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A synthesis of environmental and recreational mitigation requirements at hydropower projects in the United States

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ABSTRACT

Environmental mitigation plays an important role in the environmentally sustainable development of hydropower resources. However, comprehensive data on mitigation required by the Federal Energy Regulatory Commission (FERC) at United States (US) hydropower projects is lacking. Therefore, our objective was to create a comprehensive database of mitigation required at non-federal hydropower projects and provide a synthesis of available mitigation data. Mitigation data was collated for over 300 plants licensed or relicensed from 1998 through 2013. We observed that the majority of FERC mitigation requirements deal with either hydrologic flows or recreation and that hydropower plants in the Pacific Northwest had the highest number of requirements. Our data indicate opportunities exist to further explore hydropower mitigation in the areas of environmental flows, fish passage, and water quality. Connecting these data with ecological outcomes, actual flow data, and larger landscape level information will be necessary to evaluate the effectiveness of mitigation and ultimately inform regulators, managers, and planners.

1. Introduction

The environmental impacts of hydropower, including alteration of flow and sediment regimes, riparian habitat, biodiversity, and water quality (Poff et al., 2007, 1997), disruption of fish migration (Liermann et al., 2012), and fragmentation of habitat (Nilsson et al., 2005), are well established. In the United States (US), the federal regulation of these environmental impacts is a relatively recent development, despite the establishment of federal licensing and oversight of hydropower facilities occurring in 1920 (Richardson, 2000). The authority to determine and issue 30–50 year licenses for the operation of non-federal hydropower facilities currently falls under the US Federal Energy Regulatory Commission (FERC). Not until the passage of environmental legislation, such as the National Environmental Policy Act in 1970 (NEPA), the Clean Water Act in 1972 (CWA), and the Endangered Species Act in 1973 (ESA), was FERC required to incorporate environmental protections into project licensing decisions (Kosnik, 2010).

In particular, the passage of the Electric Consumers Protection Act of 1986 (ECPA) substantially changed FERC's consideration of environmental impacts with the requirement that FERC give equal consideration to the protection and enhancement of, and mitigation of damage to, wildlife, environmental quality, and recreational opportunity. Furthermore, a string of court rulings eroded FERC's singular authority to determine environmental mitigation by requiring FERC to include fishway prescriptions from the National Marine Fisheries Service or US Fish and Wildlife Service, as well as minimum streamflow requirements included as part of state water quality certificates (Blumm and Nadol, 2001; Tarlock, 2012). The result was a significant increase in the number of mitigation requirements included in FERC licenses (DeShazo and Freeman, 2005; Kosnik, 2010) and a growing role of other federal and state agencies in the licensing process (Blumm and Nadol, 2001; DeShazo and Freeman, 2005). The FERC and hydropower industry have suggested that this evolving policy context and increased regulatory plurality resulted in increased licensing time and increased uncertainty in mitigation requirements (FERC, 2001; U.S. House Commitee on Natural Resources, 2012).

Despite the importance that environmental mitigation requirements play in the licensing process, no comprehensive, centralized mitigation datasets exist for FERC-licensed projects. With this in mind we set out to create a national scale database of mitigation required at FERC-licensed hydropower projects with two intentions. First, relicenses provide a once in every 30- to 50-year opportunity to address environmental concerns at hydropower projects. With over 300 relicence applications anticipated between

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2016 and 2026 (FERC, 2015, Appendix A Fig. A4), there is new urgency to evaluate and balance the environmental costs of hydropower projects with the associated ancillary benefits. Moreover, environmentally sustainable development of hydropower resources requires addressing socioeconomic and environmental costs and benefits at multiple scales and will require scale appropriate data (Brown et al., 2009; McManamay et al., 2015). Underlying completion of these broad objectives, however, is the need for collated spatial data of FERC-ordered mitigation that can be combined with existing data of past and current ecological conditions to evaluate mitigation effectiveness and feed into decision making frameworks. Second, both developers and regulators face some level of uncertainty in mitigation included by FERC in hydropower licenses due to changes in policy over time (FERC, 2001; U.S. House Commitee on Natural Resources, 2012). A comprehensive and up-to-date database provides a resource to evaluate and better anticipate the range and types of mitigation that a project may face prior to licensing proceedings. Here we (1) report the development of a national scale database of mitigation required at non-federal hydropower projects and (2) provide a synthesis of mitigation information and hydropower projects included in the database.

2. Methods

2.1. Data sources

We conducted a manual review of FERC hydropower licenses followed by keyword searches to identify mitigation requirements at licensed hydropower projects and to ensure completeness of mitigation identification. FERC licenses were obtained from the FERC e-library (http://www.ferc.gov/docs-filing/elibrary.asp). Because we did not have the resources to review all 2044 FERC licenses (as of March 2016); we limited the manual review to licenses issued from 1998 through 2013 with an assumption that more recently issued licenses would better reflect mitigation requirements for upcoming relicenses. Hydropower plant attributes were obtained from the National Hydropower Asset Assessment Program (NHAAP) database (http://nhaap.ornl.gov).

2.2. Database design

Prior to database design, a random sample of twenty licenses was reviewed to identify the types of data that could be retrieved from the documents and possible mitigation scenarios. We then identified six broad categories of mitigation and 20 subcategories used to classify specific mitigation types in the database (Table 1). The tier one and two classifications were derived from major hydropower environmental impacts and associated mitigation measures outlined in Trussart et al. (2002) and Kumar et al. (2011), which can be summarized as: (1) impacts on biodiversity, (2) barriers to fish migration, (3) changes in aquatic and terrestrial habitat, (4) changes to hydrological regimes, and (5) alteration of water quality. Classifications were exclusive; no mitigation type could be placed in more than one classification and were based on hydropower mitigation literature reviews and expert opinion.

We recognize that the classifications are quite broad and many mitigation measures can address multiple objectives. For example, a habitat restoration measure such as downstream gravel restoration might be required as a means to restore aquatic habitat for salmonids or benthic macroinvertebrates, a clear biodiversity implication. However, we made an effort not to infer intent of any mitigation measures due to the limited technical information included within individual licenses and to reduce subjectivity. Therefore, biodiversity mitigation requirements required clearly articulated species-specific protection, restoration efforts, monitoring, or studies. Another example is trash or bar racks, which generally serve to exclude large debris from turbine intakes. However, if a FERC license required the installation of a trash rack for a stated purpose of preventing fish entrainment, it was recorded as fish passage mitigation. Finally, although the recreational requirements imposed within hydropower licenses were not considered as environmental mitigation, we decided to record and include recreation requirements as a sixth classification due to FERC's legislative mandate to consider the protection and mitigation of recreational opportunity.

The database was created and populated in Microsoft Access (Microsoft Corporation, Redmond, Washington) with unique hydropower plant identifiers related to hydropower plant

Table 1
Mitigation classification used in the database and examples of mitigation included in FERC licenses.

Tier one classification	Tier two classification	Examples of mitigation
Biodiversity	Terrestrial	Critical habitat conservation
	Aquatic	Stocking fish species of concern
Fish passage	Upstream fish passage	Fish ladder
	Downstream fish passage	Surface collector
	Entrainment	Guidance net
	Passage planning	Passage feasibility assessment
Habitat	Fisheries	Downstream gravel restoration
	Reservoir	Noxious plant control
	Riparian	Establish riparian buffer zones
	Wetlands	Wetland protection
Hydrology	Flow mitigation	Ramping rates
	Tailrace minimum flow	Run-of-river
	Bypass minimum flow	Year-round
	Sediment	Sediment/erosion plan
	Operations	Compliance monitoring plan
Recreation	Recreation flow	Recreational flow releases
	Resources and mitigation	Shoreline access
	Planning	Recreational plans or studies
Water quality	Downstream water quality	Forebay aeration
	Upstream water quality	Water quality monitoring