as in the recent drastic decline of the Peruvian anchovy fishery and shortage of fish meal, causing a doubling of the price of soybeans. Finally, both agriculture and fisheries, at least in the United States, have been predominantly the domain of the private businessman.

Fisheries and agriculture (animal husbandry) also differ in several important respects. First, the fishing industry is dependent upon capturing wild fish, except in the area of agriculture, which will be discussed later. Assessing wild stocks in the sea as to their total numbers and potential sustainable yield can be difficult, costly, or both. Pelagic fishes (excepting salmonids) have traditionally belonged to no one (when outside exclusive fishing zones) until captured. None but the most primitive peoples is dependent upon wild "livestock" today, but about 95 percent of the world's fish catch consists of "wild" fish.

Fish also differ from farm animals in trophic level. Most domestic animals are plant eaters. Many fish eat zooplankton (which eats plants) or eat other larger animals which eat zooplankton, while relatively few fish (some herring-like fishes, for example) eat plants directly. Salmon and tuna, for example, are both secondary or tertiary predators and, thus, ecologically inefficient in terms of requiring a long food chain to support them, with conversion (to new tissue) losses occurring at each step of the food chain.

C. Fish Stocks

1. Types of Animals Fished

Worldwide, there are more than 25,000 species of fish. Only a few hundred of these fish and even fewer shellfish are commercially significant, for a variety of reasons. In the past, a primary consideration was size - each fish was eviscerated and filleted by hand, and processing small fish costs too much to be economically practical. Processing machines such as shrimp peelers and fish mincing machines have eliminated some of these problems in developed countries, while development of the fish meal industry enables utilization of small-sized whole fish. Fish have to be available to fishing gear of some kind and must be available in reasonable quantities and with reasonable dependability. This leads to emphasis on fish that swim in schools, at least part of the time, or otherwise aggregate, such as for spawning or periodic migrations, so as to maximize the fisherman's catch per unit of effort. Until one has participated in exploratory fishing, it is difficult to appreciate how easy it is to use a piece of fishing gear blindly and catch nothing with it. Further, fishing gear also limits the stocks fished - one does not put down a bottom trawl on any but a relatively smooth bottom or to depths beyond the limit of one's cables, thus restricting the catch to those species that live in "fishable" areas.

Fish stocks are usefully categorized by the system used by FAO under the headings shown in Table 1. The table is a revised and modified version of one published by Gulland (1971) including updated catch data for 1972 and the original estimate of potential yield. This estimate is based mostly on extrapolation of previous harvesting of stocks and is probably a relatively conservative estimate. It is also conservative in that it excludes items D through H, which are speculative now. For example, even if the present supply of squid and lantern fish could be greatly expanded, there are relatively few cultures where they would be readily accepted into the routine diet. We are not even sure at this time whether cropping of the squid might not reduce the tuna catch, since squid probably form an important part of their food supply.

2. Regional Distribution of Fish Stocks and Fishing Effort

Table 2 presents the FAO data on regional fish catches for 1972 and Gulland's (1971) estimate of potential yield in each region. There are a number of comparisons that can be read into these data and yield estimates. First, the areas from which the least additional yield can be expected are in the northern temperate seas and near the major fishing and technologically advanced nations, i.e. the North Atlantic and the North Pacific, especially near Japan. Another factor is that the seas are the smallest and the land masses and population the largest in the northern hemisphere. Thus, the markets and the processing capabilities are relatively near the fishing grounds. Conversely, many of the lesser developed countries (LDC's) are in the southern hemisphere with its smaller land masses.

The southern hemisphere waters hold considerable potential for increased fish production, and this has attracted distant-water fishing from many nations, particularly Japan and Russia. Neither is it surprising that the LDC's also recognize this potential and want to establish 200-mile fishing limits to get jurisdiction over this potential.

In the northern temperate zone, the potential increases for the northwest Atlantic appear negligible, except for stocks like squid, and lantern fish for which new markets and perhaps new processing would have to be developed. In the remaining northern temperate zones, the unexploited fish consist of small schooling fish such as herring, saury, and capelin, which presumably would go for industrial uses.

In the tropical zone, there is potential for additional catches of large pelagic fish such as mackerels, horse mackerels, and tuna off the west coast of Africa (eastern central Atlantic). In the western central Atlantic, the United States carries on a major shrimp fishery, but this and the snapper and grouper fishery could be greatly expanded into the Caribbean and the northern coast of South America.

The western central Pacific suggests great opportunities because of its extensive shallow waters. However, the fact that Japan's distant water fleets have presumably looked there and are not making major efforts in the area suggests that there are problems - that the fish are not there, or that they are scattered. The Indian Ocean is the least known. In some areas the fish are fully utilized, especially close to heavily populated shorelines, but other areas are less known, and the offshore fishery potential is largely unexplored. Gulland considers the waters offshore from Indonesia, the west coast of India, and near Arabia likely places to look for additional fish stocks.

In the southern temperate zone, there is considerable area of continental shelf, both east and south of Australia, which is considered to be grossly underfished. This seems far away, even for the major distant-water fishing fleets, so most of the fish appear to go for local consumption. The eastern Pacific includes the anchovy (anchovetta) fishery of Peru (some taken by Chile) which is now showing slight recovery from its near collapse several years ago. The degree to which it eventually recovers should be a good test of the estimate of 8 MMT as a sustainable yield for that fishery.

The whole west coast of South America suffers from a very narrow continental shelf, except around the islands of southern Chile, where there is a king crab fishery that could probably be expanded. Even then, there are underutilized species on Chile's narrow continental shelf. The east coast of South America is being explored now, with an underutilized offshore stock of anchovy and hake, and considerable potential in unutilized squid and lantern fish stocks. The west coast of Africa may yield twice as much hake and pilchard as 1967 catches show.

The Antarctic is the least known area, with krill, a small, shrimp-like species, being the major resource. Recent surveys have identified over 90 species of larger fish and major stocks of squid. However, fishing conditions in the Antarctic leave much to be desired, even for large fishing vessels, so development of this resource is likely to be slow. On the other hand, if the establishment of a 200-mile limit prevents distant-water fleets from fishing on some of their traditional grounds, the Antarctic may suddenly become more attractive in spite of its difficulties.

D. Aquaculture

At its most sophisticated level, aquaculture is comparable to the practice of animal husbandry in agriculture, *i.e.* the animal is cultured for its entire life cycle. As shown in Table 3, there are many forms of aquaculture that are more primitive than that, however, such as capturing immature wild animals and keeping them in natural enclosures, feeding on natural food.

The United States' best aquaculture product is salmonids. The whole life cycle is under control, and commercially produced feeds are used, comparable to those used for livestock. However, these are high protein feeds, and the product sells for more than $2.50/lb. This is gourmet food, not a poor man's manna. Catfish aquaculture runs a weak second to salmonids, having borrowed and adapted salmonid technology, but still yields a relatively costly product. Oyster hatcheries have become a production level reality in just the last two to three years. In oyster aquaculture, oysters are not fed once they are past the larval stages, so the food cost is small, but because of high labor costs, the final product is still expensive. Thus, no major aquaculture product is ideal for transfer to LDC's except as a cash crop for the country's few rich people or for export to wealthier countries. Oysters, however, could be a good crop where labor is cheap.

One problem with salmonids and catfish is they are too high on the food chain - partial or complete predators in the wild. Culture of organisms that eat plants would be preferable in LDC's. This has already been done with carp, milkfish, and tilapia in the Far East for up to 2,000 years, and carp will produce twice as much protein as a pig for a given ration. However, the real potential appears to be in the area of polyculture - growing several crops together to the benefit of all.

The United States has some expertise in the culture of warmwater fishes could probably transfer and adapt related information on nutrition and disease control. Other animals cultured in the United States - shrimp, crayfish pompano, pin fish, mullet, blue-gills, lobster, mussels, abalone, sea perch - might be of value in LDC's. Before introducing a new species, it is important t consider the biological ramifications of introducing an exotic species, the feasibility of culturing it, and its potential acceptance by the local people. While modern aquaculture has accomplished great things in some places, for example, doubled the supply of fish in Israel, it has done so most successfully in technically sophisticated countries.

E. Effects of Fishing on Stocks

Except in cultured stocks where exact control of a fish population is possible, the response of all fish and shellfish populations to fishing can be known only approximately. However, a number of generalities can be stated. If the population has not been exploited previously, it will be composed of a large proportion of older individuals which are growing rather slowly, with slow reproduction. Catches are large and profits high for the first few boats to enter the fishery, and this attracts additional boats. Soon they have to go further to find fish, but catches are still increasing. Eventually, enough boats enter the fishery that the fishermen must work harder and longer to bring in their same amount of catch, but their fears are usually allayed by an occasional good year. However, a fisheries biologist will notice that the catch consists of younger and smaller fish. Finally, there is usually a catastrophic decline as a small year class of fish combines with too many fishermen trying to catch them, and the yield suffers dramatically. At that point, yield far exceeds the rate at which the population is replacing itself by reproduction and growth. Overfishing has taken place.

The significance of this pattern is twofold. First, it has happened to almost every major United States fishery, except perhaps the Gulf prawn fishery. This includes Pacific salmon, Alaska king crab, California anchovy, four species of tuna, Atlantic salmon, menhaden, whales, and turtles. Even the Pacific halibut, which used to be a model of a scientifically-managed fishery, has taken a severe setback because of recent trawling on the halibut grounds for other species and incidentally catching young halibut. In the face of decreasing catches and increasing effort for a given catch, the usual management system in the United States has been to adopt restrictive measures that reduce the fisherman's efficiency. This was about the only kind of regulation politically possible in our free enterprise system until recently, when the situation has become bad enough that corrective measures in the form of a limited entry fishery (also called a limited effort fishery) have been established. This means restricting by regulation the number of boats permitted to fish a certain stock. Thus, the United States has plenty of expertise in recognizing the effects of overfishing, and LDC's might be excellent places to set up limited entry fisheries. A productive and economically stable fishery could result if it properly takes into account the local and regional effects on employment and other social factors.

Second, the level of sophistication in the statistics of fishery management and population dynamics needed to begin simple fishery management does not necessarily require computers and other elaborate hardware. However, a training program could be begun within the country that would eventually lead to this kind of capability. Management capability needs to begin early and grow with the fishery. In this case, the LDC's could profit from our mistakes.

F. Fishing Technology

1. Overview

Fish and shellfish are harvested by a wide variety of methods, determined by such factors as local conditions, materials, fish and fish behavior, local traditions and local economics. A thorough review would be a lifetime study. Recent trends have been towards standardization in certain areas of technology - most modern nets use synthetic fibers, most large nets are handled by power hauling gear, and a number of devices have been developed to handle large quantities of tiny fish. The trend in most technologically advanced countries has been to increase the size of the vessels and the gear to catch more fish per unit of time and to substitute machinery for manpower to increase productivity relative to labor costs. Many U.S. fisheries, partly because of restrictive legislation, have remained underdeveloped in a limited sense of the term (discussed later) and thus may have considerably more in common with LDC's than countries such as Russia, with their huge vessels and distant water operations. Many of our fishermen still use small boats and operate as private entrepreneurs. This is not to say that our small boats are technologically backward or that fishing vessels must be huge to be efficient.

2. Fishing Gear

Fish are most commonly caught on hooks or in nets. Spears and harpoons are very old, but little used today except for valuable species with large individuals,such as whales and swordfish. In developed countries, obsolete methods have been adopted for sport, and so sport divers, for example, are perhaps now the major users of fish spears.

A hook and line are equally ancient, but still an important part of modern fishing, both sport and commercial. The main commercial developments consist of ways to multiply the number of hooks that can be tended by one fisherman. The long line, with its variants, accounts for most of these: a central line with the hooks attached by short side lines (gangions) that may be placed on the botton (halibut), or hung just beneath the surface from floats (salmon, swordfish), or simply laid in great numbers and profusion where fish move about and entangle them. The first two long lines are baited; the latter are not. Single hooks are still used in some fisheries where the fish have a high individual value.

A great variety of fish traps have been made by primitive peoples, using brush, vines, basket-making technology, and by modern people using wire mesh or netting. These may be set up on the bottom, be floating but anchored to the bottom, or be completely free-floating, depending on whether the fish can be expected to move through an area, whether water movements will carry the fish past the net, or whether the trap must be baited to attract the fish or the fish herded into the trap. If the fish enter the trap of their own volition, it is easy to find the way in and difficult to find the way out. If fish are driven into the trap, there is usually some portion of the trap which is raised or closed to complete the capture. Both salmon and herring traps worked so well on the Pacific coast of the United States and Canada that they were outlawed on the basis of being monopolistic. The only remaining few belong to Indians who are accorded special privileges.

The traps most used in modern fishing operations are those used for lobster, crabs, and king crabs. A significant feature of crab pots in particular and traps in general is that the fish and shellfish need not be killed at the time of capture. This allows for management (throw back small ones or females unharmed, allow escapement of a breeding population) and quality control (deliver the animals to the consumer or the processor alive).

Certainly the most common gear of modern commercial fishing is the net. Nets may be stationary or drifting, depending on the fish desired, or they may be used to encircle and trap part of a school of fish, or they may be used to scoop up fish from near the bottom, as in the case of the trawl. Modern nets differ little from those of 25 years ago, except now they are made of synthetic fibers. They last longer because they resist decay, are stronger and larger, and yet tow more easily because they have smaller diameter threads, with less drag. Some can be made almost invisible in the water, and because they are both stronger and less bulky, are more amenable to handling with power equipment such as the power block for purse seines or the drum for seines, trawls, or gill nets. Thus, many factors of size and efficiency in nets have greatly improved in the last 10 years, even if the basic methods have not.

a. Stationary or Drifting Nets

Most stationary nets depend on the fish to push their heads through the mesh of the net far enough so that the gill covers prevent them from backing out. The fish are too large at mid-body to pass through. Thus, such nets can be a good management tool because they can be very size-selective in the catch, although such gill nets would fail to catch very large fish, as well as the small ones which might need to be protected. Two major importances of gill nets to LDC fisheries are that they can be fished from relatively small boats with minimal or no machinery and require minimal capital outlay or training for their use.

b. Encircling Nets

Purse seines include a variety of nets that can be set or pulled into a circle and the bottom then closed, either by hauling a special pursing line attached to the bottom of the net or by hauling the lead line faster than the cork line. They can range from a cast net a few feet in diameter to a small lampera seine 500' by 50' deep, which can be hauled by hand from one or two 20' boats to a tuna seine nearly a mile long, 200' or more deep, and requires a 225' seiner with complete power equipment to handle its 10 tons of bulk. Purse seines are the main fishing tool for salmon, herring, Ceruvian anchovetta, and menhaden, to name some of the larger fisheries. The Puretic power block, invented in the United States, has been adopted by most of these fisheries as a standard piece of equipment for handling purse seines.

c. Scooping Nets

Trawl nets began as simple mesh bags, held open by a metal framework at the mouth of the bag, and dragged along the bottom. The beam trawls of the Atlantic scallop draggers are not greatly changed from that even today, although the bag is made from entwined steel rings for durability, rather than from netting. Most modern trawls, however, consist of a nylon mesh bag with long sides called wings, held open by planing devices known as doors or otter boards, which are attached in such a way that they pull downward and outward on the towing cables. This kind of net accounts for most of the bottom fish (sole, flounder, turbot, plaice) and near bottom fish (cod, hake, pollack, rockfish, sablefish) taken in the world. It is also the major producer of shrimp (prawns) in the Gulf of Mexico and the Gulf of Alaska. Its limitations include the need for a smooth bottom and its inability to fish beyond a given depth (varies with the particular boat and gear). At best, it is a fishery which is primarily on the continental shelf and thus is of great interest for LDC's to control with their proposed 200-mile limit.

A recent and still-developing variant on the bottom trawl is the mid-water trawl. This is somewhat like a bottom trawl in which the doors pull mostly sideways and not downwards, so that the net can be fished at any depth desired. Coupled with sonar (described below) to find strata of fish, it is possible to catch fish which were unavailable to any of the gear described above (such as hake at certain times). This is a technologically sophisticated type of fishing requiring both electronic equipment and training in how to use it.

d. Fish Detection

It is sometimes surprising to landsmen that fish do not live everywhere in the sea, although they take the differences between forests and deserts for granted. Since fish are not evenly distributed, one of the more important skills of a fisherman is to find fish. This has been done in the past in many ways, not the least of which is the try net - a small version of the larger gear which involves less work and less cost in case it gets damaged than putting down the standard fishing gear. Much exploratory fishing with a variety of gear has been done by various governmental agencies in just this way. However, most commercial fishermen prefer the bird in the hand, rather than the possible two birds in the bush, and commonly fish on known grounds year after year, rather than seeking new grounds. Even then, fish finding skills are important. Most cues, such as the presence of birds or the color of the water, are learned by trial and error. Sometimes the fish to be caught can be seen. Visibility into the water is improved by height, so the masthead lookout is an important part of some fisheries. An airplane flying at about 1,500' altitude with radio contact to the boats is very effective in the menhaden, anchovy, and tuna fisheries. In most LDC's, local artisanal fishermen would probably be teaching foreign experts about how to find fish visually and in relation to local conditions.

The use of sonar for fish finding is still developing. It began during World War II, when pulses of high frequency sound were used by surface craft to find submarines. Continued refinement and increased sensitivity led to fish detection.

The continuing problem with both the research and the fishing efforts has been to place the net reliably at the same depth as the sonar shows the fish to be. There have been a number of solutions attempted to this problem, none of which has been completely satisfactory. However, sonar as a fish finder makes an excellent exploratory tool when used in conjunction with another kind of gear which can capture some of the same fish for identification. The United States has considerable expertise in its use, and it is possible that the United States could help find and evaluate new fish stocks for LDC's rather than teach them how to do it themselves. LDC's should probably not be taught to use sonar until they have developed considerable fishing technology. This is in contrast to most other areas of technology transfer, where the objective has been to work with LDC's and eventually to make them independent of foreign aid. Similarly, if there are fisheries resources within an LDC's 200-mile jurisdictional zone that require the use of sonar to capture in commercial quantities, then it could be argued that the right to harvest this resource probably should be licensed or otherwise grant to a technologically advanced nation. It is unlikely that LDC's would be capable of harvesting it for themselves very soon.

G. Fishing Boats and Fishing Operations

1. Overview

At one time artisanal fishermen were the only kind of fishermen - operat from small boats, providing fish for their family or village, fishing close t home. All of their catch was either used fresh or was cured primitively. Almost always, some kind of boat was involved, the design and construction of which was intimately related to local waters, local fishing gear, and local skills and building materials. Things changed as markets grew, processing capabilities enlarged, more distant fishing grounds were depleted, until the largest piece of modern fisheries technology afloat today is the distant-water fishing fleet with side- or stern-ramp trawlers supplying a factory mothership, which processes their catch and which can stay at sea for months and fish anywhere in the world. Along with these extremes of size, there are also great variations in sophistication and production efficiency, with the latter not necessarily proportional to size. While reviewing some of these many variations, we will point out where relatively small additions from the United States fishing methods to the existing local technology could make large differences in fish production, especially that which contributes to human food supply, rather than trying to make every LDC the instant owner of a maximally-sophisticated fishing fleet.

2. Artisanal Fishing

A very simple artisanal fishing operation might consist of a dugout canoe, one or two men, and simple fishing gear, either hook and line or small nets. In Ecquador, for example, such boats are still in regular use, fishing for fresh fish in the Guayas River in Guayaquil, with the catch delivered to the municipal market for sale. The same dugouts are also used along the seacoast for handline fishing and for a tangle-net (using rocks for weight, polypropylene fiber net, with floats of scrap styrofoam, an interesting mixture of old and new materials) fishery for spiny lobster. They fish out of slightly protected bays (not launched through the surf as is necessary in some areas) and sell most of their catch locally, although some of it may find its way the 120 miles to metropolitan Guayaquil. However, dugouts have their problems, and the beginning of a trend to replace them with similarly-shaped boats made of planks can be seen. One difficulty is that dugouts tend to crack and leak as this huge, single piece of wood is repeatedly wetted and dried. In one coastal cooperative, it appeared to be one old man's job to crudely drip hot tar into these cracks - thus upkeep was an expense, even though the original cost of the dugout may not have been much. Further, dugouts are heavy and round-bottomed and do not work very well with outboard motors, while the planked hulls (essentially a long, slim, flat-bottomed skiff) which are beginning to replace the dugouts, plane with a 20 hp outboard and are much lighter to handle on the beach. In the same coastal area, other fishermen are using about 24' and 30' sailboats, constructed right there on the beach, to fish in the same area, but a little farther offshore and for different species. The point to this story, as far as technology transfer is concerned, would appear to be that the fishermen using the dugouts were doing so by choice and/or necessity, so that if their situation was to be improved, what they needed was a better dugout, not something totally different.

An example of a slightly more advanced (technologically) artisanal fishery can be seen in Valparaiso, Chile, in which the basic fishing boat is either a 7 meter or a 9 meter long surfboat (bongo). A considerable evolution in technology could be seen in looking at their boats. The older boats were narrow and tippy (had high deadrise), which made them seakindly and easy to row. Then the heavy-duty Swedish outboard motor (12 hp) was introduced and a small transom for mounting it appeared, but the boat was still basically the same below the water line. The newer boats became wider and flatter amidships to perform better under power (also to carry larger gear). The transom became a little wider to accommodate the motors more easily, but the boat remained basically a double-ended surfboat, because it was still taken through the surf under oars.

Small one-, two-, or three-man boats operated on a family basis are widespread in the world fishery and are found in both LDC's and developed countries. In developed countries, the boats are usually provided with powered facilities for net or line handling and often proper storage areas for fish and ice. Moreover, the small boat fisheries in developed countries usually feed their catch into a well-defined commercial marketing system which expects high quality. LDC artisanal fisheries are most often characterized by minimal mechanization, poor expertise in fish handling, a poorly organized marketing system, and low quality products. The common feature is the small scale of the fishing effort by individual boats and the one-day type operation. However, it should be noted that day fisheries account for a large part of the fresh fish supply in many countries.

The United States has an unusual amount of expertise in the small boat fishery area and this is perhaps not recognized. Many of our fishermen own their own small boats and operate them single-handed or with one crewman, oftentimes a family member. They may be outboard powered or may be highly sophisticated, hign-speed inboards. The term "Yankee ingenuity" appropriately describes the wealth of gadgetry built into these boats to improve their fishing efficiency in a great many ways. When people describe the United States as a backward country in terms of fishing, they are talking about our lack of large, modern draggers and seiners (excepting tuna seiners), but they forget about some of the many fine smaller boats such as trollers, gillnetters, small seiners, and small trawlers, which we produce. These boats contain a wealth of technology which should be readily transferable to LDC's, provided that one selectively chooses those segments of this overwhelming richness in technology which fit the given situation being considered.

3. Middle Sized Boat Fisheries

Until 10 or 15 years ago, the middle sized fishing vessel, including trawlers, seiners, and in a few special cases (halibut and cod) long liners, was the backbone of the fishing industry. The boats had a 3 to 7 man crew, could go to sea for a few days, and could handle the largest types of gear commonly made with cotton twine. The catch, if not delivered ashore each day, was commonly iced. Most were constructed of wood, and improved technology in gear and fish-handling equipment was added or adapted as it came along.

In the United States, while many boats were updated, the oldest boats often were not replaced and are approaching obsolescence. To this extent, some segments of the United States fishing industry are underdeveloped.

Ownership was as varied as the fishery - sometimes the boat would be owned by one individual who would hire crew; more often it would be owned by a family and fished on shares. Sometimes it would be owned by the processing company who would either hire a skipper and crew outright or lease it to them on a share basis, with a certain percentage for the company. Also, individually-owned boats might contract to fish for a given company for a fishing season at a prearranged price. The Pacific halibut fishery was an unusual case in which the fishermen and vessel owners set up their own cooperative marketing and processing plant ashore. The results of this kind of steady evolution are well documented in FAO and other publications.

A good deal of the technology of middle-sized fishing boats has already been transferred to LDC's by the commercial industry. Thus, in Chile an informed visitor is struck by the similarity of fishing boats to those of the Pacific Northwest. This is due to effective and profitable technology transfer by at least one Seattle-based shipbuilding and fishing company. The vessels have been slightly modified for working in the local waters, but show their heritage quite clearly.

There has been considerable development in the design of middle-sized multi-purpose fishing vessels in recent years. Such craft have the ability to fish a variety of gear aimed at different types of fish. They present an attractive alternative for LDC's, as opposed to extensive building of single-purpose vessels. Unfortunately, to be most effective, such vessels require a reasonably high level of mechanization and skillful crews able to maintain and use the relatively sophisticated equipment. This further points up the need to include training as a major component of any technology transfer program.

4. Distant Water Large Boat Fisheries

A recent development in the area of fishing vessel development is one in which the United States has been essentially nonparticipant, except for our distant-water tuna fisheries, with the giant trawlers serviced by factory ships. These fleets have been appearing with increasing frequency off foreign shores in the last 10 years or more, beginning perhaps first with the whaling industry and then transferring to the bottom trawling sector and growing in size - trawlers up to 240' and factory ships over 400' in length. The major fleets are Russian and Japanese in origin, though Europe, Korea, Poland, Cuba and other areas or countries are involved in such operations. This kind of fleet operation, with its heavy capital investment, is not something that the United States either can or should be offering to LDC's as technological assistance, except, perhaps, insofar as management of stocks being fished by such fleets in waters adjacent to LDC's is concerned. Only when an LDC wants to fish and has no new fishing grounds locally, does it need distant water fleets. This is the case with Taiwan and Korea.

5. Problems and Potential for Technology Transfer in Artisanal Fisheries

The previous discussion of fishing emphasizes artisanal fisheries (using the broadest sense of the term). Some discussion of the sociological and economic viability of these fisheries seems in order, because the general trend in most major fishing nations appears to be toward larger, more highly mechanized fishing vessels. Based on published comments in various FAO publications, even the experts do not agree. Von Brandt says that canoes (any of a great variety of small dugouts and planked boats which are long and narrow) must eventually be replaced by more efficient vessels and therefore should not be promoted. Both Traung and Heath say there are hundreds of thousands of canoes in developing countries and that canoes will be important in various forms for at least the next hundred years. Hard data to support either of these points of view are fragmentary.

Royce's textbook (1972) gives a general idea of the catch to be expected from different kinds of fishing gear and technological sophistication (Table 4). The estimates fit any specific situation only approximately, but are of the correct order of magnitude. For example, in an FAO report on artisanal fishermen in Nigeria in 1970, there were about 5,000 seagoing canoes and about 48,000 river/lake canoes, using about a dozen different kinds of gear and landing a total of 12,500 tons of marine fish and 16,500 tons of freshwater fish. This meant that the 14 percent of the fishermen who fished from the seacoast landed 39 percent of the catch at a rate of about 1.5 tons/man/yr while the inland fisheries landed only 0.6 tons/yr/man. In another report on Ceylon (now Sri Lanka), an 11-ton, 36 1/2 foot powered boat could catch 700 lbs of mullet or 1,600 lbs of shark per day of longlining. If these boats were two-man operations, which fished 240 days a year, then it works out to about 8 tons/man/yr and 18 tons/man/yr, respectively. These boats could also operate small otter trawls, with the catch being somewhere between the two listed above. Incidentally, this was a very successful FAO project in boat design - there are now about 400 of these vessels in regular operation in Ceylon. Thus, Royce's estimates seem to fit the two specific examples within plus or minus 50 percent.

Japan, one of the major fishing nations and a technologically advanced country, has a major small boat fishery. In 1967, Japan had about 350,000 small, wooden fishing vessels and was experiencing the same problems as the United States - lack of suitable lumber, rising labor costs, and lack of skilled workers. However, the vessels of 3 to 5 gross tons (GT) were considered even then the main producers of the coastal fisheries. Most of the intermediate-sized vessels of 5 to 10 GT had been replaced, however, by larger vessels of 20 to 30 GT, which were more efficient. At the 40 to 50 GT sizes of vessels, the operations were highly capitalized, using hired crews.

Of the fishing enterprises (I assume this to mean a single business entity regardless of size), 213,000 were in the coastal fisheries and only 8,400 in pelagic (offshore) fisheries. There was an increasing trend toward reduction of the number of enterprises in both categories at a rate of about 5 percent/yr. with no reason given for the trend, but one might guess at a combination of factors, such as obsolescence, large companies buying up small ones, some of both kinds going out of business, sons not following their fathers' trade (this was noted as a marked increase in the average age of the fishermen), and increased cost of labor. The catch landed by each size of vessel was not given. However, the fact that a basically artisanal fishery, even though mostly motorized and with some technology apparent, could compete effectively in the same country with one of the more modern fleet-type operations, should be some indication of its worth.

FAO reports, which give details of specific projects to improve artisanal fisheries in India, Ceylon, Mexico, Thailand, Uganda, and other countries. provide insight into the problems faced by artisanal fishermen and the kinds of help which are effective. The following comparison between Peru and Thailand, using both FAO and in-country sources of information, is an example of the diversity of artisanal fisheries in LDC's.

6. <u>Peru and Thailand: A Comparative Case Study</u>

Both Peru and Thailand are generally classed as LDC's in fisheries, and both have very large fish catches. Beyond those similarities, their differences illustrate the problems in attempting to transfer marine technology from too generalized basis.

Looking only at the total fishing landings of Peru and Thailand for recent years, it is clear that both rank high among the world's fishing nations. Peru ranked first for several years while the anchovetta catch was at its peak, but has slipped considerably. Thailand has climbed in the catch statistics steadily since the early 1960s. Their ranks as of 1972 are shown in Table 6.

The major points for which roughly comparable data were available are shown in Table 5. There are a number of gaps in the tabular data - either the data were not available or were not available in comparable form. Some additional comments are included to cover outstanding differences not suitable for tabular presentation.

Both countries have about the same number of vessels in their food fisheries (excluding anchovetta boats), and recent increases in their total catches have resulted in large part by adopting moderate-sized (35-75 foot) modernized fishing vessels. Thailand, however, has extensive shallow-water areas where trawlers can work profitably. Thus, most of its recent catch increases have come through trawling. Peru, on the other hand, has a narrow continental shelf and little trawling area, and so most of its modernized expansion has gone into purse seining. Both countries have artisanal gill-net fisheries of considerable size, perhaps reflecting the fact that gillnets can be handled more effectively out of smaller boats and with less capital investment than either trawls or purse seines.

Both countries have large artisanal fisheries. In Peru it is relatively safe to say that any boat outside of the anchovetta fishery is probably artisanal, because the Peruvian government has chosen to develop the fish meal industry largely to the exclusion of any other segment of their fishing industry. Thus, it is not surprising that less than half of the fishermen catch more than 98 percent of the catch as anchovetta and make a relatively good income compared to the artisanal fishermen. Even noting that the figure given in Table 5 may not be realistic for the artisanal fishermen's earnings, the comments in the reports of the Peruvian government point out a large disparity between the standard of living of the two kinds of fishermen. In Thailand, it is less clear who is an artisanal fisherman and who is not. The Thai government has a fisheries development program operating at several levels, which seems to have upgraded fish production all along the line - fishermen who used to fish alone now have slightly larger, powered vessels and may hire a crewman, etc., and so status is changing. Still, in 1967, the great majority of their fishermen (70 percent) were defined as artisanal. No value was placed on the Thai artisanal catch because it was too dispersed for reliable statistics, but FAO reports implied that the Thai artisanal fishermen ranked similarly in socio-economic status with their more modernized co-workers.

The most striking difference between the two countries is in the disposition of the catch. In Peru, most of the catch is used for fish meal and oil, while most of the catch in Thailand goes for human consumption, and only about one-sixth goes for fish meal. Further, Peru exports nearly 80 percent of its fish meal (about 6 MMT at the peak of production), while the major export from Thailand recently has been frozen shrimp (0.054 MMT in 1970). Nearly half of the Thai catch is listed by FAO as "Misc. Species," which might be a large catch of scrap fish going into fish meal or other low-value products. But upon closer examination, one can see that the Thai people eat a lot of fish and shellfish of a wide variety of species. Some of the less valuable fish in Thailand go into a fermented fish paste, which is very popular there, for which there is no comparable product in Peru. Per capita consumption of fish in Thailand is approximately 25 to 50 kg/person/year. In Peru, of that part of the catch eaten by people, half is consumed in metropolitan Lima (13 kg/person/year), while the rest of the country has a much lower per capita consumption of fish (3-6 kg/person/year).

From this disparity between urban and rural fish consumption, one can assume that Peru has a distribution problem outside the major metropolitan areas, complicated by the geography of the country. Similar problems occur in Thailand for marine fish, but inland people are supplied with locally-grown freshwater fish. Thailand is a wet country, with considerable aquaculture present and even more possible, while Peru is relatively dry, at least on the west slopes of the Andes. It is noteworthy that recent visitors to Peru speak of a new hake fishery there for human consumption, which utilizes some of the fishing capability now excess to the anchovetta fishery. The hake is frozen into blocks and sold to the United States for manufacture into fish sticks, rather than being consumed locally. Neither country seems to have much capability for marketing frozen fish for their own consumption.

In neither country has the catch been sustainable in their own waters. The anchovetta decline was partly the result of changes in the ocean currents (a phenomenon called "El Nino" there, since it occurs around Christmas time), but was also partly the result of over-fishing In Thailand, most of the recent catch increases resulted from the extension of the Thai fishery into the waters of South Vietnam. Thus, one area of U.S. expertise which possibly could be useful to both countries is attention to the problems of over-fishing. The general inabilities to deal with this problem in the United States have been primarily political problems rather than technical ones.

Thailand has extensive potential for estuarine and freshwater aquaculture and a long history of practicing it. Thailand already has about 9,500 hectares producing fish and shellfish, with an estimated potential of an additional 150,000 hectares of mangrove swamps and other wetlands which also could be developed. The Thais need assistance in learning to spawn their cultivated species - most are now captured as wild larvae or juveniles and then reared - and in controlling diseases. Peru, on the other hand, has little background in aquaculture and little water on the west slopes of the Andes with which to practice it. Northeastern Peru, however, contains two major branches of the upper Amazon River and might hold potential for aquaculture. Peru's neighbor to the north, Ecuador, is now developing oil resources on its own eastern Andean slopes, although with considerable difficulty. Everything is flown through the mountain passes into jungle landing strips at great cost and hazard. Only a highly valued fish product would be worth flying back to the population centers on the other side of the Andes. Another possibility is the culture of salmonids in the high mountain streams of Peru, where the water is cold enough - this is now being done in Colombia Again, this produces a high-priced product which only the rich minority can buy. Development depends, in part, on who one is trying to help or feed.

Some economic data for aquaculture in Thailand might provide some incentive to other LDC's. With a wide range of sizes and types of aquaculture operations in Thailand, the income is from $300 to $1,500 U.S./yr/operation (not per person), with mussel cultivation producing the most tonnage (presumably including the shells), being the most dependable from year to year, and being the most profitable.

Government policies aggravate the differences between the two countries. In Thailand, artisanal fishermen have had low-interest loans, port development projects, distribution and marketing support, and many other smaller forms of assistance and motivation. Development has been steady and broadly-based. In Peru, almost all of the effort has been put into the anchovetta export fishery, with the stated objective of producing dollar inflow into the country. Development was rapid and temporary. The artisanal fishery has been largely ignored and left to its own resources. Its percentage rate of increase annually has been comparable to that of Thailand (Table 5), but the quantity of fish for human consumption is much less. Thus, local government must also be a part of any program in technology transfer and assist in developing realistic and clearly-defined objectives.

To summarize the role of the artisanal fisheries in the world fishery picture, then, it appears that they can still exist, even in direct competition with major fishing fleets in technologically advanced countries and can contribute even more significantly in LDC's, depending on local circumstances. The process of aiding artisanal fishermen to increase their catch, improve their boats and working conditions has had mixed success and failure, at least as far as reported by FAO. The examples given indicate that there is still considerable room for technological improvement in the artisanal fisheries of LDC's, but that one should proceed cautiously when attempting to achieve such a transfer of technology.

H. Recreational Fisheries

Development of recreational fisheries is of debatable interest for overseas work. In one way, this is a part of the tourist industry, rather than the fishing industry. On the other hand, the salmon catch off the Washington coast last year was larger in the recreational sector than in the commercial troll fishery. In terms of dollars and jobs generated, the recreational fishery in Washington is perhaps 20 times more valuable than the commercial fishery, and most of the fish still end up being eaten by people, even though this may be an inefficient way to catch fish. Mexico is beginning to recognize this potential and has some charter boats in heavily-travelled tourist spots such as Mazatlan, Guaymas, Baja California, and Acapulco. The whole objective of the fishery, of course, is to provide sport and to cater to the sport fisherman's whims, during the fishing as well as the rest of the time. The tourist pays the same whether he catches anything or not, although if there never was any catch, it would be difficult to attract fisherman-tourists.

A number of LDC's have begun to recognize their potential as tourist attractions on the land - why not recreational fisheries? Many of them have the potential for it, and the United States certainly must be one of the major nations in developing recreational fisheries. Most universities have some kind of sport fishing oriented program if they have any fisheries program at all. Thus, the expertise is readily available.

III. THE PROCESSING SECTOR

A. On Board Ship

Handling and processing procedures begin with capture of the fish, the equivalent to the slaughterhouse stage in processing of land animals. A few species, particularly crab and lobster, may be held alive on board the fishing vessel in special sea water wells or tanks, but most are killed or allowed to die on deck. Except in the most primitive fisheries and in the special case of day-fisheries for industrial fish (e.g. Peruvian anchovetta or North American menhaden), some treatment is given to the fish to reduce the rate of spoilage. In most cases this involves chilling, frequently by use of ice or sometimes refrigerated sea water. Chilling is particularly effective in preserving fish caught in warm tropical waters, but ice is often difficult to obtain or very expensive in tropical areas. Moreover, there is a problem of protecting the ice itself from melting on the voyage to the fishing grounds. This is a major problem of the smaller-scale tropical and sub-tropical fisheries, and there is real need for the development of a cheap technique for short-term preservation of fresh fish under high temperature conditions without the use of ice or refrigeration. Fish may or may not be eviscerated (gutted) at sea. In most cases, this is a desirable practice for preservation, but there are situations where gutting can be harmful to the product. Practices vary according to experience.

B. Off-Loading and Sale

The fish are brought to port and off-loaded by a variety of means, ranging from simple manual procedures to fairly sophisticated pumping, fluming, or mechanical conveying systems. The off-loading process can damage the fish and foster spoilage where hooks and pitchforks are used and the catch is unnecessarily exposed to a hot sun.

In some countries the fish auction, an intermediate step in the chain of fish handling, occurs prior to processing. However desirable it may be economically or socially, this step is extremely undesirable from a technological standpoint, because it exposes unnecessarily fish to conditions which enhance spoilage. The catches are laid out so that a significant proportion of the fish can be directly seen by the buyers, usually with minimal provision for cooling or protection from insects or other sources of contamination. This is a common European practice, made tolerable there by the relatively low air temperatures, but unfortunately followed in other areas where temperatures make the practice unsuitable and, indeed, foolish. In other countries, a practice of direct sale to the processor or distributor is followed, and in these cases there is minimum exposure of the fish.

In small-scale fisheries, such as the dominant artisanal or day-fisheries of the world, fish may be purchased directly from individual fishermen by the housewife or in small quantities by street vendors who market the product without further processing. Obviously in tropical areas this means the fish must be sold and eaten on the day of landing. Small cooperatives are increasingly being formed among artisanal fishermen, and these organizations may have facilities for butchering and cleaning fish and even refrigerated storage facilities for holding them prior to sale.

C. Fresh Fish and Shellfish

Traditional processing of fresh fish - and it should be noted that close to 30 percent of the total world catch is sold and consumed in the fresh form - involves evisceration, beheading, scaling, filleting, or steaking. Generally, as societies and food marketing systems become more sophisticated, the degree of primary processing increases. Thus, in a simple street market situation the consumer demands and receives whole or whole but eviscerated fish, while at the other extreme of the supermarket, prepared skinless fillets are sold. In the uneven state of development of many so-called developing countries, one frequently finds all stages of this consumer demand range co-existent with different branches of the fish processing (and sometimes fish catching) industry supplying each. Generally, however, there is a progressive trend towards fillets and other prepared products.

Most molluscan shellfish such as oysters, clams, etc. are sold in fresh condition; indeed, they are commonly alive at the time of sale. The principal problem with such products is not freshness, but safety. They grow in and are harvested from inshore, tidal waters, often subject to human sewage contamination, and may carry disease-causing microorganisms. There is need in many developing countries for assistance in developing procedures for ensuring the safety of molluscs as food for humans.

Other invertebrate marine animals such as scallops, sea urchins and abalone, are also commonly marketed fresh, with minimal processing, and they present similar problems to those of fresh fish.

Crustaceans, mainly shrimp, crab and lobster, are marketed in a variety of "fresh" conditions. Lobster and crab are either sold live or, after a preliminary cooking, as chilled products. They cannot be held dead without cooking because of intrinsic instability caused by enzymes. Shrimp and prawns are certainly more stable after cooking but may be sold in the "green" condition, sometimes whole, sometimes "headed" (and eviscerated), and sometimes fully peeled. However, world market demand and prices for crustaceans are so high that most crustaceans caught in developing countries are processed further for export. In fact, nearly 50 percent of world shrimp production is exported.

D. Further Processing

Further processing of fish for human consumption includes a large variety of techniques of varying degrees of technological complexity and sophistication. Traditional processes include drying, salting, smoking, and fermentation, while the more modern techniques of freezing or canning account for the bulk of the processed fish. It is often difficult to categorize precisely a process under a single descriptive head, since traditional processes may be followed by modern techniques or modified through recent technology, or a combination of techniques may be applied. Examples of these types of situation include: smoked fish which are then canned; fish sauce production, using enzymes to replace or supplement the natural fermentation, followed by canning of the product; canned tuna which is prepared from fish which are frozen at sea.

1. Freezing

Freezing, though the most recent of the processes to be used generally in the fish industry, now accounts for the largest proportion of fish for human use (16 percent), after fresh fish. The percentage increase in frozen fish as a component of the total fish production quite closely matches the decline in traditional "cured" products. In the period 1966 to 1971, frozen fish went from 12.1 percent to 14.8 percent, while cured fish went from 14.3 percent to 11.5 percent. The extent of the increase in frozen product production has varied considerably from country to country in the last decade and appears to be related to two factors, the degree of urbanization and related technological development in the country and the importance of the export market. This is understandable because frozen products can only be successfully marketed where proper facilities for their distribution and retail are available. This requires cold stores and freezer facilities in the markets, at least. Obviously where conditions do not exist to support such facilities, the export market provided by developed countries is the rationale for freezing seafoods. Fish may be frozen whole, or eviscerated and beheaded, or as cut sections, or as fillets individually, or compressed into blocks. They may also be minced or comminuted and frozen in blocks in this form, or converted by a variety of processes into new products which then are frozen.

There has been a tremendous increase over the last decade in production of so-called portions and fish cakes. Such products are cut from compressed, frozen blocks of fish flesh prepared from fillets or minced fish and are uniform in size, shape, and quality. They may be breaded and even cooked prior to refreezing and packaging. This development has enormously increased world demand for frozen blocks prepared from white-fleshed fish. The technology of block production, particularly from minced fish, is quite sophisticated, and developing countries seeking to compete in the world market for blocks usually need technological help. Minced fish technology is a relatively new development, though based on a somewhat older Japanese technology, which could be important in developing countries because it provides for immense reduction in waste. This topic will be discussed later.

A relatively small amount of fish is frozen, and even less processed and frozen (mostly on European, Russian, and Japanese factory vessels) at sea. Nations engaged in distant-water fisheries have increasingly equipped their vessels with freezing facilities so that the catch may be returned to the home ports in good (edible) condition. Usually on such vessels the fish will be frozen whole or after evisceration and beheading and thawed on landing, prior to further processing. Examples of this include the U.S. distant-water tuna fishery, where fish are frozen at sea for later reprocessing and canning onshore, and the European Arctic cod fisheries, where cod is frozen as whole fish blocks at sea, thawed out, and reprocessed for the fresh or frozen fish market in the home country.

The bulk of fish freezing takes place in freezing plants onshore using fresh-caught fish. Some freezing of whole fish or eviscerated, beheaded fish destined for subsequent reprocessing does take place in shore plants. Considerable quantities of frozen tuna loins are prepared in this way and shipped to canneries, often in distant countries. Halibut and salmon are similarly frozen, both for later canning and for distribution to retail centers, where they may be cut and repackaged for sale. However, a major part of freezing is the freezing of prepared fish products. In addition to the items listed earlier, these include crustaceans such as shrimp and prawns (cooked and uncooked, peeled or unpeeled), picked or partly picked cooked crabmeat and lobster, lobster tails and crayfish, and molluscs such as scallops, clams, and oysters. An increasing variety of precooked fish and shellfish products, often compounded with cereals or other nonmarine foods, is also being frozen. Freezing technology is obviously quite sophisticated. There is a variety of freezing methods available, some more expensive than others, each having different applicability within the enormous range of fish products. Moreover, each species of fish or shellfish responds differently to freezing, and even the same species may yield different results when prepared in a number of ways. The technology of freezing fish products is not well understood in developing (and some developed) countries, but there is good expertise in this field available in the United States.

2. Canning

Canning is a much older process in the commercial fishing industry than is freezing; however, it is much less widely distributed as a major process. This is probably due to the large investment needed for tin plate and can manufacture. It is not surprising, therefore, to find that 80 percent of the world's canned fish is produced by Japan, the United States, Canada, the European countries, and the U.S.S.R. Indeed, only South Africa and Morocco, with its long-standing sardine canning industry, appear outside of this group as producing significantly large quantities (40,000 metric tons/year) of canned fish. The dominant types of fish which are canned include herrings, sardines and anchovies (usually all called popularly "sardines"), tunas, and salmon. In addition, specialty products, such as caviar, other fish roes, fish balls, fish cakes, and smoked fish constitute a significant proportion of the total pack.

Crustacea and molluscs are also canned, and here the total world pack is dominated by two countries, with the United States and Japan accounting for 50 to 60 percent of the world pack. Included species are crab (all types), shrimps and prawns, lobsters, oysters and clams and other invertebrates such as squid and octopus (cephalopods).

Small-scale canning operations are not uncommon in developing countries where the product is designed principally for local consumption. Cans are press formed from tinned sheet steel at the cannery and, while perfectly adequate, are not of a style widely accepted in international trade. Intermediate-scale canning enterprises in developing countries may be run quite well. However, canning process times are often (indeed usually) excessive, and equipment is often not used to full advantage. Such plants frequently seek to export some of their production to the United States and other developed countries. New regulations recently promulgated by FDA will require plants in exporting countries to meet the requirement that trained (certificated) supervisors be on hand during processing of low acid foods (includes nearly all fish products). A number of U.S. universities have been involved in presenting certification schools for U. S. industry personnel and could probably assist with such schools in other countries. Additionally, the small-scale canneries badly need expert technical help and advice, and this is certainly available through University Advisory Services.

The condition of large-scale, mainly export, canneries in other countries is not universally good. However, such enterprises usually have funding to hire their own experts and are, in any case, frequently directly competitive with U.S. businesses, so that aid, based on tax-generated public money, would not seem appropriate here.

3. Curing

Somewhere between 11 and 12 percent of total fisheries production is processed by the traditional processes collectively referred to as curing. In most cases, these involve drying or salting to stabilize the final product. However, smoking, which was originally designed to provide color and flavor to dried (while smoking) products, has increasingly become a flavoring process, and many smoked products produced in developed countries must be held under refrigeration or canned after smoking to provide product stability. Nevertheless, sun (really "air") drying and smoking are still important village industry level preservative processes for fish in many developing countries. Production figures on a world scale and in terms of individual countries tend to indicate, however, that the demand for traditionally cured products diminishes as society develops. This is understandable, not only from a social standpoint, but also technologically. Most traditionally cured products are of poor intrinsic quality, unpleasantly strong in flavor, and frequently partly decomposed. They commonly represent a minimal compromise between the needs for preservation and the inadequate primitive technology. Salting, whether or not coupled with air drying, is still a widely accepted preservative technique. In Southeast Asia, pickled and fermented fish products are produced in quantity and widely consumed. Fish sauces and fish pastes are produced by a natural fermentation of small fish and crustaceae mixed with salt. Large quantities of this type of material are used as condiments and protein additives to other foods, though its high salt content limits its usefulness as a protein source, and its strong flavor restricts its distribution to populations accustomed to it. It is doubtful that there is any particular expertise in the United

States in traditional processing operations. Exceptions to this might include some expertise in smoking and, in a few schools, in some of the Oriental fermentation processes. Mechanization of drying operations and design of small-scale smokehouses for use in primitive areas have been attempted in the past with varying degrees of success, and it is possible that the United States might be able to help in this area. On balance, however, it seems that in most cases, excepting locally-important, strongly traditional products, help to develop more efficient traditional curing processes would provide only short-term benefits unless adaptable to a changing public taste.

4. Newer Processes

Two of the most significant developments in fish processing technology in recent years are closely linked. These are the fish sausage/kamaboko industry of Japan and the burgeoning minced fish-based industry, mostly in North America. Fish sausage, composed mainly of comminuted fish muscle, but with other nutritious substances added for flavor and texture, closely resembles meat sausage and is stable without refrigeration for relatively long periods of time. It is essentially a modern development of the older kamaboko, a washed fish meat paste-like product. The stability of fish sausage depends on the casing material, a heating process, and the use of nitrofurans - antibacterial chemicals whose use in food is not permitted in the United States and other developed countries. This is probably why attempts to duplicate the Japanese process in this country have been unsuccessful. There have been numerous attempts to develop a fish sausage industry in a number of developing countries without notable success, and it is not clear whether this is due to technological failures or to consumer resistance.

To provide the separated muscle tissues needed in sausage and kamaboko production, the Japanese developed machines for separating flesh from the bones and skin of fish. Probably because of the specialized nature of the fish sausage industry, little attention was paid to this mechanical development by the rest of the world until a few years ago. At that time, due to rising prices and pressures of regulatory agencies, the food industry became very concerned with waste recovery, and attempts were made to develop equipment to separate chicken meat from bones and skin in scrap portions. The fishing industry seized upon the Japanese machines as a possible answer to low recovery problems, and after a few false starts began to produce minced fish frozen blocks. The Japanese machines designed for the specific task of producing meat for kamaboko and sausage manufacture were not entirely satisfactory for North American industry needs, and machines produced in the United States now dominate the industry.

The most exciting aspect of the minced fish development is the flexibility it brings to an industry long constrained within traditional concepts of fillets, steaks, and separately marketed species. Running eviscerated fish through a deboner yields a recovery of in excess of 90 percent of the usable protein in the form of a mince retaining the basic fiber structure of the original flesh. In association with more traditional fillet production, the deboners can be used to recover high quality flesh from the "frame" of bones left by hand filleter or machine. Special skills needed for hand dressing and filleting fish are no longer needed. The minced fish can be used directly, frozen in blocks, compounded with other fish or shellfish material, or with cereal or oilseed protein, and formed into patties, cakes, or shaped materials which can be retailed fresh or frozen. Minced fish technology is the beginning of a new direction in fish processing, which must be taken into account in any technology transfer program to developing countries.

E. Fish Meal and Oil

More than 35 percent of the total world fish catch is used for the manufacture of fish meal and oil. Fish meal is used in animal feeds and ultimately reaches the consumer as poultry, eggs, or bacon, but, as pointed out earlier, this is an inefficient way to use animal protein. Pelagic schooling oily fish such as herring, anchovy, and menhaden, which congregate in enormous numbers and are easily captured by purse seines, are most commonly fished for meal and oil production; however, some abundant species of low-fat fish such as hake are also fished for meal. Fish waste, spoiled fish, and scrap from large-scale processing such as tuna canning are also used to make fish meal.

There are several schools of thought on the desirability of using fish to make meal and oil. One theory is that it is economically desirable for Peru, for example, to sell fish meal on the world market to produce an inflow of hard currency. This is supposed to improve the food supply in

Peru by improving the general standard of living and national buying power. One informed observer said that the most conspicuous change in Peruvian buying during the rise of the anchovy fishery was an increase in the number of TV sets, with little change in food. Another point of view is that if a man prefers to eat chicken (or beef or cultured salmon) rather than herring, then using fish meal to grow more chickens is desirable, since he probably would not eat the fish meal or any product derived directly from it anyway. There is much anecdotal information on the importance of food preferences, both pro and con, but the degree of benefit certainly depends to an extent on the price and availability of the fish meal and the resulting chicken. Our point of view is that many people in the world are already jobless and protein deficient, and any way that we can directly influence this favorably should be given a high priority.

Fish meal is most commonly produced by the so-called wet rendering process. The fish are cooked in a steam cooker to break up the tissues and liberate oil and water. The cooked fish is then pressed, releasing most of the oil and reducing the water content of the pressed material. The oil-water mixture is run through screens and centrifuges to separate off solid material (which is added back to the cake), water, and oil. The oil is purified and sold for a variety of uses ranging from paints to margarine. The water, containing dissolved nutrient materials, is concentrated by evaporation and sold as fish solubles, which are used in some animal feed formulations. In small plants, all or some of the solubles may be sprayed back onto the cake for drying. The fish cake coming from the press is dried in what is essentially a hot air drier to a final water content of about 8 percent and fat content of 8 to 13 percent. The material thus normally contains more than 60 percent protein. Driers vary considerably in size and also in design. Large rotary flame driers capable of processing 200 tons of fish per day are common in the large-scale industries of Peru and Chile, while small steam-heated driers are common in plants drying fish or shellfish waste. Investment costs vary accordingly. Generally fish meal plants require little labor to operate but do require technically trained people. They are usually not economical unless there is a good supply of suitable cheap fish or fish waste.

In recent years newer processes for producing protein concentrate, often for direct human use, have been developed. The best known of these are the organic solvent processes for producing fish protein concentrate (FPC). However, other processes involving enzyme digestion or aqueous separation of protein have also been described. Some of these processes may provide for conversion of "industrial" fish to human uses in developing countries. The enzyme digestion process seems particularly adaptable to conditions in developing countries.

Because of the strong demand for fish meal on world markets, fish meal production is usually large-scale business with sufficient capital to hire good technical and economic back-up if it is not already available. The industry is quite capable of dealing with most of its own problems.

Reduction of offal to fish meal is one method for dealing with fish processing wastes. However, meal operations are not economic for small fish plants or for plants operating for short seasons in remote areas. Moreover, the fish meal operation only deals with solid wastes. Fish processing plants generally use a considerable amount of water, which they customarily discharge into adjacent waterways. This waste water is more or less heavily loaded with dissolved or suspended fish waste material which pollutes the water into which it is dumped.

Unfortunately fish plants tend to be clustered around the waterfront area of fishing ports, frequently situated in bays and inlets. Pollution of the harbor area waters can thus become a serious problem. The self-multiplying nature of this problem is not well recognized in most developing countries, where such situations are commonly dismissed on the basis that they only have aesthetic significance. This is unfortunate because it is in the early stages of development of an industry that corrective measures can most easily be taken. Indeed, an adequate water supply for processing is commonly difficult to obtain in developing countries, and correction of the waste problem by reduction of water use or, ultimately, closed loop operation involving water reuse would greatly help improve efficiency at minimal cost. A number of systems for dealing with waste from fish processing plants are now being worked on in the United States.

F. Structure of the Industry

The structure of the industry is extremely diverse, ranging from the giant vertically integrated fishing companies of Japan and Europe to the artisan canoe (dugout) fisherman of Africa or Latin America. In the truly integrated system, a single company or corporation owns and operates a fishing fleet, icing, and boat-supply operations, processing plants, and sometimes retail operations. A number of such companies, mostly European and Japanese, have integrated operations in developing countries. There are also some examples, but on a small scale, of vertically integrated fishing companies domestic to developing countries.

In situations where processors are dependent on constant and sufficient supplies of raw material such as in fish meal production or sardine canning, processors will not infrequently own and operate their own fleet or contract a fleet on a seasonal basis. Contracts, usually short-term, are a common feature of fisherman-processor relationships throughout the world, since a processor must be able to anticipate enough raw material supply to meet his market. Payment to fishermen is most commonly based on a salary plus a share of the catch profits. The system may be quite complex, involving different proportional shares for skipper, owner, mate or deck hand. In systems where sale of the catch is on an auction basis, especially when the catch is auctioned in parts, the income of fishermen can fluctuate very widely. The simplest system is one in which the fisherman sells directly to the consumer or to a retailer.

The fishermen's supply industry is a more or less important component of the total fishing industry, depending on the size, type, and number of boats involved. It may include boat building yards, engine shops, gear manufacturers and suppliers, ice makers, marine instrument makers or ship chandlers. It is not uncommon in developing countries to find the processor acting as the supply agent for many of these needs. Supply of ice to boats is almost always a service of the processor. However, net and gear repair and routine engine maintenance are frequently performed by the fishing crew. There is strong need for some training assistance in this sector. Engine maintenance and gear repair constitute a particular problem in small fisheries in which modern methods have just recently been introduced.

The processing segment of the industry is extremely varied in size, capitalization, complexity of operations, and manpower employed. As might be expected, the smaller plants usually engage in preparing fish or shellfish for a fresh fish market, and in traditional curing processes, most are labor intensive. However, some of the larger operations in developing countries do use quite large labor forces because processes are done by hand rather than by machine (e.g. filleting, shrimp peeling) or because the nature of the operation requires hand operations (e.g. shellfish shucking). At the other extreme there are large fish plants in developing countries which are mechanized to a much higher degree than is normally the case in U.S. fish plants. Such installations are found in countries where government policies provide strong investment incentives to build fish plants or where an overseas company from a developed country has moved into the local fishery in the last few years. Unfortunately such plants are often built to a capacity which exceeding the local supply of raw product and sometimes are run at less than peak efficiency because of inadequately trained and inexperienced personnel.

There are many parallels between the U.S. fish processing industry and that in developing countries. For rather different reasons, development and modernization are unevenly distributed in both cases. Within a single fishery, it is common to find both in the United States and abroad unmechanized and highly mechanized processing systems. Moreover, it is not unusual to find this mixture within a single plant, such as a hand filleting operation supplying a modern nitrogen (cryogenic) freezer.

Smaller and most medium-sized plants are fresh fish plants, or canners, or freezers, or curers, dealing with only a single process. Larger plants may also only have a single primary process, especially when production is seasonal and large. Thus, fish meal and oil plants produce only meal and oil, and tuna canneries mainly canned tuna. Large-scale operations involving fish processing usually result in considerable generation of fish waste. Consequently large canneries and freezing installations frequently have a small fish meal operation associated with them. There has been a tendency, supported by government action, to develop multipurpose fish processing plants in developing countries, and we have seen the same trend in the United States as a consequence of the consolidation of fish processing operations within large companies. This reduces the seasonal or species dependence of single process operations and permits more economical use of facilities by year-round operation. It also tends to produce a more stable food supply and more certain job stability for employees, both important factors in developing countries. However, versatility of operations requires versatility in management and technology, which is not always available in developing countries.

Fish and fish products are distributed through many different marketing systems. Fresh fish generally moves within local markets, limited by the perishability of the material. The advent of air transportation for fresh fishery products of sufficiently high intrinsic value to justify the expense (such as lobster, crab, salmon) has changed this pattern somewhat, but not on any massive scale. Traditionally, fresh fishery products are marketed through fish vendors, fish markets, and fishmongers. The increasing diversion of food marketing to supermarket type operations in urban areas has changed this pattern, increasing demand for prepared fish products such as fillets and de-emphasizing whole or partly butchered fish sales.

Frozen seafood products are mostly distributed to and retailed in urban areas where frozen storage facilities exist. Attempts have been made to utilize a regional network of cold stores to distribute frozen products to be finally sold as "fresh" products in local markets in developing countries. It is not known how successful this process has been. This system is used in many European countries where fish is landed in the frozen state and thawed prior to processing for retail sale. Enormous quantities of frozen seafood products move in international trade, mostly destined for markets in the developed countries. The patterns of such movement are complex and sometimes unexpected. Thus, pollack is caught in Alaskan waters by Korean fishermen, processed in Japan, and shipped back frozen to the United States to be reprocessed into breaded fish portions for the U.S. market. In this type of trade, the developing country participation is most commonly in the relatively labor-intensive processes of catching and primary processing.

Canned and traditionally cured seafood products are relatively stable and consequently are mostly distributed through regular food retail channels.

Surprisingly, six LDC's ranked among the top 13 countries by fish catch in 1972 (Table 6). This suggests a much greater potential for processing industry development in these countries than has been achieved and, concomitantly, a larger role for fish in the commonly protein-deficient diets of the population. Most processed seafood products prepared in LDC's are destined for "protein-rich" developed countries, and this represents a large net loss of valuable protein. Worse, much of the LDC catch is reduced to meal for animal feed - again for export to developed countries - causing a protein drain and yielding minimal cash return. This is illustrated by data in Table 7. For the countries listed, the average calculated value of the catch was about \$200/metric ton. Five countries showed values of less than \$100/MT. All of these were major fishmeal producers, and four were LDC's. Above average values are found for a few LDC's with large total catches, including India, Thailand, and the Philippines, and in these cases fish and shellfish are overwhelmingly destined for human food. Of course, high value export products such as shrimp also played a role.

G. Fish Consumption and Acceptance

Fish consumption on a per capita basis varies widely throughout different countries of the world. Thus, Iceland, Japan, and Norway, traditionally fish-eating countries, consume 86 pounds, 68 pounds, and 45 pounds respectively (1971 statistics), while the United States consumes about 11 pounds.

For centuries, governments have tried to increase fish consumption by their populations. In recent years such efforts have been directed primarily towards conservation of meat supplies, minimizing import needs and, of course, trying to deal with the serious problem of protein malnutrition, which has been estimated to involve two-thirds of the world population. Considerable difficulty has been experienced in many areas in persuading people to eat more fish. Frequently this has been because fish is foreign to the diet of the people concerned, and people tend to be conservative in their food habits. Another reason is the poor quality and flavor of many fish products made available to them, which produces a revulsion towards all fish. Canned fish is generally well accepted but is too expensive for most people.

The new minced fish technology referred to earlier provides another avenue of approach to the problem. Fish may be substituted for meat in many products up to a certain maximum limit without changing the flavor of the product, and sometimes with an improvement in texture. This is true for sausage or wiener type products which are widely eaten and well accepted up to 20 percent or more of th meat in wieners can be replaced with comminuted fish flesh without change in flavor. This is one example of what can be done and is representative of an approach to marketing problems common in the U.S. food industry known as "product development." Tremendous expertise in this area available in the United States is rarely used in LDC's. A deliberate application of this approach to the problems of fish and seafood acceptance in developing countries might reap rich dividends. A new product development specialist and the marketing person can match a new product to an existing dietary item and nudge the public towards acceptance of new food materials.

IV. TECHNOLOGY TRANSFER

A. General Considerations

Is technology transfer possible in the fisheries field? Is it desirable? Can it be effective?

Technology transfer is clearly possible, since it happens all the time. Fishermen move from sail or hand powered boats to motorized vessels when they can. U.S.-style combination fishing boats dominate the industrial level fisheries of the West Coast of Latin America, and U.S.-style shrimp boats are beginning to displace traditional boats in Brazilian fisheries. Nylon or polyester nets increasingly replace cotton or other natural fiber gear all over the world. Modern processing technology appears suddenly in fisheries of developing countries, usually under government pressure. Supermarkets proliferate and the demand for fillets and frozen shrimp increases.

The desirability of technology transfer must be judged on the basis of the consequences flowing from it. Such judgment is often subjective, being based on specific attitudes related to social or political change. Technology transfer which improves life for people of the recipient nation in the short or long term is clearly desirable, and there is, of course, an added bonus (to the United States) if the recipient also shows a friendlier attitude to the United States as a consequence. More specifically, desirable technology transfer might be identified as that which relieves hunger and reduces malnutrition, increases rather than reduces employment, and yet increases productivity and improves the income of the people and reduces or removes poverty. More intangible but important consequences of effective technology transfer might include improvement of self image by an increased self-sufficiency in a technological sense and a better capability to deal with developed countries' societies and people without a sense of inferiority or the frustration which leads to violent response. This might also be stated in terms of making changes which allow retention of important items of cultural heritage, while minimizing unemployment and cash outflow Obviously, no single program of technology transfer in one field such as fisheries is going to achieve all these objectives, but each program should be directed in some way towards their fulfillment. Projects with immediate negative consequences in the social sense (ours, theirs, or both) should be avoided, even though these can be shown theoretically to be beneficial in the long run. Thus, technology, which has the principal immediate effect of replacing manpower with machines, leading to short-term unemployment, is not appropriate for transfer unless an alternative use can be projected for the displaced people and other immediate and obvious benefits demonstrated. Short chain rather than long chain technological change is best; that is, a total program should be designed to proceed in short, achievable stages to an ultimate goal. Each stage should represent a clearcut gain and step forward. Long-term programs that show benefits only after a lapse of several years are too easily dropped, changed, destroyed, or sidetracked by economic or political change in either the recipient or donor countries. Large programs should be built on a series of small projects protected from total failure by their number and limited objectives and providing a number of alternative pathways to the ultimate goal, however that is defined. This is not intended to be an encomium in praise of short-term projects per se. Effective technology transfer requires a long-term commitment and sustained effort on the part of both donor and recipient. The suggestion is that this can better be done through integration of a series of "human-sized" small-scale projects than by attempting to develop enormous multinational efforts in which the administrators rapidly exceed in number the productive workers, and human effects are lost sight of in a (im)purely statistical evaluation of success or failure.

One measure of the effectiveness of technology transfer is its permanence. If a technology persists only as long as the donor is available to maintain it and then is dropped or decays, transfer cannot be said to be effective. Alternatively, if a new technology is entirely dependent on continuous infusions of trained help from overseas, it can hardly be considered it is borrowed, not transferred technology. Effective technology transfer of the capability to sustain the technology. Thus, internal generation of projects and education or training are essential components of technology transfer. However, training itself can be an evanescent thing unless it is self-sustaining too. This implies that such training should be firmly based within continuing institution(s) of a recipient country. Specialized training schools tend to fade rapidly in most cases.

How can these general comments be interpreted in terms of technology transfer in the fisheries industry? Fortunately, because of its intrinsically fragmented nature, fisheries technology is amenable to a piecemeal approach to technology transfer, which can still lead to an integrated program result. Of course it is vitally important that technology transfer within different sectors of the industry be coordinated. Increasing fishing capability so that more fish are landed is not too effective unless provision is made to preserve the extra fish and distribute them to appropriate markets. On the other side, there is little utility in developing new products based on fish if the fish are not available. It is necessary, therefore, to look at the whole picture of fisheries in developing countries, to identify areas of technological need (in the broadest sense) or opportunity, develop possible technology transfer projects for each, and somehow integrate this into a master plan or concept of development which will fit the parts together.

Transfer of technology involves people as well as machinery or management systems. Most effective transfer seems to occur through direct contact and actual working together of individuals. Effective technology transfer usually requires adaptation of equipment or processes to local conditions, and this can best be done by arranging for experts and local people to work together in the actual location where the new technology is to be applied.

Past experience indicates that the most promising target for technology transfer is the local fishery operating primarily to serve local needs. Improvement provides for an immediate increase in food supply and local income. Then if fish stocks are sufficient and capital is available, it may be possible to broaden the operation to include export or regional supply aspects. This is a necessary sequence because isolated industries developed solely for export have a doubtful positive effect on the domestic food supply and, despite the apparent advantages of hard currency income, usually result in a drain of needed food away from the area. The domestic fish supply is a function of fishing effectiveness, processing capability, and distribution methods. Assistance can be provided in all three areas but should be initially directed at immediate problems. This requires careful evaluation of the current status of the industry and definition of problems. Consideration must, of course, be given to the relationship between this particular fishery and other food supply activities, as well as adjacent fisheries, so that impediments to development outside the fishery itself can be anticipated and dealt with. A working plan can then be drawn up to deal with problems in each sector, proceeding from those which at the same time seem most urgent and capable of rapid solution, to the more difficult problems with long-range implications. Simultaneously, steps should be taken to develop sustained capability for internal improvement by the promotion of training schemes or (better) training programs within the existing educational system to produce technical and managerial personnel.

Such a technology program is thus multistage in nature, with both short-term and long-term objectives. Short-term and long-term projects should be scaled to each other and coordinated, both in purpose and in timing. The short-term projects will by and large deal with single problems by the introduction of new techniques, new equipment (e.g. boats or engines or gear) and new procedures, adaptation of these to the local situation, and application to the problem(s). Relatively small numbers of people should be involved in each, and time scale could range from a few weeks to a year or so. Obviously, training programs can and should be both short-term and long-term. Short-term training is associated with the immediate technology transfer projects - how to use new gear, how to maintain an engine, etc. Long-term training should be designed to produce technological and managerial personnel and to provide domestic programs for such training to continue.

B. Program Planning and Development

Technology transfer programs should be designed to meet the actual needs of the LDC, not to fit some grandiose plan of development prepared by outside experts ignorant of country conditions and perhaps motivated by political or social reformist views, unrealistic in that context. Programs should not be structured simply to satisfy the developed country participants. On the other hand, there is almost always need to involve outside experts in the preliminary identification of LDC needs and *ipso facto* the measures needed for their resolution, since this process often requires both expert knowledge and experience. All of this calls for careful selection of participants, both people and countries, and sensitive management of the initial phases of the project to ensure mutual agreement on needs and methods and actual cooperation between LDC nationals and overseas experts.

Some things which the authors feel are absolutely necessary for the success of overseas development programs follow:

1. Conditions in the selected country or area must be such that effective work can be done. This means that the various projects should be developed in cooperation with people in the country who are convinced of their utility, willing and able to work cooperatively, and have the necessary authority or authorization to see that the work is done.

2. Some commitment must be obtained from the authorities in the country to support the program. Ideally, this should be a commitment of people, facilities, and money.

3. Each program should be flexibly structured to provide for changes of direction or emphasis, but no such change should be made without full agreement between the United States and overseas participants.

4. Program goals should be set in advance and a reasonable timetable for their achievement agreed upon.

5. Technology transfer programs should lead to independence, not to dependence. This means that a serious effort should always be made to train people in the use and maintenance of new equipment or new technologies and, indeed, to develop in-country training capability.

6. Most program decisions should be made in the country jointly.

7. A serious attempt must be made to overcome language barriers.

C. Project Suggestions

The following list of specific areas of overseas need for technology transfer assistance is submitted as a guide to the formulation of program:

1. Improvement of Artisan Fisheries
    a. Motorization of fishing boats
    b. New cheap fishing boat design
    c. Better catching methods; new gear
    d. Better assessment of stocks and how to locate fish
    e. Methods for preserving the catch - substitutes for ice and refrigeration
    f. Instruction in handling and simple processing - technology, sanitation, etc.
    g. Improvement of marketing systems and methods
    h. Development of simple small-scale processing operations (e.g. by cooperatives)

i. Development of advisory system for this level of production

2. Small-scale Fishing Industry

a. Mechanization of boat operations

b. Improved instrumentation on boats

c. Training of skippers in navigation, fishing methods, handling, and preserving the catch

d. Boat and engine maintenance - training

e. Simple processing procedures, fish handling - training

f. Sanitation - improved procedures and training

g. Improvement - improved procedures and training

h. Quality control procedures - demonstration and training

i. Technical assistance in processing operations - direct help and establishment of technician training

j. Business and marketing assistance - help and training

General:

a. Assistance to state agencies in assessment and management of fisheries - direct help and training

b. Assistance to technical schools and universities in development of training programs for sub-professionals and professionals

c. Assistance in setting up both regulatory and advisory systems

d. Specialized training needs, e.g. certification of retort operators; quality control schools; fisherman training, etc.

e. Specialized research and development assistance, i.e. help with specific problems and initiation of applied research programs within the LDC.

D. A Note on Aggregated Technology Transfer

Obviously an effective marine technology transfer program should involve a number of marine-related activities coordinatedly treated. It has already been indicated that fisheries interacts very directly with shipbuilding, marine instrument and gear manufacturing, and recreation. Port facilities involve fish landing facilities and fishing boat moorage. The design of fish processing facilities is specialized and requires technical and architectural expertise.

Fishing must also involve resource economics and marketing skills. Oceanography is a base-line science for practical fisheries and weather prediction and related atmospheric sciences are important. There are thus many lines of scholarly effort which fisheries intersects as a science and as a way of life. Overseas technology transfer should link efforts in these various fields to improve marine resource utilization for the welfare of LDC inhabitants.

TABLE 1

ESTIMATED FISH YIELD BY ANIMAL GROUP[1]

	Potential Estimated[2]	1972 Catch	1972 as % of Estimate	% Estimate Caught in 1969
A. Large Pelagic	4.3	4.0[3]	93	46.5
B. Demersal	43.8	26.3	60	51.1
C. Shoaling Pelagic	56.7	20.4	36	46.6
Cephalopods	10-100	1.1	1-10	-
Myctophids	100	-	-	-
Euphausids	-	-	-	-
Crustaceans	2.3	1.7	74	60.9
Molluscs	-	3.5	-	-
Total A, B, & C	105.0	50.7	48	48.4

[1]1972 catch data from Yearbook of Fishery Statistics (1972), Vol. 34, FAO 1973.

[2]From Gulland, 1971

[3]Includes salmon, etc.

TABLE 2

POTENTIAL FISH RESOURCES AND ACTUAL CATCH[1]

	Estimated Yield[2] (Million Metric Tons)	1972 Catch	1972 Percent of Estimate	Gulland[2] (Percent of Estimate 1967-1969)
North Temp. Zone				
N. W. Atlantic	6.4	4.33	68	66
N. E. Atlantic	13.3	10.71	81	68
Medit. & Black Sea	1.2	1.09	91	75
N. W. Pacific	[5.2][3]	14.58	~100	~100
N. E. Pacific	4.6	2.74	60	46
Tropical Zone				
E. C. Atlantic	3.4	2.92	81	59
W. C. Atlantic	5.5	1.51	27	27
Indian Ocean	14.1	2.51	18	19
W. Central Pacific	16.0	4.74	30	21
E. Central Pacific	6.0	0.91	15	23
Southern Temp. Zone				
S. W. Pacific	2.0	0.29	15	10
S. E. Pacific	12.5[4]	6.22[5]	50 (~100)	81
S. W. Atlantic	7.3	0.76	10	10
S. E. Atlantic	4.3	2.93	68	53

[1] 1972 catch data from Yearbook of Fishery Statistics (1972), Vol. 34, FAO 1973.

[2] Taken from Gulland, 1971

[3] This estimate does not seem to be correct, since production apparently exceeded the figure.

[4] Should be revised downward due to overestimate of Peruvian anchovetta stock.

[5] Due to decline of Peruvian anchovetta fishery.

TABLE 3

SELECTED EXAMPLES OF AQUACULTURAL YIELDS ARRANGED BY ASCENDING INTENSITY OR COMPLEXITY OF CULTURE METHODS

Culture Method	Species	Yield [Kg/(Ha)(Year)] or Economic Gain
Transplantation	Plaice (Denmark, 1919-1957)	Cost:benefit of transplantation, 1:1 or 1:1-1.3 in best years (other social benefits)
	Pacific salmon (U.S.)	Cost:benefit, based on return of hatchery fish in commercial catch, 1:2.3-5.1
Release of reared young into natural environment	Pacific salmon (Japan)	Cost:benefit, 1:14-20, on above basis
	Shrimp, abalone, puffer fish (Japan)	Not assessed; reputed to increase income of fisherme
	Brown trout (Denmark, 1961-1963)	Maximum net profit/100 planted fish: 163%
Retention in enclosures of young or juveniles from wild populations with no fertilization, no feeding	Mullet	150-300
	Eel, miscellaneous fish (Italy)	
	Shrimp (Singapore)	1,250
Stocking and rearing in fertilized enclosures with no feeding	Milkfish (Taiwan)	1,000
	Carp and related spp. (Israel, S.E. Asia)	125-700
	Tilapia (Africa)	400-1,200
	Carp (Java, sewage streams) (1/4-1/2 of water area used)	62,500-125,000
Stocking and rearing with fertilization and feeding	Channel catfish (U.S.)	3,000
	Carp, mullet (Israel)	2,100
	Tilapia (Cambodia)	8,000-12,000
	Carp and related spp. in polyculture (China, Hong Kong, Malaysia)	3,000-5,000
	Clarias (Thailand)	97,000
Intensive cultivation in running water with feeding	Rainbow trout (U.S.)	2,000,000 [170 kg/(liter)(sec)]
	Carp (Japan)	1,000,000-4,000,000 [about 100 kg/(liter) (sec)]
	Shrimp (Japan)	6,000
Intensive cultivation of sessile organisms, mollusks and algae	Oysters (Japan, Inland Sea)*	20,000
	Oysters (U.S.)	5,000 (best yields)
	Mussels (Spain)*	300,000
	Porphyra, Nori (Japan)*	7,500
	Undaria, Wakame (Japan)	47,500

Source: Lampe, Marshall, Sutinen, Vidaeus, Westin (1974).

* Raft culture calculations based on an area one-fourth covered by rafts.

TABLE 4

GENERAL PRODUCTION LEVELS OF VARIOUS FISHING PRACTICES

Catch (tons/man/year)	Fishing Method
1	Primitive fisheries in which lines, traps, spears or nets are fished from manually operated boats
3	Primitive fisheries as above with small power boats
10	Fishing from small coastal vessels with lines, trawls or gill nets for highly valuable fish
30	Fishing from medium to large vessels with lines, trawls or purse seines for moderately and highly valuable fish
100	Fishing with the best modern trawlers and purse seiners for moderately and highly valuable fish
300	Fishing with modern purse seiners for fish of low value, such as pilchard or anchovies
1000	Fishing with most efficient purse seiners for anchovies

From Royce: Introduction to the Fishery Sciences, p. 290, 1970.

TABLE 5

SOME COMPARISONS BETWEEN THE FISHERIES OF PERU AND THAILAND

Factor	Peru	Thailand
No. Vessels for Food Fish	3384 (1970)	3704 (1967)
Tuna Boats	14	--
Trawlers	65	1705
Small Purse Seiners	295	620
Gillnetters	2146	1055
Other Artisanal	867	324
No. Vessels for Fish Meal Species	about 1500	--
Area of recent, major catch increase	seining anchoveta	trawling many species
Fisherman		
Using modern boats (including anchoveta fishing)	22,000 (44%)	-- (30%)
Using artisanal boats (including subsistence fisheries)	28,000 (56%)	-- (70%)
Per capita income (U.S. $/yr)		
Owners	260	--
Skippers	110	300
Crewmen	110	60
Artisanal	1-8*	Similar to above, probably
Catch Disposition (% of total catch, including anchovetta)		
Fish Meal	98.5 (1971)	16 (1970)
Fresh Fish	0.87	37
Fermented Fish	--	6
Canned Fish	0.28	--
Salted/Dried Fish	0.15	7
Frozen Fish	0.20	3
Other	--	20
Proportion Exported	80	10
Major Export	Fish Meal	Frozen Shrimp
Amount (MMT/year) of above	up to 6	0.054
Rate of Increase of food fisheries	13.4% (as of 1972)	15.3% (av. for 1965-72)

*Possibly represents part-time fishermen, fishing for personal use rather than selling; excludes free board and room at co-ops or represents net profits after maintenance of boat and fishing gear, etc. (from Peruvian data, but seems unreasonably low).

TABLE 6

TOP 13 COUNTRIES BY FISH CATCH, 1972[1]

Japan	10,247.8
U.S.S.R.	7,756.9
China	7,574.0
Peru	4,768.3[2]
Norway	3,162.9
U.S.A.	2,649.5
Thailand	1,678.9[2]
India	1,637.3[2]
Spain	1,616.9
Chile	1,486.9[2]
Denmark	1,442.9
South Korea	1,338.6[2]
Indonesia	1,267.8[2]

[1] From Yearbook of Fishery Statistics (1972), Vol. 35, FAO 1973.

[2] Indicates LDC

TABLE 7

NOMINAL CATCHES BY WEIGHT AND VALUE

FOR SELECTED COUNTRIES

	1965			1972		
Country	Wt. TMT[1]	Value[2]	Value/MT[3]	Wt. TMT	Value	Value/MT
Algeria	18.3	5.47	299.0	28.3	10.77	380.0
Angola	257.5	6.16	23.9	598.8	18.32	30.6
Ghana	64.5	24.9	386.0	281.2	45.74	162.7
Morocco	215.1	13.0	60.4	246.5	21.0	85.1
Canada	1,125.1	146.0	129.7	1,073.5	236.0	219.8
Mexico	256.4	58.3	227.5	402.5	95.1[4]	236.2
U.S.A.	2,724.5	445.1	163.3	2,649.5	703.6	265.6
Argentina	205.2	15.04	73.3	238.2	44.6	187.3
Brazil	393.1	67.94[5]	172.8	580.7	160.4[4]	276.2
Chile	708.5	22.09	31.2	1,181.4	31.3[6]	26.5
Ecuador	53.5	7.63	142.6	105.2	14.25[4]	135.5
Peru	8,844.5	113.65[5]	12.8	4,768.3	90.8	19.05
India	1,525.6	186.2[7]	122.0	1,637.3	356.7	217.9
Indonesia	1,102.3	not available		1,267.8	not available	
Japan	6,947.8	1,552.4	223.4	9,948.9	3,135.0[4]	315.1
Korea	640.4	73.38	114.6	1,338.6	264.3	197.4
Philippines	685.7	193.57	282.3	1,148.7	359.2	312.7
Thailand	626.7	118.73	189.4	1,678.9	342.4	203.9
Norway	2,311.8	155.08	67.1	3,162.9	235.0	74.3
Spain	1,355.1	261.65	193.1	1,616.9	602.13	372.4

[1]Nominal catch in thousand metric tons (FAO, 1973)

[2]Value of landed catch in millions of U.S. dollars (FAO, 1973)

[3]Calculated value per metric ton, U.S. dollars.

[4]Values for 1971

[5]Values for 1966

[6]Values for 1970

[7]Values for 1968

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Volume III

INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY

A Three-Volume Study

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PROPOSALS FOR A UNITED STATES PROGRAM IN INTERNATIONAL MARINE COOPERATION

by

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TABLE OF CONTENTS

	Page
Acknowledgment	3
Proposals for a U.S. Program in International Marine Cooperation	5
Structure of International Marine Technology Sharing Program	8
Operations	13
Functions	21
International Program Participants	23
United States Government Agency Location	25
Multinational Corporations - The Issue	30
Alternatives to Direct Investment	32
Perceptions by Industry	34
Entrance of Industry - Incentives/Restrictions	36
An Example of Host Country/Industry/International Program Office Cooperation	40
Mexico - A Country Case Study	42
Resource Climate of the Mexican Marine Community	83
Joint Programs	89
Footnotes	97
Bibliography	98
Appendix	100

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International Marine Cooperation

A government program created to facilitate primarily "soft" technology cooperation between the United States and other nations has the potential to address both developing and developed nation needs.

Developing national support for the concept of the 200-mile economic zones in the Law of the Sea negotiations reflects their concern for controlling the utilization and management of their marine resources. Of equal concern, though, to these nations is their own ability to build up indigenous marine capabilities to properly understand and manage these resources. The developing nations' more active participation in international and regional conferences and organization have made them keenly aware of both the potential wealth of their adjacent waters and of the gaps in their scientific and technological capabilities. A number of the developing countries are concerned with the extent to which they are capable of interpreting data on their resources and carefully managing them.[1] Such institution-building needs can be addressed initially through education and marine technical training projects geared towards helping foreign nationals train themselves.

The range of institution-building needs obviously varies with the country. But cooperation in marine technology sharing with long range institution-building goals in mind is essential if the U.S. government hopes to participate in credible and broadly useful programs in marine cooperation.

The United States has an opportunity to build up patterns of trust with some developing nations, and thus enrich its understanding of specific foreign country conditions (scientific, cultural, political) and international marine conditions in general. Greater interaction between international scientific communities can improve intergovernmental relations and improve the spread and utilization of data. The United States also needs to learn and, by encouraging projects that offer unusual, challenging opportunities to American and foreign participants, it can enhance its own expertise.

It is expected that the sharing programs between the United States and developing nations will be a first phase in a much more comprehensive effort that would encompass all other developed nations that choose to participate. The U.S. scientific and technical community agrees that there are areas of expertise in other nations which the United States could very usefully draw upon to meet some of its own marine-related needs. The international sharing program may well be the most suitable institutional structure for bringing together global marine interests and providing far broader and more varied points of contact and interaction than could be achieved by an effort that confined itself to just the advanced marine science and technical community based in the United States.

While mechanisms by which this ideal state of affairs might be accomplished are likely to evolve naturally over time as the International Program Office acquires operational experience, much effort will need to be expended to achieve success.

The formulation of a U.S. government program in international marine technology cooperation might also prove a useful first step towards creating a more coherent domestic marine policy and centralizing the marine-related activities of various government agencies, breaking with one-sided "technical assistance" of the past.

Structure of International Marine Technology Sharing Program

A. Location

Two agencies, the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA), both based in Washington, appear to be the natural choices for housing the international program illustrated in Box 3 of the model* derived in an earlier paper by the authors.[2] They are the only federal organizations that have an interest in civilian international marine research, education and training. Neither, however, has official responsibility for undertaking these activities which are relegated to a secondary position with respect to program priorities. The NSF has the International Decade of Ocean Exploration (IDOE) and concerns itself with research, while NOAA occupies itself with data collection, research, some training and education and houses the National Sea Grant Program. The National Sea Grant has, as its mandate, activities and operations similar to the ones proposed for the international organization except that they are generally limited to a national scale. Locating the international effort in either agency could focus attention on the importance of marine-related programs, provide an international dimension, and clearly delineate a center of responsibility.

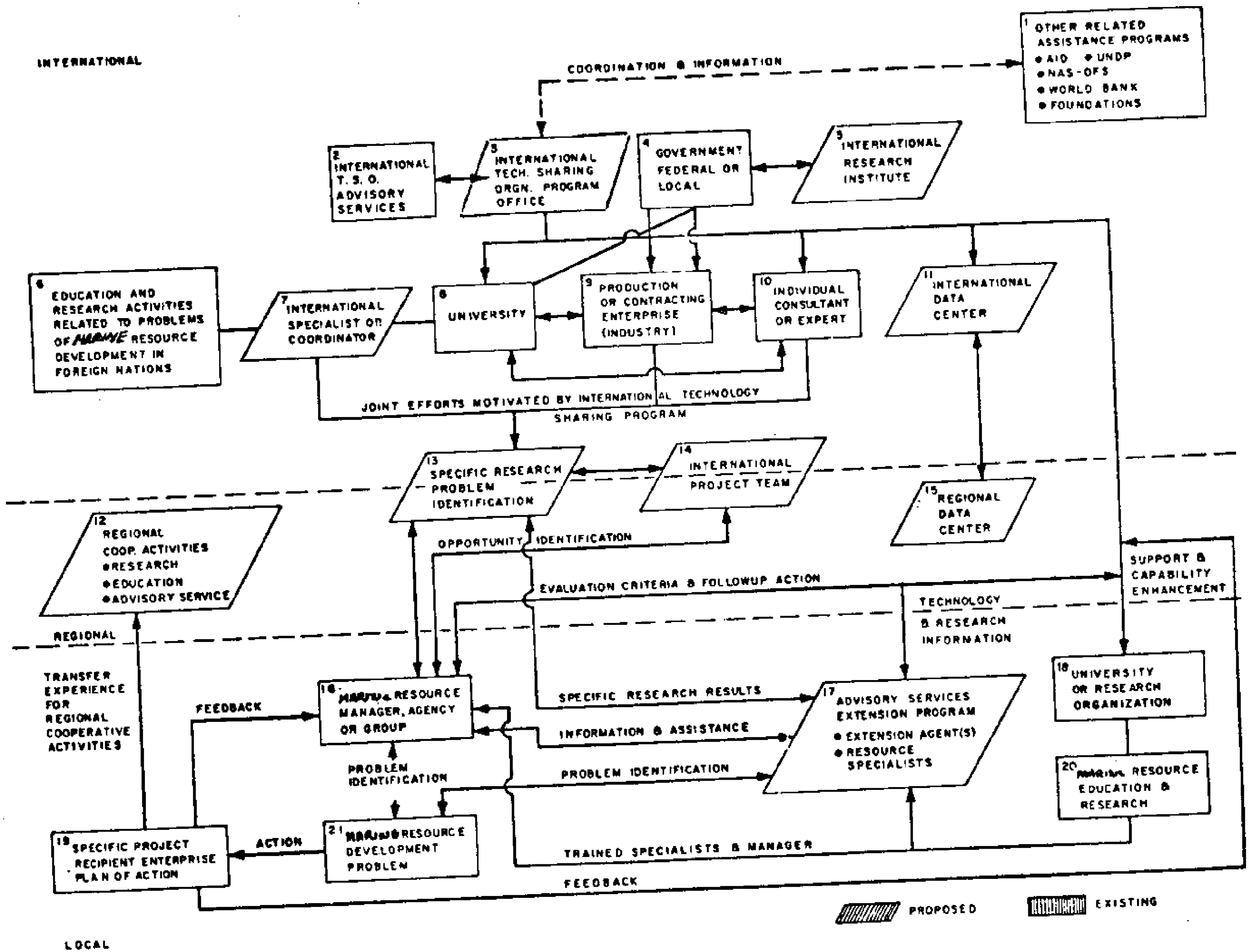
* See Page 6.

B. Orientation

The environment of the international organization would be civilian marine-related education, research, training, and extension activities oriented towards developing countries, with the more advanced of the nations constituting a point of departure for the initial pilot efforts. Three countries could be selected and small cooperative ventures initiated. Because universities are the source of most marine science training education and research, it is suggested that the program be university based. The discussions in the section on industry and university define the advantages of such a link.

C. Size

Restrictions on the availability of funds and the necessity for allocating the largest amounts possible to projects argue for a small core staff coordinated by a director. Initially, three or four people could function as a liaison between various government agencies and provide a point of contact for foreign officials. They would also organize projects around the expertise within NOAA, the NSF, AID and various universities. The director should be a person with extensive international experience and recognized professional capabilities. The staff must be competent in international affairs, marine technology, and education.


INTERNATIONAL
COORDINATION & INFORMATION
1 OTHER RELATED ASSISTANCE PROGRAMS
● AID ● UNDP
● NAS-OFS
● WORLD BANK
● FOUNDATIONS
2 INTERNATIONAL T. S. O. ADVISORY SERVICES
3 INTERNATIONAL TECH. SHARING ORGN. PROGRAM OFFICE
4 GOVERNMENT FEDERAL OR LOCAL
5 INTERNATIONAL RESEARCH INSTITUTE
6 EDUCATION AND RESEARCH ACTIVITIES RELATED TO PROBLEMS OF MARINE RESOURCE DEVELOPMENT IN FOREIGN NATIONS
7 INTERNATIONAL SPECIALIST OR COORDINATOR
8 UNIVERSITY
9 PRODUCTION OR CONTRACTING ENTERPRISE (INDUSTRY)
10 INDIVIDUAL CONSULTANT OR EXPERT
11 INTERNATIONAL DATA CENTER
JOINT EFFORTS MOTIVATED BY INTERNATIONAL TECHNOLOGY SHARING PROGRAM
13 SPECIFIC RESEARCH PROBLEM IDENTIFICATION
14 INTERNATIONAL PROJECT TEAM
15 REGIONAL DATA CENTER
12 REGIONAL COOP. ACTIVITIES
● RESEARCH
● EDUCATION
● ADVISORY SERVICE
OPPORTUNITY IDENTIFICATION
EVALUATION CRITERIA & FOLLOWUP ACTION
SUPPORT & CAPABILITY ENHANCEMENT
TECHNOLOGY & RESEARCH INFORMATION
REGIONAL
TRANSFER EXPERIENCE FOR REGIONAL COOPERATIVE ACTIVITIES
FEEDBACK
16 MARINE RESOURCE MANAGER, AGENCY OR GROUP
SPECIFIC RESEARCH RESULTS
INFORMATION & ASSISTANCE
17 ADVISORY SERVICES EXTENSION PROGRAM
● EXTENSION AGENT(S)
● RESOURCE SPECIALISTS
18 UNIVERSITY OR RESEARCH ORGANIZATION
PROBLEM IDENTIFICATION
PROBLEM IDENTIFICATION
20 MARINE RESOURCE EDUCATION & RESEARCH
19 SPECIFIC PROJECT RECIPIENT ENTERPRISE PLAN OF ACTION
ACTION
21 MARINE RESOURCE DEVELOPMENT PROBLEM
TRAINED SPECIALISTS & MANAGER
FEEDBACK
PROPOSED
EXISTING
LOCAL

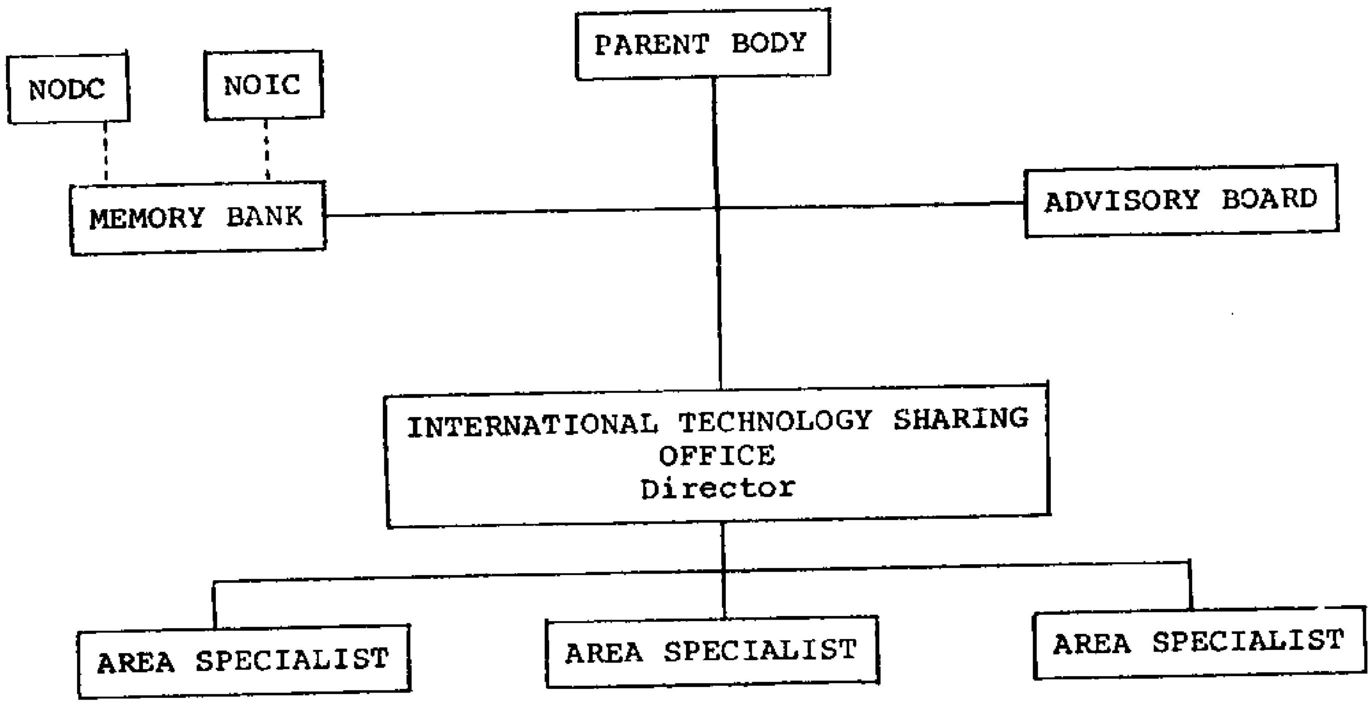
It would be desirable to allocate one person to a country and then gradually increase the responsibility to cover a geographical region that shares relevant aspects. A structure that is organized by area should finally evolve as shown in Figure 1. Sectoral specialization will greatly enhance the ability of the organization to administer and evaluate programs as well as accumulate experience on the operating characteristics of the region within which projects are attempted.

A standing advisory board would be constituted to provide guidance, expertise and project evaluation and scrutinizing capability. The bulk of the funds would be allocated to cover:

(a). Seed money for project

(b). Traveling by staff members for monitoring, evaluation and follow-up activities

FIGURE 1


NODC
NOIC
PARENT BODY
MEMORY BANK
ADVISORY BOARD
INTERNATIONAL TECHNOLOGY SHARING
OFFICE
Director
AREA SPECIALIST
AREA SPECIALIST
AREA SPECIALIST

Operations

Regardless of where such a program is housed or what the organizational structure might be, there are certain characteristics which should be maintained. The program, beginning with a modest budget, should be limited to funding of seed projects. Small amounts, matched by universities (Box 8 of the model), private industries (Box 9 of the model), or recipient nations (in as yet some unspecified manner) (Box 16 of the model), would be available to initiate or support projects serving as a base for further endeavors coordinated by the country itself. The central office would act only on those requests which were initiated by the developing country. Scanning for potential projects is not desirable for this program. One of the first necessary steps which must be taken is to compile a list of all universities, private organizations, and individuals interested in participating in such a program. The importance of an all out effort in this phase cannot be overstated. It is these organizations and people which will form the parameters for the future of each project. Therefore, the more extensive and diverse the list of participants, the larger the probability of locating the needed expertise for any given project.

The next phase deals with the mechanisms employed to handle project requests. Three feasible alternatives are discussed, any one of which could be operationalized with approximately the same degree of ease and efficiency. The three alternatives are not intended to be mutually exclusive.

The projects may be handled individually and any of the following mechanisms best suited for them at any particular time could be employed.

The three alternative mechanisms are:

1. When a proposal is submitted to the International Office from the recipient country, it is forwarded to all participants to decide whether or not they have the needed expertise and, if so, whether or not they are interested in such a project.

   If the final decision is that they have both the expertise and the interest, a reply is sent to the International Office.

   The office submits these replies to the advisory board (Box 2 of the model), which determines which organizations are the best suited for the projects based on such criteria as expertise, personnel and knowledge of the country and people with whom the project will be conducted.

   When the representatives from the developing country and the United States meet, if they wish to apply to the International Program Office for seed money, the appropriate next step would be to draft a formal proposal. This proposal would be sent to the International Office in order for the preparations necessary for seed funding to begin.

2. This alternative is identical to number one until the point at which the U.S. participants decide if they are interested in the request from the foreign nation.

   If they are interested, their replies will go directly to the requesting country, whose representative will decide upon the organization(s) with which they would like to work (Boxes 16 and/or 18 of the model). A final formal proposal to the International Office would be a necessary component of this alternative.

3. This alternative in some ways serves to eliminate the middleman. The country sends a request to the International Office which in turn will send the country a list of those participating organizations possessing the required expertise. From this point, the decision as to who will be contacted will rest with the requesting country. However, in order to legitimize this process, the participants should be required to submit a copy of the proposal to the International Office so as to keep the U.S. government up-to-date on the activities taking place.

Each of the three mechanisms potentially has a two-stage existence. First, the official function of the International Office could end once the requesting country and its official counterpart begin negotiations. In spite of the fact that the official function might end at this point, it is crucial that information and records be sent to the International Office during the project's progress. Without these records, the memory function of the entire program would be inaccurate and virtually useless (Box 11 of the model). Second, the negotiations between the two parties could evolve into a formal request which would be submitted to the advisory board for further action and possible seed money. (An activity conducted by Box 13 of the model.) In this stage, the International Office would remain officially involved with the entire seed project.

During the lifespan of any project, various stages exist. These stages may be delineated as joint need identification, project formulation, acquisition of relevant resources, implementation, evaluation, feedback and follow-up.

Based on the type of organizational structure proposed for this program, it would be reasonable to assume that the International Office would not be actively involved in the actual implementation of the project. If the International Office continued to work with the participants beyond the initial coordinating function, then official responsibility for evaluation, feedback and follow-up is retained. If, on the other hand, official responsibility for the project ceases at the point where the participants locate one another, there is no authorized delegation of responsibility for the implementation of these three points by the International Office unless it is built into the organization's mandate. It is felt that evaluation, feedback and follow-up are vital to all projects, whether they are seed or full scale. It is for this reason that the following suggestion is made. At the onset of any project, there must be an agreement between the requesting country and the International Office that on-going monitoring will be allowed.

Project evaluation should occur both during and after completion of the activity being monitored. The immediate effects of the project need to be evaluated during its implementation; the secondary and tertiary impacts need to be evaluated at predetermined intervals after the completion of the project. Time lags often will occur between the application of resources and the emergence of results. This would be especially true in education, training and research, where the resources expended on immediate activities may yield future returns. These results can be observed when the training and research is actually applied to concrete situations.

There are problems in this process, however. The very selection of criteria used to evaluate the success of projects introduces biases. In addition, if the evaluation focuses upon a pilot project that recommends a major effort, the participant's commitment to the project may elicit behavior in which this commitment becomes apparent and recommendations reflect this bias (Box 19 of the model). This becomes important in determining whether a proposal is accepted, modified, postponed, or rejected. The investigation tends to create commitments over time that bias the end report towards acceptance unless the evaluator is an impartial third party representative. The person(s) initiating the investigation, the group investigating, and the various groups monitoring are compelled to make increasing financial, psychological, and social investments as the process continues. This often causes both the initiators and the evaluators to be committed to the success of the project. The evaluation function, therefore, should be conducted by people who are least influenced by the outcome but have some knowledge of the nature of the project. The standing advisory board (Box 2) or a subcommittee designated from the board could serve as a monitoring committee.

The frequency of this monitoring should be clearly delineated at the beginning of each project and should be individually ascertained on the nature of the tasks being undertaken.

Feedback affords the opportunity, during and upon completion of a project, to discover inadequacies and variations from initial plans. It should be objective and determine if performance is consistent with planning and should be used to identify planning errors. The following criteria are essential for effective feedback.

1. The data gathering should be done during, not after, the life of the project. This serves as a check on distortion by the observer.

2. Data should be based on experiences of all parties involved, and it should be available to all parties to avoid subjective influence.

3. As many sources as possible are needed to serve as a check so as to ascertain reality and accuracy and avoid the scapegoat tendency.

Some time after the project is completed, a follow-up could be aimed in any one of a number of directions. Were the needs of the community identical to the perceived needs identified at the onset, i.e., were the needs identified correctly? Are the needs of the user community still identical to the original perceived needs that instigated the project, i.e., have their needs shifted over time? What were the long run effects of the change effort as a result of the combination of perceived needs, actual needs and project content? The gaps identified at this point can be used to redefine needs and tailor the project if it is an ongoing one. When a project begins and ends within a certain time frame, follow-up can still be useful in order to restructure future projects, i.e., avoid reinventing the wheel. In essence, then, follow-up can be used to enhance the marketability and appreciation of output which, in the final analysis are the two most significant criteria that determine the relevance of a training, education, research, or advisory activity.

An additional service should be available from the International Office to participants of seeded projects. If at the conclusion of a seed project, potential economic opportunities are identified, the participants could submit another joint proposal to the International Office requesting the capital and expertise in order to launch a full-scale program (Boxes 13 and 14 of the model). The office could submit this request to the advisory board, which could circulate it throughout the industrial community. This is merely a service function of the International Office, a liaison between industry and the participants of the project.

No further U.S. government intervention is necessary. Any company possessing the required expertise could directly contact representatives involved in the project. In this case, too, an attempt should be made to secure full information and records of the subsequent project to facilitate the growth of the memory bank.

It is not the purpose of an International Technology and Information Sharing Program to enter a country, set up an extension service, and attempt to compete with any form of extension service, or advisory agency already in existence within the country. On the contrary, the focus is on mutual benefits, and if this can be accomplished most efficiently by coordinating efforts and meshing into existing agencies, then this should be the preferred method of operation.

Functions

The International Office would have the following functions:

1. Service and Liaison:

   A. Domestic: providing a liaison function within the U.S. government, creating interdependency among agencies, strengthening international marine programs, and filling structural and administrative gaps.

   B. International: providing a point of contact for foreign officials and a point of responsibility for international marine sharing programs.

2. Brokerage: bringing together the sources of expertise and the needs of potential users through scanning and matching.

3. Memory: accumulating project information, operating expertise, information on operational and cultural constraints, evaluation and follow-up information. The computer facilities of the NODC and NOIC could be drawn upon for storage and information.

4. Standing Advisory Board:
   functioning as a source of expertise within the organization. It would combine knowledge of marine education and technology with international affairs and screen project proposals. It would

be composed of government officials, public figures, representatives from industry and academic and persons with vested interest and expertise in the work being done.

5. Project Monitoring:

   obtaining feedback on current projects and surveying their implementation.

6. Evaluation and Follow-up:

   analyzing current and completed projects along the dimensions described in the section on Operations.

7. Seeding of Projects:

   providing funds for pilot projects, feasibility studies, surveys, research and training activities, etc.

8. Administration:

   serving the bureaucratic function of the office.

9. Communication:

   disseminating information to various participants in marine related activities, e.g., government agencies, universities, international organizations, etc.

International Program Participants

Much of the expertise for the kind of cooperation recommended in this report lies within the domestic university system. The advantages of utilizing university personnel involved in marine-related areas are five-fold. First, academics have dual experience as specialists and educators. Second, as a group, many are already interacting with others around the world involved in the same or related disciplines (i.e., through conferences, research cruises, literature, publishing). Third, not only do they have something to offer, but they have something to gain through international marine cooperative projects. Academicians have a chance to broaden their exposure in their fields and thus enrich the quality of their research and their capability as educators. Fourth, the nine-month academic calendar makes their schedules comparatively flexible; with sabbaticals, half-year leaves, and summer leaves not at all atypical. Finally, university personnel already have home institutions, and thus would not be "hired" on a permanent basis by a formal bureaucracy.

The incentives for academicians and/or university researchers to become involved in an international project and spend some time abroad are both personal and professional. American faculty members have cooperated in international exchanges in the past for several reasons: the attraction of a new culture; availability of research funds; scientific challenge; access to data; the lure of underutilized facilities at foreign labs or universities; greater prestige in another culture or a chance to apply familiar scientific and engineering tools and techniques to foreign country conditions.

There are incentives too for particular universities to support the involvement of their faculty in an international marine technology sharing program. Institutions of higher learning seek research funds, and this might be a new source. United States-foreign university "twinning" arrangements are a possibility. Exchange programs (both faculty and student) are feasible with extra guidance for those changing cultures.

Constraints on participation by university personnel do exist and cannot be ignored. To begin with, not everyone is interested in either moving abroad for a period of months or making a commitment to visit at regular intervals. Even those who might be interested in such projects feel that they have much to lose at their home institution by taking a leave of absence to work abroad. For younger faculty especially, the loss of visibility at this early stage of their careers can be harmful in a number of ways. Varying with the length of a stay abroad, they can lose their involvement in curricular development at their home institution and might forfeit opportunities to author proposals for upcoming research funding.

Institutional commitment can help alleviate some of the constraints on university participation. Mechanisms to assure that those involved abroad for part of the academic year or for the whole year are not penalized in tenure considerations or research funding could be encouraged by the federal agency.

Perhaps research funding for a specified amount of time after the conclusion of an international project could be guaranteed by the International Program Office in conjunction with the National Sea Grant Program. This funding, of course, would be for the United States' participants in the international project and could support follow-up research. Salary guarantee programs for absentee professors are also a possibility. In addition, a severe problem in U.S. universities now being foreseen is a declining growth in student enrollment as a result of a stabilizing population. This is anticipated to cause problems in faculty utilization since tenured faculty are guaranteed incomes, even if there are fewer students to go around. Far-sighted administrators are looking at the problem and considering ways to more effectively employ anticipated excess research and teaching resources. This program might offer one alternative.

United States Government Agency Location

The incentives for using academic personnel have weighed heavily in considering a federal agency for a new program in international marine technology cooperation. In fact, the two federal agencies best identified with marine science and technology programs--the National Sea Grant Program in NOAA and the National Science Foundation (NSF), which houses the IDOE--are heavily involved with university personnel.

Although research efforts are a means of cooperating internationally in marine technology, the needs of developing countries are more practically oriented--education, training and advisory work. NSF's mandate is to fund research; training and education are secondary to this.

It is precisely the practical functions that an international agency would need to coordinate that make the National Sea Grant Program a more suitable choice as a home agency.

Like its predecessor, the Land Grant Program, the National Sea Grant Program is a decentralized university-based program with designated "colleges" and "institutions" (the difference in terms relates to the level of program development) across the country. It is the major government program involved with research in marine resource development. Briefly, the agency's mandate is to address problems in marine resource development through research, educational and advisory service activities.

Each Sea Grant institution or college has a small administrative staff coordinating activities at the specific university and responsible for reporting to the central Washington program office. The Washington office's job is "... to initiate and support Sea Grant colleges and programs capable of carrying out the purposes and policies of the legislation...."[3] (See Appendix for the legislation.) The matching funds provisions of the program, by which "... the grantee is required to provide at least one-third of the cost," emphasizes the specific university's stake in the quality and applicability of research.

The Sea Grant Program has developed a unique approach to tackling problems in marine resource development. The agency is committed, where possible, to sponsoring projects geared towards potential users in the local, state or regional marine communities (both public and private).[4] To accomplish this end, multi-disciplinary project teams are encouraged, strengthening a project team's ability to assess the breadth of project implications and impacts.

Proposals are thus evaluated at each Sea Grant college or institution and in Washington for a number of qualities. Attention is given to technical competence, the coherency and timeliness of project goals as well as the research approach. The advisory services attached to specific university programs or coastal regions personify the uniqueness of the Sea Grant approach.

The local advisory programs "... emphasize people-to-people contact and have a major responsibility for transferring information and identifying problems." [5] This field work adjunct to the college or institution program has emphasized communication skills and exposed all those connected with Sea Grant Programs, at the very least, to the importance of identifying and understanding those potentially affected by and concerned with Sea Grant research in marine resource development.

The National Sea Grant Program, though described briefly, has structural and philosophical elements that might be highly suited to an international marine technology sharing program. Structurally, the program places the burden of responsibility with the professionals at each university. The advantage here is that central Washington bureaucracy is kept to the barest minimum-- for it is not, by very definition, the expanding part of the program.

Both of these elements create an environment that in many ways can reduce the traditional tension and frustration of dealing with large bureaucracies.[6] Important too is the fact that a small Sea Grant staff has been established at each university. This gives Sea Grant administrators proximity to university affairs and university personnel, and a chance to establish both credibility and communication channels.

The matching funds requirement has proven effective in terms of providing all those involved in a project with a stake in performance. This would count as an important factor in any recommendation for an international marine technology sharing program.

The Sea Grant approach to marine problem identification and the advisory service function that Sea Grant tries to fulfill for the interested local marine community are two facets of the program that might be applicable to small international projects in marine cooperation. Some of the traditionally recognized obstacles to the success of many international science and technology programs (i.e., little awareness and exposure to indigenous cultural patterns, social systems and problems, no tie-ins with informal communication channels) could be overcome.

Finally, Sea Grant Program participants are university-based professionals from all marine-related disciplines. The advantages of using university educators in such a program, discussed earlier, demonstrate the advantage of using professionals who have been exposed to the Sea Grant approach. In addition, Sea Grant's home agency, the National Oceanic and Atmospheric Administration, might well be an appropriate base for a new bilateral or multilateral marine technology sharing agency. This location would automatically afford easy liaisons with other key marine agencies, some of which already have international programs and/or liaisons, but none of which have official responsibility or specially trained staffs to carry out such a mission. It would be unrealistic to assume that an International Program Office could function, tied to the National Sea Grant Program, without some reorganization within NOAA. Other agencies within NOAA, such as the National Marine Fisheries Service (NMFS) and the Office of Coastal Zone Management (OCZM), have some international contacts and cooperative arrangements. Some of these activities--and similar activities in any other NOAA agency--would have to, at the very least, be closely aligned with the International Program Office's activities.

Multinational Corporations - The Issue

An investigation of the role of industry in a proposed international sharing program needs to place in global perspective the consequences and benefits of multinational enterprise. The debate on the costs and benefits of multinational business operations continues to be extended and confused. It is widely believed, however, that the distribution of the gains and losses with respect to the corporation, the host country and the parent country is asymmetric with the gains being biased in favor of the corporation. Extensive studies have been conducted on the subject, though few definitive conclusions have emerged.

The issues, briefly, emanate from the following categories:

(1) Political

- impact on domestic and foreign relations when large or key segments of the economy are controlled by foreign interest.

(2) Economic

- comparative benefit/cost of technology transferred
- contribution to national income
- exploitation of natural resources
- exports
- duties/taxes
- repatriation of profits and capital
- transfer prices
- royalties, fees, service charges
- bundling of management, technology and capital
- conflict or convergence between the investment plans of multinational corporations and the development objectives of host countries
- creation/destruction of job opportunities

(3) Social

- pollution
- skill levels of workers
- standard of living
- ownership of the means of production
- social services (health, housing, education)

(4) Cultural

- value systems
- work habits and norms
- consumption choices and patterns

It is imperative that the transfer of marine technology by the multinational corporation (MNC) be viewed along the dimension outlined above. It is alleged that international corporations often transfer technology not relevant to the needs of the host country, that the technology ignores the relative abundance of labor to capital in a developing country and tends to be excessively capital intensive, that it tends to be restrictive and proprietary and that it inhibits local technological progress. In addition, host countries often feel that alternative means of acquiring the technology (through technical assistance programs for example) may be less expensive than relying on the MNC for the expertise. It should be recognized, however, that few developing countries have the sophistication or administrative capability to seek and effectively evaluate alternative channels for acquiring technology

Alternatives to Direct Investment

Various mechanisms designed to maximize the contribution multinational corporations could make to the economies in which they operate have evolved over the past few years. Many of these focus on the strengths of the international corporations that have given them the unique ability to operate globally. At the same time, they minimize direct control of assets by these corporations, thus reducing the region of conflict between multinationals and nation-states.

Some of these mechanisms are:

(1) Service contracts: where the corporation would be paid a fee for managing an enterprise and providing technological inputs without owning the assests it manages. A variation of this is the renting and leasing of facilities by MNC's to enterprises in host countries.

(2) Turnkey operations: where the corporation builds a facility and then hands it over to local managers, working on a cost-plus-fee basis.

(3) Co-Production agreements: where the payment to the corporation consists of sharing the product rather than transfers of money e.g. in the mining of manganese nodules and subsequent distribution of the nodules as opposed to cash distribution.

(4) 3-Way ventures: where the capital comes from countries with surplus funds, the management and technology is supplied by a multinational corporation and the labor and business opportunity is made available by a third country. This mechanism has considerable potential since each participant contributes according to relative abundance of resources.

Several of these mechanisms could be employed by industry if it chooses to participate in commercial activities that might accrue from projects undertaken by the federal international marine program.

In some instances, industrial expertise may be either unattainable or undesirable. In such cases, the availability of alternative mechanisms is vital. The following options may be employed as viable resources for continuing projects:

(1) The technology and training may be found in other locations through the use of the international program advisory committee. One such location might be a Sea Grant university. Funds may be obtained from the World Bank or similar agencies.

(2) The technology and training could be conducted by United Nations personnel with capital coming from either United Nations funds or from the World Bank or regional development banks.

It is very likely that an international sharing program has a vital role to play in fostering indigenous capacity for technological evaluation. In some instances, it is very possible that the international corporation is the most efficient vehicle for the transmission of marine technology, and objective evaluation may well persuade host countries that widespread antagonism towards the MNC is not always warranted. International agencies often demand that the MNC be socially and economically sensitive. It is unreasonable to expect MNCs to enthusiastically participate in the sharing program if their rights are not protected from acts of expropriation, seizure of assets, etc. The international marine sharing program should bear this in mind when exploring the role of industry.

It needs to be recognized that the interests of industry are not always congruent with the interests of participants in international sharing programs which are oriented towards research, teaching and education. Industry typically is concerned about assessing its activities in terms of financial profit and tends to assign intangible benefits a lower priority when evaluating projects and return on its contribution. The international marine sharing program, however, is liable to participate in activities that will be predominantly noncommercial with little, if any, immediate economic return. The benefits that accrue from its projects will eventually manifest themselves over a number of years and will be in the area of institution building, human resource development and the accumulation of scientific and technical expertise.

Perceptions by Industry

1. The scale of the proposed program is so small that industry views it as being either peripheral or totally irrelevant to its activities. More specifically, the petroleum and mining company representatives who were contacted expressed the view that they were not presently interested in a program of such a nature.

2. Because it can perceive no benefits, industry is not particularly interested in entering the program at the project planning stage. Some industrial interests, though, may like to associate themselves later if the projects undertaken can help satisfy certain entry restrictions imposed by developing countries as regards the introduction of technology and the training of local personnel, or if some realizable economic gain can be drawn from results of such a program.

3. Industries with new and proprietary technologies are averse to sharing their expertise since doing so would entail sacrificing some of the economic returns on that technology. Therefore, involvement in programs of technology sharing would not be appealing to industry if it were to entail the sharing of the newest available technological information. Firms might logically wish to exploit lucrative markets first and perhaps share information which is part of a product in the declining stage of the life cycle.

4. Multinationals having products in the declining stage of the life cycle would probably want to diversify away from those products. Since they could continue to manufacture these products in developing countries at a minimal capital investment and free resources for activities that have a higher rate of return in the developing countries, they might be interested in a program which would allow them to do so. On the other hand, the host country would pay a price for such industrial participation. They would be receiving intermediate technology. Although such a level might be appropriate for a country not yet scientifically capable of handling the most modern technology, some resentment might ensue if there is an awareness that the information received is not the newest.

5. To some extent, the dictates of social responsibility and public relations might elicit a measure of support for such a program. The testimony of various chief executives of multinationals before the United Nations Group of Eminent Persons on

the Multinational Corporation indicates a growing awareness that international industry must adopt postures of increasing cooperation and responsibility if it is to continue its evolution as a viable economic phenomenon.

Entrance of Industry - Incentives/Restrictions

Previously, consideration of industry's participation in an international sharing program has been focused in terms of the costs and benefits for developing nations. The emphasis must shift at some point to the perceptions and needs of industry as opposed to the perceptions of the countries. If a positive decision is reached to utilize the managerial expertise, capital, and technical capabilities of a firm, a new question arises: What are the incentives and restrictions for entry and participation in such a program based on the viewpoint of the company?

There are a number of benefits which industry might receive in associating their resources with an international sharing program. For instance, a company may gain greater legitimacy in a foreign country by being linked with an agency that has been politically and socially accepted within the developing country. Working on a project sponsored by an international sharing office may provide the opportunity for initial entry into a country, thus opening the possibility of penetration into various other markets. It could potentially yield new investment and venture opportunities not previously perceived by a firm, while simultaneously presenting a minimal amount of risk as a result of the association with an established program. The FAO Industrial Program is an example of a cooperative effort conducted under the auspices of an international organization which has proven advantageous to both industry and host countries.

Resources, previously undiscovered or considered insignificant, may prove to have economic potential during the course of a seed project. In such cases, while deriving financial gain from the process, industry may also be in a position to develop these resources for a country. Furthermore, upon completion of the seed project, industry may, if a profitable outcome can be perceived, become committed enough to continue the idea or begin a new project along similar lines.

Presently, U.S. organized labor is lobbying in Congress for the passage of the Burke-Hartke bill, which, if passed, could create strong disincentives for industry to export capital, patents and technology.* The provisions of this bill include:

1. Repeal of foreign tax credit
2. Repeal of tax deferral
3. Ban accelerated depreciation
4. Tax income on transferred patents
5. Establish a United States Foreign Trade and Investment Commission
6. Restrict imports to 1965-69 level
7. Impose a dumping duty
8. Restrict exports of capital and technology

* This bill has been in Congress for three years and is not likely to be passed immediately.

If the multinational is disputing with Congress, it may prove beneficial for it to be viewed as a carrier of technology, diplomacy and cooperation, rather than in the traditional role. A linkage to an international technology sharing project might be one vehicle industry needs to attain this end.

Another possible incentive depends upon the future of the 200-mile economic zone. Companies desiring to work in such areas as offshore drilling or exploration of a continental shelf would benefit from favorable relations with the relevant countries. This relationship may be facilitated by a connection with an international sharing program.

The fact that industry's focus is not primarily directed towards objectives of international development but rather towards profitability, must be realized. The absence of an infrastructure base may often make the poorest areas least attractive to industry for direct investment purposes. Also, the economic and political risks are much higher so that the multinational requires a greater rate of return on investment. According to a UN report, multinationals could be more willing to enter developing countries if there exists some sort of national planning and predetermined goals.* This is in harmony with the structure previously outlined for the international sharing program, where at the termination of a seed project, the project team determines what the necessary next step would be and proceeds to locate those most capable of undertaking its implementation.

*The Impact of Multinational Corporations on Development and on International Relations, United Nations, New York, 1974, p. 33.

The restrictions for industrial entrance into such a program also exist. On the whole, developing countries have a very general set of entry restrictions. State-owned industries tend to be in petroleum, bsic petrochemicals, nuclear energy, electricity, mining, transportation, and communication. Most developing countries welcome foreign investment if it is on a minority basis and will complement rather than displace local investment. Foreign investment is usually completely closed to the state-owned industries, which vary from country to country. For example, with the sudden increase in marine-related interest in Mexico within the past few years, the fishing industry has become increasingly government controlled. Private industry does still exist, but it is being rapidly phased out and foreign investment in this area is restricted. The idea that foreign investment should be limited to minority holdings is stated for every country, but is easily bypassed if it is obviously in the interest of the recipient country.

The investment is particularly welcome when it presents advanced technology, capital, and managerial expertise and is located in less developed areas of the country. It is also welcomed if it increases exports. No matter what the official restrictions tend to be, if it can be proven that the foreign investment will benefit the country, the restrictions are lifted or bypassed.

Although some do exist, there seem to be few entry restrictions to foreign investment with regard to marine-related areas.

Whether or not it is because developing countries have discouraged assistance or whether there has been no foreign interest in this area is difficult to ascertain. The lack of restrictions may also be a result of the fact that few countries perceive the value of their marine resources presently. But, as their awareness increases, so will the number of restrictions.

An Example of Host Country/Industry/International Program Office Cooperation

Institutions in developing countries often find their work hampered by: 1) lack of funds to purchase even the most basic equipment; 2) lack of information about equipment available, and; 3) inability to obtain fair prices for equipment and facilities obtained from large corporations. A possible mechanism for obviating some of these deficiencies is suggested.

An organization, the Central Processing Office could be established within an appropriate government agency. Requests from various local institutions could be sent to this central office which would be able to better coordinate the acquisition of relevant resources. A small full time staff, concentrating on processing information on equipment available and procuring it directly if requested by a local institution, would help utilize more efficiently the limited funds available. Some functions this organization might perform are summarized below:

(1) Surveying equipment available globally and then buying the best equipment for the money budgeted.

(2) Helping local institutions establish a rational facilities maintenance, replacement and purchasing system.

(3) Renting and leasing large, expensive equipment that could be shared by several local institutions and agencies.

(4) Circulating information on equipment and prices to various local organizations.

(5) Engaging in central purchasing of standard equipment in order to avail themselves of quantity discounts and exert greater leverage on suppliers for better quality and delivery dates.

(6) Searching for second hand equipment where such equipment reasonably meets the needs of local organization and either disseminating the information to the organization itself or purchasing it directly, paying a fair depreciated price as opposed to some higher price a corporation might otherwise charge if the purchaser were ignorant of the true market value of the good.

Such a project could well be initiated as a seed project of the international program if a country or group of countries decides to establish it or some variation of it. Such a central processing office may serve as a point of contact for involving industries in international programs.

MEXICO - A COUNTRY CASE STUDY

Introduction

Mexico is selected for a country case study because that nation meets several of the criteria (see Vol. I, A Study of Marine Technology Sharing) for initiating joint projects. Some of these criteria are:

1) A strong commitment on the part of the Mexican government to foster development of marine-related areas.

2) A pool of scientists and technicians capable of making a useful contribution to an international marine sharing program.

3) A fairly extensive network of contacts among the U.S. and Mexican marine science and technology communities.

The proximity of Mexico is an added consideration in selecting that country for a case study.

The study was undertaken not to initiate programs but to consider this case as an example for international marine cooperative ventures. It was also felt that the study would demonstrate that technology sharing need not be a unilateral act of sharing but rather a joint program of cooperation. It was further envisaged that the study would summarize many of the authors' conclusions about the necessary prerequisites for successful cooperation, including the need for people in different cultures to understand and appreciate each other and the imperatives of effective communication.

As the idea of an International Marine Technology Sharing Program develops, Mexico becomes an ideal location for potential cooperative programs. It is a rapidly developing country in which the government has made a major commitment to promoting marine activities through federal and state funding. The pool of expertise is adequately sophisticated in 1975 to benefit greatly from joint endeavors, while simultaneously being able to contribute to the scientific and technical community of a more advanced country. The following case study afforded the opportunity to begin learning something of the cultural, political, and economic structure of Mexico, to isolate problems within the marine community, to identify potential areas of cooperation, and to discern if there would be any interest and commitment to a program of this general nature.

The findings of this study are based on specific information received as a consequence of detailed i-terviews conducted with academicians, administrators, scientists, technicians and entrepreneurs in Mexico during January 1975. The perceptions of the Mexican marine community are bounded by the cultural, educational, sociological and attitudinal perspectives of the researchers and limited by the short duration of the field trip. While this study reports the situation perceived by the researchers, a conscious effort has been made to filter out preconceptions and biases.

It may sometimes appear that the study adopts an inflexible stance about cultural differences, organizational processes and community norms. It is done merely to focus attention upon these differences without intending to assign value judgments to them. It is imperative that administrators and researchers be aware of the dissimilarities and points of divergence between their native system and the foreign environment with which they interact, as well as points of convergence and similarity.

The thrust of the investigation is towards international program management. The international administrator often needs to address issues which are immediate and important to the participants. Factors which could change over the long term are essentially unvarying over the project horizon and being such, define the existing operating environment. These boundary conditions, which the international team must accept as given, limit the area within which the quest for a feasible solution can be conducted.

Conceivably, political, sociological and historical theories are available to explain what are perceived as obstacles and barriers to international cooperative ventures. While these explanations may serve to illuminate and sensitize the international actors, they do not mitigate the physical manifestations which are the very real and diverse barriers. Accordingly, this study will not pursue the investigation of the causes and differences.

This disclaimer is not to imply that the international team be politically, sociologically or culturally naive. Quite the contrary; it should recognize, for instance, that many of the problems are generic to developing nations and not unique to Mexico. Some, however, are endemic to Mexico and need to be viewed as such. Still others exist in all countries to varying degrees, depending upon the level of development. In some situations, models derived from international experiences are generally valid. In others, these paradigms are of little applicability.

In making the evaluation, the researchers attempted to use certain dimensions such as:

1. The type and structure of the bureaucracy and complex organizations.
2. The diversity of agencies.
3. Checks and balances within the scientific community.
4. The population and expertise within the scientific community.
5. The accepted practices and norms within the scientific community.

The search for a standard scale led to adopting the U.S. environment as a standard, not because it is necessarily the best, but because it is the one most familiar to the authors.

The study goals were:

1. Identifying government agencies, academic, and industrial organizations involved in marine affairs. Determining their activities by nature and extent. Investigating channels, sources and content of information received.

2. Studying the role of these organizations in the dissemination of assistance, innovation and information. Identifying links with actors, both local and foreign.

3. Identifying key people within the community and determining areas for cooperation.

Methodology

A number of alternative methods were available for establishing contacts to conduct the research. These could be formal and governmental or informal and nongovernmental. Formal methods are generally slow and bureaucratic. These contacts accomplished what bureaucratic formal means had been unable to do in this case. A lesson can be learned from the obstacles encountered. When embarking upon an international project, it is not sufficient to locate key people and begin establishing contacts. One should seek to identify and consider the political and sociological barriers to ensure a smooth process. Government bureaucracies and personalities, as in all international arrangements, must be handled carefully and sensitively. Bypassing official channels for small exploratory work can have its advantages by avoiding red tape. However, it is essential to go through proper diplomatic channels for any major undertaking of an international nature.

After careful consideration, it was determined that the most efficient means of obtaining the desired information would be through personal interviews. Before leaving for Mexico, a detailed interview outline was prepared. This outline could be tailored to suit the people who were being interviewed, i.e., academicians, government employees, and industrialists. The focus of the interviews covered fisheries and related areas. The interviews were conducted by starting in the relatively small fishing cities of Ensenada, Guaymas, and Mazatlan, and proceeding finally to Mexico City. The purpose of this was to get a grassroots picture of the fishing environment, and the global view available from Mexico City, the heart of the marine community.

Cultural Aspects

The initiation of a bilateral cooperative program requires the participants of both countries to learn as much as possible about the cultural and social differences which will ultimately be encountered. An appreciation of these differences will not only ease tension and improve rapport between individuals, but it can be a valuable means for avoiding potentially disastrous mistakes. For example, if women are involved, the machismo concept in the Mexican culture is important to understand. Machismo, briefly explained, is an attitude of male dominance. It emphasizes the demonstration of virility and masculinity, and its manifestations can range from excessive pride and inability to admit mistakes to treating women as subordinates. This attitude of superiority of men was described by two women (a marine scientist and a teacher of literature) who were interviewed. (This is also documented in anthropological and sociological texts by Oscar Lewis such as Death in the Sanchez Family.)

Further, the Mexican people are extremely sensitive to criticism-- constructive or otherwise. Long-established friendships can be destroyed permanently during such exchanges.

The result of this is not necessarily lower quality of productive work, but possibly a longer learning curve for improvement of research techniques. A person working on a paper will not generally allow others to read it for comments and recommendations. This attitude is perhaps explainable by reason of the absence of any institutional mechanism to avoid piracy of work results in a narrower research perspective. Besides distaste for criticism, the ever-present fear of piracy prevents people from sharing research findings. The Mexican people have been exploited for centuries and, therefore, it is no wonder they take extensive precautions to prevent further exploitation.

This fear of exploitation common to many developing nations pervades their dealings with foreigners. There tends to be an immediate distrust on their part until confidence is earned by the outsider. Before this point is reached, one must be aware of the lack of acceptance, because chances are that the people with whom a project is being conducted will not be entirely open until trust is achieved.

There are numerous other reasons for what may appear to be prevarication to a foreigner, whereas this may be a natural mode of social communication to other Mexicans. The Mexicans are aware of the cultural implications and generally know when and what to believe. For instance, Mexicans are extremely courteous people. It would be inhospitable to say no to someone. So, rather than say no in a situation in which that might be the appropriate response, they will agree rather than risk offending a person. There also seems to be a loss of face in admitting a lack of knowledge in a subject. Therefore, one might receive an answer to any question asked, regardless of whether or not it is correct. (This is not uncommon in academic communities around the world.)

The scientific research style of Mexico seems to be similar to that of the Europeans rather than Americans. They are inclined to work as individuals or in small isolated groups as opposed to larger multidisciplinary collaborative groups, which are perhaps more characteristic of the United States. This may be due to early European influence or to the previously mentioned fear of exploitation. However, the lack of multi-disciplinary effort may be endemic to the entire international marine community.

Mexicans are also taught at a young, impressionable age to respect "authority figures," such as fathers and teachers. Therefore, students tend to accept the teachings of a professor at face value.

Nationalism is widely prevalent in Mexico. Therefore, extended overseas training programs would not be overwhelmingly accepted. Mexicans proudly admit that they miss the motherland when away for long periods of time. This is why they prefer to study in the United States as opposed to European countries. The close proximity of the United States enables them to return home more frequently than would be possible if they were in Europe. This also implies less of a problem in reintegrating into the society after being trained abroad. Because they are never away for too long a period of time, their cultural readjustment is less upon return, although it should not be underestimated.

Finally, a problem not at all unique to Mexico but of vital importance to efficient communication is the language barrier. There are some phrases which are impossible to translate without loss of meaning. Because the research team frequently relied on interpreters, without whom research could not have been conducted, it was painfully obvious that they lost much valuable information during the translation.

Key People

Locating the key people inside the Mexican marine community was a relatively simple exercise. Even before entering Mexico, the same names continually emerged as being those with the greatest amount of information. In addition, these people had the largest number of both formal and informal contacts. This relatively small list is composed of men from academia, government, and industry who form a tight-knit group. Speaking to one of them, the impression is relayed that he can tell exactly what professional work the others are doing and where they are located. They assemble for advisory meetings and cocktail parties; they are officially and unofficially on the same national committees; they have tight control over information flow within the country and are slowly building an elite community.

The gatekeeper (see Vol. II of this report, Dar/Levis, for detailed explanation of his concept) can be a formidable obstacle if he does not want to communicate. The findings in

Mexico are no exception. One of the key people holds a number of positions linking various organizations. Among other things, he is the coordinator for scientific and technological investigation at a large Mexican university; he heads the marine sciences division of the CONACyT; he is the head of the UNDP effort in Mexico and is an officer of an international marine organization. With his aid, doors opened wide for investigations because he knew the people to interview. Although it is necessary to use these official channels in order to avoid creating international problems, this process makes it difficult to obtain outside contacts. It must be realized that the information received is biased by the process of selecting the people to be interviewed.

Another key man holds a powerful position, as a fund-raiser, politician, and disseminator of information. This man heads the marine effort of a prominent private university in Mexico; he has studied in the United States and travels extensively; he attends international conferences where friendships and organizational links are established and cemented. But, although he is in a position to regulate information flow from outside the university, his internal role is quite different. The students within the university do not usually look to him for support and guidance. They bring problems, issues, and new ideas to department heads or others in the system. This man appears to awe those beneath him. He appears authoritarian and remote. He is extremely effective as an external gatekeeper, bringing new information into the system, but does not serve a liaison role within the internal organization.

Structure and Links of the Marine Community

Mexico has an extensive coastline which stretches across 10,000 km. It has a continental shelf that covers 250,000 square kilometers and estuaries and lagoons that cover an additional 150,000 square kilometers. A recent analysis by G. Pontecorvo and M. Wilkinson (Vol. 2 of this study) attempts to compare Mexico with other nations along the dimensions of economic need, interest in marine resource, and potential of marine resources. Need is measured as GNP per capita; interest is indicated by seaborne trade as a percentage of GNP. For the most part, information on the marine resources of the country is fragmentary and management capability is in the infant stage.

There is significant activity in fisheries (largely shrimp) and oil exploration. Recently, the Mexican government has displayed great enthusiasm in developing marine resources.* Some instances of this are:

1. The Mexican Navy has two research vessels conducting surveys.

2. A National Fisheries Institute is in operation with the intention of doubling the catch between 1970-1978. In addition, construction of 500 new fishing ships and around 4,000 small boats is underway.

3. The Secretariat of Hydraulic Resources has undertaken several aquaculture projects along the coast.

4. The Mexican Oil Company has increased offshore exploration and production activities.

* See Bibliography: Ayala Castanares.

5. A Research Center of Marine Sciences and Limnology has been created and is now in operation.

6. An ambitious UNESCO-UNDP program centered at the Universidad Nacional Autonoma de Mexico (UNAM) to enhance marine science capability is gathering momentum.

A number of organizations were canvassed in Mexico in industry, government, and academia. Within these areas an attempt was made to discover what organizational representatives felt to be their formal and informal links with other institutions both nationally and internationally. Furthermore, a study was made on how information was disseminated inside the specific institutions visited. One striking phenomenon appeared above all others. Regardless of the type of organization or its orientation, personal, oral communication is used far more often than the written word. In spite of the ease with which a letter or a memo can be dictated, most of the interviewees claimed that personal contact was far more effective.

The academic institutions which were visited included the Autonomous University of Baja California, two of 30 plus fisheries schools, the University of Guaymas (an extension of Monterrey Institute of Technology), and Universidad Nacional Autonoma de Mexico.

Academia

Universidad Autonoma de Baja California
Unidad de Ciencias Marinas

The university in Baja California has a small school offering a bachelor's degree in marine science. Its funding is proportioned so that 75 percent comes from state and

25 percent from federal sources. Enrollment must be proportional to funding, meaning that 75 percent of the students are from the state of Baja California. Although the school is not itself new, the marine science orientation began to take form during the last three or four years. The orientation is primarily research, which the university has been conducting in the fishing community. It is now trying to attract faculty from abroad in order to set up a master's program. There are formal links with the CONACyT (Consejo Nacional de Ciencia y Technologia) and UNAM (Universidad Nacional Autonoma de Mexico). It contracts with the CANACyT to allow people to study abroad so that when they return, they will be able to make meaningful contributions to Mexico. Visiting professors are also subsidized by the CONACyT. Both informal and formal connections are made with U.S. academic institutions such as Scripps Institution of Oceanography.

There are also informal links with Productos Pesquero Mexicanos (PPM), which is a government-owned marine food processing organization. Whenever PPM has boats not in use, it loans them to the university. In return, PPM feels it is getting new methodologies through research which could prove very helpful in a commercial environment.

Visiting professors to the university establish a one-to-one relationship with students during their stay and involve them with the work being done. In this way, when the professor leaves, there is someone who knows enough about what is going on to continue the work.

There are representatives who do some international traveling, but the majority of the traveling is confined to the United States and Mexico. The strongest informal links are those established during National Congress of Oceanography meetings, which occur every two years.

Intraorganization communication is predominantly on a personal level. The school is small and the offices arranged so as to facilitate ease of verbal communication. One of the key men there receives research papers from faculty and students and in turn distributes them to those whom he feels will be interested. The university is also in the process of preparing to publish its first technical journal.

Instituto Technologico y De Estudios Superiores de Monterrey:
Escuela De Ciencias Maritimas y Technologia de Alimentos
Guaymas

This school also offers a bachelor's degree in the field of marine science. In contrast to the university at Baja, Guaymas's orientation focuses more towards commercial training, with approximately 67 percent of its graduates going on to work in industry. Its staff consists predominantly of people with bachelor's and master's degrees. It was learned from the investigation that there were only three Ph.D.s at the school of marine sciences. As a result of a Ford Foundation grant and World Bank contributions, Guaymas has some very modern equipment, but for the most part, this equipment lies idle. The expertise needed for its operation is not presently held by students or faculty.

Regarding formal and informal links, those interviewed felt that personal contacts were the most useful in getting scientific information. They have formal links with the CONACyT. The director at Guaymas is one of the people identified as an important gatekeeper in Mexico. He is a member of a number of CONACyT committees both in his official and personal capacity. Outside the university, information is disseminated through technical newspapers, bulletins, informal meetings, international conferences, national congresses, and joint projects, such as with the Department of Hydraulic Resources of the Mexican government. Within the school, memos, weekly meetings, circulars, institute newspapers from Monterrey and most important, what is called "coffee break talk," serve to disseminate information. Coffee break talk is the informal sort of conversation during which important information may be exchanged on a casual basis. An interesting point is that although the facility at Guaymas has been a part of international projects from the Ford Foundation, the U.N., etc., and has some exchange students and visiting professors, it is not really interested in international programs and is not actively promoting this concept.

Universidad Nacional Autonoma De Mexico (UNAM)

UNAM has had a marine program for 15 years, but real growth has only occurred within the last two or three years, as is the case with marine affairs all over Mexico. UNAM facilities house a number of activities, directly and indirectly related to academia. For instance, the Centro de Ciencias del Mar y Limnologia (Marine Science and Limnology Center), the Mexican Oceanic Sorting Center (CPOM), and UNESCO effort are all located inside the gigantic UNAM campus.

The marine science center was created in 1973 as a part of UNAM dealing specifically with the marine science area and its needs. The center has its own boats, but welcomes opportunities for joint projects with Scripps or the Mexican Navy. Joint projects can be planned by individuals. After project formulation, a representative takes the project to the department head, who gets in touch with the CONACyT for coordination purposes and approval. It appears at this point that the center has not established many links, but the director does a great deal of traveling for specific information on programs and to explore the feasibility of exchanging personnel and students. Apparently, there is a gestation period which is necessary in building up informal links within one's scientific community. The director made it clear that he is given a great deal of freedom to communicate with whomever he chooses, a first step in the formation of informal contacts.

Escuelas Technologicas Pesqueras (Technical Fisheries Schools)

These schools, established in 1972, are a part of the Direcion General De Education En Ciencias y Technologias Del Mar, which is under the Secretariat for Public Education. The approximately 30 fishery schools scattered throughout Mexico have as a primary purpose the training of students, generally ages 12 to 15, to bring new skills and technology into the

Mexican fishing community. However, the schools also offer training in the areas of Spanish, mathematics, natural and social sciences, foreign languages, art, and physical education.

The three-year program is a delicate balance combining practice and theory. The schools are usually attended by the children of members of the fishing cooperatives, and thus have both formal and informal links with the cooperatives.

Admission Breakdown

Sons of fishermen	50%
Sons of farmers	30%
Other members of the marine community	20%

The control of the schools is highly centralized, with adaptations made for local needs. Headquartered in Mexico City, the schools are organized along two functions: technical and administrative. There is a parallel organization in each of the 30 schools. There also exists a fairly active parent teacher organization in each school. The technical department has control over the academic structure of the curriculum. Each school has a slightly different orientation. Students are drawn from the local community, so the place in which a person lives, in some respects, determines his/her future education.

Informal links with the local community are forged in the form of community services conducted on a regular basis by the students. In the process, they are able to learn more about local needs, which are a prime concern in establishing course content at the schools. They maintain links with various universities in order to use the university facilities. On each voyage made by the cooperatives, at least one instructor and one student accompanies the crew in order to gain first-hand fishing experience. Another formal link the schools have with the fishing industry is through PPM, in the form of practical training at the plants.

The students are organized in a highly disciplined fashion and retain a great deal of power. There are student representatives on the school board. These students were on strike because they felt the degree of politicking among teachers had significantly reduced the quality of education. Negotiations were underway between the students, administrators, and representatives in Mexico City to correct this situation.

Industry

Fisheries Cooperatives

The fisheries cooperatives are a powerful, highly organized group of fishermen in Mexico. They have constitutional validity and exercise a monopoly on the fishing of certain species of fish. The Mexican government actively sponsors these cooperatives which undertake the bulk of fishing activity in the country. Legislation restricts fishing to certain seasons in order to prevent overfishing and stock depletion. Although there was initial resistance, the cooperatives have largely accepted this law after perceiving the benefits accruing from seasonal fishing.

The cooperatives sell predominantly to Productos Pesqueros Mexicanos, but are allowed to sell through contracts to private companies. The members of the fishing cooperatives are overwhelmingly from the older generation of fishermen, using outmoded techniques and exhibiting resistance to change. They have an aversion to communicating with outsiders, which inhibits the introduction of innovations. Gradually, though, things are beginning to change. The graduates of the fisheries schools will be joining the cooperatives. They already have established links with the members through their schools so they will face a reduced integration problem. The ideas of these young graduates may be slow in gaining acceptance, but change will occur. Even now, if a representative from a university or government agency is able to obtain the trust of the chief of an individual cooperative; if he is willing to proceed at a very slow, careful pace; and if he is able to show some proof of physical improvement, receptivity to change does exist. An interesting formal link is that of the cooperatives with the Banco de Formento Cooperativo, a government organization which finances long-term loans to the cooperatives, which in a real sense are grants. These loans are seldom repaid, but the financial organization knows and expects this; it is an informal mechanism for subsidizing the cooperatives.

Other than the cooperatives, the marine industry in Mexico is predominantly government-controlled. This aspect will be elaborated upon later in this section. But as a result of this fact, interviews with people in the private industrial sector were fairly limited.

One man, on the board of directors of a private fishing company, said that the share of private industry in fishing was declining each year. His company does have some direct formal links with the U.S. fishing industry. Because industry undertakes no original research in Mexico, his firm sends staff to six-week training sessions and laboratory demonstrations. It also has formal links with U.S. companies for the purposes of promotion and advertising. This man said that his company exports only to the United States. He was educated at a U.S. university and maintains many informal contacts with people in the United States, which may account for the U.S. orientation of his company.

Within Mexico, both the formal and informal contacts prove extremely beneficial. Officially, this executive is a member of the CONACyT advisory committee, which he views with some skepticism, in that he feels that the committee gets too bogged down in semantics and accomplishes little at its meetings. Unofficially, he is working with the fisheries department to promote fish consumption inside of Mexico. He also has informal meetings periodically with government agencies in order to inform them of what he feels to be the latest innovation in the field. His links with the fishing cooperatives consist of contracting with them in order to gain legal rights to sell certain types of fish. His philosophy is that Mexicans must share information if they expect to grow.

Productos Pesqueros Mexicanos

This is a government-owned fisheries enterprise, headquartered in Mexico City with production facilities all over the country. Their activities include purchasing fish from the fisheries cooperatives, warehousing, processing, canning and exporting.

The facilities in Ensenada and Mazatlan were visited and striking differences were noticed between the two. For example, in Ensenada there was the distinct impression that the PPM branch works together with schools providing boats for research, but in Mazatlan no programs of this sort surfaced. The international links of PPM are predominantly formal, such as working with American canning companies, attending training programs in California, and having people from canning companies in California come to Mexico and conduct training sessions. The younger people who come from headquarters travel to the different plants. They are uncomfortable with what is going on because of what they perceive to be outmoded methods being employed at the various branches. Therefore, they go to the plants and use a two-way communications style. They watch and learn exactly what is being done and gradually try to transmit new ideas to plant employees.

A young quality control engineer in Ensenada said he had learned that informal contacts provide the best channels of communication. He began his work using formal links in that he contacted organizations as a representative of PPM. But over a period of time, he learned that if he was able to establish personal links inside the company, his work was considerably reduced. He began a training program for employees at the Ensenada branch conducted by other Productos Pesqueros representatives. If it proves successful, his aim is to take these people and have them do the same activity at other branches throughout Mexico. There was a genuine pride attached to his organization of this training group.

The fishing cooperatives are a powerful, highly organized group of fishermen in Mexico. They have constitutional validity and retain a monopoly.

Government Agencies

Consejo Nacional De Ciencia y Technologia (CONACyT)

The CONACyT is the Mexican equivalent for the U.S. National Science Foundation. It was established in 1970 because scientific research was largely isolated in Mexico. Figure 8 is an organization chart of the CONACyT. Dotted lines surrounding functions represent planned activities, which at present do not exist. Further details on the CONACyT may be found in a booklet titled Atribuciones, Estructura y Programas de CONACyT, by Gerardo Bueno Zirion. The booklet is part of a series of articles published by the CONACyT.

The CONACyT maintains formal international links with the UN through a UNESCO/UNDP program. The purpose of this venture is to create an infrastructure conducive to higher level studies. For example, the program furnishes support for master's and Ph.D. students, scholarships for research, and equipment. The

FIGURE 2

CONSEJO NACIONAL OF CIENCIA Y TECHNOLOGIA JANUARY 1974

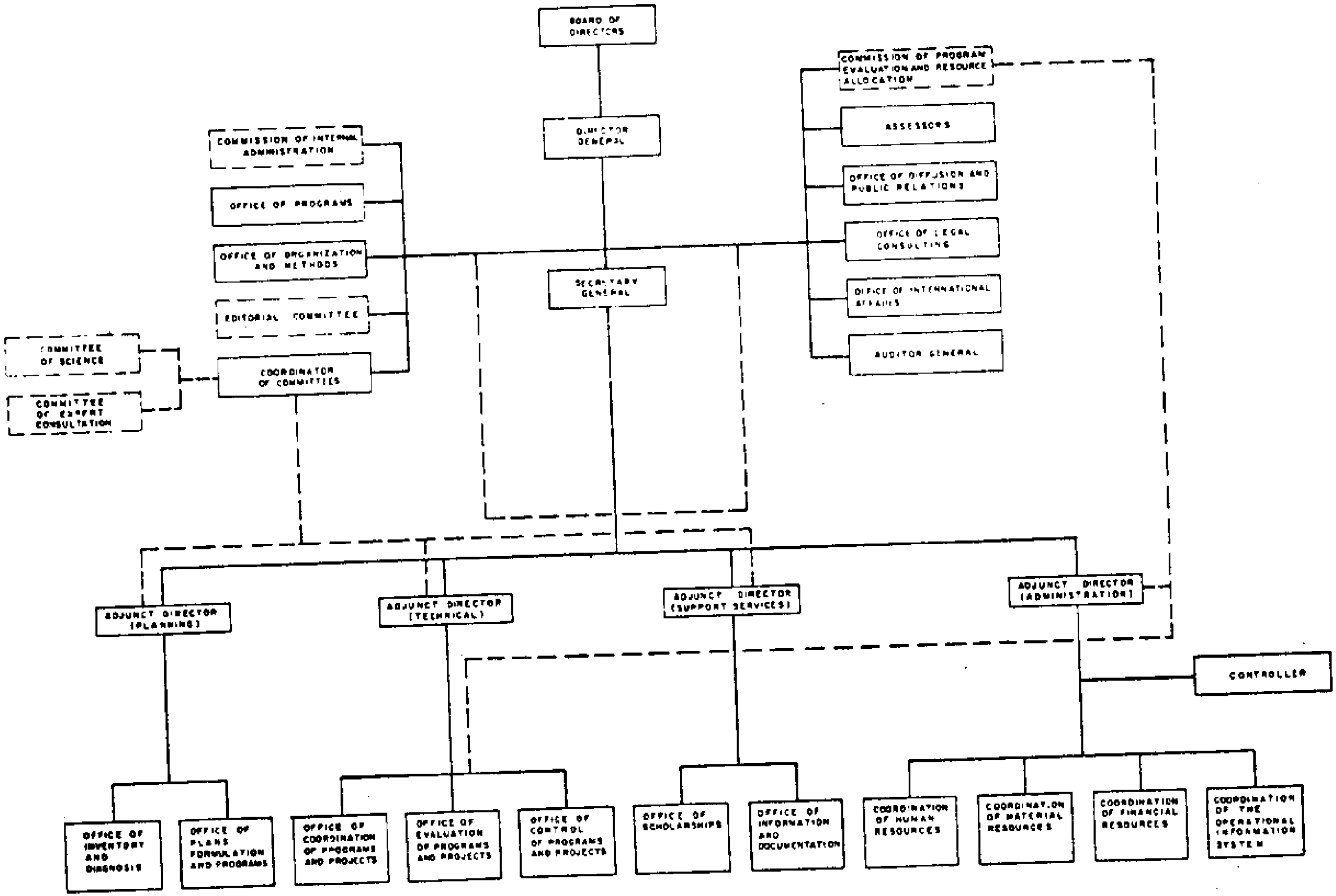
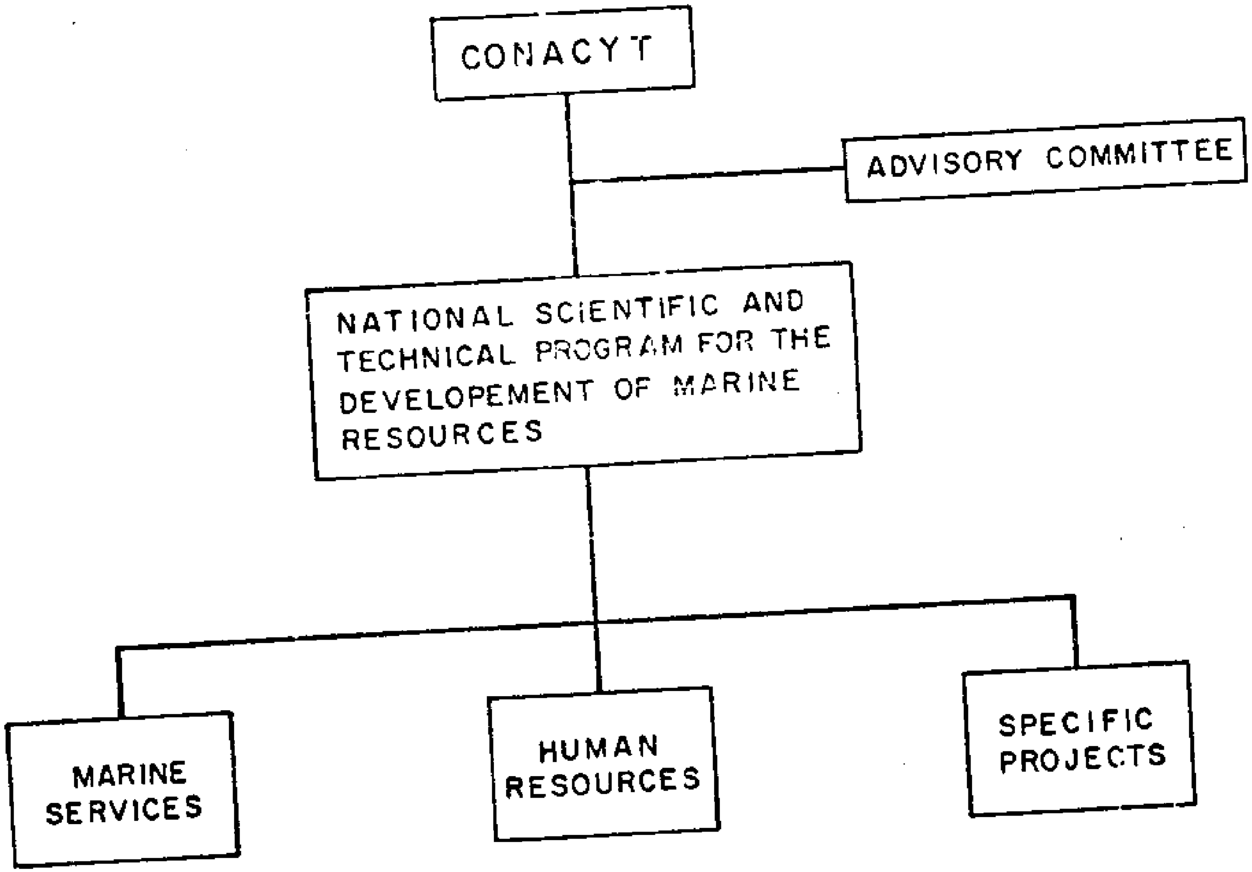


FIGURE 3


CONACYT
ADVISORY COMMITTEE
NATIONAL SCIENTIFIC AND TECHNICAL PROGRAM FOR THE DEVELOPEMENT OF MARINE RESOURCES
MARINE SERVICES
HUMAN RESOURCES
SPECIFIC PROJECTS

program is implemented through the selection of a UNESCO project leader. Experts in various areas including marine geography, physical oceanography, marine chemistry, marine biology, fisheries biology, aquaculture, ocean instrumentation, marine ecology, ocean engineering, and geophysics are sent to various institutions throughout Mexico. Representatives of the CONACyT stated that a new UN project will be beginning sometime in 1975.

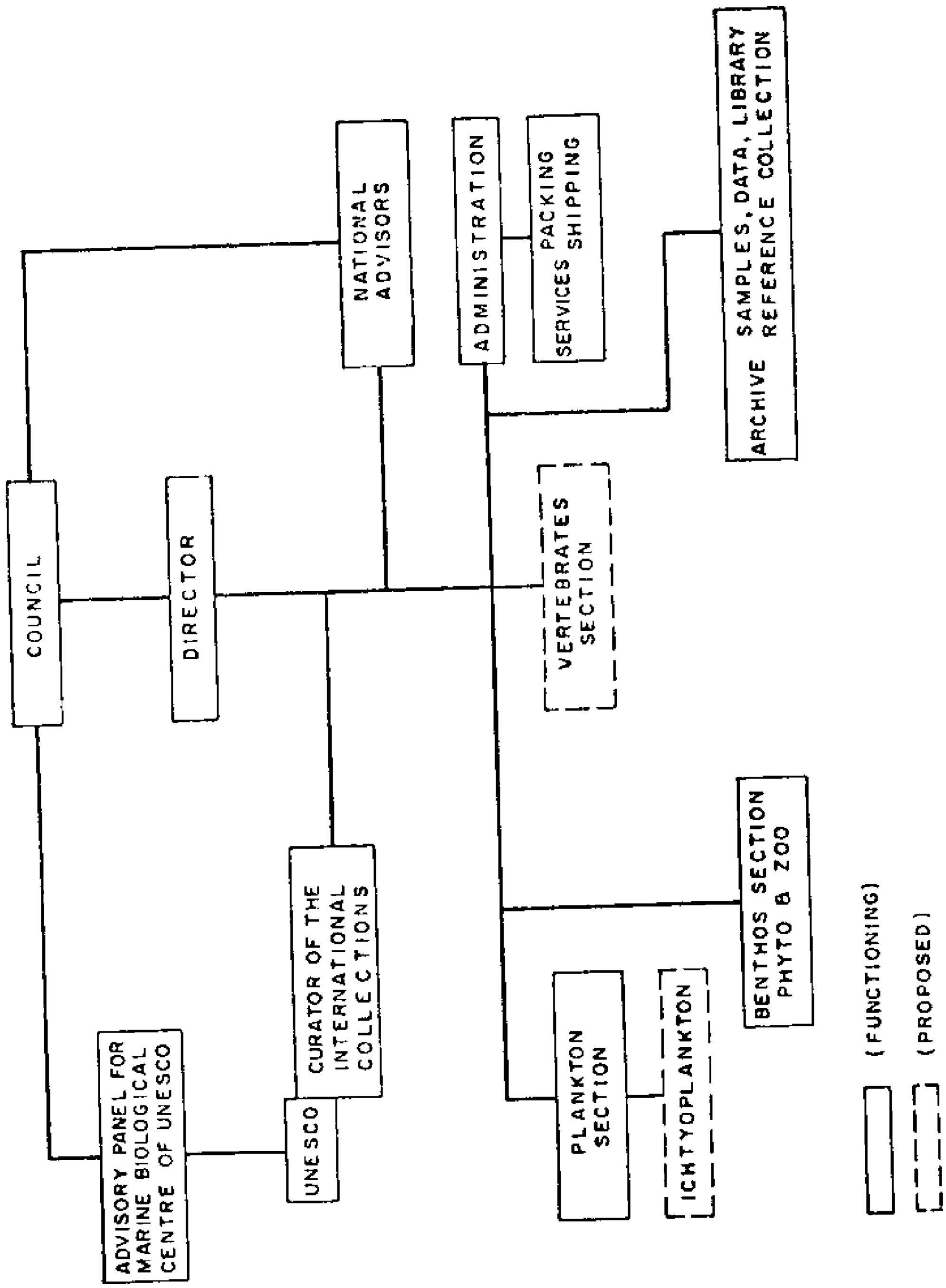
Centro De Preclasificacion Oceanica De Mexico (Mexican Oceanic Sorting Center) (CPOM)*

The Mexican Sorting Center was started as a part of the Mexican contribution to the Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR).

The center is intended to be a regional service unit to sort marine biological samples, to store and retrieve oceanic and marine biology data, to prepare and curate reference collections. It also has seminars and training programs for students in biology and oceanography at UNAM. The data originating from the center as well as those received by it are processed and stored according to a system compatible with that being developed in cooperation with other centers. The library and reference collection are limited to identification material, information directly related to sorting procedures, techniques and visual aids. See Figure 4 for an organization chart of the center.

* See Bibliography

FIGURE 4
CENTRO DEPRECLASIFICACION OCEANICA DE MEXICO
(MEXICAN OCEANIC SORTING CENTRE)
-CPOM-



The following is a summarized description of the fundamental steps in the working plan of the Mexican Sorting Center.

1. Specimens sent to the center by the different nations participating in CICAR and containing samples are opened in a special area; the samples are then transferred to the reception desk where they receive an entry number (the Sorting Center number), and are stored on the shelves of the storage room. The original label prepared aboard ship is stored in a special register and is replaced in the jar by an exact copy of the original label. Three identical identification cards for each sample are prepared giving all the data of same and filed by: (a) Name of ship; (b) Geographical area; and (c) Country.

2. Samples are transferred to the laboratory. Measurements of settling and displacement volume are taken of the whole samples and after removing large organisms.

3. If the volume of the samples is larger than 15cc, the sample is split and an aliquot of same is removed for dry weight and total catch measurements.

4. Whatever the size of the sample, an aliquot of about half the bulk of the sample is conserved as archive. The archive collection bears the same number and is labeled as described under item 1. Whenever the sample is about 3cc or slightly larger than 3cc only fractions smaller than 3cc are stored.

5. The sorted fractions are labeled and number of specimens sorted in each bowl are recorded on both the subsamples to be sent to the specialist and on special forms kept at the center. These forms contain the number of specimens sorted for each bowl of every sample sorted.

6. The sorted fractions are packed for dispatch to specialists along with a list of samples from which the subsamples were taken.

The results of the research are kept at the center and at the time of the interview, written results had not been sent to anyone. However, people working at the center were working on an appropriate vehicle for doing so. Again, because it is so new, very few people know of its existence and, thus, its use is extremely limited. CPOM is oriented primarily towards other Latin American countries, but is not restricted to giving information to only Latin American scientists. It has sent people to California for workshops and is in direct contact with a sorting center in India in order to establish links and advertise their own facilities. It also exchanges a limited amount of information with centers in Italy and Algeria.

Secretaria de Marina

The Secretaria de Marina exercises control over the merchant marine and the Navy and is represented on the advisory committee of the CONACyT. The representative of the Secretaria who was interviewed is the Director General of the Centro de Datos Oceanograficos (the Oceanographic Data Center of the Navy).

Figure 5 provides a functional chart of the data center. In addition to the functions shown on the chart, the center sponsors a number of joint oceanographic cruises with scientists from U.S. universities, in the Gulf of Mexico and the Pacific Ocean. Information on the cruises is disseminated to other members of the marine community and various organizations nominate people to participate in these cruises. As a result of the feeling that the CONACyT is slow, the center tends to bypass the CONACyT as much as possible. This is becoming increasingly more difficult since the CONACyT has legal authority over the center and requests all cruise information.

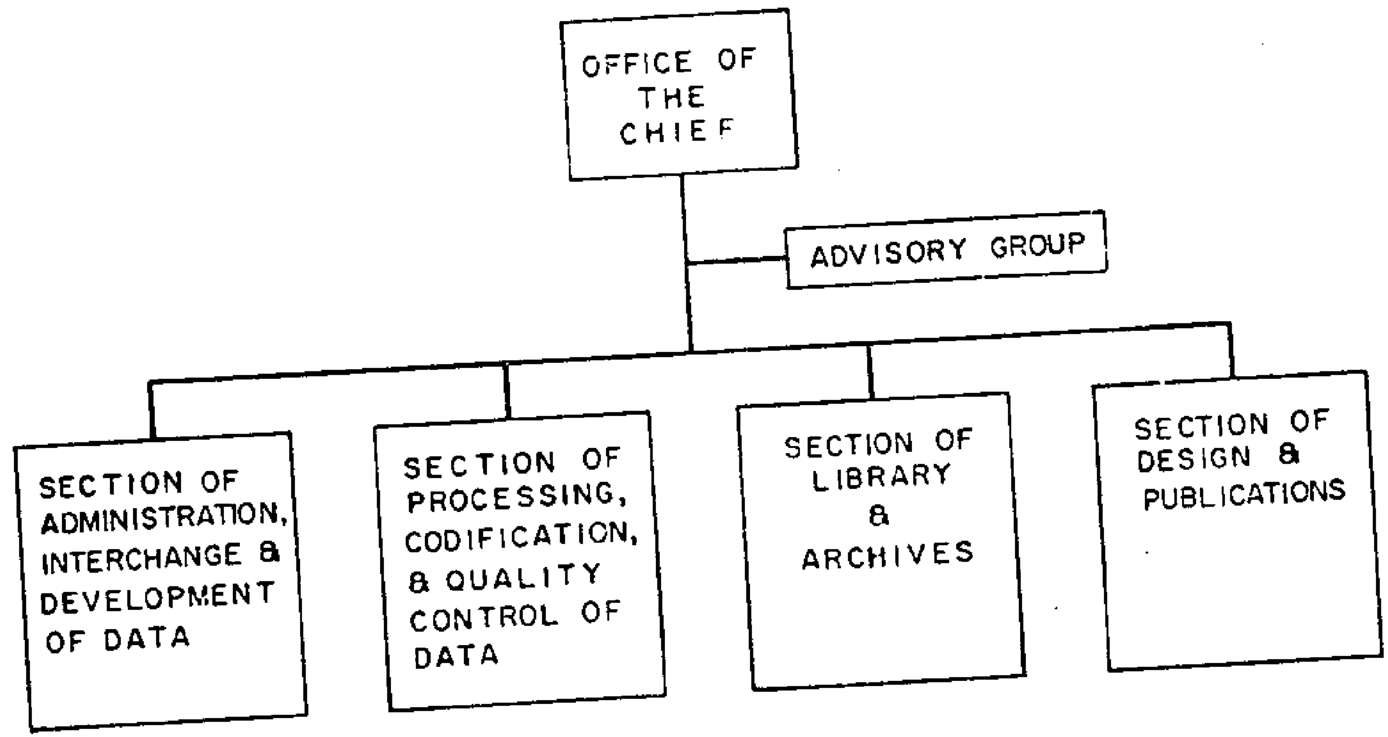
Proposals for joint projects have to be sent to the CONACyT which reviews them for scientific content and to the Navy which must authorize sailing in territorial waters. No formal mechanism exists, as yet, to work out projects with the CONACyT. An official from the CONACyT, however, was working on a way to regulate investigations at the time of the study.

A major project envisaged by the center is a six-year effort to plot a chart showing the living and mineral resources of Mexican territorial waters. The center has a staff of around 500, most of whom have some training in oceanography and hydrography and a bachelor's degree in a marine-related discipline. The center is trying to undertake its own training programs with the assistance of CONACyT scholarships.

The data center has concluded several survey contracts with some institutions in Mexico to make harbor charts. A large proportion of the contracts are with UNAM owing to the UNESCO-UNDP

FIGURE 5

CENTER OF OCEANOGRAPHIC DATA



project referred to previously. Frequent meetings with representatives from universities, the department of fisheries, regional agencies and other organizations have helped reduce duplication of research.

Representatives from the center frequently attend conferences and meetings held by a number of international agencies such as CICAR and IMCO (Inter-Governmental Maritime Consultative Organization). Contact with industry is maintained through an Environmental Office which is a part of the Department of Health and Welfare. The center has requested personnel from the Navy to look out for contamination of the marine environment caused by industrial activity. Another link with industry is through an Advisory Service run by the center. A special telephone number is available to people from industry who seek information on oceanographic-related matters. The call gets routed to the official who has the information and direct contact between this official and the representative from industry is established.

International links include contact with almost all U.S. universities working in the Gulf of Mexico and the Pacific Ocean. The center receives information from the U.S. National Oceanographic Center; it obtains a list of universities and sends them publications; it corresponds with scientists at Texas A&M and the University of Oregon; it maintains contacts with a number of hydrographers in the United States.

Representatives from the center feel they receive a great deal of useful information and equipment on loan on the basis of personal contacts. They also expressed the opinion that an international organization for coordination of activities with other Latin American countries is necessary but presently nonexistent.

Instituto Nacional de Pesca (National Institute of Fisheries)

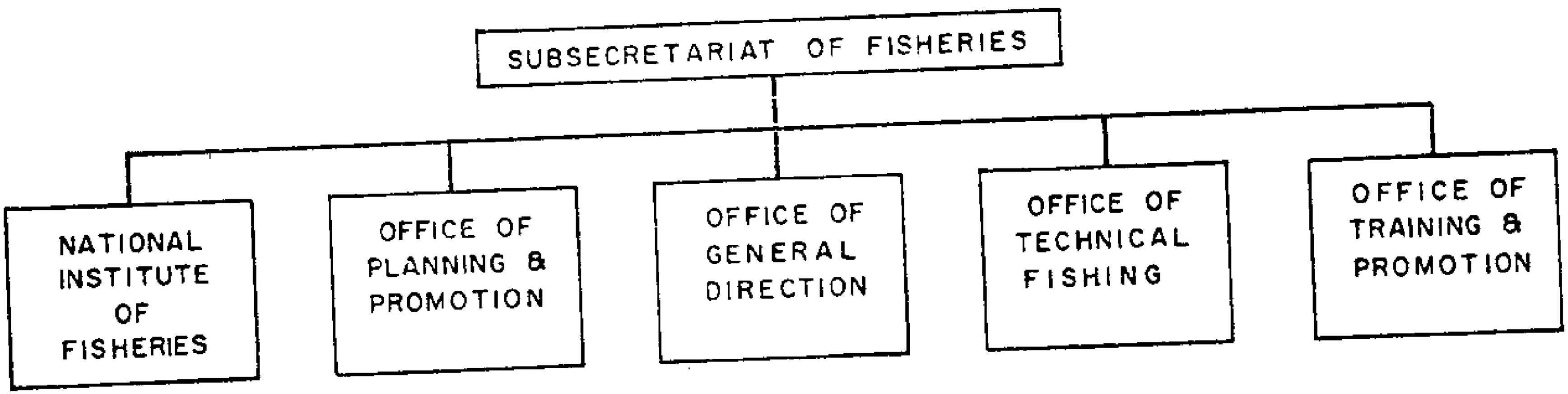
This institute is one of five divisions of the Subsecretaria de Pesca. The others are the Office of Planning and Promotion, General Direction, Technical Fisheries and Office of Training and Promotion as shown in Figure 6.

The Institute itself has 10 field stations located all over Mexico. The formal functions of the Institute are as follows:*

1. Act in close coordination with other Subsecretariat divisions.
2. Complete and maintain an inventory of actual or potential national fisheries resources and distribute this information to members of the fishing industry.
3. Attend technical seminars on the development of the fisheries resources. Assess means of conserving fish stocks based on various scientific studies.
4. Determine for each resource, utilized or not, the optimal catch level indicating in each case the season and geographic area which will optimize the operation of the fishing industry.
5. Promote the use of modern methods of cultivating and expanding fishing resources in rural areas and shrimp and oysters in adjacent bays.
6. Study the biochemistry of fish products, processes for conservation and use; quality control standards; distribution and industrial and commercial applications; evaluate the technology for above; and promote the general use of new and better technological processes.

* See Bibliography: Informacion General.

FIGURE 6


SUBSECRETARIAT OF FISHERIES
NATIONAL INSTITUTE OF FISHERIES
OFFICE OF PLANNING & PROMOTION
OFFICE OF GENERAL DIRECTION
OFFICE OF TECHNICAL FISHING
OFFICE OF TRAINING & PROMOTION

7. Begin investigating the manners and methods of new ways to catch fish which facilitate and increase production period.

8. Participate in the development of the plans and programs of fisheries education. Attempt to put this into practice in the regional courses of the Direccion General De Capacitacion y Formento Cooperative Pesqueros.

9. Initiate works of scientific investigation at the field stations on the coast. Collaborate with state and federal government on plans for regional fisheries development and thus develop and disseminate information and conduct activities oriented towards fishing. The objective of this is to arouse interest in these activities and improve techniques.

10. In conjunction with other agencies, address the problems of contamination in fishing waters, such as establishing standards for the handling, conservation and commercialization of fish products.

Representatives from the field stations work with members of the fisheries cooperatives to introduce new ideas. The latter is not a formal function of the agency but is felt to be necessary in order for it to better perform its official duties. Representatives at the field stations have informal meetings with members of the cooperatives and use posters, pictures and demonstrations. They also emphasize the need for slow introduction of new ideas to ensure acceptance.

The Institute houses a computer facility with remote terminals in all field stations. The prepunched computer cards are given to the cooperatives for them to fill in data concerning place of catch, duration of trip, quantity of catch, and depth of catch. The fishermen are suspicious, so the prepunched card enables the central organization to know which ship filled in what information without the cooperative members being aware of it. In other words, the cooperatives believe when they are filling in the cards that the Instituto de Pesca has no idea which ship the data are coming from. Because they feel no threat, they are willing to comply.

Various programs exist within the These include: (1) study of shrimp in the Gulf of Mexico and the Pacific Ocean; (2) study of abalone in Baja California; (3) study of lobster in the Pacific and Caribbean Oceans; (4) study of the sea turtle in the Gulf of Mexico, Pacific Ocean, and the Caribbean; (5) a program for fish exploration; (6) a program for technical services; (7) a program for the industrial processing of fish; (8) a program for quality control of fish products; (9) a study of offshore contamination; (10) a program of scaled fish of the Gulf of Mexico; (11) a program of oyster culture in the Gulf of Mexico and the Pacific Ocean; (12) a program of experimental fish culture.

The five divisions of the Subsecretariat hold meetings for the establishment of yearly priorities. It is these priorities upon which the field stations concentrate. Programs are laid out by the Subsecretariat according to which division will perform certain tasks. Then, a general program, including a time and work schedule, is established.

The Institute maintains contacts with the CONACyT and the Navy for the purposes of conducting projects and obtaining research vessels. They also have university contacts, including inviting students to join the crew on voyages.

Representatives of the Institute are sent to national and international congresses. They maintain a library of magazines and technical journals from all over the world.

Contacts with the field stations are conducted by telephone, visits, periodical reports, and computer terminals. Although the various mechanisms are available, very little communication actually takes place between the 10 field stations and the Institute.

Figure 7 provides a flow diagram of a joint project, initiated at an Institute field station and including industry, fishing cooperatives, the government (Instituto Nacional de Pesca), and the Center for Fish Promotion. An abalone fund managed by a group known as patrons makes resources available to the Center for Fish Promotion (one of eight in the country). Part of these funds are used at the field station for abalone culture and fish management. The study by the field station and patrol monitoring by the patrons leads to more efficient fishing and commercial development by the cooperatives and industry. Part of the profits from these activities replenish the abalone fund.

Direccion de Aquaculture

This department is a part of the Secretariat of Hydraulic Resources. An organization chart, Figure 8, shows the various subsections of the organization. The functions of the various departments are:

Department of Promotion:

1. Registration, classification, and analysis of information
2. Publication and diffusion

FIGURE 7

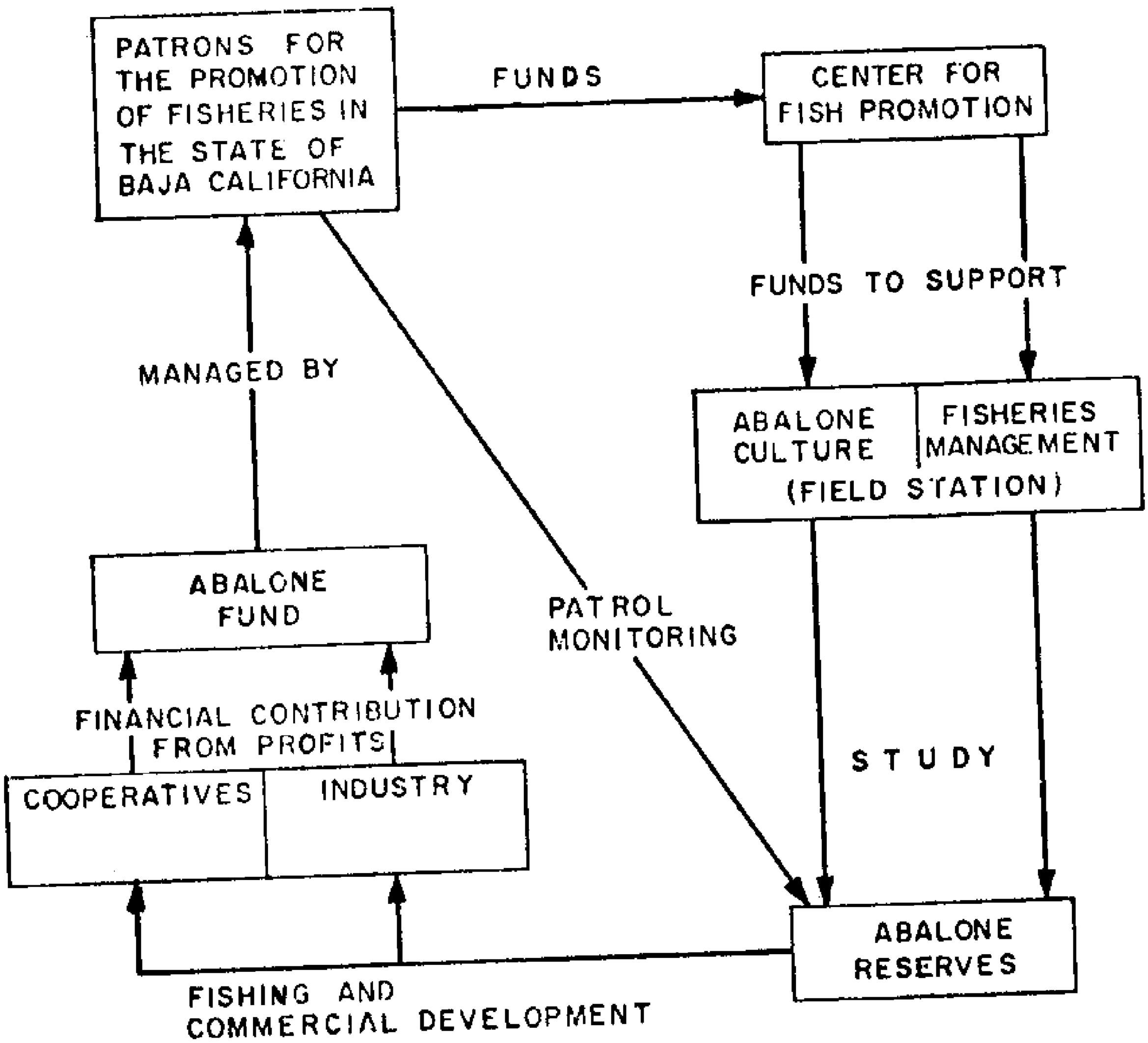
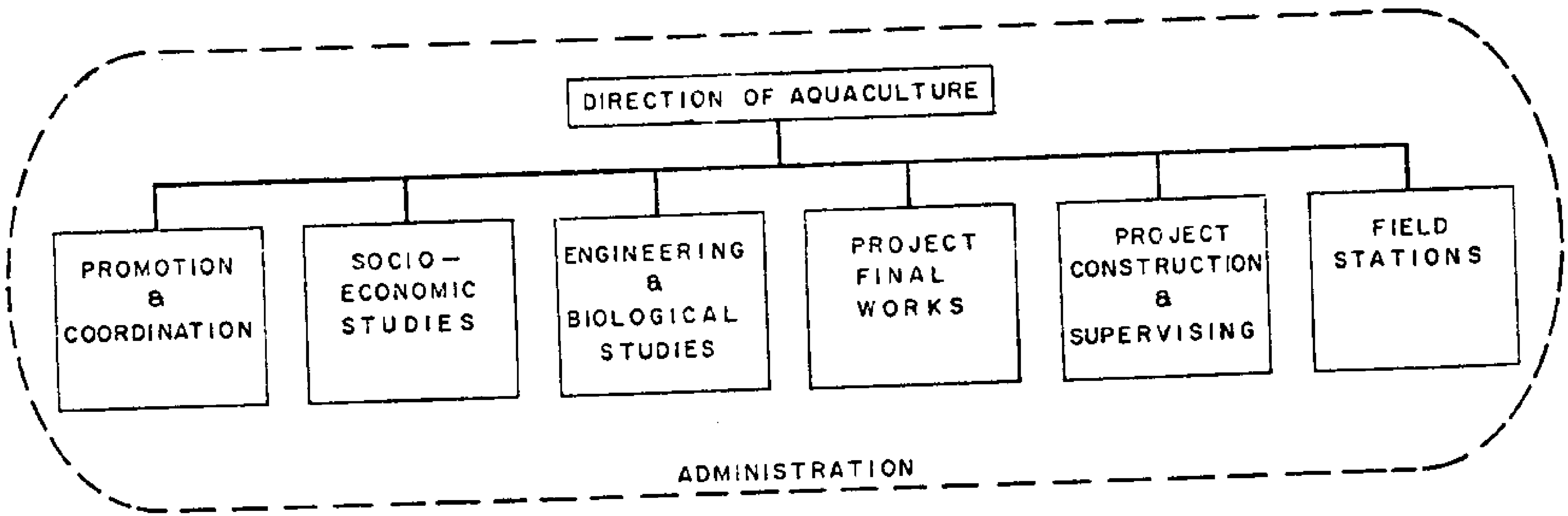

PATRONS FOR THE PROMOTION OF FISHERIES IN THE STATE OF BAJA CALIFORNIA
FUNDS
CENTER FOR FISH PROMOTION
FUNDS TO SUPPORT
ABALONE CULTURE
FISHERIES MANAGEMENT
(FIELD STATION)
MANAGED BY
ABALONE FUND
PATROL MONITORING
FINANCIAL CONTRIBUTION FROM PROFITS
COOPERATIVES
INDUSTRY
STUDY
ABALONE RESERVES
FISHING AND COMMERCIAL DEVELOPMENT

FIGURE 8



DIRECTION OF AQUACULTURE
PROMOTION & COORDINATION
SOCIO-ECONOMIC STUDIES
ENGINEERING & BIOLOGICAL STUDIES
PROJECT FINAL WORKS
PROJECT CONSTRUCTION & SUPERVISING
FIELD STATIONS
ADMINISTRATION

3. Coordination and legal matters
4. Expositions and graphical representation

Department of Socio-Economic Studies:

1. Statistics
2. Investigation
3. Project evaluation

Department of Engineering and Biological Studies:

1. Basic engineering studies
2. Basic biological studies

Department of Projects:

1. Maritime engineering
2. Hydraulic engineering
3. Special projects

Department of Construction:

1. Central costing
2. Contracts
3. Control of Pacific field stations
4. Control of Gulf field stations

The various departments and field stations are managed by an administrative office.

This four-year-old organization has 21 field stations through Mexico. Each field station, staffed with scientists and administrators, does some of its own training so not all the people working there were educated in Mexico City. Progress reports are conducted by having headquarters' representatives visit the field stations rather than vice versa, although these visits seldom occur. Project priorities are established by meetings of various government agencies, which also determine the area of effort allocation and schedule for project completion.

The Secretariat's contacts are widely dispersed. It contracts with the universities and has joint projects with the fishing cooperatives; it provides funds for boats and shares equipment and data with other government agencies; it sends people to conferences and general meetings in specific interest areas; it distributes monthly bulletins to the field stations as an information disseminating technique. It does not use the CONACyT a great deal because the Secretariat has experts on its staff capable of locating needed skills. It has no formal international contacts, but the informal ones have proved extremely helpful. For example, through informal negotiations a simulation technique was adapted from a U.S. university to the Mexican needs. After approval by the Secretariat's board, it was set up with the aid of UNAM and found to be extremely useful. The curious thing is that no one seems to know who first suggested it or from which university the idea originated.

Links with commerce and industry are maintained for the purposes of marketing and production activities. There are weekly staff meetings within the Institute. Specific meetings dealing with zonal problems take place at random intervals. Institute staff members are selected to attend conferences and congresses around the world. Representatives, although sent abroad for educational purposes, are seldom away for periods exceeding one year.

Contacts with universities and specialized people within the universities exist. To contract for a specific study, however, the process must be done through the university as opposed to individuals.

Evaluation and follow-up of projects conducted at the Department of Aquaculture are generally point specific. This refers to the method of isolating one variable and tracing the changes which occur during the lifetime of the project. They are primarily based on numerical calculations, such as size of fish catch from one year to another. They exclude secondary and tertiary effects of programs. The evaluation occurs continuously, enabling modifications to be implemented before the project's termination.

This section described each individual organization by structure and links. Figure 9 illustrates the Mexican marine community in relation to formal flows of materials, people, and capital. It is an aggregate picture of what was described in the previous pages and may be somewhat incomplete. It is stressed that this figure is based on perceptions of the researchers formed during the interviews. It could serve as a useful device in identifying the gaps in the flow of funds and expertise and perhaps motivate people to establish programs designed to improve the existing structure.

Resource Climate of the Mexican Marine Community

The resource climate of Mexico illustrates examples of problems and potential depending upon one's perspective. Because it is so young, a well-trained foreign expert might immediately focus in on what are believed to be obvious problems. On the other hand, its very youth provides tremendous challenges for scientific research and new methods. Some of the problems they face are endemic to the nation and others typical of a developing country that endeavors to foster indigenous expertise and establish local industry. A number of problems listed are inherent to all countries, large or small, developed or not.

A survey of government agencies, universities, technical schools and industry yielded a catalog of perspectives, perceptions and difficulties that largely overlapped, sometimes contradicted and often reinforced each other. Many of these perspectives are highly personal opinions enunciated by specific individuals interviewed; others are views broadly shared by the general community. This section attempts to delineate what is considered a synthesis of perceptions, largely attempting to avoid individual biases and dialectics.

1. The CONACyT, as is typical of most organizations, is not as effective in coordinating programs and policy as it might be. It is getting increasingly more bureaucratic, with scientists and engineers being supplanted by lawyers and economists who are not very comfortable with technology. The organization

started strongly, but it now is beginning to falter as the marine environment becomes more complex and the problems of coordination more imperative; e.g., one individual said he did not like to go to CONACyT advisory committee meetings because the talks got so bogged down in semantics that nothing was accomplished.

2. As in most organizations, there is a critical need for more and better leadership within the community of agencies in Mexico.

3. There is a great need for the communication of ideas, policies, and scientific information with the community. Inadequate information flow often results in duplication of effort and poor coordination of national policy.

4. Mexican scientists feel there is grossly inadequate funding to support research, training and education.

5. Since the community is very young, a critical mass has not yet been established, which hampers tne development of viable research programs.

6. Owing to the centralization of activities in Mexico City, those outside this area find access to information difficult.

7. Some feel that the university training could be more practically oriented, but that is countered by those who recognize the need for an academic community as well.

8. Universities often find it difficult to persuade the government to apply the findings of research unless there is obvious commercial application.

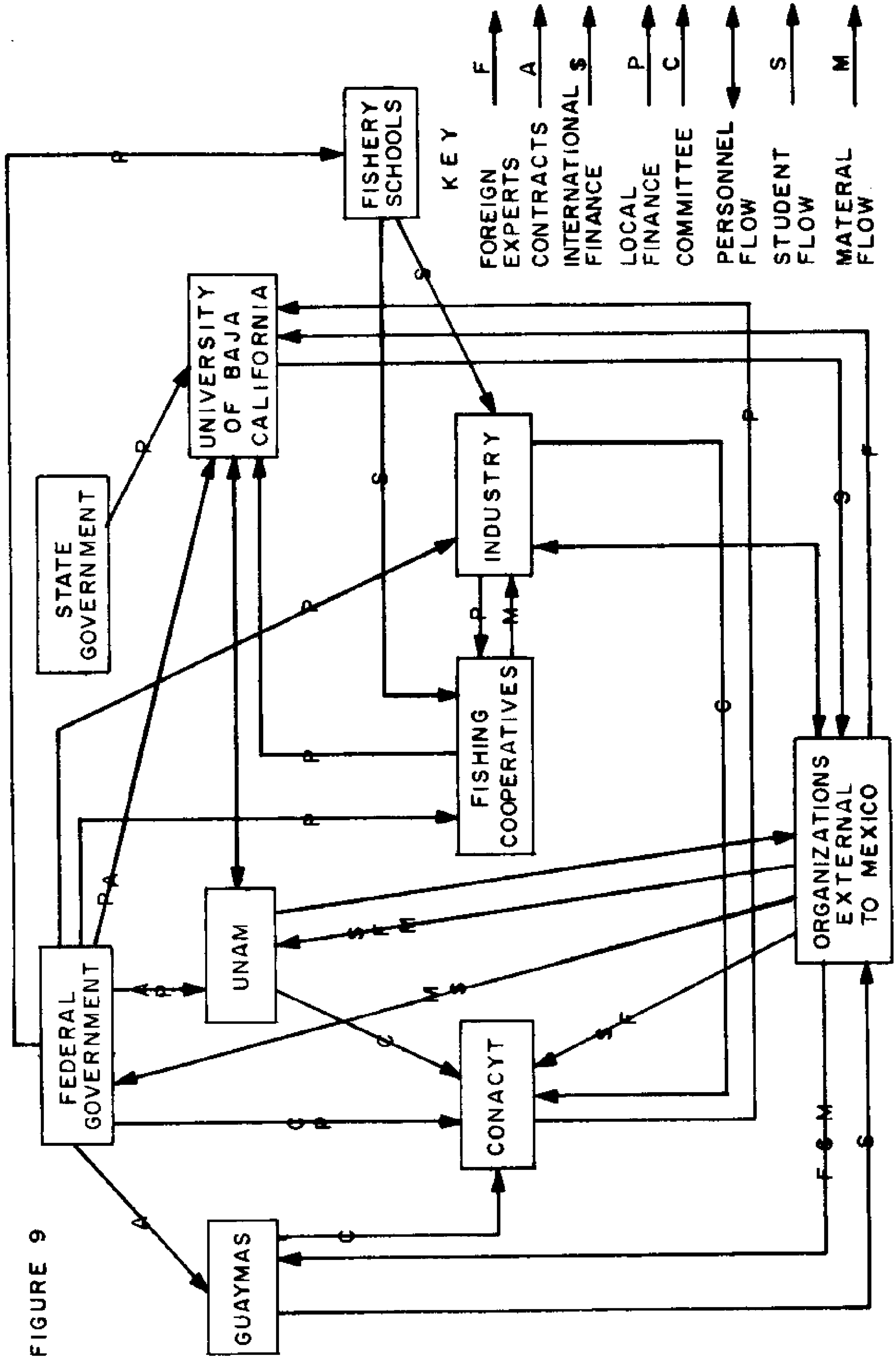

FISHERY SCHOOLS
UNIVERSITY OF BAJA CALIFORNIA
STATE GOVERNMENT
INDUSTRY
FISHING COOPERATIVES
FEDERAL GOVERNMENT
UNAM
CONACYT
GUAYMAS
ORGANIZATIONS EXTERNAL TO MEXICO
KEY
FOREIGN EXPERTS F
CONTRACTS A
INTERNATIONAL FINANCE $
LOCAL FINANCE P
COMMITTEE C
PERSONNEL FLOW
STUDENT FLOW S
MATERAL FLOW M

FIGURE 9

9. The community seems largely preoccupied with short-term gains. The government, in particular, seems interested in leaping to commercial exploitation and application without making a basic study of the processes involved. Considerable danger of making serious mistakes lurks behind such a policy of haste and forced development. The universities are compelled to undertake commercially applicable projects in order to secure funding. This results in a diversion of resources from more substantial research activities.

10. There is some question about the efficiency of the planning process and the foresight embodied in the plans generated. People in Mexico City feel that planning done in the outlying areas lacks a global perspective and is much too narrow in definition of goals.

11. This bureaucracy has an unfortunate tendency to keep useful information confidential. Further, inter-organizational communication is almost absent except at the highest levels. It seems that unless the information-seeker belongs to the agency that provided funding for a project, there is no legal right to see the results of the research. Although this is not always rigidly enforced, it can prove somewhat of a stumbling block.

12. Scientific activity is undertaken in isolation or in small clusters owing to fear of piracy of work. This concern over professional ethics is a strong disincentive to the dissemination of information and expertise.

13. The scientific worker is extremely sensitive to criticism which prevents his work from benefiting by informed evaluations.

14. The community is plagued by politics, as are all communities. The younger members are more concerned with securing tenured positions than in research. They have a tendency to propagate the attitudes of mistrust and empire-building in which their superiors engage.

15. There is little interdisciplinary work. Different departments and sciences do not generally combine resources to focus on a problem.

16. Trained people exhibit a strong disinclination to leave large urban centers, especially Mexico City, and go to the field where the need for their expertise is greatest. The large city is so much more attractive that people linger on in less prestigious positions rather than go into the rural parts, which results in the underemployment of human resources.

17. There is aversion to consuming fish and fish products in the interior of Mexico. The reason for this is largely historical. Poor transportation and inadequate refrigeration facilities caused people to fall ill from eating spoiled fish.

18. There is considerable resistance to change among the old fishermen, but this problem should gradually wither away as graduates of the new fisheries schools enter the community.

19. Some representatives of the community see no great problem that there is a resistance to adopting new techniques. Their attitude is that while existing methods are not the most efficient, they still work fairly well.

20. A large proportion of the fish catch, termed trash fish, is unused because the market for these species remains unperceived by the fishermen. Considerable loss of protein resources ensues.

21. There is little concern for population dynamics, resulting in overfishing certain species.

22. There is no substantial lack of technicians, but there is the problem of locating potential scientific expertise in the students of the academic environment. This implies that whereas the students are competent in pursuing a course once it has been delineated for them, they are rarely successful in identifying and defining scientific problems and developing independent methodologies.

23. Very few universities offer more than a bachelor's degree in marine science. A number of universities, being aware of this problem, are vigorously attempting to initiate master's programs.

24. The fear of foreign exploitation is prevalent--a situation that could easily hamper joint international project potential.

25. The largest marine effort continues to grow inland, in Mexico City, rather than on the coast. This is due to the fact that the greatest concentration of power, both political and scientific, lies inland.

Joint Programs

Constraints. The evolution of technological cooperation has perhaps advanced sufficiently for programs to be based on partnerships rather than paternalism. Of course, strict equality is neither realistic nor expected, since it is the disequilibrium in technology, resources and expertise that motivates cooperative programs in the first place. Nevertheless, the ultimate contribution of both parties will certainly be superior because of the early investment in human resource development. The implication of respect and equality in a joint program is an attitudinal impetus that can make the difference between active contribution and passive reception.

International programs have, at best, a very limited chance of success if they are based on naive altruism. The gains for the participants must be mutual and they must be perceived. The process of negotiation and the allocation of contribution must be informed by a willingness to share rather than be plagued by a desire to demonstrate power or extract monopoly rent.

Since amity necessitates a greater exchange of information than enmity, the problems of communication, so apparent in unilateral transfer, become even more critical in bilateral sharing. The early establishment of a reliable and efficient communication system becomes crucial to the ultimate success of the program. This is a major structural constraint that is universally valid. Noble intentions, expertise and the spirit of cooperation are of little avail unless they are communicated promptly and regularly.

The country case study undertaken in Mexico reveals several areas which pose possible constraints, but nonetheless must be overcome for successful project results.

1. Participants from both donor and receiver nations must jointly identify needs, design programs, implement plans and evaluate results. A conscious effort to overcome suspicion of unequity and exploitation is required.

2. Evaluation criteria and a control system have to be established at the time of program initiation to ensure that objectives are realized. Often resources are misallocated, inefficiently employed, or merely wasted because a monitoring and evaluation mechanism does not exist.

3. Mexico, like most societies, has a ponderous bureaucratic structure that makes swift action difficult. There are multiple decision points that have to be activated before a program can be initiated. A close observer of the bureaucracy related an instance where 22 signatures were required on a document before it could be approved. Provisions for dealing with involved paperwork and multiple government channels need to be incorporated in project formulation to avoid subsequent frustration.

4. The potential for direct investment by foreign industry is severely limited because of the fact that this area is predominantly government controlled. There are possibilities, however,

for entering the environment in a service or consulting capacity.

5. The outlook for regional cooperation is not very promising at the moment. Mexico is far too preoccupied with developing its own capabilities to spare expertise for other countries in Latin America. The limited cooperative activity that exists among Latin American nations does not seem capable of providing a base for an extensive regional effort in the near future.

6. An official at the CONACyT indicated a possibility of contributing to an international memory facility provided bilateral agreements were made with participating nations.

7. Mexico is largely interested in projects that yield immediate gain. This is a problem that will have to be borne in mind when programs are designed. Basic research may be difficult unless the project includes an applications component.

Incentives. Aside from the fact that there are many constraints facing any international project--joint or otherwise--there are a number of incentives behind such a concept. These may range from individual, to organizational, to national in scope. After a careful cost/benefit analysis, it may appear that the incentives afforded far outweigh the constraints, both in human and in capital resource allocations. Some problems initially apparent, such as obtaining qualified personnel to staff project teams, can be alleviated by drawing from professors during sabbatical years. Furthermore, specific incentives may include the following:

1. A university in Baja California, which has no summer session, provides campus facilities to students and faculty from California. This could be valuable for any U.S. researcher who needs a base from which to conduct projects.

2. Other universities in Mexico, although using their campus year-round, are willing to provide office space and lab facilities for researchers.

3. Mexico is willing to provide matching funds for projects, although these may not always be in the form of capital outlays. Their idea of matching funds may include lab facilities, manpower, and providing access to local clearinghouse functions.

4. Mexicans are very willing to establish extensive contacts for a person if they understand and agree with the line of work being pursued.

5. For a young professor, the opportunities are extensive. While high-level, responsible positions are difficult to obtain in a U.S. university, a young assistant professor in the United States may be afforded the opportunity to be a department head in a Mexican school. Not only is a vast amount of knowledge and experience obtained, but an impressive background becomes a part of the academician's record, thus opening new doors of opportunity.

6. Within Mexico, the marine area is almost virgin territory. It has recently obtained a great deal of backing from the federal government in terms of increased funding so that tremendous opportunities for research and teaching abound for visiting scientists.

7. At this point in time, international relations between Mexico and the United States are not as harmonious as is possible. A senior scientist at one Mexican university expressed his opinion on U.S./Mexican relations in the following manner: "The United States and Mexico have a good neighbor policy. Mexico is good and the United States is the neighbor." Joint projects, such as cruises in Mexican waters in which local scientists participate with U.S. experts, if executed in an effective, efficient manner, could not help but improve these strained relations.

8. At the same time, both parties can gain valuable information. For instance, a faculty member from one U.S. university spent some time in Guaymas learning more efficient methods for working with brown shrimp, a specialty of the Guaymas area.

9. At the conclusion of a joint project, the resulting publication lends credence to both groups of scientists.

Areas for Potential Cooperative Programs. An incipient sharing program must necessarily be viewed along the perspectives of past results and present aspirations. The history of past ventures in marine science is filled with instances of exploitation of good faith. U.S. research vessels have sometimes done studies in Mexican waters, availing themselves of the benefits of local facilities without including the Mexican scientists as participants and failing to share data and results. There are some instances of bilateral endeavor and amity, but these unfortunately are a minority of the cases. Several members of the community in Mexico expressed their resentment at what they saw as encroachment by U.S. local institutions and insincerity with respect to joint projects. The Mexican response to what is obviously blatant discourtesy has ranged from protest to seizure of equipment. An administrator at the University of Baja California related that a team of investigators from the United States had entered Ensenada and set up equipment without informing local authorities. This was a clear violation of both international courtesy and Mexican regulations. The local authorities accordingly confiscated the unauthorized equipment. Retaliation, of course, is a deterrent, but does little to evoke mutual warmth or foster an atmosphere of cooperation.

It is encouraging, however, that change is now discernible, as the number of Mexican marine scientists has grown from but a handful to a full effort. There is increasing emphasis on joint U.S.-Mexican involvement in research projects and cruises. Indeed, this emphasis on cooperative effort is being stressed with considerable energy and firmness by the Mexican authorities.

Mexican officials view international sharing programs as an activity that must complement, not dominate, national policy and effort. The intent of Mexican planners is to control the physical resources and nurture expertise in the domestic community, from the local fisherman to the university scientists. They will seek external aid and participate in joint programs whenever domestic capability is either inadequate or the gains from international activity are tangible and clearly perceived.

A case study in oyster culture in Baja California illustrates this observation. A local university in Baja California determined that it would like to undertake research for a fishing cooperative in the area. The research was prompted by a need to discover an additional fishery resource since existing resources were being overfished. A preliminary study indicated that the Japanese oyster would be a suitable species for culture. After an initial investigation, San Quantin Bay was chosen and government support secured. The need for relevant expertise next presented itself. After conducting a survey of scientists, the university contacted an expert from the University of Washington. The Janss Foundation provided funds at this stage so that a meeting between the expert and the university could take place. As a consequence, contacts were established in six facilities under the U.S. National Marine Fisheries Service, a training program devised and a project schedule established.

A pilot project was subsequently undertaken. Initial results were encouraging and a more ambitious effort has recently been undertaken with the support of the Mexican Fisheries Cooperative.

Other cooperatives in the area have also voiced some interest and, contingent on demonstrable success, will join the university in further projects. The Mexican government has sanctioned extended support. The information generated by this project should be of use and interest to both U.S. and other Mexican universities.

Several areas for potential cooperation have emerged. They would fall under the following categories, with the strongest commitment being evoked from people in relation to programs in the first three categories.

1. Coastal zone management
2. Pollution
3. Aquaculture
4. Tourism
5. Fisheries
6. Conservation
7. Fish proteins
8. Population dynamics

FOOTNOTES

1. See Marine Science Workshop, Report of the Marine Science Workshop (Bologna, Italy: 15-19 October 1973) and G. Pontecorvo and J. Gamble (eds.), Law of the Sea: The Emerging Regime of the Oceans (Cambridge, Mass.: Ballinger Pub. Co., 1973).

2. Vinod K. Dar and Marcia S. Levis.

3. National Sea Grant Program, What Sea Grant Is and Does, Draft No. 2, May 7, 1974 (unpublished), p. 8.

4. Ibid. p. 34ff.

5. Ibid. p. 65.

6. See G. Posz, J. Jun and W. Storm, Administrative Alternatives in Development Assistance (Cambridge, Mass.: Ballinger Pub. Co., 1973).

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APPENDIX

Interview Outline

1. Would you mind telling us about your educational and professional background?

   I would like to ask you some general questions about technical change. What I mean by technical change is any new form or different manner of doing things, such as methods of production or administration procedures, etc.

2. What do you believe is the most important marine-related technical change that has taken place in your organization in the past five years?

   When we speak of marine-related, we mean any of the following areas:

shipping	port and harbor design
pollution	packaging; handling
conservation	offshore drilling
fishing	tourist development
minerals	food processing
fish farming	pharmaceuticals

3. What were the means by which you received information on this change?

4. What means do you use to communicate information within your organization?

5. How does your organization disseminate information to others in the marine community?

6. Do you maintain formal/informal links with other organizations? With specific people within the organizations?

7. Who do you feel benefits most from your work?

8. a) What do you feel are the chief problems of the marine community, i.e., industry, government, academia?

   b) What do you feel are the chief problems in your own organization?

9. a) Has your organization participated in joint programs with other organizations in Mexico?

   b) Abroad?

   c) Do you feel there is a need for such programs?

   d) In what areas could such programs be most useful?

   e) What, in your opinion, should be the structure and content of such programs?

   f) Could you suggest some programs, projects, etc., that you would like to see initiated?

10. What do you perceive to be the incentives and benefits for both parties in undertaking such projects?

11. Does your organization place any emphasis on sending your members abroad for training and/or conferences?