Integrating Science in Participatory Decisions for Water Quality: Case Studies from North Carolina, USA

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Abstract

North Carolina has embraced stakeholder participation in water quality management, convening public involvement processes to help design regulations for reducing nutrient loads in watersheds impaired by stormwater run-off, wastewater disposal and confined animal feeding operations, among other sources. The Tar-Pamlico and Neuse watersheds each terminate in broad, shallow estuaries susceptible to fish kills. Deciding which watershed users should do how much to reduce nutrient inputs has been contentious, prompting the state to convene stakeholder working groups to help design water quality regulations. The Tar-Pamlico process suffered from a rushed time schedule, which limited participation by non-government stakeholders and made it difficult for them to digest complex data needed to inform regulations. Most of the analysis was supplied by the convening government agency. In contrast, the Neuse process took place over several years, incorporated stakeholder input in designing water quality modeling and monitoring to support the decision process, and used a subset of technically capable stakeholders as liaison to the research effort.

The Neuse process clearly followed more of the practices recommended for integrating technical analysis and public participation in environmental decisions than the Tar-Pamlico did. Less clear are the extent to which the results of the Neuse process are “better” than those of the Tar-Pamlico and what measures, both procedural and substantive, should be used to assess success. The purpose of comparing these contrasting cases is to propose measures for evaluating successful integration of science and public participation and look for evidence of successes and failures in these cases.

1. Background

Solving environmental problems requires both scientific understanding of the sources of the problems and public support for undertaking the actions that are needed to solve them. Engaging those who need to take action in deciding what to do is one way to muster public support. The North Carolina Division of Water Quality (DWQ), the state agency responsible for protecting water quality, has embraced this strategy, bringing users of watershed resources together with regulatory agencies and scientists to develop programs to reduce the excessive nutrient loads that impair water quality.

These participatory efforts to develop regulations and voluntary programs to reduce nutrients consume public and private resources, raising the question of whether the effort invested is justified in terms of improvements to water quality. Answering that question is not simple; there are many steps from participatory rule-making through changes in land and water management to changes in water quality. In attempting to answer the question, I am particularly interested in how integration of scientific information into participatory processes to draft water management regulations may influence the chain of events from process to impact on problem: does doing a better job of integrating scientific information in water quality participatory processes improve the results?

To answer this question, I compared water quality participatory processes convened by DWQ for two North Carolina watersheds, the Neuse and the Tar-Pamlico. Both are large river systems originating in the Piedmont region of the state and flowing east through the coastal plain before terminating in broad, shallow estuaries bordered by barrier islands shielding the estuaries from the Atlantic Ocean (Fig. 1). Both watersheds have more urban development in the upper watershed, especially the Neuse, and more agricultural and rural residential land uses near the estuaries. Both estuaries have suffered noxious algal blooms and fish kills in the past two decades. Although these events are influenced by short-term weather patterns, especially hurricanes, the fundamental cause is believed to be excessive nitrogen (both watersheds) and phosphorus (Tar-Pamlico) from point sources (e.g., municipal and industrial wastewater disposal) and non-point sources (e.g., stormwater run-off from urban and rural lands).

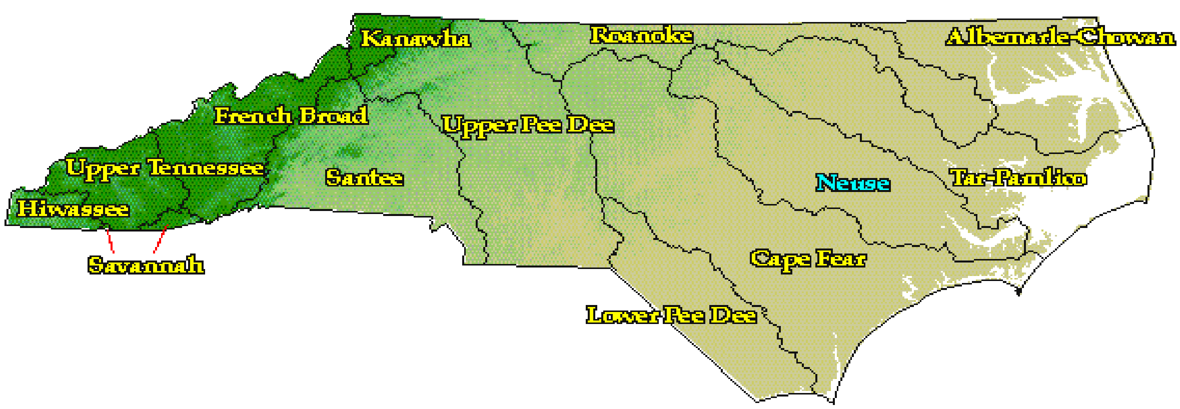


Figure 1. The Tar-Pamlico and Neuse watersheds in North Carolina on the Atlantic coast of the United States.

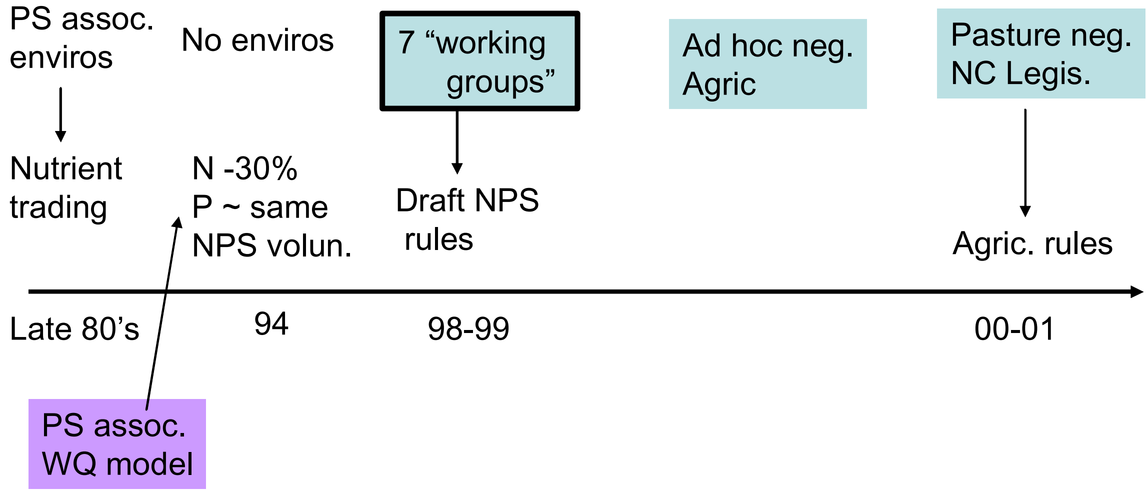
2. Tar-Pamlico and Neuse Water Quality Planning Processes

Efforts to clean up the Tar-Pamlico and Neuse estuaries have followed similar patterns (Fig. 2a and b): (1) fish kills and algal blooms triggered tighter limits on nutrients from point sources, which proved inadequate; then (2) non-point sources took first voluntary and then required actions to reduce nutrients. That is where participation by stakeholders intensified. In the Tar-Pamlico (Fig. 2a), seven working groups consisting of stakeholders from industry, agriculture and environmental organizations were convened by DWQ to draft rules for reducing nitrogen (by 30%) and maintaining phosphorus levels from non-point sources. Most of the resulting rules were enacted by the state legislature. Those pertaining to agriculture were opposed by parties not present during the working group sessions, resulting in protracted additional negotiations to satisfy those interested in pasture management. The main scientific input that engaged stakeholders was a preliminary model of estuarine water quality developed by consulting scientists hired by an association of point source dischargers (http://h2o.enr.state.nc.us/nps/documents/PhIIIAgreementFinal4-05.pdf).

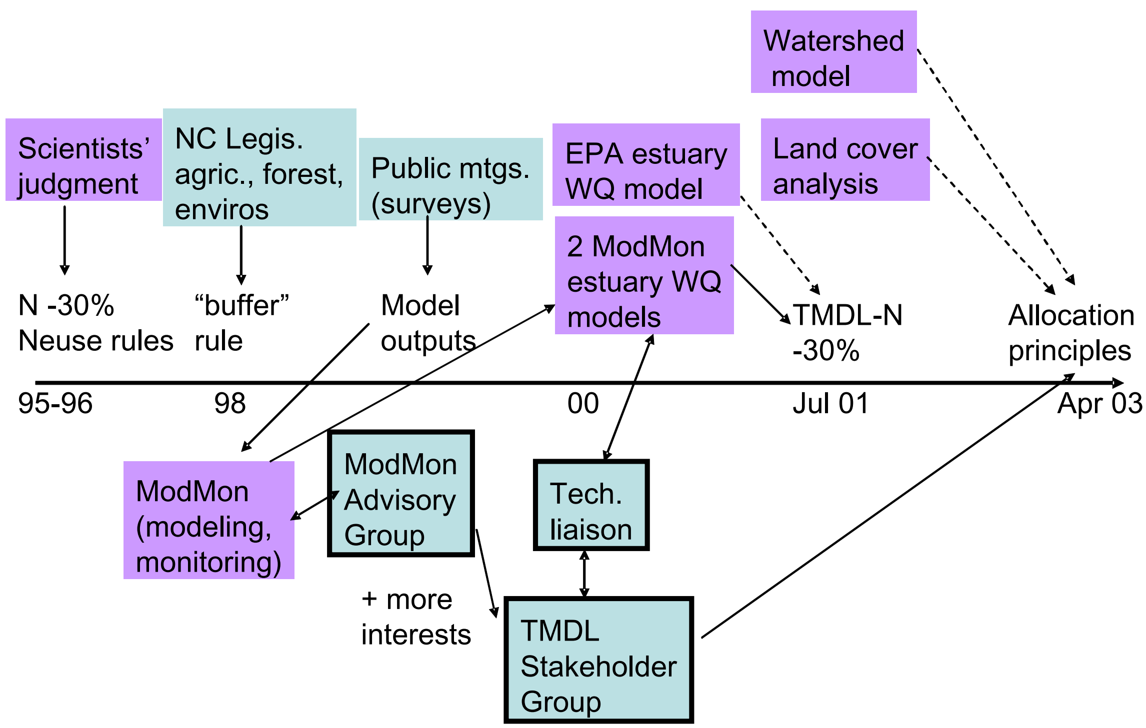
In the Neuse, both the scientific inputs and the participatory inputs were more elaborate and extended over a longer period of time. Shortly after a group of scientists used best judgment to set a target of reducing nitrogen by 30% and developed the "Neuse rules," which directed non-point sources to take action to achieve this goal, an extensive water quality modeling and monitoring effort (ModMon) was initiated to put this effort on a more solid scientific footing. A participatory process to elicit the goals of stakeholders and the general public for water quality in the Neuse informed the selection of output variables for one of the estuarine water quality models being developed, and DWQ selected a limited group of stakeholders to interact with the ModMon scientists. When a threatened lawsuit required DWQ to set a nitrogen budget for the Neuse (a Total Maximum Daily Load, TMDL), this stakeholder group was augmented with additional interests to advise the TMDL process, particularly on how to allocate responsibility for meeting the nitrogen budget among different point and non-point sources in different parts of the watershed. Additional estuarine water quality models and models to help identify the fate of nitrogen discharged in different places in the watershed were initiated at this time, and a subset of technically adept stakeholders acted as liaison between the larger stakeholder group and the modelers. The TMDL process suffered many delays in receiving modeling results, but eventually affirmed the previously set target of reducing nitrogen by 30%. Stakeholder efforts to allocate that reduction among sources were ultimately stymied by an inability to model the spatial distribution of nitrogen from various sources throughout the watershed, so the stakeholders produced a set of principles for allocating responsibility, rather than a numerical allocation.

It should be clear from these descriptions that the Neuse process involved more scientific information than the Tar-Pamlico and engaged participants with the scientific information and with scientists more thoroughly and over a longer period of time. If it is ever going to be possible to tease the effect of better integration of science in participatory processes out of the morass of other influences on environmental outcomes, comparing these very different water quality planning processes should be a fruitful place to attempt it.

I am interested in what an examination of the Tar-Pamlico and Neuse cases, in particular, might reveal about how better integration of science in participatory processes could improve results, but I am also interested in these more general questions: (1) What framework should be used to evaluate these processes? What do we mean by "better" integration and by "better" results? What evidence should we examine? and (2) What are the pitfalls that could interfere with our ability to draw conclusions about the connection between integration of scientific information and successful participatory processes?



(a) Tar-Pamlico



(b) Neuse

Figure 2. Schematic of science inputs (purple) and participatory inputs (blue) to the (a) Tar-Pamlico and (b) Neuse water quality planning processes. PS = point source; NPS = non-point source; N = nitrogen; P = phosphorus; EPA = U.S. Environmental Protection Agency; WQ = water quality; TMDL = Total Maximum Daily Load (for N); NC = North Carolina.

3. Evaluative Framework

Schemes to evaluate participatory processes have often focused entirely on inputs, although Koontz et al. (2004, pp. 26-28) and Lubell et al. (2005) have urged researchers to also examine outputs and outcomes of participatory processes, using quantitative assessments where possible. Here I outline an evaluative framework that includes both inputs (process design and execution) and outputs/outcomes, social (e.g., Beierle 1999) as well as environmental (Table 1). Outputs and outcomes include (1) the proximate products of the water quality planning processes, such as draft rules or other agreements reached; (2) participants' reported experience of the processes, because these are often cited as valued ends in themselves, as well as means of enhancing compliance with agreements (Lind and Tyler 1988); (3) the behavior of both participants and others whose actions are affected by agreements, in terms of both formal enactment of management rules and implementation of those rules; and (4) effects of implemented agreements on the water quality problems that motivated these participatory processes, including socioeconomic effects of implementation.

Table 1. Framework for evaluating successes and failures of participatory processes.

- Inputs
  - Process design
  - Process execution – integration of scientific analysis
    - Scientific information offered? By whom? Engagement of nontechnical participants?
- Outputs/outcomes
  - Products (agreements, process documents)
  - Participant experiences (e.g., learning, satisfaction)
  - Observable behavior (participants, regulated parties, non-participants)
    - Enacting agreements
    - Implementing agreements
  - Impact on original problem
    - WQ improvements
    - Socioeconomic consequences

Evidence for successes and failures of various elements of this evaluative framework comes from a variety of written and oral sources, mostly qualitative (Table 2).

4. Evidence for Successes and Failures of Tar-Pamlico and Neuse Processes

4.1 Process Inputs – Design and Execution

4.1.1 Tar-Pamlico

The main participatory elements in water quality planning for the Tar-Pamlico were groups of industry, agency and environmental representatives convened by the DWQ

Table 2. Sources of data for evaluation of successes and failures of the Tar-Pamlico and Neuse water quality planning processes. TMDL = Total Maximum Daily Load (for nitrogen).

- Tar-Pamlico
  - Archives (letters, minutes, process products, websites)
  - Interviews (convenor, facilitator)
  - Small-scale survey of working group participants immediately post-process
  - Large-scale, follow-up survey of participants, and non-participants two years post- process
  - Public statements by convenors, participants
- Neuse
  - Archives (agency products, websites, minutes, process products
  - Participant/researcher (public values analysis, TMDL stakeholder group)
  - Publications (modeling, water quality monitoring)
  - Small-scale surveys (public meeting participants, TMDL stakeholder group) immediately post-process
  - Public statements by convenors, participants

to draft rules for nutrient reduction in seven subject areas (see list in Table 3). Meetings of these groups took place in a very compressed timeframe (Fig. 2), with little opportunity for participants to gather, review and understand complex water quality information. One consequence of the rushed process was that consideration of science was almost entirely one-way, with DWQ and other state and federal agencies supplying the bulk of the scientific information (Table 3).

Table 3. Sources of scientific information provided to the Tar-Pamlico working groups (from written minutes of meetings).

	Who provided information		
	DWQ	Other State/Federal	Other
Agriculture	6	5	4
Atmospheric emissions	0	6	0
Erosion/sedimentation	3	7	5
Onsite wastewater	1	6	1
Stormwater	12	0	0
Urban nutrient	1	1	0
Wetland restoration	5	4	0
Total	28	29	10

DWQ=Division of Water Quality employees; ‘Other State/Federal’ also includes state university and extension employees, as well as agency employees; ‘Other” also includes any subcommittee where at least one subcommittee member was not a federal or state agency employee.
From Table 3, Maguire and Lind (2003).

4.1.2 Neuse

Both the scientific and the participatory elements of the Neuse process extended over a much longer timeframe and included much more interaction between scientific information, scientists and participants (Fig. 3). Public values guided the choice of outputs for one of three main estuarine water quality models (Borsuk et al. 2001). There were many joint meetings of the ModMon stakeholder group and its successor Neuse TMDL stakeholder group with the modeling teams (Maguire 2003). Members of the Neuse TMDL stakeholder group were actively involved with development of the watershed source model, supplying data and suggesting model tests. However, ultimately the watershed source model failed to provide the information the stakeholder group needed to allocate the nitrogen budget among sources.

4.2 Process Outputs and Outcomes

4.2.1 Tar-Pamlico

In terms of products from the seven Tar-Pamlico working groups, three drafted rules as they had been charged, but the remaining four refused, instead offering resolutions about what should be done. These groups complained that they were unable to fulfill their charge because of "*lack of information*" and ". . . *timeframe too short for such a broad topic*" (quoted in Maguire and Lind 2003).

In terms of participant experiences, the convening agency (DWQ) rated the Tar-Pamlico working group process as a "mixed success," believing that the follow-up negotiation on pasture management lacked a sound technical basis and was unduly influenced by a few individuals (Mr. Richard Gannon, Non-point Source Planning Unit, North Carolina Division of Water Quality, presentation, Raleigh, North Carolina, February 10, 2006). Stakeholder participants surveyed immediately after the working group process stated that "*There was no processing time for gathering data and assessing possible strategies for protection of the Tar-Pamlico basin between meetings*." However, their quantitative responses were slightly more positive, rating the statement "*I had ample time to understand the issue"* as a little better than neutral (3.4 on a 5-point Likert scale) (Maguire and Lind 2003).

In terms of enacting working group draft rules into law, the work of most of the subject area groups went through public hearings and reviews by the state legislature with few problems, but the agriculture rules required extensive further negotiation and revision (Fig. 2).

Implementation of the resulting Tar-Pamlico rules has gone smoothly, although some rules (e.g., a system for tallying phosphorus inputs from agricultural sources) have come into force only very recently. A similar system accounting for agricultural sources of nitrogen suggests a 47% reduction from 1991 to 2004 (http://h2o.enr.state.nc.us/nps/documents/EMCTarPamAgRuleAnnRpt11-05.pdf). Eleven local governments have enacted stormwater management rules affecting new development. Point sources discharges are down by 50% for nitrogen and more than 60% for phosphorus (http://www.asiwpca.org/presentations/docs/wlsraleigh/RGannonNeuseTarPamlicoNutrientStrategies.pdf).

In terms of river and estuarine water quality, an analysis of nutrient concentrations in the river system just above the estuary between 1991 and 2002 shows nitrogen down by 18% and phosphorus down by 33%, missing the targeted 30% reduction for nitrogen but exceeding the goal of maintaining levels of phosphorus (http://h2o.enr.state.nc.us/nps/TrendGrimesland91-02prn.pdf). The area of the Tar-Pamlico estuary declared to be "impaired" according to water quality standards is down by 90% from 1994 to 2004 (http://www.deq.state.va.us/vpdes/pdf/tarpamlicoriverpresentaug31tac.pdf). As far as socioeconomic effects of these accomplishments, there is little basis for judgment. There are nutrient trading schemes and regional groupings of agricultural users, both of which are intended to increase economic efficiency of actions taken to reduce nutrient loads, although the nutrient trading options have received little or no use as yet. There have been some attempts to estimate expenditures for some nutrient management activities (http://www.deq.state.va.us/vpdes/pdf/tarpamlicoriverpresentaug31tac.pdf), but no comprehensive analyses that reveal socioeconomic consequences of implementing nutrient reductions.

4.2.2 Neuse

In terms of products resulting from the Neuse participatory processes, the DWQ did set a Total Maximum Daily Load for nitrogen, based at least in part on the modeling and monitoring done under the ModMon research effort and on comments received over the long interaction among stakeholders, agency scientists and modelers (Fig. 3). However, the stakeholders had limited involvement in deciding what the TMDL level should be. They were more actively involved in allocating responsibility for meeting that TMDL among nitrogen sources in the watershed, but were stopped short of determining a numerical allocation by problems with the scientific information they needed, settling instead for a declaration of principles to be used to allocate responsibility (Maguire 2003).

In terms of participant experiences, the convening agency (DWQ) rates early negotiations of the "Neuse buffer rule" (requiring maintenance of vegetated buffer strips along waterways) as a "clear success," negotiation of stormwater management in the Neuse as "largely successful," and the Neuse TMDL process as "mixed," citing the limited progress on allocation of responsibility, but success in developing the TMDL for nitrogen with stakeholder input and without litigation (Mr. Richard Gannon, Non-point Source Planning Unit, North Carolina Division of Water Quality, presentation, Raleigh, North Carolina, February 10, 2006). A very small sample of participants in the Neuse TMDL stakeholder group completed a survey after the TMDL had been set but before it became apparent that the allocation could not be completed as originally envisioned. They responded slightly more favorably than neutrally to these statements: "*There was a good foundation of technical information to support the stakeholder's work*" (2.3 out of a 4-point Likert scale), and "*I had access to the technical information I needed to participate fully*" (2.7 out of 4). They were a bit more positive about these statements: "*The technical information was provided at the right level for me*" (3 out of 4), and "*I had sufficient time to digest the technical information provided*" (2.8 out of 4).

In terms of enacting process agreements into regulations, the vegetated buffer provisions of the initial "Neuse rules" required some additional negotiation before they were adopted (Fig. 3). The TMDL for nitrogen was approved by the U.S. Environmental Protection Agency and was not litigated by either industry or environmental organizations; however, the fact that the TMDL required the same reduction that scientists had estimated in 1995 (30%) undoubtedly contributed to its acceptance.

Experience with implementing enacted agreements in the Neuse has been similar to the Tar-Pamlico. An accounting system to estimate reductions in agricultural sources of nitrogen is in use, showing reductions of 44% between the 1991-4 baseline and 2004 (Annual Progress Report on the Neuse Agricultural Rule: A report to the NC Environmental Management Commission from the Neuse Basin Oversight Committee, November 10, 2005). Fifteen local governments enacted stormwater management programs for new development. Point source discharges of nitrogen are down 69% from 1995 to 2004 (http://www.deq.virginia.gov/vpdes/pdf/neuseriverpresentaug31tac.pdf).

In terms of effect on the estuarine water quality problems that motivated the Neuse science and participation efforts, some analyses of nitrogen concentrations at the upper end of the estuary, after adjustment for variations in river flow, suggest that concentrations were relatively stable from 1979 to 1995, but then declined by about 23% between then and 2000 (Stow and Borsuk 2003). However, this conclusion has been controversial, and a recent challenge has suggested that the adjustment for river flow was insufficient and that estuarine water quality has continued to decline (Burkholder et al. 2006). No parts of the Neuse estuary originally declared to have "impaired" water quality have yet been designated as meeting water quality standards (http://h2o.enr.state.nc.us/basinwide/Neuse/2002/plan.htm contains the most recent designation), although that also is a matter of some controversy because these designations can have a strategic (some might say political) element to them. Like the Tar-Pamlico, there is little that can be said as yet about the socioeconomic effects of implementing these regulations.

5. Summary of Comparative Performance of Tar-Pamlico and Neuse Processes (Table 4)

Can we now answer the original question: Which water quality planning process was better in terms of integrating scientific information and participation? The Neuse participatory processes were clearly superior to the Tar-Pamlico processes in terms of the inputs, process design and execution. More care and more time were taken in the Neuse to engage participants and to provide them with scientific information and opportunities to interact with scientists. The Tar-Pamlico process was unduly hurried, compromising participants' opportunities to gather and digest scientific information.

It is less clear which process is better in terms of process outputs and outcomes. The Tar-Pamlico process seems to have a slight edge in terms of the quality of the draft rules produced, but it had the advantage of using the rules developed earlier for the Neuse watershed as a starting point. Both the convening agency (the Division of Water Quality) and stakeholder participants expressed somewhat greater satisfaction with the Neuse process in public meetings and in survey ratings completed after the processes were completed. (The surveys did not ask participants to compare the two processes, although some attended both.) The water quality rules developed in both the Neuse and the Tar-Pamlico processes eventually were enacted through the North Carolina legislature, but the Neuse process encountered somewhat less difficulty than the Tar-Pamlico, which suffered through a protracted additional negotiation in order to resolve conflicts about the rules pertaining to agricultural practices. Both the Neuse and the Tar-Pamlico watersheds appear to have been equally successful in implementing the rules that have been put in place (although some have only recently come into force).

In terms of addressing the water quality problems that motivated these rule-making processes, the Tar-Pamlico appears to have been more successful in improving estuarine water quality, in that a substantial portion of the estuary listed as having "impaired" water quality has now been removed from that list. Both the Neuse and Tar-Pamlico show reductions in nutrient concentrations just upstream of the estuaries. In terms of socioeconomic consequences of new management practices, there is not enough information to compare the two cases.

Table 4. Summary of comparative performance of Tar-Pamlico and Neuse participatory processes.

	Inputs
Neuse ++	Process design
Neuse ++	Process execution (integration of scientific analysis)
	Scientific information offered? By whom? Engagement of nontechnical participants?
	Outputs/outcomes
Tar-Pam +	Products (agreements, process documents)
	Participant experiences (e.g., learning, satisfaction)
Neuse +	Convening agency (DWQ)
Neuse +	Stakeholders
	Observable behavior (participants, regulated parties, non-participants)
Neuse +	Enacting agreements
?	Implementing agreements
	Impact on original problem
Tar-Pam +	WQ improvements
?(little info)	Socioeconomic consequences

6. Critique of Evaluative Framework

The evaluative framework in Table 1 assumes a cascade of connected results, in which sound design and execution of a participatory process lead to better agreements and better experiences for participants, which lead to successful enactment and implementation of those agreements, which help solve the original problem. It has been possible to reach at least tentative conclusions about the performance of the Neuse and Tar-Pamlico processes using this framework, but there are grounds for skepticism as well.

Foremost are inherent difficulties in attributing changes in water quality to actions taken under agreements reached through these participatory processes. A suite of anthropogenic and biophysical factors may overwhelm the effects of those actions. These include (1) time lags in the response of estuarine water quality to reductions in nutrient inputs, in part due to nutrient storage in sediments; (2) variations in river flow, especially due to hurricanes, that affect nutrient concentrations; and (3) ongoing land use and demographic changes, especially urbanization and shifts from row crop agriculture to confined animal feeding operations. The apparent lack of improvement in the Neuse estuary compared to the Tar-Pamlico may be attributed to inertia inherent in a more heavily developed and more rapidly urbanizing watershed, where only new development must meet more stringent stormwater regulations, and to the rise in industrial scale hog farms in the lower watershed.

Another source of disconnection between process and result may be the sheer amount of scientific information brought to bear on the problem. The Neuse case is unusual among water quality planning processes not only for the extended and intense interaction between stakeholders and scientists, but also for the huge investment in water quality modeling and monitoring over many years. Perhaps having more and better scientific information leads to agreements that do a better job of addressing water quality problems quite apart from any benefits realized from integrating that information into participatory processes. Because investments in science are probably greater where water quality problems are worse and where they receive more public attention, disentangling the effects of information quantity and quality from its use in participatory processes will be problematic.

On the other hand, research in procedural justice has shown that sound participatory processes can lead to support of regulatory decisions somewhat independent of the substantive content of those decisions (e.g., Lind et al. 1990). Well-designed and well-executed participatory processes might produce satisfied participants, who then willingly implement agreements reached, independent of the scientific soundness of those agreements. In these circumstances, improvements in water quality might occur independently of successful integration of science into the participatory process (although perceiving decisions to be soundly based in the facts is one element of procedural justice).

These potential disconnections in the chain of influences represented by the evaluative framework could perhaps be investigated through large-scale comparative analyses of the use of science in participatory processes, but it is daunting to think of the number of such cases that would be needed to decide which influences have a demonstrated empirical basis.

Acknowledgments

I want to thank Dr. Toddi Steelman for expert guidance to the literature on evaluating participatory processes, Mr. Richard Gannon and his colleagues at the North Carolina

Division of Water Quality for great help with evidence for the outcomes of the Neuse and Tar-Pamlico processes, and colleagues at North Carolina State University, University of North Carolina-Chapel Hill and Duke for their helpful comments.

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