FWS/OBS-80/34
July 1980

STRATEGY FOR ASSESSING IMPACTS OF POWER PLANTS ON FISH AND SHELLFISH POPULATIONS

by

Eugene S. Fritz

and

Paul J. Rago

National Power Plant Team
U.S. Fish and Wildlife Service
2929 Plymouth Road, Room 206
Ann Arbor, Michigan 48105

and

Ishwar P. Murarka[1]

Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Power Plant Project
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

[1]Present Address: Electric Power Research Institute
Palo Alto, California 94304

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

are, however, constrained by the simplified mathematical functions employed and the lack of potentially complex and hierarchical relationships. Consequently, the range of system responses is highly constrained by the forms of the modeling language. Thus, these procedures can serve only as first cut approximations of model behavior.

Quantitative simulation models such as those described by Electric Power Research Institute (1979) represent the most rigorous type of conceptual models. Even in these latter models many levels of resolution are possible, but complex data and parameter requirements for detailed simulation often restrict their use in an assessment. A generalized simulation can be effective in examining broad ranges of possibilities which require fewer constraints on the functional form of relationships, the magnitude of state variables, or the time sequence of events.

Whichever technique(s) are used, the interdisciplinary group should be aware of the advantages and disadvantages of qualitative and quantitative analyses. The group should ensure that the conclusions derived from a conceptual model are not artifacts of the analyses technique.

Identification of Potential Impacts

Assembling extant information, along with developing and exercising the conceptual model in light of the sources of impact, will permit the identification of system components most susceptable to the impact of power plant design, construction, and operation. The interdisciplinary group should, in its first approximation of potential impacts, be very broad in scope. Utilization of a "brainstorming" process will help prevent the exclusion of possible impacts. Later, when hypotheses are defined and constraints become evident, effort can be focused on the most important impacts to the system.

Typically, impacts are identified by changes in population density, direct mortality, and loss or exclusion from habitat. Many impacts, however, are manifested in less obvious ways. For example, most investigators usually address direct mortality from plant passage when considering the impacts associated with entrainment. Few investigators ever estimate sublethal effects such as increased predation, or changes in fecundity, egg and larvae viability, or behavior. Other examples are discussed by Goodyear et al. (1974) and Shubel and Marcy (1978).

Steps in Potential Impact Identification. Impact identification involves three steps:

- Identify species and life stages affected with respect to each source of impact.

- Predict the magnitude of the impact.

- Rank predicted adverse effects.

Identification of species and life stages affected. Available information should be assembled on the life history of important species found or suspected present at the plant site. This information is used in identifying species to be studied. The decision tree provided in Figure 4 is useful in this identification process and also helps determine primary impacts, such as periods of entrainment and impingement vulnerability, and indirect effects such as depletion of food resources.

Two aspects of life history that are essential in determining impact are the timing and extent of reproduction in the area of the proposed plant, and the temporal and spatial distribution of all life stages--including movement routes to feeding and nursing areas and factors influencing movements. Other types of life history information important in impact identification are feeding habits, thermal requirements, and distribution of generation times. A frequency distribution of generation times of major system components may indicate time lags between the perturbation and the system's response (Figure 8). Changes in adult fish stock, for example, will occur more rapidly and be more discernible among short-lived species than among long-lived species.

Determine the magnitude of impact. Key elements to be considered in determining the magnitude of the impact are: (1) the acute and chronic effects, (2) the trophic level(s) affected, and (3) the reversibility of the impact. In evaluating entrainment, for example, consideration should be given not only to the acute effect, i.e., the immediate loss of fish, but also to the chronic effects, such as the reduced viability of organisms that survived plant passage. Because of lower population densities, losses to high trophic level organisms will generally be more serious than losses to organisms at lower trophic levels. The reversibility or mitigation of an impact is also of importance. Loss of habitat is usually irreversible whereas population stresses through impingement losses are not. Losses of sessile organisms may be temporary if recolonizing sources are located nearby.

In determining the magnitude of impacts one should realize that effects of environmental impacts do not necessarily diminish with distance from their source (Holling 1978). Entrainment and impingement losses may affect ecosystems many miles from the power plant, particularly when species are migratory. Similarly, time lags in response may mask severe impacts.

Rank seriousness of impacts. Potential ecological problems should be ranked according to the amount of change anticipated as a result of an expected impact. Ranks are assigned because time, manpower, and financial resources are always limiting. The ranking process, however, is conducted independently of constraints. The following question should be considered in selecting those impacts to be investigated. "Given unlimited time, money, and manpower, which impacts are most important to investigate?" One rule that must be followed is - high ranking impacts should be given highest priority.

Hypothetical Fish Species	Approximate Mean Generation Time (Years)
A	2
B	1
C	3
D	7
E	5
F	4
G	3
H	2
I	3
J	2
K	4

Generation Time (Years)	Frequency # of Species
1	1
2	3
3	3
4	2
5	1
6	0
7	1

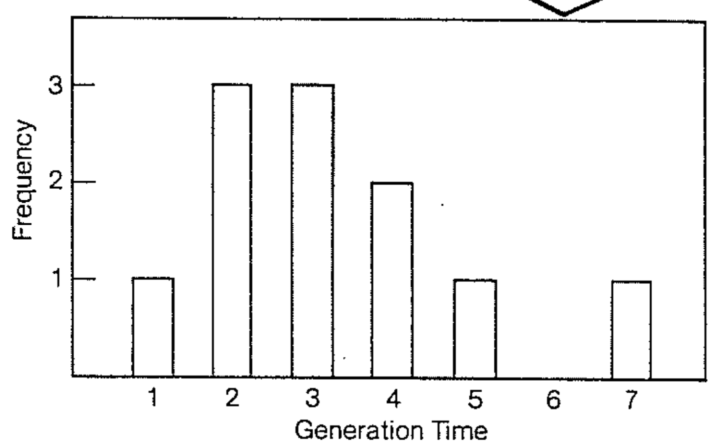

Figure 8. Example of a frequency distribution of generation times for a hypothetical community consisting of 11 fish species. The graph indicates that population changes in most species would be evident within 4 years. Changes in species B (with a generation time of 1 yr) would occur most rapidly while significant changes in species D (generation time of 7 yrs) would occur much more slowly. At an ecosystem level, one could expect changes in most system components within 3 yrs of start of power plant impact.