

SUBSTANTIVE RESULTS  
OF THE  
UNIVERSITY OF MICHIGAN'S  
SEA GRANT DELPHI INQUIRY

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## ABSTRACT

This paper presents the substantive results of the Sea Grant Delphi exercises, which were designed to support the following Sea Grant goals: (1) to encourage the involvement of university people in comprehensive management of the water resources of the Great Lakes, (2) to integrate their informed judgments, and (3) to communicate these judgments to communities whose social and economic development is closely related to management of their water resources. This report is one of three related to the findings of the Sea Grant Delphi exercises. Another report regards research and information priorities in the Sea Grant programs and will be made available only to Sea Grant researchers. The third report evaluates the methodology of the University of Michigan's Sea Grant Delphi inquiry.

## BACKGROUND

This study was funded by the Sea Grant Program of the University of Michigan and conducted by the Bureau of Business Research, Graduate School of Business Administration. We are greatly indebted to the sixty-nine University of Michigan researchers and concerned citizens from the Grand Traverse Bay area who contributed to the substantive results of the Delphi exercises and to an evaluation of the methodology.



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## INTRODUCTION

### Basic Objectives of the Study

One objective of this study was to utilize the Delphi techniques in obtaining the judgments of a multidisciplinary team of researchers in the Sea Grant Program regarding the following:

1. Potential technical, social, economic, and political developments that could influence the management of water resources in a region similar to the Grand Traverse Bay area
2. Assessment of the relative importance of future sources of pollution of a body of water similar to Grand Traverse Bay
3. Recommended waste-water treatment and disposal systems
4. Regional opportunities, problems, and planning strategies

Another objective of the study was to communicate the researchers' judgments to people in the Grand Traverse Bay area. Individuals from the region who were believed to be influential in the political processes through which regional planning is accomplished were therefore included on the Delphi panels.

A third objective was to evaluate the effectiveness of the Delphi techniques in solving the problem of integrating the judgments of the researchers and conveying their informed insights to decision makers. Respondents in these exercises--a group with exceptional qualifications who represent a broad range of academic disciplines and experience--served as the primary resource in evaluating the methodology. Their evaluations are contained in another report on the findings of the Sea Grant Delphi exercises.<sup>1/</sup>

The Grand Traverse Bay area (Figure 1) was selected as the locus of pilot efforts to develop methodologies that will be applicable for the entire Great Lakes system. The area, which has been identified as socially and economically disadvantaged, is part of an Upper Great Lakes region consisting of 119 counties in the northern parts of Michigan, Minnesota, and Wisconsin.

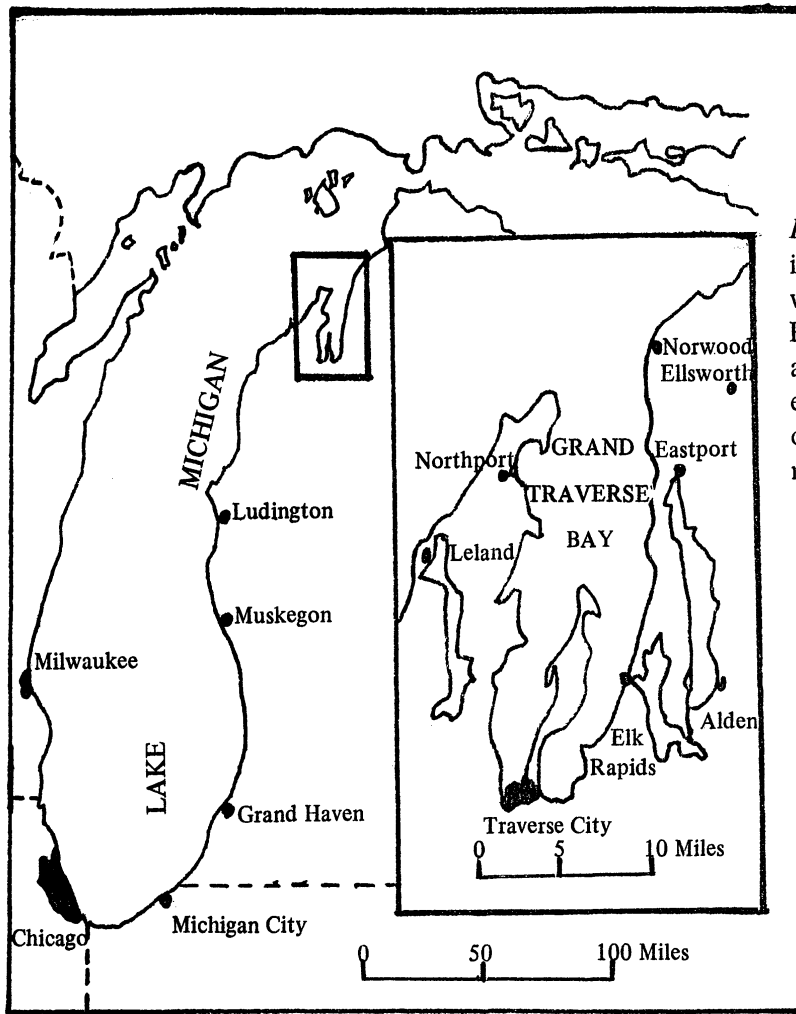
### Issues

Preparation for the Delphi exercises included a study to determine which technical, social, economic, and political issues might have a significant effect on the region's resources.<sup>2/</sup> Technical experts

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<sup>1/</sup> John D. Ludlow, "Evaluation of Methodology in the University of Michigan's Delphi Inquiry." To be published as Sea Grant Technical Report No. 22.

<sup>2/</sup> John D. Ludlow and Patricia L. Braden, "Socioeconomic Development in the Grand Traverse Bay Area," Working Paper No. 35 (Ann Arbor, Mich.: Bureau of Business Research, University of Michigan, April 1971).



*LEFT.* The Grand Traverse Bay (see inset) serves as a model for the University of Michigan's Sea Grant Pilot Program. It is representative of many areas in the Great Lakes basin where economic development and quality of life are closely related to water resources.

*RIGHT.* The ten counties making up the Northwest Michigan Development District approximate the Grand Traverse Bay watershed area. The numbers are 1970 census population figures. Asterisks indicate counties which include off-shore islands.

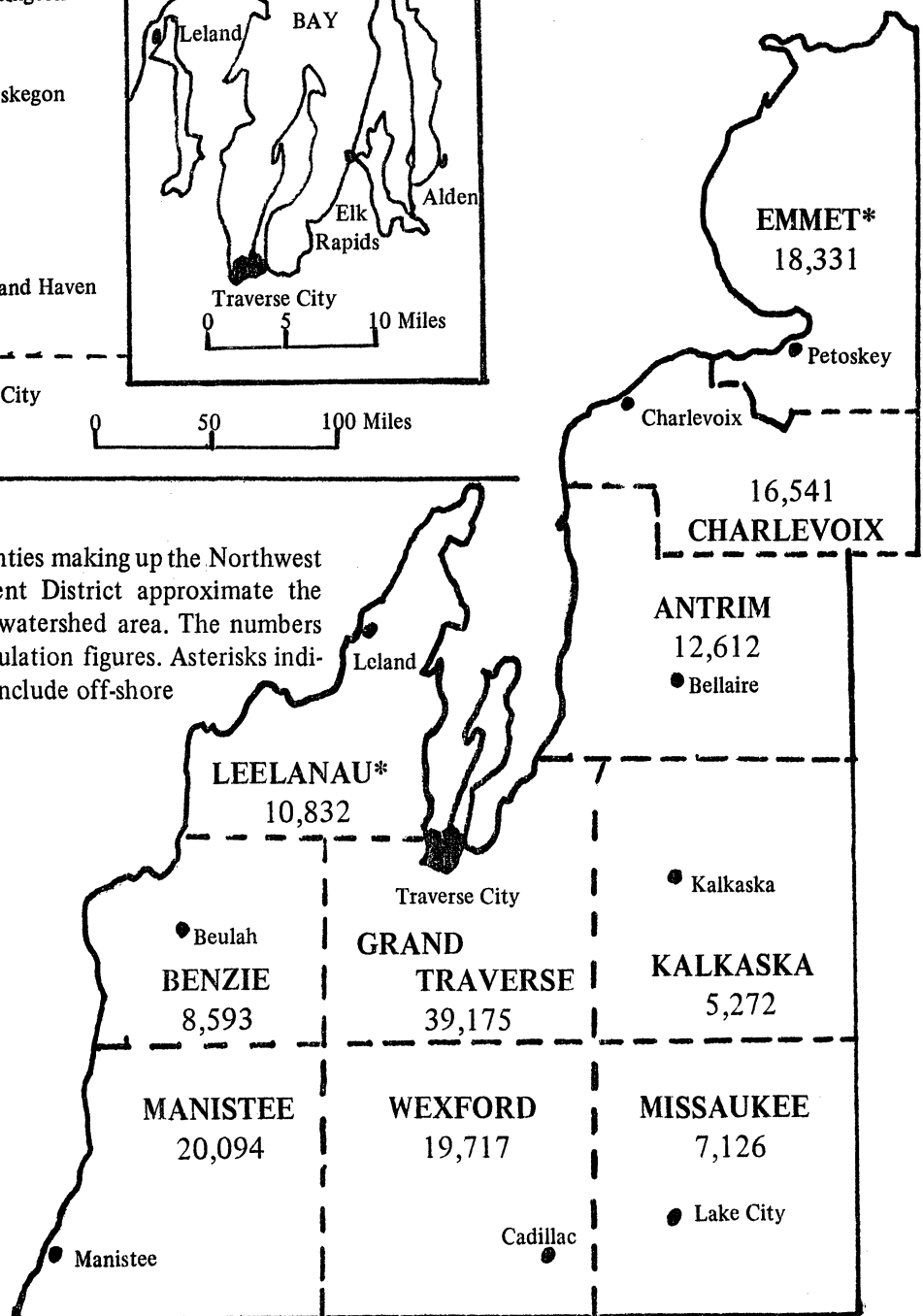


Fig. 1. The Grand Traverse Bay area.

considered issues believed to have a relatively high technical content before their examination and evaluation by the broader-based panels.

Two issues were identified as particularly appropriate for evaluating the effectiveness of the methodology in expediting information exchange among university researchers and regional planners. The first issue, the treatment and disposal of waste water, is perhaps the most critical issue facing many communities in the Great Lakes basin, and its timeliness for the Grand Traverse Bay area is shown in the following article from Traverse City's Record-Eagle (September 17, 1970):

#### SPRAY IRRIGATION TOO COSTLY?

There is no doubt about it. Spray irrigation as the ideal solution to sewage disposal in the Traverse City area has a long, tough road ahead to become reality--if it ever does.

City Manager Lawrence Savage reported at Monday night's commission meeting that the townships cooperating in the \$8.6 million area program favor going with secondary treatment only. The reason: Spray irrigation would cost too much.

There are other problems, too. Engineering has yet to be completed. Land for possible spray irrigation has to be checked, as to suitability, and acquired.

Removal of phosphates--the enriching element that produces the floating algae--will be a big step ahead. But the question remains: Will secondary treatment, or the chemical removal of the phosphates, be enough if the volume of sewage to be treated goes up? Thus, even with removal of all but 10 or 20 per cent of the phosphates, the Boardman River could end up just as contaminated as before, since the additional sewage volume might produce the same, or nearly the same, quantity of phosphates as at present.

Not all the facts are in. The city commission Monday night wisely reapplied to the Department of Natural Resources for spray irrigation so that this possibility remains "alive."

One factor, however, is fairly certain: If Traverse City and the adjoining townships want the ideal system (spray irrigation), it will be costly. When these cost figures are finally apparent, then will come the time of soul-searching and value adjustments. Then we must decide if we are truly willing to pay what it costs to protect our environment.

Only half of the communities in the Grand Traverse Bay area provide a sewer system. Inadequate septic tanks and outdoor privies in close proximity to lakes and streams present an added hazard to the environment when the population is more than doubled during the summer months. Though recreation and tourism create a tremendous seasonal burden on the water and sewage treatment facilities, industries are also burdens on the area's water resources. For example, one fruit canning plant was reportedly dumping 547,000 gallons of waste daily into Traverse Bay during the canning season in July and August.<sup>3/</sup> Such practices only compound the problem of the already overtaxed water resources in the region. The people of Traverse City, in cooperation with five surrounding townships, have assumed the leadership in seeking solutions to the area's water pollution problems by initiating the development of a regional sewage treatment plan.

In a consideration of waste-water treatment and disposal systems, the characteristics and uses of the receiving waters must be taken into account. The broader issue of sources of pollution and pollutants is the

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<sup>3/</sup> "Traverse City's 'Shaggy' Waters Endanger Tourism," Chicago Tribune, Oct. 26, 1970.

second specific issue that the technical panel evaluated prior to its consideration by the broader-based panels.<sup>4/</sup>

### Methodology

When this research was undertaken the Delphi method had been used primarily to forecast long-range technological developments. The most distinctive characteristics of the method are anonymity, statistical summaries of the subjective judgments provided by a group of people, and information feedback as part of an iterative process to help in reassessing initial judgments. One cycle of information packages and written responses is referred to as a Delphi round. An administrator functions as a communications intermediary in collating the responses for further consideration by the panels on subsequent rounds.

In the Sea Grant exercises a change in emphasis led to essentially new applications of the Delphi techniques. The inherent characteristic of the method--to inform in the process of soliciting judgments--was utilized in exploring the communication potential of the method. The series of information feedbacks and reassessments of estimates were intended to be cumulative--each series building on the previous one in guiding respondents to carefully formulated judgments. This progressive

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<sup>4/</sup> A more detailed discussion of the research plan may be found in "Sea Grant Delphi Exercises: Techniques for Utilizing Informed Judgments of a Multidisciplinary Team of Researchers," by John D. Ludlow, Working Paper No. 22 (Ann Arbor, Mich.: Bureau of Business Research, University of Michigan, 1971).



type of Delphi inquiry was planned so that important developments in the technical environment could be generated and assessed by a panel of technical experts before being considered by the broader-based panels.

### Participation

Participants on two of the three panels were designated technicians and behaviorists on the basis of their training and experience. The third group was made up of concerned citizens from the Grand Traverse Bay area--beneficiaries of the work of the researchers--and these were called decision makers. The names associated with the panels were somewhat arbitrary, and the groups were not homogeneous. However, the names were reasonably consistent with the roles each group would be expected to play in planning how regional water resources will be managed.

The technical panel was composed of thirty-three individuals whose expertise was primarily in the physical sciences and who were divided about equally between Sea Grant researchers and faculty, graduate students, and others in the School of Engineering. All the technicians were males, half were over forty years of age, and engineers predominated. They represented many of the schools and laboratories at the University of Michigan, and sixteen were present or past members of the Sea Grant Program committee. Twenty-eight panelists submitted responses to one or more rounds, and thirteen submitted responses to three or more. Six became unavailable after the start of the exercises.

Another panel included Sea Grant researchers who were not selected for the technical panel. Generally their academic backgrounds and interests were more oriented to the behavioral sciences, and for this reason they were labeled behaviorists. They represented a wide range of ages, academic disciplines, and university schools and laboratories. Of the sixteen panelists, eleven submitted responses to one or more rounds and six submitted responses to three or more.

Participants for the third panel were randomly selected from groups of Grand Traverse Bay area residents believed to be influential in the following fields: civics, business, planning, politics, natural resources, government, and education. Twenty-one of the eighty panelists selected responded to a letter requesting their participation in the Delphi exercises. Twenty of the respondents submitted written suggestions or evaluations on one or more rounds, and nine submitted responses on three or more rounds. Three respondents became unavailable after the start of the exercises.

## II

### RESULTS OF THE STUDY

#### Social, Political, and Economic Trends

The portion of the Sea Grant Delphi exercises concerned with social, political, and economic trends was designed to provide respondents on the broader-based panels with some basic reference points in making their subjective judgments regarding future social and technical developments.

The information package for Round 1 presented the trends for eight measures which have commonly been used to indicate the social and economic development of a region (Figure 2). The curves were plotted from 1950 to 1970, taking advantage of the 1970 census and the standardized enumeration procedures of the Bureau of the Census. Panel members were asked to extend the curves through 1990 and to indicate the numerical values for 1980 and 1990.<sup>1/</sup>

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<sup>1/</sup> The techniques and procedures used in this series of interrogations and information feedback are similar to those described in Some Potential Societal Developments--1970-2000, by Raoul de Brigard and Olaf Helmer, IFF Report R-7 (Middletown, Conn.: Institute for the Future, April 1970).

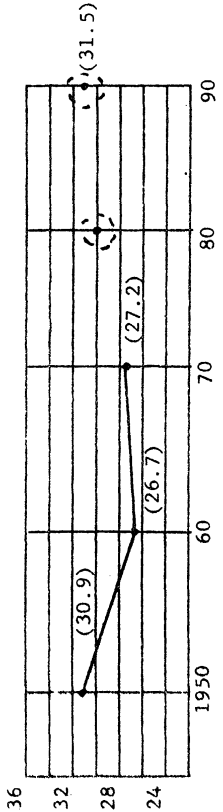
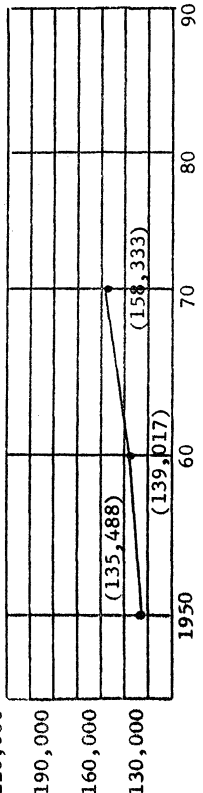
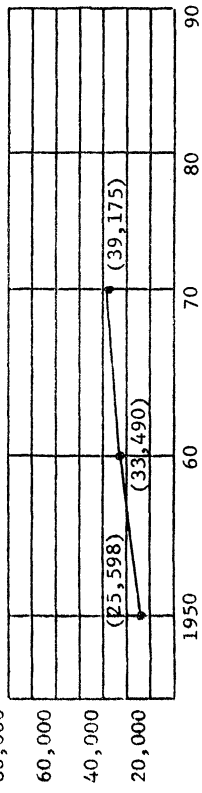
INDICATOR	COMMENTS												
<p data-bbox="375 1532 400 2107">Percentage of region's population in ages 20-44</p>  <table border="1" data-bbox="422 1240 646 2049"> <thead> <tr> <th>Year</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>1950</td> <td>30.9</td> </tr> <tr> <td>1960</td> <td>26.7</td> </tr> <tr> <td>1970</td> <td>27.2</td> </tr> <tr> <td>1980</td> <td>31.5</td> </tr> <tr> <td>1990</td> <td>31.5</td> </tr> </tbody> </table>	Year	Percentage	1950	30.9	1960	26.7	1970	27.2	1980	31.5	1990	31.5	<p data-bbox="453 434 568 1055">This is an example only. Your estimates for 1980 and 1990 should be clearly indicated by a mark on the grid. Include numerical figures also when appropriate, as for example when your plot would be off the grid.</p>
Year	Percentage												
1950	30.9												
1960	26.7												
1970	27.2												
1980	31.5												
1990	31.5												
<p data-bbox="683 1749 708 2107">1. Total regional population</p>  <table border="1" data-bbox="746 1317 949 2107"> <thead> <tr> <th>Year</th> <th>Population</th> </tr> </thead> <tbody> <tr> <td>1950</td> <td>135,488</td> </tr> <tr> <td>1960</td> <td>139,017</td> </tr> <tr> <td>1970</td> <td>158,333</td> </tr> <tr> <td>1980</td> <td></td> </tr> <tr> <td>1990</td> <td></td> </tr> </tbody> </table>	Year	Population	1950	135,488	1960	139,017	1970	158,333	1980		1990		
Year	Population												
1950	135,488												
1960	139,017												
1970	158,333												
1980													
1990													
<p data-bbox="991 1592 1016 2107">2. Total Grand Traverse county population</p>  <table border="1" data-bbox="1054 1317 1257 2107"> <thead> <tr> <th>Year</th> <th>Population</th> </tr> </thead> <tbody> <tr> <td>1950</td> <td>25,598</td> </tr> <tr> <td>1960</td> <td>33,490</td> </tr> <tr> <td>1970</td> <td>39,175</td> </tr> <tr> <td>1980</td> <td></td> </tr> <tr> <td>1990</td> <td></td> </tr> </tbody> </table>	Year	Population	1950	25,598	1960	33,490	1970	39,175	1980		1990		
Year	Population												
1950	25,598												
1960	33,490												
1970	39,175												
1980													
1990													

Fig. 2. Social, political, and economic trends, Round 1.

In the second round, curves representing the medians and inter-quartile ranges were provided for the panelists, as well as pertinent comments submitted by respondents on the previous round (Figure 3). Panelists were asked to reconsider their estimates, and if any of the new estimates were outside the designated consensus range for the previous round they were asked to support their position briefly. On this round the graphs of three additional statistical measures were introduced for consideration. A cumulative summary of the group response was provided in the information package for Round 3 to serve as background information for other panel deliberations.

The primary objective in this portion of the exercises was to inform and educate the panel members. The results were not analyzed further since they were rough estimates of standard statistical measures for which precise quantitative data and sophisticated forecasting models are available.

#### Important Developments and Requisite Technology

The Delphi method has had its greatest application and acceptance as a means of compiling a list of future technical events or developments and collecting subjective judgments regarding them. In the Sea Grant exercises social, political, and economic developments were also solicited and evaluated so that panelists would be encouraged to consider all environments in making judgments regarding water quality, wastewater treatment systems, and research priorities.

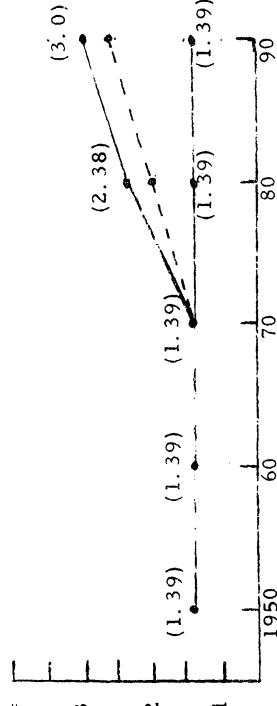
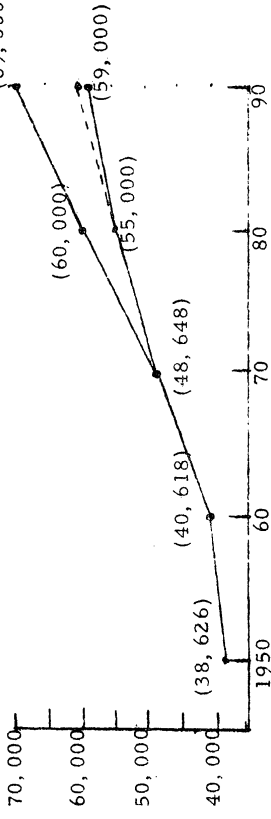
INDICATOR	COMMENTS						
<p>5. Region's nonwhite population (percentage)</p>  <p>Supporting arguments for new estimates that are outside the consensus range -- middle 50% of estimates on previous rounds.</p>	<p>DELPHI ADMINISTRATOR'S COMMENTS</p> <p>Percentage of region's population that is black:</p> <table border="1"> <tr> <td>1950</td> <td>.21</td> </tr> <tr> <td>1960</td> <td>.24</td> </tr> <tr> <td>1970</td> <td>.25</td> </tr> </table> <p>The remaining nonwhite population is almost solely made up of American Indians.</p> <p>Median nonwhite values for 1980 = 2.0%; 1990 = 2.6%</p> <p>RESPONDENT'S COMMENTS</p> <p>General Comment:</p> <p>Don't understand the difference between percentage of region's population that is black and the percentage that is nonwhite.</p> <p>(Administrator: American Indians account almost exclusively for the difference)</p> <p>The ratio of nonwhite will increase as educational opportunities for the entire community improve.</p>	1950	.21	1960	.24	1970	.25
1950	.21						
1960	.24						
1970	.25						
<p>6. Number of occupied housing units in the region</p>  <p>Supporting arguments for new estimates that are outside the consensus range -- middle 50% of estimates on previous rounds.</p>	<p>DELPHI ADMINISTRATOR'S COMMENTS</p> <p>A housing unit is classified as occupied if persons are living in it at the time of the census or are only temporarily absent. If persons living in the unit have their usual place of residence elsewhere, the unit is classified as vacant.</p> <p>Median values for 1980 = 55,000; 1990 = 60,000</p> <p>RESPONDENT'S COMMENTS</p> <p>General Comment:</p> <p>Increase will be proportionate to population increase.</p>						

Fig. 3. Social, political, and economic trends, Round 2.

The initial evaluation matrix for the technical panel did not present a list of potential developments, something which is usually done in order to facilitate participation and generate additional items. It was believed that this unstructured approach would result in a wider range of suggestions; however, the information feedback of the second round did include--in addition to items suggested by respondents--thirteen events that were taken from Delphi exercises conducted at RAND and the Institute for the Future. These events covered areas considered by the researcher to be of interest to the panel and were also good examples of how developments should be specified to avoid ambiguity, particularly with respect to occurrence or nonoccurrence. (The specification of events by respondents on the first round was quite general, necessitating considerable editing by the administrator and consequently introducing a degree of bias.)

The evaluation matrix for the third round (Figure 4) provided the respondent with his estimates for the second round and a summary of the group's response. Comments submitted by respondents were also provided, as were the median estimates for technical and economic feasibility if they differed significantly. Eleven items were added to the evaluation matrix after respondents suggested that they were closely related to items considered on the second round because their occurrence or nonoccurrence would affect the nature or the timing of listed developments. Two items considered on the second round were reworded to specify a level of performance more appropriate for the planning period under consideration, and these were entered as new items on Round 3. The evaluation matrix for the

DEVELOPMENTS AND REQUISITE TECHNICAL EVENTS SUGGESTED BY RESPONDENTS		SELF-EVALUATION		IMPORTANCE	PROBABILITY AND TIMING			REMARKS--ADMINISTRATOR
		How familiar are you with the development or event?	How important is the event or development to the exercise?	What is the probability that the development or event will occur in:	Indicate the year by which the probability is x that the event will have first occurred.			If there was a significant difference between economic and technical feasibility indicated in the last round it will be noted under remarks.  Support for extreme positions should be presented under remarks or attached to this form.
		1=unfamiliar 2=slightly familiar 3=generally acquainted 4=well acquainted 5=expert	0=no importance 1=minor 2=great 3=very great		x=25% (1 to 3 odds)	x=50% (even chance)	x=75% (3 to 1 odds)	
ITEM NO.	GROUP OR SUBGROUP	Scale 1-5	Scale 0-3	0-100%	Year	Year	Year	REMARKS--RESPONDENTS
D-7 Mobile homes constitute 25% or more of the "second homes" in the region								
	Your previous estimates							
	Total panel estimates	2	2	50 (15-80)*	1978	1980	1985	
	Your next estimates							
D-42 Adequate treatment of food-processing wastes								
	Your previous estimates							
	Total panel estimates	2	3	65 (60-75)*	1973	1975	1981	Economic feasibility = 2 Technical feasibility = 5 (Scale 1-5)
	Your next estimates							
D-10 New sports fisheries established in the Grand Traverse Bay region								
	Your previous estimates							
	Total panel estimates	3	3	80 (28-85)*	1975	1978	1979	
	Your next estimates							
D-58 Large-scale development of summer homes as a result of more leisure time and faster transportation systems								
	Your previous estimates							
	Total panel estimates	3	3	50 (50-100)*	1975	1980	1990	
	Your next estimates							

\*Interquartile range--contains the middle 50% of the estimates.

Fig. 4. Technical panel's third round evaluation matrix--important developments and requisite technical events.



third round was designed so that a panel member could easily determine if his reassessed estimates for a specific development were outside the group's consensus range--arbitrarily identified as the group's median 25 per cent and 75 per cent estimates. If a respondent's latest estimate was outside the consensus range for the previous round he was asked to support this "extreme" position briefly.

The evaluation matrix for the fourth round (Figure 5) presented a more comprehensive summary of the previous round than had been provided up to this point in the exercises. Statistical summaries were presented not only for all the respondents but also for those who rated their competence relatively high and for those in the latter group who indicated a familiarity with the Grand Traverse Bay area. In addition, the persons arguing for an earlier or later probability date than that indicated as the consensus were identified by panel member number (respondents were given basic biographical data to correlate with the panel member numbers). On this final round respondents were asked to make conditional probability estimates for developments that panel members had suggested were closely related. These procedures are discussed later in conjunction with a summary of the estimates. For the rest of the developments, respondents were asked to record final estimates only for those developments on which they were making estimates for the first time or on which they intended to revise previous estimates.

On the basis of the experience of the technical panel, several procedural modifications were introduced into the broad panel exercises.

DEVELOPMENTS AND REQUISITE TECHNICAL EVENTS SUGGESTED BY RESPONDENTS	SELF-EVALUATION	IMPORTANCE	PROBABILITY 1971-80	50% PROBABILITY DATE	RESPONDENTS' ARGUMENTS TO SUPPORT A POSITION AND GENERAL COMMENTS
ITEM NO.	1-5	0-3	Median (IQ)†	Median (IQ)†	
D-42 Adequate treatment of food-processing wastes					
Your previous estimates					General Comments: Economic Feasibility (Scale 1-5) = 2 Technical Feasibility (Scale 1-5) = 5 For Earlier Date: It can be done now. (18)
Panel estimates, Round 3	2	3	70(60-75)†	1978(1975-80)†	
Familiarity with item ≥ 3 *	4	3	60(50-75)†	1980(1975-85)†	
Fam. with item and region ≥ 3 *	3.5	2	70(60-80)†	1978(1975-80)†	
Your final estimates					
D-10 New sports fisheries established in the Grand Traverse Bay region					
Your previous estimates					General Comments: For Earlier Date: Could be done sooner with money available. (18)
Panel estimates, Round 3	2	3	80(50-85)†	1976(1975-79)†	
Familiarity with item ≥ 3 *	3	3	80(70-85)†	1978(1975-80)†	
Fam. with item and region ≥ 3 *	4	3	70(28-80)†	1978(1975-78)†	
Your final estimates					
D-58 Large-scale development of summer homes as a result of more leisure time and faster transportation systems					
Your previous estimates					General Comments: What is large scale? It's pretty large now. (11)
Panel estimates, Round 3	3	3	75(55-80)†	1980(1977-80)†	
Familiarity with item ≥ 3 *	3	3	75(75-85)†	1980(1974-80)†	
Fam. with item and region ≥ 3 *	3	3	75(67-83)†	1980(1980-80)†	
Your final estimates					
E-18 Demonstration of a capability to quantify algae nutrition					
Your previous estimates					General Comments: Much work has already been done. (26) Depends on what is meant by "quantify." (39)
Panel estimates, Round 3	2	2	50(45-80)†	1975(1975-76)†	
Familiarity with item ≥ 3 *	4	2	45(25-80)†	1976(1975-76)†	
Fam. with item and region ≥ 3 *	--	--	--	--	
Your final estimates					
E-27 Legislation which eliminates or effectively controls the use of products which do not decay					
Your previous estimates					General Comments: Economic Feasibility = 2 (Scale 1-5) Technical Feasibility = 4 (Scale 1-5) Phony economics of waste will be exposed by 1980. (25) Other alternatives will be available. (26)
Panel estimates, Round 3	3	3	50(25-75)†	1976(1975-84)†	
Familiarity with item ≥ 3 *	3	3	70(25-75)†	1976(1973-90)†	
Fam. with item and region ≥ 3 *	--	--	--	--	
Your final estimates					
* ≥ means equal to or greater than. † IQ--interquartile range containing the middle 50% of the estimates					

\* means equal to or greater than. † IQ--interquartile range containing the middle 50% of the estimates.

Fig. 5. Technical panel's fourth round evaluation matrix--important developments.

The number of items considered on each round was limited; the first round therefore included only 27 developments. Most of the developments initially selected were those that the technical panel had considered previously, since there was interest in how the different groups of evaluators viewed similar sets of developments and in the consistency of the Delphi method with different groups.

An analysis of the estimates of the technical panel showed that some respondents appeared to have considerable difficulty making probability estimates both for a fixed period (1971-80) and for fixed levels of probability (25, 50, and 75 per cent). In some cases inconsistent estimates were made (for example, the probability of occurrence during 1971-80 was estimated to be greater than 50 per cent, but the year associated with a 50 per cent probability was later than 1980).

Fixed probabilities of 25, 50, and 75 per cent were selected for personal probability assessments in the broad panel exercises for several reasons:

1. There was strong agreement among the three groups involved in the exercises--technical, behavioral, and decision makers--on the words and phrases that they associated with the numerical probabilities of 25, 50, and 75 per cent.

2. Individual distributions provide the decision makers with more information than single probability estimates and were believed to be helpful to the estimator in making assessments that were consistent with his judgment.

3. The 25, 50, and 75 per cent levels of probability were ideal for using a betting rationale, that is, systematically dividing the future into equally attractive segments.

4. It was believed that group medians associated with these fixed probabilities would provide an easily identifiable consensus range.

Since it was likely that many of the decision makers would have had little experience with the notion of personal probabilities, a guide for making personal estimates of probability was sent to all members of the broad panels--researchers as well as decision makers. The evaluation form for the first two rounds is shown in Figure 6. On the following round the information feedback included arguments to support extreme positions and the statistical summaries for the technicians who had rated their competence relatively high (Figure 7).

In presenting the results of this phase of the Delphi exercises it may be of interest to consider items that were suggested and evaluated by respondents but subsequently dropped from the Delphi inquiry. The screening process used in the elimination was designed to retain only those items which the combined panels had judged to be important to the region. The panels had indicated some familiarity with the items but had disagreed on the timing. Items suggested by the administrator are marked with an asterisk. It is interesting that none of these survived the screening process.

In the technical panel exercises the following items were dropped from further consideration because respondents indicated that they were relatively unimportant to the exercise.

Developments Suggested by Respondents	How familiar are you with the development?	How important is the development to the region?	Timing		
			Using a betting rationale: (A) Select the year that divides the future into two periods in such a way that there is equal likelihood of the development's occurring in either period. (B) and (C) Using similar procedures divide the resulting two time periods--with the stipulation that if the development occurs in the period not being considered, all bets are off.		
<p>Reassess your position with respect to all factors listed in the column headings.</p> <p>If your new estimate for the year by which there is an even chance that the event will have occurred (circled space) is earlier or later than the group's median 25% and 75% estimates (heavy border), briefly support your position.</p>	<p>1 = unfamiliar</p> <p>2 = casually acquainted</p> <p>3 = well acquainted with a few aspects of it</p> <p>4 = generally familiar</p> <p>5 = expert or researcher in the area</p>	<p>0 = little or no importance</p> <p>1 = minor importance</p> <p>2 = considerable importance</p> <p>3 = very great importance</p>	<p>50% probability 1 to 1 odds even chance</p> <p>25% probability 1 to 3 odds rather unlikely</p> <p>75% probability 3 to 1 odds good chance</p>	(A) Year	(B) Year
Number	Scale 1-5	Scale 0-3			(C) Year
3. Mobile homes constitute 25% or more of the "second homes" in the region.					
Your previous estimates				1979*	1978*
Total panel estimates	3*	2.5*			1984*
Your next estimates					
Supporting arguments for position outside of consensus range:					
5. Production of nuclear-fueled electric energy reaches 50% or more of that produced by fossil-fueled plants in 1970 in the Grand Traverse Bay region.					
Your previous estimates				1980*	1977*
Total panel estimates	2.5*	2*			1986*
Your next estimates					
Supporting arguments for position outside of consensus range:					

\*Median group estimates.

Fig. 6. Broad panel's second round evaluation matrix--  
technological and social developments.

DEVELOPMENTS SUGGESTED BY RESPONDENTS	SELF- EVALUATION	IMPOR- TANCE	50% PROBABILITY DATE	GENERAL COMMENTS RESPONDENTS' COMMENTS (MEMBER NUMBER) ADMINISTRATOR'S COMMENTS (A)
ITEM NO.	GROUP OR SUBGROUP	1-5	Median (IQ)*	ITEM
29	An airborne water pollution information and control system becomes operational for a region in the Great Lakes Basin.			29 General Comments: Economic Feasibility = 2 (Scale 1-5) Technical Feasibility = 4 (Scale 1-5)
	Your previous estimates			
	Technical panel estimates	3	2	
	Broad panel estimates	2 (1-3)*	2	
	Your final estimates			
30	Widespread use of self-contained dwelling units, using life-support systems that recycle water to provide independence from water supply and from waste-water treatment and disposal systems.			30 For Later Date: - It is necessary that the very conserva- tive Public Health Department go along with this--which seems very unlikely. (31) - Too many social roadblocks. (11) - Unlikely within the next 30 years in our water surplus area. (52)
	Your previous estimates			
	Technical panel estimates	2	2	
	Broad panel estimates	2 (2-2)*	2	
	Your final estimates			
31	An expanded waste-water collection system for Traverse City which would include the east arm of the Traverse Bay area.			31 General Comment: - Sewerage now under construction to be in operation by December 30, 1972.
	Your previous estimates			
	Technical panel estimates	2	3	
	Broad panel estimates	3 (2-4)*	3	
	Your final estimates			
32	A commercially competitive vertical or short-run takeoff and landing system (VTOL/STOL) for air travel between the urban areas to the south and the Grand Traverse Bay area.			32 General Comments: Economic Feasibility = 1 (Scale 1-5) Technical Feasibility = 4 (Scale 1-5) For Earlier Date: - The vehicle exists--the question is whether or not the market will support them. VTOL/STOL attractive for winter because of the runway snow removal problem. (31)
	Your previous estimates			
	Technical panel estimates	2	2	
	Broad panel estimates	2 (1-2)*	1	
	Your final estimates			

\*IQ--interquartile range containing the middle 50% of the estimates.

Fig. 7. Broad panel's third round evaluation matrix--technological and social developments.

Items Rated Zero (0 = no importance)

- \*D-3 A large-scale desalination plant capable of economically producing water useful for agricultural purposes begins operating somewhere in the United States.
- \*E-48 Nonsurgical techniques which enable parents to choose the sex of babies with 90 per cent reliability.

Items Rated One (1 = minor importance)

- \*D-1 Availability of tools and processes which permit economic exploitation of the Grand Traverse Bay bottom through mining.
- \*D-2 Demonstration of techniques which permit economic "farming" of the Grand Traverse Bay bottom.
- \*D-4 New materials and reinforced composites (for example, boron fibers) for ultralight construction (density of aluminum, strength and toughness of steel), commercially available for private use at competitive prices.
- \*D-5 Commercial fish farming in natural or man-made lakes accounts for over 5 per cent of the region's income in wages and salaries.
- D-6 Underwater recreation with submersibles becomes a significant recreational activity in the region--participation of 5 per cent or more of the people who vacation in the area for a week or more.
- \*D-11 First prototype thermonuclear (fusion) plant for generating electric power begins operation.
- \*E-12 Laboratory demonstration of the feasibility of a nuclear-fueled plant generating electric power from nuclear fusion.
- \*D-13 Operations of the first fast breeder in the United States (a nuclear-fueled generating plant which produces more fissionable material than it consumes while generating electricity.
- D-22 Daily population counts for the Grand Traverse Bay region, recorded by instruments operating from an aerospace vehicle.

- E-30 Demonstration of the feasibility of techniques to accomplish artificial upwelling of a body of water such as Grand Traverse Bay.
- D-43 Control of thermal pollution from Traverse City power plant.
- D-46 Change in age distribution so that persons over 65 make up 15 per cent (or more) of the population of the region.
- \*D-55 A 20 per cent share of new cars sold are automobiles which have acceptable performance, are economically competitive with other forms of transportation, and permit operation without harmful exhaust.

The following items were dropped because of a median self-evaluation of familiarity by the panel of less than two (2 = casually acquainted).

Item	Median Importance (Scale 0-3)	Median Probability 1971-80 (Percentage)
D-8 Feasibility of new fruit-processing techniques employing significant technological improvements.	2	50
D-34 Construction completed on an integrated bay shore peripheral sewage collection and treatment system in the Grand Traverse region.	3	25
D-52 A positive net migration rate for the Grand Traverse Bay area over a five-year period.	3	75
D-59 Widespread use of surface-effects ships for commercial transportation in the Great Lakes.	1	25
D-60 A 50 per cent increase in facilities for commercial water shipping on the periphery of Grand Traverse Bay.	2	25



Item	Median Importance (Scale 0-3)	Median Probability 1971-80 (Percentage)
D-64 A 50 per cent or more increase over 1970 of bulk shipments by water to and from the Grand Traverse Bay region.	2	50
D-69 Government ownership of 25 per cent of the shoreline of Grand Traverse Bay, Lake Michigan, and inland lakes in the region.	3	20
D-70 A 50 per cent rise in the rate of serious crimes in the region over that of 1970, measured by comparable techniques.	2	10
D-71 A 50 per cent greater output from oil wells than in 1970.	1	25
D-73 A 25 per cent decrease in food processing compared to 1970, as measured by employment.	2	50

The items below were dropped because they were judged to have less than a 50 per cent probability of occurring during 1971-80 and received a median importance rating of less than three (3 = very great).

Item	Median Probability 1971-80 (Percentage)
D-23 Federal assistance for an area, on the basis of visitors to a region.	20
*D-24 Demonstration of regular and reliable weather forecasts fourteen days in advance for areas as small as the Grand Traverse Bay region.	25

	Item	Median Probability 1971-80 (Percentage)
*D-25	Limited weather control, in the sense that weather is predictably affected in a region at an acceptable cost.	5
E-47	Wide availability of immunizing agents which can protect against most bacterial and viral diseases.	40
*E-49	Clinical control of the aging process, permitting extension of the life span by 50 years.	5
D-50	A drop in the fertility rate to 2.2 or less (a rate which will equate to a zero population).	25
D-51	A zero population growth rate for the United States.	10
D-62	Use of thermal discharge from nuclear-fueled power plants to maintain ice-free ports on Lake Michigan.	25
D-67	Significant diversion of water from Lake Michigan.	10
D-72	A decrease in fruit production for two consecutive years that is not attributable to weather.	40

The following item was dropped because of an indication of ambiguity in its specification.

		Probability 1971-80 Interquartile Range (Percentage)
D-53	A 20 per cent increase in the ratio of year-round population to vacationing population compared to that of 1970.	0-85

These items were deleted because a reasonably strong group consensus was indicated.

	Item	Probability 1971-80	25% Prob. Date	50% Prob. Date	75% Prob. Date
D-9	Recreational boating increases by 20 per cent or more compared to 1970.	80	1973	1975	1980
D-15	Demand for electrical energy in the region increases at least 50 per cent over the demand in 1970.	75	1975	1977	1980

In the broad panel exercises the following items were dropped because respondents indicated that they were relatively unimportant to the deliberations. (Note that the estimates made by the technical panel are also shown.)

	Item	Median Importance (Scale 0-3)	50% Prob. Date	25% Prob. Date	75% Prob. Date
1	Commercial fish farming in natural or man-made lakes accounts for over 5 per cent of the region's income in wages and salaries.	1	1986	1980	1987
	- - - Technical panel ratings	1	1988	1975	1990
2	Underwater recreation with submersibles becomes a significant recreational activity in the region-- participation of 5 per cent or more of the people who vacation in the area for a week or more.	1	1985	1979	1989
	- - - Technical panel ratings	1	1985	1979	1998

	Item	Median Importance (Scale 0-3)	50% Prob. Date	25% Prob. Date	75% Prob. Date
20	A ground transportation system permitting speeds greater than 150 mph between the Chicago-Detroit megalopolis and the Grand Traverse Bay region.	1	1988	1985	1993

The following item was removed because the panel gave it a median self-evaluation of familiarity of less than two (2 = casually acquainted).

	Item	Median Importance (Scale 0-3)	50% Prob. Date	25% Prob. Date	75% Prob. Date
6	Federal assistance for an area on the basis of visitors to a region.	2	1981	1975	1990
	- - - Technical panel ratings	2	1980	1978	1985

The items below were given the status of background information because a reasonably strong consensus was indicated.

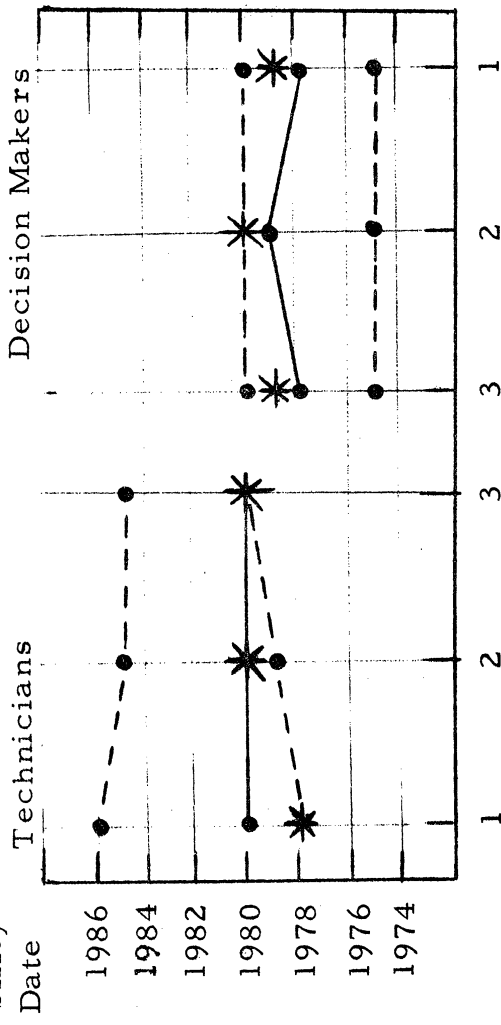
	Item	Median Importance (Scale 0-3)	50% Prob. Date	25% Prob. Date	75% Prob. Date
4	Recreational boating increases by 20 per cent or more compared to 1970.	2	1976	1974	1979
	- - - Technical panel estimates	2	1975	1973	1980
9	Requirements by the state calling for tertiary treatment of municipal sewage for Traverse City.	3	1975	1973	1979
	- - - Technical panel estimates	3	1977	1975	1980

The following items were removed because respondents' comments and the wide spread in the median probability estimates of at least one of the panels indicated ambiguous wording.

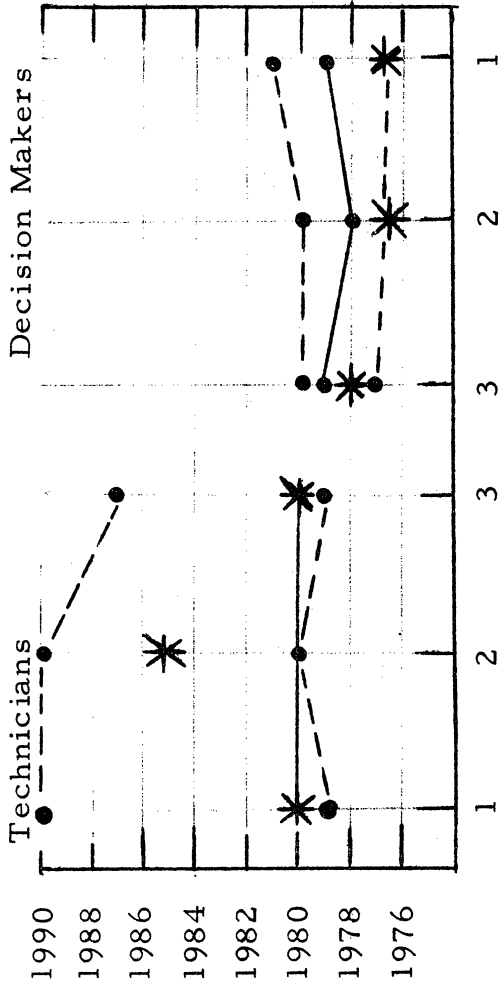
	Item	Median Importance (Scale 0-3)	50% Prob. Date	25% Prob. Date	75% Prob. Date
21	Large-scale development of summer homes as a result of more leisure time and faster transportation systems.	3	1980	1974	1983
	- - - Broad panel, Regionals	3	1980	1974	1985
27	A significant increase in light industry, developed because large amounts of high-quality water are available.	3	1980	1976	1984
	- - - Technical panel estimates		1975	1975	1987

A comparison of the estimates of the technical panel respondents with those of the decision makers for the eighteen developments considered by both panels is provided in Figure 8. For each round the panel medians (connected by a solid line) and the interquartile ranges (connected by dashed lines) are shown. The rounds are numbered from left to right for the researchers and from right to left for the decision makers to facilitate the comparisons. The average judgments of respondents in each group who rated their competence in the area being considered relatively high are indicated by asterisks. First round estimates are missing for those items that were not introduced until the second round. The number under each figure is the item number

50%  
Proba-  
bility  
Date



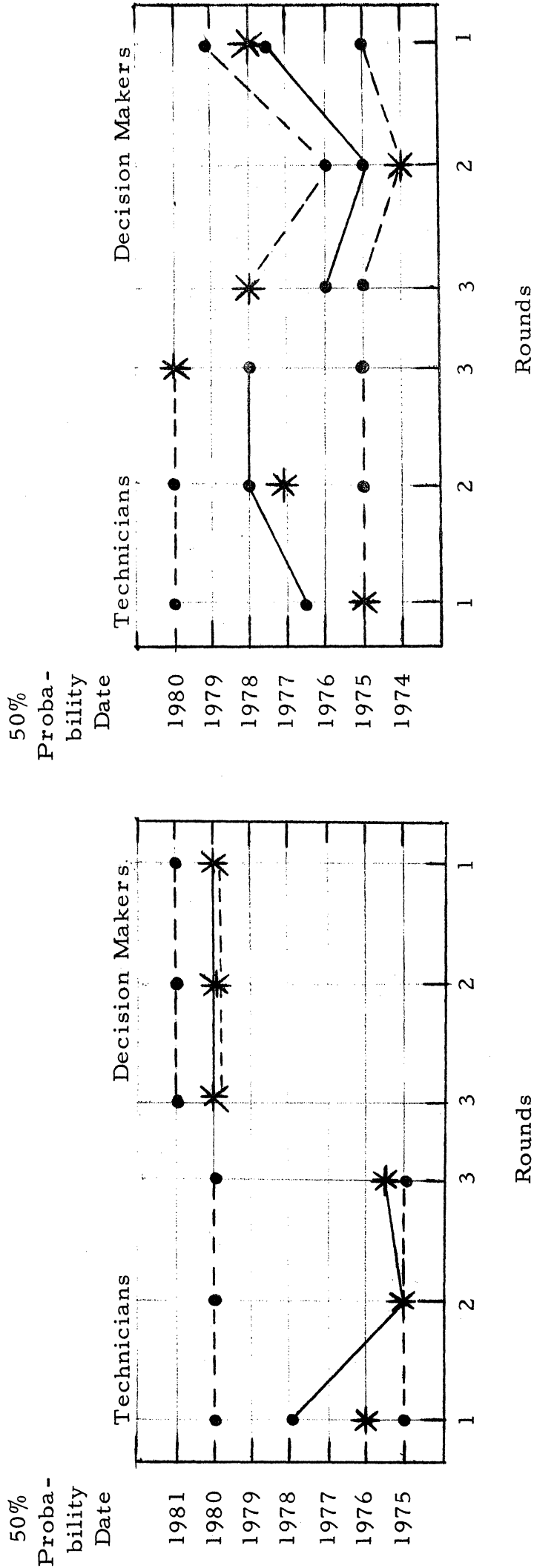
Item 7 Demonstration of regular and reliable weather forecasts fourteen days in advance for areas as small as the Grand Traverse Bay region



Item 31 Construction of a spray irrigation system for waste-water disposal in the Grand Traverse Bay region

- \* Median estimates of those who rated their competence relatively high.
- Median estimates of entire panel.
- Boundaries for middle 50% of estimates.

Fig. 8. Statistical summaries --technicians and decision makers.



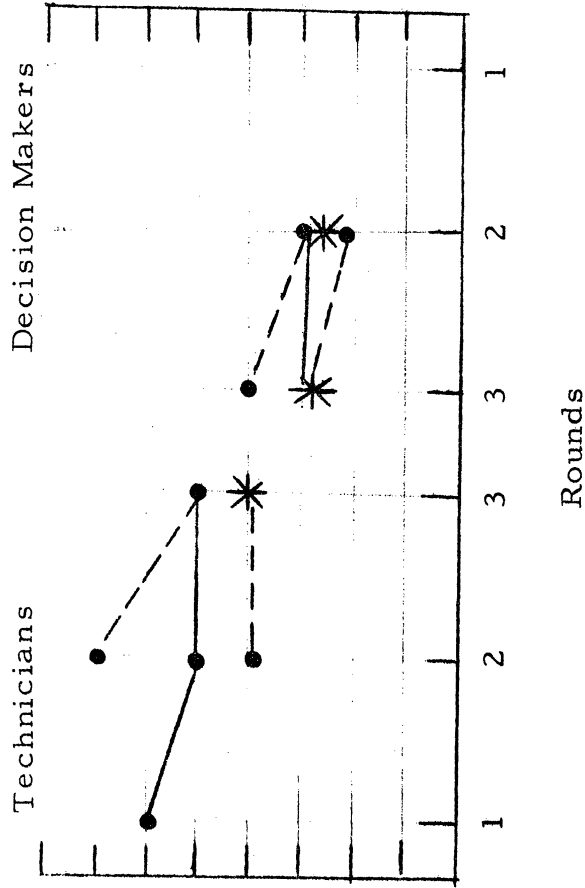
Item 35 An increase of 50% in industrial requirements for water from 1970 in the Grand Traverse Bay region

Item 42 Adequate treatment of food-processing wastes

\* Median estimates of those who rated their competence relatively high.  
 ● Median estimates of entire panel.  
 ●-● Boundaries for middle 50% of estimates.

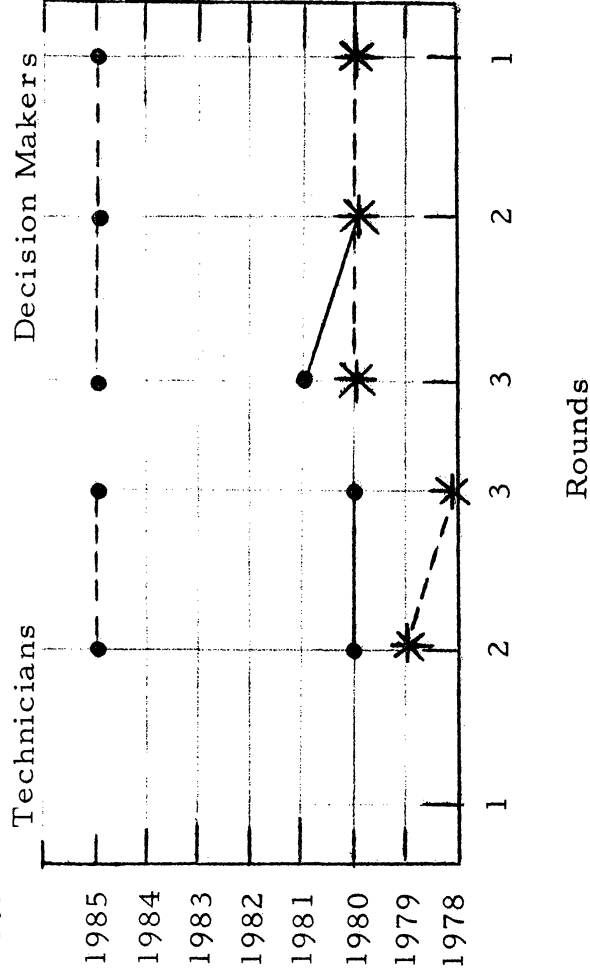
Fig. 8. (Cont.)

50%  
Probability  
Date



Item 57 A commercially competitive vertical or short-run takeoff and landing system (VTOL/STOL) for air travel between the urban areas to the south and the Grand Traverse Bay area

50%  
Probability  
Date



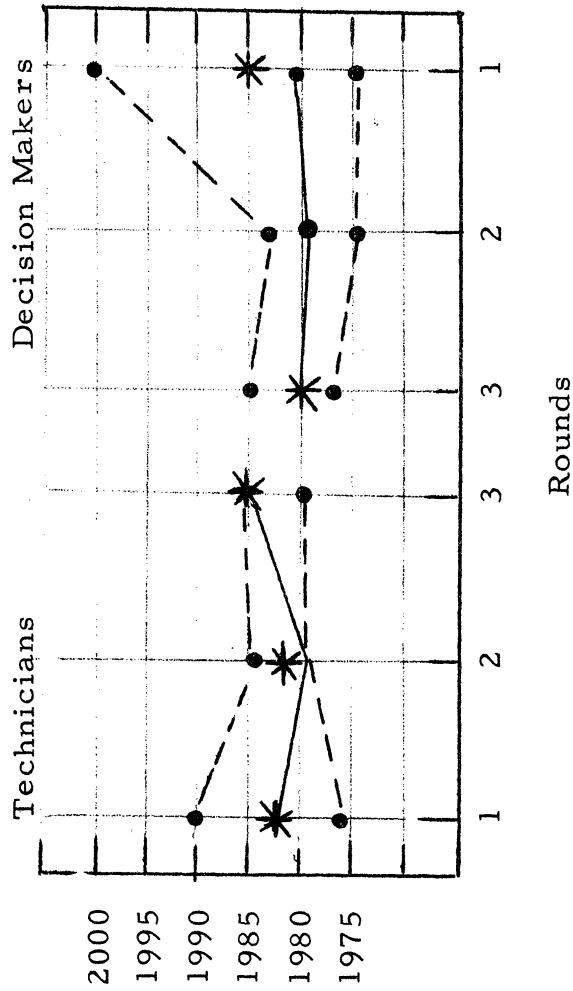
Item 76 Production of nuclear-fueled electric energy reaches 25% (50%) or more of the energy produced by fossil-fueled plants in 1970 in the Grand Traverse Bay region

- \* Median estimates of those who rated their competence relatively high.
- Median estimates of entire panel.
- Boundaries for middle 50% of estimates.

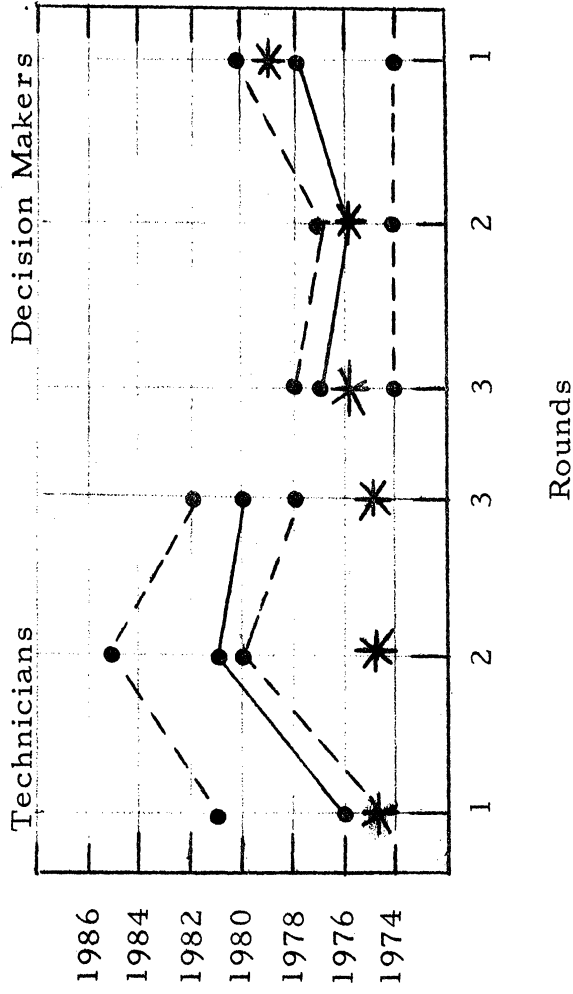
Fig. 8. (Cont.)



50%  
Proba-  
bility  
Date



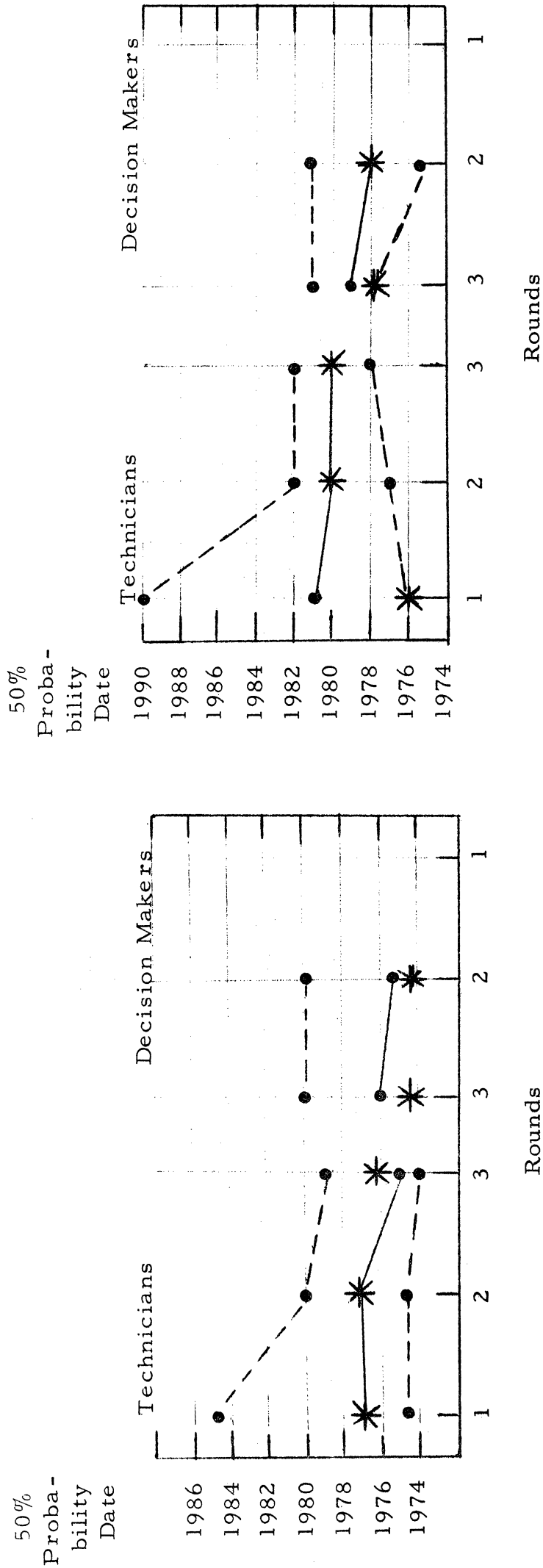
Item 36 A significant change in the quality of Grand Traverse Bay water because of activities outside of the Grand Traverse Bay region



Item 54 A four-day work week for 25% of the labor force in the United States

- \* Median estimates of those who rated their competence relatively high.
- Median estimates of entire panel.
- --- ● Boundaries for middle 50% of estimates.

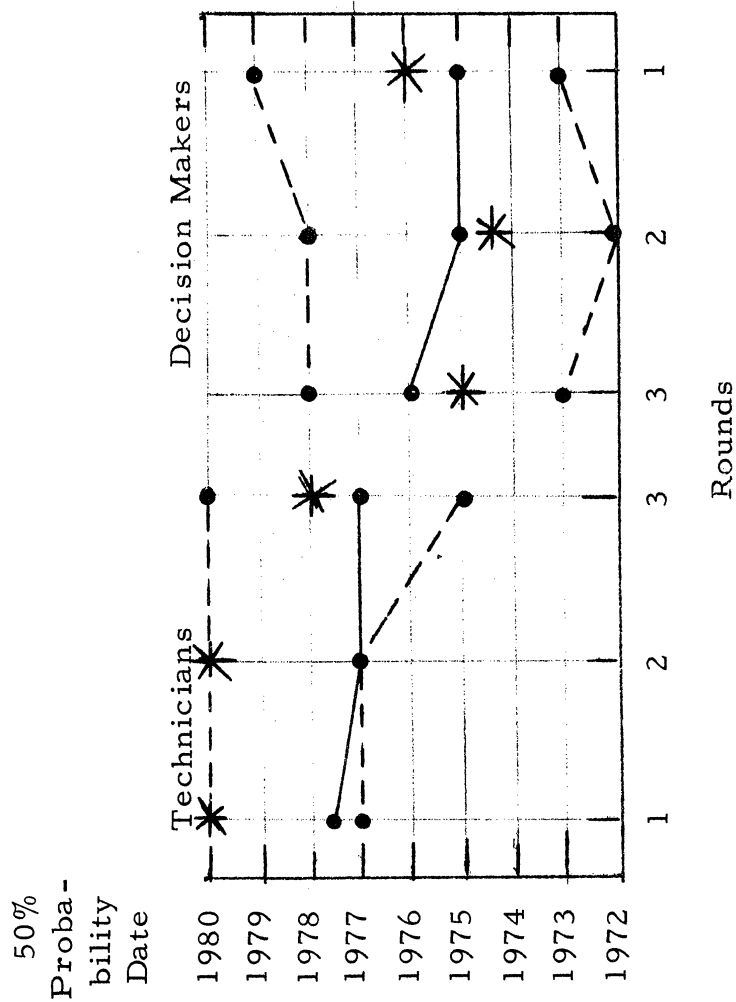
Fig. 8. (Cont.)



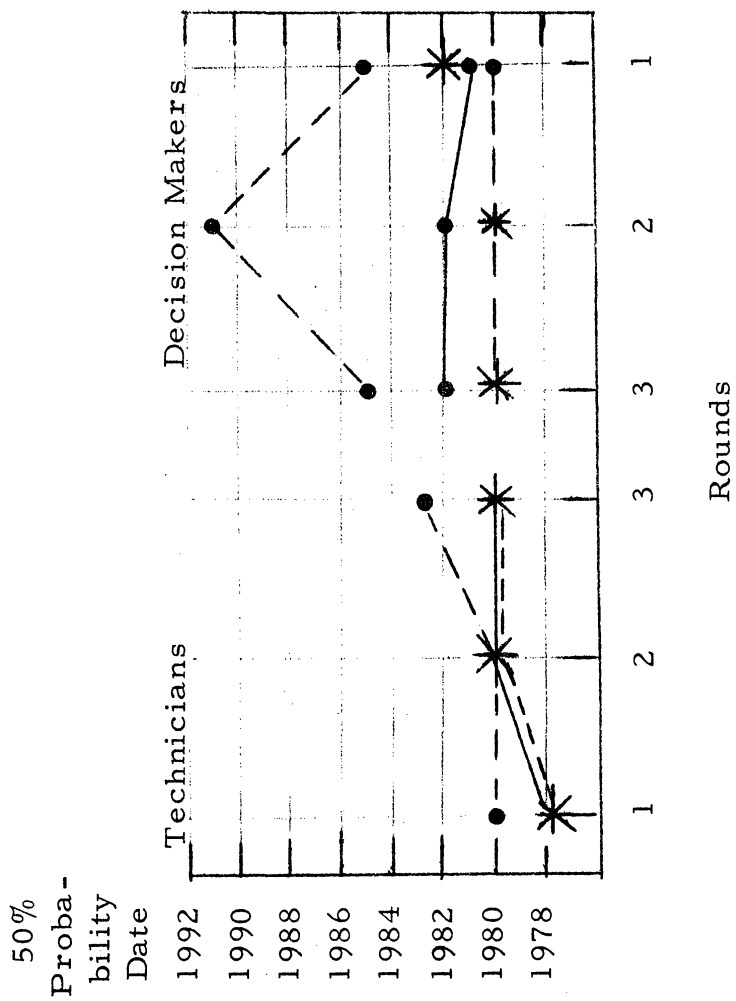
Item 10 New sports fisheries established in the Grand Traverse Bay region

Item 41 An expanded waste-water collection system for Traverse City which would include the east arm of the Traverse Bay area

\* Median estimates of those who rated their competence relatively high.  
 ● Median estimates of entire panel.  
 --- Boundaries for middle 50% of estimates.



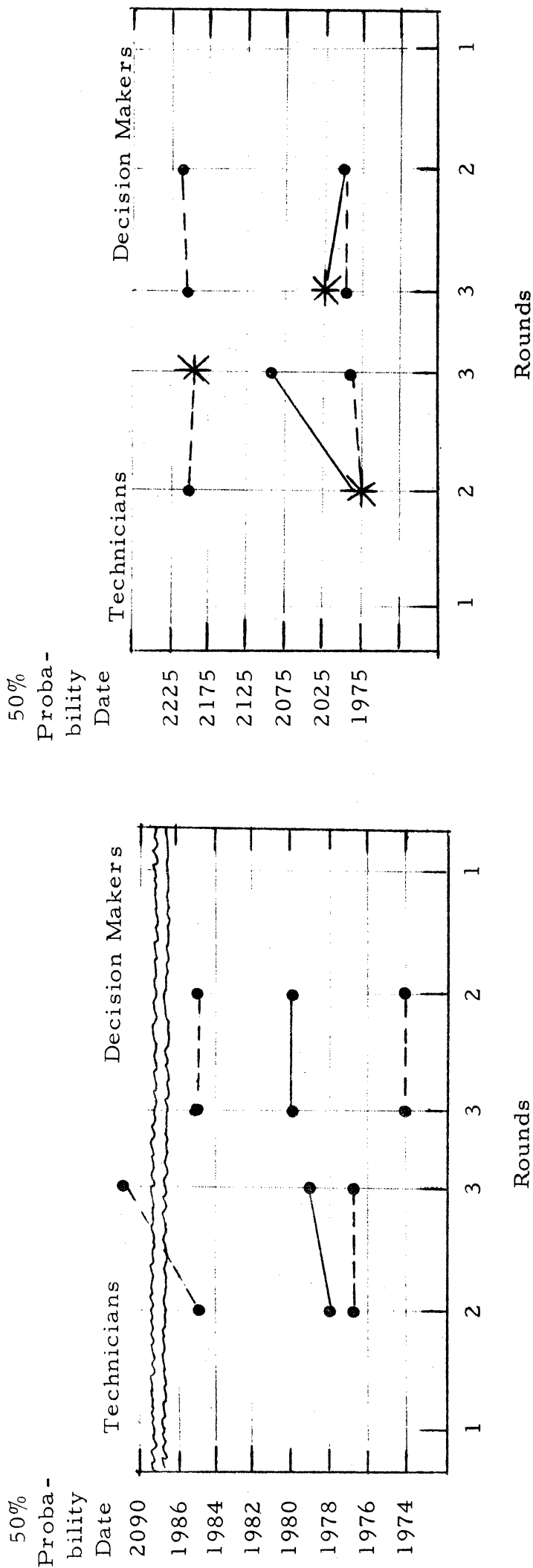
Item 44 Adequate control of marine waste water



Item 61 Year-round shipping on Great Lakes

\* Median estimates of those who rated their competence relatively high.  
 ● Median estimates of entire panel.  
 --- Boundaries for middle 50% of estimates.

Fig. 8. (Cont.)

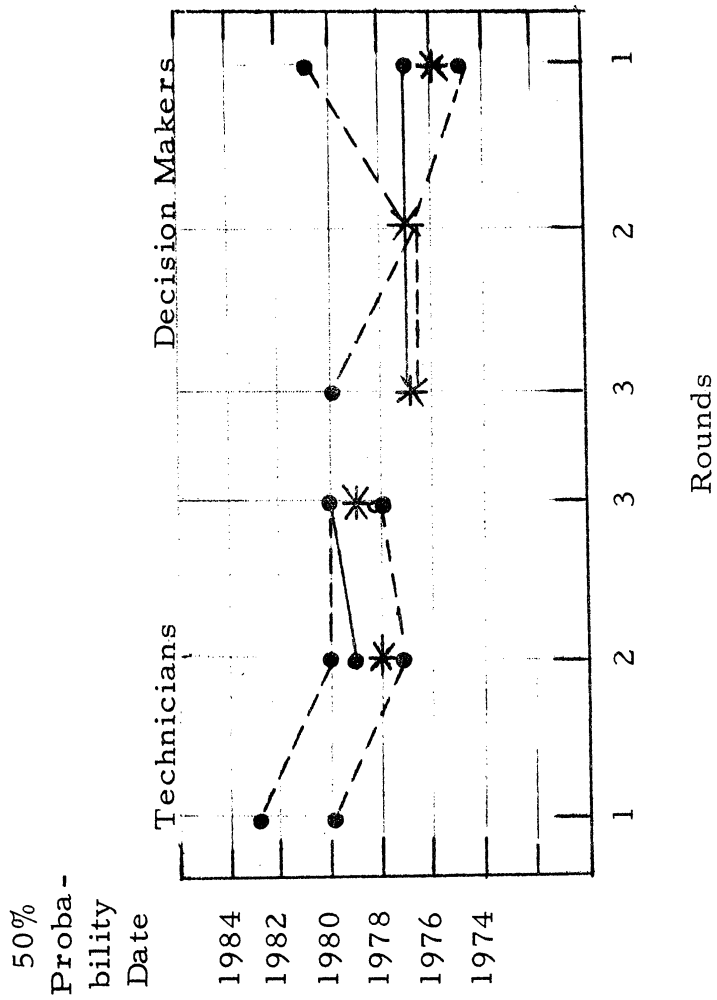


Item 79 The extinction of commercial fishing in Lake Michigan

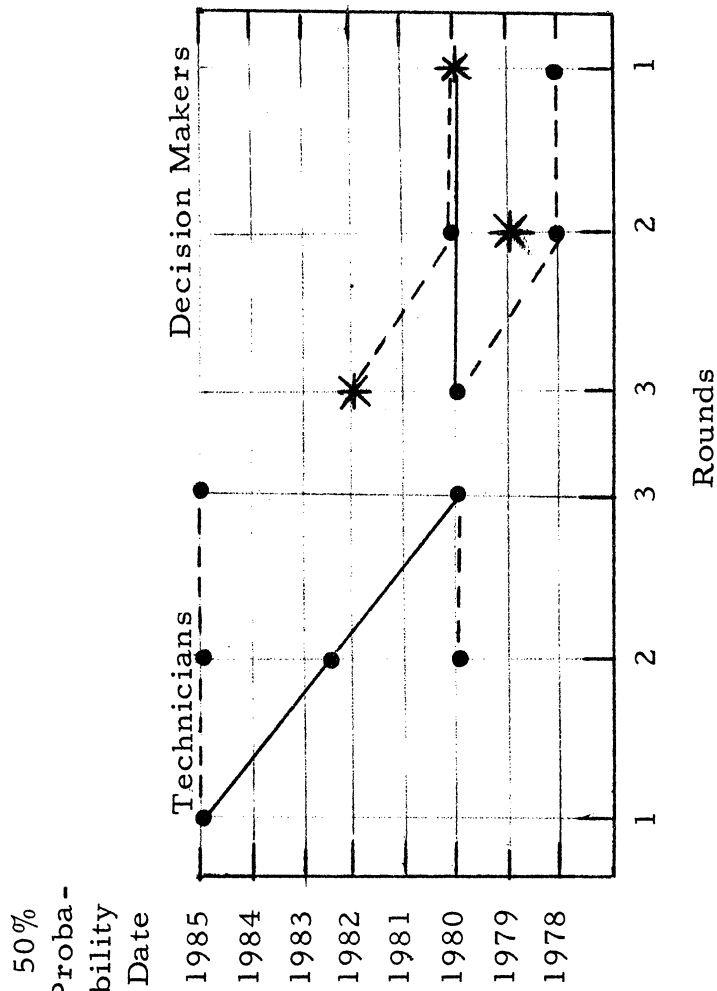
Item 78 The occurrence of a famine comparable to that in China in 1877-79 in which approximately 9 million people died

- \* Median estimates of those who rated their competence relatively high.
- Median estimates of entire panel.
- - - Boundaries for middle 50% of estimates.

Fig. 8. (Cont.)



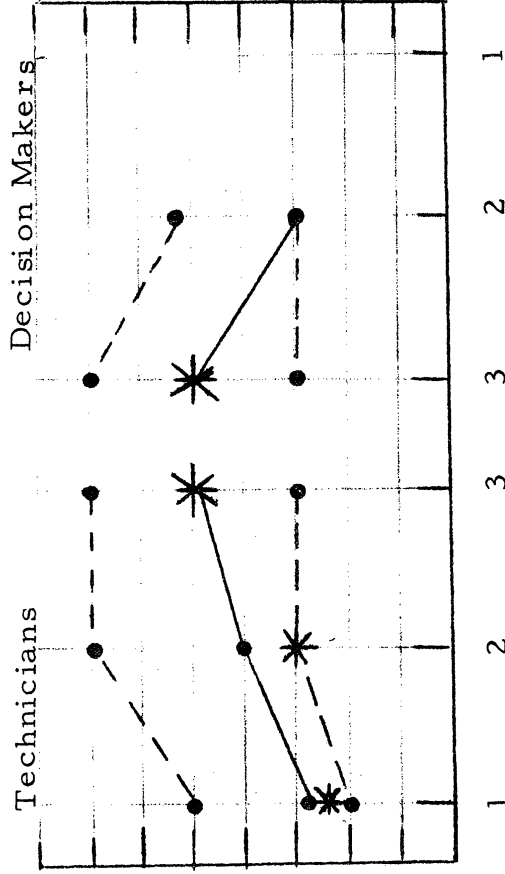
Item 65 Expansion of airport facilities in the region by 50% compared to 1970--measured in terms of capital investment



Item 68 Complete zoning for land use of the shoreline of Grand Traverse Bay

- \* Median estimates of those who rated their competence relatively high.
- Median estimates of entire panel.
- Boundaries for middle 50% of estimates.

50%  
Probability  
Date



Rounds

Item 17 An airborne water pollution information and control system becomes operational for a region in the Great Lakes basin

Item 29 Widespread use of self-contained dwelling units, using life-support systems that recycle water to provide independence from water supply and from waste-water treatment and disposal systems

- \* Median estimates of those who rated their competence relatively high.
- Median estimates of entire panel.
- - -●- - - Boundaries for middle 50% of estimates.

Fig. 8. (Cont.)

on the estimating forms. Note that for over half of the items (7, 31, 36, 10, 41, 44, 61, 65, 68, 17, and 57) the pattern is one a decision maker would be pleased to see in a systematic development of group judgments. Generally, each group's median estimate for the final round is very close to the median estimates of those who consider themselves relatively competent in the subject. Also, the consensus--as measured by the interquartile range--narrows and the average estimates of the two groups tend to come closer together. Some of the other patterns, while not ideal from the standpoint of movement toward a narrower consensus, provide a decision maker with information as to a course of further inquiry.

For example, the consensus of the technicians on Item 35 (page 29), as measured by the interquartile range, has not narrowed. Further analysis shows that the development is considered to be of great importance, and a high percentage of the technicians (9 out of 14) rate their competence regarding it relatively high. Thus a further exchange of information among the technicians using a variety of techniques (conferences, seminars) is indicated. There also appears to be no change in the estimates of the decision makers through three rounds of feedback and reassessment, although their average judgments differ considerably from those of the technicians. This difference suggests that an exchange of information between these two groups would be worthwhile.

While the pattern for Item 76 (page 30) appears to be similar to that for Item 35, the performance level specified for the technicians

increased the production of nuclear-fueled electric energy 25 per cent or more, while the performance level specified for the decision makers increased 50 per cent or more. The average estimates of the two groups appear to be consistent with the difference in performance levels. For the developments on which three rounds of estimates were requested, most of the movement in the summary statistics is associated with the reassessments of the second round.

On the final round of the technical panel exercises respondents were asked to make specific conditional probability estimates for pairs of events that panel members had suggested were closely related. First they were to consider the effects of the occurrence of the conditioning event and then the effects of the nonoccurrence of the conditioning event. One of the objectives of this procedure was to encourage panelists to re-examine their estimates for individual events in the light of the influence and probabilities of related events. Individual responses showed that a relatively high percentage of respondents altered their final estimates for these events, as is partially revealed by the graphs of the round-by-round group statistics in Figure 9. In contrast, Figure 8 shows that for those developments on which three rounds of estimates were requested--but on which specific conditional estimates of related pairs of events were not made--most of the movement in the summary statistics was related to reassessments of the second round.

Statistical summaries for the balance of the developments suggested and evaluated by the technical and broad panels are shown in Tables 1 and



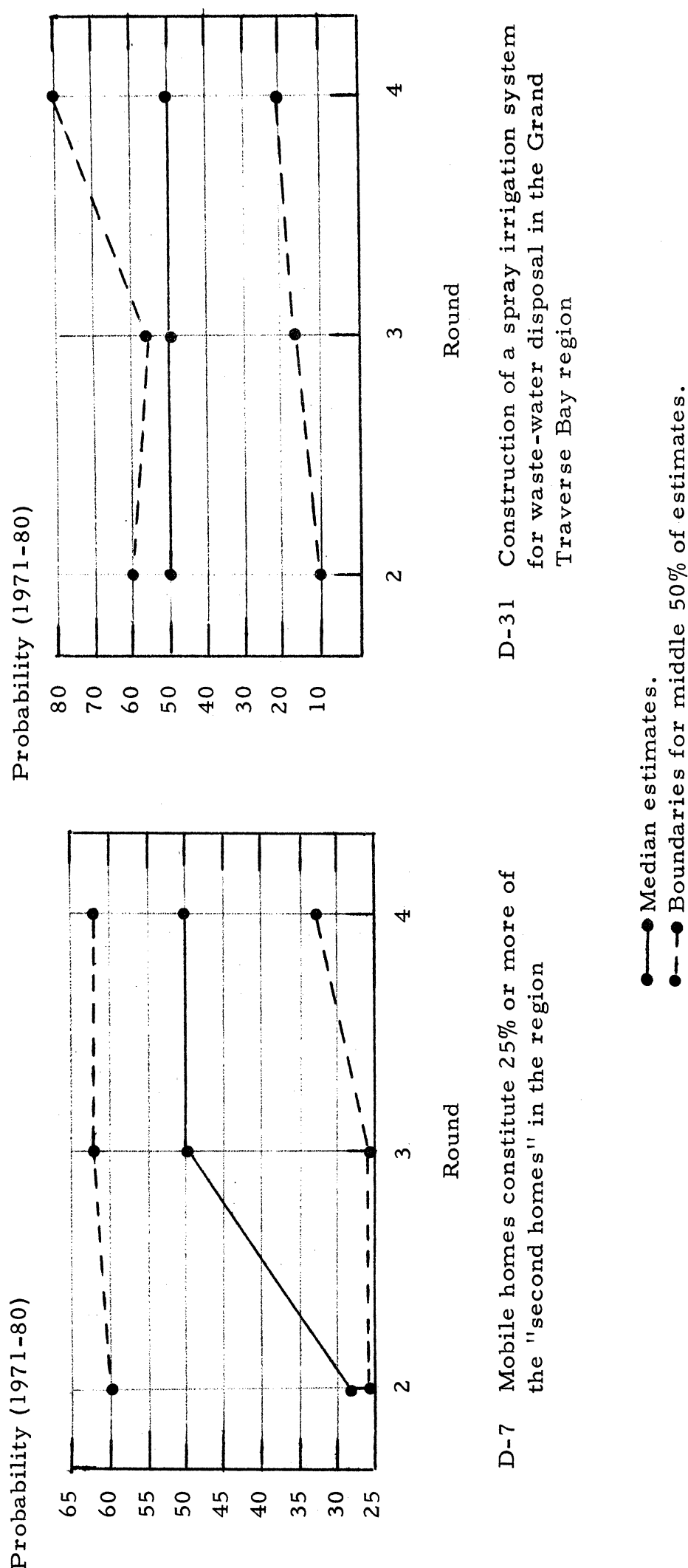
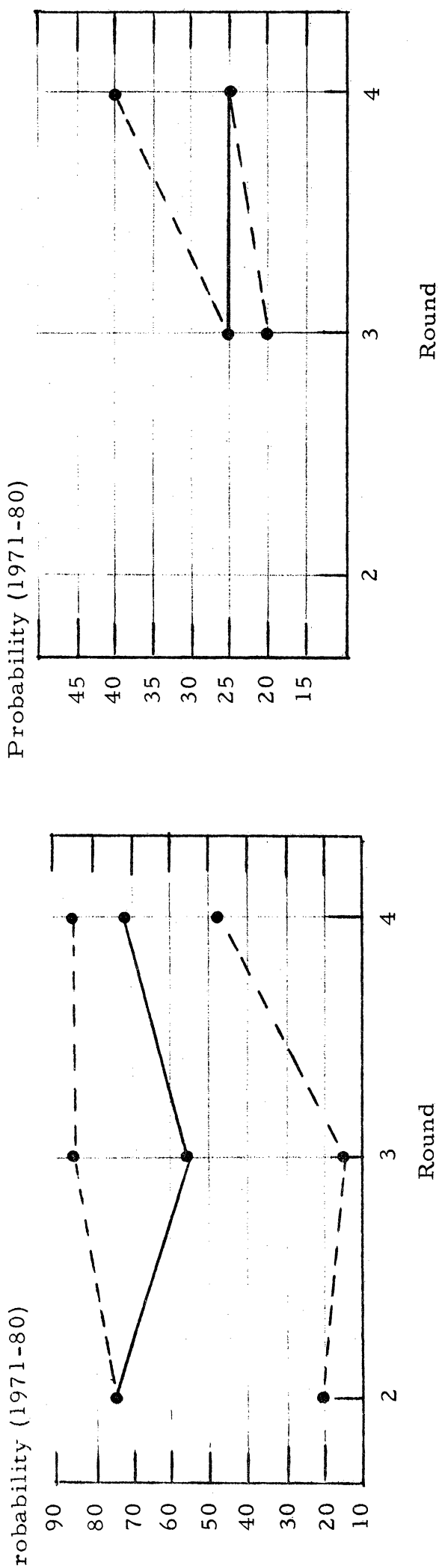


Fig. 9. Statistical summaries--dependent and conditional events.



D-39 Full-scale operation somewhere in the United States of a physico-chemical system for waste-water treatment applied directly to primary waste, which is economically competitive with 1970-designed facilities using activated sludge secondary treatments - with chemical precipitation for phosphate removal

E-80 Demonstration of technology which will economically remove persistent salts, minerals, and organics which would otherwise accumulate to unacceptable levels in recycled water

●—● Median estimates.  
 ●-● Boundaries for middle 50% of estimates.

Fig. 9. (Cont.)

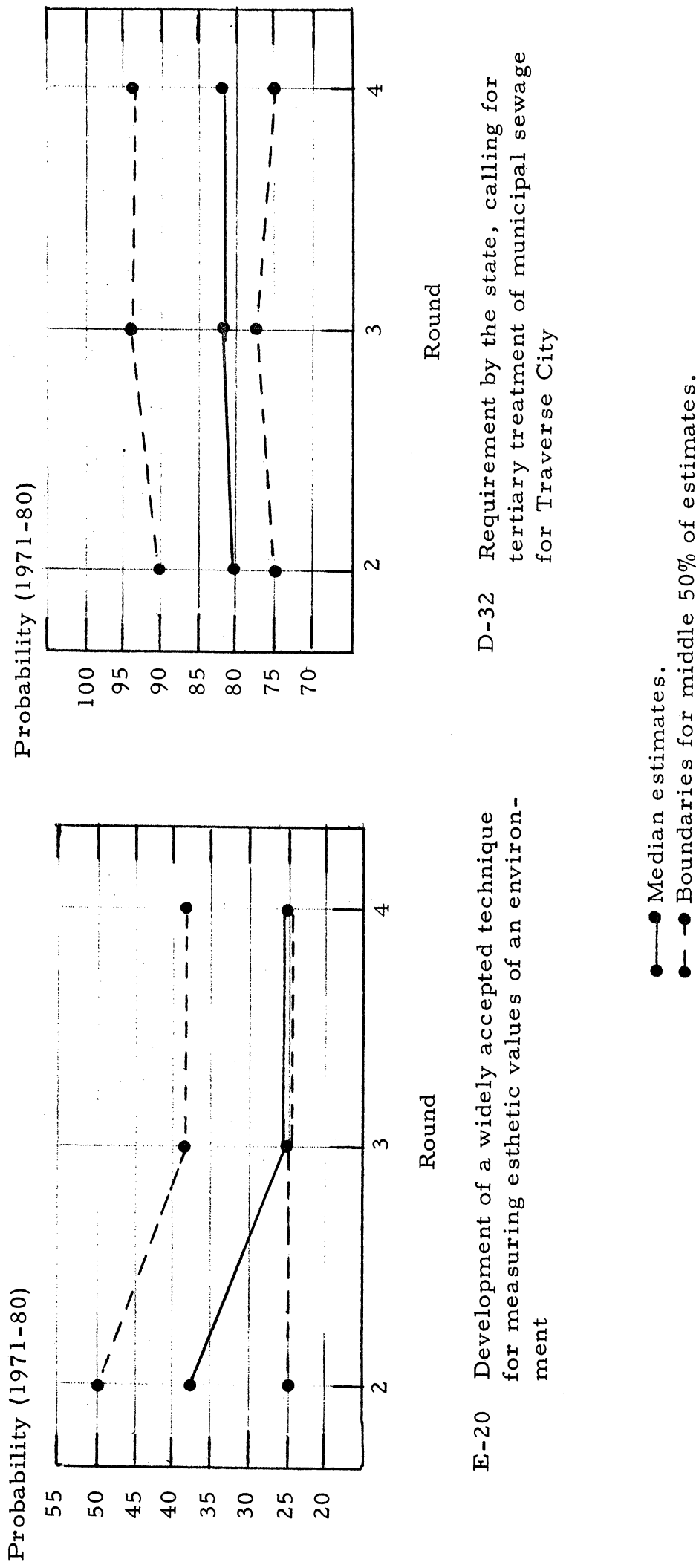
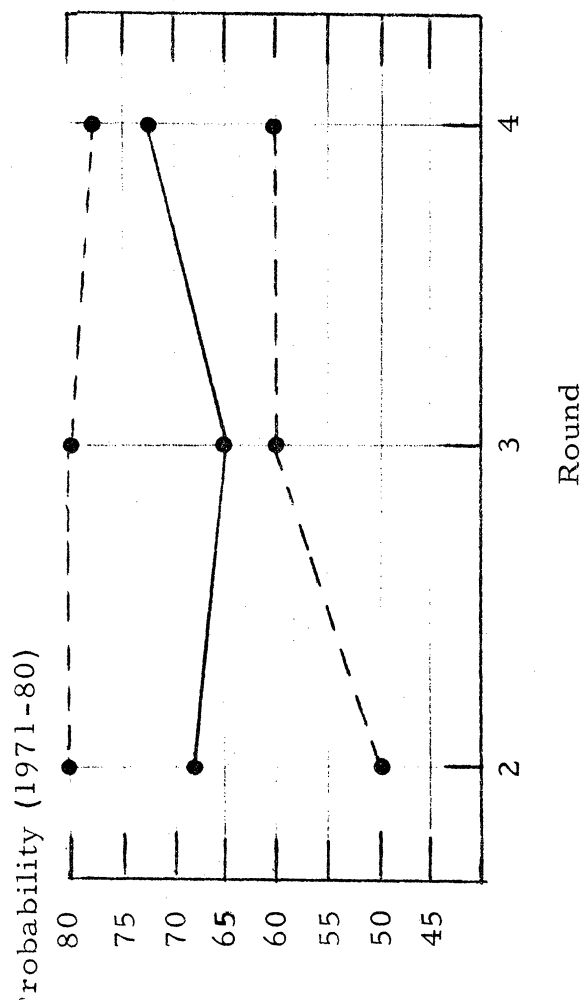
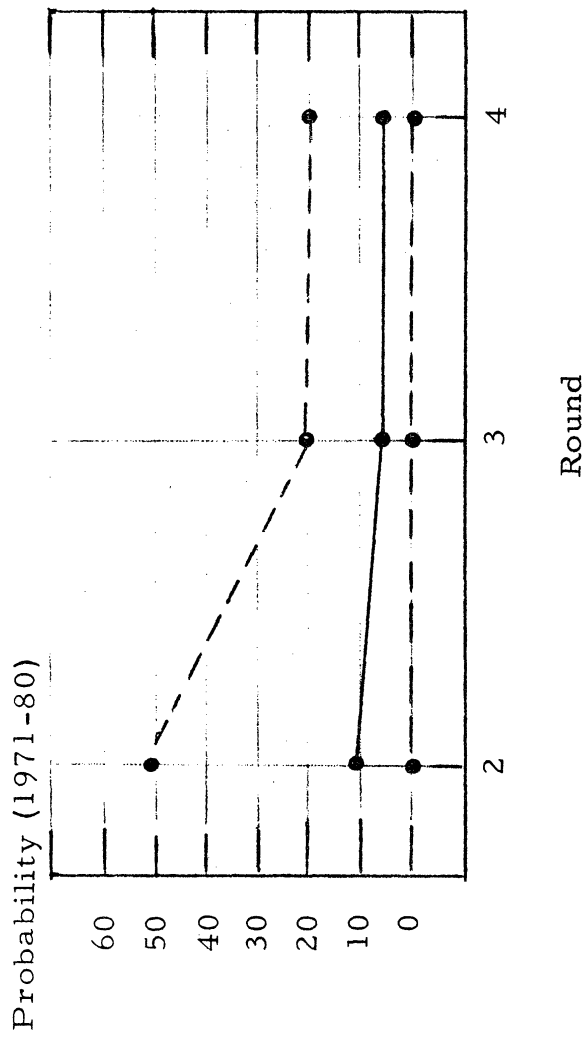


Fig. 9. (Cont.)



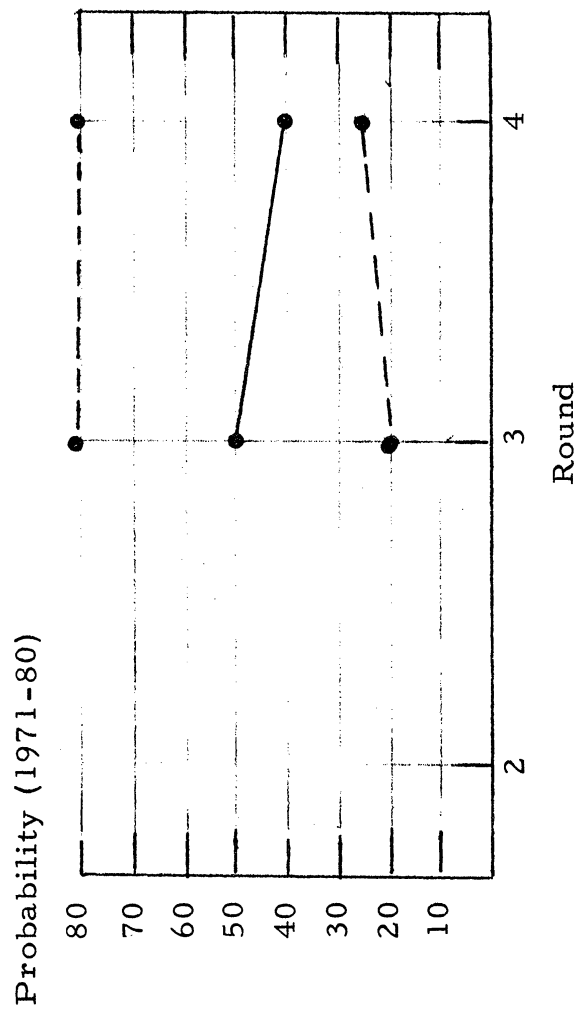
D-38 Recycling by U.S. industry of 20% of the total waste water



D-45 Economic recycling of municipal water for an urban area of 50,000 population, i.e., development of a closed system for a public water supply

●—● Median estimates.  
●---● Boundaries for middle 50% of estimates.

Fig. 9. (Cont.)



E-84 Development of a comprehensive management plan for the Grand Traverse Bay area as a recreational area, the plan based on esthetic values

- Median estimates.
- -● Boundaries for middle 50% of estimates.

TABLE 1

Additional Items Evaluated by the Technical Panel

Item Number	Suggested Development	Proba- bility 1971-80	50% Proba- bility Date	IQ Range* 50% Proba- bility Date	Importance (0-3)
E-16	An information system for monitoring water quality-- based primarily on airborne or satellite remote sensors--becomes operational for a region in the Great Lakes basin	50	1980	1980-80	1.9
E-17	An airborne water pollution information and control system becomes operational for a region in the Great Lakes basin	50	1980	1980-81	2.1
E-18	Demonstration of a capability to quantify algae nutrition	50	1975	1975-76	2.0
E-19	Demonstration of a capability to quantify microbial interactions	75	1975	1975-75	2.4
E-20	Development of a widely accepted technique for measuring esthetic values of an environment	32.5	1984.5	1983-90	2.2
E-21	Launching of continuously manned earth orbital space station to collect scientific data	55	1984	1980-85	1.4

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 1--Continued

## Additional Items Evaluated by the Technical Panel

Item Number	Suggested Development	50% IQ Range*			Importance (0-3)
		Proba- bility 1971-80	Proba- bility Date	50% Proba- bility Date	
D-26	Efficient and economical means of disposing of solid waste products	75	1976.5	1975-78	2.8
E-27	Legislation which eliminates or effectively controls the use of products which do not decay	50	1975	1975-85	2.7
E-28	Prohibition of direct dumping of wastes	90	1975	1975-78	3.0
D-37	General marketing of household detergents that are 90% pollutant free as compared to 1970 standards	50	1978	1975-80	2.1
D-38	Recycling by U.S. industry of 20% of the total waste water	65	1978	1978-80	2.4
D-39	Full-scale operation of a physico-chemical system for waste-water treatment applied directly to primary waste, which is economically competitive with 1970-designed facilities using activated sludge secondary treatments--with chemical precipitation for phosphate removal	50	1978	1975-80	2.2

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 1--Continued

Additional Items Evaluated by the Technical Panel

Item Number	Suggested Development	50%		IQ Range*		Importance (0-3)
		Proba- bility 1971-80	Proba- bility Date	50% Proba- bility Date	50% Proba- bility Date	
D-40	Adequate separation and treatment of Traverse City's storm water	50	1980	1980-85		2.7
D-45	Economic recycling of municipal water for an urban area of 50,000 population, i.e., development of a closed system for a public water supply	35	1990	1980-95		2.1
D-58	Large-scale development of summer homes as a result of more leisure time and faster transportation systems	75	1980	1980-80		3.0
D-66	Outbreak of nuclear war in which weapons with yields of 100,000 tons are detonated	20	1980	1980-80		2.9
D-74	A significant increase in light industry, developed because large amounts of high-quality water are available	75	1975	1975-77		2.8
D-75	A ground transportation system permitting speeds greater than 120 mph between the Chicago-Detroit megalopolis and the Grand Traverse Bay region	22.5	1985	1980-95		2.0

\* Interquartile range--contains middle 50 per cent of the estimates.



TABLE 1 -- Continued

Additional Items Evaluated by the Technical Panel

Item Number	Suggested Development	50%		IQ Range*		Importance (0-3)
		Proba-bility 1971-80	Proba-bility Date	50% Proba-bility Date	50% Proba-bility Date	
D-77	The occurrence of a pandemic (world epidemic) comparable to the influenza epidemic of 1918-19 that caused approximately 20 million deaths	10	1990	1980-2000		1.8
E-80	Demonstration of technology which will economically remove persistent salts, minerals, and organics which would otherwise accumulate to unacceptable levels in recycled water	25	1985	1982-90		2.6
E-81	Development of a desalination technique which is, by an order of magnitude or so, more efficient than the distillation method	25	1980	1980-90		1.0
E-82	Development of a fail-safe system ensuring protection of the local environment from radioactive contamination and thermal influence	25	1985	1980-90		2.0
E-83	Development of rational water quality standards for Grand Traverse Bay to prevent excessive algal growth, based on knowledge of nutritional requirements and microbial interactions	50	1980	1976-85		2.9

\* Interquartile range -- contains middle 50 per cent of the estimates.

TABLE 1--Continued

Additional Items Evaluated by the Technical Panel

Item Number	Suggested Development	50%		IQ Range*		Importance (0-3)
		Proba- bility 1971-80	Proba- bility Date	50% Proba- bility Date	50% Proba- bility Date	
E-84	Development of a comprehensive management plan on the basis of esthetic values for the Grand Traverse Bay area as a recreational area	45	1980	1979-83		2.8
E-85	Development of some sort of underground central collection system for transport of solid wastes to "disposal" site	20	1990	1985-95		1.7
E-86	Development of alternatives to paper and plastic packaging (e.g., edible or soluble packaging)	30	1983	1980-90		1.7
D-87	Availability of refuse incineration methods which are economical in relatively small-scale applications with acceptable air pollution levels	50	1980	1978-83		1.9

\* Interquartile range--contains middle 50 per cent of the estimates.

2. These summaries do not include those items that were suggested and evaluated but subsequently screened from the deliberations, items that were evaluated by all panels, or items subjected to specific conditional probability estimates.

### Sources of Pollution

A crucial consideration in planning for intelligent management of water resources is the identification of the most important sources of pollution. In making their judgments, panelists were asked to assume a future social and political environment consistent with present trends. However, it was expected that concurrent Delphi inquiries regarding important developments and requisite technology would influence their estimates.

On the first round the technical panel was provided with a list of sources of pollution and specific pollutants thought to be important. Panelists were requested to add other items that they felt would affect a body of water comparable to Grand Traverse Bay in the next twenty years. The collated responses identified seventeen additional sources of pollution and eighteen additional pollutants for the panel to consider. Since there were too many alternatives to present in a matrix designed to encourage the careful consideration of several evaluation factors, the primary objective of Round 2 was to narrow the number of alternatives. The evaluation matrix of Round 3 presented the ten most important sources of pollution as determined by a statistical summary of the

TABLE 2

Additional Items Evaluated by the Broad Panels

Item Number	Suggested Development	50% Probability Date (Behaviorists)	Inter-quartile Range*	50% Probability Date (Decision Makers)	Inter-quartile Range*
7†	Demonstration of regular and reliable weather forecasts fourteen days in advance for areas as small as the Grand Traverse Bay region	1981	1981-85	1980	1980-82
10†	A quickly available and effective method to control oil spills in Grand Traverse Bay	1979	1978-80	1978	1977-80
11†	Construction completed on an integrated bay shore peripheral sewage collection and treatment system in the Grand Traverse Bay region	1990	1985-90	1980	1977-82
16†	Wide availability of immunizing agents which can protect against most bacterial and viral diseases	1985	1985-85	1980	1978-85
17	A positive net migration rate for the Grand Traverse Bay area over a five-year period	1977.5	1975-78	1978	1975-81
19†	One-fifth of the new cars sold have acceptable performance, are economically competitive with other forms of transportation, and permit operation without harmful exhaust	1981	1980-83	1979	1978-80

\* Contains middle 50 per cent of the estimates.

† Items suggested by the Delphi administrator.

TABLE 2--Continued

Additional Items Evaluated by the Broad Panels

Item Number	Suggested Development	50% Proba- bility Date (Behaviorists)	Inter- quartile Range*	50% Proba- bility Date (Decision Makers)	Inter- quartile Range*
25	A 50% rise in the rate of serious crimes in the region compared to the 1970 rate, measured by comparable techniques	1979	1978-82	1980	1980-80
26	A decrease in fruit production that occurs in two consecutive years and is not attributable to weather	1979	1978-80	1978	1975-80
35	City government services have 50% less influence than regional groups performing similar activities--measured by total wages of city government employees per person living within the city's jurisdiction	1985	1982-85	1985	1979-85
36	A 50% increase--compared with 1970--in the immigration to the region of retirees 55 to 65 years of age (Respondents will be provided with migration statistics for 1970 when they become available from the census bureau.)	1981	1980-82	1978	1977-80

\* Contains middle 50 per cent of the estimates.

TABLE 2--Continued

Additional Items Evaluated by the Broad Panels

Item Number	Suggested Development	50%			Inter- quartile Range*	Inter- quartile Range*
		Proba- bility Date (Behaviorists)	Proba- bility Date (Decision Makers)	50% Proba- bility Date (Decision Makers)		
37	A 50% increase--compared with 1970--in the immigration to the region of husbands and wives leaving the metropolitan area when their children no longer reside with them	1983		1980	1981-84	1976-82
38	Development of a youth culture in Traverse City	1980		1980	1973-82	1975-83
39	"Instant cities" to accommodate 10,000 and more residents	1977.5		1982	1971-84	1979-85
40	Quality of life becomes the major factor in family relocation	1980		1978	1975-82	1975-80
41	Completion of a major freeway system to serve western Michigan	1980		1980	1980-85	1978-80
43	Development of a "metropolitan" type of government for Traverse City	1980		1978	1980-81	1978-80

\* Contains middle 50 per cent of the estimates.

TABLE 2--Continued

## Additional Items Evaluated by the Broad Panels

Item Number	Suggested Development	50% Proba-			50% Proba-	
		bility Date (Behaviorists)	Inter- quartile Range*	bility Date (Decision Makers)	Inter- quartile Range*	Inter- quartile Range*
44	Development of regional financial institutions to the point that the lack of venture capital is not a restricting factor in the region's economic growth	1995	1982-Later	1977		1977-80
45	Visitors of a week or less commit a larger portion of the serious crimes than any other group	1984	1982-Later	1980		1975-85
46	Discontinuance of the employment of migrant workers in the area	1978	1978-78	1975		1975-77
47	Reservation of large areas in the region for agriculture	1980	1980-90	1980		1979-80
48	A national economic depression comparable to the depression of the early 1930s	1986	1985-87	1987		1985-90

\* Contains middle 50 per cent of the estimates.

estimates made in Round 2 (see Figure 10). Panelists were asked to distribute 100 points among the sources of pollution, according to each one's relative importance, for two future periods. The information feedback for the following round provided statistical summaries for Group A, all respondents; Group B, those who rated their competence on sources of pollution relatively high; and Group C, respondents in Group B who were also relatively familiar with the Grand Traverse Bay watershed area (Table 3). Although Group B differed considerably in size from Group C, the average estimates of the two were remarkably close. This finding might suggest that technical competence is a more important requisite for panel membership than familiarity with a specific region, an idea that could have important implications for interdisciplinary programs such as Sea Grant, in which research methodologies developed for a subregion are to be applied to a larger socioeconomic system.

In the broad panel exercises the evaluation matrix for Round 2 was similar to the final matrix used in the technical panel. The evaluation matrix for the following round provided statistical summaries of the estimates of both the technical panel and the broader-based panels (Figure 11).

Final estimates of respondents of all groups who rated their competence relatively high are presented in Table 4. A significant difference in the estimates regarding the relative importance of the effluent from the Traverse City sewage system suggests that a series



SOURCES OF POLLUTION SUGGESTED BY RESPONDENTS	ABATEMENT FEASIBILITY 1971-80		RELATIVE IMPORTANCE			
	ECONOMIC	TECHNICAL	1971-80		1981-90	
	1 = Extreme subsidy required 2 = Substantial subsidy 3 = Moderate subsidy 4 = Slight subsidy 5 = Routine	1 = Extremely difficult 2 = Very difficult 3 = Moderately difficult 4 = Slightly difficult 5 = Routine	Example	Your Rating	Example	Your Rating
Evaluate each source with respect to the factors on the right. Assume a social and political environment consistent with present trends.						
Effluent, Traverse City sewage system	Scale 1-5	Scale 1-5	28		32	
Septic tanks in the region			9		1	
Storm water run-off, urban			11		1	
Food-processing wastes			12		5	
Industry wastes (less food processing and agriculture)			6		5	
Power production utilities			1		15	
Agriculture			6		10	
Oil spillage, bulk marine vessels			10		10	
Direct contact inputs, human use			11		10	
Ground water run-off carrying natural pollutants			6		11	
			100		100	

Fig. 10. Technical panel's third round evaluation matrix--sources of pollution.

TABLE 3

Ranking of Sources of Pollution by Importance--  
Technical Panel, Round 3

Panel members were asked to distribute 100 points among the most important sources of pollution (listed below) during the two periods indicated.	1971-80			1981-90		
	Those who rated familiarity 3 or more regarding:			Those who rated familiarity 3 or more regarding:		
	A All Re-spondents (16)*	B Sources (13)*	C Sources + Region (8)*	A All Re-spondents (15)*	B Sources (12)*	C Sources + Region (7)*
Effluent, Traverse City sewage system	29	31	34	27	29	32
Septic tanks in the region	13	15	14	11	13	13
Storm water run-off, urban	11	12	11	10	11	12
Food-processing wastes	12	11	10	8	7	8
Industry wastes (less food processing and agriculture)	7	7	4	11	10	6
Power production utilities	4	4	6	8	6	7
Agriculture	9	9	8	9	10	7
Oil spillage, bulk marine vessels	6	4	4	5	4	4
Direct contact inputs, human use	5	4	5	5	5	7
Ground water run-off carrying natural pollutants	$\frac{4}{100}$	$\frac{3}{100}$	$\frac{4}{100}$	$\frac{6}{100}$	$\frac{5}{100}$	$\frac{4}{100}$

\* Number of respondents.

Ten Most Important Sources of Pollution	ABATEMENT FEASIBILITY				RELATIVE IMPORTANCE			
	1971-80				Panel members were asked to distribute 100 points among the most important sources of pollution during the two periods indicated.			
	ECONOMIC Scale 1-5 1=Extreme subsidy required 2=Substantial subsidy 3=Moderate subsidy 4=Slight subsidy 5=Routine		TECHNICAL Scale 1-5 1=Extremely difficult 2=Very difficult 3=Moderately difficult 4=Slightly difficult 5=Routine		1971-80		1981-90	
	Technical Panel	Broad Panel	Technical Panel	Broad Panel	Those on technical panel who rated familiarity 3 or more (13)†	Broad Panel (13)†	Those on technical panel who rated familiarity 3 or more (12)†	Broad Panel (12)†
Effluent, Traverse City sewage system	3(2-3)*	2(1-2)*	4(3-5)*	3(2-4)*	31	22	27	15
Septic tanks in the region	2(2-3)*	5(2-5)*	3(3-4)*	4(3-4)*	15	13	10	14
Storm water run-off, urban	2(2-4)*	3(1-3)*	3(2-5)*	3(2-4)*	12	9	9	9
Food-processing wastes	5(3-5)*	4(4-5)*	3(3-4)*	3(3-4)*	10	13	7	8
Industry wastes (less food processing and agriculture)	4(3-5)*	4(4-5)*	3(3-4)*	3(2-3)*	7	8	9	9
Power production utilities	4(4-5)*	5(4-5)*	3(3-5)*	4(2-5)*	5	4	10	8
Agriculture	4(2-5)*	4(3-4)*	4(3-4)*	3(2-4)*	9	13	9	12
Oil spillage, bulk marine vessels	5(2-5)*	5(5-5)*	3(2-3.5)*	4(4-5)*	4	4	4	6
Direct contact inputs, human use	4(1-5)*	5(4-5)*	3(2-3.5)*	3(2-5)*	4	6	8	9
Ground water run-off carrying natural pollutants	2.5(1-4)*	3(1-5)*	3(1-4)*	2(1-5)*	3	8	8	10

\* Median--interquartile range in parentheses. Interquartile range contains the middle 50% of the estimates.

† Number of respondents who contributed numerical estimates.

Fig. 11. Broad panels' third round evaluation matrix--sources of pollution.

TABLE 4

## Sources of Pollution--Technical and Broad Panel Estimates

Panel members were asked to distribute 100 points among the most important sources of pollution (listed below) during the two periods indicated.	1971-80		1981-90	
	Technical Panel Experts Only (13)*	Broad Panels (17)*	Technical Panel Experts Only (12)*	Broad Panels (16)*
Effluent, Traverse City sewage system	31	22	29	17
Septic tanks in the region	15	15	13	15
Storm water run-off, urban	12	9	11	10
Food-processing wastes	11	12	7	8
Industry wastes (less food processing, and agriculture)	7	8	10	9
Power production utilities	4	4	6	8
Agriculture	9	12	10	10
Oil spillage, bulk marine vessels	4	4	4	5
Direct contact inputs, human use	4	6	5	9
Ground water run-off carrying natural pollutants	<u>3</u> 100	<u>8</u> 100	<u>5</u> 100	<u>9</u> 100

\* Number of respondents.

of estimates conditional on specific social, political, or technical developments could be used to determine the assumptions on which the evaluators based their estimates. The reason for the differences in estimates could also be sought through interviews and other means of communication.

If recommendations were requested regarding a specific situation, technical experts would insist on specific quantitative data and analysis regarding the major components of the waste water, the characteristics and uses of the receiving water, and the efficiency of specific technical approaches. In this exercise their recommendations apply to a hypothetical community in a region similar to the Grand Traverse Bay watershed area. Their judgments would undoubtedly be influenced by estimates relating to social, economic, and political developments but would be conditioned primarily by their knowledge of available technology.

#### Recommended Waste-Water Treatment and Disposal Systems

Many communities in the Great Lakes basin are confronted with decisions on waste-water treatment and disposal systems that will have important consequences for the future socioeconomic development of their region. This is a highly technical and complex issue, and decision makers must intuitively assess the judgments of experts in many specialized areas.

A systematic consideration of the available alternatives and the identification of areas of agreement and disagreement within and between the three general groups involved in these Delphi exercises will aid

planners from this region as well as those from many other communities in the Great Lakes region facing similar problems and decisions.

Included in the technical panel's Round 3 information package was an evaluation matrix that listed six alternative waste-water treatment and disposal systems. Panel members were asked to suggest other alternatives and to evaluate each of them in terms of two different starting dates for the construction of the necessary facilities. Variances in the estimates were to be attributed to assumptions about the technology that would be available at the two starting dates. Panel members were instructed to give 100 points to their first choice for each time period and a portion of 100 points to the remaining alternatives according to their value relative to the first choice.

The Round 4 information package provided panel members with a summary of the estimates made in the third round. The evaluation matrix for that round (Figure 12) requested two evaluations for the six alternative waste-water treatment and disposal systems for two different starting dates. In the first evaluation the respondents were asked to consider all factors, in particular the technology available at the start of construction; in the second evaluation they were to consider only 10-year operating costs. Table 5 presents a summary of the estimates of the technical panel for Rounds 3 and 4 relative to all factors. Note that the estimates of those who rated themselves relatively competent are remarkably close to those for the total panel on the final round--significantly closer than on Round 3. As measured by the interquartile range (middle 50 per cent), the dispersion in their estimates narrowed considerably.

Listed below are several waste-water treatment methods and several disposal techniques which respondents have suggested can be combined to make up six alternative waste-water treatment and disposal systems. You are requested to score each alternative system for its suitability in a region similar to the Grand Traverse Bay area. Two different dates are indicated for the start of construction. For each starting date make two evaluations. First, consider all factors, but particularly the technology available at the start of construction, and second, consider only 10-year operating costs after the system becomes operational. For each evaluation give 100 points to your first choice and a portion of 100 points to each alternative according to its value relative to your first choice.

WASTE-WATER TREATMENT		DISPOSAL		RECOMMENDED APPROACHES								
				Start July 1972				Start July 1976				
				Summaries		Next Estimates		Summaries		Next Estimates		
				Total Panel	Your Last Estimate	All Factors (1)	Cost Only (2)	Total Panel	Your Last Estimate	All Factors (1)	Cost Only (2)	
1	Physico-chemical	A	Discharge to bay	1A	84			87				
2	Activated sludge or trickling filter biological treatment (sludge disposed of by incineration or land disposal)	A	Discharge to scenic river	2A	38			35				
		B	Discharge to bay	2B	82			84				
		C	Spray irrigation	2C	65			60				
3	Biological treatment followed by "tertiary" treatment	A	Discharge to scenic river	3A	55			49				
		B	Discharge to bay	3B	100			100				

Please mark the one phrase that comes closest to expressing your familiarity with waste-water treatment and disposal techniques and with the Grand Traverse Bay region.

Waste-Water Treatment/Disposal	G. T. B. Region	Descriptive Words for Numerical Rating Scale
(1) <input type="checkbox"/>	(1) <input type="checkbox"/>	(1) = Totally unfamiliar
(2) <input type="checkbox"/>	(2) <input type="checkbox"/>	(2) = Casually acquainted
(3) <input type="checkbox"/>	(3) <input type="checkbox"/>	(3) = Well acquainted
(4) <input type="checkbox"/>	(4) <input type="checkbox"/>	(4) = Generally familiar
(5) <input type="checkbox"/>	(5) <input type="checkbox"/>	(5) = Actively studying

Fig. 12. Evaluation matrix-- recommended waste-water treatment and disposal systems.

TABLE 5

Waste-Water Treatment and Disposal Systems--  
Technical Panel Recommendations

Treatment	Disposal Alternative	Start July 1972				Start July 1976			
		Round 3		Round 4		Round 3		Round 4	
		Total Panel (11)*	Experts (3)*	Total Panel (15)*	Experts (6)*	Total Panel (11)*	Experts (3)*	Total Panel (15)*	Experts (6)*
Physico- chemical	Bay	76	76	80	76	88	80	84	84
Activated sludge	River	32	48	32	40	32	40	36	36
Activated sludge	Bay	84	64	84	80	84	52	80	72
Activated sludge	Spray irrigation	56	36	60	56	60	36	60	52
Biological	River	56	76	44	52	44	88	44	52
Biological	Bay	100	100	100	100	100	100	100	100

\* Number of respondents.



The primary reason for including a highly technical and complex issue in the deliberations of the broader-based panels was to communicate the judgments of the technical panel effectively to people in the Grand Traverse Bay region who will influence the way this issue will be finally decided for their region through the political process.

The broad panels used the same evaluation matrix as the technical panel in their final round of estimates, and they were also given a summary of the results of the technical panel's evaluation of all factors except for cost estimates. The broad panelists were advised that the technical panel probably emphasized technical factors in making their estimates. They were also told that the recommendations applied to a region similar to the Grand Traverse Bay area and could differ significantly if the technical panel had considered a specific situation.

A comparison of the average estimates of those on the technical panel who rated their competence relatively high with the average estimates of the respondents on the broad panels shows a very close agreement for both planning periods (Table 6). This agreement is evident when panelists considered all factors and also when they considered ten-year operating costs, although the values assigned to each alternative relative to operating costs varied considerably from the values assigned when all factors were considered.

Respondents submitted comments such as the following to support their estimates:

TABLE 6

Waste-Water Treatment and Disposal Systems--  
Technical and Broad Panel Estimates

		Recommended Approaches					
		Start 1972			Start 1976		
		Broad	Technical*	Broad	Technical*	Broad	Technical*
Treatment	Disposal Alternative	All Factors	Cost Only	All Factors	Cost Only	All Factors	Cost Only
Physico-chemical	Bay	72	80	88	80	84	100
Activated sludge	River	32	48	32	45	36	26
Activated sludge	Bay	68	84	64	81	72	48
Activated sludge	Spray irrigation	76	52	80	59	52	36
Biological	River	48	48	44	40	52	42
Biological	Bay	100	100	100	64	100	66

\* Experts only.

Discharge to the bay of the effluent from systems based on the technology of alternatives one and three (physico-chemical; biological followed by tertiary) is preferable since some additional purification will occur without making the river less scenic.

The judgments of the technical experts are believed to embody risk considerations applied to a general situation, whereas the judgments of the broad panels are thought to be more oriented to the benefits of alternative approaches for a specific region and to the recognized needs and values of the respondents. Cost estimates include operating costs only; the consideration of investment costs and financing methods could be equally important to the decision maker.

The waste-water treatment and disposal system issue was undertaken primarily to educate the participants and to explore the problem of gathering a representative group of people and interesting them in the problem. The results could provide important material for gaming techniques and background information for deliberations using a variety of methods of information exchange and analysis.

#### Regional Opportunities, Problems, and Planning Strategies

A Delphi methodology was used to generate and evaluate suggestions regarding regional opportunities, problems, and planning strategies. The group summaries represent initial individual judgments because these items were suggested on one round and evaluated on a subsequent round but not subjected to iterative cycles of reassessments based on statistical feedback. However, many of the assessments have been influenced by prior consideration of the following in other phases of

the Delphi exercises: (1) the trends of statistical measures which have traditionally been used to describe social and economic development; (2) the probabilities and importance associated with potential technical, social, economic, and political developments; (3) the relative importance of future sources of pollution; and (4) alternative waste-water treatment and disposal systems.

On the final round a list of suggestions regarding opportunities, problems, and planning strategies was presented to the broader-based panels. Panel members were asked to indicate whether an individual item should be singled out for special consideration by regional planners according to the following scale:

1 = strongly disagree	4 = somewhat agree
2 = disagree	5 = agree
3 = somewhat disagree	6 = strongly agree

Tables 7 through 9 compare the judgments of the Sea Grant researchers on the broader-based panels with those of the decision makers. The influence of the technical panelists is reflected in these judgments to the extent that many of the items presented were suggested by them, and their judgments in related exercises were available to the broader-based panels. The group means are shown--a value of 3.5 can be viewed as a neutral group judgment--and ranking of the group means provides an additional measure of relative importance. The interquartile range ( $Q_3 - Q_1$ ), which measures the total range of the middle 50 per cent of the individual estimates, shows the dispersion of estimates within a group.

TABLE 7

## Regional Opportunities

Item Number	Opportunity	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
1	Flexibility to diversify and coordinate the industrial development of the region	4.00	1	16	4.82	1	10
2	Potential availability of nuclear-fueled plants generating electric power	2.43	2	34	3.80	4	29
3	Strategic geographical location--access to waterways reaching all sections of the United States	3.86	1	19	5.00	2	6
4	Adequate quality and quantity of water for recreation and industry	5.86	0	1	5.64	1	1
5	Public awareness of environmental problems	5.71	1	2	4.82	2	12
6	Agricultural development--for example, meat production secondary to new forage-food development	3.43	1	28	3.80	2	30
7	Gas well development and transmission of products	3.86	1	20	4.45	3	21

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 7--Continued

## Regional Opportunities

Item Number	Opportunity	Researchers			Decision Makers		
		Mean	$Q_3-Q_1^*$	Rank Order	Mean	$Q_3-Q_1^*$	Rank Order
8	Sod production on peat soils	3.00	2	31	3.20	2	34
9	Chemical industry based on cellulose	3.29	1	29	4.27	2	25
10	Conversion of wood fiber into new building materials	3.71	1	25	4.55	1	20
11	Better fruit-processing and freezing facilities	4.57	1	10	4.73	1	13
12	Conservation and development of private woodlands and farms	4.29	1	12	5.09	2	5
13	Recycling of natural resources	5.14	2	3	5.00	2	7
14	Increased economic activity in the counties outside of Grand Traverse County	4.33	1	11	4.64	1	18
15	Potential for development of a cultural center similar to Aspen, Colorado	4.29	2	13	3.45	3	32

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 7--Continued

## Regional Opportunities

Item Number	Opportunity	Researchers		Decision Makers			
		Mean	$Q_3-Q_1^*$	Rank Order	Mean	$Q_3-Q_1^*$	Rank Order
16	Time to plan for and control future growth	4.86	2	8	4.45	3	22
17	Sports fisheries	4.00	2	17	4.73	2	14
18	Year-round tourism and recreation; winter-snowmobiling, skiing, ice fishing; fall--color tours, hunting, fishing, horseback riding; spring--Petoskey stones, mushroom hunting, canoeing, ski touring, cherry blossoms; summer--unlimited activities	5.14	2	4	5.36	1	2
19	A growth in people's awareness and respect for individuality	3.14	1	30	3.60	1	31
20	Mineral development; e.g., gravel mining and export	3.00	1	32	3.40	2	33
21	Development of limited access highways within the region	3.86	0	21	5.20	1	3

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 7--Continued

## Regional Opportunities

Item Number	Opportunity	Researchers		Decision Makers		
		Mean	$Q_3-Q_1$ *	Rank Order	Mean	$Q_3-Q_1$ * Rank Order
22	Sleeping Bear Dunes recreational development	5.00	2	6	4.82	2 11
23	Growth of industrial parks	4.00	2	23	4.91	1 8
24	Continued expansion of region's professional community	5.14	1	5	4.70	2 15
25	Further dissatisfaction with large cities	5.00	2	7	5.18	2 4
26	Continued emergence of the winter season as prime generator of income from commercial recreation	4.57	3	9	4.91	2 9
27	Trend of federal decentralization; e.g., proposed revenue-sharing programs	3.57	3	26	4.00	2 28
28	Timber harvesting--mechanized equipment that will function as "tree eaters," converting the trunk, limbs, twigs, etc. into usable products	2.43	1	33	4.45	2 23

\* Interquartile range--contains middle 50 per cent of the estimates.



TABLE 7--Continued

## Regional Opportunities

Item Number	Opportunity	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
29	A breakthrough in modular housing concepts	4.14	1	15	4.64	1	16
30	Enhancement of sport fishing in inland lakes and rivers	3.86	2	22	4.64	1	17
31	Available labor force	3.86	2	23	4.36	1	24
32	Continued boom in recreational vehicles--water-based, land-based, snow-based	3.57	3	27	4.55	1	19
33	Low population density	4.29	2	14	4.09	2	27
34	A lessening of the dominance of area governments by city governments as population in surrounding regions grows relative to city populations	3.71	2	24	4.18	2	26

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 8

## Regional Problems

Item Number	Problem	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
35	Pressures from developers and business interests	5.57	1	4	4.82	2	9
36	Increased use of the area by a transient population which has less concern than residents for the environment	4.43	1	19	5.00	1	4
37	Greater use of boats, accompanied by pollution, noise, and damage to fishing	4.57	2	16	4.36	2	22
38	Urbanization and changed land uses	5.14	2	7	4.73	1	12
39	Limitation of access to environment	4.29	1	24	4.89	2	8
40	Progressive deterioration of environment	6.00	0	2	4.73	1	14
41	General breaking down of traditional cultural and social restraints	3.00	3	36	4.36	2	23

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 8--Continued

Regional Problems

Item Number	Problem	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
42	The principles of something for nothing and <u>everything immediately</u> underlying many attitudes	3.71	2	31	4.60	3	15
43	Lake shore erosion	4.43	1	22	4.60	1	16
44	Unrestricted development of subdivisions for homes and mobile homes	5.71	1	3	4.82	2	10
45	Exploitation of the area by oil companies in their quest for oil and gas	5.29	1	6	4.36	2	21
46	Conflict over resource allocation between: a. Middle-class conservationists oriented to leisure b. Need for expanding employment for the working class c. Demands of the black and poor for compensatory treatment	5.43	1	5	4.45	1	18

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 8--Continued

## Regional Problems

Item Number	Problem	Researchers		Decision Makers		
		Mean	$Q_3-Q_1^*$	Rank Order	Mean	$Q_3-Q_1^*$ Rank Order
47	Withdrawal of privately owned timber- lands from management and harvesting-- resulting in reduced economic contribu- tion and deterioration in natural beauty	3.50	1	34	4.50	1 17
48	Fish predators such as sea lamprey	4.43	1	21	4.73	2 14
49	Pollution by fish--such as dead alewives and salmon die-off in spawning streams	4.29	1	25	3.64	2 34
50	Increasing use of water properties for homesites and resort areas	5.00	2	10	5.36	1 1
51	Decline of wildlife	5.14	1	8	4.91	1 6
52	Growth of land ownership by absentee owners	5.00	0	11	5.27	1 2
53	The upward trend of property taxes	4.00	2	29	4.82	2 11
54	Insufficient land-use planning measures	5.14	2	9	5.18	1 3

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 8--Continued

Regional Problems

Item Number	Problem	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
55	Sleeping Bear Park and associated social tensions	4.83	2	15	4.18	2	27
56	Effective control and treatment of delinquency and drug abuse	4.29	2	26	4.30	1	24
57	Variable levels of defense spending	3.50	1	35	4.30	2	25
58	A decline in the quality of water-based recreation	4.43	1	18	3.91	2	32
59	Changing land-use patterns adversely affecting the development of seasonal home construction	3.71	2	30	3.45	3	35
60	Weather modification	3.57	1	32	3.00	1	36
61	The dumping of raw sewage in state waters by both commercial and recreational boaters	4.57	2	17	5.00	2	5

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 8--Continued

## Regional Problems

Item Number	Problem	Researchers			Decision Makers		
		Mean	$Q_3-Q_1^*$	Rank Order	Mean	$Q_3-Q_1^*$	Rank Order
62	Understaffing of all small-city departments--police, water, streets, and administrative	5.00	1	12	4.09	2	28
63	Overburden of taxation because of the influx of retired persons	4.33	1	23	4.09	2	29
64	Air pollution	4.86	2	13	4.36	1	20
65	Extra millage for school systems	3.57	1	33	4.45	3	19
66	Greater use of Grand Traverse Bay water for industrial cooling	4.86	1	13	3.70	1	33
67	Depletion of timber resources as mature hardwoods reach quality size sawtimber; e.g., sugar maples converted to veneer and fine furniture	4.43	1	20	4.09	2	36
68	Growth in provisions for "outside" review of local activities--state, regional, and federal "rules of the game" will become increasingly numerous and encompassing	4.29	1	27	4.90	2	7

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 8--Continued

Regional Problems

Item Number	Problem	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
69	Providing creative opportunities for retired people	4.29	1	28	4.09	2	31
70	An increasing inability of present institutional structures and frameworks at the local level to deal with the complexities arising in the management of the natural environment	6.00	0	1	4.20	2	26

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 9

## Regional Planning Strategies

Item Number	Strategy	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
71	Increased technical and financial assistance to private woodland owners and farmers	3.29	2	29	4.55	2	20
72	Setting aside large areas for agricultural purposes	3.29	1	30	4.82	3	12
73	Direct service counseling and preventive programs of premarital counseling to arrest the present high divorce rate	3.57	1	27	3.27	1	31
74	Assessing the value of measures dealing with the maintenance of the environment and of getting along with or adjusting to change	5.00	1	13	4.50	1	21
75	Development of greater speed and volume in industrial transportation	4.00	2	24	3.90	2	28

\* Interquartile range--contains middle 50 per cent of the estimates.



TABLE 9--Continued

## Regional Planning Strategies

Item Number	Strategy	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$	Rank Order	Mean	$Q_3 - Q_1$	Rank Order
76	A comprehensive study of the contribution of Northwestern Michigan College and North Central College to the economic life of the region	3.14	2	32	4.27	2	23
77	Establishment of a federal law guaranteeing a minimum income	4.86	2	16	2.73	1	32
78	Development of adequate resources for treatment and housing of neglected and abused children	5.00	2	14	4.09	2	25
79	Legal establishment of abortion freedom	5.43	1	8	4.00	2	27
80	The adoption and enforcement of a "Green Belt Plan" pertaining to all area water frontage	5.29	1	9	5.27	1	4

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 9--Continued

## Regional Planning Strategies

Item Number	Strategy	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$ *	Rank Order	Mean	$Q_3 - Q_1$ *	Rank Order
81	Establishment of a use permit for those who neither hunt nor fish so that they may pay their share of the cost of administration, purchasing, etc. of state and federal lands. Use permit would entitle holder to use trails, pick mushrooms, and otherwise use these lands for purposes other than hunting or fishing	3.86	2	26	3.55	3	30
82	Development of a regional planning council to direct area development on a broad scale	5.57	1	5	4.73	2	16
83	Repeat of Item No. 72 as a check on reliability of estimates	3.43	2	28	4.70	3	18
84	Stiffer regulations regarding zoning requirements pertaining to residential, industrial, and commercial areas	5.43	1	7	5.36	1	3
85	Greater control of undesirable industry and business	5.29	1	10	4.64	1	19

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 9--Continued

## Regional Planning Strategies

Item Number	Strategy	Researchers			Decision Makers		
		Mean	$Q_3 - Q_1$	Rank Order	Mean	$Q_3 - Q_1$	Rank Order
86	Development of regional (central) locations for trash disposal to reduce air pollution	5.00	2	12	5.09	2	8
87	Development of a large Indian village	3.17	3	31	2.73	1	33
88	Stronger legislation and enforcement regarding the dumping of contaminants into water resources	6.00	0	1	5.36	1	2
89	Further introduction of highly desired forms of game fish	4.57	1	19	4.82	2	13
90	Providing greater access to beaches and campsites	5.29	1	11	5.09	1	7
91	Enlargement of activities of Interlochen	4.33	0	22	4.73	2	17
92	Enlargement of activities of Northwestern Michigan College	4.50	1	21	4.82	2	14

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 9--Continued

## Regional Planning Strategies

Item Number	Strategy	Researchers			Decision Makers		
		Mean	$Q_3-Q_1^*$	Rank Order	Mean	$Q_3-Q_1^*$	Rank Order
93	Enlargement of activities of North Central Michigan College	4.50	1	20	4.82	2	15
94	More tightly controlled management of the area's natural resources	5.71	1	4	5.18	2	6
95	Elimination of low-level political entities	2.50	1	33	3.82	2	29
96	Increased support for vocational education	4.67	2	18	5.09	2	9
97	Density restrictions for all types of activity within a region; e.g., amount of boating, number of people in parks, etc.	4.00	2	23	4.09	2	26
98	Regional cooperation in solid waste treatment standards	5.71	0	3	5.60	0	1

\* Interquartile range--contains middle 50 per cent of the estimates.

TABLE 9--Continued

## Regional Planning Strategies

Item Number	Strategy	Researchers			Decision Makers		
		Mean	$Q_3-Q_1^*$	Rank Order	Mean	$Q_3-Q_1^*$	Rank Order
99	Support for the growth of large study teams in and out of universities to solve current and potential problems	4.86	0	15	4.30	2	22
100	Support of state land-use zoning including power plant siting and transmission line location, preservation of natural areas, etc.	5.86	0	2	5.20	2	5
101	Political annexation of areas contiguous to Traverse City	3.86	2	25	4.10	1	24
102	Definition of planning responsibility for protection of open spaces	5.57	1	6	4.89	2	11
103	Support of the Northwest Michigan Resource Conservation and Development Project	4.83	1	17	4.90	2	10

\* Interquartile range--contains middle 50 per cent of the estimates.

These tables indicate reasonable agreement within groups (as indicated by the interquartile range) and between groups (as shown by a comparison of the group means). Although the primary interest in these exercises was to identify areas of disagreement and the underlying reasons for them, a Delphi inquiry<sup>2/</sup> provides an accounting of the complete set of items that was considered by the respondents--an important concept when an interdisciplinary team of researchers is involved.

### Regional opportunities

Considerable disagreement was evident among the answers the decision makers gave in their evaluation of regional opportunities:

- |             |  |
|-------------|--|
| Item No. 2  | Potential availability of nuclear-fueled plants generating electric power<br>( $Q_3 - Q_1 = 4$ ) |
| Item No. 7  | Gas well development and transmission of products ( $Q_3 - Q_1 = 3$ )                            |
| Item No. 15 | Potential for development of a cultural center similar to Aspen, Colorado<br>( $Q_3 - Q_1 = 3$ ) |

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<sup>2/</sup> The term Delphi inquiry refers to the complete Delphi process. It was suggested by Turoff, who observed that any particular Delphi design can be characterized in terms of the "inquiring systems" specified in Churchman's writings. See Murray Turoff, Delphi and Its Potential Impact on Information Systems, Paper 81, paper presented at the Fall Joint Computer Conference, Washington, D.C., Nov., 1971 (Washington, D.C.: Office of Emergency Planning, 1971).

Item No. 16 Time to plan and control future growth  
( $Q_3 - Q_1 = 3$ )

The answers given by the researchers and decision makers indicated disagreement between the two groups, on the average, regarding the following items:

Item No. 3 Strategic geographical location--access to waterways reaching all sections of the United States ( $R = 3.86$ ,  $\bar{X}_{DM} = 5.00$ )

Item No. 5 Public awareness of environmental problems  
( $\bar{X}_R = 5.71$ ,  $\bar{X}_{DM} = 4.82$ )

Item No. 15 Potential for development of a cultural center similar to Aspen, Colorado  
( $\bar{X}_R = 4.29$ ,  $\bar{X}_{DM} = 3.45$ )

Item No. 21 Development of limited access highways within the region  
( $\bar{X}_R = 3.86$ ,  $\bar{X}_{DM} = 5.20$ )

Item No. 23 Growth of industrial parks  
( $\bar{X}_R = 4.00$ ,  $\bar{X}_{DM} = 4.91$ )

### Regional problems

There was considerable disagreement among researchers' evaluations of regional problems:

Item No. 41 General breaking down of traditional cultural and social restraints  
( $Q_3 - Q_1 = 3$ )

Answers of decision makers indicated disagreement regarding the following items:

- Item No. 42    The principles of something for nothing  
and everything immediately underlying  
many attitudes ( $Q_3 - Q_1 = 3$ )
- Item No. 59    Changing land-use patterns affecting the  
development of seasonal home construction  
( $Q_3 - Q_1 = 3$ )
- Item No. 65    Extra millage for school systems ( $Q_3 - Q_1 = 3$ )

The answers given by researchers and decision makers indicated disagreement between the two groups, on the average, concerning these items:

- Item No. 40    Progressive deterioration of environment  
  
( $\bar{X}_R = 6.00, \bar{X}_{DM} = 4.73$ )
- Item No. 42    The principles of something for nothing  
and everything immediately underlying  
many attitudes  
  
( $\bar{X}_R = 3.71, \bar{X}_{DM} = 4.60$ )
- Item No. 45    Exploitation of the area by oil  
companies in their quest for oil  
and gas  
  
( $\bar{X}_R = 5.29, \bar{X}_{DM} = 4.36$ )
- Item No. 46    Conflict over resource allocation between:  
    a. Middle-class conservationists  
        oriented to leisure;  
    b. Needs for expanding the economy;  
        and  
    c. Demands of the black and poor for  
        compensatory treatment  
  
( $\bar{X}_R = 5.43, \bar{X}_{DM} = 4.45$ )



- Item No. 66 Greater use of Grand Traverse Bay water for industrial cooling

$$(\bar{X}_R = 4.86, \bar{X}_{DM} = 3.70)$$

- Item No. 70 An increasing inability of present institutional structures and frameworks at the local level to deal with the complexities arising in the management of the natural environment

$$(\bar{X}_R = 6.00, \bar{X}_{DM} = 4.20)$$

### Regional planning strategies

Researchers disagreed on this item in their evaluation of regional planning strategies:

- Item No. 87 Development of a large Indian village  
( $Q_3 - Q_1 = 3$ )

The answers of researchers and decision makers showed disagreement between the two groups, on the average, regarding these items:

- Item No. 72 Setting aside large areas for agricultural purposes ( $Q_3 - Q_1 = 3$ )

- Item No. 81 Establishment of a use permit for those who neither hunt nor fish so that they may pay their share of the cost of administration, purchasing, etc. of state and federal lands. Use permit would entitle holder to use trails, pick mushrooms, and otherwise use these lands for purposes other than hunting or fishing ( $Q_3 - Q_1 = 3$ )

Items 72 and 83 were identical to check the reliability of the estimates. The group means for these items were 3.29 and 3.43 for the researchers, 4.82 and 4.70 for the decision makers. This indication of reliability is consistent with findings regarding the

reliability of estimates in other phases of the Sea Grant Delphi exercises.<sup>3/</sup>

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<sup>3/</sup> See John D. Ludlow, Evaluation of Methodology in the University of Michigan's Sea Grant Delphi Inquiry. To be published as Sea Grant Technical Report No. 22.

### III

#### FUTURE USE OF A DELPHI METHODOLOGY

The three groups who participated in the Michigan Sea Grant Delphi exercises--technicians, behaviorists, and decision makers--contributed to a comprehensive evaluation of the methodology. Their evaluations and the information obtained in several specific applications of the techniques provide empirical data for judgments regarding future use of the method in the Sea Grant program. Only two potential applications will be mentioned here. The phases of the present Delphi inquiry that correspond to the recommended procedure are cited.

#### Selection of Research Projects

The results of the phase of the Delphi exercises devoted to research priorities will be valuable as background information in selecting research projects for the Sea Grant program. A cost-benefit type of analysis similar to that used to evaluate waste-water treatment and disposal systems appears to be feasible and should include at least the first two steps outlined below.<sup>1/</sup>

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<sup>1/</sup> For another approach to project selection that is based on a Delphi methodology see Future Opportunities for Foundation Support by Olaf Helmer, IFF Report R-11 (Middletown, Conn.: Institute for the Future, June 1970).

1. Identify and weigh the objectives of the Sea Grant program using a Delphi inquiry. The objectives used in the formal evaluation of the method's effectiveness were related to three management tasks that corresponded closely to stated objectives of the Sea Grant program: the involvement of an interdisciplinary group of researchers, the integration of their informed judgments, and the communication of these judgments to regional decision makers. Projects could also be evaluated on the basis of their contribution to the more general goals of the Sea Grant program: education, research, and public service.
2. Evaluate each project against the basic objectives or goals identified in Step 1 to obtain an effectiveness factor,  $E$ .
3. Modify the effectiveness factor by a risk factor,  $r_i$ , associated with the probability of success of the project at several levels of funding,  $C_i$ ,  $i = 1, 2, \dots, k$  where  $k$  is equal to the number of levels of funding (normally a minimum level and a recommended level).
4. Thus obtain a rough cost-effectiveness factor for each project on each level of funding:

$$X_i = \frac{Er_i}{C_i}, \quad i = 1, 2, \dots, k$$

5. Modify the effectiveness factor for a project on the basis of its relationships with other projects. The degree of modification would be a function of the number of projects supported, their effectiveness factors, and the nature of the interdependencies.

In the phase devoted to judgments concerning research and information priorities, two important issues were raised which are pertinent to project selection.

The first issue concerned the integrity of the individual or group responsible for designing the evaluation forms, collating the responses, and determining the information that will be fed back. Respondents must be assured that their remarks and evaluations will remain anonymous and that the specification of the projects and the summaries of the group responses will be impartial.

The second issue concerned the threat to the policy-making group of having their responsibility for decisions replaced by a mechanical process which could not possibly quantify or combine all of the factors that are normally considered by a decision maker. A Delphi methodology is intended to support the policy-making groups by providing information that may not otherwise be available to them. If policy is determined by a committee, for example, some administrative, sociological, and psychological barriers to a candid exchange of views are introduced which may be best overcome by a combination of a

Delphi methodology and interpersonal techniques. In addition, a Delphi inquiry can provide feedback on views held by researchers who do not normally attend policy-making meetings and colleagues who are not directly associated with the Sea Grant program.

In the light of our experience with the Delphi method relative to research and information priorities, it is recommended that the procedures for project selection which are suggested above be used only to narrow the number of projects for the policy committee's consideration, leaving a good bit of discretion to those responsible for making programming decisions. Areas in which discretion would normally be exercised in the Sea Grant program include:

1. Judging balance between problem solving and  
basic research
2. Integrating cooperative activities of other  
resource management projects in the university,  
business and industry, state and local agencies,  
and interested citizen groups
3. Obtaining inputs from all basic disciplines  
that can contribute to the concepts of an  
interdisciplinary team and a systems approach  
to problem solving
4. Exploiting the competence of persons or groups  
that are capable of exercising state and national  
leadership

5. Evaluating the credentials of investigators

A systematic procedure for considering projects that make up the Sea Grant program would not only provide better information for the decision makers but also would have other important benefits, such as:

1. Encouraging those who advocate projects to consider their contributions to the objectives and goals of the Sea Grant program and their relationships with other projects--thus stimulating an integrated mission-oriented viewpoint
2. Convincing present and future Sea Grant participants that their projects will be judged in a systematic way
3. Providing an effective mechanism for stimulating communication between participants in different projects

Communication between Researchers and Decision Makers

In the formal evaluation of methodology associated with the present exercises, the Delphi techniques were judged to be effective in conveying the informed judgments of researchers to regional decision makers. Success in this role was attributed primarily to the participation of local community leaders on the panels and the reinforcing effect of iterative cycles of feedback and reassessment. The Michigan Sea

Grant program provides some indirect opportunities for the Delphi techniques to contribute to the improvement of communications between researchers and decision makers. For example, an objective of the gaming-simulation project is to function as a communications mechanism through which research findings and results can be presented to local decision makers and leaders who will be invited to participate in gaming-simulation exercises. The substantive results of the Delphi exercises could provide the following types of inputs to the gaming-simulation activities.<sup>2/</sup>

1. Data which can be helpful in describing social, economic, and political forces affecting the region's development during the next twenty years
2. Regional planning strategies, listed in order of preference for both university researchers and regional planners
3. Problems and issues which provide the link between the simulated regional area and a set of decision roles which are gamed<sup>3/</sup>

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<sup>2/</sup> The gaming-simulation concept for the Sea Grant program is presented in "Developing Alternative Management Policies," Unpublished report, University of Michigan Sea Grant Office, 1971.

<sup>3/</sup> Ibid.



In addition, a Delphi methodology could be integrated with the gaming-simulation concept to provide a consensus of expert judgments regarding forecasts for the region and the consequences of alternative planning strategies. This would give the gaming-simulation exercises a more dynamic aspect and provide motivation for the participant.

#### General Applications of the Method

A Delphi inquiry interspersed with interpersonal techniques has advantages over other methods in a wide range of situations involving subjective judgments and group communication. . At a meeting of the District Commission for the Northwest Development District,<sup>4/</sup> interest was shown in an interim report on the Sea Grant Delphi exercises which outlined a simplified type of Delphi inquiry designed to make the monthly meetings of the commission more effective. Each county in the district is represented by a commissioner. The commissioner has advisory and decision-making authority for a program with the goal of improving the economic well-being of present and future inhabitants of the district.<sup>5/</sup> It was suggested by the conference that

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<sup>4/</sup> See Figure 1.

<sup>5/</sup> "Prologue for Accelerated Growth of Economy," Report of the Northwest Michigan Development District, Traverse City, Michigan, October 1968.

a Delphi inquiry would permit the commissioner and the people he represents to identify key items and issues for consideration jointly at the monthly meetings. The procedure would provide the commissioner with feedback regarding preferences, needs, and capabilities, and the people in the region would have assurance that their viewpoints were being solicited and fairly represented. Both groups would have a continuous accounting of the items considered by the commission, with some descriptive term denoting importance, desirability, feasibility, impact on other projects, and so forth. Commissioners who participate in several planning groups (city, township, county, and region) indicated that committee meetings make heavy demands on their time, particularly since considerable travel is involved. It was suggested that a continuous Delphi including planning groups whose interests overlapped and timed to support committee meetings would offer the following benefits in addition to those mentioned above:

1. Obviate the need for attendance at some meetings  
for some individuals
2. Better utilize the time spent at meetings
3. Improve communication among planning groups  
and avoid unnecessary duplication and conflict
4. Promote a better understanding of the complexities  
and interdependencies associated with the decision-  
making process

5. Concentrate attention on the most important issues
6. Help alleviate the information gap resulting from an overload of data

The Sea Grant Delphi exercises have provided some initial judgments of a multidisciplinary team of researchers and potential users of research data regarding: the importance and effects of technical, social, economic, and political developments; sources of pollution and recommended waste-water treatment and disposal systems; and regional opportunities, problems, and planning strategies. More important, a critical evaluation of the method has shown the potential of a Delphi inquiry for improving the dialogue between researchers and regional problem solvers.

## BIBLIOGRAPHY

### Books

- Brech, Ronald. Britain 1984: Unilever's Forecast--An Experiment in Economic History of the Future. London: Darton, Longman, and Todd, Ltd., 1963.
- Bright, James R., ed. Technological Forecasting for Industry and Government. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968.
- Drucker, Peter F. The Age of Discontinuity. New York: Harper & Row, Publishers, 1969.
- Jantsch, Erich. Perspectives of Planning. Paris: Organisation for Economic Cooperation and Development, 1969.
- \_\_\_\_\_. Technological Forecasting in Perspective. Paris: Organisation for Economic Cooperation and Development, 1967.
- Kahn, H., and Wiener, A.J. The Year 2000: A Framework for Speculation on the Next 33 Years. London: Collier-Macmillan, Ltd., 1967.

### Articles and Reports

- Bright, James R. "Evaluating Signals of Technological Change." Harvard Business Review, XLVIII (Jan.-Feb. 1970), 62-70.
- \_\_\_\_\_. "An Academician's Introduction to Technological Forecasting," and "Some Insights from the Analysis of Past Forecasts." Papers presented at a conference entitled, "Technological Forecasting: An Academic Inquiry," Austin, Texas, Apr. 22-26, 1969.
- Carter, Anne P. "The Economics of Technological Change." Reprinted from Scientific American, CCXIV (Apr. 1966), 25-31.

Cetron, Marvin J., and Dick, Donald N. "Technological Forecasting-- Practical Problems and Pitfalls." Institute for Electrical and Electronic Engineers Transactions on Engineering Management, XVI (Nov. 1969), 161-72.

Chicago Tribune. "Traverse City's 'Shaggy' Waters Endanger Tourism." Oct. 26, 1970.

"Development Strategies--Upper Great Lakes Region." Annual Report of the Upper Great Lakes Regional Commission. Washington, D.C.: Government Printing Office, 1969.

Helmer, Olaf, and Rescher, Nicholas. "On the Epistemology of the Inexact Sciences." Management Science, VI (Oct. 1959).

Martino, Joseph P. "An Experiment with the Delphi Procedure for Long-Range Forecasting." Institute for Electrical and Electronic Engineers, Feb. 1967.

North, Harper Q. "A Probe of TRW's Future." TRW Corporation, July 1966.

North, Harper Q., and Pyke, Donald L. "Technological Forecasting in Planning for Company Growth." Institute for Electrical and Electronic Engineers Spectrum, VI (Jan. 1969), 30-36.

\_\_\_\_\_. "Technological Forecasting to Aid Research and Development Planning." Research Management, XII (July 1969).

Pyke, Donald L. "A Practical Approach to Delphi, Technological Forecasting, and Long-Range Planning." American Institute of Chemical Engineers, XV (Nov. 1969).

Sweet, David C.; Griffin, John M.; and Maggied, Hal S. Industries Suited for the Upper Great Lakes Region. Columbus, Ohio: Battelle Memorial Institute, 1970.

Turoff, Murray. "The Design of a Policy Delphi." Technological Forecasting and Social Change, II (Nov. 1970), 149-71.

\_\_\_\_\_. "The Delphi Conference." The Futurist, Apr. 1971.

\_\_\_\_\_. "Delphi and its Potential Impact on Information Systems." Paper 81. Washington, D.C.: Office of Emergency Planning Nov. 1971.

University of Michigan. Further Participation in the Sea Grant Institutional Support Program, 1970-71. A proposal to the National Science Foundation, Mar. 1970.

\_\_\_\_\_. Continued Participation in the Sea Grant Institutional Support Program, 1971-72. A proposal to the National Oceanic and Atmospheric Administration, II (Jan. 1971).

Umpleby, S. The Delphi Exploration: A Computer-Based System for Obtaining Subjective Judgments on Alternative Futures. Report F-1. Computer-Based Education Research Laboratory, University of Illinois, 1969.

Welty, Gordon. "A Critique of Some Long-Range Forecasting Developments." Proceedings of 38th Session of the International Statistics Institute. Aug. 1971.

Winkler, Robert L. "The Quantification of Judgment: Some Methodological Suggestions." Journal of the American Statistical Association, LXII (Dec. 1967).

\_\_\_\_\_. "The Consensus of Subjective Probability Distributions." Management Science, XV (Oct. 1968), 61-75.

\_\_\_\_\_. "The Assessment of Prior Distribution in Bayesian Analysis." Journal of the American Statistical Association, LXII (Sept. 1967).

Series of reports issued by the  
Institute for the Future presenting the  
findings of studies on the development  
of long-range forecasts of tech-  
nological and social events

de Brigard, Raoul, and Helmer, Olaf. "Some Potential Societal Developments: 1970-2000." Report R-7 (to be published).

Enzer, Selwyn. A Case Study Using Forecasting as a Decision-Making Aid. WP-2.1970.

Enzer, Selwyn, and de Brigard, Raoul. Issues and Opportunities in the State of Connecticut: 1970-2000. Report R-8. 1970.

Enzer, Selwyn; Gordon, Theodore J.; Rochberg, Richard; and Buchele, Robert. A Simulation Game for the Study of State Policies. Report R-9. 1969.

Gordon, Theodore J., and Ament, Robert H. Forecasts of Some Technological and Scientific Developments and Their Societal Consequences. Report R-6. 1969.

Helmer, Olaf; Gordon, Theodore J.; Enzer, Selwyn; de Brigard, Raoul; and Rochberg, Richard. Development of Long-Range Forecasting Methods for Connecticut: A Summary. Report R-5. 1969.

Rochberg, Richard; Gordon, Theodore J.; and Helmer, Olaf. The Use of Cross-Impact Matrices for Forecasting and Planning. Report R-10. 1969.

\_\_\_\_\_. Research on Cross-Impact Techniques with Applications to Selected Problems in Economics, Political Science, and Technology Assessment. Report R-12. 1970.

Publications of the RAND Corporation  
Santa Monica, California

Dalkey, Norman C. The Delphi Method: An Experimental Study of Group Opinion. RM-5888-PR. June 1969.

Gordon, T.J., and Helmer, Olaf. Prospects of Technological Progress. P-3643. Aug. 1967.

\_\_\_\_\_. Systematic Use of Expert Opinions. P-3721. Nov. 1967.

\_\_\_\_\_. Report on a Long-Range Forecasting Study. P-2982.  
Sept. 1964.

Helmer, Olaf. Analysis of the Future: The Delphi Method. P-2558.  
Mar. 1967.

\_\_\_\_\_. Systematic Use of Expert Opinions. P-3721. Nov. 1967.

\_\_\_\_\_. Methodology of Societal Studies. P-3611. June 1967.

Working Papers Issued by the Sea  
Grant Advisory Services

Ludlow, John D. "The Delphi Method: A Systems Approach to the Utilization of Experts in Technological and Environmental Forecasting." Working Paper No. 3. Ann Arbor, Mich.: Bureau of Business Research, Graduate School of Business Administration, University of Michigan, Mar. 1970.  
(Multilith.)

\_\_\_\_\_. "Sea Grant Delphi Exercises: Techniques for Utilizing Informed Judgments of a Multidisciplinary Team of Researchers." Sea Grant Technical Report No. 5. Ann Arbor, Mich.: Sea Grant Office, University of Michigan, 1971. (Multilith.)

\_\_\_\_\_, and Braden, Patricia L. "Socioeconomic Development in the Grand Traverse Bay Area." Sea Grant Technical Report No. 8. Ann Arbor, Mich.: Sea Grant Office, University of Michigan, 1971. (Multilith.)

Warner, Katherine P., and Borton, Thomas E. "Developing Alternative Management Policies." Unpublished report, University of Michigan Sea Grant Office, 1971.