Simulation of Socio-ecological Impacts: Modeling a Fishing Village

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ABSTRACT / The interrelationship of society and environment is addressed here through the study of a remote fishing village of 750 people. An interdisciplinary study evaluated demographic, economic, and social aspects of the community, and simulation modeling was used to integrate these societal characteristics with environmental factors.

The population of the village had grown gradually until the 1960's, when a decline began. Out-migration correlated with declining fish harvests and with increased communications with urban centers. Fishing had provided the greatest economic opportunity, followed by logging. A survey was conducted to investigate the costs and revenues of village fishermen. Diversification characterized the local fleet, and analysis showed that rates of return on investment in the current year were equal between vessel types.

The variable levels and rate parameters of the demographic, economic, and social components of the model were specified through static and time series data. Sensitivity analysis to assess the effects of uncertainty, and validation tests against known historical changes were also conducted. Forecast scenarios identified the development options under several levels of fish abundance and investment. The weight given to ecological versus economic resource management registered disproportionate effects due to the interaction between investment and migration rates and resource stochasticity. This finding argues against a "golden mean" rule for evaluating policy trade-offs and argues for the importance of using a dynamic, socio-ecological perspective in designing development policies for rural communities.

The Theoretical Question

How is society related to environment? This question was the focus for study of a remote fishing village located on the northern tip of Vancouver Island, off the west coast of Canada (Figure 1). The village, Sointula, shown in an overview in Figure 2, was selected because it was small enough (population 750 in 1977) to be comprehensively surveyed in one summer and because it was relatively resource-dependent, making it well suited to an analysis integrating socioeconomics and environment. The method of integration was construction of a simulation model to examine and forecast community development trends.

The origin and survival of small, resource-based communities depends on the ecology and its management. Because local planning and administration are frequently not coordinated, the relationship between environmental change and social impact is often ignored. The interdisciplinary model constructed for this study was used first to highlight typologies of community growth and to classify possible outcomes of development. Secondly, various options for resource and economic management programs were analyzed and assessed. The resilience of the model to change was observed, and the significance of local survival issues in regional, integrated rural planning was addressed.

KEY WORDS: Simulation; Resource management; Fishing communities; Rural development; Interdisciplinary models; Socio-ecology
Figure 1. Location map of Sointula off Vancouver Island.

Figure 2. Sointula wharf, July, 1977. Vessels ranging from five-man seiners to gillnetters operated by a single man, made up the fleet. Both fisheries and economic programs were assessed in modeling community change.

by a fixed multiplier. Migration factors are specified separately, with the basic concept of the migration function being that it is the outcome of decision-making based on individual maximizing criteria. The main opportunities are from employment and income levels in local fishing. A non-economic component enters as a value attached to continued residence in the same locale.

The model's structure can be represented in terms of several mathematical relations. Migration rate is a function of income levels and of the level of residential stability (Equation 1):

\[
EM = UI \times (c/AVFI)^k \times d/\log (RES)
\]

\[
IM = I \times (AVFI^k)/c
\]

\[
M = EM + IM
\]

where EM is the emigration rate (persons/year), IM is the immigration rate, M is the net migration rate, UI is the unemployment rate, AVFI is the average fishing income ($), RES is the residential stability (average number of years of residence), E is the employment rate (%), and c, d, k are constants.

Income statistics for the three gear types—gillnet, troller, and seine—were averaged. The relation between migration changes and income was estimated from time series data. A diminishing logarithmic function was used for the factor of residential stability, suggested by comparisons with neighboring towns.

The fish yields were set at current levels plus the expected variance between years (Equation 2):

\[
FISH = A \times (1 + N^*0.15) + T
\]

where A is the average abundance, N is the random number between -1 and +1, T are the trends in fish levels resulting from management decisions, and .15 is the average variance in fish yields.

In the most common fish management model, the Ricker curve (Ricker 1958, Gordon 1954, Clark 1976),