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# CONFLICTS IN INTERDISCIPLINARY RESEARCH*

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ABSTRACT

Interdisciplinary research has the potential to produce more holistic views of the interaction between modern societies and their environments. Such views are becoming increasingly necessary due to the potential environmental alterations from our expanding technology. Interdisciplinary research teams typically have many difficulties due to personnel conflicts that are not common to disciplinary research. A number of factors which produce these conflicts are identified and several methods of management are discussed.

## Introduction

This study resulted primarily from the examination of our experiences and frustrations as members of a interdisciplinary research team. The team's research was concerned with the impacts of dredging on estuaries and involved seven principal investigators.

We began by reviewing the philosophy of science. Those concepts

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which helped to explain our experiences within this research team were selected and discussed. As systematic descriptions were developed, they were presented in workshops and seminars to members of other interdisciplinary teams. Several draft copies of this paper were circulated for review for more than two years. All comments and criticisms were carefully reviewed and appropriate changes were made.

Our descriptions of the conflicts in interdisciplinary research produced a range of emotional responses. At times, reviewers became angried because the descriptions were too personal. The most common response, however, was supportive humor that acknowledged the human frustrations, insecurities, conflicts and power struggles. These humanistic aspects which bear heavily on the potential success of interdisciplinary research are rarely acknowledged or discussed.

We have examined the nature of interdisciplinary research from the perspective of participants rather than as detached observers. Our descriptions are validated not from objective data, but from honest experiences of actual participants. As such, our methods departed from the classical scientific approach. However, these methods proved to be successful in identifying subtle aspects of research organization not shown in typical organizational charts.

Our experiences are confined to a university setting; as such, we have not attempted to examine the more task-oriented research within large research organizations. However, important similarities, particularly with respect to the personal needs of participants, likely exist.

## Disciplinary Domains and Paradigms

### A FUNCTIONAL DEFINITION

Science and engineering are cooperative social enterprises which involve human communities committed to certain ambitions, attitudes, and approaches [1]. General agreement exists within such communities as to "proper" approaches to problem solutions. The nature of these commitments are related to two aspects of disciplinary communities: domains and paradigms.

A disciplinary domain generally can be described by two related characteristics:

1. the objects and systems examined and
2. the behaviors, features and problems associated with these objects and systems.

By identifying with a discipline, individuals generally limit their interests to the range of professional problems within the disciplinary domain.

Within a disciplinary domain, scientists and engineers will specialize in particular areas. Individuals tend to limit scholarly study and research to those portions of domains (sub-domains) where their contributions promote acceptance and recognition. Activities within sub-domains generally involve a narrow range of "acceptable" problems, rapid exchanges of research findings, personal contacts among established members, intensive criticism of "non-rigorous" work, and a clear identification of "experts" [2]. A common driving ambition of researchers is to become a recognized expert within their chosen sub-domain.

A disciplinary community possesses a constellation of concepts, procedures, models, examples and experiences that are useful within the disciplinary domain. Such a constellation and the attitudes, ambitions and mental frameworks consistent with it are termed paradigms [3, 4]; as such, paradigms may be considered as epistemological and methodological tools of a disciplinary community. The paradigms also express a discipline's domain and provide an identity for disciplinary communities. The commitment to this identity dominates many of the disciplinary activities of scientists and engineers, particularly researchers.

The current domains and paradigms of disciplines reflect their evolutionary history [5]. As a result, overlapping domains often employ significantly different paradigms. For example, disciplines evolving from the biological sciences typically have different paradigms than those evolving from the physical sciences. When domains overlap, as often required in the study of environmental systems, communication is extremely difficult. Thus, overlapping domains, such as in interdisciplinary research, do not necessarily mean paradigm similarity.

## PARADIGM INCULCATION

Disciplinary paradigms are inculcated within community members through repeated exposure and practice during their formal education and professional practice. The repetitive solution of "typical" problems that is common in science and engineering education serves to establish disciplinary paradigms to students. Students quickly learn that mastery of a community's paradigms receives more recognition than other educational accomplishments such as creativity or personal expression. In response, problem solutions are typically pursued through the pattern of example

problems, rather than through creative, imaginative thought. As a result, students will judge tests which depart substantially from assigned and example problems as unfair [6].

Such students' attitudes honestly reflect their experiences that science and engineering education is directed primarily toward the inculcation of disciplinary paradigms. Professional societies, disciplinary journals and conferences, institutional isolation of disciplines [7], and, in some cases, legally required certification tend to protect the integrity of a disciplinary community and its paradigms.

## COMMUNITY RECOGNITION

Paradigms serve an important function to a disciplinary community by providing guides and patterns for community activities. "Reasonable" or "acceptable" problems are identified as ones which can be addressed through use of established paradigms. "Reasonable" or "acceptable" approaches to problem-solving follow the patterns of the paradigms. "Reasonable" or "acceptable" explanations and observations are compatible with the paradigms. Thus, paradigms of a scientific or engineering community act as filters for selection and evaluation of "appropriate" problems, approaches, explanations and observations. Without them, disciplinary rigor, stability and orderly progress could not be maintained.

The disciplinary community provides recognition and acceptance for its members; as such, individuals establish much of their personal identity with this recognition and acceptance. The community demands, in turn, that individuals' research contributions be publicly observable and reproducible, which in most cases implies compatibility with the established paradigms.

Significant departures from the accepted paradigms invite the possibility of rejection or non-acceptance. As a result, most individuals will limit their research activities to sub-domains where their work remains within the established paradigms. Such research usually involves the application of established paradigms to problems of current interest with a subsequent refinement and gradual evolution of these paradigms.

Individuals become deeply committed to their disciplinary paradigms because paradigms provide established patterns for problem solution and the application of paradigms provides means for recognition. The strong agreement within a community on the "appropriateness" of behavior and the consistency of providing recognition for such "appropriate" behavior distinguishes scientific

and engineering communities from most other communities within modern societies. Toulmin stated that "Disciplinary commitment and integrity are, thus, to modern science what sanctity and loyalty to the order were to monasticism" [5].

Disciplinary paradigms are necessary for disciplinary rigor, stability and orderly progress; they provide an effective and useful, but often limited, framework for the selection and solution of problems. However, since they offer both the pathway to and means of recognition for successful problem solution, many individuals become deeply committed to their use as the only framework. For many, such commitment becomes so strong, the images provided by the paradigms are considered reality itself. Some individuals, often the most strongly committed, believe that paradigms do not exist; there is only the right way to approach a problem which, of course, is their way.

## Disciplinary Conflicts

### THE PERSPECTIVE SPECTRUM

Social and ecological systems can be viewed from a spectrum of vantage points. One end of the spectrum is characterized by high perspective and low detail, while the other end, by high detail and low perspective. Movement towards a higher detail vantage point results in detailed images becoming clearer, while assemblages, patterns, and relationships formed by these images become less discernible. Movement in the opposite direction, towards a higher perspective region, results in the opposite effect; assemblages, patterns and relationships emerge while the detailed images that form them become more obscure. Components appearing in higher perspective views disperse into systems of sub-components with a more detailed view. Views from several vantage points over the entire spectrum provide complementary understandings of real-world systems whose complete nature is beyond our perception. Such a one-dimensional spectrum, even though highly simplified, is useful in comparing different disciplinary domains and paradigms.

A traditional discipline will encompass a portion of the detail-perspective spectrum. The domain will be closed in the higher-perspective direction, but open in the higher-detail direction. Increased detail will almost always fall within the disciplinary domain; however, expanded perspective can exceed the domain boundary. As a result, disciplinary outlooks will tend toward higher-detailed views and disciplinary paradigms will reflect this

outlook. This "reductionist" orientation, however, can lead to the avoidance of questions and problems which become apparent only from an expanded perspective view that is broader than the disciplinary domain.

## THE ROLE OF INTERDISCIPLINARY RESEARCH

Disciplinary domains are not static but rather evolve often in response to societal demands. Such evolution can lead to overlap of domains. Controversy and conflict between members of different disciplines may result due to their paradigm differences, yet such conflicts can provide creative and innovative changes. Paradigms of disciplines involved in such interdisciplinary conflict may be expanded and altered or new disciplines may evolve; thus, contact between disciplines provides a means of introducing challenges to creativity and innovation [8, 9].

Interdisciplinary environmental research is a directed effort toward such interdisciplinary contact and can provide unique opportunities for innovation. However, its potential is more than a means of promoting disciplinary innovation. Understandings of systems and problems may occur which are more than a collection of disciplinary results. Socio-ecological systems are best examined from a broad range on the perspective-detail spectrum. Such wide spectrum views are required because systems exhibit properties, activities and responses which are not only dependent on component parts, but also on the organization of these parts. The organization, behavior, and response to human activities of socio-ecological systems cannot be examined from within the boundaries of individual disciplinary domains. Both perspective and detail are needed to improve understandings of socio-ecological systems and an urgency exists for such understanding due to the expansive scope of human activities.

## CONFLICTS FROM EXPANDED DOMAINS

In most cases, effective interdisciplinary research requires that participating individuals expand their vantage points towards the higher-perspective region of the spectrum. Such expanded views do not imply a rejection of detailed disciplinary views. On the contrary, good disciplinary work must complement and help form these higher perspective views. Dialogue between participants operating at a higher perspective region will be difficult due to paradigm differences. Such differences, however, are not the exclusive basis of difficulties and conflicts. More personal and

psychological reasons for conflicts exist which, although significant, are often not identified.

Significant personal conflicts are experienced by individuals whose concerns extend toward the higher-perspective views. First, they will extend beyond their comfortable disciplinary sub-domain which through professional specialization has probably molded their views toward high detail. Second, the pursuit of higher-perspective studies invites colleague criticism for being "non-rigorous" (lack of detail). Third, individuals working beyond their disciplinary domains risk separation from their support community. Thus, an individual is subjected to little reassurance for his or her present work and may not receive recognition for success. Fourth, individuals may discover that their paradigms lose their usefulness and applicability in the expanded domain.

## MANAGING CONFLICTS FROM EXPANDED DOMAINS

These personal and psychological conflicts can be severe and dominating. Their existence is rarely admitted, even by the individuals themselves due to social and professional taboos on how one pursues and receives recognition. Consequently, individuals tend to drift back to their safe disciplinary sub-domains after attempting professional work in high-perspective regions rather than dealing with the conflicts. This drift back is a critical difficulty which must be addressed throughout the life of any interdisciplinary project.

Individuals who are unwilling to work beyond their disciplinary sub-domains can be detrimental to interdisciplinary research unless they will accept direction from other group members as to which high-detail problems fit into the high-perspective views. Experienced researchers who are highly successful within their sub-domains are often reluctant to accept such commitments to higher perspective views. Unfortunately, such individuals are often considered important assets for successful funding of interdisciplinary research.

An additional danger exists that individuals who expand their domains fail to consider the limitations of their basic paradigms within the expanded domains. For example, engineers may attempt to determine social and ecological impacts of projects by employing general paradigms appropriate to mechanics. The success of paradigms within one domain does not assure a similar success within an expanded domain. Such transferred paradigms may serve to filter out the most relevant features of the expanded domain [10].

Interdisciplinary research must be approached with the attitude

that not only may paradigms be significantly different, but that such differences are desirable. The usefulness of disciplinary paradigms should not be minimized; however, their limitations must be recognized. Dialogue and agreement between participants will at times be difficult; conflict and confusion can be expected. Interdisciplinary dialogue, activity and conflict must be processed in a collaborative manner which utilizes disciplinary paradigms, yet leads to an emergent understanding which is more than a simple collage of disciplinary views. In short, corporate paradigms are needed which can direct heterogeneous research groups toward established goals without unduly restricting their potential creativity.

A process has to be developed early in the project which focuses the research team on higher-perspective views. High-detail studies that are compatible with such views then can be identified and undertaken. This procedure departs from the typical selection process for research topics which is dominated by the current interests of sub-domain communities.

A successful process that we developed to achieve broad perspective views is described in Appendix 1. We do not claim universality for this approach; we only offer it as an example of how we overcame the high perspective-high detail dilemma.

## RECOGNITION THROUGH SCIENTIFIC DISCOVERY

Recognition from the disciplinary community is a common goal of its members. The most important manner of obtaining this recognition for persons involved in research is by advancing existing knowledge [11]. Researchers are expected to provide original contributions and the degree of recognition is, hopefully, largely determined by the extent of advancement of the knowledge pool.

The accepted method of establishing priority on originality is the technical article. To the authors of such articles, the recognition from the community and other institutions accrues. Merton stated that "Recognition and fame then become symbol and reward for having done one's job well" [11]. This social norm is highly effective for promoting high-detail sub-domain research by individuals. However, it results in many problems and conflicts when used to motivate individuals in interdisciplinary terms.

The first major problem encountered is in establishing priorities of research ideas. Because the research team is operating at an expanded domain with high perspective views, new research ideas tend to be a mixture of many individuals' original contributions.

The ideas evolve through many discussions within the group and individual priority over contributions become obscure. The question over who deserves credit and who has obtained credit becomes paramount.

The second major problem relates to publication of research results. In interdisciplinary research, the importance of the results is highly dependent on the synthesis of the team's efforts. As a consequence, the results are usually published in large reports with many co-authors. Such reports dilute any priority to originality. However, if the results are published by each investigator the benefits of interdisciplinary contact may be lost.

We have not found a solution to the priority dilemma, although some suggestions are in order. First, in selection of team members, those persons who require continual recognition from the disciplinary community should be avoided. Second, individuals whose continued employment may depend on obtaining published articles (e.g., untenured assistant professors) should probably avoid large interdisciplinary efforts unless they receive institutional support and assurances. Third, questions concerning the ownership of ideas and results should be openly discussed in the early stages of the research.

## INFLUENCE OF ASSERTIVENESS

Within early stages of interdisciplinary research, some doubt about the future success of the project probably exists. This skepticism reflects an understanding of the magnitude of the research problem and the potential inappropriateness of existing methodologies. As such, this skepticism is both healthy and realistic.

The opposite image of complete confidence, however, tends to provide a competitive advantage with respect to the control of research resources. Individuals who are willing to promise specific results by specific times tend to establish a sizeable control over research funds, personnel and equipment. However, such individuals may prove to be disruptive to interdisciplinary work because such overconfidence in providing specific answers to complex problems often reflects a shallow understanding of the important questions. Thus, an attitude of healthy skepticism is useful in both the planning and execution of interdisciplinary research, but may prove to be a hindrance in the process of obtaining resources for conducting such research.

We believe that this problem can be reduced by matching an

individual's research funding to his or her personal time commitment. In this manner, the research can be closely managed by the co-principal investigators and integrated with the group's interdisciplinary approach. In addition, we believe that the tendency of granting agencies to insist on "no risk" interdisciplinary research is unrealistic due to the complexity of the environmental problems that need to be addressed.

### A TYPICAL SCENARIO WITH NO CONFLICT RESOLUTION

Large interdisciplinary projects typically start with much enthusiasm and some commitment toward the desirability of such research. As the project proceeds, however, numerous unanticipated problems appear and the work proceeds at slower and less measurable rates than expected. Co-investigators are asked to undertake studies out of their sub-domains; such studies are deemed necessary to describe the high-perspective view. The ownership of research results becomes more difficult to agree upon without the territorial markers of the disciplinary sub-domains. Enthusiasm declines. Graduate students and technicians appear unable to grasp broad perspective problems and require more supervision. Budgets are consumed in the pursuit of "blind alleys". Pressure to get "practical data" increases. The data that are obtained may not fit into high-perspective views. Publications may be rejected because of "non-rigor". The lack of "measurable success" begins to provide justification for the criticisms obtained by moving outside the disciplinary domains. Without a firm commitment to the necessity of interdisciplinary research, most individuals cannot resist the temptation to return to their sub-domains. They review their professional lives and conclude that research was "simpler", "less of a hassle", and "more gratifying" within their sub-domains. Under such conflicts, individuals tend to give only a token effort to the interdisciplinary efforts and primarily concentrate on their disciplinary studies. A typical scenario is that the principal interdisciplinary interaction occurs at report-writing time when each co-investigator writes a separate chapter.

## Activity Conflicts

The personal identity of most researchers is closely tied to their work, far more than most would admit. Thus, recognition of one's work represents recognition of one's personal identity; rejection of one's work is a personal rejection. As previously discussed, strong agreement exists within disciplinary communities to the type of

work that assures recognition and acceptance. In response, individuals tend to establish their identity through such communities.

## RESEARCH ACTIVITIES

The activities necessary for effective team research cannot be differentiated solely on a disciplinary basis. Thus, it is important to further identify research activities and the nature of the recognitions and risks associated with them. Four general categories of research activities common to a wide range of research teams are

1. administration,
2. data collection,
3. development of unifying concepts within established paradigms, and
4. development of unifying concepts outside of established paradigms.

Hereafter these activities will be identified by the above numbers.

Activity 1 often leads to institutional titles and positions. The title "director" or "principal investigator" is frequently given to the administrator, often at the insistance of granting agencies. Identity is largely established through the size, sophistication and prestige of staff and facilities. Institutional demands are usually directed to administrators. Numerous necessary tasks are performed on a day-to-day basis and recognition for successful accomplishment, when it does occur, is typically of short duration. The use of disciplinary paradigms is seldom required; thus, recognitions and risks of a disciplinary nature are relatively low. A low-risk, broad professional recognition, however, is provided largely because of title and position.

Activity 2 generally is associated with a low level of recognition through institutional titles and positions. Individuals establish some identity and recognition through the size and sophistication of facilities and support personnel. The research team itself is often the primary source of recognition. Work generally is conducted safely within established paradigms and a moderate disciplinary recognition of short to moderate duration with a low risk of rejection typically can be expected. Scheduling and coordinated supplies, equipment and personnel can at times be a demanding task. Long periods of consistent, repetitive and sometimes boring activities are common. Progress is readily identified by measurable results.

Activity 3 can lead to moderate institutional titles and positions;

Table 1. Nature of Recognition and Risks for Different Research Activities

| *Risk or Recognition* | *Activity* | | | |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |
| A. Title and Salary | H | L | M | M |
| B. Size of Staff, Facilities Equipment and Project | H | H | M | L |
| C. Duration of Recognition or Rejection | L | M | H-M | H |
| D. Risk of Rejection by Professional Discipline | L | L | M | H |
| E. Risk of Rejection by Institution | H | M | M | L |

Note: H = high, M = moderate, L = low; ratings give importance or duration.

however, higher advances usually require a shift to administrative activity. New applications of the general paradigms are often needed; cautious expansion and refinement of paradigms may be required. Disciplinary risk and recognition is generally moderate; nevertheless, success can occasionally bring about substantial recognition of a long duration. Cautious collaboration and overlap with Activity 2 are common. Individuals in Activity 3, however, are often required to "save" a project by making some sense of data previously collected.

Activity 4 is generally considered to be the most radical by disciplinary communities and institutions; consequently, high institutional positions and titles are not easily obtained. The risk of disciplinary rejection is high; however, if new concepts become accepted, the extent and duration of recognition are most significant. To offset the high risk of disciplinary rejection, individuals tend to ignore the risks of departing from institutional procedures, a reaction which removes them still further from the upper levels of institutional hierarchies. Individuals establish strong identities with concepts rather than with facilities and the size of projects.

## PERSONAL CONFLICTS FROM UNREALISTIC EXPECTATIONS

A major difficulty in team research results from individuals not realistically dealing with the recognitions and risks associated with their activities (see Table 1). Individuals who identify with Activity 1 or Activity 4 are most vulnerable. Activity 1 individuals may aspire for long term recognition for disciplinary contributions and they may feel frustrated by the difficulties of attaining this goal from their present position. Activity 4 individuals may be frustrated by the lack of day-to-day measurable progress and recognition; they

may become bitter because "lesser" individuals have risen to higher and more prestigious institutional positions.

Failure to realistically deal with individual recognition needs and risks can be destructive to research efforts, especially interdisciplinary ones. Most commonly, individuals tend to drift back to the relative safety of their sub-domains. They also may attempt to compensate by identifying simultaneously with several of the four activities which results in conflicting recognition requirements and risks. Such individuals feel constant pressure; they attempt to compensate by leading hectic schedules and working long hours. Some may be able to gain an acceptable identity from such conflicting activities. Frequently, however, they do not achieve satisfaction and compensate by accepting more tasks. The resulting work overloads typically are detrimental because individuals often do not have time to examine new concepts or creatively interact with other team members.

## CONFLICTS BETWEEN INDIVIDUALS FROM ACTIVITY DIFFERENCES

Individuals tend to establish their primary identity with one of the four activities, although their actual responsibilities and interests may span more than one activity. This identity choice belongs primarily to the individual and reflects the individual's personality and ambitions. In a reasonably balanced research team, the personality and ambitions of individuals will differ considerably. The activities within the group will often conflict because individuals are responding to different frameworks of perceived recognitions and risks. The relative differences of these recognitions and risks are identified in Table 1. We believe that these differences are major factors in establishing conflicts.

In Table 2 a number of research team conflicts are related to the recognitions and risks shown in Table 1. These conflicts were identified in our team or other teams which we interviewed and are believed to be quite common. Failure to resolve and process these conflicts appears to follow a pattern. Research teams fragment (usually into sub-domains); administrators feel pressured to get out measurable results and Activity 4 is abandoned. Final reports generally deal with problems of low disciplinary risks, and the bulk of unused data is large. An overall conceptual framework and rationale which explains why particular data were collected and particular procedures and concepts were employed are most often absent.

Table 2. Potential Conflicts that Could Arise Between Individuals Who Largely Function in one of the Activities of Table 1

| *Conflicting needs*[a] | | | *Description of conflict* |
|---|---|---|---|
| A1 | A2 | 2 | feels unappreciated in terms of title and salary and may feel powerless. |
| | | 1 | feels he has all of the responsibility and 2 does not appreciate this. |
| B1<br>B2 | B4 | 1 and 2 | feel that work schedules must be carefully prepared long in advance; it is essential that needed equipment be ordered as soon as possible. |
| | | 4 | does not want to be included in any rigid work schedule and has a low interest in equipment; expects staff to function with minimal supervision. |
| | | 1 | identifies with project reports which include all of the work done in the study. |
| | | 4 | identifies with professional papers where authorship of specific concepts and ideas can be clearly identified; does not want to be known as an "et al". (2 and 3 may share this concern.) |
| | | 1 and 2 | feel that 4 is a loner and just wants to spend his time thinking and writing rather than getting down to work. |
| | | 4 | feels that 1 and 2 are empire builders, that they do not know what to do, will not admit they do not know, but are determined to do something (whatever it is) in a big way. |
| | | | If you want a tour of the labs, ask 1 or 2; not 4. |
| C1<br>D1 | C4<br>D4 | 1 | sees importance of frequent meetings, workshops, memos, and written reports; sees a need for frequent and widespread communication; takes frequent trips; invites outside short-term participation. |
| | | 4 | wants long periods of unobstructed time to think, read and carefully, personally, prepare work before release; sees no need to rush; sees a danger of "premature" release; feels material should be released whenever it is ready. |
| | | 1 | sees 4 as uncooperative in keeping everyone posted on progress; too abstract; too philosophical; not able to get on with measurable progress and impractical (2 and 3 may agree). |
| | | 4 | sees 1 as an annoyance who holds meaningless meetings; sends meaningless memos and cuts off meaningful dialogue; feels that 1 does not understand the systems and problems being studied and is unimaginative. |
| A1<br>E1 | E4 | 1 | is usually the focal point of institutional criticism for the entire project; feels vulnerable for the shortcomings of others and may be resentful of their freedom. |
| | | 1 | feels that 4 is stubborn, defiant and even at times embarrassing. |
| | | 1 | feels that he (1) is holding the project together. |

Table 2. (Cont.)

| *Conflicting needs*[a] | | | *Description of conflict* |
|---|---|---|---|
| | | 4 | feels that 1 is unwilling to take time and effort to really understand the systems and problems; constrains (possibly eliminates) essential creative aspects of research to obtain "measurable" progress; is too easily influenced by "naive" demands for "simple" answers. |
| | | 1 | feels the pressure of time schedules, sees the importance of good progress reports; thinks it important to maintain close contact with federal and state agencies. |
| | | 4 | forgets institutional meetings; doesn't answer memos; is late in getting reports in; forgets names and titles of federal and state officials. |
| | | 1 | feels that practical research must provide results which can be used by existing agencies. |
| | | 4 | feels that existing agencies must change to deal with the realities of complex problems. |
| B2 | B3 | 2 | sees the need to obtain real data as soon as possible; |
| C2 | B4 | | baseline data are extremely important; sampling |
| D2 | C3 | | schedule is important; sees significant need to |
| E2 | C4 | | coordinate sampling efforts; sees concepts |
| A4 | D4 | | originating from the examination of data. |
| | E4 | 3 and 4 | want to know how data are to be used before they are collected; see low probability of using data unless a good conceptual framework is first established. |
| | | 2 | is not particularly impressed with ideas without data; sees himself as having increased influence and importance once data collection program has begun. |
| | | 4 | is not particularly impressed with extensive data alone; sees a decrease of influence once data collection program has begun. |
| | | 1 | generally supports 2 in order to gain measurable progress. |
| | | 1 and 2 | are reluctant to change sampling program or experiment once begun or discard old data. |
| | | 3 and 4 | are not interested in or impressed by data which are not related to a conceptual framework. |

[a] Needs shown in the first column conflict with needs in the second column. See Table 1 for identification of needs; letter refers to relevant recognition and risk while number refers to activity.

We do not presume to have a solution to these conflicts; however, some suggestions are offered. First, individuals must honestly and realistically deal with their aspirations and capabilities. Participants need to clarify their personal needs from their research efforts. Having done this, an organizational framework may be developed that allows pursuit of research goals which is compatible with the aspirations and capabilities of participants. In most cases, all four activities are needed and a major organizational task is to resolve power struggles between these activities.

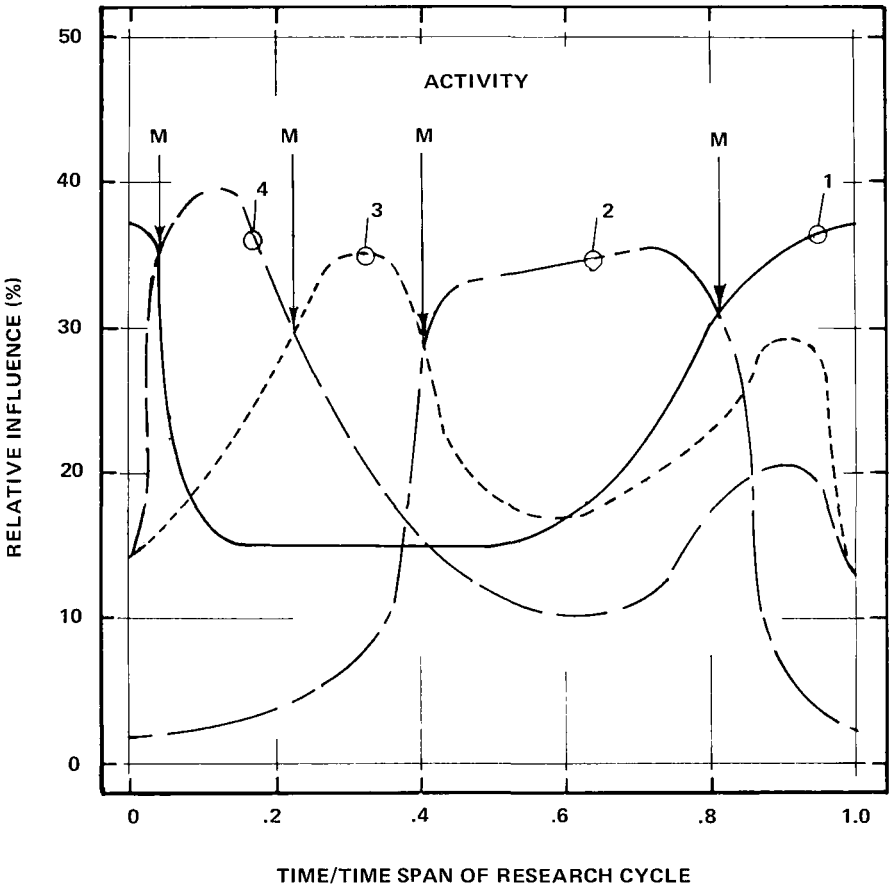


Figure 1. Relative activity influence vs. time (location of milestones shown by M).

The activities of importance for research projects pass through cycles, often spanning a granting period. The relative influence of these four activities should vary within the cycle. It is a useful exercise for the research team to describe the relative influences of these four activities over the life of a research cycle. The approach we used was to ask each co-investigator to distribute a given number of influence points for each activity over different phases of the cycle. Influence was defined as the degree of direction provided by those individuals who identify most closely with a particular activity. An example of our point distribution is shown in Figure 1. At points where the primary influence changes from one activity to another, milestones were established to describe

general expectations. Each of three sub-groups in our team was required to describe to the entire group how it intended to pass a given milestone. This approach has tended to reduce destructive power struggles and internalize recognitions and risks.

If one portion of the research effort fails to meet a milestone, then the entire team may suffer. As a result, the team as a whole needs to have some defined authority over the activities of the component parts such as being able to adjust budgets and personnel when long term expectations are not satisfactorily met. Reliance upon the authority of the single director may not be satisfactory because such centered authority is contrary to the goals of creative interdisciplinary research. The problem of dealing with investigators who could not meet milestone goals was never overcome in our study. This problem was common to every interdisciplinary research team we contacted and is a serious problem within team research.

## Summary

Interdisciplinary research has the potential to produce results that exceed the sum of disciplinary contributions. More holistic understandings can emerge from such research. These understandings are becoming increasingly necessary due to the potential magnitude and complexity of environmental alterations made possible through expanding technological capabilities. Typically, however, interdisciplinary research efforts rapidly decompose into loosely related disciplinary studies. A number of factors which contribute to this decomposition are examined. Methods of overcoming these factors in a manner which encourages collaborative and creative research were discussed.

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## APPENDIX 1

### An Approach to Interdisciplinary Collaboration

In our study on the environmental impacts of estuarine dredging, the research team developed a shared conception of a typical temperate estuary. Estuarine features of interest to different disciplines were meshed in this conception such that disciplinary bias was discouraged. This conception itself did not provide specific answers, but served to identify a high perspective-low detail corporate domain within which more detailed collaborative study could proceed.

This shared conception of a typical estuary was formed by considering all regions within a typical estuary as points on a plot of two parameters (e.g., temperature and salinity). Such a plot would have texture since regions of common characteristics could be spatially congregated on the plot and appear darker than less common combinations of parameters. The precise dimensions and texture of the plot are not necessary to the success of this approach; only an agreement of a conceptual existence of such a plot is required. Additional dimensions now are added to form an $n^{th}$-dimensional conceptual object which contains the geographical, geological, hydraulic, chemical and biological features of a typical temperate estuary. Spatial dimensions applicable to a broad class of estuaries (e.g., water depth, sediment slope) would be included.

It is not necessary to specify, describe or define each of these n dimensions, but only to imagine that such an $n^{th}$-dimensional conception could exist. Its shape and texture will change with time in response to the temporal changes typical of estuaries. Changes in given parameters will cause deflections or distortions throughout the conception. The effects of dredging or other activities can be envisioned as alterations of the shape and texture of this shared conception.

Collaborative team dialogue must focus on more identifiable features of this

conception to obtain useful information. This is accomplished by "dissecting" it with a $k^{th}$-dimensional dissection space where $k < n$ and usually equal to 2. For $k = 2$, dissection spaces become planes and the purpose of the dissection process is to locate relevant images and textures from the $n^{th}$-dimensional conception onto such planes. This process is not a formal mathematical procedure, but rather describes the interdisciplinary dialogue which seeks to identify those images and textures which can be located on particular dissection planes. Such images and textures will usually lack precision and detail; complementary views from other dissection planes or higher dimensioned dissection objects may be needed. An example of a dissection plane which has been used in this current study is shown in Figure 2. Alterations in

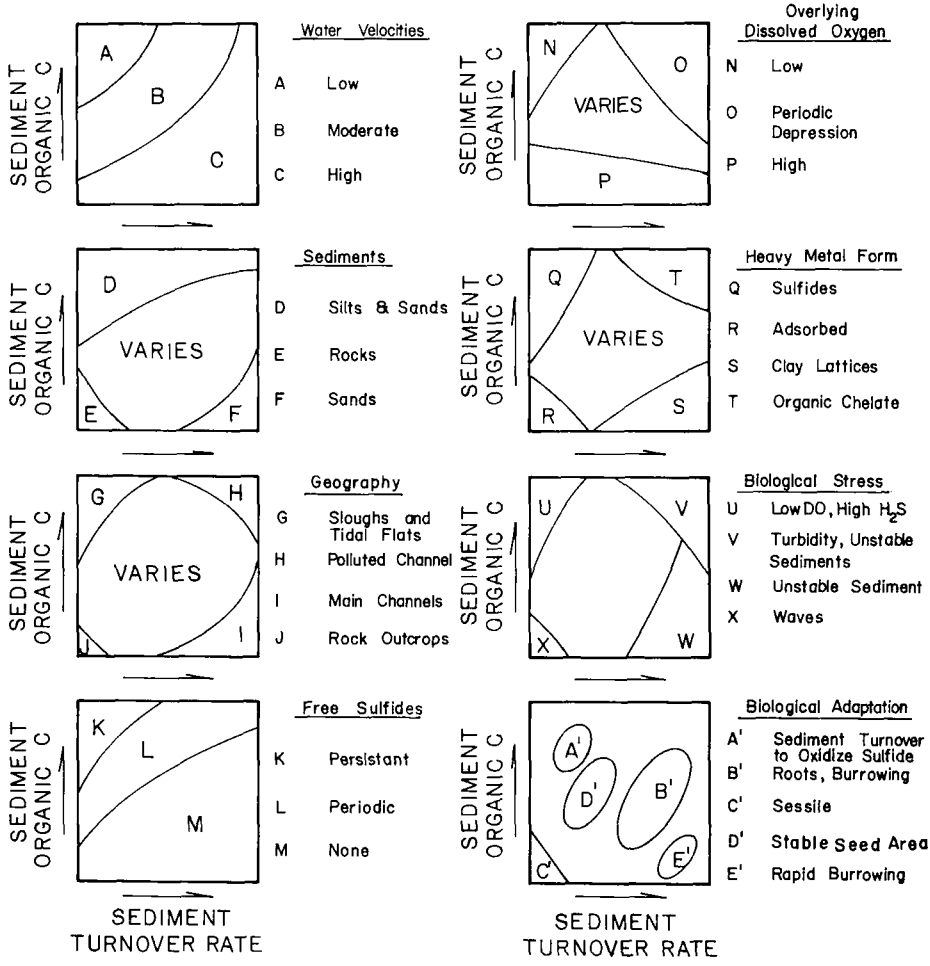


Figure 2. Example images on an estuarine dissection plane.

estuarine systems due to dredging activities can be described as position changes on dissection planes. As an example, the construction of a dike which partially encloses a tidal flat area can shift this area into the upper left corner of the dissection plane shown in Figure 2.

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