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24-inch hydraulic MUDCAT™ Dredge (photo courtesy of Baywest Inc.)

IN THIS ISSUE

AIMS & SCOPE OF THE JOURNAL

The *Journal of Dredging* is published by the Western Dredging Association (WEDA) to provide dissemination of technical and project information on dredging engineering topics. The peer-reviewed papers in this practice-oriented journal will present engineering solutions to dredging and placement problems, which are not normally available from traditional journals. Topics of interest include, but are not limited to, dredging techniques, hydrographic surveys, dredge automation, dredge safety, instrumentation, design aspects of dredging projects, dredged material placement, environmental and beneficial uses, contaminated sediments, litigation, economic aspects and case studies.

TRADEOFF ANALYSIS FOR THE USE OF ENVIRONMENTAL DREDGING WINDOWS

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ABSTRACT

This paper is motivated by the fact that important coastal management decisions incite controversy, because of difficult tradeoffs that are necessary among different stakeholder objectives. For example, the decision to preserve aquatic habitats may result in the loss of aquaculture or other development opportunities; the decision to restore one coastal wetland may preclude restoration of another; or the decision to allow dredging operations may imply significant long term cumulative environmental impacts. Such tradeoffs are not easy for individuals to make, because they typically require giving up something of value. In recent years, the growth of public interest and advocacy groups, along with a trend toward empowering stakeholders, has resulted in demands for a higher level of accountability on the part of coastal management decision-makers. Decisions that were once discussed behind closed doors must now be debated in public fora and before television cameras. Decisions that were once made on an ad hoc basis must be defended with reference to explicit criteria and a logical approach.

The shift in decision-making authority coincides with recognition that coastal management issues must be addressed in light of both broad economic goals and ecosystem integrity. The question then is how best to recognize and explicitly include multiple objectives and tradeoffs in coastal management decision-making. This paper outlines the notion of explicitly multiple stakeholder objectives and community values. It discusses an application of a structured decision approach to public involvement to elicit values and tradeoffs among conflicting community interests for improving the quality of Tillamook Bay in terms of habitat, water quality, sedimentation and flooding, and offer recommendations for its application in the dredging windows controversy.

CHALLENGES IN COASTAL MANAGEMENT DECISION-MAKING

Important coastal management decisions, such as the determination of environmental dredging windows, incite controversy because of difficult tradeoffs that are necessary among different stakeholder objectives. For example, the decision to preserve aquatic habitats may result in the loss of dredging or other development opportunities and with it significant economic impacts. On the other hand the decision to allow indiscriminate dredging may have significant detrimental impacts to marine resources that provide goods and services that are valued by society. Such tradeoffs are not easy for individuals to make because they typically require giving up something

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of value. Tradeoff decisions are particularly complex when dealing with environmental resources and resource services because these goods are not typically traded in markets and thus have no specific market prices attached to them. As a result, not only do different stakeholders disagree about key objectives for these resources but they may disagree about their relative importance as well.

In recent years, the growth of public interest and advocacy groups, along with a trend toward empowering stakeholders, has resulted in demands for a higher level of accountability on the part of coastal management decision-makers. Decisions that were once discussed behind closed doors must now be debated in public fora and before television cameras. Decisions that were once made on an ad hoc basis must be defended with reference to explicit criteria and a logical approach. The shift in decision-making authority coincides with recognition that coastal management issues must be addressed in light of both broad economic goals and ecosystem integrity. The question then is how best to recognize and explicitly include multiple objectives, values for environmental goods and services, and tradeoffs related to their use in coastal management decision-making. There are several approaches that can aid in or be part of any decision-making process – approaches that approximate the values that society holds for environmental resources and rationalize choices about their use, management, and or preservation. In the case of environmental windows, these approaches can theoretically be used to identify both the commercial and environmental costs and benefits of the various options designed to minimize the impacts of dredging (e.g., windows, silt curtains, operational controls, no dredge options, etc.). This information can be used to inform decision-makers as to the most socially acceptable and or economically efficient options available and in general enlighten the debate. Two of the most widely recognized approaches – classical economic and risk analysis are highlighted below. This is followed by a brief description of an alternative approach that is the major focus of this paper – a structured decision approach to value assessment and public involvement. The latter recognizes the need to make tradeoffs between groups, between the environment and the economy, and between alternative options. It is an approach which explicitly recognizing multiple stakeholder objectives and community values in the context of management and policy decision-making. In Section three we provide a case study example of the structured decision. Finally, we outline some conclusions and recommendations for the use of this approach in environmental dredging windows management and policy decision-making.

CHOOSING THE RIGHT APPROACH TO ASSESS ENVIRONMENTAL VALUES IN COASTAL MANAGEMENT DECISION-MAKING

Classical Economic Analysis

Environmental valuation, or the estimation of the economic value of natural resources and services that they provide, is an important tool available to enlighten any resource management or policy debate. Economic valuation involves the estimation of the economic value of environmental or natural resource goods and services. The term economic value has a very specific interpretation. It is not (as many think) income earned from resource services or the number of jobs supported by resource-dependent industries (e.g., commercial fisheries, and oil and gas development). Rather economic value is revealed through the tradeoffs individuals make in choosing to pursue certain types of uses over others and in protecting some resources while sacrificing others. Economic value is measured as the amount an individual or society is willing to give up in order to obtain some good or service (or accept as compensation to forego an existing good or service). In many instances, arguments against marine and coastal environmental management are made in terms of costs and economic impacts, such as the capital cost of pollution control infrastructure or the revenues lost due to industry regulation. Information on environmental values may be helpful in developing arguments in favor of management actions that are expressed in a similar unit of measure, dollars.

There are various market and non-market environmental valuation techniques available to assess the value of coastal and marine resource services.

- Market approaches, which focus on local supply and demand conditions, can be used to estimate the net economic value of a commercial activity that is directly dependent on environmental resources (e.g., commercial fishing).
- Non-market indirect valuation methods, including the travel cost method, random utility models and hedonic price approach, use observations about individuals' spending in related markets to value resource services not directly provided by commercial producers (e.g., recreational activities, beach access).
- Non-market direct methods such as contingent valuation methods, can be used to develop estimates of use and passive use values to assess the benefits of other less obvious resource services (e.g., existence value, bequest value).
- Benefits transfer relies on past studies to determine potential economic benefits attributable to a new area of interest.

Table 1 presents a brief summary of the relationship between different types of environmental or natural resource services to the methods that can be applied to develop specific valuation estimates. Factors such as cost, timing, and data availability may dictate the choice of one method over another. (Please see Wellman, 2001 for an overview and description of the advantages and disadvantages of each of these various approaches).

An extensive literature illustrates the application of environmental valuation studies to issues of marine and coastal management and their contribution to solid and acceptable management plans and policies. Economic information leads to an increase in the public's understanding of the value of coastal and marine resources that public programs attempt to preserve and enhance (including the cost of not doing so) and can be helpful in the tough process of prioritizing actions to be included in any plan.

The process of environmental valuation has its limitations however. First, the acquisition of economic information is rarely quick or inexpensive. Managers and decision-makers must make careful decisions about what kinds of economic information is most helpful and what kinds are worth the investment of their limited funds. Second, approaches such as contingent valuation methods are fraught with methodological complexities that make it subject to criticism, and costs that limit its use in some cases. Other techniques such as hedonic price and random utility models suffer from the same problems. All valuation techniques can be difficult to explain to people who do not have a clear understanding of the underlying economic ideas and many well resist the idea that one can place a dollar value on ecological resources no matter what the state of the art. The latter point is related to the fact that valuation is not necessarily cognitive and rationale but often emotional or affective. Asking respondents to "give a number" may not match the affective nature of people's held or inherent value system.

Table 1. Appropriate Tools for Valuing Different Resource Services

	Valuation Method					
Resource Services	Market Analysis	Travel Cost	Random Utility	Hedonic Pricing	Contingent Valuation	Benefits Transfer
Ecological Services						
Water Supply				●	●	●
Wildlife Habitat					●	●
Flood Control				●	●	●
Storm Protection				●	●	●
Tertiary Waste Treatment					●	●
Erosion Control				●	●	●
Commercial and Recreational Services						
Commercial Fishing	●				●	●
Recreational Fishing		●	●		●	●
Boating		●	●		●	●
Wildlife Observation		●	●		●	●
Beach Use		●	●		●	●
Hunting		●	●		●	●
Aesthetics				●	●	●
Navigation	●				●	●
Private Property	●			●	●	●
Cultural and Historical					●	●
Passive Use Values					●	●

At a more general level there are several types of economic analysis that can provide useful information for decision-makers dealing with environmental windows. Some of these methods actually involve the use of environmental values as part of the analysis. Information generated from these analyses can help frame the tradeoffs inherent in dredging planning and management. For example, in selecting among different options designed to minimize the impacts of dredging, decision makers may need to understand the relative costs and benefits of different proposals and or the wider economic impacts that may result. The three analytical tools most widely used by economists are:

- *Benefit-Costs Analysis* – a tool which provides a quantitative method for comparing the economic benefits and costs associated with specific policies and programs, including the types of management actions being proposed to minimize impacts of dredging on the environment. Environmental values, as described above are often part of a comprehensive benefit-cost analysis.
- *Economic Impact Analysis* – an approach that allows one to asses show the direct impact of an action will ripple through the local economy and affect regional employment and income.
- *Cost-effectiveness Analysis* – a technique used to rank the relative merits of policy/program alternatives in situations where it is impossible or impractical to estimate the dollar value of potential benefits.

The decision to pursue one or more of these approaches will depend on what information is needed to support dredging policy decisions and the resources available for conducting economic studies. (For a more detailed outline and set of examples of these general approaches please see Wellman, 2001).

Risk Analysis

Many believe that increased use of risk analysis is appropriate as a tool for developing more effective and acceptable public policies; that clear and concise characterizations of existing information about risks, costs, and benefits will lead to better informed and acceptable regulatory and management decisions. However, as indicated in Understanding Risk (NRC, 1996) this point of view may be naïve because of the inadequacies of techniques available for risk analysis and the fundamental and continuing uncertainty in information about risks. The NRC report indicates that risk characterization involves complex, value-laden judgements and requires effective dialogue between technical experts and interested and affected citizens, who may lack technical expertise, yet have essential information and often hold strong views and substantial power. The report goes on to outline an iterative analytical-deliberative process that they feel can improve risk characterization, informing decisions, and making those decisions more acceptable to interested and affected parties. It suggests that "the technical and analytical aspects of risk analysis must be balanced with a concern for appropriate involvement by interested and affected parties in all steps of the decision- making process, including those leading to risk characterization. Analysis and citizen involvement are not separate steps to be carried out in sequence, but must be combined into an effective synthesis" (NRC, 1996).

Structured Decision Approach to Value Assessment and Public Involvement

The structured decision approach to value assessment and public involvement reflects the basic conceptual thinking presented in NRC (1996) about the characterization of risks, costs and benefits and notions of involving resource stakeholders in resource valuation exercises. It supplements economic valuation techniques with other methods, such as focus groups, designed to assess broad ranges of public values. Recalling that economic value is defined as what one is willing to give up, questions and discussions in this case may be structured to present alternative strategies and consequences, along with possible costs. Respondents can then be presented with a set of structured choices in order to elicit their preferences. The economic values underlying those preferences can be assessed with proper structuring of the questions or the information generated in the process about objectives, preferences, and values can be used as is to inform decision-making.

The fundamental tasks of a structured decision approach include:

- Defining the decision problem to solve the right issue. This task may be viewed as clarifying what one is really trying to achieve with the decision. What are the main aspects of a decision situation? What is a reasonable goal of the consultation process?
- Defining key objectives. How do people think they will be affected by some proposed action? What values matter most to stakeholders?
- Creating better alternatives to choose from. In light of all relevant constraints, what are the alternative actions that might be undertaken to meet stated objectives?
- Describing how well each alternative meets the stated objectives. This is essentially the identification of consequences. What are the most important impacts that could affect stated objectives and how certain are you that they will occur?
- Balancing objectives when they cannot all be achieved at once (clarifying tradeoffs). What are the important conflicts between objectives, and how can this knowledge be used to create new and better alternatives?
- Identifying and quantifying the major uncertainties affecting the decision.
- Counting for tolerance for risk.
- Planning ahead by coordinating current and future decision (linking decisions).

The root idea of a structured decision approach to public involvement reflects common sense and good judgement. However, the application of a structured approach emphasizes qualitative guidance for how to think clearly and make smart choices rather than quantitative analysis to make an optimum decision (the focus of most B/C analysis). It goes beyond classical economic approaches by identifying tradeoffs and offering an opportunity to learn a great deal about individual objectives, how these objectives link to acceptable actions and the fundamental rational for the tradeoffs expressed. In addition, the approach leads to a better-informed public and a process that more fully incorporates their views and concerns. It has proved to be an effective decision-making tool in a number of settings.

It must be noted however, that providing additional insights to decision makers requires an improved understanding of the concerns of stakeholders, an improved base for identifying the primary consequences of alternative actions on these objectives, and a transparent mechanism for reflecting the most important tradeoffs in policy development. Implementation of a structured approach remains challenging in part because it is different from what decision-makers or stakeholders have come to expect. It requires the development of trust between the stakeholders, decision-makers, and analysts (something that can be particularly challenging in small rural communities). It requires willingness on the part of policy makers to acknowledge stakeholder's expressions of values and tradeoffs explicitly. This approach, in fact, rather than shifting the focus away from the divergent views of participants in favor of consensus, looks to differences in expressed values and objectives as the source of valuable insights that lead to a broadly acceptable agreement. Policy makers knowing this information ultimately will be able to advocate a specific project or program with a more complete understanding of its ability to satisfy the expressed objectives of a wide range of constituents.

The following section outlines a case example of the use of this type of approach, illuminating its benefits and potential limitations.

CASE STUDY: THE TILLAMOOK BAY NATIONAL ESTUARY PROJECT

Several years ago Tillamook Bay was designated as an estuary of national significance and included in the National Estuary Program (NEP). As part of the NEP, the Tillamook Bay National Estuary Project (TBNEP), over a four year period developed a Comprehensive Conservation and Management Plan (CCMP) to deal with several environmental problems and protect the ecological integrity of the estuary. The stated goal of the TBNEP was to develop a CCMP that represented a science-based community supported management plan for the watershed. In the process of developing the CCMP TBNEP staff was aided by the ongoing work of a Management Conference made up of local citizens and government agency representatives. This group took the lead on research and analysis that served as a basis for the 62 specific solutions (actions) outlined in the CCMP. The CCMP was submitted to EPA and accepted in 1999 and is now being carried out by the Tillamook County Performance Partnership. The plan combines several different types of actions to achieve environmental quality goals. It includes actions for on-the ground projects to improve forest roads, upgrade drainage systems, restore habitat, implement farm management plans etc. Some actions recommend new and innovative partnerships among agencies, citizens, businesses and schools, and others call for stronger enforcement of existing environmental laws, more research, monitoring and or planning. Theoretically, the Plan represents a comprehensive framework that combines local, state, and federal initiatives into a coordinated management plan for the Tillamook Bay watershed.

Our strategy to evaluate community values involved a combination of multi-attribute utility theory and decision analytic approaches. It included the identification of underlying objectives, the definition of a small set of key CCMP action alternatives, and design and implementation of a value integration instrument to elicit and compare stakeholder tradeoffs and values relating to these action alternatives (Gregory, 2000). Our goals were: (1) to inform decision-makers of key tradeoffs across conflicting objectives held in the community; (2) to estimate numerical values for water quality and habitat improvements in Tillamook Bay; and (3) to lay the foundation for continuing and expanding dialogue among key user groups. Our work took place over a 15-month period during the last two of four years of the TBNEP planning process.

Our five-step strategy followed the standard set of tasks of a structured decision approach outlined above (Gregory and Wellman, 1999). We began our process by working through the TBNEP's list of 150 potential actions and asked for each the simple question "why". This allowed us to track the rationale for each action and, in some cases, pointed out the need to define more clearly its intended purpose. This process resulting in a list of fundamental objectives for the project, showing what ultimately mattered to the TBNEP in terms of desired outcomes from project initiatives. Together, these objectives provided the basis for deciding what should and should not be included as part of the project CCMP as well as an initial mechanism for linking costs and benefits of the intended actions. Many of these key linkages are shown in Figure 1, which illustrates "means-ends network" (Keeney, 1992). The figure depicts objectives considered to be of fundamental importance (ends) and those considered important because they help to achieve these ends (means). This type of analysis was useful in illustrating the relationships among actions and highlighted the fact that for many of the valued ends, a range of means could be used to achieve them.

The former step also allowed us to refine the initial list of proposed actions (or "alternatives" as discussed above) to a set of highly significant (in terms of economic, environmental and social impacts) actions – actions that would not be undertaken if not for the leadership of the TBNEP. Further focus group work on the perceived importance of each remaining action and additional information about the impacts of each led to a list of three critical yet controversial actions that were chosen for us to include in our value integration/trade-off survey described below. These three actions included:

- Protect and restore tidal wetlands
- Upgrade forest management roads
- Limit livestock access to streams (through a combination of fencing and vegetative buffers)

The next step in our process was to identify the anticipated consequences of actions. Environmental impact assessments were derived from information provided by TBNEP staff and Management Committee members and interviews conducted with scientific experts and state and local agency representatives. Whenever possible, we conducted these interviews as "expert judgement" elicitation. Generally, the data on the range of impacts of possible actions was limited. In terms of economic impacts we drew on reviews of the published literature and recent unpublished studies and summarized the available quantitative and qualitative information, noting our assessment of its quality. In general, we provided consequences in terms of (a) engineering costs, (b) environmental costs, (c) opportunity costs, (d) social, community, and indirect economic impacts, and (e) environmental benefits for each action.

The fundamental step in our work was the identification of key tradeoffs and underlying stakeholder values (Gregory and Wellman, 2001). After some discussion with the TBNEP and local stakeholder groups we decided to develop a value integration workbook that would inform stakeholders about anticipated costs and benefits of key project action alternatives and then allow them to "vote" for their preferred actions. Participants were able to explain their thinking by stating their willingness to pay for an action (or willingness to trade increases in benefits or reduction in costs) and by responding to open-ended questions. Participants were chosen randomly from the community and worked in small groups of 8-12 people. The groups were co-led by an analyst and a local citizen.

The workbook had three parts. Part 1 asked participants to make choices among policy alternatives for the three key actions (limiting livestock access to streams, protecting tidal wetlands, and upgrading forest roads) (Figure 2). Part 2 asked respondents to consider only one of the three actions and used an objective by alternatives matrix (or consequences table). The latter provided a mechanism for eliciting tradeoffs across an action's objectives as a means for refining respondent's estimates of its economic benefits and costs. Part 3 (Table 2) inquired about the degree of involvement that participants desired in the ongoing planning of economic and environmental initiatives within Tillamook County.

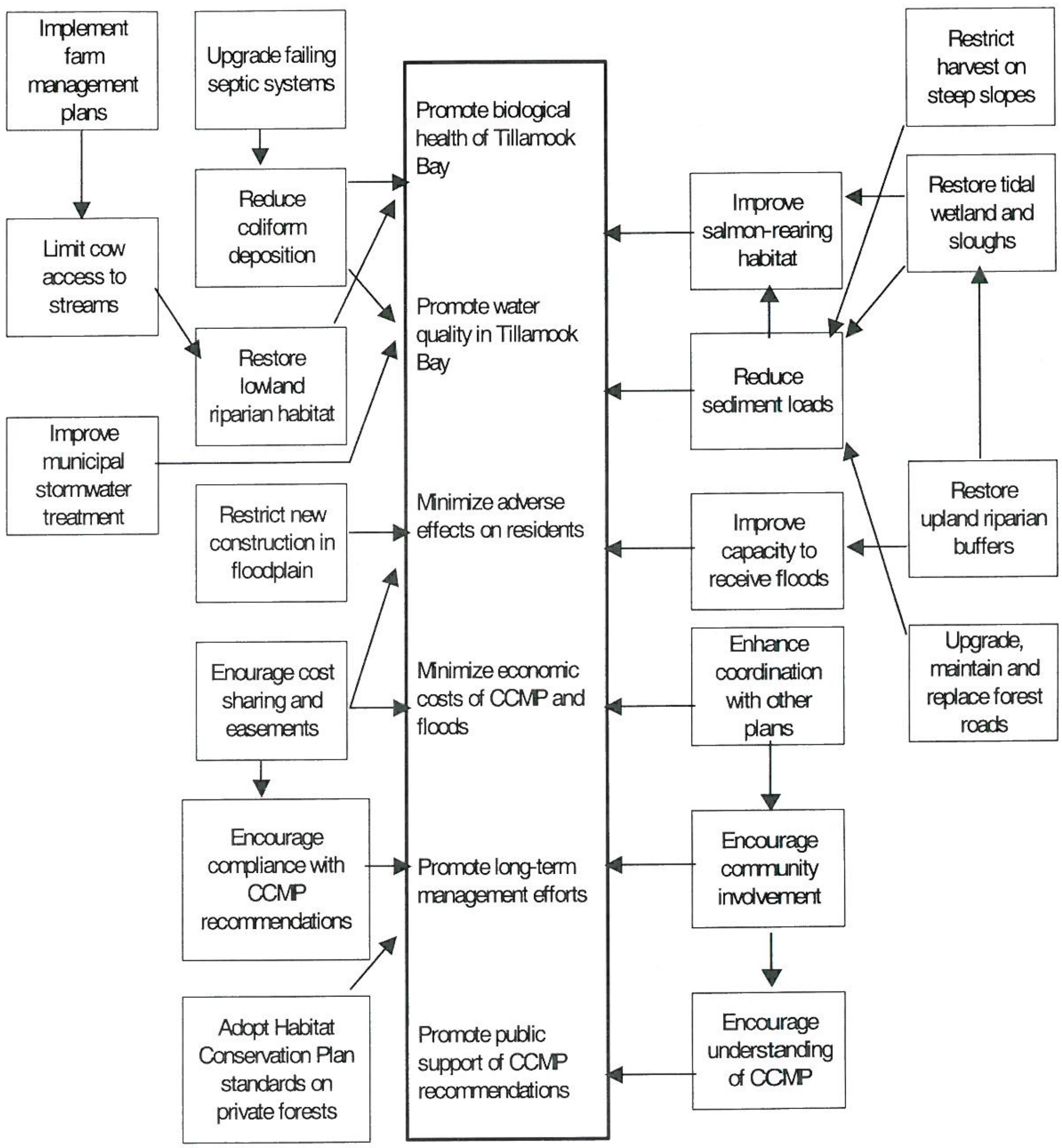
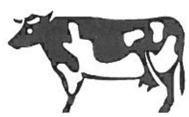
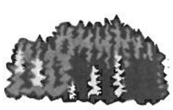


Fig. 1. Means-ends network for the Tillamook Bay National Estuary Project

[Note: The six fundamental (ends) objectives are shown in the center box. Means objectives, many of which become actions in the Tillamook CCMP, are shown at the sides. An arrow denotes "influences" between means objectives and from means to ends.]

Different amounts could be done on each of these three action areas. Listed below are two levels of intensity for each of the three actions. What advice would you give to the TBNEP in making a choice about these three actions and the preferred level for each? First, please review the table below.

ACTION	IMPACTS	LEVEL I (moderate effects)	LEVEL 2 (high effects)
1. PROTECTION & RESTORE tidal wetlands	Main Benefit:	Better floodwater storage; small increase in salmonid habitat (200 acres).	Much better floodwater storage; large increase in salmonid habitat (750 acres)
	Main Cost:	Some loss of marginal farmland. Some added costs and taxes	Moderate loss of marginal farmland. Much higher costs and taxes
2. LIMIT livestock access to streams	Main Benefit:	Less bacterial pollution in estuary. Slightly higher water quality and salmon habitat	Much less bacterial pollution in estuary. Much higher water quality and salmon habitat
	Main Cost:	Low loss of productive farmland; construction costs.	High loss of productive farmland; construction costs.
3. UPGRADE forest-management roads	Main Benefit:	Moderate decrease in sediment delivery to streams; better fish passage.	Large decrease in sediment delivery to streams; much better fish passage.
	Main Cost:	State and federal taxes for road improvements ($3.2 million/year)	State and federal taxes for road improvements ($7.0 million/year)

1. If you had to choose just one action, which would you choose? What level would you prefer? (Write in one action and one level)

   Preferred Action:______________________________
   Preferred Level: ______________________________

2. Why?____

Fig. 2. Choosing Among Actions

The key to eliciting structured tradeoffs in Part 2 of the workbook was a systematic, coupled comparison for each of the three key actions. Using this framework, participants could identify alternatives that were better than others on all key dimensions. A simple 2x2 or 2x3 matrix was used (see Table 2) with the associated levels of benefits and costs changed systematically to illustrate for each participant the point at which alternative actions would be rated equally for a given objective (e.g., they both cost the same, or they achieved the same increase in fish populations). Because the objective was then effectively the same for the two options, it could be ignored. This type of "trading" -- increasing the value of an alternative in terms of one objective while decreasing its value by an equivalent amount in terms of another objective -- constitutes the heart of the "even –swap" method for making tradeoffs (Hammond et al, 1999)

Table 2. Costs and Benefits of Protecting and Restoring Tidal Wetlands: Tillamook NEP Tradeoff Analysis Project Survey

	Plan A (one-time)	Plan B (ongoing)	Plan C "Better"
+ Benefits			
Increased storage for floodwaters	Low improvement	Moderate improvement	
Increased off-channel Coho, Chinook and steelhead habitat	Low (200 acres)	High (750 acres)	
Lower pollution levels in Tillamook Bay			
- Costs			
Loss of access to productive farmland	Low	Low	
Federal and state taxes for dike removal, replanting and land purchase	Low $200,000 ($1,000/acre)	High $2.2 million ($3000/acre)	

Note: The timeline is for five years. The "Plan C" column was included to encourage participants to create a preferred alternative using the Plan A and Plan B benefits and costs as starting points.
Source: Gregory, 2000

The actual detailed methodology and complete set of findings for this case study are available in Gregory and Wellman (1999). Some of the most notable findings and results are outlined below. We discovered through the initial phases of the project that stakeholders in Tillamook wanted to restore local water quality and fish populations, which had been damaged by waterborne pollution from animal wastes and increased sediment loading. They also worried about the health of the dairy and forest industries and did not want to impose unnecessary cost burdens on any one group. The problem was difficult for residents to think about because a cost seemed to offset every benefit. Typically these conflicts involved different parties -- conservation and management actions that helped coastal anglers would hurt regional dairy farmers, and actions that helped the tourist industry would result in higher costs to forest operators. The structured decision process allowed stakeholders to work through these tradeoffs in a way that attempted to balance their competing objectives and interests and to facilitate informed choice. Tillamook participants found the task informative and relatively easy, although many respondents did comment that they had gained a new sensitivity for the depth of thinking required to address tough resource management tradeoffs effectively.

While the primary goal of our work was to help TBNEP develop a good community plan – one that included an understanding of difficult tradeoffs, our approach also allowed us to back out some total value willingness to pay (economic value) estimates of community members for the three actions analyzed. In general the value integration survey workbook results showed strong support for actions to protect and restore tidal wetlands and an endorsement of several higher intensity even if more costly initiatives, including improvements in forest roads and the construction of additional fences along streams. More specifically, quantitative results show an estimated social value of approximately $5000 for each additional acre of salmon habitat. In addition, 82% of all respondents showed support of expenditures of $1.2 million for each of five years for new fencing and planting of riparian buffers (so long as land losses can be kept to a minimum). Finally, 75% of all respondents supported payments of $7 million per year for forest road improvement to enhance fish passage and water quality.

CONCLUSIONS AND RECOMMENDATIONS FOR APPLICATION TO THE ENVIRONMENTAL DREDGING WINDOWS

The goal of the structured decision approach to public involvement is to provide policy makers with improved insight about a decision at hand. This contrasts with the goal of conventional economic analysis to provide numbers for incorporation to a B/C study or the goal of conventional public participation process to achieve consensus. In contrast to many projects on environmental valuation, which focus on providing economic values as an end product (most often, average willingness to pay numbers), the approach outlined above focuses on providing insights to decision makers about the relative percentages of the population that would support or oppose specified actions. In addition, this approach has a second and equal focus on the public involvement and community participation aspects of the evaluation effort.

The choice of acceptable dredging windows is a controversial issue. Many believe that the windows are overly restrictive, inconsistent, and established with minimum justification. Some feel that windows should be negotiated on a project-by-project basis instead of the traditional approach of automatically rolling from one year to the next. It involves many stakeholders (ports, transportation companies, state and federal resource management agencies, local environmental groups, and etc). It also explicitly involves the need to make tradeoffs between regional economic impacts and environmental or ecological integrity. We do not believe that the use of conventional risk analysis or the identification of environmental costs and or benefits of dredging and dredging windows through the various economic models available will alone adequately enlighten the discourse regarding the setting of environmental windows for dredging projects. These tools do not effectively identify all the required tradeoffs or recognize explicitly the objectives and individual values of the various stakeholders involved. We believe that a structured decision approach to public involvement moves us towards integrated decision-making and management and suggest that it would be appropriate in assessing options to dredging windows or rationalizing their use subject to several concerns outlined below.

For any policy regarding the setting of environmental windows for dredging projects to be acceptable it must clearly identify the problem at hand and address the baseline objectives of the stakeholder groups involved. What is the real issue regarding the establishment of dredging windows? What ultimately do stakeholders care about? Protecting the environment? Reducing economic impacts to ports? These questions must be answered up front before a set of alternatives can be established and analyzed. In the process of determining objectives, those involved in the dredging windows debate may find that the set of concerns are much less (or perhaps greater) than presumed. And, as found in the Tillamook case, developing a means-ends objective table (as identified by the stakeholders) will most likely lead to informative discussions among participants. Useful input can be obtained from all stakeholder groups including information about linkages between possible alternative actions and their values. The dynamic nature of exploring objectives will not only help to energize the discussion among stakeholder group members but also serve as a mechanism for encouraging brainstorming and creative thinking by all participants.

As outlined above the next step in the structured decision approach to public involvement is to outline an initial set of alternatives (e.g., establish windows on a project by project basis, automatically roll windows from year to year, and etc.) based on the objectives expressed by both public and expert stakeholders. Designing this list may be seen as both and an art and a science and it may take more than one conversation between scientists, agencies, industry, and other interested parties. Discussions may serve to highlight previously neglected concerns and shed light on proposed or new alternatives. Note it will be necessary to develop a thoughtful mechanism that allows all stakeholders to participate in the prioritization of the alternatives and to allow for direct input into the design of those alternatives designated as most significant.

Identifying the consequences of alternative dredging window strategies may be difficult but not impossible. One of the most critical aspects of this exercise is obtaining and linking information on the ecological impacts of actions to the social and economic effects. As was true in the Tillamook case study the quality of value estimates relies in large part on the level of ambiguity and uncertainty in the environmental information base. Another major component of identifying consequences in the dredging window case will understand the marginal benefits and costs of actions. Again, as was true in the Tillamook case, a high percentage of the benefits of a proposed strategy may be obtained for only a very small percentage of its total costs (or vice versa). Finally, the distribution of the consequences must be recognized. Many stakeholder groups will have strong (though possibly incorrect) ideas about who will likely gain or lose from some action.

Stakeholders in the environmental windows are concerned about the integrity of environmental resources potentially affected by dredging activities. They are also concerned about the need to maintain open navigational channels for commerce and trade. The problem is that actions that benefit the environment may negatively impact industry and vice versa. The structured decision process will allow stakeholders to work through these tradeoffs in a way that attempts to balance their competing objectives and interests and to facilitate informed choices. In developing a tradeoff analysis for environmental windows pros and cons of alternatives will have to be presented so that tradeoffs can be simplified and addressed in an iterative fashion. In addition, participants should be encouraged to concentrate on the amount of an objective that would be gained or lost rather than the importance per se of the objective itself. In the case of Tillamook, this was accomplished using the "objective by alternatives" matrix or consequences table, something that theoretically could be set up for the environmental windows debate and result in Significant, if not path breaking results.

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OPERATIONAL AND PHYSICAL CONTROLS TO MINIMIZE WATER QUALITY IMPACTS RESULTING FROM DREDGING OPERATIONS

Donald F. Hayes[1]

INTRODUCTION

Mechanical actions associated with dredging operations induce water currents and disperse sediment particles in the water column near the dredging operation. Sand particles redeposit near the point of suspension except in high-energy environments. Smaller silt and clay particles, however, settle much slower. These small particles remain in suspension long enough to be dispersed by induced currents and transported away from the dredging site by even small ambient currents. The resulting turbidity plume of suspended sediment particles can usually be observed surrounding the dredging operation and spreading both laterally and down-current. Controversy over water quality and aquatic impacts resulting from dredging-induced turbidity plumes began several decades ago and continues today. Impacts to fish and bottom biota are primary concerns.

CUTTERHEAD DREDGE CONTROLS

Control measures for cutterhead dredging operations have mostly focused upon operational restrictions. Operational restrictions date back to the early 1980's and probably before in some areas of the US. These controls seems to have been based primarily on intuitive knowledge that excessive swing speeds, cutter rotation speeds, and cutting depths can feed sediment to the suction faster than the dredge can pump the sediment away. Field data has since shown that this intuition was correct. Unfortunately, available data are insufficient to establish specific operating criteria that apply correctly to a wide range of dredging equipment.

Even if protective operating controls could be established, it would not solve all problems. Many US dredges are equipped with single-speed motors for the swing pulleys and cutter rotation. Additionally, ensuring that a dredge operator adheres to these limits requires monitoring that can be difficult and time consuming.

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Data are available that show excessive sediment cutting depths or very thin cuts result in higher rates of sediment resuspension. Depth controls have been implemented successfully to eliminate excessively thick cuts. However, local conditions often necessitate dredges completing a final sweep using a very thin cut to complete a dredging operation.

MECHANICAL DREDGE CONTROLS

A similar approach has been taken to operational controls for mechanical dredges in some cases. Limits on bucket fall speed are the most common control in an attempt to limit resuspension due to bucket impact. Similar to the cutterhead controls, there is limited data upon which to derive a maximum allowable bucket fall speed. Bucket fall speed is also very difficult to monitor and control.

Mechanical dredges are more easily subjected to other control measures, however. Probably the most effective in reducing the turbidity plume is not allowing supernatant from the disposal barge to overflow into the surrounding waters. Supernatant overflow is common practice for many navigational dredging projects that do not involve contaminated sediments. Barge overflow is economically beneficial because it increases the sediment load the barge can carry to the disposal location. The economic load varies considerably between dredging projects, but load increases of 100% are not unusual.

A variety of bucket designs are also available intended to reduce leakage from the bucket. Studies have shown that these buckets are capable of reducing turbidity in the water column, particularly in mid to upper depths. These buckets generally have lower production rates, however, and may have operational limitations.

PHYSICAL CONTAINMENT

A variety of physical containment methods have been used around dredging operations. Silt screens (sometimes referred to as silt curtains) are routinely used in many dredging projects. They can be purchased commercially in a wide variety of sizes and styles. The most arrangement consists of a floating boom with a geotextile fabric suspended into the water column beneath the boom. The most common type uses an open mesh geotextile that can be purchased in a wide range of opening sizes. Screens also come in a variety of depths and are typically weighted to maintain a vertical position in the water column.

Although silt screens have been used extensively, their application is limited primarily to relatively quiescent environments and their effectiveness has not been fully verified. They are virtually impossible to anchor in high-energy environments or even in areas with substantial sustained currents. Even if silt curtains can be held in place, it is very difficult to maintain the curtain in a vertical position and attached to the bottom. The slightest current lifts the geotextile allowing flow between the curtain and bottom sediments rather than forcing flow through the small openings. These currents allow the plume to escape the containment and potentially increase resuspension if the currents get sufficiently high. However, silt screens do force suspended sediment particles closer to the bottom and may reduce the lateral extent of water quality and aquatic impacts. They definitely provide aesthetic benefits by reducing visible turbidity from above the water column.

SUMMARY

Physical and operational controls have been implemented in a wide variety of forms. The success of these controls, however, usually carry some cost with them. These costs may be direct costs of the controls and indirect costs resulting from lower dredge production rates. Additional research is needed to verify the value of specific controls and develop approaches for their application.

Technical Note

MINIMIZING ENVIRONMENTAL EFFECTS OF DREDGED MATERIAL PLACEMENT

Robert E. Randall[1]

INTRODUCTION

Deepening and maintaining waterways, ports, harbors, marinas is necessary to accommodate international trade and provide recreation for peoples around the world. The primary method for deepening and maintaining these water facilities is dredging. Dredging is the excavation of underwater sediments and the transport of the dredged material to a placement facility. The United States dredges about 400 million cubic yards of dredged material on an annual basis. The dredged material is typically placed in open water or upland placement areas. A small percentage the dredged material is used for beneficial uses. The placement of the dredged material has an environmental effect in the water column and at the bottom of the water body or placement facility. In today's world it is useful to discuss methods of minimizing the environmental effects resulting from the placement of dredged material.

The objective of this presentation and discussion is present possible methods to minimize the environmental effects of dredged material placement and suggest possible research to address the feasibility of some promising methods, cost incentives, management techniques, equipment modifications and optimization. For the purpose to this discussion, the placement of dredged material will be confined to applications in the United States.

DREDGED MATERIAL PLACEMENT OPTIONS

Open Water Placement

Open water placement is the placement of dredged material in rivers, lakes, estuaries, and ocean waters. In ocean waters the Environmental Protection Agency designates these sites that are commonly known as Ocean Dredged Material Disposal Sites (ODMDS) and placement is regulated by the US Army Corps of Engineers. Placement of the dredged material is regulated under the US Clean Water Act and the London Convention (Marine Protection Research Sanctions Act).

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Upland Placement

Upland placement of dredged material is accomplished usually in diked areas call confined disposal facilities (CDF). Dredged material is placed in these facilities and after the sediment settles; the entrained water is discharged over an outlet weir and back to the water body. The effluent must pass state water quality and Clean Water Act standards. The placement areas are allowed to dewater and the dredged material consolidates. After consolidation, dewatering, and desiccation (drying) the site may again be used for dredged material placement provided dikes provide enough storage area.

Beneficial Uses

Dredged material is a natural resource of sand, silt and clay and in some cases it can be used beneficially. Some of the general beneficial use applications are beach nourishment, habitat restoration (wetlands, bird habitats, island), recreation parks, land fill and land reclamation, industrial use (airports, port facilities), fill (dikes, levees, roads, parking lots), shoreline stabilization (submerged berms, artificial reefs), agriculture and aquaculture. This is a very attractive solution, but the cost of the beneficial use usually costs significantly more that the upland or open water placement options.

DREDGING EQUIPMENT USED FOR PLACEMENT OPTIONS

Open Water Placement

The placement of dredged material in open water placement sites is accomplished with hopper dredges, pipeline dredges, and barges/scows. Hopper dredges carry dredged material to the open water site and open bottom doors that allow the dredged material to fall through the water column to the bottom. Pipeline dredges pump the dredged material as slurry through long pipelines to the placement area. Barges and scows received dredged material from mechanical dredges and carry the material to the open water placement area where it is discharged through split hull openings. Open water sites are usually classified as dispersive or non-dispersive sites. Dispersive sites mean the dredged material placed at the site is dispersed by ocean currents and waves out of the placement area in between annual or near annual placement operations. Non-dispersive sites mean the dredged material does not leave the placement area.

Upland Placement

The placement of dredged material in upland placement areas (Confined Disposal Facilities) is usually accomplished by pipeline dredges or mechanical dredges. The most common technique is to use a pipeline dredge to pump the slurry of dredged material into the diked placement area. The dredged material is allowed to settle and the effluent water is discharged over an outlet weir back into the water body. Mechanical dredges can place the dredged material in barges or scows that are moved to the placement area. The dredged material is removed from the scow/barge using mechanical equipment or water is added and the dredged material is pump as slurry to the placement area similar to a pipeline dredge.

ENVIRONMENTAL EFFECTS OF PLACEMENT OPTIONS

Open Water

The environmental effects of placing dredged material in open water disposal sites include:

- Water column turbidity for short period of time.
- Suspended material in water column can drift out of the placement area
- Benthic organisms are buried beneath the dredged material mound on the bottom
- Recolonization of the area may be by different benthic organisms due the different dredged material characteristics
- Movement of dredged material from dispersive sites may inundate adjacent aquatic bottom environments.

Upland

The environmental effects of placing dredged material in upland disposal sites include:

- Turbid water returned to the water body due to inadequate settling time in site
- Dikes fail due to poor design.
- Land must be purchased and right away obtained
- Odors and appearance are often offensive to the public

METHODS TO MINIMIZE ENVIRONMENTAL EFFECTS

Open Water

Suggestions for minimizing environmental effects of placing dredged material in open water placement areas:

- Construct underwater dikes or berms to contain the placed dredged material in dispersive sites.
- Use dredging equipment to excavate depressions to contain placed dredged material
- Use natural depressions or pits for placement of dredged material in designated disposal areas
- Use the dredged material for beneficial use whenever possible

- Find cost incentives to beneficially use dredged material so that beneficial use becomes cost effective.
- Use current GPS navigation in placing the dredged material to eliminate environmental effects outside the designated placement area.
- Isolate beach quality dredged material in a section of the placement area so that it can be reexcavated at a later time for a beach nourishment project.
- Investigate cost effectiveness of submerged pipeline discharge near the bottom to reduce water column effects

Upland

Suggestions for minimizing environmental effects of dredged material placement in upland sites include:

- Use thin layer disposal in wetland areas
- Segregate sand and fines in confined disposal areas when possible. Sand can be reused for beach nourishment. Fines can be reused for manufactured soil.
- Find cost effective ways to reuse dewatered dredged material. Removal of the dredged material will allow continued use of the confined disposal site.
- Effectively manage the upland sites to provide esthetic appearance to enhance public acceptance.
- Pursue uses of the dredged material to create wildlife islands and other habitat
- Design and manage upland sites for optimum usage (design for dike raising, use a dewatering plan, allow for consolidation, insure hydraulic effectiveness)

CONCLUSIONS AND RECOMMENDATIONS

The placement of dredged material in upland and open water sites causes environmental impacts, but these impacts can be minimized. It is recommended that cost incentives be investigated to make beneficial uses competitive with the least cost alternates of open water and upland placement. Research techniques of optimizing the dredging operation to increase solids content of slurry and hopper contents to reduce environmental effects of placement. Utilize advance positioning to insure accurate placement of dredged material. Engineer dispersive sites such that dredged material doesn't leave the placement area and impact adjacent aquatic areas.

NOTES FOR CONTRIBUTORS

GENERAL

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April 25, 2002

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Re: Journal of Dredging Engineering – Poplar Island Article

Dear Dr. Mohan,

I am writing to you in regards to the Journal of Dredging Engineering article entitled "*Modeling Approaches For Estimating Dredged Material Settlement – A Comparison Of the PSDDF and CONDES Models.*" This communication is intended to clarify and provide acknowledgements to local sponsors for this project and the work described in the article.

The work associated with the referenced paper was sponsored through a contract with the Maryland Environmental Service for the Maryland Port Administration. The statements presented in the paper are the opinion of the authors listed and not necessarily the view of the Maryland State agencies listed.

If you have any questions or comments regarding this clarification, please feel free to contact me.

Very Truly Yours,

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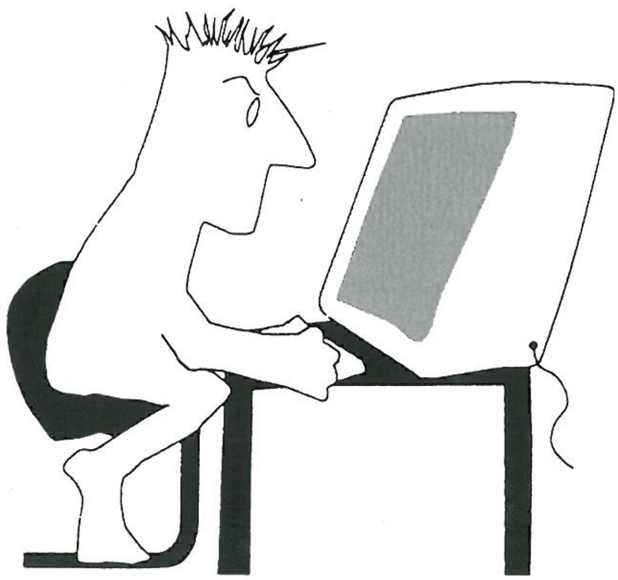

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