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AUG 29 1979

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Saul Levine, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER # 58 - COMPARISON OF SIMULATION MODELS USED IN ASSESSING THE EFFECTS OF POWER PLANT INDUCED MORTALITY ON FISH POPULATIONS

Introduction and Summary

This memorandum transmits the results of completed research on comparison of simulation models used in assessing the effects of power-plant-induced mortality on fish populations[1]. This work was performed by the Center for Quantitative Science at the University of Washington's College of Fisheries under the direction of the Environmental Effects Branch of RES.

Research Request NRR 78-7, "Evaluation of Ecosystem Simulation Models as Tools for Confirmatory Assessment of Power Plant Impacts," stated that the NRR staff lacks quantitative methodologies for predicting and assessing potential impacts on fisheries resources which may result from power plant effects. It also stated that theoretical models and computer simulations provide a possible approach to resolving these inadequacies. This report provides information on the currently available models and simulations, documents their underlying assumptions, specifies data input and parameter estimation requirements and discusses their theoretical limitations and verification procedures.

Methodology

The approach used to review the models for predicting the impact of power plant operation on economically important fish species involved several steps. The model equations and underlying assumptions were compared. Parameter values were compared and the data sources used in obtaining them were investigated. Since many of the models had differing assumptions, parameter values or both, general simulators were developed to evaluate the relative predictive ability of the various models.

[1]NUREG/CR-0474, "Comparison of Simulation Models Used in Assessing the Effects of Power-Plant-Induced Mortality on Fish Populations"

The eight models reviewed were partitioned into two submodels: A young-of-the-year model which simulates the annual effect of plant entrainment and impingement on recruitment of young-of-the-year into the adult population, and a life-cycle model, which simulates the subsequent, long-term effect of reduced recruitment on the adult population. The interactive life-cycle model simulator developed to compare the available models is diagramed in Figure 1. This model can accept density-dependent assumptions for both young-of-the-year and fishing survival. It allows parameters to be varied easily from run to run and allows plant operation to go on or off at any time.

Results

Table 1 summarizes the predictions of percentage reduction young-of-the-year of the various models and Table 2 summarizes the predictions of impact on adult fish populations of the various life-cycle models. As shown in Table 1, the percentage reduction values for the ORNL 1-D and LMS models differ greatly for similar cases. These models are complex and are the only models reviewed that consider migration explicitly. Therefore a large proportion of the text is devoted to an analysis of them. Because the predictions given in Table 2 are not directly comparable, the authors developed their own life-cycle model simulator. Sensitivity studies and results are given for sex ratio, compensatory mortality, life-cycle parameters, and entrainment factors.

Conclusions and Recommendations

Major differences between the models include the life stage lengths, density-dependent or density-independent young-of-the-year mortality, density-dependent or density-independent fishing mortality, and the method for computing recruitment of young-of-the-year fish into the adult population. Major differences in parameter values include entrainment factors, total egg production, equilibrium population size, and survival probabilities for the life-cycle models.

No presently existing impact model can be used to make quantitative predictions due to the large year-to-year variability in young-of-the-year densities and spatial distribution and the sensitivity of results to uncertainties in the parameters used in the density-dependent mortality function.

We recommend that additional research be carried out to develop a better model for predicting the impact of power plant operation on fisheries. In the meantime NUREG/CR-0474 can be used to evaluate the limitations of presently available models.

If you have any questions with regard to this report, please contact Mr. Frank Swanberg, Jr., Chief, Environmental Effects Branch (427-4358).

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Enclosure: NUREG/CR-0474

1074 149

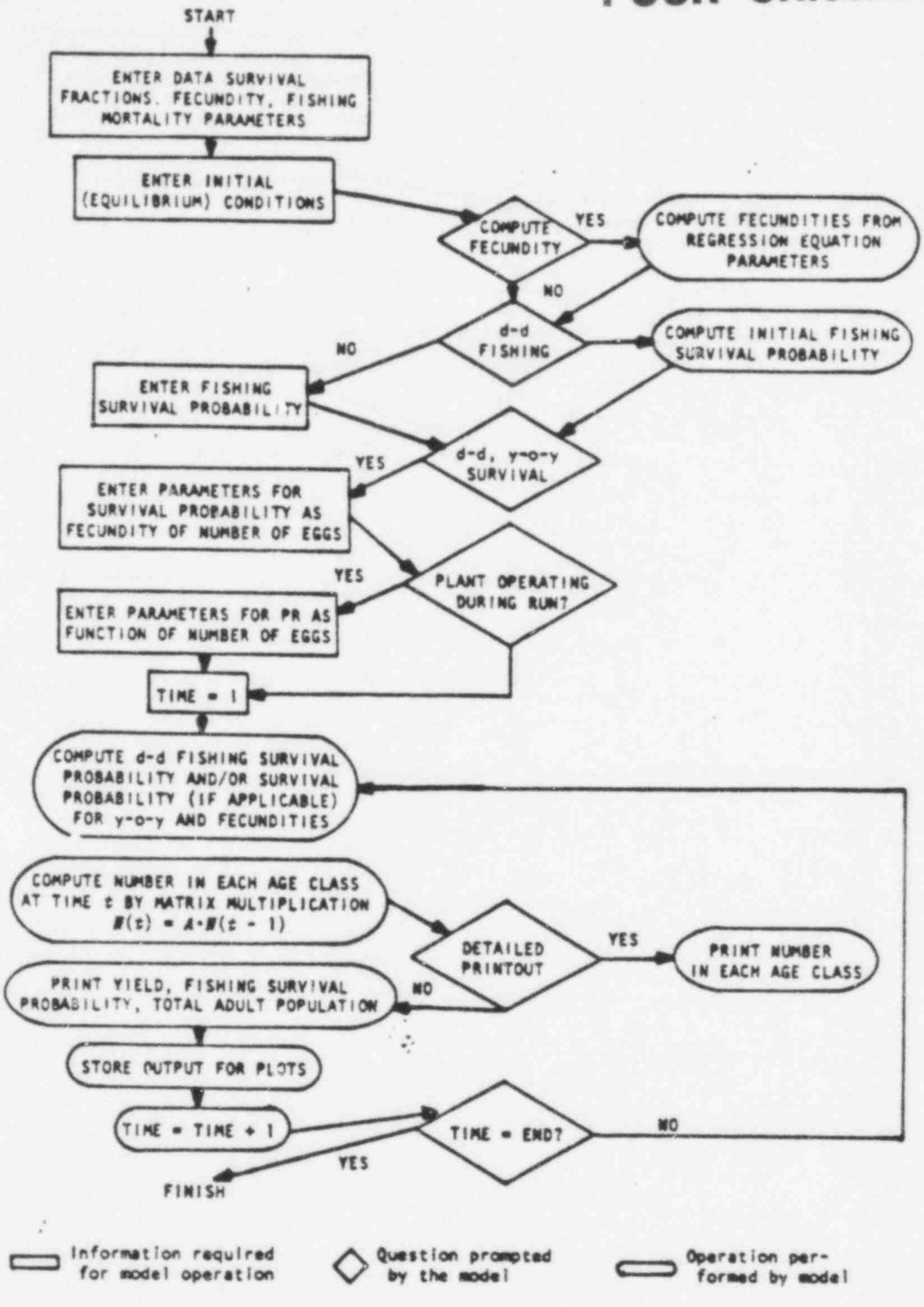

Figure 1. Flow chart for life cycle model simulator.

Table 1. Comparison of predictions of percentage reduction (PR) for various models.

Model	Compensation	Entrainment factors	PR	Plants operating
LMS 1-D 1967	High	Best estimate	2.5	Indian Point Units 1 & 2
	High	Maximum	4.0	
LMS 1-D 1973	High	Best estimate	2.77	Indian Point Units 1, 2, & 3 and Cornwall
	Low	Best estimate	4.88	
LMS 2-D	High	Best estimate	1.257	Indian Point Units 1, 2, & 3
	Low	Best estimate	3.138	
	Low	Minimum	2.44	
ORNL 1-D	None	Minimum	18.0	Bowline Unit 2, Indian Point Units 1, 2, & 3, Roseton Units 1 & 2
	None	Best estimate	34.0	
	None	Maximum	42.0	
ORNL Summit			4.5	Summit
JHU			1.0-5.0	Summit
Delmarva			0.71-5.53	Summit

1074 151

Table 2. Comparison of life cycle model impact predictions.

Model	PR	y-o-y compensation	PR in total adults			PR in 1-year-old fish		
			Number of years			Number of years		
			5	10		5	10	
LMS 1-D(67)	2.07	High	2.52	3.93		2.71	4.01	
	3.42	Low	4.93	9.74		5.68	7.49	
	3.13	None	4.82	11.39		5.55	12.00	
			Number of years			Number of years		
			7	10	40	7	10	40
LMS 2-D	1.21	High	1.29	1.64	2.18	1.33	1.68	2.18
	1.26	High	1.34	1.70	2.26	1.38	1.75	2.26
	2.44	Low	2.64	3.70	6.82	2.81	3.91	6.99
	3.14	Low	3.46	4.86	8.95	3.61	5.03	8.99
	4.47	Low	4.93	6.88	12.42	5.13	7.11	12.46

Model	PR	y-o-y compensation	Relative yield				PR in 1-year-old fish			
			Number of years				Number of years			
			5	10	20	40	5	10	20	40
ORNL	10	None	0.96	0.90	0.85	0.83	10	14	17	18
	25	None	0.88	0.75	0.64	0.60	25	33	38	42
	50	None	0.78	0.52	0.35	0.26	50	62	70	75

Table 2. Comparison of life cycle model impact predictions - (Continued).

Model	PR	y-o-y compensation	PR in annual yield
ORNL Summit	0.5	None	0.03
	2.75	None	0.77
	5.0	None	3.7
JHU	2.5	None	0.45
	5.0	None	1.7
Model	**PR**	**y-o-y compensation**	**PR in total adults**
			35 years
Winter Flounder	1.0	Best estimate	6.0
	1.0	None	9.0