Modelling as an Instrument of Change

Presented at *Pacem in Maribus XXVI*, Halifax, November 30, 1998

by

Robert Hoffman

Effective public policy requires an informed public, particularly when public and private interests diverge. This is clearly the case in problems of 'management of the commons' of which fisheries management is a prime example. Creating an informed public requires methods for synthesizing knowledge from pertinent scientific disciplines and experience and communicating that understanding to all stakeholders to the policy process. Failure to create an informed public results in problem denial or policy that serves the short term interests of the most politically powerful, often at the expense of the long term public good. Experience with a Global Systems Simulator being developed by ROBBERT Associates and the Canadian Association for the Club of Rome demonstrates the power of this unique simulation approach in enhancing understanding of complex issues as the basis for effective policy development and exposing the real trade-offs among interests

Need for an Informed Public

The international oceans are effectively a global commons. They are an integral and important, indeed the most important, component of the global systems that sustain humankind and life itself.

The problem of the 'management of the commons' is well known. Unfettered use of the commons to serve individual interests may result in overuse and potentially the destruction of the commons. The prerequisite for effective public policy to manage the commons is an informed public: one that understands the full and longer-term consequences of the policies adopted by the agencies with responsibility for governance. In the absence of an informed public, public policy is dominated by short-term interests and is reduced to mediation among those interests. Management of the global commons requires a long-term perspective.

Public policy implies making choices from among possible futures. It is not to be confused with the creation of 'visions' of the future. Vision statements, as popularly understood, are merely concatenations of individuals' wish lists not bounded by the possible. Making choices implies understanding the trade-offs among various goals and making decisions in full understanding of those trade-offs. For example, it is too easy to embrace the objectives of 'full employment for all fishers' and 'increased use of modern technology' without understanding that these objectives may be contradictory and that one might be achieved at the cost of not achieving the other.

Canadian playwright John Gray has observed that "Canadian leadership over the last decade has consisted of leading the bow to the inevitable. The leaders are not leaders. And when because of this, they begin to feel desperate, they engage in symbolic acts – as though they were leading". Gray's words may be rather harsh, but they do remind us that the public cynicism about those whom we trust to govern represents a call for leadership. But do those who govern have the support of those they lead? And herein lies the problem. Without a well-informed public who recognize the problems that need to be addressed and the trade-offs among interests, the only option available to leaders is to create such an informed public.

The Gap between Science and Public Policy

Increasingly, those delegated with responsibility for decision making are confronted with a large body of scientific knowledge bearing upon the issue at hand. Often the knowledge originates in more than one discipline; sometimes it is contradictory; usually it is incomplete and/or subject to caveats. Just as often as not, the decision making process is incapable of assimilating all this information and this results in decisions which are based on the authority of 'experts' or on criteria which reflect the relative power of the various stakeholders. Interest groups use the techniques of persuasion to further their advocacy; and while persuasion may trigger action, it seldom conveys understanding, since it relies on rhetorical technique and selective arguments. Argument, according to Northrop Frye, relies on the arrangement of data. Arrangement means selecting for emphasis, and selecting for emphasis can never be definitively right or wrong [Frye, 1990].

One of the reasons for the gap between science and public policy may be that the culture and methods of science are incompatible with the imperatives of public policy analysis and decision making.

Decision-making implies choice: the future is not predetermined, but can be influenced by what we decide to do; there are alternatives from among which we must choose and the choice to do nothing is a wilful one. For science, the concept of choice has been problematic.

Two quotations from a remarkable new book by Nobel Laureate Ilya Prigogine entitled *The End of Certainty: Time, Chaos and the New Laws of Nature* illustrate why this is so: "*... ... we owe to the ancient Greeks two ideals that have since shaped human history. The first is the intelligibility of nature, or in Whitehead's words, "the attempt to frame a coherent, logical, necessary system of general ideas in terms of which every element of our experience can be interpreted." The second is the idea of democracy based on the assumption of human freedom, creativity and responsibility. As long as science led to the description of nature as an automation, these two ideals were contradictory.*

" This (contradiction) requires a new formulation of the laws of nature that is no longer based on certitudes, but rather possibilities. In accepting that the future is not determined, we come to the end of certainty" In science, the emphasis is on analysis - reduction to the point where controlled experimentation is possible, whereas in policy analysis the emphasis is on synthesis. Policy analysis must bring together all the knowledge bearing on the problem domain, and decisions must often be taken before understanding is complete. In the face of uncertainty, risks must be (subjectively) evaluated.

The Global Systems Simulator accounts for the stocks and flows of natural resources, land, materials, energy, finished goods, and wastes over a 100 year time horizon. It represents the physical substrate of the global socio-economy in terms of both human-designed and naturally-occurring processes that transform flows of material and energy.

In science, communication of understanding is focused on communication within a specialized peer group and the language of communication within the group is not readily accessible outside the group. Decision processes almost always involve communication of understanding to a much broader community of stakeholders – often the 'public' at large.

The need for robust methods for the synthesis and communication of understanding of complex systems is critical. How then might 'a science of whole' be further developed?

Systems Simulators

Simulators are descriptions of complex systems representing the interrelationships among the processes that constitute the system; they combine observations of past states of the system with the scientific understanding of processes. As such, simulators are explicit and communicable representations of the mental models that guide our perceptions and actions. Unlike verbal or mathematical descriptions of systems, simulators are active and can be experienced. Learning how the system works arises from the experience of using the simulator. The user will come to appreciate the complex system-as-a-whole behaviour as it emerges out of dynamic interactions among relatively well-understood processes.

Unlike the deterministic models of classical science, the simulator approach is open to adaptation or learning. The simulators are designed in such a way that the system of feedback loops necessary to assure consistency among the constituent processes of the system is incomplete: those feedbacks embodying the behavioural responses that are subject to adaptation are excluded from the simulator because they are not knowable.

Consequently, the possibility of inconsistency or disequilibrium arises. Disequilibrium is indicated by tensions that must be resolved by the user of the simulator. In this way the user becomes an integral part of the system as the source of novelty for adaptation, not an observer of a closed system. These concepts have their origins in modern science. The work of Ilya Prigogine shows the indeterminacy of systems far from equilibrium and the possibilities of adaptation through the emergence of higher levels of order [Prigogine 1984]. Indeterminacy is a property of evolutionary systems. Erwin Laszlo states the evolutionary principle in the following terms: *The evolutionary paradigm challenges concepts of equilibrium and determinacy in scientific theories; and it modifies the classical deterministic conception of scientific laws. The laws conceptualized in the evolutionary context are not deterministic and prescriptive: they do not uniquely determine the course of evolution. Rather, they state ensembles of possibilities within which evolutionary processes can unfold.* [Laszlo, 1987]Thus, simulators are primarily learning devices that extend our powers of perception; they cannot predict what will happen nor can they prescribe what should happen. Just as flight simulators support learning how the aircraft responds to the controls, global systems simulators may be used for exploring the responsiveness global systems to potential societal actions involving, for example, population growth, life-style and technology.

The Global Systems Simulator

The Global Systems Simulator developed by Robert Hoffman and Bert McInnis as part of their ongoing collaboration with the Canadian Association for the Club of Rome, serves to illustrate how a systems model can be implemented. The GSS is designed to explore the relationships among human population, lifestyle, technology and the natural resource base at a global scale. It is particularly well suited for exploring the concepts of 'sustainable development' and the 'carrying capacity' of the earth.

The Global Systems Simulator (Figure 1) accounts for the stocks and flows of natural resources, land, materials, energy, finished goods, and wastes over a 100 year time horizon. It represents the physical substrate of the global socio-economy in terms of both human-designed and naturally-occurring processes that transform flows of material and energy. The eighteen processes represented as sub-models in the simulator were chosen as the minimum number required to explore the concept of sustainability, The Global Systems Simulator contains 253 multi-dimensioned variables. For example, 'population' is a single variable that has the dimensions sex, time, and age – two sexes, time from 1995 to 2100 in steps of one year, and age from 0 to 100 in one year age categories; it contains 21,412 data elements. It has been calibrated for the period 1950 to 1994 using data sets compiled by the United Nations and the Worldwatch Institute. As a result, there is historical data for all of the variables in the simulator. Future scenarios can only be developed in the context of history.

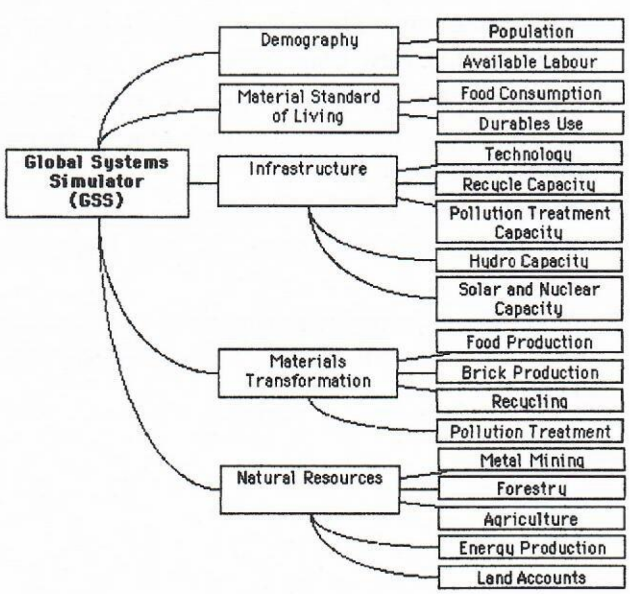

Figure 1. The Global Systems Simulator (GSS)

Figure 2 shows the interaction between the User/Society and the Global Systems Simulator. The User/Society sets the control variables over the 100-year time horizon and asks to see the resulting scenario. Tension reports are produced that indicate whether the scenario is internally coherent or feasible and the time at which inconsistencies occur.

Should the scenario be inconsistent, the user experiments with the settings of the control variables until consistent settings are found. There may be a large number of feasible solutions – the simulator does not indicate or seek best solutions. Which solution is to be preferred and acted upon is subjective and hence a political choice.

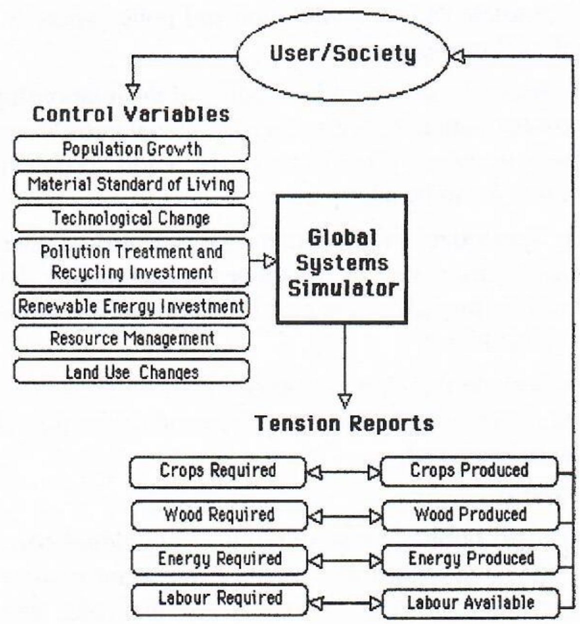

Figure 2. Interaction between the User Society and the GSS

To illustrate, one of the scenarios that lies well outside of the feasible region is one based on continuation of the following trends:

- The doubling of human populations to 10 to 12 billion before levelling off or declining. These populations result if fertility rates continue to decrease until replacement fertility rates are reached by the middle of the 21st century
- Modest increases in the material standard of living
- Continued deployment technology that minimizes private costs – i.e. one that persists in substituting energy and material for labour.

Even in the highly simplified representation of global systems of the GSS, it became clear that finding feasible solutions was difficult. There did not appear to be a single intervention, such as population control, or even a small number of interventions that could effect a reasonable result. It may be concluded that any resolution strategy will involve carefully co-ordinated combinations of actions. To users, it underlines the danger of prescribing single actions, whether it is population control, renewable energy, or pollution control and the need to seek understanding of the system as a whole. The Global Systems Simulator has been used in a number of workshops and seminars and it is being tested for use in high school courses on global issues. On the basis of this experience, the Canadian Association for the Club of Rome is proceeding to establish The Global Systems Centre to facilitate further development of the simulator and to promote its use in education and policy analysis. It has the following mandate:

- To foster the shared understanding of the relationship between human activities and the global ecosystems that is necessary if the issues of the world "problematique" are to be addressed.
- To synthesize and communicate scientific understanding from various disciplines in such a way that it can be brought to bear on the issues of the world problematique.
- To provide the global context within which actions and decisions to be taken at a local and national level can be evaluated.

Conclusions

An informed public is a prerequisite if the global commons, of which oceans are the most important component, are to be managed in such a way that long term sustainability prevails over short term interests. New institutions and new methods are required for the synthesis of the scientific knowledge pertaining to the management of the global commons and for the communication of that understanding to create an informed public.

Simulators, as described herein, are potentially powerful tools for synthesis and communication.

References

1. Capra, Fritjof. *The Web of Life: A New Scientific Understanding of Living Systems*. Anchor Books, NewYork, 1996.
2. Cohen, Joel E. *How Many People Can the Earth Support?* W. W. Norton & Company, New York, 1995.
3. Forrester, Jay. *World Dynamics*. Wright-Allen Press, 1971.
4. Frye, Northrop. *Words with Power: Being a Second Study of "the Bible and Literature"*. Harcourt Brace Janovitch, Publishers, New York, 1990.
5. Gault, F. D., K. E. Hamilton, R. B. Hoffman, and B. C. McInnis, "The Design Approach to Socio-Economic Modelling", *Futures*, February, 1987.
6. Hoffman, Robert. *Concepts for a New Generation of Global Modelling Tools: Expanding our Capacity for Perception*. Report of the CACOR Global Modelling Project Team. September, 1993.
7. Hoffman, Robert and Bert Mcinnis. *An Overview of the Global Systems Simulator*. ROBBERT Associates Ltd. September, 1997.
8. Kelly, Kevin. *Out of Control: The New Biology of Machines, Social Systems, and the Economic World*. Addison-Wesley Publishing Co., 1994.
9. Laszlo, Ervin. Evolution, The Grand Synthesis. Shambhala Publications Inc., Boston, 1987
10. Meadows, Donella H., Dennis L. Meadows, J. Randers, and W. W. Behrens. *The Limits to Growth*. Universe Books, New York, 1972.
11. Meadows, Donella, Dennis L. Meadows, Jorgen Randers. *Beyond the Limits*. McClelland and Stewart, 1992.
12. Mesarovic, Mihajlo and Eduard Pestel. *Mankind at the Turning Point: The Second Report to the Club of Rome*. Dutton, New York, 1974
13. Prigogine, Ilya and Isabelle Stengers. *Order Out of Chaos: Man's New Dialogue with Nature*. Bantam Books, Toronto, 1984
14. Prigogine, Ilya. *The End of Certainty: Time, Chaos, and the New Laws of Nature*. The Free Press, New York, 1997.
15. World Commission on Environment and Development. *Our Common Future*. United Nations, New York, 1987