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The MIT Marine Industry Advisory Service

A Critical Review and Progress Report

MIT Sea Grant
College Program

Massachusetts
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Cambridge
Massachusetts 02139

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FOREWORD

The MIT Marine Industry Advisory Service and its Collegium activities are a successful experiment in industry/government/academia collaboration. This report reviews and assesses the first three and one-half years of operations. Problem areas are identified and additional activities are suggested to improve the Collegium.

Readers are encouraged to contact the author with comments and suggestions concerning the Marine Industry Advisory Service in particular or any other aspect of government/industry/academia cooperation.

Norman Doelling

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THE MIT MARINE INDUSTRY ADVISORY SERVICES PROJECT (MIDAS)

1.0 Background

This project was originally a three year project ending on 1 July 1978, at which time a comprehensive evaluation of the initial three years was due. Owing to the shift to the new biannual cycle of Sea Grant reviews, the project is now into its fourth year, allowing a more comprehensive review and analysis of the first $3\frac{1}{2}$ years' results. This proposal embodies both the evaluation of this project and a proposal for an additional three years' funding.

The standard against which this evaluation is made is the statement of Objectives for the Marine Industry Advisory Service (MIDAS) as given in the MIT Sea Grant 1975-1976 proposal. To wit,

"A new project, the Marine Industry Advisory Service (MIDAS), has been developed to foster greater involvement in and awareness of marine-related product and business developments and opportunity potentials for the nation's industries.

The specific objectives are, by means of highly structured studies, workshops, conferences, working papers, and publications, to:

A. Transfer to industry usable information in the form of comprehensive, interdisciplinary assessments and analyses of business opportunities and strategies in selected areas whose content and boundaries will be determined by the MIT Advisory Services in cooperation with industry, and to

B. Create an MIT environment and standing link with industry to

elicit new ideas and feedback on unsolved industrial problems and prospects, with the expectation that MIT and/or the MIT Sea Grant Program can contribute to the solution of some of these."

As will be shown, we have fulfilled these objectives and indeed made some important extensions beyond them. A particularly important extension has been that our MIT activities are beginning to create a "link with industry" extending far beyond MIT to other Sea Grant Institutions, to the National Sea Grant Program itself, and to cooperative projects involving Sea Grant and several other government agencies.

A serendipitous result also of note is that the NOAA Office of Ocean Engineering is now supporting the MIT Sea Grant Marine Advisory Services on a pass-through grant which represents one of the first instances of a true NOAA Marine Advisory Services effort.

Our evaluation of the MIDAS program leads to four important directions for future activity proposed herein:

1) to develop ways and means for creating broader, closer partnerships with the Sea Grant Institutions to further improve Sea Grant links with industry throughout the nation;
2) to develop ways and means of serving the needs of smaller companies;
3) to develop ways and means for extending participation and cooperation of other government agencies;
4) to develop ways and means of surveying and satisfying the needs of a more widely defined marine industry which includes fishing, aquaculture, food processing, and living resources.

Since MIT makes important contributions to industrial and business ventures of national significance, further development of the Institute's marine advisory service capabilities in the direction of national industry is a natural extension of our normal Institute activities. Such development can be achieved by enlarging the contact, dialogue, and information exchange with appropriate industries. We consider this effort to be essential for the Sea Grant Program at MIT and believe that it may also be a useful model for consideration by other Sea Grant universities where projects of national industrial relevance are pursued.

The MIT Sea Grant College Program (MITSG) will continue to give information, advice, and assistance to local and regional authorities, industries, and private organizations on an opportunity basis and in situations where the program is competent to do so.

2.0 The MIT Marine Industry Collegium

2.1 General

Our main efforts to date have focused on development and refinement of the services offered by MIDAS to the MIT Marine Industry Collegium members. A Collegium is defined (in older dictionaries) as a "voluntary association of peers sharing a common interest or objective." The MIT Marine Industry Collegium can be described in many ways; our brochure describing it to prospective members defines it as "a working partnership between the MIT Sea Grant Program and U. S. industry. Its goal is to promote the commercial development and application of new marine technologies. The Collegium identifies significant new business opportunities emerging from marine research at MIT and within the nation's network of Sea Grant universities and works closely with companies to translate these opportunities into profitable business ventures."

Equally important to prospective members and to MIT Sea Grant and the National Program is the following: "The involvement and participation of our members make the Collegium work. The organizations that join each year play a vital role in shaping the coming year's program - making the Collegium responsive to business and industrial needs for marine research. The guidance that the Collegium receives from its members promises to make the next Collegium year an exciting and rewarding one for companies interested in marine business opportunities. Companies participating in the Collegium will work with individuals from MIT and industry who share common interests in marine research and business opportunities."

While we emphasized Sea Grant, MIT, and U.S. Industry, we are

pleased that its appeal has been much broader. The Collegium has attracted participation from 12 government agencies (see Appendix II) of which 4 are paying members, and 23 universities and schools (see Appendix II) in addition to the corporate participation which involved over 100 Collegium member companies (see Appendix II). When we count multiple members of the same organizations who attended, the total number of participants in workshops and symposia is over 600.

2.2 Format of the Collegium Program

When the basic Collegium concepts were being evolved, we consulted with our State-Industry Advisory Committee and with other industry representatives in determining the form and content of the Collegium program. It was envisioned that about five Working Drafts of Opportunity Briefs per year would be written and distributed to members. Each Opportunity Brief would be a "concise, well-documented survey of a specific marine business opportunity generated by Sea Grant research. These surveys would describe a new technology or process, assess market potentials, and outline economic considerations." Through written correspondence and telephone calls, comments and feedback on the topic of the Brief would be obtained. In addition to the Briefs, about two meetings with members would be held each year.

After our first Collegium meeting and Opportunity Brief/Workshop (on "Chitin and Chitosan"), we surveyed all members concerning their interests in Opportunity Brief topics and solicited suggestions concerning services of the Collegium. We planned and published our second Brief ("Offshore Mining of Sand and Gravel") without a workshop and quickly learned that interaction response with members was almost nil. Therefore we changed the format to the successful pattern we are using today of

publishing a working draft of an Opportunity Brief for members and approximately one month later holding a Workshop involving Collegium, faculty, and students. This cycle is now carried out four times per year.

2.3 Opportunity Brief/Workshop Program

The Collegium schedule of Opportunity Briefs and Workshops is given as Table I, along with various measures of attendance. Several comments are in order about the various topics and their significance.

Opportunity Brief/Workshops #1, #6, #10 and #14 were the first workshops of their respective years. At these opening meetings we featured a broader program involving, at various times, a presentation by the National Director of Sea Grant (both Drs. Abel and Ostenso), by the NMAS Director (R. Shepard), by our Sea Grant Contract Monitor (Dr. R. Duane), by the Director of MIT Sea Grant, by the Research Director of MIT Sea Grant, and by other distinguished persons. Twice we have held the opening workshop earlier in the day on which our annual Sea Grant Lecture is held. These factors tend to increase attendance, but may or may not measure increased interest of members in the Opportunity Brief topics.

By contrast, an important workshop which was small was #7, "Closed-Cycle Aquaculture", presented as a joint effort of the MIT and University of Delaware Sea Grant Programs. The Opportunity Brief, one of the most popular (based on a survey of our members), and the Workshop (held at the Lewes campus of the University of Delaware) revealed the aquaculture program to an important audience of industry and government representatives. The University of Delaware reprinted the Opportunity Brief for use in explaining their process and program to both visitors and potential industrial sponsors.

Finally, as we will show below, two of the least well-attended

TABLE I

COLLEGIUM OPPORTUNITY BRIEF/WORKSHOP SCHEDULE

Opportunity Brief Title	Date of Workshop	PARTICIPANTS Industry/ Government	Sea Grant Institutions	M I T	Sea Grant National Office	Total
Chitin and Chitin Derivatives (#1)	October 16, 1975	58	3	11	1	73
Offshore Mining of Sand and Gravel (#2)	no workshop was held					
Telemanipulators for Undersea Tasks (#3)	February 19, 1976	10	-	3	-	13
Advances in Underwater Welding Techniques (#4)	April 13, 1976	7	-	3	1	11
Untethered Robot Submersible Instrumentation Systems (#5)	June 14, 1976	11	-	9	-	20
Electron Irradiation, Sewage Sludge and Aquaculture (#6)	October 15, 1976	26	-	6	3	35
Closed-Cycle Aquaculture (#7)	December 3, 1976	12	7	1	1	21
Computer Models for Environmental Engineering and Research in Near-Coastal Environments (#8)	March 17, 1977	37	-	8	-	48
Oil Spills: Problems and Opportunities (#9)	May 17, 1977	32	2	9	-	43
Vibration Response and the Structural Integrity of Deepwater Structures (#10)	October 6, 1977	43	-	9	1	53

continued

TABLE I, continued

COLLEGIUM OPPORTUNITY BRIEF/WORKSHOP SCHEDULE

Opportunity Brief Title	Date of Workshop	PARTICIPANTS Industry/ Government	Sea Grant Institutions	M I T	Sea Grant National Office	Total
The Economics and Engineering of Large Scale Algae Energy Biomass Systems (#11)	January 24-25, 1978	148	9	7	1	165
Deep Ocean Mineral Mining (#12)	April 6, 1978	12	-	10	-	22
Computer-Aided Preliminary Design of Ships (#13)	May 23, 1978	55	1	10	-	67
Teleoperators Under the Sea (#14)	October 24, 1978	32	2	13	-	47
Wave Power (#15)	January 16, 1979	29	1	14	1	45
Towards Improved Techniques for Predicting Soil Strength in Offshore Environments (#16)	March 29, 1979	12	-	6	2	20
Risks and Costs for Ocean Structures (#17)	May 9, 1979					
TOTAL PARTICIPANTS		521	28	119	11	682

Workshops, "Telemanipulators for Undersea Tasks" and "Untethered Robot Submersible Instrumentation Systems," have had the greatest impact on Sea Grant research.

The meeting held in conjunction with Opportunity Brief #11 was an "open" meeting to which many non-Collegium members were invited. The meeting was held together with Dynatech R/D Corporation, which held a contract from the Department of Energy. It represented an innovation in several dimensions. First, the program subject, "The Economics and Engineering of Large Scale Algae Biomass Systems", was part of the Department of Energy's Fuels from Biomass program; second, it represented work being done by a Collegium member company; and third, it was a two-day workshop. The topic was appropriate for the Collegium, and many Sea Grant-sponsored Principal Investigators participated as consultants to Dynatech. We were pleased that Dynatech and the Department of Energy recognized the Collegium as an appropriate and efficient mechanism for holding a dialogue with industry and other government agencies concerning the results of this important component of the Fuels from Biomass program.

Similarly, the program on "Computer-Aided Preliminary Design of Ships" was held in conjunction with the New England section of SNAME (Society of Naval Architects and Marine Engineers).

To extend the program further, to embrace a broader range of Sea Grant capabilities, and to promote the "national" or "network" aspects of Sea Grant, we have consciously embraced a policy of inviting principal investigators from other Sea Grant institutions to participate in the workshops.

Thus principal investigators from the University of New Hampshire and the University of Miami gave presentations at Workshop #8, "Computer Models for Environmental Engineering and Research in Near-Coastal Environments." Principal Investigators from MIT, Woods Hole Oceanographic Institute, and California were involved in Opportunity Brief and Workshop #11, "The Economics and Engineering of Large Scale Algae Energy Biomass Systems"; and Principal Investigators from MIT, Michigan, and the University of Colorado were involved in Opportunity Brief #13, "Computer-Aided Preliminary Design of Ships." In addition, MIT and the University of Delaware Principal Investigators participated in Opportunity Brief/Workshop #15 on wave energy.

The cooperative efforts with the University of Delaware have been beneficial to Collegium members, to Delaware, to MIT, and to the national or network image of Sea Grant. As a result, we are tentatively planning a small follow-up workshop to be held under joint Collegium/Delaware auspices which would include a revised Opportunity Brief to supplement the original. Such a Workshop/Opportunity Brief would be held in addition to the four Opportunity Briefs normally offered to the Collegium. In addition, non-Collegium members would be invited as appropriate.

2.4 Some Measures of Opportunity Brief Responsiveness to Industry Interests

In various ways we have consistently urged our members help us in planning our program and in finding topics of interest to members (and the larger Sea Grant audience of users). One measure of effectiveness is the number of published Opportunity Briefs requested by outside users,

sent to members, etc.

Table II summarizes the information on a quantitative basis. By this measure, Brief #7 ("Closed-Cycle Aquaculture") was the most popular, with 461 reports sent out and an additional 100 reprinted and used by the University of Delaware.

A cursory glance reveals that Opportunity Briefs #3, #4, and #5 were the next most popular, all dealing with doing work beneath the sea. Beyond those observations, very little can be clearly discerned. The low number of Opportunity Briefs #10, #11, #12, and #13 requested probably results from the fact that the abstract announcements were mailed only very recently.

Another measure of relative importance or ranking of the topics was derived from a survey of this year's Collegium members, in which they were asked to rate each brief as "Very Useful," "Useful," or "Not Useful." These ranking scores are presented in Table III along with the rankings from Table II for comparison.

Doing work under the sea remains a matter of commanding interest as indicated again by the high ranking of Briefs #3, 4, and 5. In addition, interest in oil spill and offshore structures (a potential source of spills) is evidenced in the high ranking of Opportunity Briefs #9 ("Oil Spills: Problems and Opportunities") and #10 ("Vibration Response and the Structural Integrity of Deepwater Structures").

It is also apparent that at least this year's Collegium members rate the two Briefs related to living things very low - i.e. #1 ("Chitin and Chitin Derivatives") and #7 ("Closed-Cycle Aquaculture").

It should be noted, however, that in reviewing the data and in deriving the related rank, a fairly narrow range of raw scores res-

TABLE II - Opportunity Briefs Disseminated

Opportunity Brief Topic	Total Reports Sent Out	Rank Based on Number Sent
1. Chitin/Chitin Derivatives	281	8
2. Offshore Mining Sand/Gravel	294	6
3. Telemanipulators	326	3
4. Underwater Welding	315	4
5. Robot Submersibles	348	2
6. Irradiation/Aquaculture	293	7
7. Closed-Cycle Aquaculture	*561	1
8. Computer Models of Near-Coastal Environments	304	5
9. Oil Spills	234	9
10. Vibration Response of Deepwater Structures	110	12
11. Algae Energy Biomass Systems	147	10
12. Deep Ocean Mineral Mining	111	11
13. Computer-Aided Ship Design	102	13

* Including 100 reprinted by the University of Delaware.

NOTE: Opportunity Briefs #1-5 were published on June 30, 1976;
Opportunity Briefs #6-9 were published on June 30, 1977;
Opportunity Briefs #10-13 were published on June 30, 1978

TABLE III - Some Measures of Effectiveness and Interest in Opportunity Brief Topics

Opportunity Brief Topic	Rank Based on Number of Reports Sent	Rank Based on Survey of Current Members
1. Chitin/Chitin Derivatives	8	13
2. Offshore Mining Sand/Gravel	6	**10
3. Telemanipulators	3	3
4. Underwater Welding	4	6
5. Robot Submersibles	2	*1
6. Irradiation/Aquaculture	7	12
7. Closed-Cycle Aquaculture	1	9
8. Computer Models in Near-Coastal Environments	5	8
9. Oil Spills	9	4
10. Vibration Response of Deepwater Structures	12	5
11. Algae Energy Biomass Systems	10	7
12. Deep Ocean Mineral Mining	10	*1
13. Computer-Aided Ship Design	13	**10

* Members indicated equal interest in these Briefs.

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ulted, and hence more specific generalizations are not justified.

We do feel that the differences in the two ranking schemes may reflect certain possible trends which we would like to see reversed. In particular, we feel the ranking reflected by reports sent out in some sense is a measure of the merit of topics as seen by a more general audience... and that general audience finds the living resources as represented by aquaculture, algae, and chitin more important than the current Collegium members do. Have we responded to the companies having hardware interests and inadvertently neglected and/or lost interest of other companies? We deal with this issue later.

2.5 Collegium Membership

The membership of the Collegium has shown a generally increasing trend since its inception, as follows:

Year	Number of Companies/Agencies
1975–1976	75
1976–1977	83
1977–1978	93
1978–1979	90 (year to date)

The record to date has been achieved by active solicitation of new members each spring - "active" is perhaps too strong a word, owing to the obvious and not so obvious constraints imposed upon a non-profit, private educational institution. The slight drop in 78–79 reflects a less active membership drive. We have at various times in conjunction with earlier proposals and site visits, and in conjunction with a review of MIDAS for the Council of Sea Grant Directors, attempted

to describe the membership of the Collegium in meaningful ways. It's a difficult task. Standard Industrial Classifications (SIC Codes) are meaningless to describe General Electric, for example, in terms of motivation for Collegium membership. Nonetheless, some measures are relevant and instructive. First, we took a measure of their size, by number of employees and by annual sales (these analyses were somewhat redundant). Representative results from 1975 are summarized below in Table IV.

Table IV - Size of Collegium Member Companies as Measured by Sales

	Less Than $100 million	$100 million to $1 billion	Greater than $1 billion	Total Sample
Number of Companies	35	18	27	80

Total Annual Sales of Collegium Member Companies: $125 billion

As can be seen, in a certain sense the Collegium interacts with companies whose sales represent a significant fraction of the gross national product.

When we look at the geographical distribution, we see the membership is indeed a national and to a small extent international one. However, the distribution shows that the membership is regional, reflecting perhaps MIT's natural constituency of alumni, friends, and students. The figures are given below in Table V.

There is, however, another important influence on Collegium participation. The direct expense of participating in the Collegium and in the workshops increases with distance from MIT. Perhaps more important, the indirect cost (or opportunity cost) of having personnel come to Collegium workshops doubles at some distance from MIT because

TABLE V

COLLEGIUM MEMBER ORGANIZATIONS: GEOGRAPHICAL DISTRIBUTION

INTERNATIONAL DISTRIBUTION

U.S.	82	(Including 4 U.S.-based subsidiaries of foreign companies.)
FOREIGN	6	
TOTAL:	88	
TOTAL INDIVIDUAL REPRESENTATIVES RECEIVING COLLEGIUM NOTICES:	225	(approximately)

DISTRIBUTION IN THE UNITED STATED

Coastal Area	Percent of Organication
New England	30
Mid and South Atlantic	43
Gulf Coast	11
West Coast	14
Non-Coastal (Oklahoma, Minnesota)	2
TOTAL:	100

an overnight trip means that effectively two days of time are lost. This is one of the factors that led us to believe that greater cooperative efforts with other Sea Grant Institutions will better serve smaller, more regional companies.

As noted earlier, a somewhat unexpected but desirable result of our efforts has been the participation and support of five government agencies in Collegium activities. Specifically, the following organizations have joined the Collegium:

1) Massachusetts Port Authority (3 years)
2) U.S. Coast Guard R/D (4 years)
3) Maritime Administration (3 years)
4) Naval Explosive Ordnance Disposal Facility (2 years)
5) U.S. Geological Survey (1 year)

Obviously the Collegium membership has been useful to these agencies for some different reasons than corporate members. Clearly, in fulfilling their missions, both groups value the "window on research and/or research resources" aspect of Collegium membership. In addition, at various times they are given an opportunity to publicize their own research needs at workshops. The Collegium workshops, featuring faculty and student researchers from MIT, from industry, from other universities and from other government agencies, are obviously an excellent forum for such presentations.

Last, and perhaps most important, Collegium workshops, being specific and of an intimate size, provide a unique opportunity for these government representatives to learn about industry needs, goals, capabilities, etc., to help direct government R/D efforts. Similarly, the Collegium

provides an additional meeting place and a mechanism for government agencies to learn about each other's research programs and to discuss and discover ways of collaborating with academic and industry Principal Investigators on jointly sponsored projects to achieve the best cost/benefit ratio for the government's R/D expense.

It is instructive, perhaps, to ask ourselves about causes and reasons for which former members of one or more years' standing did not rejoin the Collegium. This list of companies is given in Appendix III. The large number of companies that dropped out the first year is due in large part to the fact that many companies joined out of goodwill towards MIT, towards personnel at MIT Sea Grant, and out of a desire to contribute to a new experiment in government/industry/academia - quite independent of their long-term interest. Hydronautics, Pearlson Engineering, Massa Corporation, and others are representative of such companies. Phone calls to these members and letters from them reveal various reasons. Some specifically stated Opportunity Brief topics were not sufficiently relevant to their interests. A class of food/aquaculture/biology companies cited this (Castle & Cooke, Food Chemical and Research Laboratory, Groton Associates, Marine Colloids, Pine State By-Products, Inc., Marine Commodities, International, Hart Corporations, Marine Research).

However, the very large majority (about 80%) of the remaining non-renewing companies are relatively small (less than 500 people), and/or are distant from MIT.

Thus a likely hypothesis is that we have not adequately designed a program that responds to small companies' needs at a dollar cost and

opportunity cost which is sufficiently low to have them perceive a positive value in re-joining.

3.0 Benefits to Date

In describing benefits, it appears sensible to describe the benefits in terms of who was the recipient of what benefit. However, most of the beneficial activities we report below are of a truly reciprocal nature, and - happily - it is difficult to identify who is the prime beneficiary of many of our activities since we as the nominal source of the benefits often receive as much as we give. The technology transfer function of the Collegium is a good example. We frequently learn as much as we teach. Consequently we have organized the benefits by kind or type of benefit and identify within each type of benefit who has participated in them.

3.1 Sea Grant/Industry Awareness and Interaction

When industry members first joined the Collegium, they joined because they perceived the program as an MIT marine activity. Awareness of Sea Grant as a national network was very low, as was awareness of Sea Grant at all. A survey made in cooperation with the National Office of Sea Grant during the second year of Collegium showed that about three quarters of the corporate Collegium members had not previously participated in Sea Grant programs anywhere in the country. About 150 companies have now been involved in the Collegium Program as members, and almost 300 have participated, belonged, and/or attended Collegium workshops.

In addition, many others have been exposed to Sea Grant through articles and editorials about the Collegium in trade magazines and newspapers. Our announcements in Technology Review and Sea Technology stress the availability of Sea Grant Research and Advisory Services as a national industrial resource. Inquiries resulting from these activities

extend beyond the Collegium itself. Some are referred to researchers at MIT; some are referred to Sea Grant Directors at their schools.

Interestingly, some MIDAS articles lead to totally unexpected results. An article in Industry magazine, August, 1975, for example, drew an inquiry from the City of Lynn, Massachusetts, which in turn led to one of our more successful and widely publicized multi-disciplinary studies carried out by Professor William Seifert's students.

The major way in which MIDAS has contributed to industry's awareness of the National Program and of the many individual Sea Grant Programs has been through the workshops and Opportunity Briefs. By reference to other Sea Grant publications in bibliographies of Briefs, by bringing in speakers from other Sea Grant schools, and by inviting other Sea Grant Principal Investigators to workshops, we have exposed Collegium members to the Sea Grant network as a source of results of research and as a resource for getting needed research carried out. This type of benefit is clearly reciprocal.

Since its beginning, the Collegium has also been a stimulus to and resource for the Sea Grant network and the National Office to learn about industry's perceptions of needed, useful research. An important attribute of the individual members of the Collegium is that they are often professional peers of the Principal Investigators and Sea Grant Directors. Thus awareness, interaction, and technology transfer are truly mutual and reciprocal.

In promoting the Collegium, we have had booths at two trade shows, the Annual Meeting of ASNE (American Society of Naval Engineers) in Washington, May, 1977, and the Oceans '78 meeting in Washington. At both these shows we were the only exhibitor representative of Sea

Grant. At Oceans '78 we devoted about half the exhibit to the Collegium and half to research publications from MIT, Alaska, Oregon, Florida, Delaware, California, Hawaii, and Rhode Island Sea Grant Programs. Orders for publications were taken and were sent to each school for fulfillment.

3.2 Industry Interaction in Research and Planning

As noted above in Section 2, through various kinds of surveys, we use Collegium members as an important input in directing our research activities. In addition, through face-to-face interaction at workshops, Principal Investigators get an "industrial peer review of their research." Equally important, we have from time-to-time reported results and evaluations to the National office and to Sea Grant Directors in our annual proposals and in separate memos.

Our report to Sea Grant Directors on Industry Research Needs was cited in the report by the Council of Sea Grant Directors Ad Hoc Committee in Ocean Engineering as a valuable document which we should submit annually. This survey, (Appendix IV), pointed out to both MIT and UNH (and perhaps others) and to the National Sea Grant Office the need for research associated with unmanned, untethered vehicles. Consequently several new important research programs are being carried out under diverse sponsorship (See section following). The 1978 National Sea Grant Workshop on Ocean Engineering in Sea Grant held at MIT was arranged by the MIDAS staff and drew upon knowledgeable Collegium members for industry representation and for representation by other government agencies with an interest in ocean engineering.

We are pleased that NOAA's Office of Ocean Engineering has recognized the expertise of the MIDAS staff in interacting with industry as

well as the need and desirability of fostering industry participation in research while research is taking place. NOAA/OOE is sponsoring a program via Sea Grant which will enable us to broaden industry awareness of ocean engineering research in academic institutions and to encourage further interaction among academic and industry researchers.

3.3 Impact of the Collegium on Academic Research Programs

The survey shown in Appendix-IV and an earlier Collegium survey showed a strong interest in two related areas, "preventing and controlling failures related to the offshore oil business" and "a strong need to work, measure, and to control operations beneath the sea surface." Based on the survey, we scheduled two Opportunity Brief/Workshops directed towards the second topic and provided "seed money" for Professor Thomas Sheridan to begin working on telemanipulator ideas. Professor Sheridan was later funded under a Sea Grant research project. We also provided a short follow-up seminar on his work, Professor Douglas Carmichael's work on robot submersibles, and on some of Professor Arthur Baggeroer's ideas on acoustic telemetry about one year later (September 1977) in conjunction with Kim Vandiver's workshop on Vibration of Offshore Structures. Industry members provided continued, useful input to the program in terms of important information and data (e.g what do divers really do and how often do they dive to accomplish various kinds of tasks) and input about future needs, tasks, etc.

The Office of Naval Research later provided more substantial funding to expand Professor Sheridan's work and gave supplemental funding to Professor Baggeroer to look at how acoustic holography might aid control problems. Harbor Branch Foundation, a Collegium member, has also provided funding to investigate and develop microcomputer-based displays for

command and control of untethered submersibles. MIT Sea Grant is now sponsoring Professor Baggeroer's research on acoustic telemetry for command and control. In parallel another Collegium member, United States Naval Explosive Ordnance Disposal Facility, is sponsoring further vehicle development under Professor Carmichael as an extension of the Sea Grant-developed "Robot-I" submersible. Thus a strong multi-sponsor "man-not-under-the-sea" research theme has evolved from industry needs and MIDAS organized efforts.

As noted earlier, influenced to some extent by the 1976 survey, the University of New Hampshire began a complementary program on underwater vehicles that is sponsored by United States Geological Survey (also a Collegium member) and monitored by the Naval Ocean Systems Center, which in turn has a jointly sponsored unmanned underwater vehicle program. We are now in the process of discussing with USGS and NOSC the possibility of collaboration with them to integrate some of our concepts on manipulators into the UNH/USGS/NOSC systems.

The Collegium has been a catalyst in developing a new research theme area proposed by industry members, responsive to their needs, and to which industry has provided valuable data. Through synergism fostered by the Collegium the project is being developed and funded by several government agencies and a private foundation in an efficient, economical way.

A second important and notable impact the Collegium has had on a research project relates to Opportunity Brief/Workshop #10, "Vibration Response and the Structural Integrity of Deepwater Structures", based on Professor Kim Vandiver's work. Professor Vandiver's research was first supported by Sea Grant under a Doherty Professorship and had shown

exceptional promise on some Coast Guard structures; but a major problem had been getting cooperation and data from oil companies. Through Collegium members, Professor Vandiver was able to obtain proprietary data from one oil company to analyze according to his techniques and was subsequently asked to observe some proprietary experiments on a new offshore structure. Professor Vandiver reported that this was the first time he had been able to get "real" data and to participate in such an experiment. Again the Collegium provided only the catalyst; but now better, more useful, and more relevant results are being obtained, and the work is continuing through the sponsorship of USGS.

Other examples could be listed, but the important point is that industry, academic researchers, Sea Grant, and other government agencies have mutually benefited in important, significant ways through face--to-face interaction fostered by the Collegium in its catalyst role.

4.0 Advisory Plan

Our basic advisory plan is to continue our core program of four Opportunity Briefs and four Workshops per year and to provide special information services and assistance for Collegium members while increasing our efforts to improve and broaden MIDAS services. The addition in December, 1978, of a full-time Assistant Manager of MIDAS, Mr. John Bidwell, and the synergistic and serendipitous efforts of having the NOAA Office of Ocean Engineering contract will make some of the improvements possible.

We plan four improvement efforts. First, a prime objective of next year's plan is to increase participation of other Sea Grant Institutions in Collegium activities. The benefits of the MIDAS activities to MIT, to Sea Grant Institutions, and to the National program have become clearer over the past three-and-a-half years. To date, however, MIT has been the main Sea Grant participant and beneficiary. We have been exploring, or are beginning to explore, with Delaware, with Texas A & M University and with the University of Southern California ways and means of expanding the Collegium concept. We must find a way to do so which respects the independence and individuality of each Program and which reflects the contributions of each while allocating income, expenses, and intangible benefits in an equitable manner. At the same time an expanded program must reflect the unity of the Sea Grant program and the contribution and support of the National Office. Clearly the task is not an easy one, but since the concept of industry/academia cooperation fostered by government sponsorship has proven successful and mutually beneficial to date, we believe it will become possible.

Our general concept is to maintain the identity of the MIT Marine

Industry Collegium as a focal point and to invite association with other Sea Grant programs that will provide additional workshops and Briefs for the central Collegium activity. Each participating school would have local or regional activities in which all corporate/government members could participate. We envision MIT playing a lead role as "first among equals" in the overall national effort.

Second, we plan to work with past and present small companies to find ways of more satisfactorily meeting their needs for marine research. Expanding MIDAS' efforts in a national direction is a first step, since distance is clearly a problem in interesting smaller companies. Our off-campus Undergraduate Research Opportunities Program (UROP) is an available vehicle for serving small companies, but we have not as yet adequately promoted this concept. The addition of a MIDAS Assistant Manager will enable us to visit small companies in the Northeast and to elicit their cooperation in designing better services. Working with other Sea Grant schools in joint Collegium activities will also help serve small companies more effectively.

The aforementioned project sponsored by the NOAA Office of Ocean Engineering has already begun to have synergistic effects by helping us become aware of more undergraduate and graduate research projects at MIT that may be relevant to small company needs.

Third, the MIT Sea Grant College Program and the Collegium members have all benefited from participation of the four government agencies who are members. As noted, the industrial Collegium members have been an important source of ideas for the government agencies concerning industrial needs for research. Thus the Collegium has provided an important

mechanism for improving government/industry/academic cooperation. Equally important, MIT Sea Grant has played a significant role in fostering inter-governmental cooperation and cooperative, coordinated sponsorship of academic research in the undersea vehicle area.

We intend to more actively solicit other government agencies, state and national, to participate in the Collegium and to maintain and further extend the MIDAS role in coordinating cooperative, interagency research projects using the unmanned vehicle program as a model effort. We also intend to solicit a "common interest group" of companies to join the government agencies in supporting the unmanned vehicle research theme area financially, to provide an industrial resource base for proposing directions for research, to offer continual input for policy studies, for market studies, for economic evaluations, and for getting the research ideas into commercial prototype vehicles at the earliest practical time. In essence we will be using the government/academia research effort as a base for providing the starting point of a joint government/academia/-industry project incorporating some of the objectives of our original MARIBUS program. The significant difference is one of emphasizing and selling already-sponsored research programs and asking the corporate members to add to this sponsorship, particularly with regard to economic, regulatory, and marketing aspects. We will carry out such additional research effort only to the extent that it is funded.

Fourth, as noted in the Project Review and Progress Report section above, the Collegium program has included very few Opportunity Briefs on aquaculture, biology, food or other living resources. Correspondingly, our membership includes very few food and life science-oriented companies. We intend to make a special effort to develop a broader base of Collegium

membership and a broader Collegium program by stronger emphasis on life sciences, aquaculture and food. Since we feel the current program and emphases on "hard" science and engineering cannot be cut back, we hope to utilize the increased participation of other Sea Grant schools as a means for expanding Collegium activity and membership in these areas.

5.0 Expected Significance

The execution of this project will continue to:

1. bring the results of specific Sea Grant-sponsored industry-oriented research and development programs to the attention of U.S. industry in an organized and useful form;
2. help identify important marine engineering and business opportunities and problems worthy of further research or development by elements within the Sea Grant network;
3. establish new Sea Grant/industry/government ties to facilitate the transfer and exchange of technical information with industry;
4. assist Sea Grant and other government agencies in identifying appropriate directions for their sponsored research activities; and
5. provide Sea Grant leadership in fostering government/industry/academia cooperation in research programs.

APPENDICES

The MIT Marine Industry Advisory Service:
A Critical Review and Progress Report
MITSG 79-10
April 1979

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APPENDIX I

MIT MARINE INDUSTRY COLLEGIUM

CURRENT MEMBERSHIP

1978 - 1979

MIT MARINE INDUSTRY COLLEGIUM - CURRENT MEMBERSHIP (1978-1979)

Akzona, Inc.
American Cyanamid Company
The Anaconda Company
Aquatec International, Inc.
Arcair Company
Arthur D. Little, Inc.
Avco Everett Research Laboratory, Inc.
Beatrice Foods Company
Becton, Dickinson Research Center
Bell Aerospace Textron
Bell Laboratories
The Boeing Company
BOC Limited
Bolt Beranek & Newman, Inc.
Boston Edison Company
Campbell Soup Company
Caterpillar Tractor Company
Celanese Research Company
Central Research Laboratories, Inc.
Chevron Research Company (Standard Oil Company of California)
Combustion Engineering, Inc.
Compass Publications, Inc.
Continental Group, Inc.
Continental Oil Company
The DeLaval Separator Company (Alfa-Laval)
Dow Chemical Company
Dravo Corporation
E. I. du Pont de Nemours Company, Inc.
E G & G, Inc.
Environmental Devices Corporation
Exxon Research & Engineering Company
Foxboro/Trans-Sonics, Inc.
General Dynamics (Electric Boat Division)
General Electric Company, Industrial/Marine Steam Turbine Operations
General Electric Company, Re-Entry/Environmental Systems
Getty Oil Company
Goodyear Aerospace Corporation
Gould, Inc.
Grumman Aerospace Corporation
Gulf Oil Company
Hercules, Inc.
Honeywell Inc.
IHC Holland (IHC SMIT BV)
Imperial Chemical Industries Ltd.
International Proteins Corporation
International Underwater Contractors, Inc.
InterOcean Systems, Inc.
ITT Cable - Hydrospace Division
JBF Scientific Corporation
Kennecott Copper Corporation

continued

MIT Marine Industry Collegium - Current Membership

Litton Industries, Ingalls Shipbuilding Division
Lockheed Missiles and Space Company, Inc., Ocean Systems
Lord Kinematics
MacLaren Atlantic Ltd.
Marathon Oil Company
Maritime Administration
Massachusetts Science and Technology Foundation
Massport
McLelland Engineers, Inc.
Mitsui & Company, Ltd.
Mobil Research and Development Corporation
Montedison S.p.A.
Naval EOD Facility
New England Power Company
Oceaneering International, Inc.
The Plessey Company Limited
Raytheon Company, Submarine Signal Division
RCA Corporation
Rockwell International Corporation
Sanders Associates, Inc.
Sea Land Services, Inc. (R.J. Reynolds)
Shell Oil Company
Spar Aerospace Products Ltd.
Sperry Marine Systems
Standard Oil Company of Indiana
Stone & Webster Engineering Corporation
Sun Shipbuilding & Dry Dock Company
Tecnomare S.p.A.
Texaco, Inc.
TRW, Inc.
Unilever Ltd.
Union Oil Company of California
U.S. Coast Guard
U.S. Geological Survey
Union Carbide Corporation
United Technologies Research Center
Westinghouse Electric Corporation, Oceanic Division
Woodward-Clyde Consultants

TOTAL: 88

APPENDIX II

ORGANIZATIONS REPRESENTED AT COLLEGIUM WORKSHOPS

1. Members of the Collegium
2. Non-Members of the Collegium
3. Educational Institutions
4. Government Agencies

ORGANIZATIONS REPRESENTED AT COLLEGIUM WORKSHOPS

1. Members of the Collegium

American Cyanamid
Amoco Corporation
The Anaconda Company
Aquatec International
Aquatic Farms
Arthur D. Little
Avco Everett Research Laboratories
Bell Aerospace Textron
Bell Laboratories
Bird-Johnson
Beatrice Foods Co.
Boeing Co.
Bolt Beranek & Newman
Boston Edison
Campbell Soup Co.
Castle & Cooke Inc.
Central Research Labs
Combustion Engineering
The Continental Group
Compass Publications
Consolidated Controls
Deepsea Ventures
De Laval Separator Co.
Digicourse Inc.
Dow Chemical Co.
E. I. du Pont de Nemours & Co., Inc.
Dravo Corporation
Dynatech R/D
Environmental Devices Corp.
E G & G, Inc.
Energy Resources
Environmental Research & Technology
Exxon Corp.
Food, Chemicals & Research Lab, Inc.
Foxboro/Trans-Sonics
Kypro Co.
G. E. Re-Entry/Environmental Systems
General Dynamics
General Research Corp.
Gibbs & Cox
B. F. Goodrich
Goodyear Aerospace
Gould, Inc.
Groton Associates
Grumman Aerospace
Gulf Oil Co.
Harbor Branch Foundation
Harbridge House, Inc.
Frederic R. Harris

continued

1. Members of the Collegium, continued

Hart Corporation
Hercules, Inc.
HydroAcoustics, inc.
Hydronautics Inc.
InterOcean Systems
InterTechnology Corp.
JBF Scientific Corp.
Kennecott Copper Corp.
Kimberly Clark
Klein Associates, Inc.
Kockums Mekaniska Verstads AB
Lockheed Missiles & Space
Lord Corporation
John J. McMullen Associates Inc.
MacLaren Atlantic Ltd.
Marine Colloids Inc.
Marine Commodities International Inc.
Marine Research Inc.
Maritime Administration
Massa Corporation
Massachusetts Science & Technology Foundation
Massachusetts Port Authority
Mitsui & Co., Inc.
Mobil R/D Corp.
National Forge Co.
Naval Explosive Ordnance Disposal Facility
New England Power Service
Nomura Research Institute
Oceaneering International
Pechiney Ugine Kuhlmann
Pine State By-Products
Proto-Power Inc.
RCA Corporation
Raytheon Corp.
Rockwell International
Sanders Associates
Sea Technology Magazine
Seaward International
Shell Oil Co.
Spar Aerospace
Specialized Systems, Inc.
Standard Oil (Indiana)
Stone & Webster
Sun Shipbuilding & Dry Dock
Tecnomare S.p.A.
Thermo Electron
TRW
Unimation, Inc.
Union Carbide Co.
Union Oil Co.
United States Coast Guard
United States Geological Survey
Woodward-Clyde Consultants

TOTAL: 102

ORGANIZATIONS REPRESENTED AT COLLEGIUM WORKSKHOPS

2. Non-Members of the Collegium

Aerospace Corporation
Aetna Life & Casualty
Amoco Production Research Center
Aquacultural Research Group
Battelle Columbus Lab
Battelle Pacific NW Lab
Bay Biochemical Research
The BioEnergy Council
Boston Gas Co.
Botan & Redmann
Brookhaven National Lab
Bruker Instruments
C & C Yachts Ltd.
Camp Dresser & McKee Inc.
Cape Cod Sea Camps
Christian Science Monitor
Chromalloy Ocean Resources
Department of Fisheries & Environment (Canada)
Department of the Navy
Department of Commerce
Department of Energy
Ecological Research Associates
Embassy of France
Enertech Corp.
Filtration Consulting Associates
Foster Miller Associates Inc.
General Research Corp.
Genu Products Canada Ltd.
Gilbert Associates
IEEE Spectrum
International Development Research Centre
International Salt
Kanematsu Gosho Inc.
Keith, Feibusch Association
Leicons Euphoria Monadnock AEC
Little Harbor Laboratories
Los Alamos Scientific Lab.
Marine Product Development
Mass. PIRG
Mittelhauser Corp.
MITRE Corp.
Monsanto Corporation
Mueller Associates Inc.
Murphy Pacific Marine Salvage
Nalco Chemical Corp.
National Advisory Comm. of Oceans & Atmosphere
National Research Council (Halifax)
Naval Ocean System Center
Naval Ship R/D Center

continued

2. Non-Members of the Collegium, continued

Naval Underwater Systems Center
New England Electric Co.
New England Ocean Services
New Mexico Solar Energy Institute
New York Life Insurance Co.
Northeast Solar Energy Center
Ocean Industry Magazine
Ocean Minerals Co.
Office of Ocean Engineering
Office of Sea Grant
Offshore Devices
Pacific Gas & Electric
Portsmouth Naval Shipyard
Potter & McArthur Inc.
The Process Co.
SNC Protein Consultants Ltd.
Science Applications Inc.
Sea Foundation, Inc.
Southern California Gas Co.
Stanford Research Institute
Stauffer Chemical Co.
Sunmark Exploration Co.
Technical Consulting Service
Tetra Tech, Inc.
Transportation Systems Center, Dept. of Transportation
USSIA Associates

TOTAL: 75

ORGANIZATIONS REPRESENTED AT COLLEGIUM WORKSHOPS

3. Educational Institutions

California Institute of Technology
Clemson University
Columbia University
Harvard Unversity
Karolinska Institute
*Massachusetts Institute of Technology
New York Institute of Technology
*Oregon State University
Purdue University
Rutgers Medical School
State University of Ghent
*Texas A & M
*University of California
University of Colorado
*University of Delaware
*University of Florida
*University of Hawaii
University of Massachusetts
*University of Miami
*University of New Hampshire
*University of Puerto Rico
*University of Rhode Island
*Woods Hole Oceanographic Institute
Worcester Polytechnic Institute

TOTAL: 24

*A Sea Grant Institution

ORGANIZATIONS REPRESENTED AT COLLEGIUM WORKSHOPS

4. Government Agencies

Members of the Collegium (from list #1):

Maritime Administration
Massachusetts Port Authority
U.S. Coast Guard
U.S. Geological Survey
Naval Explosive Ordnance Disposal Facility

TOTAL: 5

Non-Members of the Collegium (from list #2):

Department of Commerce*
Department of Energy
Department of Fisheries & Environment (Canada)
Department of the Navy*
Embassy of France
National Advisory Commission on Oceans & Atmosphere
National Research Council (Halifax)
Naval Ocean System Center*
Naval Ship R/D Center*
Naval Underwater Systems Center*
Office of Ocean Engineering*
Office of Sea Grant*
Portsmouth Naval Shipyard*
Transportation Systems Center, Dept. of Transportation

Total: 14

TOTAL GOVERNMENT AGENCIES REPRESENTED: 19

*Note: These are not redundant listings. For example, persons who indicated they were on the Department of Commerce staff are differentiated from those who indicated they were part of OOE.

APPENDIX III

FORMER MEMBERS OF THE MARINE INDUSTRY COLLEGIUM

MEMBERS FOR ONE YEAR

1975-1976

BASF Wyandotte Corp.
Carter Chemical Co.
Bird-Johnson Co.
Food Chemical & Research Lab, Inc.
Harbridge House, Inc.
High Voltage Engineering Corp.
Hydroacoustics, Inc.
Hydronautics, Inc.
IMC Corporation
InterTechnology Corporation
Marine Commodities International
Marine Research, inc.
Massa Corporation
John J. McMullen Associates, Inc.
National Forge Co.
Oceanics, Inc.
Pearlson Engineering Co., Inc.
Pechiney Ugine Kuhlmann Development, Inc.
Pine State By-Products, Inc.
Purex Corp., Ltd.
The Rochester Corp.
TRACOR, Inc.
UOP, Inc.

1976-1977

B. F. Goodrich
Groton Associates
Hooker Chemical
Margen Internacional
Proto-Power Management Corp.
Seaward International, Inc.
Versar, Inc.

1977-1978

Dynatech Corporation
Harbor Branch Foundation
Hart Corporation
Liberty Mutual Insurance Co.
Swedish Industrial Development Corp.

continued

MEMBERS FOR TWO YEARS

1975-1977

Gibbs & Cox Inc.
Frederic R. Harris Inc.
Kimberly-Clark Corp.
Klein Associates, Inc.
Kockums Shipyard
Nomura Research Institute
Perry Oceanographics, Inc.
Specialized Systems Inc.
Union Carbide Corp.
Zapata Corp.

1976-1978

Consolidated Controls Corp.
Digicourse, Inc.
Environmental Research & Technology, Inc.

MEMBERS FOR THREE YEARS

1975-1978

Castle & Cooke, Inc.
Deepsea Ventures, Inc.
Marine Colloids
Stanwick Corporation

APPENDIX IV

RESULTS OF 1976 COLLEGIUM SURVEY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Sea Grant Program

C915 ND:dh
November 23, 1976

TO: Sea Grant Directors

FROM: Norman Doelling

SUBJECT: Industry Research Interests and Needs

One of the benefits of the MIT/Marine Industry Collegium is the opportunity to interact with industrial members on formal and informal levels to obtain suggestions, evaluations and critiques from them concerning our program.

One of the formal mechanisms of interaction is an annual survey of Collegium members' research interests and needs which we use as one input in planning Collegium activities, our research programs and our advisory programs. The results of this survey should be useful also to the Sea Grant network and to the National Office, hence this memo. If you have any comments or questions on the summary below please call me.

SUMMARY OF SURVEY

A. First Ten Topics

Based on the responses of 62 members, the ten most important topics were:

1. Marine Materials
2. Detection and Monitoring of Oil Spills
3. Acoustic Navigation and Positioning
4. Underwater Inspection of Offshore Structures
5. Acoustic Data Communication
6. Underwater Power Sources
7. Prevention of Oil Spills
8. Oil Spill Clean Up
9. Acoustic Command and Control
10. Monitoring Structural Integrity of Offshore Structures

Room 1-215 77 Massachusetts Avenue Cambridge, Massachusetts 02139 617/253-4434

These apparently diverse subjects really reduce themselves to two major areas of interest, concern and need:

A. Topics 1,2,4,7,8 and 10 relate to needs for preventing and controlling failures related to the offshore oil business.

B. Topics 3,5,6 and 9 show a strong need to work, to measure and to control operations beneath the sea surface. Acoustic waves have been and will remain the appropriate tool. The theory and practice, however, needs more support and stimulation to reach the levels of technology of the equivalent electromagnetic theory and practice.

In addition to selected lists of topics which Collegium members were asked to rate, members were given the opportunity to suggest topics of their own. It is difficult to summarize the rich variety of subjects suggested under each category, but some generalizations can be made.

First, for all categories the comments above (concerning interest in preventing and controlling oil spills, and the interest in underwater acoustics) strongly apply.

Second, there is a strong interest in shipboard instrumentation for better navigation and control, for docking, for measuring motion of and resulting strains in ships in a sea way, for measuring the state of the sea from a ship and the like.

Third, there is a family of interests in measuring and monitoring sea states and monitoring environmental variables over great areas and long times, and interest in doing so remotely.

Fourth, the interests and ranking clearly show a strong interest in engineering in the ocean environment.

B. The Last Twenty Topics

The last twenty topics are listed below. Note that this industrial audience does not perceive the life science related topics as interesting.

11. Wave Forces on Offshore Structures
12. Transmission of Power in a Sea Environment
13. Location of Offshore Pipelines
14. Bottom, Sub-Bottom Profiling
15. Collision Avoidance for Ships
16. Conversion of Wave and Tide Energy
17. Wind Energy for Marine Systems

18. Secruity and Protection of Offshore Structures
19. Stability and Integrity of Pipelines
20. Automation of Merchant Ships
21. Oil Spill Trajectories
22. Wave Forces on Pipelines
23. Properties of Marine Soils
24. High Performance Water Craft
25. Voice Communication Underwater
26. Shell Fish Aquaculture
27. Closed Cycle Aquaculture
28. Fin Fish Aquaculture
29. Farming of Kelp
30. Economic Uses of Underutilized Species