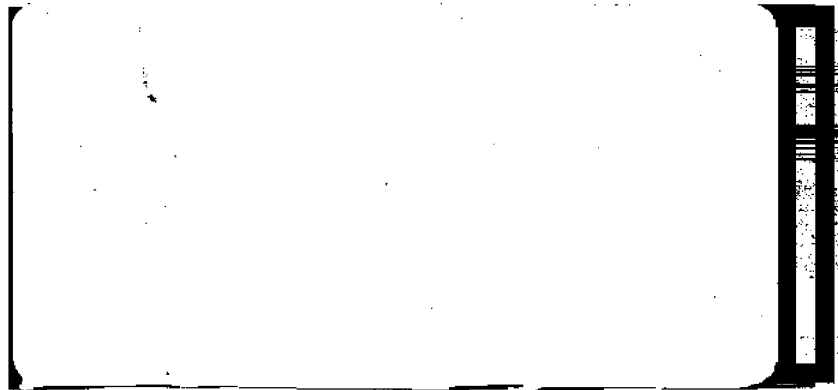


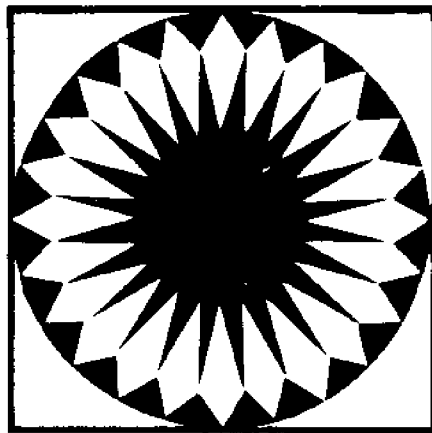
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A REEVALUATION IN 1981 OF THE COMMERCIAL USE  
OF SEA GRANT PROJECTS FUNDED IN 1975

CPA/82/13

September 1, 1982

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with

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## PREFACE

This report is a reevaluation of projections made in a project that was funded directly from the National Office of Sea Grant to the Center for Policy Alternatives (CPA) at the Massachusetts Institute Technology (MIT). The first study, An Analysis of the Potential Commercial and Foreign Trade Impacts of the Sea Grant Program, projected the economic outcome of 77 Sea Grant projects and provided policy guidance to enhance the Sea Grant Program's effectiveness in providing commercial benefits in addition to its larger research purposes. This study is designed to update and verify the projections made in the former study.

Professor James M. Utterback from the MIT Center for Policy Alternatives and Margaret Linskey of the MIT Sea Grant Program are responsible for the content of this report. Margaret Linskey has invested the better part of six months contacting the heads of projects in the base sample. Her knowledge of marine industries and of the Sea Grant Program has been a tremendous asset. Ron Grand also interviewed principal investigators and contacted Sea Grant directors for additional documentation of project success. Dr. Blair McGugan, an author of the first report reviewed the new interviews and research approach to ensure consistency with the 1977 study. Junco Norton carried out the data analysis, designed the format for this report and prepared it.

There would be nothing to write about if it were not for the eager assistance of Sea Grant principal investigators, industry contacts and Sea Grant directors. Our special thanks go to the New England Sea Grant directors, for so carefully listening and commenting on our mid-term presentation of the results of this project. Last, but not least, we extend our warmest gratitude to Dean Horn for his constant encouragement during the past six months.

James Utterback  
Principal Investigator  
Cambridge, Massachusetts  
August 1, 1982

## EXECUTIVE SUMMARY

In 1976 the MIT Center for Policy Alternatives conducted an analysis of the potential commercial use of the results of a sample of 77 Sea Grant projects which promised such use. Of these 77 projects, follow-up data were obtained for 59 projects in 1981.

The purpose of this study is to compare the economic projections made in 1976 for a five-year period with actual results experienced for the sampled projects. How valid were those projections and to what extent has industry used the results produced by the sampled projects? Our results are summarized in two sections: quantitative results and results for discussion.

### Quantitative Results

- Nineteen of the 59 projects that were reevaluated in 1982 resulted in annual sales totalling 44-62 million dollars in 1981. Forty-four million dollars is based on data that are comparable with the 1976 projections. Sixty-two million dollars is a sum of all sales reported during interviews regardless of their consistency with the 1976 data. Forty of the 59 projects have not led to commercial use to date.
- The projects studied have produced many but not all of the results forecast. Twenty-nine of the 59 projects reevaluated in 1981 had actual annual sales that coincided with 1976 projections, dominated by 21 projects with no projected or actual sales. Six projects have stronger records than anticipated while 24 turned in a weaker than projected direction.
- Of the 40 projects with no commercial use to date, fifteen are still thought to have the potential envisioned in the 1976 study. In seven of the 15 cases active research is still going on. However, the earlier projections were much too optimistic in terms of the ease and timing with which technical problems faced in the projects could be solved.
- Eleven new products have resulted as a direct consequence of the Sea Grant projects studied.

- Ten new companies have been formed primarily as a direct result of Sea Grant efforts to introduce the projects' results commercially.
- Twenty-five secondary companies have been formed to imitate the efforts of the 10 primary companies.
- Sea Grant research results have been effectively transferred to industry or government agencies by graduate students. Principal investigators for 24 of the 59 projects reported 31 students in industry, 23 students in government, 11 students in American universities and 2 in foreign research who are presently using Sea Grant project results and skills learned while working on Sea Grant funded research.

Results for Discussion:

- High risk, broadly based research projects have actually produced more of the values reported than have those that were seemingly less risky at the outset. Commercial use of broadly based projects has characteristically gone in different and unanticipated directions that have often led to profitable industrial applications, whereas projects with narrow and specific interest appear to have been defeated by modest increases in production costs or shifts in market demand.
- Sea Grant has built a stable and reliable marine research base. We recontacted 37 of the 38 researchers whose 1975 projects were originally forecast to have major commercial results. They all had received additional Sea Grant funding to continue with research that had been funded in 1975; 31 of them are being supported by the same Sea Grant programs while two researchers have been able to continue their work under other funding sources.
- More successful projects often go in different directions than their originally stated objectives, exhibiting Sea Grant flexibility to accommodate emerging industrial and market needs.
- In many cases, a six-year period is too short to produce actual or significant sales figures as a result of Sea Grant research. This fact is illustrated by the number of projects that are reported today as still having potential but whose commercial use is awaiting added scientific knowledge, changes in cost or availability of inputs, or changes in people's tastes and demands.

Public and private research programs have historically shown large direct commercial returns and even greater indirect or social returns. The Sea Grant projects studied are consistent with this pattern having enabled several industries to expand. Sea Grant has had an effect on both private industry and society as a whole, for example, by increasing personal safety at sea, increasing quality and availability of seafood products and introducing new methods and uses for products originated in the oceans -- benefits which do not readily relate to dollar value analyses.

Key dates mentioned throughout this report:

The original sample: Sea Grant projects which were actively funded during the year	1975
The original study done:	1975-1977
Date of the original report:	1977
Projections of sales and other variables for the period	
1976-1980	
Last year for projected project results	1980
Year of actual data gathered for comparison	1981
Present research done and report date	1982



## 1. INTRODUCTION

In 1976 the MIT Center for Policy Alternatives conducted an analysis of the potential commercial and foreign trade impacts of a sample of projects funded by the Sea Grant program under the sponsorship of the National Office of Sea Grant. Several industry sectors were analyzed in depth in 1976 to understand the market environment. It is clear that the Sea Grant Program also has primary objectives and outcomes other than direct economic benefits. Educational, environmental and research activities in support of the prudent utilization and management of the coastal zone and the oceans are important, regardless of direct economic benefit. However, some projects promise commercial benefits as well, and a sample of those is the subject of this study.

During the earlier study, a sample of 77 Sea Grant projects at 26 universities was examined and over 50 industrial firms engaged in related commercial activities were visited. The analysis and interpretation of the primary data was reported in terms of project characteristics and project outcomes including estimated annual sales, profits and impact on the balance of payments over the period 1976-1980. Estimates for each individual project were categorized as relatively certain or uncertain, and specific limitations or barriers envisioned to the use and diffusion of the results of the projects were indicated.

The purpose of this study is to update and verify the economic projections that were made in 1976. How valid are the 1976 projections, and to what extent has industry been affected by Sea Grant research results, were key questions this study set out to answer. Fifty-nine of the original principal investigators (PIs) were contacted again for information about the status of further development and commercial use of their project's results. Follow-up interviews with contacts in industry were made when the principal investigator recommended a specific contact. In several cases, these contacts were former students of the principal investigator questioned. Our conversations with industry

people as well as with the principal investigators were extremely helpful in documenting the process of technology transfer from university to industry. Our results are presented in the form of a study of the commercial use and diffusion of research results over a six-year period.

Summaries of all the projects being funded in 1975 were reviewed by a CPA research team. All the projects with positive economic returns in the economic benefit section of the summary sheets were chosen for the analysis presented in the 1977 report, An Analysis of the Potential Commercial and Foreign Trade Impacts of the Sea Grant Program. In 1982, 59 of the 77 projects were reevaluated. Therefore, the reader should understand that this study is a reflection of the commercial impact of only 59 projects that were projected in 1976 to have positive commercial results by 1981, rather than it being a reflection of all the research funded in 1975.

Sea Grant has definitely expanded and diversified in its research approach since 1975. New school and industry participants have joined the Sea Grant network since 1975. The analysis presented here may be viewed as a framework that could be used to monitor and assess the additional work that Sea Grant has sponsored since 1975.

A general update of the status of the marine industry sectors that were evaluated in the 1977 report was not made because of time and resource limitations. Instead, we gathered data from only the industries that have had quantifiable economic benefit from Sea Grant projects in the original sample. Our discussion about industry is based on qualitative data pertaining to a specific company's use of a Sea Grant product or concept. A separate, additional study, with a sample of all Sea Grant projects that would characterize the types of industries that consistently use Sea Grant research results, would be necessary to fully understand the present commercial and industrial contributions to the economy of the Sea Grant Program.

The body of the report below is organized in five major sections. Section 2 mentions the earlier studies of Sea Grant on which this study is based and outlines the present study method and questions. Section 3 then compares the measures of project commercial performance as projected in 1976 for 1980 and as actually experienced in 1981. Project performance is viewed in terms of sales, new firms and new products created. Section 4 concerns ways in which and frequency with which researchers in universities working on Sea Grant projects come into contact with counterparts in industry, a prerequisite for the transfer to and use of project results in industry. Section 5 correlates sales with other types of project outcomes, the creation of new firms and new products, and with the frequency and means through which university-industry links are formed. These links primarily involve flows of information and people between universities and firms. Finally, Section 6 reviews the changing environment of technical problems, funding, market forces and regulatory constraints as these have influenced the sample projects, at least as perceived by the principal investigators interviewed. Many of the projections made earlier will be seen to be much too high or much too low. A major reason for the variance experienced lies in unforeseen and often uncontrollable changes in the world at large. These changes have greatly enhanced the usefulness of some projects while hindering others.

## 2. RESEARCH METHOD AND QUESTIONS

### Research Method

Seventy-seven Sea Grant projects were included in the 1977 report, An Analysis of the Potential Commercial and Foreign Trade Impacts of the Sea Grant Program. These projects were placed into four categories in order of decreasing economic potential: projects with expected annual sales from 1976 through 1980 greater than 10 million, 1 to 10 million, 0 to 1 million dollars and "nil" or no projected impact. To determine to what degree Sea Grant research results had actually been used commercially, principal investigators, industry contacts and in some cases, Sea Grant directors were asked to update the 1976 projections based on actual experience.

Telephone interviews with former graduate students, industry contacts that were recommended by the principal investigator, benefit information from the host Sea Grant offices, and an analysis of the overlapping project results reported in the March 1981 Sea Grant Task Force Report, Economic Effects of Sea Grant, were also helpful in determining actual sales benefit obtained from Sea Grant research.

In 1976 we found each projected measure of commercial benefit to be strongly related to all other projected measures of project commercial benefit: sales, profits, number of firms interested in using project results, formation of new firms, employment, exports and net contribution to the balance of payments. For purposes of this study, emphasis has been placed on the measures of economic benefit that are most clearly verifiable in 1982. Actual annual sales, firms and products formed as a direct result of Sea Grant research, and the trend of industry interest in the results of the projects seem to be key indicators of project success. In 1982, as predicted in 1976, positive sales creation is a prerequisite to all of the other outcomes listed above.

The Sea Grant Task Force report discussed social, economic and educational benefits of 55 selected Sea Grant projects funded between 1975 and 1981. Our reevaluation, however, is limited only to discussing the direct economic impact of the 77 Sea Grant projects studied in 1976. In the 10 overlapping cases, correlations between our findings and those reported by the Sea Grant Task Force provided valuable documentation of the commercial use of research results. In those overlapping cases, follow-up telephone calls were made to the Sea Grant program directors, additional principal investigators, and additional industry contacts to obtain further explanation of the economic benefits of Sea Grant research.

We found that all the principal investigators in the upper two annual sales categories, i.e., greater than 10 million dollars and the 1 to 10 million dollars, were still at the same universities, had had follow-on Sea Grant research projects funded since the 1977 report, and were working in the same field. This fact illustrates that over time Sea Grant has established a reliable resource of people to do marine related research.

The discussions of results in the report refer generally to a 79 percent sample of the original sample, or to data collected for 59 of 77 projects. But not every principal investigator answered every question, so the analysis of each question is based on a different number of responses. The number of responses to each question is explained at the beginning of each analysis section. Follow-up interviews with 37 of the 38 principal investigators of the projects in the upper three sales categories (0-1 million, 1-10 millions and greater than 10 millions) were conducted in January, February and March, 1982. We were unable to obtain any information about one of the projects in this category.

In addition to the telephone surveys mentioned above, the 39 principal investigators of the projects with no projected sales were recontacted using a brief questionnaire which requested general information about the status of the use of the results of their projects by industry and graduate students, about sources of additional funding

and barriers to commercial use. Twenty-two of these questionnaires were returned to us. We telephoned 17 principal investigators of projects within this category who responded positively to the questions pertaining to sales, new firms and new products. The high percentage of responses to both our interview and questionnaire contacts enhances the accuracy and credibility of the study as a whole.

### Research Questions

The following questions are those this reevaluation study set out to answer. Discussions of the responses follow in Sections 3 and 4.

1) What is the status of commercial use of the results of each of the 77 Sea Grant projects that were analyzed in 1976? 2) What are the characteristics of those projects that have received additional Sea Grant and/or industry support? 3) Who or what mechanism has been most effective in transferring research results into industry? 4) What are the actual annual sales that have been generated as a direct result of each Sea Grant project? 5) Have any new firms, departments or products been designed around Sea Grant results? 6) What differentiates projects with more commercial potential from others at the beginning of the project's funding?

Many of the current interviews brought out points that were not included in the 1976 study. Consequently we added some new variables. They are: Were new products formed as a direct result of Sea Grant research? The location of graduate students now using research results in industry, government or university? How many follow-on Sea Grant projects have been funded since 1976? From whom did additional funding come: Sea Grant, industry or government? And finally, what are the updated project results in terms of funding termination, commercial impact, and still having commercial potential? We found that these questions provided additional information which helped us better understand the projects that were more or less successful than predicted.

In sum, updated information included a summary of the status of commercial use of the results of the sample projects, the number of new firms or products started, the location and professional activities of graduate students, the number of continuing projects funded by Sea Grant and other sources, suggestions of industry contacts and economic benefit information pertaining to each project provided by the host Sea Grant Programs. Comparative tables and brief discussions of the 1976 projections and 1981 data follow. These data are recorded as percentages of the number of cases for which a particular question was answered. Differences between the forecasts made in 1976 and actual results experienced in 1981 are emphasized in the discussion below.

3. A COMPARISON OF 1976 PROJECTIONS AND 1981 RESULTS

As noted above, all measures of economic benefit of Sea Grant projects generated in the earlier study were strongly related. Three of the most reliable earlier measures (sales, creation of new firms and of new products) derived from a project's results have been examined in detail in this study and are discussed below.

1976 Annual Sales Projections and 1981 Actual Annual Sales

Table 1 shows the distribution of 1980 annual sales for the sample projects as projected in 1976. Fifteen projects can be seen to provide the bulk of the commercial potential in the sample of projects. Twenty-three others were thought to have positive but small potential, with no commercial use expected in 39 cases. In the present research

TABLE 1  
ANNUAL SALES EXPECTED FROM A SAMPLE OF SEA GRANT PROJECTS  
AS PROJECTED IN 1976

Projection of Annual Sales Expected in 1980	1976 Projections of Annual Sales for 77 Sea Grant Projects Funded in 1975	
	Number of Projects	Percent
No Sales	39	50.6
\$0 - 1 million	23	29.9
\$1 - 10 million	13	16.9
More than 10 million	2	2.6
TOTAL	77	100.0



data were gathered first for the projects thought in 1976 to have potential commercial use. The 39 "no sales" cases were given lower priority. Only 59 of the original 77 projects studied were included in the follow-up study. The 18 cases dropped from the follow-up study were either projected in 1976 to have no sales potential (16 cases) or very small potential (2 cases). In summary, based on the original study half of the 77 projects sampled were expected to have some commercial results during the five-year period from 1976 through 1980 in terms of sales created.

Table 2 compares the actual 1981 sales for 59 projects with the projections made in 1976. One-third of those 59 projects have resulted in sales in 1981. There are sizable actual commercial results to be seen, though less than expected in 1976. Generally the projections made in the 1976 study were too high, though some were also too low. The bulk of the commercial potential still can be seen to lie in a few (seven) projects. Another 12 have actually yielded modest results.

TABLE 2  
PROJECTIONS OF SALES FOR THE YEAR 1980 MADE IN 1976  
AND ACTUAL 1981 SALES

	1976 Projections of Annual Sales in 1980		1981 Actual Annual Sales	
	Number of Projects	Percent	Number of Projects	Percent
No Sales	23	39.0	40	68.0
\$0 - 1 million	21	35.6	12	20.3
\$1 - 10 million	13	22.0	5	8.5
More than 10 million	2	3.4	2	3.4
TOTAL	59	100.0	59	100.0

Total Projected Sales = 82 million dollars.  
Total Actual Sales = 44 million dollars.  
The 1976 sample has been reduced here to the same set of cases studied in 1982.

Forty projects have not led to any commercial use. Fifteen of these are still thought to have the potential envisioned in the 1976 study. In seven of the 15 cases active research is still going on. However, the earlier projections were much too optimistic in terms of the ease and timing with which technical problems faced in the projects could be solved.

Table 3 illustrates the degree to which projections of 1980 sales made in 1976 were a valid measure of actual sales in 1981. It shows that, while the projection made of the potential of the whole sample of projects was fairly good, projections for particular projects are not so reliable.

TABLE 3

1980 SALES AS PROJECTED IN 1976 COMPARED WITH SALES ACTUALLY REALIZED IN 1981 FOR A SAMPLE OF 59 PROJECTS STUDIED IN BOTH 1976 AND 1982

1976 Projected Annual Sales for 59 Projects Studied in 1976 and 1981	Actual Annual Sales in 1981 for 59 Projects Studied in 1976 and 1981			
	No Sales	0-1 million	1-10 million	More than 10 million
No sales	21	2	0	0
0 - 1 million	13	5	3	0
1 - 10 million	6	4	2	1
More than 10 million	0	1	0	1

Total number of cases = 59. Twenty-nine of the 59 cases had actual sales which were within the 1976 projection ranges, dominated by 21 projects with no projected or actual sales. Six projects have stronger records than anticipated while 24 turned in a weaker than projected performance. The group of weaker projects is dominated by 19 which have not yet produced any returns. Some of these still show promise, but the problems to be solved have proven tougher in many instances than originally anticipated.

In the 1977 report, Analysis of the Potential and Foreign Trade Impacts of the Sea Grant Program, it was judged to be relatively certain that 17 projects would have sales amounting to 82 million dollars by 1980. An additional 21 projects were projected to have an aggregate sales potential of 40 million dollars, but this potential was assessed in 1976 to be highly uncertain.\* Using the same conservative criteria for measurement, we found that 19 of the sample projects have actually resulted in annual sales of 44 million dollars in 1981. This figure could be as high as 62 million dollars if we included all the sales claimed during interviews. (All sales figures in this discussion are in 1976 and 1981 current dollars respectively. No adjustment has been made for inflation.)

In both the 1976 study and the present one, the evaluation criteria used require that commercial results can be documented and traced directly to a Sea Grant project in our sample. One firm worked closely with a Sea Grant investigator to develop a new product and production technology which has been highly successful. This idea has been imitated by ten or more other firms. Sales for only the first firm are counted in our analysis.

One Sea Grant project studied in 1976 led directly to formation of a company to produce a highly valuable product. Rapidly growing sales and exports were expected to result. However, sophisticated customers can produce this product themselves and have several reasons to do so. Thus, fewer and smaller customers remain for the innovating firm. The production by users for their own needs cannot be documented nor a value set on it, though its value is considerable. Cases of this nature make up the bulk of the difference between the higher and lower figures stated above. One could make a valid case that the lower figure is much too conservative, but it is the figure that is consistent with the projections in the earlier study.

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\* In fact, of the 19 projects with results in active use today, 10 were in the "certain" category in 1976 and 7 in the "uncertain" category.

In sum, many projects thought to be risky or uncertain in their outcome in 1976 have resulted in valuable products for industry. Some projects which were more narrowly focussed and thought to be highly certain in their promised results then have failed due to shifts in customer priorities, unforeseen competition, or economic factors such as changes in costs or, in a few cases, technical factors. In other words, new unforeseen factors arose in the interim that either inhibited or enhanced the outcome of projects. Some projects thought to be highly uncertain in their focus and outcome in 1976 have paid off in unexpected ways. In our opinion, predicting products and sales to result from research over a period as brief as five years is difficult. Aggregate ranges of sales with consideration of economic fluctuations can be reasonably certain. Regardless of the 1976 projections, many projects within our sample that have not yet been used commercially have potential to do so sometime in the future. Because of the reasons discussed above it is difficult to say when research results will become attractive to industry.

#### New Firms and New Products Formed as a Result of Sea Grant Research

##### New Firms

This section is based on data from 56 of the 77 Sea Grant projects studied in 1976. New firm formation was a good indicator of a successful project. Table 4 shows that ten new firms have been formed as a direct result of Sea Grant research. Table 5 comparing 1976 projections with 1981 experience shows that 5 projects from which no new businesses were expected, actually did result in new firms. Table 5 also shows that identifying a group of more or less successful projects is possible, but identifying specific projects that will definitely result in new firm formation is more difficult.

In addition to the 10 firms that were formed as a direct result of Sea Grant research that was being funded in 1975 at least 25 secondary companies were formed in the interim to imitate or modify the product or process introduced by the 10 primary firms. Often those secondary firms are unaware of Sea Grant's involvement in the origin of the technology. It would not be surprising if the secondary firms were totally unfamiliar with Sea Grant.

TABLE 4  
NUMBER OF PROJECTS EXPECTED IN 1976 TO RESULT IN  
THE FORMATION OF ONE OR MORE FIRMS, AND NUMBER OF PROJECTS  
ACTUALLY RESULTING IN FIRM FORMATION FROM 1976-1981

	Number of New Firms Projected to be Formed from 1975 to 1980		Number of Firms <u>Actually</u> Formed since 1975		
	Number of Firms	Percent	Number of Firms	Percent	
None	46	82.1	None	48	85.7
One or More	10	17.9	One or More	8*	14.3
TOTAL	56	100.0	TOTAL	56	100.0

\*NOTE: For 1981 one of nine projects resulted in 2 firms, thus 10 firms in all. One project is not included in the table because comparable data are not available from the 1976 study.

TABLE 5

A COMPARISON OF THE NUMBER OF PROJECTS RESULTING IN NEW FIRMS PROJECTED AND THE NEW FIRMS THAT HAVE ACTUALLY BEEN FORMED AS A RESULT OF 56 SEA GRANT PROJECTS

New Firm Formation Projected in 1976	Projects Resulting in New Firms Actually Formed Since 1975	
	None n=48	One or More n=8
None n = 46	41	5
One or More n = 10	7	3

Total number of cases studied = 56. Nine projects have led to the formation of 10 new firms. One case was omitted from the tabulation above, as comparable data were not available for 1976.

#### New Products

Projecting specific new product developments was just as difficult as projecting the exact sales and number of new firms to be formed. As this variable was added in the present study, comparable data for 1976 are not available.

Interview data show that 11 new products were formed as a direct result of using Sea Grant research results. Table 11 relates new products to sales in 1981. Five of the new firms mentioned above were formed to produce 5 of the 11 new products. The remaining products were produced by existing firms. The new products range from pharmaceuticals made from marine organisms to diving apparatus, to minced fish blocks, to plant fertilizer, to name a few.

The one project projected to have annual sales of 15 to 20 million dollars actually resulted in sales of 8 to 10 million dollars (Table 11). This decrease in measured annual sales is partly due to the fact that the technology introduced by Sea Grant was used directly by the potential customers of the 2 to 3 firms formed to produce and sell the product since 1975. This is an example of Sea Grant effecting cost savings to one group of companies while enabling others to go into production of the same product. Thus, the value of the project to users may be even greater than projected, though this cannot be shown based on transactions in the marketplace. Actual annual sales were also difficult to attribute to the few cases in which Sea Grant research introduced new sources of supply for existing products or new, more economic methods for production. Sea Grant research in these cases resulted in cost savings rather than sales as reported in this study.

In sum, although projections of sales, new firm and product formation are good indicators of project success, predicting specific results in a six-year period is extremely difficult. Many unforeseen, but understandable factors arose in the interim which either inhibited or enhanced the commercial use of the research results.

#### 4. CHANNELS FOR TRANSFER OF RESEARCH RESULTS FROM UNIVERSITIES TO INDUSTRY

An important goal of the Sea Grant Program is to make research results available to the public as well as to private industry at any point during the research. In order to ensure that Sea Grant supports applied research, all programs are required to obtain one-third of their funding from industry, other government or foundation sources. Often, before a project is completed, industries are informed of the projects' findings and invited to comment on the work being done. We have found that this informal interaction between university researchers and people in industry often results in contributions from industry to the researcher in the form of in-kind services or funds. Graduate students who have worked on Sea Grant projects were also traced to industry positions where they are continuing with Sea Grant research, thus creating a mutually beneficial transfer of research into industry. This section will discuss the significance of the level of interest from industry and the fact that graduate students have also been excellent "carriers" of research results into industry since 1976.

##### Industry Interest in The Sample of Sea Grant Projects from 1976-1981

The following discussion of industry interest in Sea Grant research results since 1976 includes data on 54 of the 59 projects. As we would expect with completion of the projects in the original sample and with the passage of time for disseminating research results, a greater level of industry interest has arisen since 1976. In 1976 about half of the projects had received some interest from industry. Interest here is defined as one or more visits or inquiries by industry to discuss the technology or information generated by Sea Grant sponsored research. Table 6 indicates that by 1981 almost all of the 54 projects (83 percent) for which comparable data have been obtained have generated some specific interest by industry.



TABLE 6  
INDUSTRY INTEREST IN SEA GRANT RESEARCH IN 1976 AND 1981

	Number of Industry Inquiries in 1976 Reported by Principal Investigators		Number Industry Inquiries Reported in 1981	
	Number of P.I.s	Percent	Number of P.I.s	Percent
No contacts by industry	25	46.3	9	16.7
One or more inquiries by industry	29	53.7	45	83.4
TOTAL	54	100.0	54	100.0

Table 7 shows that 19 projects that had not yet received industry interest in 1976 report specific industry interest in 1981. It also shows that the degree of industry interest is increasing as well. For instance, in 1976, 13 of 54 projects had generated inquiries from 3 or more firms. In 1981, 32 of the projects studied generated 3 or more inquiries.

TABLE 7  
INDUSTRY INTEREST IN SEA GRANT RESEARCH IN 1976 AND 1981 AS REPORTED BY PRINCIPAL INVESTIGATORS

Number of Industry Contacts in 1976 Reported by Principal Investigators	Number of Industry Contacts Reported in 1981		
	No interest n=9	1 or 2 n=13	3 or 4 n=32
No Contact by Industry (n=25)	6	4	15
One or 2 Inquiries by Industry (n=16)	1	5	10
Three or 4 Inquiries by Industry (n=13)	2	4	7

Total number of cases studied = 54

Additional Funding for Sea Grant Research from 1975 - 1981

Another measure of economic impact or potential economic impact lies in the number of additional Sea Grant projects that have been funded since 1975, and in additional funding from industry, government or from private foundations. Based on data from 58 of the 59 projects, 27 of the 58 projects that were reevaluated received additional Sea Grant funds to continue with the work that was closely related to the project funded in 1975. Five projects received a combination of Sea Grant and industry funds, and one project received only industry money and two projects received funds from another government agency since 1975.

In addition, 23 projects that were reevaluated in 1981 received funding or "interest" from industry in the form of in-kind support. In-kind support means that a company did not contribute cash but contributed personnel, facilities, or equipment or all three. Table 8 shows the breakdown of industry match as in the form of cash only, in-kind only and a combination of the two: in-kind and cash. This is important to know, because contributions of people or facilities lead directly to close university to industry ties. Cash contributions may lead to follow-on contacts or indicate close communications, but this is not true in all cases.

When matching funds come from industry, there is usually a communication link between the industry and the researcher, thus creating a strong connection between the two. This is vividly clear in Table 8. From 1975 to 1981, 33 of the 38 projects which received industry matching funds also received contributions of personnel or facilities from industry meaning that valuable exchanges of people occurred.

Our interviews indicate that when industry provides some form of in-kind contribution, an extremely effective transfer of information from the university to industry is facilitated. From an industry's perspective, providing personnel or facilities with which a researcher

can do his work is a cost effective way of ensuring that Sea Grant research results are tailored to their needs. The fact that projects receiving industry matching funds more often produced commercially interesting results is not surprising.

In two cases in particular where Sea Grant had provided seed money to identify a source of supply for a unique chemical application using marine organisms, funding was continued by other funding sources, the National Institute of Health or the National Cancer Institute, for instance.

TABLE 8  
FORM OF INDUSTRY MATCHING FUNDS  
RECEIVED BY PRINCIPAL INVESTIGATORS FOR 58 SEA GRANT PROJECTS  
STUDIED FROM 1975 TO 1981

	Form of Industry Match in 1975		Form of Added Industry Match from 1976 Through 1981	
	<u>Number of Projects</u>	<u>Percent</u>	<u>Number of Projects</u>	<u>Percent</u>
No match	20	34.5	25	43.1
Received cash only	5	8.6	10	17.2
Received in kind only	16	27.6	19	32.8
Received cash and in kind	17	29.3	4	6.9
TOTAL	58	100.0	58	100.0

Graduate Students Using Sea Grant Research Results in Industry,  
Government and Universities

Personal contact continues to be a primary avenue for transfer of project results near completion and following project completion. Two of the more effective avenues of technology transfer are through graduate students who leave the university setting and use research results in industry and the other is through marine advisory agents who see to the timely and appropriate dissemination of project results to the proper commercial interests. Principal investigators for 24 of the 59 projects stated that one or more of their students continue to use project results in their employment in industry, in government or in universities. Table 9 shows the totals of graduate students in these areas.

TABLE 9

NUMBER OF GRADUATE STUDENTS USING SEA GRANT RESEARCH RESULTS  
IN THEIR EMPLOYMENT SINCE 1976

Industry	Government	University	Foreign Research	Total
31	23	11	3	68

Interviews with former Sea Grant graduate students who were working in industry and using project results indicated that they made their job contacts while working on Sea Grant projects. The nature of their Sea Grant research was such that they were often conducting experiments in a commercial facility to obtain commercial scale data. Informal information and expertise "exchange" between university and industry thus often led to commercial use of project results. All of the projects

whose results were in the form of a new product had between one and three graduate students in industry, government or university doing related work. Aquaculture projects sent more students to industry than any of the other sectors. It is also in this sector that the majority of new businesses have been created.

5. SALES IN 1981 RELATED TO NEW FIRM FORMATION, NEW PRODUCT DEVELOPMENT AND CHANNELS FOR TRANSFER OF RESEARCH RESULTS

Formation of a new firm based on the outcome of research represents a strong commitment to moving the technology or knowledge developed into commercial use. Creation of a new product usually requires a more entrepreneurial commitment than does say a product or process improvement. Five of the 11 new enterprises formed to carry results of sample projects into use were carrying new products into the market. One should not be surprised then to find that these two indicators, that something of commercial value has come from a project, are strongly related to sales in 1981 from project developments. Table 10 shows that all but one case in which a new firm was formed created some sales. Eight of the 19 cases in which sales were positive and 4 of 6 cases for which sales are now more than one-million dollars annually are ones in which new firms have been started. Table 11 shows that nearly the same conclusions are true for new products. All but 3 projects which created new products had positive sales. Eight of 19 projects with positive sales, and 3 or 6 projects with more than one-million dollars in annual sales were those which developed new products.

Greater levels of contact between people in universities and those in industry was noted above as one of the most effective possible means of technology transfer. Tables 12 and 13 make this point in detail. Industry gave 32 of 57 projects one or more types of matching support in the form of cash, use of facilities or personnel. While 15 of 39 projects which did not result in any 1981 sales also received industry support, all but one of those with positive 1981 sales had matching support from industry. The same can be said, though not quite as strongly of transfer which occurs through industry hiring a student trained during a Sea Grant project. More than half of all the projects generating sales in 1981 are ones in which one or more students have played a direct role in technology transfer to industry (10 of 17 cases) though students who participated in an equal number of less successful projects have, of course also found employment in industry (8 of 39 cases). If a firm identifies a university project as having potential

commercial interest it should clearly invite the researchers to use the firm's ships, laboratories and other facilities, encourage exchanges of personnel, and endeavor to employ graduates who have worked for the principal investigator.

TABLE 10  
SALES IN 1981 RELATED TO FIRM FORMATION FOR EACH OF  
THE SAMPLE PROJECTS

Sales in 1981	Have New Firms Formed Since 1976 On the Basis of Project Results?	
	None (n=48)	One or two (n=9)
None (n=39)	38	1
0 - 1 million dollars (n=12)	8	4
1 - 10 million dollars (n=4)	2	2
More than 10 million dollars (n=2)	0	2

Total number of cases studied = 57.

TABLE 11  
SALES IN 1981 FOR SEA GRANT PROJECTS WHICH  
RESULTED IN CREATION OF NEW PRODUCTS

Sales in 1981	New Products Created as a Result of Sea Grant Projects	
	None (n=47)	One or More (n=11)
None (n=39)	36	3
0 - 1 million dollars (n=12)	7	5
1 - 10 million dollars (n=5)	3	2
More than 10 million dollars (n=2)	1	1

Total number of cases studied = 58.

TABLE 12

SALES IN 1981 RELATED TO INDUSTRY MATCHING SUPPORT FOR EACH OF THE SAMPLE PROJECTS

Sales in 1981	Type of Industry Matching Support			
	None (n=25)	Cash Only (n=10)	Personnel or Facilities (n=18)	Cash and Personnel/Facilities (n=4)
None (n=39)	24	5	10	0
0 - 1 million dollars (n=12)	1	3	6	2
1 - 10 million dollars (n=4)	0	1	2	1
More than 10 million dollars (n=2)	0	1	0	1

Total number of cases studied = 57.

TABLE 13

SALES IN 1981 RELATED TO STUDENTS USING RESEARCH RESULTS IN INDUSTRY FOR EACH OF THE SAMPLE PROJECTS

Sales in 1981	Number of Graduate Students Using Research Results in Industry			
	None	1 or 2	3 to 5	5 or more
None (n=39)	28	5	1	1
0 - 1 million dollars (n=11)	5	3	0	3
1 - 10 million dollars (n=4)	2	1	1	0
More than 10 million dollars (n=2)	0	1	1	0

Total number of cases studied = 56.



## 6. BARRIERS TO COMMERCIAL USE COMPARED FOR 1976 AND 1981

Why were our original projections of commercial success decreased by half for 38 cases in which commercial use of project results seemed reasonable in 1976? The purpose of this section of the report is to compare the reasons given by principal investigators as to why some of the sampled project results were carried further into commercial use than others. The original sample covered a wide range of projects whose proposed summaries indicated potential financial success and whose results were directed toward a variety of specific industrial needs. It was difficult to standardize the evaluations. Potential obstructions to commercial use of sample project results were discussed in the 1976 study. The 1981 updated evaluation indicates modifications, actual achievements and shifts in the importance of these barriers. Table 14 lists the barriers seen in 1976 versus those seen by principal investigators today.

The numbers in the table give the frequency of responses for each barrier, 84 in 1975 and 136 in 1981. The reason there are many more barriers reported in 1981 than in 1976 is probably due to a difference in interviewing procedure. In 1981, 59 researchers were asked to respond to a list of the possible factors limiting the commercial use of their project results. Consequently, principal investigator's were led to consider the whole range of limiting factors. In 1976, 77 principal investigators were simply asked to discuss only the most important factors that might hinder commercial use of the results of their project. The fact that principal investigators interviewed in 1981 were aware of so many more barriers to the use of their project results may also indicate that during the interim they have had more contact with industry and in doing so, have become aware of the commercial limitations or potentials of their research. But due to the difference in interviewing method we cannot be sure.

The 1981 barriers to development are ranked in Table 14 in terms of frequency of responses. Technical complexity ranked highest at 27 mentions, variations and/or limitations of supply ranked second at 18 mentions, lack of public and private interest ranked third at 16 mentions, and market demand and industry structure ranked fourth at 13

mentions each. The second highest ranking barrier to commercial development of a research project in 1981 was the reluctance on the part of a variety of industries to introduce a new product that is totally dependent upon an unstable supply of raw material.

TABLE 14  
BARRIERS LIMITING THE COMMERCIAL USE OF SEA GRANT RESEARCH  
RESULTS AS SEEN IN 1976 AND 1981

Factors* viewed as limiting the use of project results	1976	1981
Technical Complexity	9	27
Limitation of Supply	6	18
Lack of Public and Private Interest	4	16
Industry Structure	4	13
Market Demand	14	13
Risk and Returns	2	11
Capital	4	10
Legal	13	8
Environmental Safeguards	11	6
Product Cost and Economics	14	6
Consumer Behavior	3	5
Labor Displacement	-	3

\* Based on data from 59 cases.

(Numbers in 1981 are based on a different interview procedure than in 1976)

Perhaps, the simplest way to summarize the data would be to say that the three most frequently reported barriers in 1976, legal, regulatory and environmental issues shifted in 1981 to technical complexity, limitation of supply and market demand with differences in priority depending on the sector of the marine industry that the work is addressing. For instance, the projects whose commercial use was dependent upon a stable supply of fish or fish by-products found limitation of supply to be the most important barrier with market demand and industry structure as close seconds. Some projects which resulted in equipment or systems design have not been used commercially because of remaining technical complexities that neither Sea Grant nor private industry found it advantageous to pursue further, thus the reason for the high frequency of mentions of lack of public and private interest and technical complexities.

It is difficult for industries to structure their finances around an unpredictable supply of raw product. The two to three year stock availability projections which characterize fishing inventories are unsuitable for industries whose source of material is usually guaranteed for 10 to 20 years. Fish processors are also reluctant to gear up to include an underutilized fish species in their product lines because of uncertain markets and unpredictable supply. There is no assurance, unless under a contractual agreement, that a fisherman will deliver less expensive fish regularly if he can sell less of a more marketable species while expending less effort and receive a higher market price for the fish.

Some of the projects (13 cases) that were originally thought to have greater than 10 and 1 to 10 million dollar annual sales have not yet produced commercial results for one reason or another. These projects were placed in the upper two categories based on their high payoff and high risk potential. Six years was not a long enough period of time for industry to implement the results. Generally, in these cases predictions that were based on scientific progress were disappointing because the research results took longer to realize.

Common barriers to commercial use of some of the aquaculture projects are technical complexity, risk and return on investment and the high cost of energy. Both Sea Grant and the United States generally were optimistic about aquaculture development in 1976. Salmon aquaculture, for instance, has not progressed nearly as quickly as was predicted in 1976. However, the aquaculture area still shows great promise. One of the values of the Sea Grant Program in terms of the commercial potentials of these projects is that it has provided a consistent source of funding for some of the riskier yet potentially higher economic benefit projects over the years.

Several small aquaculture and vaccine companies have not only managed to market their product domestically but they have tipped the tradebalance scale in their direction, but not in the magnitude that was originally projected. To cite another example, in 1976 U.S. independence from foreign oyster seed imports was a prime objective of the Sea Grant program. Sea Grant funded several projects in different parts of the country exploring several methods of oyster seed production, some of which were part of our research sample. One project developed a novel methodology for producing oyster seed that resulted in a 90 percent replacement of European oyster seed being imported from Japan.

Research for a dynamic marketplace is exciting to say the least, and the marine industry is in fact dynamic and unpredictable. In many cases, the actual commercial use of a Sea Grant product or concept found a better application in an industry other than what was originally envisioned by the researchers and industry advisors. Consequently research was either discontinued, funded by the "other" industry or simply modified in its purpose. Often more successful projects go in different directions than their originally stated objectives, exhibiting Sea Grant flexibility to accomodate emerging industrial and market needs.

## 7. CONCLUSION

We believe that even the rather brief outline of results given above provides many insights about the values of the Sea Grant Program or of similar research programs. Many benefits have accrued to industry from even a small sample of the projects funded to date. Continuous contact, flows of people and mutual support between industry and university researchers appear to be critical to the communication and use of project results. The sustained activity produced by the Sea Grant Program over time has, in our opinion, been a key element in building the strong relationships over a six-year period that we have documented here.

Few studies which rigorously evaluate the commercial importance of a research program have been done. Fewer still have been reviewed over a period of years as in the present study. We suggest that a small but continuing and comprehensive annual effort to collect the kinds of evidence reported here would be of value both to scholars and program managers concerned with strengthening the ultimate usefulness of their work to industry and to society.

