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The role of science and scientists in marine environmental policy and management

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The College of William and Mary in Virginia PH.D. 1986

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THE ROLE OF SCIENCE AND SCIENTISTS IN MARINE ENVIRONMENTAL POLICY AND MANAGEMENT

A Dissertation

Presented to

The Faculty of the School of Marine Science

The College of William and Mary in Virginia

In Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

by

Teny Topalian

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APPROVAL SHEET

This dissertation is submitted in partial fulfillment of
the requirements for the degree of

Doctor of Philosophy

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ABSTRACT

The role of science and scientists in environmental policy and management is and has been an important, complex, and controversial subject for many years.

The objective of this study is to determine how science and scientists interact in environmental policy formation and management and how science is or could be used in the development of policy which can ultimately be used as a basis for effective resource management plans.

In the very broad sense this study attempts to evaluate the general hypothesis that "Scientists do not play a role in promoting or encouraging science as a means of changing attitudes and opinions of management and the public so as to influence public policy and ultimately environmental management."

The use of science in establishing well developed management plans for coral reef areas in Australia's Great Barrier Reef; Jamaica's - Ocho Rios Marine Park System; St. Croix's - Buck Island; Anguilla; the Netherlands Antilles - including Bonaire and Curacao Marine Parks; Puerto Rico's - La Parguera National Marine Sanctuary; and several of the Florida State reefs such as Key Largo and Looe Key Marine Sanctuaries were examined through analysis of management plans.

The second component of the study involved structured interviews with a number of scientists and managers. These individuals included scientists who had been working on coral reefs as well as managers of these systems - individuals who have an interest in formulating public policy as well as those who do not have. The general hypothesis was divided into a number of statements or subhypotheses which were examined to help evaluate the hypothesis. Close-ended questions allowed the opportunity for statistical analysis and open-ended questions allowed determination of the reasons why scientists and/or managers feel the way they do in their responses. Appropriate statistics were used to determine if there is a difference in the way scientists perceive their role, as compared to how managers perceive the role of scientists. The null hypothesis that no significant difference exists between attitudes of scientists and managers could not be rejected. The general hypothesis was accepted both by scientists and managers.

THE ROLE OF SCIENCE AND SCIENTISTS
IN MARINE ENVIRONMENTAL POLICY AND MANAGEMENT

INTRODUCTION

The role of science and scientists in environmental policy and management has been an area of important, complex, and controversial debate for many years (Haskins, 1964; Dubos, 1970; George, 1970; Ben-David, 1971; Grobstein, 1982; Mullineaux, 1982).

The purpose of this study is to determine how science comes to be used in policy and management and particularly the role scientists play.

Scientists and policy-makers are uncertain how scientific facts are to be integrated with social values. Scientists are uncertain as to whether they should merely present facts, leaving the policy judgement entirely to the political decision-makers, or whether they should also advise politicians which course the scientist believes to be best. Politicians are also uncertain as to how much scientific information they are supposed to absorb and how much dependence they should place on scientists for guidance in reaching a judgement about policy (Grobstein, 1982).

In this study, two contrasting viewpoints of the role of the scientist were examined:

1) Scientists should only be responsible for presenting unbiased information and must leave final decisions to the policy-makers and the public.
2) Scientists should provide advice with regard to the implications of scientific information and offer policy judgements.

The first view is represented by Handler, former President of the National Academy of Sciences in the Wall Street Journal of 1975 (in Mullineaux, 1982). According to him, once the scientific community has presented the facts it must leave final decisions to the policy-makers and the public. Similarly, two Executive Orders (1918, 1956) concerning the role of the National Research Council in the past have stated that scientists are to render information to those who are entitled to receive it, but they do not imply that scientists should offer their judgement as to what public policy should follow from their studies.

Dubos (1961) in The Dreams of Reason embodies the second viewpoint: "It is for society, of course, to decide what goals it wishes to reach and what risks it is willing to take. But it is the task of the scientific community to formulate as clearly as possible and to make public the probable consequences of any step that it takes and of any action that it advocates. In other words, the responsibility of the scientist does not stop when he has developed the knowledge and techniques that lead to a process or a product. Beyond that, he must secure and make public the kind of information on which the social body as a whole can base the value-judgements that alone will decide policies."

Does the scientist now inform fellow citizens on important science-based issues? A related question is: Should he or she have the responsibility to do so? Before answering this, it is important to understand a number of concepts such as attitudes, beliefs, values and opinions; to comprehend how scientists function; and to know attitudes the public has towards science. It is only after doing so, that the issue of effective communication on scientific aspects of vital issues can be addressed.

It can be argued that many natural scientists are notably "single-minded" and professionally "simple-minded". They are "single-minded" in their conviction that expansion of scientific knowledge and its application is highly desirable, will bring abundant benefits, and ultimately can yield definitive solutions to most problems. They are "simple-minded" in that their forte is in framing questions in isolation from complicating social contexts. They create controlled study environments in problem-solving-laboratories and frame narrow hypotheses as a framework for their field observations. Usually, this leads to "clean", decisive answers to questions that have been isolated from usual "real world" situations. Their training and experience teaches them to sniff out and exclude special interests, hopes, values, and aspirations when approaching a problem (Grobstein, 1982).

Yet, does public policy seek objective truth or accommodation of conflicting views? Attitudes, values, and aspirations are important factors to be taken into account. Is there an essential role for scientific and technological input to policy analysis? Is this role to open the decision process to the public - recognizing that in human affairs, values, hopes and aspirations are often as important, or even more important, than neutral, objective facts? These are some of the ethical considerations inherent in this study.

In order to understand how the scientist functions, if he/she is effective, or how the output (products of science) is incorporated or evaluated in policy and management, it is important to understand the difference between several terms such as attitudes, beliefs, opinions, values and habits.

According to Allport (1968), an attitude is a mental or neural state of readiness, organized through experience, exerting a direction or dynamic influence upon the individual's response to all objects and situations with which it is related.

Concepts that are related to attitude include the following:

"Belief" - Fishbein and Ajzen (1972) define beliefs as statements indicating a person's subjective probability that an object has a particular characteristic. This viewpoint holds that beliefs are cognitive - thoughts and ideas, whereas attitudes are affective - feelings and emotions.

"Opinion" - One viewpoint equates opinions with beliefs; they are generally narrower in content or scope than the broad orientation which one calls attitude, and they are primarily cognitive rather than emotion-laden. Or, one may say opinions involve a person's judgements, whereas attitudes involve a person's wishes and desires (McGuire, 1960).

"Value" - The most common view is that a value is an important life goal or standard of behavior for a person - a standard toward which the individual has a strong positive attitude. Values are the most important and central elements in a person's system of attitudes and beliefs. They are ends rather than means; they are goals a person strives for and which help to determine many of his or her other attitudes and beliefs.

"Habit" - Habits can be easily distinguished from attitudes. They are frequently repeated patterns of behavior, whereas attitudes are not behavior. Habits are usually quite automatic and standardized in their manner of performance, but they require the presence of the appropriate stimulus object in order to occur. By contrast, attitudes may be expressed in the absence of the stimulus object. Like attitudes, habits are acquired through experience; but unlike them, they are frequently nonevaluative in nature.

In order to look at the process of incorporating science into environmental policy, coral reef management has been chosen for investigation and analysis. This area is a subset of the general problem of submerged lands management. Coral reef areas have been chosen partly because the issues in submerged lands management have not generated the polarization of opinion that surround many environmental issues (i.e. acid rain, strip-mining, nuclear power generation, etc.). In addition, there is a long history of submerged land management for single purposes, such as sand and gravel-mining and oil recovery, which until recently has not concerned itself with environmental issues. In recent years, however, environmental concerns in this area, as in many others, have taken on increasing importance. Much environmental concern and scientific study has been focused on coral reefs.

In trying to determine how the various players, i.e. scientists, managers and policy analysts view the role of scientists, a synthesis of the science used to understand coral reefs will be developed to allow evaluation of how this scientific information has been used or not used in management or policy forming processes.

Coral Reefs

Besides intrinsic beauty, there are also important economic and ecological values attributed to coral reefs. Reef fish are important sources of protein and food for many people living in the Tropics (Ehrlich, 1981). They are also an aesthetic resource important to the tourist industry, especially for SCUBA-diving and snorkeling. Some corals are used in jewelry production. Reef areas are of high productivity within the relatively unproductive ecosystems of the tropical seas (Grassle, 1973). Coral reefs are also thought to protect nearby shores and harbors from erosion and wave action (Levinton, 1982). Healthy reefs play a role in beach stability. When living corals on the reefs begin to die, the structural framework of the reef begins to erode at a faster rate than it can be rebuilt by the remaining live corals, and the reef structure becomes weakened. Weakened and eroded reef structures sharply increase the likelihood of extensive damage to beach properties during times of tropical depressions, storms and hurricanes (Levinton, 1982). Reefs create vast evaporation lagoons between themselves and tropical shores which may be involved in regulating the salt content of the oceans. They are known for their tremendous diversity and complexity of living organisms (Grassle, 1973). Coral reefs provide the feeding grounds for reef organisms as well as shelter and habitat (Ehrlich, 1981).

The aesthetic, economic and ecological values of coral reefs have been extensively documented (Proceedings of the Third International Coral Reef Symposium, 1977; Proceedings of the Fourth International Coral Reef Symposium, 1981; Odgen and Gladfelter, 1983).

In some areas of the world concern over deterioration or destruction of reefs, particularly that attributed to man, has led to development of management strategies or plans to protect these resources. For instance, in Australia, the Great Barrier Reef is protected by a comprehensive marine resource management program. In the United States specific coral areas have been set aside as marine sanctuaries, i.e. St. Croix - Buck Island; Puerto Rico - La Parguera; Florida - Looe Key and Key Largo.

There is extensive documentation of deleterious impacts of man on coral reefs (McCloskey and Cheser, 1971; Fishelson, 1973; Campbell, 1977; Kinsey and Davies, 1979; Walker and Ormond, 1982; Dodge et al., 1984). Many of the individual practices detailed in the planning documents or regulations used to manage coral reef areas are based on this documentation. How was the information on man's impacts presented to the policy-makers? What role did scientists play in this transfer? These are the questions that I will attempt to answer.

Is this topic, coral reef management, a suitable subject for a study of the role of science and scientists in environmental management? I believe it is! One advantage of this area as a topic for case study is the lack of extreme polarization on the overall importance of these areas. There may be differences on specific issues, but there are no strong proponents of wholesale destruction of coral reefs.

One area I have selected for particular study is the Great Barrier Reef of Australia. The Great Barrier Reef is considered to be a world heritage that must be preserved (Commonwealth of Australia, 1981).

The Commonwealth of Australia and the State of Queensland, through the Great Barrier Reef Marine Park Authority (GBRMPA) are embarked on a coastal and marine resources management program of tremendous scope and significance.

The Australian section of the Great Barrier Reef, off the northeast shore of Queensland, is about 1,200 miles (2,000 km.) long, encompassing approximately 80,000 square miles (207,000 sq. km.). There are 1,500 to 2,000 identified reefs. About 70 of these have developed reef cays (coral sand islands), which are important for bird breeding and nesting. The Reef is of world significance for turtle breeding. Six species of turtles are present. About 2,000 species of fish and 400 species of coral are native. Dugongs, dolphins and whales use the Reef lagoon. There are research field stations on Heron, Lizard and Orpheus islands.

The Great Barrier Reef Marine Park Authority Act of 1975 created a statutory authority mandated to establish plans for multiple-use management of the Barrier Reef region. Basically, GBRMPA is responsible for:

1) the conservation of the Great Barrier Reef,
2) the regulations for use of the Marine Park, to protect the Reef while allowing reasonable use,
3) the regulation of activities that exploit the resources of the Reef to minimize the effect of these activities on the Reef,
4) the reservation of some areas of the Reef for appreciation and enjoyment by the public,
5) the preservation of some areas of the Reef in its natural state except for purposes of scientific research.

Three bodies play specific roles in developing and/or approving policy for proper management and conservation of the Great Barrier Reef. These are:

1) a Queensland - Commonwealth Municipal Council,

2) a three-member governing Authority,

3) a 15-member Consultative Committee.

It seems that much is being done in Australia in the way of policy-making and management of coral reefs.

OBJECTIVE

The objective of this study is to see if science and scientists play a role in policy formation and management or how science is used in the development of policy which can ultimately be used for an effective management plan. This involved examining what scientists are doing and have done, determining if they have been effective, and if not, why not?

HYPOTHESIS

During the course of this study, a general hypothesis was evaluated:

> "Scientists do not play a role in promoting or encouraging science as a means of changing attitudes and opinions of management and the public so as to influence public policy and ultimately environmental management."

Concerned laymen claim that managers have often ignored science in efforts to serve development-minded clientele. Is this true? And if so, can one perhaps foresee the role of the scientist changing from one who only "seeks truth and knowledge" to one who also is concerned with the utilization of this knowledge in policy matters for management plans through direct intervention as an advisor or activist?

METHODS

A case study approach using coral reefs was taken which was supplemented by questionnaires completed during interviews.

Management plans exist for coral reefs in such areas as Australia's Great Barrier Reef (Salm and Clark, 1984); Jamaica's Ocho Rios Marine Park System (Mailer, 1984); Anguilla (Jackson, 1981); St. Croix's Buck Island (DOI, 1983); the Netherlands Antilles including Bonaire (Van't Hof, 1982) and Curacao Marine Parks (Van't Hof, 1985); Puerto Rico's La Parguera National Marine Sanctuary (DOC, 1983); and several of the Florida reefs such as Key Largo (DOC, 1979) and Looe Key Marine Sanctuaries (DOC, 1983). The use of science in development of these plans was examined.

The management plans of the individual reef areas were thoroughly analyzed. The extent to which natural resources of the marine park or sanctuary were described, and the uses, impacts, and objectives of the plans were evaluated. The use of science in management was examined, particularly as to whether primary or secondary sources were employed. The case studies reviewed the scientific justification for policy and/or management approaches and tried to determine how this information was transmitted to the policy definers or managers. In other words, what is the source of science used for management plans or policies? Is it from primary, refereed, literature, management-oriented "grey" literature reports, or popularized articles? Do the interpretations come from scientists themselves, or are they evaluated by scientifically trained bureaucrats? Is there a relationship between expected results published in the scientific literature and actual management plans? How the management plans were developed, whether or not they are effective, and what recommendations can be made for improvement were the subjects of analysis. Particular attention was paid to developing examples of how scientific interaction has resulted in specific regulations or policies.

Interviews made up the second component of the study. In order to evaluate the general hypothesis, an attempt was made to evaluate the following ten sub-hypotheses, or propositions:

1) If scientific research is "pure" or "basic," then the results will not be directly utilized.
2) The more formal education one has, the more one will utilize the scientific information relevant to policy-making and/or management decisions.
3) Scientists in natural resource fields do not give advice that has applicability to immediate problems in management.
4) Scientific advice is sought from research personnel to gain support for opinions and objectives rather than obtain unbiased advice on management choices.
5) Scientists are not "actively" involved in influencing public policy.
6) Scientists involved in management decision-making violate the scientific ethic of avoiding bias in their actions.
7) Research reports are often written in language that neither "managers" nor the "public" can understand.
8) Scientists seldom communicate their knowledge to the public effectively.

9) Scientists feel that they should not concern themselves with attitudes, values and beliefs the public has towards management of resources, nor do they feel it is their "duty" to change them.
10) Scientists feel that their role is only to seek knowledge and truth; that they are not qualified to make value-judgements.

A pilot test was given to one individual from Jamaica, one individual from Puerto Rico, and 16 individuals on the staffs of the Virginia Institute of Marine Science (scientists) and the Virginia Marine Resources Commission (managers). The results of this pilot test were used to develop the test vehicle.

For each of these 10 sub-hypotheses, questions (both close-ended and open-ended) were developed for use during interviews. The interviews consisted of asking 10 open-ended questions followed by 50 close-ended statements (see Appendix A). One must note here that these sub-hypotheses were basically statements which provided the relative framework for the study and were not necessarily proven or disproven. But they did, when considered with the results of questionnaires and interviews, help to determine the attitudes of scientists and managers in environmental management and policy. Also, they did assist in evaluating how the various individuals perceived the role of the scientist. The close-ended questions allowed the opportunity for statistical analysis. Open-ended questions allowed the interviewer to probe for the reasons why scientists and/or managers made their responses.

Structured interviews were conducted with a number of scientists and managers responsible for marine environmental policy formation. Thus, the primary data for this portion of the study were collected by interviewing individuals who were or are presently playing an active role in the development of coral reef policy and those active or formerly active in coral reef research.

Thirty-six individuals were interviewed (18 managers and 18 scientists). The interviews lasted between one and four hours per person, the majority running two hours (see Appendix B). Respondents classified themselves as scientists or managers. The respondents were chosen from different categories of employment, with varying degrees of experience and education in their backgrounds (Tables 1 and 2).

Personal interviewing was the preferred method of collecting data. Due to the nature of the information sought, it was felt that a potential respondent might not understand a mailed questionnaire. It was also important for the interviewer to have the opportunity to perceive any kind of possible resentment and reduce its effects. Because responses to the questionnaire were obtained during trips to Washington, D.C., and various places in Florida, I was able to evaluate and gain considerable insight as to how interviewees perceive the role of the scientist. The probes allowed for much discussion and better rapport which proved to be invaluable for interpretation of data. Most individuals responded with openness and no apparent constraints. Confidentiality of specific statements made by specific individuals has been respected. As desirable as face-to-face interviews were, a few telephone interviews were necessary.

An interview schedule with pertinent questions was prepared to structure the interviews so that information obtained on the hypothesized factors was as uniform as possible. In order to be as consistent as possible, I conducted all the interviews.

TABLE I

EMPLOYMENT OF SCIENTISTS AND MANAGERS PARTICIPATING IN INTERVIEWS

Respondents	EMPLOYMENT			
	Federal Government	State Government	University	Private
Scientists	9	3	3	3
Managers	15	1	0	2

TABLE 2

HIGHEST ACADEMIC DEGREE HELD BY INDIVIDUALS PARTICIPATING IN INTERVIEWS

	DEGREES					
	BA/BS		MA/MS		PhD	
Respondents	Science	Nonscience	Science	Nonscience	Science	Nonscience
Scientists	2	0	6	0	10	0
Managers	3	0	6	6	3	0

A search of Environmental Bibliography (which covers fields of general human ecology, atmospheric studies, energy, land resources, water resources and nutrition and health; with more than 300 periodicals indexed from January 1974-March 1986) indicated 303 papers published on the subject "coral" (including coral reefs, coral reef management and/or impacts). Four hundred and seventy different authors presented papers at the Proceedings of the Fourth International Coral Reef Symposium in 1981. Based upon these figures, I estimate the number of scientists and managers publishing in the area of coral reef or coral reef management at 300-600 individuals. My sample size of 36, therefore, probably represents 6%-12% of the population. I consider this a "good" sample. With this large sample size to population size ratio, I can confidently assume that another sample of equal size would give similar responses.

Appropriate statistics such as chi-square (Ferguson, 1971) and Likert mean scores (Blalock, 1974) were used to evaluate responses to close-ended questions. The reliability of Likert scales as a method of measuring attitudes has been shown to be high (Murphy and Likert, 1938; McNemar, 1946; Poppleton and Pilkington, 1964). In this method, a large number of opinion statements on a given topic are collected and phrased in such a way that they can be answered on a five-point scale. This procedure is based on the assumption that all of the items are measuring the same underlying attitude. As a consequence of this assumption, it follows that all items should be positively correlated, which may impose constraints. A number of variations have gained wide usage. One variation is to eliminate the "undecided" category (which was done for this study), thus forcing respondents to choose between favorable and unfavorable stances (Oskamp, 1977). The null hypothesis states that no actual differences exist between the observed and expected frequencies. The chi-square distribution is used to test significance of the null hypothesis. Responses may be reduced to a 2 x 2 table in order to test significance of chi-square. This procedure has been adopted for this study and considered legitimate. The procedure for testing the significance of the difference between both independent and correlated proportions was adopted (Ferguson, 1971).

The discussion and analysis of the responses are presented in the form of arguments for and against the stated hypothesis.

RESULTS

Analysis of Questionnaire

Tables 3-12 summarize the responses given to questions by environmental managers and scientists under each of the 10 propositions. Calculations of chi-square for each of the questions as well as Likert mean scores for appropriate questions are tabulated. No significant differences were detected between attitudes of scientists and managers for all but three questions, numbers 28, 31 and 42. The probes, however, lead to discussions during the interviews which revealed marked differences of opinions, attitudes and beliefs between scientists and managers.

The following are the results of the discussions of each proposition by scientists and managers.

[1] If Scientific Research Is "Pure" Or "Basic", Then The Results Will Not Be Directly Utilized

The null hypothesis that no significant difference exists between attitudes of scientists and managers cannot be rejected (Table 3).

Managers and scientists gave similar opinions as to why they considered there to be a difference between "applied" versus "basic" research. "Basic" research was thought to be "investigating questions for purely academic reasons, science for science's sake, searching for answers to questions for the purpose of scientific discovery. It is a satisfaction of intellectual curiosity about a process with no vested

TABLE 3

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: IF SCIENTIFIC RESEARCH IS "PURE" OR "BASIC", THEN THE RESULTS WILL NOT BE DIRECTLY UTILIZED.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
1	*Scientists	56	22	22		0.17	1.66
	*Managers	66	17	17			1.50
2	Scientists	22	17	50	11	0.00	2.50
	Managers	6	33	61			2.55
3	Scientists	6	66	22	6	0.14	2.27
	Managers	22	56	17	6		2.05
4	Scientists	6	33	50	11	0.00	2.66
	Managers		39	56	6		2.66

* Total number of scientists = 18
Total number of managers = 18

1. There is a difference between "pure" or "basic" research and "applied" research.
2. Scientists involved in "pure" research are not likely to be directly interested in how their findings will be utilized or applied in policy formation or in management plans.
3. In general, "grey" literature scientific reports published by government agencies and/or universities are useful to either scientists or managers in their planning of management projects.
4. Scientific criticism of a management proposal causes management agencies to take account of the "pure" research literature.

interests nor motives and with no application, material gain, nor guidance. It is the freedom to wonder and pursue any study." "Applied" research was thought "to have immediate application, with a specific reason or problem that requires a specific end product. The problem is previously defined, and the answers will be immediately used to provide a benefit to society." Managers added that it deals with management issues and is "directed research with a directed application."

Quite a few scientists and managers (61%) (Table 3, Question 2) believed that scientists involved in "pure" research are interested in how their research will eventually be applied. One reason given was that scientists have an "ego"; they want their work to be of some value or use so that it will not be forgotten. Some managers believed that "even though "pure" scientists are interested in having their work applied to management problems, it is naive on the scientists' part to think so, because "pure" research usually is not applicable."

Scientists (72%) and managers (78%) (Table 3, Question 3) both find "grey" literature useful, and when there is scientific criticism of a management proposal, management agencies will take account of the "applied" research. "Pure" research usually would not be considered by management. Managers felt that there usually was not any criticism, and if there was, additional information, if valid, would just be incorporated into the plan without any further research.

Despite its recognized usefulness, certain weaknesses or concerns regarding "grey" literature were expressed by respondents. These concerns were: lack of scientific or technical rigor, lack of wide circulation, lack of accessibility, and inability to learn of its existence. Despite criticisms of lack of scientific rigor, some managers felt even "grey" literature was often too technical and therefore difficult to read.

There was general consensus on this question. In general, the responses given by both scientists and managers support the proposition that "pure" research is not usually directly utilized. This is accounted for by the definitions given, by the importance given to "grey" literature and "applied" research to management and by the attitudes and reasons given as to why "pure" scientists are interested in the application of their work. A minority expressed the opinion that only a fine line exists between "basic" and "applied" research, for it is a continuum. To them there should not be a dichotomy; for if research is posing questions and using the scientific method, there should not be a distinction between "basic" and "applied" science.

[2] The More Formal Education One Has, The More One Will Utilize The Scientific Information Relevant To Policy-Making And/Or Management Decisions

The null hypothesis that no significant difference exists between attitudes of scientists and managers cannot be rejected (Table 4).

Both scientists (55%) and managers (33%) that agreed with this statement gave essentially similar reasons in response to the probes (Table 4, Question 5). Experience was considered more important than formal education. In fact, some managers believed that advanced training can be an impediment to the utilization of science in management because the advice would be too narrow and limited. This

TABLE 4

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: THE MORE FORMAL EDUCATION ONE HAS, THE MORE ONE WILL UTILIZE THE SCIENTIFIC INFORMATION RELEVANT TO POLICY-MAKING AND/OR MANAGEMENT DECISIONS.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
5	*Scientists	11	44	44		1.80	2.33
	*Managers		33	50	17		2.83

* Total number of scientists = 18
Total number of managers = 18

5. One's degree of formal education indicates the amount of scientific information one will utilize when making policy or management decisions.

proposition or sub-hypothesis was refuted by the answers given by both managers and scientists.

[3] Scientists In Natural Resource Fields Do Not Give Advice That Has Applicability To Immediate Problems In Management

The null hypothesis that no significant difference exists in attitudes between scientists and managers cannot be rejected (Table 5).

Scientists and managers (89%) thought that research on the applications of science is a valid and proper role for the scientist (Table 5, Question 6). Most believed that one is a scientist whether involved in "basic" or "applied" research.

Management decisions are thought to be influenced both by an individual scientist's work and the work done by the scientist's peers.

If the scientific study is designed specifically to direct management and if scientists communicate their data to the managers, then it was thought by more scientists (94%) than managers (72%) that scientific research helps solve some of the immediate problems in management (Table 5, Question 8).

Though most scientists felt that ideally they should volunteer advice or criticism on a management plan, especially if it goes contrary to their findings, they were still hesitant to do so. Their concerns were that once a plan is approved, it is too late to do something about it because managers will not listen at that point. Scientists only like to get involved with issues about which they feel strongly. Managers seemed to be bothered that scientists do not get

TABLE 5

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: SCIENTISTS IN NATURAL RESOURCE FIELDS DO NOT GIVE ADVICE THAT HAS APPLICABILITY TO IMMEDIATE PROBLEMS IN MANAGEMENT.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
6	*Scientists	33	56	11		0.00	1.77
	*Managers	33	56	11			1.77
7	Scientists		50	33	17	0.01	2.72
	Managers	11	22	61	6		2.61
8	Scientists	6	88	6		3.20	2.00
	Managers	11	61	28			2.27
9	Scientists	11	50	28	11	0.45	2.38
	Managers	6	44	50			2.44
10	Scientists		72	22	6	0.00	2.33
	Managers	11	61	28			2.16
11	Scientists		28	72		0.13	2.72
	Managers	6	27	61	6		2.66
12	Scientists			50	50	2.11	3.50
	Managers		11	33	56		3.38

* Total number of scientists = 18
Total number of managers = 18

6. Research on the applications of science is a valid and proper role for a scientist.
7. Most scientists try to influence management decisions based only on their own scientific work.
8. Scientific research helps solve some of the immediate problems in management.
9. Scientists often voluntarily offer advice or criticism on a management issue and/or option.
10. Scientists often voluntarily offer criticism on an approved management plan that appears to go contrary to their findings.
11. One of the functions of research scientists is to develop their findings into management techniques.
12. All research is geared towards "real world" problems.

involved from the beginning by giving their recommendations, yet complain about the plans at the end when an "institutional" decision has been made.

Most managers (67%) and scientists (72%) agreed that it is not the function of research scientists to develop their findings into management practices, rather it is the task of management agencies, for they felt that scientists are not trained to do so (Table 5, Question 11).

There was almost unanimous consent (100% scientists and 89% managers) that all research is not geared towards "real world" problems, nor should it be (Table 5, Question 12). The most common response was that scientists should be given the academic freedom to pursue any subject. Otherwise, dictating what study should be done was thought to be detrimental to independent thinking and creativity. In addition, some respondents felt that it would be impossible to define what a "real world" problem would be. All research was believed to have value, and at times the greatest advances were made in areas of research thought to be of least importance.

Although one cannot strongly accept or reject this proposition, the interviews seemed to indicate that advice to solve immediate problems in management is not often given by scientists.

[4] Scientific Advice Is Sought From Research Personnel By Managers To Gain Support For Opinions And Objectives Rather Than Obtain Unbiased Advice On Management Choices

The null hypothesis that no significant difference exists between attitudes of scientists and managers cannot be rejected (Table 6).

TABLE 6

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: SCIENTIFIC ADVICE IS SOUGHT FROM RESEARCH PERSONNEL TO GAIN SUPPORT FOR OPINIONS AND OBJECTIVES RATHER THAN OBTAIN UNBIASED ADVICE ON MANAGEMENT CHOICES.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
13	*Scientists	6	33	55	6	1.00	2.61
	*Managers	17	39	33	11		2.38
14	Scientists		50	44	6	1.87	2.55
	Managers		28	72			2.72
15	Scientists	11	83	6		2.09	1.94
	Managers	17	61	22			2.05
16	Scientists	6	83	11		0.36	2.05
	Managers	22	72	6			1.83
17	Scientists		61	39		0.12	2.38
	Managers		67	33			2.33

* Total number of scientists = 18
Total number of managers = 18

13. Managers constantly demand scientific information and knowledge from scientists to use in policy-making and for management decisions.
14. The information given by scientists to resource managers is often used to support the managers' opinion only.
15. The information given by scientists to resource managers is used to shed new light on management problems.
16. Upon planning a management project, a manager consults with such persons as experienced project planners, applied scientists, and engineers for advice.
17. Upon planning a management project, a manager consults with research scientists.

There was no consensus as to whether or not managers constantly demand scientific information and knowledge from scientists to use in policy-making and management decisions. Some scientists (39%) (Table 6, Question 13) thought that managers asked constantly, others thought they asked occasionally. Those scientists who did not mind being asked felt that they are not often asked because managers either did not trust them or did not want interference. Other scientists minded being asked when they were not interested in getting involved. Managers in general felt that scientists do not mind being asked, but when quick answers cannot be given by scientists, they must make decisions without scientific input.

While developing a management plan, managers consulted project planners and "applied" scientists more so than "basic" scientists. Engineers were rarely consulted. Much depended on the project itself and the manager's background. Managers felt that many scientists did not help them in long-term planning, rather they proposed research topics that interested the scientists themselves.

There was no clear-cut consensus as to whether or not unbiased information was sought to shed new light on management problems or the information sought from scientists was to support the manager's opinion. Some scientists believed that unbiased advice is taken, other scientists disagreed. Others admitted that due to time constraints and politics, a manager may have a preconceived idea and seek scientists who will support institutional desires.

There is no conclusive opinion on this proposition. If scientists are consulted, which does not seem to be often, at times it may be to support the manager's opinion and at other times to obtain unbiased advice.

[5] Scientists Are Not "Actively" Involved In Influencing Public Policy

The null hypothesis that there is no significant difference between the attitudes of scientists and managers cannot be rejected (Table 7).

Through discussions held with interviewees, four models of participation in policy-making were identified:

1) active involvement in all three phases,
2) lesser involvement in later phases,
3) passive involvement in initial phases,
4) no involvement in any phase.

Some believed policy-making is outside the domain of expertise of the scientist. Others believed that so long as scientists do not lose their integrity and credibility, they should not be excluded from the process. Otherwise, it was felt that without scientific input, decisions would only be based on politics and economics.

In general, more managers (78%) than scientists (56%) thought that scientists concerned themselves with influencing policy (Table 7, Question 20). Managers felt that scientists could be very opinionated and should at times make strong statements as a social obligation.

Most scientists (88%) and managers (84%) agreed that it is not appropriate for scientists to represent themselves as experts in an area not directly in their field of experience during formal proceedings involving policy matters (Table 7, Question 19). The main objection was that there would be misinterpretations of scientific facts. It was thought that getting involved as citizens would be more appropriate.

TABLE 7

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: SCIENTISTS ARE NOT "ACTIVELY" INVOLVED IN INFLUENCING PUBLIC POLICY.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
18	*Scientists		33	61	6	0.13	2.72
	*Managers	11	17	72			2.66
19	Scientists	27	61	6	6	0.23	1.88
	Managers	6	78	16			2.11
20	Scientists	11	33	39	17	2.00	2.61
	Managers		22	56	22		3.00

* Total number of scientists = 18
Total number of managers = 18

18. It is appropriate for scientists to play an "active" role during the fact-gathering phase of policy-making, but not during policy development and promulgation.
19. It is not appropriate for scientists to represent themselves as a scientific expert in a controversial policy matter in an area not directly in their field of experience or in which they have not done specific research during formal proceedings.
20. Scientists do not at all want to concern themselves (or be burdened) with influencing or forming public policy.

Scientists and managers expressed different opinions as to how actively scientists are or should be involved in public policy. It seems that scientists are more often involved in only certain phases of public policy than in all phases.

[6] Scientists Involved In Management Decision-Making Violate The Scientific Ethic Of Avoiding Bias In Their Actions

The null hypothesis that no significant difference exists between attitudes of scientists and managers cannot be rejected (Table 8).

Scientists and managers unanimously (100%) agreed that when managing a resource, not only must the scientific information relevant to the natural resource be considered, but cultural, social, economic and political factors are also of importance (Table 8, Question 21).

Almost all respondents agreed that they must "manage people" as well. Three separate approaches to management came about from the discussions:

1) educate or guide people passively,
2) indoctrinate people unfamiliar with the resource,
3) force upon people certain ideas pertaining to the values of resources.

No matter what term was used, all agreed that "something must be done to meet management goals." "Without recognition and respect, goals and objectives can be useless."

Most scientists (94%) and managers (78%) thought that scientific research involves adhering to a set of scientific ethics or codes (Table 8, Question 22). When asked what these ethics are, the main response was honesty. Other responses included:

TABLE 8

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: SCIENTISTS INVOLVED IN MANAGEMENT DECISION-MAKING VIOLATE THE SCIENTIFIC ETHIC OF AVOIDING BIAS IN THEIR ACTIONS.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
21	*Scientists			61	39	0.00	3.44
	*Managers			44	56		3.55
22	Scientists	44	50	6		2.09	1.66
	Managers	17	61	22			1.94
23	Scientists		6	61	33	1.12	3.27
	Managers		17	78	5		2.88

* Total number of scientists = 18
Total number of managers = 18

21. When "managing" a resource, only scientific information relevant to the natural resource is appropriate for consideration.
22. Scientific research involves adhering to a set of scientific ethics or codes.
23. Scientists violate scientific ethics when they become directly involved in management decisions.

1) unbiased presentation of data,
2) seeking the truth,
3) adhering to the scientific method,
4) reproducibility of work,
5) openness and integrity,
6) objectivity and accountability,
7) conducting original research,
8) curiosity,
9) not misusing funds for research.

These ethics were thought to have been derived historically from common law, western civilization and Greek philosophy based on rationality, and through common sense and past experiences.

Respondents mentioned two forms of motivation. External motivation includes factors such as peer pressure. Internal motivation includes interest in one's work, making a living, being conscientious and honest, desiring to advance knowledge, and making a positive contribution to society. Achieving self-worth, self-esteem or acceptance were other motivations, all of which require one to have self-motivation and self-discipline.

At the opposite end a minority of managers (22%) and scientists (6%) thought that scientific ethics do not exist (Table 8, Question 22). "That one need not have ethics to be a scientist, for it would be too rigorous." They contended that "it was not uncommon for a scientist to manipulate the data for desirable results, especially in applied research."

A few scientists (6%) and managers (17%) were of the opinion that scientists violate scientific ethics when involved in management decisions because often the scientific method must be compromised (Table 8, Question 23).

Although most respondents said that scientists do not have moral authority, a few thought they do because scientists possess knowledge.

When asked if scientists are torn between scientific ethics and political ethics, the responses were:

1) they are not, because both are the same ethics;
2) they are not, because being different ethics, there should be no conflicts;
3) scientists have convictions, whereas politics is the art of the possible whereby compromises are made by politicians.

For the most part, from the responses given, one may reject the proposition that scientists involved in management decision-making violate scientific ethics.

[7] <u>Research Reports Are Often Written In Language That Neither Managers Nor The Public Can Understand</u>

Two questions, numbers 28 and 31, were answered differently by scientists and managers. For all other statements, the null hypothesis that no significant difference between these groups exists cannot be rejected (Table 9).

Though scientists are thought to be involved in more than one project at a time, rarely are the projects significantly different from each other. A majority of respondents (89% of the scientists and 73% of the managers) agreed that scientists are not able to keep up with the most recent literature in areas in which they are not actively working, though they have a better grasp of the scientific

TABLE 9

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: RESEARCH REPORTS ARE OFTEN WRITTEN IN LANGUAGE THAT NEITHER "MANAGERS" NOR THE "PUBLIC" CAN UNDERSTAND.

Question	Respondents	RESPONSES % (percent) Strongly Agree	Agree	Disagree	Strongly Disagree	CHI-SQUARE Significant X^2 is 3.84 at .05 level	LIKERT Mean Scores scale runs from 1=strongly agree to 4=strongly disagree
24	*Scientists	22	67	11		0.23	1.88
	*Managers	17	66	17			2.00
25	Scientists	5	67	17	11	1.59	2.33
	Managers		89	11			2.11
26	Scientists		17	66	17	2.21	3.00
	Managers		39	61			2.61
27	Scientists			50	50	2.00	3.50
	Managers		12	44	44		3.33
28	Scientists	6	83	11		<u>6.41</u>	2.05
	Managers		50	50			2.50
29	Scientists	33	61	6		0.00	1.72
	Managers	22	72	6			1.83
30	Scientists		39	61		1.17	2.61
	Managers	6	16	72	6		2.77
31	Scientists		17	63		<u>5.89</u>	2.83
	Managers	17	39	44			2.27

* Total number of scientists = 18
Total number of managers = 16

24. Scientists are not able to keep up with the most recent literature in areas in which they are not actively working.
25. Most research reports can be read and understood by scientists.
26. Most research reports can be read and understood by resource managers.
27. Most research reports can be read and understood by the public.
28. Research on management questions is done by scientists in a number of different disciplines such as meteorologists, physicists, biologists, chemists, geologists and engineers (to name a few). The language of their reports is too difficult for managers to comprehend.
29. It is appropriate to describe the statistical analysis used in research in material published for the scientific community.
30. It is not appropriate to describe the statistical analysis used in research reports geared for the manager or the public for (or during) their decision-making process.
31. Research scientists qualify the results of their study too much.

literature than non-scientists (Table 9, Question 24). Scientists try to keep up with the literature by reading journals, attending professional meetings and conversing with colleagues.

More managers (89%) than scientists (72%) thought that most research reports can be read and understood by scientists (especially if it is within their field). Only 17% of the scientists and 39% of the managers agreed that managers could understand most research reports (Table 9, Questions 25, 26). Though scientists believed that managers with scientific backgrounds should be able to read and understand the reports, managers complained that at present, the way reports are written, they cannot read them. Both groups suggested two reports, one for the technical person and one for the manager, should be prepared. Managers felt that though executive summaries were available, they were often not well written. One hundred percent of the scientists and 88% of the managers thought that most research reports cannot be read and understood by the public simply because the public is not scientifically literate (Table 9, Question 27).

There was disagreement between scientists and managers as to managers' comprehension of the language used in research reports. Eighty-nine percent of the scientists as compared to 50% of the managers were of the opinion that managers cannot comprehend the language of the reports (Table 9, Question 28). A manager's ability to comprehend scientific reports depended on whether or not:

1) managers have had scientific training,
2) the report is geared for the manager,
3) there is direct communication between scientists and managers.

Almost all respondents agreed that disciplines involving extensive calculations such as mathematics, engineering and physics were the most difficult to understand.

Though 94% of both scientists and managers thought that it is appropriate to describe the statistical analysis for material published for the scientific community (Table 9, Question 29), a smaller percentage (scientists 61%; managers 78%) thought it was appropriate for managers (Table 9, Question 30). Respondents thought it was critical to include statistical analysis for other scientists because statistics demonstrate:

1) the limitations of the study,
2) validity and reliability,
3) how conclusions were derived.

There was no consensus as to the importance of statistics to managers and the public. Some thought statistical analysis should be included as an appendix. Others thought that statistics would just complicate the issue; there should just be trust that the statistics were done.

There was also a difference of opinion between scientists and managers as to whether or not scientists qualify the results of their study too much. Eighty-three percent of the scientists compared to 44% of the managers thought that scientists do not qualify the results of their study too much (Table 9, Question 31). Managers wished that scientists would just give their best judgement without pursuing it further. Scientists felt more comfortable qualifying their results since they usually did not have enough data to be absolutely accurate or certain; they also felt that "scientists must point out the limitations of their studies because there are no ultimate answers and much research is inconclusive and uncertain."

The results support the proposition that research reports are often written in language that neither managers nor the public can understand.

[8] Scientists Seldom Communicate Their Knowledge To The Public Effectively

The null hypothesis that no significant difference exists between attitudes of scientists and managers cannot be rejected (Table 10).

The majority of scientists (78%) and managers (94%) were of the opinion that scientists seldom communicate the knowledge of their particular research to the public (Table 10, Question 33), and even when they do, 100% thought that it is not always effective and/or adequate (Table 10, Question 35). Some respondents felt scientists should communicate better while others felt they should not have to.

The reasons given for the need for better communication by scientists were:

1) knowledge that is of concern and interest to the public should be communicated so that the public can make use of the information, and the more informed everyone is, the better it is;
2) since the public pays for science, they should know what they are paying for;
3) it is a professional responsibility, especially if it is for public decision-makers.

The reasons given as to why respondents thought scientists should not communicate their knowledge to the public were:

TABLE 10

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: SCIENTISTS SELDOM COMMUNICATE THEIR KNOWLEDGE TO THE PUBLIC EFFECTIVELY.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
32	*Scientists		33	50	17	0.00	2.83
	*Managers		33	61	6		2.77
33	Scientists	22	56	22		2.09	2.00
	Managers	11	83	6			1.94
34	Scientists	12	44	44		0.46	2.33
	Managers	6	61	33			2.27
35	Scientists	17	83			0.00	1.83
	Managers	11	89				1.88

* Total number of scientists - 18
Total number of managers - 18

32. The communication responsibility of scientists is over with the publication of peer-reviewed literature.
33. Scientists seldom communicate the knowledge of their particular research to the public.
34. Scientists seldom communicate with the public through the press, television and radio programs, and public lectures or courses offered in continuing education programs.
35. The communication efforts of scientists with the public are not always effective and/or adequate.

1) science is too complicated for people to understand;
2) unless the facts are fully explained, they may cause alarm and fear;
3) if scientists were to communicate directly to the public, they would lose their credibility;
4) managers should communicate science to the public;
5) only "applied" scientists, not those scientists involved in "basic" research, should communicate their results to the public;
6) generally tenure is achieved by evaluation of scientists' research and the amount of papers published, not by communication of their knowledge to the public;
7) there are time constraints; it takes time away from research.

When asked if it is important to communicate effectively, some respondents thought it was; otherwise there would be no purpose for the scientist's knowledge, and research would be a waste of time. Other respondents thought that if scientists had communicated adequately and effectively to the public, a lot of the environmental problems we have today would not exist. A few respondents thought it is neither important nor an obligation for the scientist to communicate effectively to the public, only to other scientists and managers. In fact, one scientist claimed that it was hard to communicate with "idiots" in the audience, perhaps it was the fault of scientists or society, but that there were no simple answers.

Some believed that even though scientists should communicate effectively, they do not know how, for scientists are not trained to be good communicators nor do they realize they need to be.

When asked what they thought the communication responsibility of the scientist should be, two opposing viewpoints were given. One school of thought was that "it is the moral obligation, duty or responsibility of the scientist to communicate knowledge and understanding to managers and to the public in laymen's terms. Decision-makers need to know the facts and if not individually, as a community scientists should advance knowledge and spread it if they are at all serious."

In contrast, there were others who thought that "the scientist's responsibility is over with the publication of peer-reviewed literature." A few respondents thought that there is mistrust between scientists and managers, and it is not appropriate for scientists to seek the managers or present themselves to the public.

Amongst those scientists who do communicate with the public, there was a consensus that television was the best form of communication to reach the masses. The newspapers were considered the worst because their accuracy was questionable. Public lectures were also thought to be effective because of the personal contact, interaction and immediate feedback from the audience. Other suggestions for transmitting information were: slide presentations; speaking engagements with special interest groups like the Audubon Society or the Sierra Club; offering workshops to teachers; short courses for senators or other government officials; testifying or reading before a congressional group; writing brochures; popular articles in magazines; books; making posters, films, and calendars; giving television and radio talks; and, video games for children.

One scientist summed up the situation by saying "Scientists should get more involved in such matters because it gives them a chance to get out and communicate to the public, but unfortunately a lot of them are hypocrites or introverts; they say communication is important, but do not want to do anything themselves. It is always the exception rather than the rule; it is only the better communicators or the well-known scientists that expose themselves."

In conclusion, the proposition that scientists seldom communicate their knowledge to the public effectively is strongly supported, whether it is thought they should or should not.

[9] <u>Scientists Feel That They Should Not Concern Themselves With Attitudes, Values And Beliefs The Public Has Towards The Protection Of The Marine Environment, Nor Do They Feel It is Their Duty To Change Them</u>

The null hypothesis that there is no significant difference between the attitudes of scientists and managers cannot be rejected (Table 11).

Scientists and managers believed that:

1) only some scientists know the attitudes people have toward protecting the marine environment (Table 11, Question 36);
2) almost all managers know (Table 11, Question 37);
3) managers know much more about attitudes than scientists (Table 11, Question 38);
4) managers are more concerned with attitudes, values and beliefs the public has towards the marine environment than scientists (Table 11, Questions 39 and 40).

It was believed by some respondents that scientists know attitudes people have by contact through public hearings, seminars and lectures. Some respondents believed that managers know more because they deal with the public and "people problems" as part of their jobs.

TABLE 11

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION: SCIENTISTS FEEL THAT THEY SHOULD NOT CONCERN THEMSELVES WITH ATTITUDES, VALUES AND BELIEFS THE PUBLIC HAS TOWARDS MANAGEMENT OF RESOURCES NOR DO THEY FEEL IT IS THEIR "DUTY" TO CHANGE THEM.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
36	*Scientists	6	50	44		0.00	2.38
	*Managers		56	44			2.44
37	Scientists		83	17		0.23	2.16
	Managers		89	11			2.11
38	Scientists		6	88	6	0.00	3.00
	Managers		6	88	6		3.00
39	Scientists	6	61	33		0.00	2.27
	Managers	6	61	33			2.27
40	Scientists	22	72	6		1.02	1.83
	Managers	39	61				1.61

* Total number of scientists = 18
Total number of managers = 18

36. Scientists know the attitudes people have toward protecting the marine environment.
37. Managers know what people want when it comes to protecting the marine environment.
38. Scientists know more than managers what the attitudes and opinions of the public are towards protecting the marine environment.
39. Scientists are concerned with attitudes, values, and beliefs the public has towards the marine environment.
40. Managers are concerned with attitudes, values, and beliefs the public has towards the marine environment.

The reasons given by respondents as to why managers should be concerned about public attitudes were:

1) it is necessary to their work;
2) it is necessary for the public good;
3) without it laws do not get enforced, and violators do not get prosecuted.

More reasons were given by respondents as to why scientists should be concerned:

1) to get money and support for research from the public;
2) scientists ought to be concerned with public opinion and social needs;
3) if scientists have the knowledge, they should transmit it for the good of the public as a professional responsibility;
4) knowing the public's attitudes can help scientists give better advice;
5) scientists should educate society as to the need to preserve resources as an ethical and moral obligation;
6) by knowing and being concerned about the public's attitudes, scientists can change public attitudes if need be.

Others believed that scientists should not be concerned about public attitudes because:

1) scientists have no time;
2) scientists do not know how to change environmental attitudes;
3) scientists are not interested in values and beliefs the public has towards the protection of the marine environment;
4) public opinion must not dictate scientific research;
5) scientists do not have more responsibilities than any other citizens.

In conclusion, even though the majority of the respondents felt that scientists should know and be concerned with attitudes, values and beliefs the public has toward the marine environment, at the present time they do not. It seems that it is the manager who is expected to know and be concerned. Therefore, the proposition cannot be rejected.

[10] Scientists Feel That Their Role Is Only To Seek Knowledge And Truth, That They Are Not Qualified To Make Value-Judgements

The null hypothesis that no significant difference exists between attitudes of scientists and managers cannot be rejected for all statements but one under this proposition (Table 12).

This last proposition was written to find out exactly what the role of the scientist is or should be. The ultimate question was posed to interviewees at the end of the questionnaire as to what they perceive the role of the scientist to be in our society, and specifically what it is in marine environmental policy and management.

Approximately half the scientists (55%) and managers (44%) thought that scientists are not effectively involved in present environmental management efforts (Table 12, Question 41). There was no real difference of thoughts between respondents that agreed or disagreed. The difference was whether they thought scientists are presently involved or whether they should be more involved in the future.

Those scientists who thought scientists are not effectively involved felt there is an uncaring attitude by managers, more science should be used, and managers should involve scientists in the

TABLE 12

RESPONSES TO QUESTIONS RELATED TO THE PROPOSITION SCIENTISTS FEEL THAT THEIR ROLE IS ONLY TO SEEK KNOWLEDGE AND TRUTH; THAT THEY ARE NOT QUALIFIED TO MAKE VALUE-JUDGEMENTS.

		RESPONSES % (percent)				CHI-SQUARE	LIKERT Mean Scores
Question	Respondents	Strongly Agree	Agree	Disagree	Strongly Disagree	Significant X^2 is 3.84 at .05 level	scale runs from 1=strongly agree to 4=strongly disagree
41	*Scientists	5	50	28	17	0.44	2.55
	*Managers		44	44	12		2.66
42	Scientists	6	28	66		5.46	2.61
	Managers		72	28			2.27
43	Scientists		5	78	17	3.20	3.11
	Managers		26	67	5		2.72
44	Scientists	6	61	27	6	0.03	2.38
	Managers	6	83	11			2.05
45	Scientists	17	61	22		0.17	2.05
	Managers	33	50	17			1.83
46	Scientists	6	56	32	6	0.45	2.38
	Managers		50	50			2.50
47	Scientists	11	89			1.02	1.88
	Managers	11	83	6			1.94
48	Scientists	11	67	22		0.00	2.11
	Managers	6	72	22			2.11
49	Scientists		56	39	5	3.27	2.50
	Managers	5	78	17			2.11
50	Scientists	61	39			0.00	1.38
	Managers	33	67				1.66

* Total number of scientists = 18
Total number of managers = 18

41. Scientists are not effectively involved in present environmental management efforts.
42. An appropriate place for scientific involvement in environmental management is in the process of policy implementation (i.e. permitting, regulatory hearings, etc.).
43. It is appropriate for scientists to become involved in surveillance and policing of policy implementation.
44. Scientists presently have a say in the development of regulations or laws pertaining to management of our natural resources during the policy development phase.
45. It is appropriate for scientists to get involved in the development and delivery of educational, recreational and interpretative programs for the general public.
46. The scientist has an important role monitoring management plans.
47. Scientists can be effectively involved with several different roles (i.e. advisor, educator, investigator) at the same time.
48. When scientists do address the public on important issues, they feel that their sole responsibility is to provide their factual knowledge and understanding.
49. The scientist's role is one that goes beyond seeking the truth.
50. The scientist plays a role in the discovery, development and dissemination of knowledge.

development of management plans. Even though scientists merely influence decisions whereas managers make the decisions, it was thought the scientists have the knowledge and the ability to apply such knowledge to management issues.

Some managers who also agreed that scientists are not effectively involved thought more scientists should be involved officially because a lot of them have good information that could be used, but it is always the same group of scientists communicating with managers. Other managers thought scientists are effectively involved. Scientists are thought to be major proponents of environmental policy, and managers and politicians want them to be involved. Scientists serve on committees and advisory boards, and managers are giving workshops to get scientists more involved. A few managers would like to see scientists not only acting as advisors but as advocates as well.

The majority of scientists (66%) thought that scientific involvement in environmental management in the process of policy implementation is not appropriate (Table 12, Question 42), nor is the surveillance and policing of policy implementation (95%) (Table 12, Question 43). But 67% believed that scientists presently have a say in the development of regulations or laws pertaining to management of our natural resources (Table 12, Question 44). Seventy-eight percent of the scientists (Table 12, Question 45) also thought that it is appropriate for scientists to get involved in the development and delivery of educational, recreational and interpretative programs for the general public. Sixty-two percent of the scientists thought that the scientist also has an important role in monitoring management plans (Table 12, Question 46). One hundred percent of the scientists believed that scientists can be effectively involved with several different roles (i.e. advisor, educator, investigator) at the same time (Table 12, Question 47).

Managers' opinions differed in a couple of cases only. Seventy-two percent of the managers thought it is appropriate for scientists to be involved in the process of policy implementation (Table 12, Question 42). Also, not as many managers (50%) (Table 12, Question 46) felt that scientists have an important role in monitoring management plans. All other opinions or attitudes did not differ significantly.

Respondents who felt that scientists should not be involved in the process of policy implementation believed that by that time it was too late, they should have already been involved prior to that stage. They thought it would be a waste of time because by then there was no longer a need for scientists. Yet one scientist thought "there should be more involvement at that stage, otherwise bureaucracy would make the decisions based on those people who make the most noise, such as big business and money, those who have no concern for natural resources."

Most respondents thought that surveillance and policing is a misdirection of a scientist's talents. If as a citizen they happen to be at a scene where a violation is done, then it is fine to get involved; otherwise it is the function of managers. Researchers do not have a regulatory responsibility to prosecute people.

Even though many respondents felt that scientists have a say in the development of laws and regulations, whether it be through the formal review process, hearings, advice giving, or making recommendations, "rarely is scientific evidence incorporated into regulations unless it is in agreement with preconceived notions the public, politicians or other interest groups may have." "Only 25%, if not less, of the scientific information is considered. Ultimately it is the manager or the politician that has the final say, and they do not want scientists to impose their views."

Getting involved in different educational, recreational or interpretative programs was approved by scientists in general if it is done in an advisory capacity. Scientists felt they could add accuracy to the programs. Some managers thought that it would be overburdening scientists. Managers thought scientists should get involved only if scientists are interested or required to do so by employment, but not as a moral obligation.

Many scientists and managers thought that monitoring management plans is out of the realm of the scientist's role because the scientist does not have the time to do it on a daily basis. The scientist can evaluate the plans but should leave the monitoring to the manager. But some thought it was an important role because the scientist is the one with the knowledge and the supplier of information pertaining to changes occurring in the natural system, so he/she should be obliged to monitor. A third category thought that even though the scientist should monitor, the role does not exist, that there is no system to provide feedback, nor anyone to see if the plan is working or not.

Both scientists and managers thought that "scientists can be effective in more than one role; perhaps not equally effective in all three, (i.e. advisor, educator, investigator) all the time, but with a lot of work, inventiveness, and dedication, the good scientist can perform well in all respects."

The majority (78%) of scientists and managers thought that when addressing the public on important issues, the sole responsibility of the scientist is to provide factual knowledge and understanding, not value-judgements (Table 12, Question 48).

Some scientists believed that "communication should be restricted to the understanding of scientific facts; if not, it can be lethal to the scientist. The system has evolved in such a way that scientists are afraid to advocate, impose their values on others, or become emotional in any way." A second school of thought consisted of scientists who believed that scientists should communicate their value-judgements. They felt that facts are not enough, and there is nothing wrong in expressing value-judgements, so long as they are separate from the facts. "Since scientists have the best information on which to base judgements, they have an obligation to give short or long-term forecasts with probabilities."

Managers were divided on this issue. Some thought that scientists should remain factual, objective, and unbiased, not "sentimental", and therefore should not offer value-judgements. Other managers thought scientists must interpret facts, and if they are indeed knowledgeable and responsible, should also present value options. They believed scientists should be entitled to an educated opinion. One manager believed that the reason why scientists do not wish to give judgements is because they feel uncomfortable in doing so. He said "It is not part of their training, which is a lack of education... scientists think that by giving value-judgements they are deviating from scientific ethics."

It was with difficulty that scientists and managers responded to the statement that the scientist's role is one that goes beyond seeking the truth, for they had not previously thought about it. More managers (83%) agreed with this statement than did scientists (56%). There was a difference in attitudes between these groups (Table 12, Question 49).

Most respondents were of the opinion that "there is no absolute truth in science, nor can it ever be reached." "There can only be an operational truth based on accountability with the theoretical knowledge available, other than that absolute truth does not exist in our mortal existence." "It is a matter of either accepting or rejecting a hypothesis." A few respondents thought that "being an educated member of society, the scientist should not only seek the truth, but deliver it, if social progress is to be made of it." It is thought that "since science is to disprove the truth as we know it, reaching an absolute truth would be the end of science."

The last statement in this proposition and questionnaire is perhaps the most important in that it summarizes the essence of this theme as to what exactly the role of the scientist is or should be. One hundred percent of the scientists and managers agreed that the scientist plays a role in the discovery, development and dissemination of knowledge (Table 12, Question 50).

It was apparent from the discussions held with the scientists involved that most scientists believed that even though the scientist does take part in all three phases of discovery, development and dissemination of knowledge, the discovery and development phase was considered to be a more important role. The majority of the scientists thought that "the primary role of the scientist is one who provides accurate factual information." "By discovering knowledge and truth about natural or physical phenomena, the scientist increases our understanding of it and expands the horizons of truth and knowledge." Only a few added that "it is also important to synthesize this information and disseminate it widely to the public."

Every scientist agreed that the specific role of the scientist in management and policy is to give advice; what differed is the degree and the time of involvement.

Two opinions existed:

1) The scientist is not only a supplier of facts, but an evaluator of policy, who is involved especially in the early phases of policy development. Since most plans are written by managers or planners who do not have a strong background in science, the scientist is the one who deciphers the information to be used in the plan if it is at all to be properly and scientifically managed.
2) The scientist should be more involved in all phases of policy and management planning, even though the plan is not a scientific document.

Better communication between scientists and managers seemed to be thought essential by scientists, and a suggestion was made that perhaps we need a liaison person between the scientist and the manager whereby management needs can be communicated to the scientist and the scientific information can be translated to the manager.

Most scientists felt that the present role of the scientist is close to what it should be, although there were a few scientists who believed differently.

Two contrasting schools of thought existed amongst scientists as to what the role of science and scientists should be.

The first school of thought held the opinion that "the scientist should alter the quality of life for the betterment and good of society, applying scientific knowledge to the human condition." "The scientist should also be more of an educator and communicator of science, one who enlightens people in order to protect our natural resources." These scientists also thought that "it is important to have a more holistic rather than reductionist view of environmental problems and to give judgements even though there may not be positive reinforcement to do so." There is also a need for ethical imperatives, for some think that "the scientific community is too isolated and introverted." "If there was public pressure to know more about the environment, initiated by scientists, it would help because politicians are swayed by public opinion." "Scientists should not be cynical and help solve environmental problems since most wrongs are done due to ignorance." "It should be a moral obligation to do so!" said another scientist. It is thought that "scientists should voice their opinions through position papers for Washington, D.C., attend national meetings, contact environmental groups and "leak out" information to them, phone Governors, express value-judgements openly and freely, educating our self-centered society." But unfortunately a few scientists concluded that "most scientists are not humanitarians."

In contrast, there were a group of scientists that had quite opposite attitudes. They believed that their role as educators "should be only to educate future scientists." "If they are to communicate to the public, it would only be to have continuing support and funding for their research." The comment was made that maybe "the public should know what they are getting for their money." "A scientist needs to be ethical, only as far as using research funds responsibly since science does not come cheap." Some scientists also felt strongly that "it is not the role of the scientist to communicate or push their ideas, or even be concerned with attitudes people have toward the environment, for one cannot and should not be a scientist and an advocate at the same time."

Managers, like scientists, were also under the opinion that scientists play more of an important role in discovery and development of knowledge rather than its dissemination. Generally speaking, the role of the scientist was thought to be "to explore new frontiers of discovery searching for new answers." "The scientist is the provider of information to help better understand nature." "The scientist should provide factual information to society, particularly to decision-makers and educators". "In addition to pursuing knowledge, scientists should be an instrument for social and public utility, for humane purposes and for the progress of society."

Managers held similar viewpoints as to what the role of the scientist is in management and policy. Many managers thought that "the scientist should communicate knowledge pertaining to management plans to the manager." Also, "to interpret and simplify research results so that managers can actually use it." "Science should be given more respect." Many managers believed that "grey" literature and personal communications were more often used in plans than "pure" literature. Managers also thought that "not only should research be more linked to answering critical management questions, but the scientist should also develop the biological impacts of alternative management decisions." Managers wished that scientists would write papers useable by managers and the public, not just for their peers. Managers realized that "the scientific community puts restraints on scientists, they have traditions to follow so it is not always their fault." "They have to publish or perish". "They cannot say man will destroy the marine environment unless they have conclusive evidence." "It is up to the manager to say we have to stop this damage." "Managers do not want scientists to become environmentalists, otherwise they lose their credibility." Managers believed that "both scientists and managers are doing the best they can under institutional and population pressures." One manager said "We recognize the importance of managing our resources, it is time the government did... more education and enforcement is imperative!"

There were two contrasting attitudes as to what the role of the scientist should be that need to be elaborated here. There was a school of thought amongst some managers that "because individual feelings matter, the scientist should not have to be involved in policy or management just because by definition he/she is a scientist." "There is no use in putting them in a role that makes them uncomfortable." "Scientists can make social contributions only if they so desire." "Scientists play a small role in policy, and it is not considered to be a disappointment to many because "people problems" do not necessarily need the involvement of scientists." The politicians are thought to be the decision-makers, not the scientists. "A scientist need not be involved in politics nor be a humanitarian unless he/she has such inclinations."

There was a second school of thought that existed amongst managers, though it was the minority (10%). They believed that "the role of science presently is knowledge for knowledge's sake rather than for social purposes." To them, "the marine environment is an area of particular importance, and the marine scientist has an unusual role for he/she is even more responsible than other scientists, especially if people cannot observe the ocean themselves." "He/she has more of a role to inform people." "Marine scientists have to have global concern to make people realize that everyone is affected, whether directly or indirectly." One interviewee stated that "most scientists think they are concerned, or even that they are humanitarians, but they are not." In the words of one manager, "Being humanitarian does not necessarily mean going on a mission to Africa, but to stand up amongst peers and state an opinion, and to act upon it. For many scientists, when they say it is not their role to do this or that... it's just a "cop out". Surely it is easier to claim that scientists should not have to be actively involved in politics or policy because that is not their responsibility nor do they have the time... Scientists should be responsible because they are educated by society... Political involvement should be an obligation of scientists. They should be more active in politics, not just yelling out opinions because they feel like it, but giving an opinion and a judgement based on facts. It is very necessary and vital. Scientists should not just complain about a policy or a management plan, but give their opinions before it is too late!"

Though there were these two contrasting viewpoints, there seemed to be stronger support to accept the proposition that scientists feel that their role is only to seek knowledge and truth, that they are not qualified to make value-judgements.

Analysis of Management Plans

The contention of most of the respondents (both scientists and managers) that the primary scientific literature (that which is peer-reviewed and in journals) is not used in the development of management plans for natural coral reef areas was supported by my analysis of the plans (see Table 13). Note that only the Ocho Rios and Bonaire plans used a higher number of primary citations than secondary citations (citations are those references cited in management plans). All of the citations in St. Croix's Buck Island plan were secondary literature. Popularized articles made up twenty-four percent of the Key Largo plan's references; no specific citations were made. The Looe Key and La Parguera plans relied heavily on personal communication compared to other plans. Most references were not cited in the text.

Table 14 summarizes the most frequently referenced journals in each of the management plans. The most referenced journal for Looe Key and Key Largo plans was the Bulletin of Marine Science. No primary literature was referenced in the Anguilla plan. Puerto Rico's La Parguera plan cited Limnology and Oceanography most, St. Croix's Buck Island plan, Herpetologica. Aquatic Botany was most frequently used in the Bonaire plan, while the Curacao plan used a regional journal, Studies on the Fauna of Curacao; Jamaica's Ocho Rios plan cited Marine Pollution Bulletin most often. All told, only a small number of primary journal articles were used in the plans. In all plans but Buck Island, different authors wrote the articles cited.

Tables 15-18 summarize the different components considered in the management plans such as geography, natural resources, cultural

TABLE 13

SOURCES OF SCIENTIFIC INFORMATION USED IN CORAL REEF MANAGEMENT PLANS

Number of References and Citations Used	Plan / Date of Plan	Florida Key Largo September 1979	Anguilla March 1981	Bonaire October 1982	Puerto Rico La Parguera January 1983	Florida Looe Key June 1983	St. Croix Buck Island September 1983	Jamaica Ocho Rios March 1984	Curacao January 1985
Primary									
No. of References		54	6	13	24	12	3	34	19
*No. of Citations		0	0	13	15	1	0	28	9
Secondary									
No. of References		15	7	6	100	15	19	5	27
No. of Citations		0	4	6	18	8	3	11	34
Popular Articles									
No. of References		22	0	0	0	0	0	0	0
No. of Citations		0	0	0	0	0	0	0	0
Personal Communication									
No. of References		0	1	0	10	3	0	0	0
No. of Citations		0	1	1	11	7	0	0	3
Total Number of References		91	14	19	134	30	22	39	46

* citations are those references cited in management plan.

TABLE 14

NAMES OF JOURNALS MOST FREQUENTLY REFERENCED IN EACH MANAGEMENT PLAN

Plan	Most frequently referenced journals (No.)	Aquatic Botany *M.A.	Stud. Fauna Curacao *M.A.	Bulletin Marine Science *M.A.	Marine Pollution Bulletin *M.A.	Limnology and Oceanography *M.A.	Herpetologica **S.A.
Anguilla	0						
Bonaire		3					
Curacao			4				
Florida Key Largo				8			
Florida Looe Key				2			
Jamaica Ocho Rios					4		
Puerto Rico La Parguera						2	
St. Croix Buck Island							2

* M.A. multiple authors
** S.A. same authors.

TABLE 15

INCORPORATION OF GEOGRAPHICAL PARAMETERS IN CORAL REEF MANAGEMENT PLANS

Site	Geographical Parameters	location and size	topography and bathymetry	climate	population and labor	economy
Anguilla		X	X	X	X	X
Bonaire		X		X		
Curacao		X		X		X
Florida Key Largo		X	X			
Florida Looe Key		X	X	X		X
Jamaica Ocho Rios		X	X	X		X
Puerto Rico La Parguera		X	X	X	X	X
St. Croix Buck Island		X	X	X		

TABLE 16

INCORPORATION OF NATURAL RESOURCE COMPONENTS IN CORAL REEF MANAGEMENT PLANS

Site	Description of Natural Resources: Biological Communities — coral reefs	salt ponds	hardgrounds	rocky shores	seagrass beds	dunes	beaches	mangroves	lagoons	endangered species	commercial species	Geological Origins	Chemical Properties	Physical Parameters	Marine Aesthetics	Environmental Education
Anguilla	X	X			X	X	X			X	X	X		X	X	
Bonaire	X								X						X	X
Curacao	X				X			X	X	X	X		X		X	X
Florida Key Largo	X		X		X		X				X				X	X
Florida Looe Key	X				X		X					X		X	X	
Jamaica Ocho Rios	X			X	X				X	X	X	X			X	X
Puerto Rico La Parguera	X	X		X	X		X	X	X	X	X	X		X	X	
St. Croix Buck Island	X			X	X		X	X	X	X		X			X	

TABLE 17

INCORPORATION OF CULTURAL RESOURCE COMPONENTS IN CORAL REEF MANAGEMENT PLANS

Site	Description of Cultural Resources	lighthouses	shipwrecks	statues	traditions
Anguilla					X
Bonaire			X		X
Curacao					
Florida Key Largo		X	X	X	
Florida Looe Key			X		
Jamaica Ocho Rios					
Puerto Rico La Parguera					
St. Croix Buck Island			X	X	X

TABLE 18

INCORPORATION OF COMMERCIAL, RECREATIONAL AND NATURAL IMPACT COMPONENTS IN CORAL REEF MANAGEMENT PLANS

Site / Impacts	dredge and fill activities	sand mining	channelization	commercial shipping	salt works	shoreline development	power stations	oil refineries	visitor use	hotel and resort development	yachting and boating	anchor damage and boat groundings	SCUBA and snorkeling	recreational fishing	natural hazards	water pollution	harvesting fish commercially	harvesting marine invertebrates
Anguilla	X	X		X	X			X	X	X			X	X		X	X	
Bonaire		X		X	X		X	X	X	X	X	X	X	X		X	X	X
Curacao	X	X		X				X	X	X	X	X	X	X		X	X	X
Jamaica	X	X	X			X		X	X	X	X	X	X	X	X	X	X	X
Florida Looe Key									X		X	X	X	X		X	X	X
Florida Key Largo	X	X	X			X			X			X	X	X		X	X	X
Puerto Rico La Parguera	X	X	X	X					X	X	X	X	X	X	X	X	X	X
St. Croix Buck Island	X							X	X		X	X	X	X	X	X	X	X

resources, and impacts (both natural and anthropogenic). Though not listed in the tables, all the management plans also had a statement of the purpose, objectives, goals, and a discussion of laws for protecting the marine environment and resources, surveillance, monitoring, and enforcement of laws, as well as a section on zoning in the Anguilla, Australia, Florida's Looe Key, Jamaica's Ocho Rios and St. Croix's Buck Island plans.

An idealized plan would include all the categories mentioned above; but, as seen from the tables, not all of the categories are considered in all the plans. In addition, the plans differ as to the extent in which each category is dealt. As examples, purpose of the plans, water pollution and environmental education will be discussed here.

Purpose

The principal or underlying purpose for establishing all of the areas reviewed were similar - maximizing human usage in consistency with conservation of the natural marine resources.

Australian and Jamaican plans only stated the principal purpose. Plans from Curacao and Bonaire stressed the importance of maintaining high productivity, ecological processes and especially preserving genetic diversity. Plans from Florida, Puerto Rico, St. Croix and Anguilla have specifically established multiple-use purposes such as conservation, ecology, aesthetics, recreation and commerce (including fisheries and tourism).

Water Pollution

The extent to which management plans dealt with water pollution varied widely. Some plans such as those for Looe Key, Anguilla, and Bonaire did not discuss possible impacts of pollution in much detail.

while others, especially Ocho Rios in Jamaica, addressed the topic in a thorough manner.

Principle pollution concerns were excessive sedimentation and turbidity, alteration of nutrient input, sewage and runoff (domestic, agricultural and industrial), oil, pesticides, insecticides, herbicides, fertilizers, litter and debris, sludge and discharges from boats.

Specific actions to mitigate, ameliorate or prevent pollution were not discussed in detail in the management plans. There were some measures mentioned in a few of the plans such as having organizations that enable its members to deploy a variety of spill-fighting equipment in case of a major spill and fining violators. There was also mention of examination of existing sewage disposal systems to ensure they meet standards and construction of tertiary sewage treatment plants but, in general, the concerns and impacts on the reefs were discussed rather than preventive measures. Enforcement of laws (although often difficult), research, and monitoring of water quality were considered essential in all management plans.

In some plans, especially the Jamaican one, the discussion on impacts of water pollution was based on results from the scientific literature. In other plans there were no references made to the scientific literature.

Environmental Education

Environmental education was dealt with in a number of ways in different management plans ranging from neglect (Anguilla and Puerto Rico's La Parguera) to elaborate (Jamaica's Ocho Rios, Bonaire, and Florida's Key Largo).

Different user groups were targeted in the different plans. The Ocho Rios management plan focused on educating local users. The belief was that localized environmental education was the main way the region can be protected. Management's intention was for local people who come into contact with the park to have some understanding of the value of the resource and the ecological sensitivity of the reefs. Lecture and discussion, press articles, radio and television programs, guidebooks, pamphlets and maps were thought to be means of educating the public. Bonaire, Curacao and Key Largo plans were also interested in environmental education and increasing public awareness for local users and all other visitors. In contrast to these plans, Anguilla and Puerto Rico's La Parguera plans did not have any specific plans for educating its public on the management strategies they planned to adopt for the utilization of their marine resources.

In a third category, the plan for St. Croix's Buck Island did not have a special section on education; no details were given as to how to promote public understanding and awareness, although a statement was made under objectives as to its importance. The plan for Looe Key in Florida did not have an educational program set up as part of its management plan either. Yet it did have a section on interpretative management whereby the opportunities, program themes and messages to bring about public understanding and appreciation of the coral reef environment were presented.

A discussion of environmental education in the management plans did not usually refer to the scientific literature. Scientists were not involved in educating the public about the marine environment.

Australia

Analyses of Australian plans were not included in any of the tables. The reason for this was that Australia employed a somewhat unique strategy for conserving its Great Barrier Reef. The great size of the reef and its biophysical and socio-economic diversity increased the difficulty of management. Priorities were determined by the Great Barrier Reef Marine Park Authority's philosophy on how to manage the reef.

The aim of the plan for the Great Barrier Reef was to ensure a level of usage consistent with maintenance of the ecological system and accepted as reasonable by society (Salm and Clark, 1984). The authority believed that opportunities for human enjoyment and use should be maximized and yet be consistent with conservation of the natural resources. In practice, regulation was deliberately held at the minimum considered necessary to achieve conservation objectives.

Thus, the concept defined in the Great Barrier Reef Marine Park Act of 1975 was close to a definition of multiple-use management, but with provisions which specifically required the authority to establish zoning as a means of managing specified areas.

In broad terms, three groups had a direct interest in the use of reef resources:

1) Fishermen and Collectors (both commercial and recreational) - Maintenance or, if possible, increase of the sustainable yield of species of interest as edible and cultural entities.
2) Tourism and Recreation - Use of particular locations for potentially large numbers of reef visitors.
3) Conservation - Minimum human impact on Great Barrier Reef.

There was considerable overlap of interests between the groups. Much fishing was recreational. Most reef visitors reached the reef aboard chartered vessels or aircraft which were part of the tourist industry. Many conservationists fished recreationally and to the extent that it was selling the "unspoiled wilderness" aspect of the Great Barrier Reef, the tourist industry had a vested interest in conservation or preservation of its assets.

This philosophy of maximizing human enjoyment, consistent with the concept of conservation, was expressed through the declaration of sections of the reef as parts of the Great Barrier Reef Marine Park and by zoning plans, which specified what uses may occur within each zone and the conditions under which those uses may proceed.

The Zoning Plan objectives were defined by the Act:

1) The conservation of the Great Barrier Reef.
2) The regulation of the use of the Marine Park so as to protect the Great Barrier Reef while allowing reasonable use of the Great Barrier Reef Region.
3) The regulation of activities that exploit the resources of the Great Barrier Reef Region so as to minimize the effect of those activities on the Reef.
4) The reservation of some areas of the Great Barrier Reef for its appreciation and enjoyment by the public.
5) The preservation of some areas of the Great Barrier Reef in its natural state undisturbed by man except for the purposes of scientific research.

To accomplish these objectives, the Reef has been zoned into a number of areas with differing degrees of restrictions on activities.

There were five zones that included provisions for three types of protected areas. The five zones include:

1) General Use A Zone - includes all the shoals on the Section as well Lady Elliot Island and covers more than 80% of the area of the Section.

   No restriction on use other than:

   (a) no operations for the recovery of minerals except for the purposes of research.

   (b) no commercial spearfishing or spearfishing with SCUBA.

2) General Use B Zone - includes about 18% of the area of the Section; provisions are the same as for General Use A Zone with additional prohibition on trawling and the navigation of vessels greater than 500 tons.

3) Marine National Park Zone - Heron Island and Western Reefs conservational management primarily for tourist purposes with fishing allowed subject to gear restriction (one hand-held line or rod and no more than two hooks).

4) Scientific Research Zone - One Tree Island Reef-specific provision of scientific research in an area as far as possible unaffected by other uses.

5) Preservation Zone - Wreck Island and Llewellyn Reefs-specific provision for management of an island reef and a lagoon reef as far as possible unaffected by human use.

The three types of protected areas include:

1) Reef Appreciation Area - An area in a zone where fishing and collecting are normally permitted, in which fishing and collecting are excluded to enable the public to observe reef life relatively undisturbed by human activity.

2) Seasonal Closure Area - An area known to be of importance to the breeding of particular animals, which may be closed during the breeding season.

3) Replenishment Areas - Seven areas, of which two may be closed at any time for a period of up to three years. The concept is at present experimental and is designed to test whether periodic closure will increase the productivity of demersal reef fisheries.

Management priorities have been to obtain the information necessary to decide what areas should be declared to be parts of the Marine Park, and then, after declaration, to obtain the more detailed information necessary to develop competent zoning plans for a Park Section.

A separate, important requirement was to establish initial reference conditions to a sufficient degree of accuracy to enable monitoring programs to detect biological or physio-chemical changes caused by human activity as distinct from natural changes, so that the Park Section could be managed competently.

Thus, the Zoning Plans were the formal overall management plans for Sections of the Great Barrier Reef Marine Park. Within these there were annual programs for the implementation of the plans which were in turn framed within three-year rolling programs.

The Great Barrier Reef Marine Park Authority's approach to research can be summarized as follows: "We seek to develop knowledge of the physical, chemical, and biological characteristics of the Reef Region, and of the social and economic factors which affect its use, not for the sake of that knowledge itself but in order to establish a competent management regime over the Reef Region. In this respect the Authority differs from many research organizations" (Kelleher, 1981).

Apparently, according to Kelleher (1981) most researchers commencing management-oriented studies on the Reef find that remarkably little scientifically-valid information is documented on the Reef from either the biological or socio-economic points of view.

Three principal areas of information requirement and of research needs came from the responsibilities of the Authority as given to it by the Great Barrier Reef Marine Park Act of 1975 for the establishment, development, control, and care of the Marine Park.

The three areas of research were developed into research programs as follows:

I. Resource Analysis

1. Bathymetry and Survey
2. Oceanography
3. Marine Geology
4. Marine Chemistry
5. Marine Ecology

II. Analysis of Use

6. Inventory of Uses
7. Impacts of Uses
8. Management Strategies
9. Socio-economic Studies

III. Information Management

10. Great Barrier Reef Data Bank
11. Mechanics of Information Transfer

For example, Bathymetry and Survey is necessary because the physical characteristics of the area must be described to demonstrate the suitability of the Park boundaries for management purposes. Marine Ecology is necessary to define the area's biological status. A knowledge of the Impacts of Uses is required for developing zoning plans. Equally, an adequate knowledge of the baseline ecological characteristics of the Reef is essential to monitor changes brought about by human activities.

Thus science was considered to some extent in the development of management plans for Australia's Great Barrier Reef. Marine scientific research has been of value in helping to understand the system one is managing, and scientists have helped in the development and implementation of management plans. But this has been coupled with socio-economic studies, since human uses and impacts of the Reef are also critical variables in the development of management plans.

DISCUSSION

It is imperative in a study such as this one, where one is investigating "The Role of Science and Scientists in Marine Environmental Policy and Management" to clearly define and understand what science is and who the scientist is. This leads to a consideration of values and ethics in science in order to better comprehend the obligations and responsibilities of scientists.

Through the ages philosophers and scientists have debated the role of science and scientists in society. Both positive and negative roles of science have been reflected by the ideas and writings of prominent historical figures.

Aristotle has stated that "All men by nature desire to know." Each human being has different views concerning what is worth knowing. One's search for knowledge is motivated and directed by an urge to create meaningful patterns out of bewildering confusion perceived by one's senses. One wants to shape reality according to one's own wishes and by doing so, one is so presumptuous as to personalize the Universe (Aristotle translated by Butcher, 1911).

To Francis Bacon, "Knowledge is power." But he also believed that power should be used for the betterment of mankind. "Scientists should focus on the practical applications of knowledge for the benefit and use of man, the relief of man's estate" (in Dubos, 1970).

Pasteur expressed an attitude about science when he said "There are not two sciences. There is only science, and the applications of science and these two activities are linked as the fruit is to the tree" (in Dubos, 1970).

Hirsch wrote "By science, I mean the search for knowledge and understanding - both the understanding of something that is complex in terms of its simpler components and the understanding of a given phenomena in terms of the relations between it and other knowledge about the world. By technology I mean the application of whatever is presumed to be already known to the accomplishment of immediate goals" (Hirsch, 1967).

Montaigne had already written in the 16th century "Science without conscience is but death of the soul, reason can become destructive when it is not guided by worthy human concerns" (in Dubos, 1970).

Tolstoy attacked the intellectual significance of the problems which scientists study. "Men of science study not everything, as they imagine and affirm, but what is profitable and easy to study... this quality belongs not to science, but to people who are inclined to occupy themselves with trifles, and to attribute to these trifles a high importance" (Tolstoy, 1898).

Ortega y Gasset in The Revolt of the Masses wrote that "Science automatically converts the scientist into a modern barbarian... the specialist... is not learned, for he is formally ignorant of all that does not enter into his specialty; but neither is he ignorant, because he is a scientist, and knows very well his tiny portion of the universe. We shall have to say that he is a learned ignoramus" (Ortega y Gasset, 1932).

Science is the offspring of a branch of philosophy called epistemology from the Greek episteme - "knowledge" and logos -

"reason" (Dubos, 1970). According to Dubos (1970), the word "science" can have several different meanings. It denotes the formulation of the laws of nature and the description of substances, events and behaviors. It may also apply to the development of particular products and techniques, all things that may be desirable or undesirable, that are made possible through technology. What is common in both is the verifiability of the assertions concerning the laws of nature, the observed phenomena or the practical application.

Science can simply be defined as knowledge or as knowledge obtained by systematic study and practice. Webster's Third New International Dictionary (1967) defines science as "accumulated and accepted knowledge that has been systematized and formulated with reference to the discovery of general truths or the operation of general laws: knowledge classified and made available in work, life, or the search for truth: comprehensive, profound, or philosophical knowledge: knowledge obtained and tested through use of the scientific method."

What most distinguishes scientific knowledge from other knowledge is the method by which it is developed. The scientific method is thought by some (Dubos, 1970; McCain and Segal, 1973; Bronowski, 1978) to be an attitude and a philosophy rather than just a method in the sense of a formal procedure. Basically, it involves the formulation of a problem, the collection of data through observation, and if possible, experimentation, the formulation of hypotheses, and the testing and confirmation of the hypotheses formulated (Medawar, 1984).

The word "scientist" is of recent origin. It does not appear in print either in English or any other language until 1841. Before that time a student of natural phenomena was called a "Man of Science" or a

"Natural Philosopher." Dubos (1970) says that in the past the man of science tended to be socially and intellectually somewhat broader than the modern scientist. They were specialized in their skills but not in their interests. They retained a scholarliness that enabled them to maintain contact with the humanities. During the second part of the 19th century, men of science began to turn into scientists. Scientists became specialized in their attitudes as well as in their fields of knowledge. They became primarily concerned almost exclusively with the problems and techniques peculiar to their scientific specialty. This was partly due to the increase in scientific knowledge which made it necessary for one to focus on a special field.

Dubos (1970) also makes the point that the intellectual narrowness of many specialists comes from the widespread assumption that the discovery of new facts is the most important aspect of knowledge. He states that if one really believes that the advancement of knowledge is more important than the possession of knowledge, then it may be justifiable to limit one's attention to the kinds of skills and facts required for technical progress in one's particular field. He believes that the so-called doctorate of philosophy is now a misnomer, a certificate of expertise in a narrow specialty rather than the philosophical understanding or even awareness of the interrelationships among the various fields of knowledge.

According to McCain and Segal (1973), what distinguishes the scientist from others is the ability to state problems and to frame questions. The scientist must be one who can gather evidence and verify conclusions, who is a keen observer, experimenter and painstaking classifier. The scientist gathers data and studies them, but in order to make the whole enterprise scientific, the scientist must organize and interpret data. Having knowledge is not what makes a scientist, it is the method of attainment of knowledge that determines whether one is playing the game according to the rules. It is the system of data-based explanation that distinguishes science from dogma. A scientist is not merely a man who makes profound imaginative discoveries, but a man who regards the world as a whole.

The ideal scientist is thought to possess such characteristics as curiosity, or the tendency to explore, skepticism, i.e. not taking things for granted, epistemic motivation, the desire for observation or experimental verification, precision, a liking for new ideas, originality, an ability to reflect critically and independently, a willingness to change opinions, loyalty to truth and honesty, perseverance, dedication, having an objective attitude, a desire for completeness of knowledge and of explanation and suspended judgement (Medawar, 1984).

According to Bronowski (1978), to be a good scientist, one needs to be belligerent, contrary, questioning and challenging. "Because this kind of personality makes changes in society, scientists are catalysts, the stimulators, the creators of change. One does not invent a new world system by being satisfied with what other people have stated about how the world works. That dissatisfaction goes through and through, and it makes a complete personality. The scientist is as completely involved in the whole of his/her work as any poet or artist. Science and knowledge are not finished enterprises. Science is essentially a self-correcting activity."

The definitions of science given by scientists during the interviews conducted in this study generally agreed with those which have been mentioned. These include: "science is an understanding of natural and physical phenomena through logical inquiry, testing and verification; science is seeking the truth, finding answers to questions using the scientific method as a tool; science is a means of solving problems or acquiring knowledge; the scientific method is a rigorous, objective procedure designed to test a hypothesis or answer a question; science is trying to comprehend a mechanistic universe where there is an ultimate cause for everything; and science may be used to judge the value of information and data, and by providing basic facts to decision-makers, it can be instrumental in decision-making for management and policy."

When scientists were then asked during the interviews what it means to them to be a scientist, the following attitudes were expressed: "the scientist is one who devotes one's life to one's work; science is a way of life, a challenge, constantly trying to know the unknown and seeking the truth; science is goal-oriented and a way of fulfilling one's curiosity by pursuing creative work; a scientist has an interest in nature, a love for it, and a fascination for the diversity of living things and their interrelationships; one who is conscientious, yet has integrity and keeps emotionalism out of science; and finally, a scientist can be a translator of science and a positive contributor to culture and society." These attitudes were similar to those expressed by the different authors.

I believe the attitudes of scientists are as important as the skills they acquire and the knowledge they obtain. Although scientific attitudes affect beliefs, specific beliefs are not its most important product; it is an attitude toward problem solution. As Betrand Russell has said "It is not what the man of science believes that distinguishes him, but how and why he believes it. His beliefs are tentative, not dogmatic, they are based on evidence, not on authority" (in Dubos, 1970).

In my opinion, attitude, already defined in the introduction, is distinctly more important as a criterion of science than is the sheer amount of solid data available or the degree of development of knowledge. Attitudes being of such importance, influence far beyond the immediate effect. When we change the way we view any important aspect of our world, our attitudes toward other aspects of the world also change. Attitudes become more important than facts.

During the interviews, most scientists indicated that there is a difference between "applied" and "pure" research and that some scientists involved in "pure" research are not often directly interested in how their findings will be utilized. In The Game of Science, McCain and Segal (1973) said there are three different kinds of scientists. The "basic" or "pure" scientist is concerned with knowledge per se regardless of its relevance to practical applications. The "applied" scientist is one whose research or development is focused sharply on well-defined technical goals. The "mission-oriented" scientist's research has a societal rather than technical goal. The "basic" scientist is engaged in the task of articulating, deriving and generating principles that have general explanatory power. Research may be narrow, and the scientist's work may consist of attempting to fill in more specific detail within an already existing conceptual schema. What is most exciting and challenging for the "basic" scientist is the creation of new principles. The "pure" scientist is primarily motivated by an urge to explore and understand, but society supports fundamental research because experience has demonstrated how essential such work is for continued progress in technology. The "applied" scientist is more closely identified with the application of principles and concepts to a specific and generally limited problem. The scientist works over a longer time span on a single problem. Since the specific problem has not been solved before, time limits are harder to apply (McCain and Segal, 1973).

Some of the scientists interviewed were of the opinion that science is just a large collection of facts and that scientists are "providers of accurate factual information." But McCain and Segal (1973) argue that saying that the accumulation of facts or data is the primary goal of science is a misunderstanding. They believe it is an important part, but it does not lead to an understanding of science. All human groups collect data, but not all are scientists. No scientific theory is just a collection of facts, for if so, then every theory would either be right or wrong, and would be so forever, which is usually not the case.

To Bronowski (1977), all science is the search for unity in hidden likeness, and science finds order and meaning in experiences. A theory is thought to be a creation, and the creative activity of science lies in the process of induction. Creation engages the whole mind - not just the rational intellect. Therefore, though most of the scientists interviewed thought that keeping emotions out of science is important, some authors such as Bronowski (1965, 1977, 1978) would debate that.

Since science is created by the scientist and is a creative, original activity, it must be more than a compilation of facts; and since science has a value system, it is not neutral. Science is not neutral because the scientist cannot be detached, disinterested and dispassionate.

Ethics is the organization of our conduct by concepts which hold it together as a whole, concepts such as honesty and human dignity. It is the study of man in society. Ethics is not a final system, it is an activity just as science is (Von Hildebrand, 1972).

The relation between science and ethics is quite complex. Most of our attitudes, including those related to ethics and morality, have been affected by scientific thinking and discovery. "Applied" scientists have made many discoveries directly related to human behavior, but scientific concepts themselves are not behaviors and therefore are ethically neutral. Science should not be a mechanism, but a human activity, and not a set of findings but the search for them. That science and scientists are ethically neutral confuses with the findings of science which are, but not the activity of science, which is not. This is why the values of science turn out to be recognizably the human values: because scientists must be human, must be fallible, and yet must be willing to correct errors. Of course a discovery, a fact or theory is neutral. There is nothing moral or immoral about a theory. But this does not mean that science is neutral; that idea is a misunderstanding of what science is. Science is the process of discovery itself. It is not only what scientists know that matters to them, but what they do not know. If science was just about matters of fact, then there would be no debates in it and no new theories. If science is an arrangement of facts and the preference of one arrangement to another, then it is a continuous attempt to find truth in nature (McCain and Segal, 1973; Bronowski, 1978).

I believe that scientific knowledge per se is not sufficient to formulate the values that govern human behavior, nor can it impose them on society. However, it can provide a more factual basis for options by giving the statistical probability that certain consequences will result from new technological and social practices. Since awareness of likely consequences plays a large role in decision-making, scientific knowledge can become an important criterion in the evaluation of old value systems and perhaps in fostering the development of new ones. Skeptics have good reasons to claim, of course, that knowledge of consequences does not necessarily modify human behavior, for most people are willing to take calculated risks. But scientific knowledge can help in deciding what risk is acceptable by defining the statistical probability that certain kinds of consequences will occur, thereby making it easier to determine the relative importance of these consequences within the framework of personal values (McCain and Segal, 1973).

The scientist may be able to say with scientific validity where a particular activity may lead but cannot use scientific principles to decide whether the activity or its result is good. However, science can play a direct role in ethical determinations in at least two ways. First, given an ethical principle, scientists can determine some external conditions that are associated with behavior violating the principle. Second, scientists can establish that the consequences of certain behaviors are independent of any ethical considerations. On this basis, anyone can make their own ethical judgements (Sullivan, 1975).

A paradigm may be defined as a society's dominant belief structure that organizes the way people perceive and interpret the functioning of the world around them. Dominant paradigms can be applied to cultures or societies or scientific disciplines. It consists of the values, metaphysical beliefs, institutions, and habits that condition individual goals and expectations and provides a definition of social problems (Kuhn, 1970).

Kuhn (1970) claims that science is now being looked to as the authority to tell us how our natural world works. He states that science has given humans the power and capability to do many things that have far-reaching social, economic and political consequences. Yet the canons of science have lead scientists to strive to keep it value free; furthermore, scientists will not try to give society a code of ethics. This study did convey that science is not being used this way.

Despite a highly-developed code of behavior regarding the scientific process, I found there is little in the background of most scientists concerning the ethical basis of the application of knowledge to resource management decisions as seen from the interviews. While the ethics of the scientific method are clearly defined (Medawar, 1984), the ethical considerations involved in the application of scientific information to resource management are not. The scientist's role in the process remains poorly defined. This may stem from the historical relationship between the scientist and society (Milbrath, 1984).

Throughout this study it was difficult to find strong scientific rationale behind the management plans, let alone an ethical one, for the two were thought, in general, to be incompatible. Instead, as I read through the aims and objectives of the management plans, I felt that natural systems are thought to be commodities in the economic and political sense whose production is to be maximized, optimized, sustained or whatever word nowadays substitutes for sensitive understanding.

Most of the scientists interviewed agreed that scientific research involves adhering to a set of scientific ethics, and a good scientist must never violate them; and that the concepts of science and those of ethics belong to the same worlds. But according to Bronowski (1977) the body of scientists has to create a code of behavior to tame the prejudices, the vanities of individuals, for the sake of reaching the truth, not by dictatorial imposition, but by the agreement of free minds. It follows that in order to be good creators, scientists must have a set of values by which to live. Science gives a special value to some forms of behavior, such as original thinking, independence of mind, honesty, tolerance, and reasoned dissent, which are virtues in the world of science. Internal values therefore do exist in science. Scientists tend to approve of knowledge and understanding, as seen during the interviews. They think it is good to understand and to be able to explain relationships. The consensus among scientists, as seen in this study, was that knowledge and understanding are good in their own right and should be strived for. Some scientists, however, felt that knowledge in itself is not important, that it should lead somewhere, have practical consequences, or make a social contribution.

Truth is not reached merely by the utterance of new ideas, it requires the confirmation of those ideas. Science requires that each person shall respect what others say. Truth is the drive at the center of science. One way of looking for truth is to find concepts which are beyond challenge, because they are held by faith or by authority or the conviction that they are self-evident (Medawar, 1984).

There is nothing absolute about the concepts of natural science. Scientific knowledge is never absolute nor final, yet it remains valid when considered in the social and intellectual framework within which it was developed (Bronowski, 1978). As seen during the interviews, most respondents also replied that "there is no absolute truth in science, nor can it ever be reached."

The results of the interviews support my opinion that there is inherent in the practice of science a set of values without which science would be impossible. Science could not be carried out without trust among scientists, without originality and the other values mentioned. These conditions are necessary to the practice of science and are clearly not a set of neutral rules. They make up a stern morality: the morality of truth, objectivity and integrity.

One of the leading humanists of our time, Bronowski, mathematician, physicist, poet and philosopher, states his main thesis as follows: "There cannot be a decent philosophy, there cannot even be a decent science, without humanity. The understanding of nature has as its goal the understanding of human nature, and of the human condition within nature" (Bronowski, 1977). It is for this reason that he places emphasis on science as a creative, original activity based on ethics and a stern morality of truth and honesty. He also places a great importance to moral conscience, responsibility and duty as values scientists should possess. The civil war in Spain, the horrors of the extermination camps and massacres, and, finally, the obliteration of the two Japanese cities - which he visited as deputy chief of the British Mission in Japan - reinforced his belief that science and philosophy had to be not only human, but humane also. Thus his theories are not based on a scientific study, but on history and experience, the conflicts and human misery he had witnessed. His opinions and beliefs are based on his lifelong search and study of the nature of science and scientists.

Bronowski (1978) claims that scientists are actively trying to break out from the aura of impersonality and even inhumanity within which tradition has bound them. He believes that duty comes from an inborn sense and education. The concept of duty as a value can be considered. The concepts of value are profound and difficult because they do two things at once: they join people into societies and yet preserve for them freedom which makes them individuals (Bronowski, 1965). This concept of Bronowski was not entirely supported by my results. Most interviewees would not consider duty as a value essential to scientists.

"Some people feel that scientists have no spiritual urges and no human scruples, because the only success that science acknowledges is in conforming to the material facts of the world. Most people see nothing but the finished discovery, dispassionate and neutral. How can they guess what devotion, what singleness of mind is needed in the pursuit of truth and knowledge. The morality of science is subtle and grown from a simple principle - the principle that the community of scientists shall be so organized that nothing shall stand in the way of the emergence of truth" (Bronowski, 1978).

Does or does not science represent a moral order? Does it represent some part of the moral spectrum? The point is that perhaps scientists are not responsible for the use society makes of their achievements, but since the public supports them and puts their trust in them, they must publicize any potential dangers they may see. The continued support of science by society will depend on the willingness of scientists to relate their professional interests to genuine human needs and goals. Eventually, says Bronowski (1965), "scientists will have to concern themselves with the problem of human happiness."

The interviews did reveal uncertainty about responsibility. As was reviewed, different opinions were given. It was because of this uncertainty that I felt a discussion of the "responsibilities and obligations" of scientists is necessary. How responsible should the scientist be, does he/she have any moral obligations above those of any other citizen? I believe that scientists are guilty of escapism and irresponsibility if they do not concern themselves with the social consequences of their work!

I think that if science is to express a conscience, it must come spontaneously out of the community of scientists. Is science as a discipline capable of inspiring in those who practice it a sense of communal responsibility? Can scientists be moved, as a body, to accept the moral decisions which their key position in this civilization has thrust upon them? I believe yes! Both are questions of moral conscience; the first is a question of humanity, the second of integrity. If there is anything special about being a scientist, I think it is being more conscious than others that one belongs to an international community. Science being an endless search for truth where there is no distinction between means and ends, rejects all those devices of expediency by which humans who seek power excuse their use of bad means for what they call good ends. Scientists are more and more going to be face to face with a choice of conscience between two moralities: the morality of science, and the morality of political power. Though not many of the scientists and managers interviewed would agree with me, I firmly believe that scientists can no longer afford to be passive, they must voice their opinions and judgements based on the best available knowledge.

Bronowski (1978) said: "In world affairs, science has always been an enterprise without frontiers and scientists as a body make up the most successful international community in the world. In a world of un-United Nations, the public is searching for someone to act for the human race as a whole and hopes that scientists will do that."

McCain and Segal (1973) said that: "If we ask the question: Do scientists have anything to say about ethics? The answer is yes. "Applied" science, in particular, is important because the "applied" scientist attempts to devise ways to achieve the ethical goals desired by individuals. Ethical goals have to be established in nonscientific ways, but once they are established, the scientist has the best opportunity to find out how to reach them. Once the goal is established, scientific methods provide the best means for reaching them."

Do scientists have a sense of right and wrong? Have scientists abandoned their own responsibility because they have lost their moral judgement? I have interviewed many individuals who believe that what is good or evil cannot be judged by the standards of science. Science tells us only what is true and what is false. True and false, they say, are matters of fact; but good and evil are matters of conscience which lie on a different plane. But Bronowski (1965) says that this separation is destructive of sound morality for it removes morality from the best by which we judge the things that happen around us every day and makes it something remote from our practical lives.

Bronowski (1965) says that true humanity is understanding, understanding nature and man. "There is a deep moral lesson in the practice of science. The pains, the care, the patience, the humility, the bewilderment, the long hours spent in trying to see all the facts in focus, the agony of rejecting an explanation which seemed plausible but which fails to fit one obstinate fact, the illumination of at last finding the thread through the whole maze. Discoveries themselves are neutral because they already belong to the past. The practice of science is moral because it goes on without pause looking for what is true and rejecting what is false."

Scientific research can never be entirely free and uncommitted. It is never value-free because science needs the support of society and affects most social decisions (as was brought out during the interview discussions). There is the need to develop new attitudes toward scientific philosophy. Bronowski (1965) says that throughout most of the world the typical scientist is trained to think of science not as a means but as an end; the professional ideal is science for science's sake. I believe that if social problems are to be considered from the purely scientific point of view, scientists, being the ones with the knowledge, are the best judges of their relative importance and optimal solution. But as was mentioned during the interviews, scientists will not readily reconcile themselves to this change of emphasis. They will not readily accept that, in fact, "applied" science is in many cases more demanding intellectually than are the so-called purely academic sciences. The investigator in "applied" science must accept the complexities of the natural world instead of selecting problems on the basis of their convenience for experimental analysis, suitability, rewarding speculation, or opportunities appeal. Even Einstein said "Sociology is more difficult than physics" (in Dubos, 1970).

Scientists find it intellectually unjustified and dangerous to introduce subjective values in their professional activities. During the interviews, most individuals thought the scientist should not make value-judgements. McCain and Segal (1973) said that one reason for this attitude is that values usually involve complex situations not readily amenable to scientific analysis, such as relationships among human beings, aesthetic experiences, and judgements as to what is desirable or not. Furthermore, values imply freedom and therefore cannot be entirely accounted for by scientific determinism.

The evaluation of social merit or relevance to human welfare and the values of man is the most difficult problem posed by the application of science. It is also the most important because at the end, our values shape our knowledge, which in turn determines the quality of life (Milbrath, 1984). But this does not mean that all science can be traced to social motivation or to the search for practical applications. The "pure" scientist who continually pursues "pure" science creates a form of knowledge which has intrinsic value and need not be justified otherwise. I believe that both "pure" and "applied" research is important.

I think that one of the greatest dangers at the present time has to do with the attempt to avoid responsibility in order to avoid the feeling of guilt. Bronowski (1978) says that "We live in a civilization in which science is no longer a profession like any other. For now power is knowledge, power over our environment grows from discovery. Therefore, those whose profession is knowledge and discovery hold a place which is crucial in our societies: crucial in importance and therefore in responsibility. This is true for everyone who follows an intellectual profession, and the responsibility of the scientist is a particular case of the moral responsibility which every intellectual must accept." He continues to say that "It is fair to give the responsibility to scientists because their pursuits have for some time had the largest practical influence on our lives. Scientists should accept the moral leadership. There is now a duty laid on scientists to set an incorruptible standard for public morality. It is the search for truth that pays no attention to received opinion, expediency or political advantage. We have to foster that public understanding because in time it will work an intellectual revolution even in affairs of state. Scientists can act as guardians and as models for the public hope that somewhere there is a moral authority in man which can overcome all obstacles."

Communication, or the need for improvement of communication, was a central important theme in all the discussions held with scientists and managers during the interviews. The respondents said that more communication is needed between "basic" and "applied" scientists, if the distinction is to be made, and between scientists and managers. The scientists should take more time to see what research needs to be done for the manager; likewise, the manager should take the time to discuss or ask questions about scientific reports with the scientists and be interested in the research carried on by the scientist - to see if it may be pertinent information for the planning or writing of management plans. Thus, I believe that one of the greatest responsibilities of scientists is communication.

The interviews revealed that scientists are not, in general, good communicators outside of their narrow specialty to their peers; they do not communicate their knowledge to the public adequately or effectively; nor are they concerned with knowing the values, attitudes and beliefs the public has towards the marine environment. Environmental education has not been a primary concern or priority in the management plans I reviewed, nor do my interviews of scientists and managers indicate that much is going on. Environmental education should primarily be involved with man and his perception and attitudes towards the environment, and this has often been disregarded. As long as the public does not support the marine conservation concept, the establishment of a marine park by force is futile, defeats the purpose, and may only cause negative reactions which can be difficult to undo. I believe that the public must be educated, for with ignorance and negligence comes the danger of overexploitation and deterioration of the natural environment.

One of the most neglected aspects of environmental processes in the public arena is the role of public education in decision-making. Many different forms of media can be used as suggested by the interviewees to educate the public, and I think there is no real substitute for the interaction of the scientist with individuals of the local community. I believe that the role the scientist can play with decision-makers in government is providing alternatives based on objective facts, for the scientist is often asked an opinion based on the best available knowledge. I think that this is where judgement should be used. Scientists need to be persuaded that a well-informed opinion is better than none at all. It is necessary not only to acquire and publish the information in recognized scientific journals for one's peers, but to interpret such data and present it in an understandable fashion for public consumption. It is in this area, the translation and dissemination of scientific knowledge, that there is, as yet, no recognized method for the scientist to follow. I think that the weakness in the system of rewards and recognition for scientists is that no credit to public education and dissemination of facts at a level understandable by a community without scientific background is given. Almost all the respondents believed that discovery and development of knowledge is more important than dissemination of scientific knowledge. In fact, one can accept the hypothesis that "Scientists do not play a role in promoting or encouraging science as a means of changing attitudes and opinions of management and the public so as to influence public policy and ultimately environmental management."

From the interviews, both scientists and managers felt that advice to solve immediate problems in management was not often volunteered by scientists, nor were scientists often consulted which was substantiated in the plans reviewed. Even when scientists were consulted, at times it was to support the managers' opinions and at other times to obtain unbiased advice.

Though most managers were confident that science was being used in the development of management plans, this was not evident when an objective analysis was made of the scientific citations used as sources for the plans. Even the "grey" literature, which was thought by many respondents to be of value, was not often cited in the management plans.

When one looks at the Proceedings of the Fourth International Coral Reef Symposium held at Manila, 1981, 42, or 19%, out of 218 papers presented were under the heading "Reef and Man," which included topics such as fisheries, environmental stress, resource management and marine park philosophy. Ten papers were on fishing impacts (both recreational and commercial), three were on the impacts made by dredge and fill activities, one on sand-mining, one on the impacts of oil refineries, one on impacts of anchor damage, and eight on other aspects of water pollution. Eighteen of the papers were on the purpose or philosophy of marine resource management and the establishment of marine parks. Only two of these articles were cited (one each in two management plans) since that meeting.

In my opinion, the essence of the dilemma lies in the limited transfer of knowledge. It is obvious from the interviews that there is a lack of the will to communicate, transfer or disseminate information, educate or even make available information comprehensible to nonscientists. It is only after accumulation and publication of scientific information and then dissemination of the data to managers and the public via various media, public meetings and presentations that interest, awareness and concern will arise.

I believe that science and scientists can play an important role in public policy and management.

In general, scientific information relevant to natural resource management consists of two types:

1) inventory data, consisting of quantitative descriptions, lists, or assessments of the resources in an area;
2) process evaluation, consisting of the analyses and descriptions of processes at work within given ecosystems.

Analysis, interpretation of the inventory data and selection of the management techniques to be applied requires knowledge of the relevant literature (Dubnick and Bardes, 1983).

Boulding (1958) states that the term "policy" generally refers to the principles that govern action directed towards given ends. A similar definition is given by Worrell (1970) as a settled course of action adopted and followed by a society. Therefore, according to Van Dyke (1968) the three components of a policy consist of:

1) goals;
2) a plan or strategy for achieving the goals, rules or guides to action or methods;
3) action.

In natural resource management policies, these components are often somewhat mixed in a chain of goals and methods ranging from broad societal goals to specific management objectives.

In Price's view (1965) the system consists of four categories:

1) the political, concerned with matters of value and judgement;
2) the administrative, concerned with applying the skills and knowledge of professionals to achieve the goals set by the members of the political estate;
3) the professional, concerned with applying the knowledge of science to the affairs of men;
4) the scientific, concerned only with the search for truth and knowledge.

In general terms, "public policy" is the application of problem-solving relative to a public problem and those actions government officials take (or avoid) in attaining those objectives (Dubnick and Bardes, 1983).

Public policies are not just pervasive. They are also meaningful in the sense that they constantly affect the quality of our lives. We should recognize public policies as responses to and sources of problems, says Dickson (1984). He says that we can also define "public policy" in problem-based terms. Public policies are usually defined as human needs, dissatisfications or deprivations and are responses to public problems.

For our purposes, I will define policy as established institutional guidelines and regulations for the purpose of achieving environmental goals. Standards developed for the protection of the environment.

Likewise, I propose that resource management is manipulating controlling factors to achieve or maintain an end result. It is managing human activities that affect the resource. It is optimal use of a resource achieved by maximizing human use while at the same time conserving the natural resource. It entails the recognition, understanding, and knowing of all the units that comprise all the resources to manage, including biological, physical, cultural, social, economic, and political factors.

Environmental policies are prevailing decisions regarding those activities that societies will undertake, permit or prohibit. These policies are characteristically made explicit in declarations, laws, regulations, judicial decisions and in what people do (Dubnick and Bardes, 1983).

It was felt by some of the interviewees that at present the scientist does not seem to make policy, or even help to make it, and most of the time scientists have no idea what shifts of policy their advice is meant to serve. The scientists are thought to have no control over the way in which what they say in council will be presented to the public.

I think that science must be concerned more with the social, political, and even moral aspects of science policy. Dubos (1970) said that "A society that blindly accepts the decisions of politicians is a sick society on its way to death. The time has come to produce, alongside specialists, another class of scholars and citizens who have broad familiarity with the facts, methods, and objectives of science and thus are capable of making judgements about scientific policy. Persons who work at the interface of science and society have become essential simply because almost everything that happens in society is influenced by science."

Caldwell (1970) wrote that "Damage to the environment has been great, in part because the opportunities to bend nature to human purposes have been great and also because of deep and often uncritical popular commitment to economic development and to personal freedom. Environmental degradation has been a defect of national virtues. The attitude of disregarding environmental damage should no longer be permissible or possible. Developing counter-technologies to correct the new kinds of damage constantly being created by technological innovations is a policy of despair which commonly provides an excuse for not facing problems and thus constitutes a form of escapism into gadgetry from the complexity of issues. Scientific knowledge, on the other hand, can provide the understanding required for a rational approach to almost any kind of difficult situation. It can give policy-makers the facts on which to base decisions and increase the numbers of options they have to work with."

The selection of scientific goals which are socially worthwhile is of crucial importance precisely because of discoveries throughout our civilization. Any social problem involves not only individual persons but even more the interplay and their relationships with the total environment. History, environmental forces, value systems, and aspirations all play some role in the practical management of human affairs, resource management being one.

H. G. Wells in A Modern Utopia (1967) said there is a "logical" future and a "willed" future. He said "Will is stronger than fact; it can mold and overcome fact. But this world has still to discover its will."

In an inspired passage in Science and the Modern World, Whitehead (1925) suggested that "The order of nature as conceived by scientific determinism has now taken the role of fate in the Greek tragedy. The great tragedians of the modern world are the scientists with their vision of fate, remorseless and indifferent, urging an incident to its inevitable issue... This remorseless inevitableness is what pervades scientific thought. The laws of physics are the decrees of fate. Fortunately, the applications of science to human affairs do not have a high degree of inevitability as do the laws of nature."

Caldwell (1970) says that the tendency in the past has been to deal with environmental problems segmentally, through specialists whose frequently conflicting judgements require compromise or arbitration. In the absence of an adequate integrating and focusing purpose, it is difficult to direct specialized knowledge into comprehensive, well-conceived and generally beneficial public action. He believes that the so-called segmental thinking, segmental decision-making - the "practical" approach - has produced impractical results and that many of the worst environmental errors have been consequences of segmental, single-purpose, public decision-making. Dealing with environments comprehensively need not imply detailed analysis and synthesis of all environmental factors before policies can be formulated (Caldwell, 1970).

The concept of "good" environment is certainly no less concrete, tangible, and specific than the concepts of freedom, security, and welfare, which have on various occasions served to focus public policy. "Environmental quality" can also be used as an organizing concept (Milbrath, 1984; Medawar, 1984).

In the introduction it was mentioned how there is uncertainty of what the interaction between science and policy should be. Science and politics need not have opposing conclusions regarding environmental policy, according to Caldwell (1970). He believes that a "body politic" better informed by science and a science applied in the service of well-considered values would provide a firmer and broader basis for public environmental decision-making. He concludes that a coherent political philosophy, with the scientific attitude and evidence respected in relation to human needs and capabilities, would greatly strengthen the conceptual base upon which sound environmental policy could be built.

Science is becoming better able to measure and describe the systematic interrelatedness of man's total environment and to ascertain the ramifications of environment-shaping activities. It is enabling man to see with a new comprehension the nature and consequences of human impact upon the environment. Science may thus afford a conceptual basis for public environmental policy that neither ethics, aesthetics, economics, nor engineering have been able, thus far, to provide (Milbrath, 1984).

Dickson (1984) claims that were environmental quality to become as politically decisive an issue as foreign policy or civil rights (as examples), one could assume it would receive more attention from political forums. Unfortunately, seldom have the destinies of political parties turned on the outcome of an environmental issue. This is partly because environmental quality, as a general proposition, is vaguely perceived in the minds of most people. "Environmental quality must somehow come to symbolize a widely-shared and deeply-felt attitude toward life itself. People have fought, bled and died for peace, justice, freedom and equality, why not for environmental quality?" (Caldwell, 1970). That is why I believe it is important for scientists to be concerned about attitudes people have toward the environment and be interested in educating them on important environmental issues. If scientific evidence and reasoned argument are the appeals that are really required to arouse support for environmental quality as a policy, then one must speed up popular understanding and preference with respect to environmental relationships. Public policies based on science-derived understanding of man/environment relationships would diminish the role of the politician and augment the policy roles of scientists.

In my opinion, the really significant policy is that which actually influences the behavior of people. The most powerful unifying force behind a policy is a commonly-shared, simple, persuasive idea. To be so, the concept must relate directly to the perceived needs of the people.

Environmental management implies guidelines and controls over the actions of men. The environment is managed through the management of human beings (Caldwell, 1970). The interviewees also agreed that one must "manage" people, whether through police powers, indoctrination or through passive means.

A rational approach to public environmental policy would seek to establish ecological base lines to meet the known needs and values of the society (Caldwell, 1970). The more ample the margin between the resources of the ecosystem and the demands upon it, the greater the capacity of the system for flexibility, variety and self-renewal. Dickson (1984) states that incomplete evidence regarding ecological processes is not necessarily a good argument for failing to adopt a protective environmental policy. Incomplete evidence is not necessarily insufficient evidence for public action, "if that is what one needs for public action, there would be almost nothing upon which governments might legitimately act" (Dickson, 1984).

I maintain that it is every human being's right to have a safe and healthful environment. An important task of environmental policy and management is to discover and apply concepts and procedures that would not only stabilize society but would also enable society to cope with environmental problems. Science and scientists can therefore play an important role in environmental policy and management by giving advice.

As I have tried to demonstrate, human perceptions and moral values are important and should be a part of science. Individual self-restraint, although important, is not a reliable means of protecting the environment. Internalizing of ecologically-valid behavior patterns could greatly facilitate the administration of public environmental policy. If protection of the ecological basis of life is both in one's self-interest and in the public-interest, then the first major task of policy development is to maximize public understanding. This implies public understanding of why it is so. Groups of scientists can make voluntary efforts to arouse public awareness and concern and to assist people and their political representatives toward understanding their collective ecological self-interest and what must be done to protect it.

Man as a species does not and cannot live alone. As Storer (1953) said, humans are part of the "web of life." By protecting the earth's environments and species, human beings not only show respect but also take practical action toward maintaining the conditions that will permit their own survival! The marine environment is one such environment that needs to be protected!

Plato said that "Education is not teaching people to know what they do not know, it also means teaching them to behave as they do not behave." When asked the question: "How can the world be created fit for men to live in?" Plato would answer: "Create men fit to live in such a world; the means for this lie in education, but it must be an education concentrated on the development of the virtues necessary to bring into being the kind of society that we should desire" (in Dubos, 1970).

CONCLUSIONS

Through analysis of the management plans, I did not always see a strong relationship between expected results published in the scientific literature and actual management plans. Most of the science used in the plans was in the description of natural resources. It was hard to determine precisely whether or not the plans are effective because they have all been written only recently. But from the few sites I did visit, I felt the plans are not as effective as they could be. A few reasons for this may be:

1) many of the objectives and goals stated in the management plans were not accomplished;
2) violators were not always prosecuted;
3) not much monitoring was done to see if there were any changes in the health of the reefs;
4) in some areas, though the marine park has been established for a few years, the public is not even aware of its existence, let alone educated as to its importance.

A number of recommendations can be made to improve the utilization of science in natural resource policy and management. I believe that the recommendations have wide application to the various fields of natural resource management, not just to coral reefs.

The interviews and analysis of plans made for coral reef areas may also provide guidance in the managing of other natural resources such as submerged aquatic vegetative areas.

These recommendations are:

1) Improve research or primary literature report style and format by including improved summaries in plain language that demonstrate clearly what was discovered and the statistical analysis interpreted in terms of importance to management. Improve the quality of "grey" or "secondary" literature by having better quality control, better synthesis and more accessibility.
2) Promote on-going, fundamental, "basic" research as well as problem-oriented "applied" research to specific management needs. Include proponents of different user philosophies in the planning of research efforts and have scientists examine completed projects.
3) Improve communications between:
   a) "applied" and "basic" scientists,
   b) scientists and managers,
   c) scientists and the public.

   In order to make public awareness, understanding, concern and action a priority, environmental education should be promoted. Scientists should be encouraged to communicate their research results to managers and the public, when pertinent, through the media or other traditional ways - not just to offer knowledge and understanding, but value-judgements on the best available information. Dissemination of knowledge can be more crucial at times than mere discovery and development of knowledge. Knowledge and concern of attitudes the public has towards marine environmental protection can only be attained through interaction and communication.

4) Encourage scientists to play an active role in environmental public policy by taking part in all phases of policy-making as advisors and consultants. While doing so, scientists must always keep in mind the essentiality of adhering to the values of science and scientific ethics.

5) Establish an advisory committee composed of scientists ("basic" and "applied"), environmentalists, educators, managers, policy analysts, planners and economists. Inclusion of representatives from the different user groups (including both opponents and proponents of the plan) in such a committee may also prove to be beneficial.

The establishment of an advisory committee for an area of management is a central recommendation. The other recommendations could be implemented within this framework. For instance, contact between scientists and others within this type of committee could provide the input necessary for revision of research report style and format. Communication problems could be identified and solutions devised. The committee would also be able to coordinate research efforts and provide an opportunity for representatives of opposing interests to actually participate in the natural resource management process. It is important that opponents participate in the establishment of the scientific base for management. Their opposition often determines the data needs for decision-making, and their participation in planning and monitoring research would prevent suspicion of bias. The committee might also guide review and synthesis of the relevant scientific information into management proposals.

The participants in most natural resource policy issues share interests in aesthetics, recreation, conservation and economic opportunities. These common interests can provide an adequate basis for negotiation and compromise (Caldwell, 1970). My study indicates that the need for new knowledge is at times less critical than the transfer of existing knowledge in the right form and at the right time. The communication gaps that presently exist between managers, scientists and decision-makers (including the public) are acknowledged to be larger and more important problems than the gaps in knowledge about environmental effects.

I believe that ethical and aesthetic considerations together with scientific, economic, political and social understanding and the incorporation of all these elements in equal or necessary proportions and importance will be the only way to salvage our natural environment and especially the marine environment. Until awareness and concern is achieved, present values, attitudes and beliefs can only lead to deterioration of our natural marine resources. The outcome will rest on a value system that is in need of reevaluation and a more uniform approach to the role of science and scientists in a rapidly changing socio-economic environment.

In conclusion, as a result of evaluation of interviews/ questionnaires and the analysis of management plans, one may accept the general hypothesis: "Scientists do not play a role in promoting or encouraging science as a means of changing attitudes and opinions of management and the public so as to influence public policy and ultimately environmental management."

The objective of the study was to see if science and scientists play a role in policy formation and management. By examining what scientists are doing and have done, one senses they are, but not as adequately nor effectively as possible. The results of this study have demonstrated weaknesses in the system.

The lengthy discussion or argument that was presented as to the role scientists should play should be joined by all scientists who believe the role of science and scientists is only "to seek knowledge and truth." Those scientists who have doubts and uncertainties as to how responsible the scientist should be in society, whether he/she has any moral obligations, should decide for themselves why or why not.

I believe that the traditional role of the scientist is changing. The time has come for a new breed of scientists who remain neutral in their scientific findings but are not afraid to give value-judgements or voice their beliefs and opinions. We need more scientists who not only have a firm commitment to seeking the truth but are willing to go a step beyond that and help communicate and understand the truth. We need scientists who want to advise and actively participate in resource management and policy formation. Also, scientists are needed who realize the importance of knowing and being concerned about attitudes, values and beliefs the public has towards protecting the marine environment. By knowing such attitudes, scientists can promote and encourage a general awareness of the causes and consequences for man, society, and the world of environmental problems and urge the adoption of ethics, attitudes and values likely to contribute to the protection and improvement of the environment. An understanding of science can do this, and scientists can play a key role for they are the ones who possess the knowledge.

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APPENDIX A

<u>Questionnaire Utilized in Interviews
With Scientists and Managers</u>

I. Degree(s) and year obtained ____________________

Major(s) ____________________________________

Age _____

Position/Title ______________________________

II. What is your working perspective of the nature of science and the scientific method?

III. What does it mean to you to be a scientist?

IV. How do scientists know what they know?

V. Of what importance is your scientific study toward its contribution to policy and/or management?

VI. What are the rewards and/or frustrations about doing scientific research?

VII. What do you classify as environmental policy?

VIII. What are the rewards and/or frustrations about getting involved in policy formation decisions?

IX. What do you consider the field resource management embraces?

X. What are the rewards and/or frustrations about designing a management plan?

[1] IF SCIENTIFIC RESEARCH IS "PURE" OR "BASIC", THEN THE RESULTS WILL NOT BE DIRECTLY UTILIZED.

1. There is a difference between "pure" or "basic" research and "applied" research.

   strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

   Probe: If you agree, what is the difference?

2. Scientists involved in "pure" research are not likely to be directly interested in how their findings will be utilized or applied in policy formation or in management plans.

   strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

   Probe: What do you personally think?

3. In general, "grey" literature scientific reports published by government agencies and/or universities are useful to either scientists or managers in their planning of management projects.

   strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

   Probe: Can you provide some specific titles or specific reports that you believe were most useful?

   Probe: Are there any reports prepared by government and/or the universities for management purposes that have little or no use?

   Probe: How would you advise making agency or university reports more useful in formulating management policy?

4. Scientific criticism of a management proposal causes management agencies to take account of the "pure" research literature.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If you agree, why?

Probe: If you disagree, then do you think they would more likely take into account the "applied" research literature?

[2] THE MORE FORMAL EDUCATION ONE HAS, THE MORE ONE WILL UTILIZE THE SCIENTIFIC INFORMATION RELEVANT TO POLICY-MAKING AND/OR MANAGEMENT DECISIONS.

5. One's degree of formal education indicates the amount of scientific information one will utilize when making policy or management decisions.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: What is more important in such a situation, knowledge or experience?

[3] SCIENTISTS IN NATURAL RESOURCE FIELDS DO NOT GIVE ADVICE THAT HAS APPLICABILITY TO IMMEDIATE PROBLEMS IN MANAGEMENT.

6. Research on the applications of science is a valid and proper role for a scientist.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Why do you feel that way?

Probe: Are you involved in applied research?

Probe: Is it proper for scientists to give advice on management decisions?

7. Most scientists try to influence management decisions based only on their own scientific work.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Does your scientific research have significance relative to management plans?

Probe: Do you influence management decisions based only on your own scientific work?

8. Scientific research helps solve some of the immediate problems in management.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If you agree, how?

Probe: If you disagree, explain why.

9. Scientists often voluntarily offer advice or criticism on a management issue and/or option.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Do you feel you should offer advice voluntarily or do you wait until it is requested by the manager?

10. Scientists often voluntarily offer criticism on an approved management plan that appears to go contrary to their findings.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Do you feel they should?

11. One of the functions of research scientists is to develop their findings into management techniques.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Why is it, or is it not appropriate? Should they do so?

    Probe: Do you think that it is more appropriate for management agencies to develop scientific findings into management techniques?

12. All research is geared towards "real world" problems.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Why or why not?

    Probe: Should it not be?

[4] SCIENTIFIC ADVICE IS SOUGHT FROM RESEARCH PERSONNEL BY MANAGERS TO GAIN SUPPORT FOR OPINIONS AND OBJECTIVES RATHER THAN OBTAIN UNBIASED ADVICE ON MANAGEMENT CHOICES.

13. Managers constantly demand scientific information and knowledge from scientists to use in policy-making and for management decisions.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Do scientists mind being asked for their opinions and knowledge?

14. The information given by scientists to resource managers is often used to support the managers' opinion only.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Why do you think so?

15. The information given by scientists to resource managers is used to shed new light on management problems.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Do you have any evidence of this?

16. Upon planning a management project, a manager consults with such persons as experienced project planners, applied scientists, and engineers for advice.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Why do you feel this is so?

    Probe: Would you necessarily ask all of them for advice?

    Probe: Whose advice would you trust the most?

17. Upon planning a management project, a manager consults with research scientists.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Is this often the case? Why or why not?

[5] SCIENTISTS ARE NOT "ACTIVELY" INVOLVED IN INFLUENCING PUBLIC POLICY.

18. It is appropriate for scientists to play an "active" role during the fact-gathering phase of policy-making, but not during policy development and promulgation.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: If you agree, why?

    Probe: If you disagree, then do you think they should play an active role in all three phases, or a passive role in some?

    Probe: How should they play a part?

19. It is not appropriate for scientists to represent themselves as a scientific expert in a controversial policy matter in an area not directly in their field of experience or in which they have not done specific research during formal proceedings.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: What may be the complications?

Probe: Have you ever been an expert witness?

Probe: How close was the topic on which you were testifying to your immediate research activities?

Probe: Is it appropriate for a scientist, as with any citizen, to become involved in controversial policy matters involving science and technology even though he/she is not an expert in the area? Why?

Probe: What should the scientist do in such a situation?

Probe: Would a scientist have more of an input than other citizens?

20. Scientists do not at all want to concern themselves (or be burdened) with influencing or forming public policy.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If not, why not?

Probe: If you agree, how "active" a role do they play? Or should they play?

Probe: How have you specifically used your knowledge of science to influence or form public policy?

[6] SCIENTISTS INVOLVED IN MANAGEMENT DECISION-MAKING VIOLATE THE SCIENTIFIC ETHIC OF AVOIDING BIAS IN THEIR ACTIONS.

21. When "managing" a resource, only scientific information relevant to the natural resource is appropriate for consideration.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: If you agree, why?

    Probe: If you disagree, then do you think that it is not enough to consider the natural resource itself, for one must "manage" people as well?

    Probe: Would "managing" people be a form of indoctrination?

22. Scientific research involves adhering to a set of scientific ethics or codes.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: What are these ethics or codes?

    Probe: Where have they been derived from?

    Probe: How are they motivated?

23. Scientists violate scientific ethics when they become directly involved in management decisions.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Because scientists need to make decisions which consider the public good, do you think they are torn between scientific ethics and political ethics?

    Probe: Does having scientific ethics make a scientist feel that he/she has moral authority as a human being?

[7] RESEARCH REPORTS ARE OFTEN WRITTEN IN LANGUAGE THAT NEITHER "MANAGERS" NOR "PUBLIC" CAN UNDERSTAND.

24. Scientists are not able to keep up with the most recent literature in areas in which they are not actively working.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Are scientists usually involved with more than one project at a time?

    Probe: How do you keep up with the literature?

25. Most research reports can be read and understood by scientists.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: How do you know?

    Probe: Can you read and do you understand most research reports in your field? Outside your field?

26. Most research reports can be read and understood by resource managers.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: How is this evident?

27. Most research reports can be read and understood by the public.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Why do you think so?

28. Research on management questions is done by scientists in a number of different disciplines such as meteorologists, physicists, biologists, chemists, geologists and engineers (to name a few). The language of their reports is too difficult for managers to comprehend.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If you agree, which of the above discipline(s) (or any other discipline(s) you may think of) have the most difficult reports to understand? Why?

29. It is appropriate to describe the statistical analysis used in research in material published for the scientific community.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Should it be?

30. It is not appropriate to describe the statistical analysis used in research reports geared for the manager or the public for (or during) their decision-making process.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Would this simplify or complicate matters?

Probe: Why should it or should it not be described?

31. Research scientists qualify the results of their study too much.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: In what context?

Probe: To what extent?

Probe: Is it better if they do or do not? Why?

[8] **SCIENTISTS SELDOM COMMUNICATE THEIR KNOWLEDGE TO THE PUBLIC EFFECTIVELY.**

32. The communication responsibility of scientists is over with the publication of peer-reviewed literature.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: What should the communication responsibility of the scientist be?

33. Scientists seldom communicate the knowledge of their particular research to the public.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: What are the reasons why they should or should not?

34. Scientists seldom communicate with the public through the press, television and radio programs, and public lectures or courses offered in continuing education programs.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Which one(s) of the above are most effective? Least effective?

Probe: Have you ever been involved in any of the above-mentioned means of communication? Do you feel you should?

Probe: Do you know of any other ways of transmitting information to the public?

35. The communication efforts of scientists with the public are not always effective and/or adequate.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Do you communicate effectively?

Probe: Explain why you think so, or how you know.

Probe: Is it important for a scientist to be able to communicate effectively?

[9] SCIENTISTS FEEL THAT THEY SHOULD NOT CONCERN THEMSELVES WITH ATTITUDES, VALUES, AND BELIEFS THE PUBLIC HAS TOWARDS THE PROTECTION OF THE MARINE ENVIRONMENT NOR DO THEY FEEL IT IS THEIR "DUTY" TO CHANGE THEM.

36. Scientists know the attitudes people have toward protecting the marine environment.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If you agree, then do scientists know what action people want when it comes to protecting the marine environment?

Probe: How do they know?

Probe: Do you know the attitudes people have?

37. Managers know what people want when it comes to protecting the marine environment.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: How do they know?

38. Scientists know more than managers what the attitudes and opinions of the public are towards protecting the marine environment.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If you agree, why do you think so?

Probe: If you disagree, do you think perhaps that managers know more so than scientists?

39. Scientists are concerned with attitudes, values, and beliefs the public has towards the marine environment.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Why or why not?

Probe: Should they be concerned?

40. Managers are concerned with attitudes, values, and beliefs the public has towards the marine environment.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Why or why not?

Probe: Should they be concerned?

[10] SCIENTISTS FEEL THAT THEIR ROLE IS ONLY TO SEEK KNOWLEDGE AND TRUTH; THAT THEY ARE NOT QUALIFIED TO MAKE VALUE-JUDGEMENTS.

41. Scientists are not effectively involved in present environmental management efforts.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If yes, how are they involved?

Probe: If no, should they be involved?

42. An appropriate place for scientific involvement in environmental management is in the process of policy implementation (i.e. permitting, regulatory hearings, etc.).

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Give reasons why you think so.

    Probe: Is there enough involvement now? Should there be more?

43. It is appropriate for scientists to become involved in surveillance and policing of policy implementation.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Why do you say this?

    Probe: Are scientists involved now in such activities? Should they be?

44. Scientists presently have a say in the development of regulations or laws pertaining to management of our natural resources during the policy development phase.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Is this a must for the scientist?

45. It is appropriate for scientists to get involved in the development and delivery of educational, recreational and interpretative programs for the general public.

    strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

    Probe: Are they involved in all three?

    Probe: Should they be involved in such functions?

46. The scientist has an important role monitoring management plans.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Explain your answer.

Probe: Is that an important role for the scientist?

47. Scientists can be effectively involved with several different roles (i.e. advisor, educator, investigator) at the same time.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: What has been your personal experience?

Probe: Even though a scientist is confronted with several different roles at times, do you think that he or she is still effective equally in all roles?

Probe: How does one know if one is being effective?

48. When scientists do address the public on important issues, they feel that their sole responsibility is to provide their factual knowledge and understanding.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: If you agree, do you think this is adequate?

Probe: If youdisagree, do you think they should also communicate their value-judgements?

49. The scientist's role is one that goes beyond seeking the truth.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: What is the "absolute truth" in science?

Probe: Can the scientist ever reach an "absolute truth"?

50. The scientist plays a role in the discovery, development and dissemination of knowledge.

strongly agree [ ] agree [ ] disagree [ ] strongly disagree [ ]

Probe: Does the scientist play an equally important role in all three phases, or only one or two of the above?

Probe: What is the role of science and scientists in our society?

Probe: What is their specific role in marine environmental policy and management?

Probe: What do you think the role of the scientist should be?

APPENDIX B

List of Individuals Interviewed

Mr. J. W. Bellinger
M.Sc. - Fisheries - 1969
Environmental Planner
U.S. Army Corps of Engineers
Board of Engineers for River and Harbors
Washington, D.C.

Dr. R. J. Berry
Ph.D. - Oceanography - 1967
Center Director
S.E. Fisheries Center/NOAA
Virginia Key, Florida

Dr. J. A. Bohnsack
Ph.D. - Ecology - 1979
Reef-Team Leader
Fisheries Biologist
National Marine Fisheries Service
S.E. Fisheries/NOAA
Virginia Key, Florida

Mr. J. T. Booker
M.Sc. - Marine Science - 1980
Program Director
New Found Harbor
Big Pine Key, Florida

Dr. B. E. Brown
Ph.D. - Fisheries and Statistics - 1969
Deputy Director of S.E. Fisheries/NOAA
Virginia Key, Florida

Mr. B. D. Causey
M.Sc. - Zoology - 1969
Sanctuary Manager
Looe Key, Florida

Dr. S. Cofer-Shabir
Ph.D. - Oceanography - 1976
Research Coordinator
Key Biscayne, Florida

Mr. D. Cottingham
M.Sc. - Environmental Management - 1978
Policy Analyst/Environmental Protection Specialist
Policy and Planning/NOAA
Washington, D.C.

Dr. R. Cressey
Ph.D. - Biology - 1965
Biologist/Smithsonian
Washington, D.C.

Mr. R. W. Curry
M.Sc. - Chemical Oceanography - 1975
Resource Management Coordinator
Key Biscayne, Florida

Ms. C. Curtis
M.Sc. - Biology - 1980
Research Coordinator/NOAA
Washington, D.C.

Ms. A. Danneberg
B.A. - Environmental Biology - 1977
Assistant Project Planner/NOAA
Washington, D.C.

Mr. J. Dobbins
M.L.A. - Landscape Architecture - 1976
President of James Dobbins Associates
Planner/Consultant
Alexandria, Virginia

Dr. A. Froelich
Ph.D. - Biological Oceanography - 1980
Research Assistant-Professor
Rosenstiel School of Atmospheric Science and Oceanography
University of Miami
Miami, Florida

Mr. J. C. Halas
B.Sc. - Marine Biology - 1966
Sanctuary Biologist
Key Largo, Florida

Dr. G. C. Han
Ph.D. - Physical Oceanography - 1973
Senior Staff Biologist
General Oceanics
Miami, Florida

Mr. B. J. Harrigan
B.A. - Marine Biology - 1972
Sanctuary Manager
Key Largo, Florida

Mr. J. Hunt
M.Sc. - Marine Science - 1981
Biologist/Supervisor
Florida Department of Natural Resources (Fisheries)
Marathon, Florida

Mr. W. Jaap
B.Sc. - Marine Science - 1970
Biologist
Department of Natural Resources
St. Petersburg, Florida

Mr. H. W. Kaufman
M.Sc. - Marine Biology - 1976
Deputy Chief
Sanctuary Programs Division/NOAA
Washington, D.C.

Mr. C. R. Kruer
M.Sc. - Marine Science - 1977
Army Corps of Engineers
Big Pine Key, Florida

Ms. V. E. Lee
M.Sc. - Oceanography - 1981
Policy Analyst
Policy and Planning/NOAA
Washington, D.C.

Mr. E. Lindelof
M.A. - Regional Planning - 1975
Senior Policy Analyst
Sanctuary Program/NOAA
Washington, D.C.

Dr. R. J. Livingston
Ph.D. - Marine Biology - 1980
Professor and Director of the Center
for Aquatic Research and Management
State University of Florida
Tallahassee, Florida

Mr. R. Lopez
B.Sc. - Physical Oceanography - 1976
Regional Manager for Florida and the Caribbean
Sanctuary Program Division/NOAA
Washington, D.C.

Mr. J. M. Meehan
M.Sc. - Wildlife Science - 1973
Leader, Assessment Program
National Resource Assessment Program
Management of Resource Research
National Marine Fisheries Service/NOAA
Washington, D.C.

Dr. C. Messing
Ph.D. - Biological Oceanography - 1979
Research Associate
Rosenstiel School of Atmospheric Science and Oceanography
Pidgeon Key Field Station
University of Miami
Miami, Florida

Dr. A. D. Parsons
Ph.D. - Zoology - 1973
National Fishery Ecology Program
National Marine Fisheries Service/NOAA
Washington, D.C.

Ms. R. S. Rootes
M.P.A. - Public Administration - 1983
Manager
Office of International Fisheries
National Marine Services/NOAA
Washington, D.C.

Dr. K. Ruetzler
Ph.D. - Biology and Anthropology - 1963
Biologist, Curator/Smithsonian
Washington, D.C.

Ms. S. K. Shutler
M.A. - Marine Affairs - 1981
Foreign Affairs Specialist
National Marine Fisheries Service/NOAA
Washington, D.C.

Dr. R. H. Stockman
Ph.D. - Marine Science Policy - 1986
Deputy Director, Office of Policy and Planning
Department of Commerce/NOAA
Washington, D.C.

Mr. J. Thomas
M.Sc. - Biology - 1975
Scientist/Instructor
New Found Harbor Institute of Marine Science
Big Pine Key, Florida

Mr. W. J. Thomas
M.Sc. - Zoology - 1978
Program Specialist
Sanctuary Programs Division
Ocean and Coastal Resource Management/NOAA
Washington, D.C.

Dr. V. A. Vail
Ph.D. - Zoology - 1975
Environmental Administrator
Department of Natural Resources
Tallahassee, Florida

Ms. E. Wilcox
M.Sc. - Environmental Systems Management - 1976
Principle Associate/Environmental Expert
Alexandria, Virginia

VITA

TENY TOPALIAN

Born in Cairo, Egypt, 9 April 1953. Canadian of Armenian ethnic origin. Graduated in 1970 from Beaconsfield High School, Beaconsfield, Quebec. Received B.Sc. in Biology in 1975 and Diploma in Education in 1977 from McGill University, Montreal, Quebec. Taught high school mathematics and biology in Hull, Quebec, and in Trinidad and Tobago, West Indies. Awarded a M.Ed. in Foundations of Education in 1980 from the University of Ottawa, Ottawa, Ontario. Entered doctoral program in the School of Marine Science at the Virginia Institute of Marine Science of The College of William and Mary in 1982.