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WATER BODIES TYPOLOGY SYSTEM: A CHILEAN CASE OF SCIENTIFIC STAKEHOLDERS AND POLICY MAKERS DIALOGUE

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Abstract

The aim of this project was to obtain a scientists-validated Typology System, which would allow to classify the surface waters bodies in Chile and, therefore, to facilitate the environmental institutional water management in the country. For this, during the years 2009 and 2011, a Typology System for the surface freshwater bodies was developed for Chile based on the methodology described by the Water Framework Directive of the European Union, which was adapted to local features through the knowledge of limnologist experts in the country, as well as policy makers' experience and their management requirements . In a first stage, national ecoregions were developed and abiotic variables were defined to compose the Typology System. The resulted Typology System for lakes and rivers was generated following an a priori and top down approach to difference biocenosis, based on geomorphologic, hydrologic and physic criteria. In a second stage, the proposed Typology System was validated by experts and policy makers, in which process new arrangements were included in the system. The working methodology used for both stages was bibliographic review, interviews to local experts in biocenosis and workshops. It is specially highlighted the participative processes and discussions in which all the agents involved were present, all of which resulted in the creation of a valid system from a scientific point of view and a product that is applicable to the necessities of the environmental institutions of the country. This work represents a successful experience in the improvement of the communication between scientists and politicians in Chile, which is a relevant factor for the elaboration of more efficient and effective environmental policies, integrating not only management and economic issues, but also more technical aspects that can influence in the final success of any long term strategy. For this reason, the replication of this kind of experiences, as well as the stimulation of new instances of communication between these actors, can contribute to reduce the gap between science and politics.

Keywords: Water management, Environmental policy, Science-policy interface.

1 INTRODUCTION

In Chile, several interventions in surface continental waters have caused modifications in their physical and biological characteristics (Soto & Campos, 1997; Habit & Parra, 2001; Oyarzún & Huber, 2003; Parra *et al.,* 2003; Goodwin *et al.,* 2006; Habit *et al.,* 2006a, 2007, 2010; Barra *et al.,* 2009), to the point where it is not always possible to determine their original natural conditions. Chilean institutions have developed important management tools to improve the environmental state of freshwater ecosystems, such as the regulations called "Secondary Regulations of Environmental Quality" (*Normas Secundarias de Calidad Ambiental*, NSCA; CONAMA, 2004) and the development of a scientists-validated Typology System, which allows to classify the surface waters bodies in Chile and to facilitate the environmental institutional management of the country (DCA & RNR, 2010; 2011). The classification of surface waters is useful not only to regulate, protect and manage aquatic ecosystems, but also to evaluate the ecological condition of these waters by means of biological markers, to plan the water monitoring and to identify the necessary measures so that the superficial waters can achieve original conditions. The development of a management tool, such as the elaboration of a water bodies Typology System, involves the participation of a group of agents who must integrate their knowledge, visions, and experience. In this sense, it will be common that the collaborative practices among the various agents are not without the risk of having difficulties related to the competences, conflicts of interest, attitudes, beliefs (Oltra, 2009), and the several technical languages used by their different disciplines, which is also common when the interaction is between decision makers and the scientific sphere. Both of them play different roles, while the politicians are mainly demanding predictions to reduce uncertainties associated to natural systems and, therefore, to make decisions that affect them (Sarewitz & Pielke, 2000), scientists define problems, produce knowledge and look for the corresponding solutions (Huitema & Turhout, 2009). These differences that, at the same time, involve heterogeneous values, visions, and goals, make difficult the transmission of knowledge and solutions to take political decisions (Ottra, 2009). Although the potential conflictive interaction that may occur among the different agents involved in the development of an environmental policy, it can be accepted and assumed that the application of this policy will result in positive benefits not only for the society but also for the environment only when it is based on scientific information (Steel *et al.*, 2004). For this reason, the establishment of suitable frameworks that facilitate the flow of information in a clear manner among the different political and scientific agents (Hoppe 2010) is essential so that public decisions can be socially and environmentally efficient. In this context, this article describes the process of the development of the first Typology System of rivers and lakes for Chile, which combines both scientific and politic criteria, and highlights the interaction between the different actors involved on it, and the tools and methods used to elaborate the Typology System. It is specially mentioned the participative processes and discussions in which all the agents involved were present, all of which resulted in the creation of a valid product from a scientific point of view which is applicable to the necessities and restrictions of the environmental institutions of the country.

2 METHODOLOGY

A typology of surface waters bodies can be generally elaborated from two approaches (Ferreól *et al.*, 2005): a) the top-down approach, in which water bodies are grouped depending on the environmental variables that characterize them (Verdonschot & Nijboer, 2004; Sánchez-Montoya *et al.*, 2007) and b) the bottom-up approach, in which the classification is made depending on the distribution of biological communities to subsequently create models using the environmental variables that characterize the rivers, parts of them, lakes, or any other water body susceptible of classification. Therefore, this methodology uses environmental variables as well as taxonomic information (Heino *et al.*, 2003; Lorenz *et al.*, 2004). In general, the typologies generated using top-down approaches have been adjusted or corrected by means of the use of bottom-up methodologies (Böhmer *et al.*, 2004; Hering *et al.*, 2004; Lorenz *et al.*, 2004). In this case, the Typology System developed for lakes and rivers was generated following an *a priori* and a top-down methodology. This decision was supported mainly due to the lack of documented information about fresh water biodiversity and the ecological processes that characterize Chilean rivers and lakes (Hauenstein, 2006; Jara *et al.*, 2006; Ortiz & Díaz-Paéz, 2006; Rivera, 2006; Villalobos, 2006). Therefore, this information, which is essential to elaborate classification systems, was supplied by expert knowledge using a top-down approach. The premise of the Typology System consisted in that the number of types needs to be as big as necessary and as small as it can possibly be. For this approach, the process of generate a Typology System applicable to a national level had two phases:

2.1 Stage 1: Creation of a Typology System

A proposal of a series of classification criteria for water bodies with their corresponding classes, that could be evaluated by experts in biocenosis in the country, was elaborated. These criteria and classes were selected taking into account the Annex II from the Water Framework Directive (WFD) of the European Parliament (WFD 2000), which was used as a reference to define this system. An ecorregión proposal was also development based on scientific literature. The criteria and ranges proposed by the WFD were modified based on a revision of scientific literature in order to make a first adjustment of this system to the Chilean geographic reality. The selected criteria were analyzed, discussed, and modified in a first focus group in which participated the consultant team, fresh water ecosystem experts and decision-makers linked to the water resources management.. The result of this dialogue was a second proposal of criteria and ranges that were analyzed in a second focus group from which a first approach to this Typology System was defined.

To gather the opinions of the parts involved in each focus group, it was carried out an exposition of the initial proposals to work with to subsequently make key questions to the participants. These questions were recorded on tape and registered in paper. The discussion was moderated by the project manager, who was neutral in all the interventions and avoid influencing the participants. In this way, there was a dialogue that allowed producing a proposal regarding a Typology System based on the expert's criteria and agreed by the potential users.

2.2 Stage 2: Validation of the Typology System

Once defined the Typology System, a validation process was carried out by means of semi-structured interviews (Hernández *et al.,* 2006) and participative maps. Both methodological tools were applied to fresh water experts depending on their experience in different areas of the country.

The semi-structured interviews (Hernández *et al.*, 2006) are qualitative tools that allow gathering the interviewee perception by means of a dialogue with the interviewer about the dimensions that the interviewer wants to gather. In this case, three main dimensions were included in the interviews :

a) The relevance of the criteria ranges used to create the Typology System.
b) The logic and basis to redefine the criteria ranges depending on local characteristics.
c) The adjustment of the ecoregion boundaries.

On the other hand, participative maps are methodological resources that allow gathering the spatial component of knowledge and are normally used to help the members of a community to visually illustrate how they perceive their territory (Rodríguez, n.d.). This tool allows defining differentiated spatial units that are part of the expert comprehension of the territory that he deals with. At the same time, this allows elaborating plans or processes of zoning (Rambaldi *et al.*, 2006). Each interviewee was asked to identify, in a paper map of the ecoregion they are most familiar with, if the application of the Typology System reflected - or not - the spatial distribution of the biocenosis, encouraging them to draw the distribution that he/she recognizes in the territory. Thus, it was expected to reflect the expert knowledge in its spatial dimension, which in turn has a later cartographic expression. The total number of potential experts in aquatic ecosystems to be interviewed was chosen taking into account the number of their international and national scientific publications about Chilean freshwater ecosystems. From this potential group, some experts (12) were selected and interviewed,. The selection was done considering their time availability, and focusing on those who had a larger number of publications. The experts were differentiated following the criteria of expertise in specific regions and the surface water bodies categories (lakes or rivers) which they have more knowledge about. Most of them had experience in more than one water body type and more than one ecorregión.

The application of both tools required the participation of two professionals to avoid biased conclusions and to facilitate the gathering of necessary information from each interview. The interviews and interactive maps were conducted by a biologist, who represented a valid interlocutor to guide the interviews, accompanied by one of the co-researchers of the team to help in the generation of the interactive maps.

For the analysis of the interviews, the method known as content analysis was used. This is defined as a technique to study and analyze communication, searching for the systematization and objectivity of that which is communicated (Krippendorff, 1990). This technique allows analyzing any form of human communication, especially the one emitted by particular subjects (Hernández *et al.,* 2006).

Finally, in order to integrate the knowledge gathered in the Typology System with the concrete needs of the decision makers, a working group was created, which included international experts in water bodies classification, members of public institutions as representatives of the Environment Ministry of Chile and the Water General Management and experts in freshwater ecosystems. In this instance, the proposed system was contrasted with the possibility of putting it in action according to the availability of information and the institution's objectives, considering as mandatory the considerations gathered by the experts through the interviews, allowing consolidating a Typology System validated both at a scientific and institutional level.

To complement the feedback from the scientific experts, the results of this system were presented in three instances considered as spaces for scientific discussion and validation:

- VII Congress of the Chilean Limnology Society, October 2010.
- Scientific Conference organized by the EULA of Universidad de Concepción.
- Seminar “River's and lake's Typology and Biological Indicators”, specially organized for the spreading and socialization of this tool, and in which experts in limnology at a national level were summoned.

3 RESULTS AND DISCUSSION

3.1 Stage 1: generation of a Typology System

First focus group: The neutrality character maintained by the project director was successful in inducing an unbiased dialogue. According to the concrete results, there was consensus on reevaluating the variables used and on decreasing the number of proposed ecoregions. Criticisms and recommendations to the proposal are shared, thus, integrated as a base for the improvement of the product.

The discussion of the classification criteria with their corresponding classes puts on the table the first discrepancies among the different individuals of how approaching the problem. Whereas for decision-making professionals the criteria and classes must be homogeneous for the whole country, for experts they have to represent the high climate and natural diversity of the country, opinion that rejected, in part, the assumption of having homogeneous criteria and classes. Scientific thoroughness is understood in order to explain the reality of the country; however, decision makers require a simple system that has to be economically applicable. On the other hand, it was insisted not to counterpart the WFD methodology, which establishes unique criteria and classes for the whole country. Finally, it was agreed to select criteria and classes that explain as much variability within the territory as possible. In this respect, and due to the lack of information, it is decided that classes must be based on the empirical experience of the different experts.

Second Focus Group: Taking into account all the criticisms and suggestions made by the experts and professionals assisting to the first focus group, a second proposal of ecoregions and classification criteria is proposed. For the first time, the proposal receives recommendations from European Union experts about classifications of water bodies. Due to the latter, it was assumed that the new products are better adjusted to the characteristics of a Typology System generated from the WFD guidelines. The absence of major conflicts during the group work with the international team, explains why there was relative clarity respect to the objectives of Typology System and to the chosen methodology.

This time, the discussion was not focused on the benefit of applying a methodology created for a different reality to the Chilean one, but it was focused on the appropriateness of selected criteria of classification. The latter was understood as a validation of the proposal, in methodological terms, by the experts.

The final product of this stage was the creation of a Typology System for rivers and lakes (see Table 1), system that includes a group of five ecoregions and a battery of five criteria of classification with their corresponding classes, both for rivers and lakes. This preliminary Typology System achieved to combine scientific with political criteria, however, the fact that this was not submitted to a consulting expert process at a sub-national level, it was not considered as validated by the national scientific community.

3.2 Stage 2: Validation of the Typology Systems for rivers and lakes

Twelve experts were finally interviewed. This process proved good willingness by each interviewee to get involved in the whole process, except for some reluctance, whose causes shown during each interview. Respect to the latter, and despite that the expert knowledge obtained during the first stage was included in the final results of the System, it can be highlighted that according to the interviewee's opinion, they were not included in a formal way. In this manner, it can be discussed the possibility of including, at a third stage, the Chilean Society of Limnology as an expert organism to assist the final Typology of this project, separating the typology of rivers from the one of lakes. In this stage, doubt about the applicability of this tool still remained. This type of circumstance is common in the processes in which the active involvement of different performers (i.e. politicians and scientists) are involved, and these agents can be faced with conflicts that are explained mainly by limited visions to tackle and solve a problem (Huitema & Turnhout, 2009; Oltra 2009). Regarding this conflict, each expert has evidenced their methodological differences, which are subject to the amount of knowledge that they have on the ecological systems and the geographic area in which they work. So it was not surprising that experts tackled the typology from a bottom-up perspective, which contravenes the top-down perspective supported in this proposal of Typology.Alternatively, whenever this Typology System was presented, it was expressed the need for clarifying the objectives that the institutions want to achieve with this Typology System, since the level of accuracy and adjustment that it should have depended on the objectives aforementioned. Considering the type of management in which it will be applied, it is absolutely necessary to make this point clear. From this phase of validation and socialization that was characterized by the high level of interaction among scientists specialized in freshwater biological systems, public administration professionals, and the consulting team, it was obtained an Typology System improved in comparison with the one obtained in Stage 1 and pertinent to the national current situation, that has five fresh water ecoregions, and a set of five criteria with their respective classes for rivers and lakes (see Table 1). The validity of the Typology Systems strengthens the idea that this tool can become the reference frame for the conservation of water resources if it's properly developed. However, it is worth mentioning that the practical validation of this tool is subject to a third stage in which there are two key elements to consider: first, the will to summon the biology experts as active members in the implementation and validation of the Typology in the field; and second, the objective of developing maps using criteria that still do not have spatial expression.

Table 1. Criteria and clases of Chilean surface water bodies Typology System. Criteria and classes (A): determined at the end of Stage 1. Criteria and classes (B): determined at the end of Stage 2.

Criteria (A)	Class (A)	Criteria (B)	Class (B)
Rivers and Lakes			
Altitude (m.a.s.l.)	Class 1: Low (< 500) Class 2: Middle Low (500 - 1000)	Altitude (m.a.s.l.)	Class 1: Very low (< 100) Class 2: Low (100 to 800)

	Class 3: Middle High (1000 - 2500) Class 4: High (> 2500)		Class 3: Middle High (800 - 1500) Class 4: High (1500 - 3500) Class 4: Very high (> 3500)
Electric conductivity	Class 1: Low Class 2: Middle Class 3: High Class 4: Very High	Geology	Class 1: Siliceous / high mineral content Class 2: Siliceous / low mineral content Class 3: Calcareous / high mineral content Class 4: Calcareous / low mineral content
Only Rivers			
Slope (%)	Class 1: Low (< 2) Class 2: Middle (2 - 4) Class 3: High (> 4)	Slope (%)	Class 1: Low (< 2) Class 2: Middle (2 - 4) Class 3: High (> 4)
Substrate	Class 1: Silt Class 2: Sand Class 3: Gravel Class 4: Stone	Substrate	Class 1: Silt Class 2: Sand Class 3: Gravel Class 4: Stone
Discharge (m^3/s)	Class 1: Low (< 10) Class 2: Middle (10 - 200) Class 3: High (> 200)	Discharge (m^3/s)	Class 1: < 5 Class 2: 5 - 50 Class 3: 50 - 200 Class 4: > 200
Only Lakes			
Lake size (area) (km^2)	Class 1: Very Small (< 1 km^2) Class 2: Small (1 a 10 km^2) Class 3: Middle (10-100 km^2) Class 3: Large (> 100 km^2)	Lake size (area) (km^2)	Class 1: Very Small (< 1) Class 2: Small (1 - 10) Class 3: Middle (10 - 100) Class 3: Large (> 100)
Depth (m)	Class 1: < 10 Class 2: 10 - 50 Class 3: > 50	Depth (m)	Class 1: < 10 Class 2: 10 - 50 Class 3: > 50
Mix regime and water stratification	Class 1: Amictic Class 2: Polimictic Class 3: Monomíctic Class 4: Meromíctic**	Mix regime and water stratification	Class 1: Amictic Class 2: Polimictic Class 3: Monomictic Class 4: Meromictic**

Source: Own elaboration. Mix regime and water stratification classes based on expert criteria and scientific literature (Campos, 1984; Soto, 2002; Parra *et al*., 2003; Villalobos *et al*., 2003; Márquez-García *et al*., 2009) **Particular class: Incomplete water circulation is incomplete due to non-termic salinity gradient. Substrate, discharge, depth and mix regime, and water stratification are criteria without cartography.

Although the main objective of our research was the achievement of the first Typology System for rivers and lakes, the successful dialogue between the academic sphere represented by scientists, and the public sector represented by decision makers, became one of the most relevant results in this process. This setting, which was favored by the environmental institutions, was brought about by recognizing that the participation of scientists is an element that increases the quality of the decision-making process (Functowicz & Ravetz, 1999). Alternatively, it seems that many of the participant researchers attributed positive elements to the collaboration among different parts, despite the conflicts that appeared during the process. Even though Oltra (2009) showed that the collaboration between scientists and politicians is a desirable yet complicated element, in this occasion, the positive attitude of the participants favored a stable environment of collaboration during the whole process, which made it possible to have a product that everybody agreed on and that they validated.

4 CONCLUSIONS

This project comes to an end with the creation of a Typology System of surface waters bodies for Chile that can be considered in tune with the state of the arts of the country's freshwater systems. In the process, communication between decision makers (in this case the Environmental Ministry) and the fresh water ecosystems expert, experimented an evolution since the beginnings when the disagreements related to the Typology’s objective and in the sub-national scale required by the decision makers wasn’t understood by the experts, until a final stage when the understanding of the objectives and the agreements about the relevance of having a Typology System showed the dialogue reached between the actors. As a product of this dialogue, scientific data and expert knowledge was gathered and systematized, which, together with supporting the decisions that were made during the planning of the system's design, transformed into a valuable source of reference for future research on the field. However, despite the experts who were consulted in this investigation agreed with the need of having a Typology of rivers and lakes for the country, they have also evidenced that the results that have been obtained so far are not enough and require more development. The process of dialogue have made of this need a shared goal between decision makers and experts, since they have come to understand each other point of view and have came to similar conclusions, strengthen the results reached in the development of this Typology System. Communication between scientists and politicians is a relevant factor to the elaboration of more efficient and effective environmental policies, which should integrate not only management and economic issues, but also more technical aspects that can influence in the final success of any long term strategy. For this reason, registering successful experience in these matters, as well as stimulate the instance of communication between these actors, can contribute to reduce the gap between science and politics.

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