History and Current Situation of River Management using Physical Habitat Models in the U.S. and Japan

Masahiko Sekine*

(Department of Science and Engineering, Yamaguchi University, 2-16-1 Tokiwadai, Ube, Yamaguchi 755-8611, Japan)

History of Instream Flow Incremental Methodology (IFIM)

Following the large reservoir and water development era of the mid-twentieth century in North America, resource agencies became concerned over the loss of many miles of riverine fish and wildlife resources in the arid western United States. Consequently, several western states began issuing rules for protecting existing stream resources from future depletions caused by accelerated water development. Many assessment methods appeared during the 1960's and early 1970's. These techniques were based on hydrologic analysis of the water supply and hydraulic considerations of critical stream channel segments, coupled with empirical observations of habitat quality and an understanding of riverine fish ecology.

Following enactment of the National Environmental Policy Act (NEPA) of 1970, attention was shifted from minimum flows to the evaluation of alternative designs and operations of federally funded water projects. Methods capable of quantifying the effect of incremental changes in stream flow to evaluate a series of possible alternative development schemes were needed. This need led to the development of habitat versus discharge functions developed from life stage-specific relations for selected species, that is, fish passage, spawning, and rearing habitat versus flow for trout or salmon.

During the late 1970's and early 1980's, an era of small hydropower development began. Hundreds of proposed hydropower sites in the Pacific Northwest and New England regions of the United States came under intensive examination by state and federal fishery management interests. During this transition period from evaluating large federal reservoirs to evaluating license applications for small hydropower, the Instream Flow Incremental Methodology (IFIM) was developed under the guidance of the U.S. Fish and Wildlife Service (USFWS).

Key words: river management, physical habitat model, IFIM, PHABSIM

* Corresponding author: Tel: +81-836-85-9311, Fax: +81-836-85-9301, E-mail: ms@yamaguchi-u.ac.jp

Ⓒ The Korean Society of Limnology. All rights reserved.
This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/3.0/), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.
Fig. 1 shows the components and model linkages of IFIM, and Fig. 2 shows activities and information flow involved in an IFIM study. This methodology attempted to integrate the planning concepts of water supply, analytical models from hydraulic and water quality engineering, and empirically derived habitat versus flow functions. This methodology produced simulations of the quantity and quality of 'potential habitat' resulting from proposed water development, illustrated through a series of alternative flow regimes. In the original IFIM, four interrelated activities or phases are required to complete the process.

**Phase 1: Problem identification and diagnosis**

This phase consists of two principal components: (1) a legal and institutional analysis to define the problem setting and the probable context of its resolution, and (2) an issues analysis that identifies concerns of the various stakeholders of a problem and the information that will be needed to resolve the problem.

There is a big difference in the US between a decision to license a hydropower project under the rules of the Federal Energy Regulatory Commission (FERC) and a decision to establish a minimum flow level in a state park. Because it is important to use the appropriate methodology in each of these different cases, the developers of the IFIM recommended that an “institutional analysis” be conducted at the beginning of each instream flow study. Software called Legal-Institutional Analysis Model (LIAM) has developed to support this process.

**Phase 2: Study planning**

This phase involves a comparison of information needs with information already available. The difference between needed and available information is the basis for the study plan. During the formulation of a study plan, an interdisciplinary team must agree on study objectives and deadlines, appropriate models and data requirements, levels of temporal and spatial detail, roles and responsibilities, products and milestones, and project budgets. Study planning should also develop a common understanding of the analytical approach that will be used for evaluating alternatives.

**Phase 3: Study implementation**

This phase involves data collection, model calibration, and verification of model input and output. Quality assurance is necessary every step in study implementation to ensure that the information produced by IFIM’s component models, such as Stream Network Temperature model (SNTEMP) and Physical Habitat Simulation Model (PHABSIM), is as accurate and realistic as possible. Macro habitat analysis using SNTEMP and/or other water quality models limits the range of a river where target species can inhabit, and micro habitat analysis using PHABSIM and/or other habitat models evaluate the segregation of target species in the inhabitable range of the river. Without trustworthy data it is difficult to accurately compare alternatives that might be proposed during the next phase.

**Phase 4: Alternatives analysis/problem resolution**

During this phase, an agreed-on set of baseline hydrologic conditions provides the essential point of reference. All parties to the decision process may then have their preferred alternatives compared with the baseline conditions. The group can collectively examine all alternatives for their effectiveness, physical feasibility, risk of failure, and economic considerations. Problem resolution is accomplished through negotiation and compromise, based on the evaluation of competing alternatives. Interdisciplinary teams composed of various stakeholder groups can derive solutions through iterative problem-solving to achieve some balance among multiple and often conflicting uses of water.

**SUCCESS AND MISUSE OF IFIM AND PHABSIM IN THE U.S.**

NEPA guidelines for examining alternatives and hydropower relicensing forced United States decision makers to balance potential conflicts among users of the riverine resources. Incremental methods became the tools of choice for quantitatively describing the consequences of alternative ways...