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Can environmental impact assessments alone conserve freshwater fish biota? Review of the Chilean experience

Shaw Nozaki Lacy [a,b,d,*], Francisco J. Meza [b,d], Pablo A. Marquet [a,c,d]

[a] Departamento de Ecología, Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile, Alameda 340, Santiago, Chile
[b] Departmento de Ecosistemas y Medio Ambiente, Pontificia Universidad Católica de Chile, Vicuña Mackenna 4860, Macul, Chile
[c] Instituto de Ecología y Biodiversidad, Las Palmeras 345, Santiago, Chile
[d] Centro Interdisciplinario de Cambio Global, Vicuña Mackenna 4860, Macul, Chile

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ABSTRACT

Chile was one of many countries that initiated environmental impact assessments in the 1990s, and has relied on their use for species conservation and territorial planning without the use of larger-scale environmental and ecological planning. The capacity of Chile's environmental impact assessment system (SEIA) to evaluate resident freshwater fishes and the potential impacts of water projects and aquaculture activities – two categories of projects that create direct threats to freshwater fishes – are assessed. Of the 3997 such submissions to the SEIA, only 0.6% conducted any freshwater fish assessment, and only 0.1% conducted any quantitative assessment of expected impacts from the associated project. The small number of assessments was characterized by poor study design, inconsistent sampling methodology, and species misidentification. Traditional assessments failed to include freshwater fish ecology in the general assessment framework. The new strategic environmental evaluation system only underscores the need for vastly improved field sampling protocols and assessment methodologies.

1. Introduction

Globally, freshwater fishes are the most threatened group of species, due to human impacts within watersheds that change hydrology, water quality, and water availability and climate changes that affect precipitation and runoff, water temperature, and water chemistry (Arthington et al., 2016). Freshwater fish conservation in Chile faces many analogous problems that are found around the world: a varied physical geography (Valdés-Pineda et al., 2014), growing environmental awareness and concern (Reyes-Mendy et al., 2014), an expanding economy based around natural resource extraction (MMA, 2011), and a dearth of knowledge about native freshwater fauna (Vila et al., 1999; Habit et al., 2006b; Vila and Habit, 2015; Cussac et al., 2016).

Addressing some of the conservation goals at this confluence of geography, society, and ecology are environmental impact assessments and strategic environmental assessments, which ideally work together to provide an indication of the potential impacts to physical and biological system at local and territorial scales, respectively. Although the strategic environmental assessment is not a new concept (Alshuwaikhat, 2005) and has been implemented in many countries, Chile only recently implemented its own system (MMA, 2015). This means that, from 1997 through 2015, Chile had been basing the bulk of its sustainable development processes on its project-based environmental impact assessment framework. The implementation of this new strategic environmental assessment process provides an opportunity to assess the capacity of the pre-existing framework in advancing sustainable development in imperiled freshwater ecosystems. In this context, Chile represents a good case study to examine the ways in which environmental impact assessments are structurally inadequate to address the myriad problems associated with environmental and ecological sustainable development in a society that is increasingly focused on themes of conservation and ecosystem protection.

The Chilean freshwater fish fauna is characterized by having very low diversity, especially compared to the rest of South America (Vila et al., 1999), with only 44 native species (Habit et al., 2006b), and with 93% classified as endangered (OECD and ECLAC, 2005). Compared to the EU and North America, relatively little research has been done on this fauna, and the Chilean Ministry of the Environment only recently formed an initial database of freshwater fishes, but distributions patterns and population structures of native Chilean freshwater fishes remain poorly understood (Figueroa et al., 2010). It is widely acknowledged that infrastructure projects have significant impacts to native fishes (Habit et al., 2006a; Soto et al., 2006), especially when it comes to direct (e.g., fishing, damming, canalization) and indirect

* Corresponding author at: Centro Interdisciplinario de Cambio Global, Vicuña Mackenna 4860, Macul, Santiago, Chile.
E-mail address: shaw.lacy@gmail.com (S.N. Lacy).

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(e.g., land-use change) human impacts (Habit and Parra, 2001; Habit et al., 2006a, 2007; Stehr et al., 2010; García et al., 2011). In addition to direct human impacts, the native freshwater fauna have been negatively affected by exotic species (Campos et al., 1993; Habit et al., 2003; Vila and Habit, 2015; Cussac et al., 2016), but most studies have focused on impacts of trout in southern Chile (Soto et al., 2006; Correa and Gross, 2008; Arismendi et al., 2009, 2014; Penaluna et al., 2009), with far less focus elsewhere, and the effect of aquaculture escapees not being a major point of research.

While protected areas can assist with species conservation, their distribution in Chile does not correspond to geographical distributions of native fishes (Tognelli et al., 2008), and even in the places where they operate, they are often understaffed, with either insufficient or outdated management plans (ECLAC and OECD, 2016).

Chile's governance of freshwater fishes can be characterized as fragmented, with relatively low levels of institutional capacity (ECLAC and OECD, 2016). Several governmental bodies are technically in charge of monitoring and managing freshwater fishes, but in actuality conduct no regular national assessments. Indeed, the only comprehensive governmental report to date assessing freshwater fishes nationally (CEA, 2010) relied heavily on non-governmental sources.

Until the full implementation of the strategic environmental assessment process, the environmental impact assessment process is the most direct means of pursuing the conservation of freshwater fishes. Briefly, the environmental impact assessment process began in Chile in 1997 (De la Maza, 2001). It is run through the Environmental Evaluation Service (*Servicio Evaluación Ambiental*, SEA), which is part of the Ministry of Environment (*Ministerio del Medio Ambiente*, MMA). There are two "levels" of environmental assessment that could be required by the SEA: the relatively brief Environmental Impact Declaration (*Declaración de Impacto Ambental*, DIA) or the far more involved Environmental Impact Study (*Estudio de Impacto Ambiental*, EIA). Any project that fits into one of the twenty category types must submit one of these documents to the SEA. For more information about the Chilean environmental impact assessment process, see De la Maza (2001).

1.1. Evaluating Chilean freshwater fish assessments

This paper considers two project categories that have direct impacts to freshwater fishes, either through changes to habitat via water storage and distribution projects (type A) or introductions of exotic species (Diana, 2009) via aquatic resource extraction projects (type N). However, from an ecosystems perspective, many of the categories could be said to have significant impacts to freshwater fishes, such as impacts from dewatering and water quality associated with mining development projects (type I).

One point that is mentioned as problematic in the structure of an environmental assessment is that it is often too narrow in scope to effectively account for concerns relating to biodiversity conservation (Geneletti, 2003), which can lead to harmful consequences, especially when considering issues like the area-of-influence of the project. In the case of rivers, the assessment of area-of-influence is compounded by the fact that rivers are hierarchically nested systems of active transport of water and sediment, creating a dynamic process of habitat formation and destruction (Frissell et al., 1986).

In the Chilean process, the determination of the area-of-influence of a project does not need to extend beyond the physical boundary of the project footprint. Furthermore, while there are specific guides for determining area-of-influence for certain types of projects, there are no guides for water or aquaculture projects, meaning that assessment of area-of-influence (and thus the rest of the assessment) need not extend beyond the footprint of the project, despite the well-described hierarchical structure of river networks.

The Chilean environmental impact assessment process has been operating for over 20 years with the mission of minimizing the impacts of projects and activities on Chile's environment, including freshwater systems and their resident fauna. However, no systematic evaluation has been done on the capacity of the existing system to adequately provide an assessment of existing ecologies and the potential impacts they would encounter. This paper will use an implicit ecosystems-based river management framework (Andreoli et al., 2012) to (1) describe the breadth of environmental impact assessments on projects with potential direct impacts to freshwater fish communities, (2) evaluate the quality of the assessments of freshwater fishes in assessment reports, and (3) assess the capacity of existing freshwater fish assessments in meeting the goals of sustainable development.

2. Methods

All registered DIAs and EIAs in project type "A" (water resource projects) and "N" (aquaculture projects) between July 1996 and June 2016 were collected through the public online portal of the SEA (Environment Evaluation Service, www.sea.gob.cl), regardless of the status of the project. These project types were *dams & reservoirs* (A1), *drainage* (A2), *dredging* (A3), *inland water alteration* (A4), *aqueducts* (A5 under DS95 and A7 under DS40), *siphons* (A6), *production >35 tons of echinoderms, mollusks, fish and other species* (N3), *production up to 15 tons conducted in non-tidal river areas* (N4), *production up to 8 tons of fish, microalgae, and other hydrobiology that require supply and or release of waters* (N5), *processing plants of hydrobiological resources* (N6), and *high intensity extraction projects of hydrobiological resources* (N7). Project types N1 and N2 were not included, since they are related to marine algal production, specifically. Although all N-type projects include non-fish, and no explicit distinctions are made between marine and freshwater operations, the categories were selected based on the potential to affect freshwater fishes, either through potential escapes of salmon or through water quality impacts (Diana, 2009).

2.1. Quality of fish assessments in water-project EIAs

An initial assessment of a random selection of DIAs indicated that fish assessments were not conducted in DIAs associated with water projects (type A) or aquaculture activities (type N). DIAs were therefore merely summarized based on general attribute data in order to understand the scope and distribution of different project types. Thus, the focus on fish assessments shifted to EIAs. Reviews of aquaculture EIAs showed no freshwater fish assessment, either, so evaluations of EIAs were limited to water projects. Here, we noted the type of equipment used, the sampling protocol, the number of sampling sites, and the number of sampling periods that were in the report. In addition, we noted the types of fish assessments reported, the type of data presented, and the quality of the fish assessment with regard to whether the project accounted for weaknesses in field survey or data assessment methodologies, the sparse fish ecology literature for native fishes, the life cycle behaviors of observed and expected resident fish species, and the implications of monitoring for uncommon and rare species.

From these evaluations, we made a series of professional assessments of the quality of existing fish assessments presented in water-project EIAs to characterize the resident freshwater fish community, characterize the potential impacts of the water project on that resident fish community, and place the assessment within a watershed context.

3. Results

Between July 1995 and June 2016, a total of 540 water projects (type A) submitted DIAs in Chile, with 520 presented with geospatial information (Fig. 1). Of these, most were in the project categories of *dams & reservoirs* (30.9%) and *drainage* (28.5%). There were relatively few "siphon" projects (5.4%), and a moderate amount of *aqueduct* (13.5%), *dredging* (10.9%), and *inland water alteration* (10.7%). The majority (59.0%) of DIAs were approved, and only a small minority (4.3%) were rejected; most of the remainder were either not admitted for review (18.6%) or