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**Supporting sustainability through community and
collaborative processes at the landscape scale**

**Ashok Lumb and Graham Whitelaw
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Performance of Ontario's Benthos Biomonitoring Network: Impacts on Participants' Social Capital, Environmental Action, and Problem-solving Ability

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Abstract

The Ontario Benthos Biomonitoring Network (OBBN) is a collaborative initiative that monitors bottom-dwelling aquatic invertebrates to assess ecological condition. The Network is led by Ontario's Ministry of Environment and Environment Canada's Ecological Monitoring and Assessment Network Coordinating Office, and is part of the Canadian Aquatic Biomonitoring Network. This paper evaluates OBBN performance, emphasizing impacts on participants' social capital, environmental action, and problem-solving ability. A questionnaire was used to

characterize participants' reasons for joining, their experience and degree of involvement, their satisfaction with the Network, and their socio-economic status and demography. Three hypotheses were tested: (1) that participants' social capital has increased as a result of Network involvement; (2) that OBBN involvement has catalyzed an increase in participants' civic environmental action, or the effectiveness of that action; and (3) that Network members' problem-solving abilities have improved as a result of their participation. Evidence supports all three hypotheses, and participants' subjective assessments suggest that the Network is performing well. New participants join the Ontario Benthos Biomonitoring Network for a variety of water-management-related and social reasons. Most participants categorize the government-participant relationship in the OBBN as a voluntary partnership or collaboration, with an acceptable distribution of funding burden among partners. Participants are generally satisfied with the OBBN, and most believe it to be credible, relevant, legitimate, and inclusive.

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Le Ontario Benthos Biomonitoring Network (OBBN) est une initiative de collaboration dont l'objet est la surveillance des invertébrés aquatiques de fond dans le but d'évaluer la situation écologique. Le réseau est dirigé par le ministère de l'Environnement de l'Ontario et par le bureau de coordination du Réseau d'évaluation et de surveillance écologique (RÉSÉ) d'Environnement Canada, et fait partie du Réseau canadien de biosurveillance aquatique (RCBA). On évalue dans cet article les résultats du OBBN, en mettant l'accent sur les répercussions sur le capital social des participants, leur action environnementale et leur capacité de résolution de problèmes. On a utilisé un questionnaire pour caractériser les motifs qui ont poussé les participants à s'engager, leur expérience et leur degré de participation, leur satisfaction par rapport au réseau, leur situation économique et démographique. On a vérifié les trois hypothèses suivantes voulant que : 1) le capital social des participants ait augmenté à la suite de leur engagement dans le réseau; 2) la participation au OBBN ait catalysé et augmenté l'action civique environnementale, ou l'efficacité de cette action, chez les participants; et 3) les capacités de résolution de problèmes des membres du réseaux se soient améliorées à la suite de leur participation. Les éléments de preuve observés soutiennent les trois hypothèses. La participation au réseau est motivée par une variété de résultats souhaitables de nature sociale et liés à la gestion de l'eau. La plupart des participants ont classé la relation gouvernement-participant au sein du réseau (OBBN) comme un partenariat bénévole ou une collaboration, avec une répartition acceptable du fardeau du financement parmi les partenaires. De manière générale, les participants sont satisfaits du OBBN et croient pour la plupart qu'il est crédible, pertinent, légitime et complet.

Keywords

Benthic macroinvertebrates, biomonitoring, Ontario, social capital, environmental action, problem solving

standardized ecosystem monitoring measures and indicators with scientific experts and Network partners.

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Introduction

The multi-partner Ontario Benthos Biomonitoring Network (OBBN) enables bioassessment of inland streams, lakes, and wetlands using benthic macroinvertebrates. The Network was co-founded in 2003 by Ontario's Ministry of Environment and Environment Canada; it complements an existing provincial water-chemistry monitoring program by enabling aquatic ecosystem condition to be assessed biologically, and it contributes information to Canada's national aquatic biomonitoring network. The OBBN has five components:

- Standard sampling procedures (Jones *et al.* 2005);
- Training and certification;
- Access to Canada's national benthos database, which allows data to be shared among participants;
- Analytical software (under development) that defines biocriteria and calculates tests of the bioassessment null-hypothesis – that a test-site is normal, or in reference condition (e.g., Wright *et al.* 2000, Bailey *et al.* 2004, Bowman and Somers 2005); and
- A collaborative, applied research, program.

This paper is one part of an OBBN performance evaluation: it reports results from a survey that was designed to gain information about participants' reasons for joining the OBBN, their experience and degree of involvement, their satisfaction with the Network, and their socio-economic status and demography. Using this survey data, we test three hypotheses: That involvement in, or association with, the OBBN has: (1) increased social capital (i.e., the value of participants' individual social networks, and the value of the collective biomonitoring-related social network in Ontario); (2) increased participants' civic environmental action, and the effectiveness of that action; and (3) increased participants' ability to overcome environmental challenges.

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Concepts

We define social capital as the value of social networks among people and organizations – characterized by trust, cooperation, community involvement, and information sharing – that build capacity to solve problems and accomplish goals of mutual benefit (e.g., Schuurman 2003, Krishna 2004, Larsen *et al.* 2004, Mansuri and Rao 2004, Overdevest *et al.* 2004, Parisi *et al.* 2004). One's social capital can be estimated by evaluating one's *social network*, which we define as a map of the relationships among individuals connected through various social familiarities ranging from casual acquaintance, to professional association, to close familial bonds (adapted from Barnes [1954]). Herein, we investigate both *bonding* social capital and *bridging* social capital. Bonding social capital is the type of social capital that strengthens ties among individuals (e.g., Larsen *et al.* 2004, Paavola and Adger 2005). We evaluated OBBN influences on bonding social capital with survey questions dealing with solidarity, unity, reciprocity, trust, frequency of communication, and the use of common terminology. Bridging social capital is the type of social capital that extends social contact beyond members' own personal social networks, thereby facilitating collective action across a broader segment of society (e.g., Larsen *et al.* 2004, Paavola and Adger 2005). Impacts on bridging social capital were evaluated based on participants' social network size, cooperation, access to information, knowledge, and their perceived influence or impact.¹

Although the questionnaire used in our survey did not directly query OBBN effects on participants' capacities to solve environmental problems, we argue that several elements of social capital are also measures of environmental problem-solving ability. For example, the level of cooperation, reciprocity, solidarity, and trust one has within one's social network, the size of that network, how knowledgeable a person is,

¹ We acknowledge that these classes of social capital are not discrete, but they represent a useful perspective from which the drivers of social-capital-related changes can be considered.

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one's access to information, the frequency of one's communication with others, the strength of connections one has with others, and the influence or impact one has, are all measures of a person's ability to help solve their community's environmental problems. We consider evidence of increased knowledge to be particularly strong evidence of improved problem-solving ability (e.g., Dobell 2000, Cross and Sproull 2004); environmental problems tend to be very complex (e.g., Grant 1997, Pollard *et al.* 2001, Thornton and Laurin 2005, Millenium Ecosystem Assessment Board 2005), but the more comprehensive one's understanding of a given problem is, the more tractable that problem is.

Several survey questions were designed to provide information about Network members that could be used to investigate sector-related, gender-related, Network-experience-related, or other biases in responses; we refer to the variables provided by these questions as *predictor variables*, whereas questions related to Network performance and social capital were considered *response variables*.

Methods

Survey Questionnaire

Our survey questionnaire provided information on 137 variables: 17 predictors; 16 social, economic, and demographic measures; and 104 response variables (Jones 2005 and Table 1). It was written according to the principles of Chakrapani and Deal (1992) and Suskie (1996). For example: when composing questions, we kept to one-dimensional queries written with simple, direct language; we accommodated all possible answers including (for most questions) *don't know*, *not applicable* or *no opinion*; and we posed questions in an emotionally-neutral, non-threatening way to avoid biasing answers. In addition, we made the questionnaire as short as possible, minimized navigational branching through lines of questioning, and varied question formats (e.g., multiple-choice, numeric, and open-ended) to avoid habituation in response sets.

Before distributing it to our intended audi-

Table 1. Questionnaire-derived variables

Question Number	Question (condensed) ^a	Type
N/A	Response group (based on order of responses received)	Ordinal (early, mid, late)
35	# months elapsed since first hearing about OBBN	numeric (continuous)
36	# months involved/associated with OBBN	numeric (continuous)
37 (a-i)	Type of involvement	Nominal
38	# months as certified participant	numeric (continuous)
39	# OBBN events attended	Ordinal
40	# sites sampled (using OBBN methods)	Ordinal
1 (a-h)	Motives for participating	Ordinal (Likert)
42	Gender	Nominal
43	Age	numeric (continuous)
44	Marital status	Nominal
45	Level of education	Nominal
46	Employment status	Nominal
47 (a-h)	Vocational sector	Nominal
48	# years in current job	Ordinal
49	# years residing in present community	Ordinal
50	Annual household income	Ordinal
2	Intended outcomes of participation	Comment (text)
10	Distribution of control and investment between partners	Comment (text)
13	Important OBBN-management issues	Comment (text)
14	Ways of improving implementation	Comment (text)
18	Impact of participation on knowledge	Comment (text)
34	Proposed changes to increase satisfaction	Comment (text)

Question Number	Question (condensed) ^a	Type
3 (a-e)	Control or influence over Network elements	Ordinal
4	Participant-government relationship type	Nominal
5	Investment in and return from the Network (present balance)	Nominal
6	Investment in and return from the Network (future balance)	Nominal
7	Distribution of contributions (participants vs. government)	Nominal
8	Acceptability of distribution of contributions	Nominal
9	Onus for further investment	Nominal
11 (a-h)	Perceptions about implementation	Ordinal (Likert)
12 (a-l)	Priority implementation issues	Ordinal (Likert)
15 (a-o)	Knowledge about OBBN (proportion correct of set of true-or-false questions)	numeric (continuous)
16	Knowledge about OBBN	Nominal
17	OBBN impact on knowledge	Ordinal (Likert)
19	OBBN effect on participation in environmental activities	Nominal
20	Drivers of increased participation	Ordinal (Likert)
21	Effectiveness of participation in environmental activities	Ordinal
22 (a-g)	Drivers of increased effectiveness	Ordinal (Likert)
23	Amount of civic participation	Ordinal
24 (a-f)	OBBN impacts on personal social network	Ordinal (Likert)
25 (a-f) ^b	OBBN impacts on collective social network	Ordinal (Likert)
26 (a-e)	OBBN impacts on personal social network	Ordinal (Likert)
27 (a-h) ^b	OBBN impacts on collective social network	Ordinal (Likert)
28	Value added to personal social network	Ordinal
29	Value added to collective social network	Ordinal
30 (a-f)	Perspectives on Implementation	Ordinal (Likert)
31 (a-f)	Satisfaction with OBBN-development procedures	Ordinal (Likert)
32 (a-e)	Satisfaction with products	Ordinal (Likert)
33	Overall satisfaction	Ordinal
41	# additional years expecting to participate	Ordinal

Response Variables

^aUnless specified otherwise in the table, questions were directed at the respondent for the purpose of self-evaluation: for example, to evaluate perspectives on *their own* involvement in the OBBN, to evaluate their own socio-economic status, and to evaluate how outcomes of their involvement have *affected themselves*. ^bdenotes an exception to rule (a) above: for example, question 27 is an exception because respondents were asked to comment on their perceptions about the impact of the OBBN on the collective social network of all OBBN participants.

ence, we tested our draft questionnaire on a sub-set of OBBN participants; this prompted some revisions, but they were minor enough that test data could be pooled with those from the final survey. On 19 September 2005, we sent the final version (hereafter referred to as *the Questionnaire*) to 252 OBBN participants. A cover letter was also sent: it explained that anyone having "some familiarity with the OBBN, or some involvement in it" was eligible to participate in the survey; it provided instructions about filling-out and anonymously submitting the Questionnaire; and it set 11 October 2005 as the deadline for responding. The 252 recipients of the Questionnaire approximated the entire population of OBBN participants at that time.

We ran two follow-up surveys in December 2005. In the first, we simply asked respondents to estimate how long it took them to complete our Questionnaire. The target group for our second follow-up survey (hereafter referred to as *the Follow-up Survey*) was a random sub-sample of Network members who *did not respond to our Questionnaire*. The Follow-up Survey's two questions allowed us to compare the views of Questionnaire-respondents and non-respondents: we used the first question to ask why recipients failed to return a completed Questionnaire, and we used the second question to ask non-respondents how satisfied they were with the OBBN (this latter question was identical in wording to question 33 of our Questionnaire [Jones 2005]).

Analyses

All Questionnaire responses were hand-coded, and data were analyzed in Microsoft Excel.

We used dummy variables to code nominal-scale categorical variables, which allowed us to investigate relationships between predictor and response variables (e.g., Zar 1984). Some categorical descriptor variables were re-coded as ordinal variables. This was done, for example, for question 37 (Jones 2005), to which participants were asked to select from a series of categories any that described their involvement in the OBBN: "Reader," "Correspondent," "Uncertified participant," "Certified participant," "Reference-site sampler," "Test-site Sampler," "Research collaborator," "Certified trainer," "Technical Advisory Committee member," and "Data user." To code these ordinally, *Reader* and *Correspondent* were combined into a single category and given a value of 1; *Uncertified participant* was assigned a value of 2; *Certified participant* was assigned a value of 3; and *Certified trainer* and *Technical Advisory Committee member* were combined into a single category and given a value of 4. Where respondents selected more than one category, the assigned code reflected the highest ordinal class selected (e.g., had both "Reader" and "Certified participant" been selected, the response would have been coded as a 3). Once all variables were coded, we graphically summarized data for each variable to show the distribution of responses.

We used linear regression and ordination to investigate relationships between sets of predictor and response variables.²

² Because of the coding system used for our measure of degree of Network involvement, regression results using this predictor are useful for indicating if a trend exists, but are of little predictive value because the incremental increase between ordinal categories is difficult to quantify (slope coefficients are therefore difficult to estimate).

Results

Data reported in this section are from 39 completed Questionnaires, which constituted a 15% return rate, as well as from our Follow-up Survey. Respondents required from 15 to 45 minutes to complete the Questionnaire (median was 30 minutes; n=6).

Follow-up Survey

Thirteen OBBN members participated in our Follow-up Survey. The most common responses to Question 1 (i.e., reasons for not completing our Questionnaire) were reported as (recipient) “too busy” (5 respondents) and “questionnaire too long” (3 respondents). Several Follow-up Survey participants also gave supplementary written reasons for not completing the Questionnaire: either they believed themselves not sufficiently involved in the Network for their responses to be relevant (7 responses), or they misplaced the Questionnaire, or they postponed or forgot about filling it out, and hence missed the deadline (3 responses).

Five of 6 respondents classified their satisfaction with the OBBN (in response to Question 2) using either the highest or second highest ordinal category. This resulted in a very similar distribution of responses as was generated by Questionnaire respondents, of which 77% rated their satisfaction as a 4 or 5 (Figure 1). Those who did not answer Follow-up Survey Question 2 claimed they were not sufficiently involved in the Network to have an opinion.

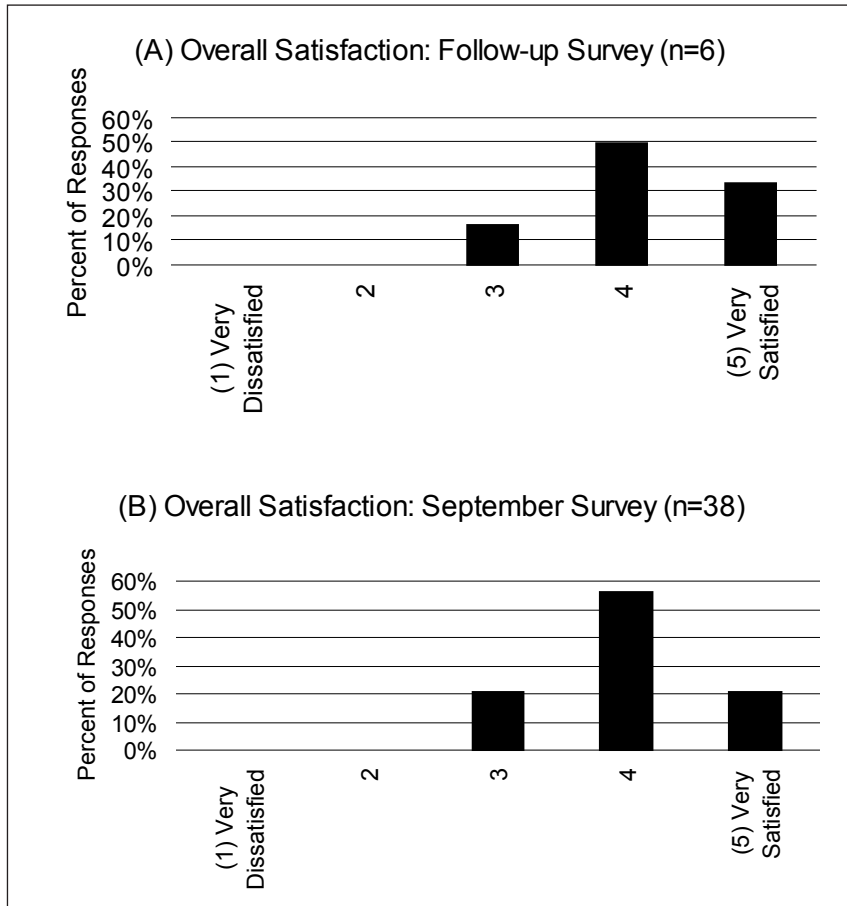
Predictor Variables

Ontario Benthos Biomonitoring Network participants with different levels of experience returned completed Questionnaires, including those who considered themselves marginally involved “readers” (20 respondents) or “correspondents” (24 respondents), more involved “certified participants” (19 respondents), or very involved “certified trainers” (7 respondents) or “Technical Advisory Committee members” (6 respondents).³ The number of months for which participants reported having known about the OBBN exhibited a nearly even distribution (categories were 0-6 months, 7-12 months, 13-18 months, 19-24 months, 25-30 months, and 31 months or more; mode was 25-30, and included 10 of 38 responses). To a similar question querying *duration of involvement*, 33% of respondents selected the “0-6 months” category, and 38% selected the “25-30 months” or “31+ months” categories (n=39). Eighty-nine percent of participants (n=37) indicated having participated in 1-3 OBBN events (including meetings, teleconferences, courses and presentations), although a small number of participants who had attended more than 25 such events were also represented.

Responses to another set of questions characterized reasons for participating in the OBBN. All respondents indicated “assessing or managing ecological condition” as an important motive of Network participation; however, all of the following motives were at least somewhat important to the majority of participants: research; meeting others; evaluating water-management-program performance; guiding rehabilitative, restorative or enforcement efforts; assessing or managing

³ The total number of responses listed here exceeds 39 because respondents indicated all categories of involvement that applied to themselves.

Figure 1. Overall OBBN satisfaction as reported in (A) our December 2005 Follow-up Survey and (B) our original September 2005 survey of OBBN participants



biodiversity; and training or education.

Questions about OBBN members' socio-economic status and demography revealed an approximately even mix of 58% men and 42% women among respondents. The distribution of ages was skewed, with the mode occurring between 20 and 39 years-of-age (accounting for 66% of respondents), and with no respondents less than 20 years-of-age. All respondents reported having earned at least a college diploma, and the most common response regarding the highest level of education achieved (accounting for 45% of those polled) was "university undergraduate degree" (n=38). The most common vocational affiliation reported was with conservation authorities, Ontario's quasi-governmental watershed-management agencies (32% of respondents), although all other affiliations (e.g., private sector, government, academic, education, and non-governmental or non-profit)

were represented among respondents (n=38). Similar to that of reported ages, the distribution of participants' on-the-job experience was skewed, the commonest response being less than three years (44% of responses; n=38), with sequentially declining representation of respondents in categories up to 20+ years' experience (categories were "<3 years," "3-5 years," "6-10 years," "11-20 years," and ">20 years"). The number of years that participants have been residing in their present community had a more even distribution, the mode (accounting for 32% of responses) situated at the "<3 years" category (n=38; categories were the same as for on-the-job experience, see above). Participants' annual household incomes had an approximately normal distribution (categories were "<\$25,000," "\$25,000-40,000," "\$40,001-70,000," "\$70,001-100,000," and ">\$100,000"), the mode, accounting for 53% of responses, was "\$40,001-70,000"(n=30).

Perspectives About OBBN Implementation

Most participants indicated having a high degree of control over which sites they sample (n=35) and which data they share with other Network participants (n=34), 86% and 79% (respectively) indicating one of the highest two ordinal categories of control. Responses to questions about participants' control over "follow-up action," "analysis and interpretation," and "developing and refining methods" were more evenly distributed, possibly reflecting some uncertainty about participant roles (especially for follow-up action). When asked to select the category from Table 2 that best described participant/founding-government-partner relationships in the OBBN, 88% of respondents categorized them as either "partnerships" or "collaborations" (n=32).

We found an even split between those who thought their return from the OBBN exceeded their investment, those who thought their investment equaled their return, and those who thought their investment exceeded their return (n=34). Sixty-one percent of respondents indicated that, following full implementation of the OBBN, they expected their balance of investment and return to shift toward more return (n=31); remaining respondents were evenly split in their opinions,

Table 2: Types of government-participant relationships in monitoring programs

	Relationship Type (based on degree of participant control) ^a			
	Control	Partnership	Collaboration	Co-optation
Who determines monitoring protocol?	Participants	Shared	Shared	Government
Who selects sites to be monitored?	Participants	Participants	Shared	Government
Who determines analytical methods, interpretation, and data distribution?	Participants	Participants	Shared	Government
Who determines follow-up action?	Participants	Participants, then government	Shared	Government

^aAdapted from Savan *et al.* (2004)

half anticipating a shift toward more investment, and half anticipating no change. Similarly, participants were about evenly split in their perspectives about the way that contributions of time, money, data, and expertise were distributed among Network partners: 35% of respondents thought government/founding partners contributed more than participants, 23% thought that participants contributed more than government/founding partners, and 38% thought contributions were equal (n=25). Regardless of how participants perceived these contributions to be partitioned, 91% indicated this distribution as “acceptable” (n=23). A follow-up question, directed only at respondents who believed the current partitioning of this investment burden to be “unacceptable,” showed that half of the respondents (i.e., 4 of 8) thought governments should increase their investment and half thought non-government participants should increase their investment.

When asked to indicate their level of agreement with a set of statements about the OBBN, participants agreed most strongly that the OBBN is “credible” (89% agreed; n=38), “relevant” (97% agreed; n=39), “legitimate” (91% agreed; n=35), “inclusive” (86% agreed; n=37), and that “participants are engaged in monitoring that supports their own mandates” (92% agreed; n=39). There was approximately equal agreement and disagreement to the claim that “participants are instruments of government agencies that do not have the resources to monitor the environment themselves” (n=39). To a similar question, at least 85% of respondents indicated the following OBBN-implementation factors or issues as at least “somewhat important” to manage: data quality assurance (n=39), stability of funding (n=38), clarity of the OBBN’s role in Ontario’s water management system (n=38), recruiting new partners (n=38), membership stability (n=36), integration with other provincial (n=37) and national programs (n=38), proportional representation of different interests (n=37), manpower and money (n=36), following-up on bioassessment results that suggest impairment (n=34), and reporting on the biological condition of aquatic ecosystems (n=38).

Participants’ Satisfaction With the OBBN

Most respondents agreed with the following claims about OBBN implementation: that the OBBN has removed barriers to participation (71% agreed; n=34), that the OBBN has improved the effectiveness (86% agreed; n=35) and efficiency (85% agreed; n=34) of benthos biomonitoring, that methods have struck a reasonable balance between standardization and flexibility (78% agreed; n=37), and that the OBBN is cost effective (73% agreed; n=33). There was substantial disagreement with the claim that there is a high probability of losing control of contributed data (51% disagreed; n=37).

Most participants indicated that they were either “somewhat satisfied” or “very satisfied” with the following OBBN products: Protocol Manual (100% of respondents; n=35), training (90% of respondents; n=31), certification (85% of respondents; n=27), and applied research (100% of respondents; n=19). The database was the only product with which there was considerable dissatisfaction (60% of respondents at least “somewhat satisfied”; n=15). General satisfaction with the *procedures* used to develop OBBN products was also reported: all respondents were satisfied with those used to develop the Protocol Manual (n=31); 87% and 86% were satisfied with training (n=31) and certification program development (n=26), respectively; 86% were satisfied with database devel-

opment procedures (n=21); 81% were satisfied with analytical software development procedures (n=16); and all respondents were satisfied with the OBBN's applied research program (n=17). Most respondents (83%; n=35) indicated that they expected to "participate in, or be associated with, the OBBN" for at least 5 more years.

When asked open-ended questions about how the OBBN could be "changed to improve (the respondent's) satisfaction," participants made several recommendations: they called for greater attention to completing Network components (especially the database and analytical software), better integration with the Canadian Aquatic Biomonitoring Network, improved training, and increased funding.

OBBN Impacts on Social Capital

Our Questionnaire permitted us to investigate OBBN influences on social capital at two different scales: impacts on respondents' *personal* social networks, and impacts on the *collective* OBBN social network. Participants reported social-capital increases at both scales. With respect to *bonding* social capital, the majority reported that the strength of their connections with others had increased (59% experienced this increase in their personal social networks, n=34; 90% perceived this to have occurred in the OBBN collective, n=30). The majority perceived increased solidarity (61% in their personal social networks, n=36; and 67% among all OBBN participants, n=30) and most reported increased unity (41% personal, n=32; 77% collective, n=31). Most reported increased reciprocity (59% reported this demonstrated to themselves, n=34; 74% perceived it in the OBBN collective, n=31). Increased trust in colleagues was reported as an outcome of OBBN involvement by many participants (42% personal, n=38; 73% collective, n=30). Most respondents reported more frequent communication (63% personal, n=35; 94% collective, n=31) and the majority indicated greater use of common biomonitoring terminology (64% personal, n=36; 85% collective, n=33).

Similar increases to *bridging* social capital were reported. Eighty-four percent of respondents indicated an increase in the size of their social network (n=38) and most perceived increased cooperation (68% personal, n=37; 80% collective, n=30). The majority reported increased access to information (84% personal, n=38; 94% collective, n=31), and 91% of respondents indicated a collective OBBN-related increase in biomonitoring-related knowledge (n=32). Thirty-five percent of respondents reported that OBBN involvement had increased the influence (or impact) of their personal social network (n=34), and 81% perceived a general increase in participants' influence (or impact) that followed their joining the Network (n=31).

OBBN Impacts on Civic Environmental Action

Forty-one percent of respondents reported that their participation in civic environmental activities had increased since joining the OBBN (n=39). Solidarity, reciprocity, better access to information, more trust in (and a larger network of) peers or colleagues, and increased knowledge were reported by most as being at least "somewhat important" drivers of this increase. Furthermore, 63% reported that OBBN involvement "increased (the) *effectiveness* of (their) partici-

pation in environmental activities" (n=38); the majority considered each of the following to have been at least a "somewhat important" driver of this increased effectiveness: solidarity (90%; n=20), reciprocity (86%; n=21), better access to information (91%; n=22), more trust in (and a 'larger network of') peers or colleagues (68% [n=19] and 95% [n=22] respectively), and increased knowledge (96%; n=23). "Changed values" was the only selection from the questionnaire that was not reported as an important driver (i.e., 76% of respondents reported it as "not important"; n=17). Quantifying their involvement in un-paid community service or civic participation, 69% of respondents reported investing less than 3 hours per week (n=36).

OBBN Impacts on Biomonitoring Knowledge

Our Questionnaire provided particularly strong evidence of OBBN-related increases in participants' knowledge: 82% of respondents rated their increase in biomonitoring-related knowledge since joining the OBBN as either a 3, 4, or 5 on a five-point ordinal scale, on which 1 indicated "no increase" and 5 indicated "dramatic increase" (n=39). To complement this self-evaluation, we asked a set of questions devised to test participants' knowledge about the OBBN and benthos biomonitoring. The only significant correlations between predictor and response variables in this study were between measures of participants' Network experience and biomonitoring knowledge. Regression analysis showed a significant increase in the number of correct answers and a significant decrease in the number of "don't-know" responses with increasing degree and duration of involvement in the network (Table 3).

Table 3: Regression results (C = number of correct answers, DK = number of questions answered as *Don't Know*, ODI = ordinal degree of OBBN involvement, MI = months involved or associated with the OBBN; all listed relationships are significant at the =0.05 level)

Equation	R ²
$C = 6.82 + 1.35(\text{ODI})$	0.27
$DK = 6.52 - 1.23(\text{ODI})$	0.26
$C = 10.5 + 0.072(\text{MI})$	0.11
$DK = 3.29 - 0.0716(\text{MI})$	0.12

Discussion and Conclusions

Based on our 15% Questionnaire response rate and evidence provided by our Follow-up Survey (that Questionnaire respondents and non-respondents shared similar views about the OBBN), we consider our results to represent the perceptions held by the Ontario Benthos Biomonitoring Network population.

A variety of intended outcomes motivate people to join the Network (e.g., better assessment of ecological condition or biodiversity, improved guidance for water management, better evaluations of management activities, greater knowledge about aquatic biota, and meeting people who share an interest in aquatic

ecosystems), and the importance of these motives is independent of gender, vocation, degree of Network experience, and social status (as measured by income, education, and seniority). The OBBN does favour the participation of those with post-secondary education and moderate to high income levels. This is partly due to the targeted recruitment of conservation authority and other water-management-agency representatives; however, we speculate that the technical subject matter and relatively large time commitment associated with training and sampling are also factors.

The OBBN is a partnership: while the Ontario Ministry of Environment and Environment Canada coordinate the Network, train, certify and provide technical support to its members, participants do most of the sampling and sample processing. In addition to measuring obvious efficiency indicators (like the number of sites sampled or the number of agencies involved) and effectiveness indicators (like the proportion of waterbodies in reference condition), the effectiveness and acceptability of OBBN partnerships must also be measured if performance evaluations are to be comprehensive. This paper is one component of such a performance evaluation.

We conclude that, at least from the perspective of its partnerships, the Ontario Benthos Biomonitoring Network is performing well. Considerable evidence supports this statement: relatively rapid uptake resulted in a membership of about 250 participants in 2.5 years; all targeted sectors are represented in the Network; participants perceive the government vs. non-government-participant balance of control and investment to be acceptable; most participants believe the Network to be credible, relevant, legitimate, and inclusive; most participants are satisfied with OBBN products (e.g., protocols, training) and the procedures used to develop them⁴; most participants expect to remain involved in the Network for at least 5 more years; and most participants believe that the OBBN has improved the efficiency and effectiveness of benthos biomonitoring. Because no significant sector-related, gender-related, or other biases were observed, we consider OBBN members as a single population for which these views are representative.

Although Network coordinators may be encouraged by these results, we caution that questionnaire responses suggest that satisfactory long-term performance depends on the following conditions: network components being delivered on time and subsequently refined if shortcomings are identified; high data-quality-assurance standards; stable (or increasing) funding; links being demonstrated between bioassessment results and water management; long-term involvement of existing members, as well as additional recruitment; and integrating the OBBN with existing and new programs.

We further conclude that our three hypotheses about OBBN-catalyzed increases in social capital, civic environmental action, and capacity for environmental problem-solving are supported. Based on participants' self-assessments, there is strong evidence of Network-related increases in key elements of social capital: cooperation, reciprocity, knowledge and access to information, trust in

⁴ The key exception to this general satisfaction was the OBBN database, which at the time of the survey had not yet been released but has since been launched (Environment Canada 2006) and is currently being used by approximately 30 different organizations.

fellow participants, and the size and strength of connections in OBBN social networks. In the case of civic environmental activism, 41% of questionnaire respondents reported their participation to have increased as a result of OBBN participation, and 63% reported an OBBN-related increase in the effectiveness of their environmental activities. Although our survey provided no direct evidence of enhanced problem-solving capacity among Network participants, we argue that our third hypothesis is nonetheless supported because many of the reported gains in social capital also suggest enhanced problem-solving ability (e.g., Dobell 2000). Most notable of these attributes was participants' knowledge, which we showed to increase with increasing degree and duration of involvement in the network, and which participants highlighted as the key driver of effective civic environmental participation.

Social elements are critical to collaborative monitoring programs like the OBBN, which seek to develop a "community of practice" (e.g., Bouwen and Tailieu 2004) or "learning community" (e.g., Falk and Harrison 1999). Because such programs are rooted in the natural sciences and are typically founded by organizations with environmental mandates, questions about the social elements of delivery are not typically considered high priorities for research. Nevertheless, studies like this one are equally as important to environmental programs as natural-science studies are. Program managers should undertake them more frequently because they help us to understand the motives of participation, they uncover the relevant "currencies" in which members are "paid" for their participation (e.g., Jones *et al.* 2002), they highlight priorities for managing network stability, and they provide a more holistic measure of performance than is otherwise possible.

Science and social capital interact synergistically in the delivery of a collaborative monitoring network like the OBBN. Science is critical to developing and evaluating sampling and analytical methods, but social capital also plays an important role in achieving all of the Network's intended outcomes. Furthermore, social capital has broader relevance because it will influence the outcome of the "enduring conflict" (Schnaiberg and Gould 2000) between environment and society. Used in the right way, social capital provides us with capacity to overcome societies' interrelated social, environmental, and economic barriers to sustainability (e.g., Wackernagel and Rees 1997, Rees 2002, Jacobs 2004, Diamond 2005).

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