How to cite: Bernier, M., Bartout, P., Touchart, L. (2022) Dynamic Limnology Between Actors and Managements. *2022 "Air and Water – Components of the Environment" Conference Proceedings*, Cluj-Napoca, Romania, p. 64-74, DOI: 10.24193/AWC2022_07.

DYNAMIC LIMNOLOGY BETWEEN ACTORS AND MANAGEMENTS

Maximilien BERNIER[1], Pascal BARTOUT[2], Laurent TOUCHART[3]

DOI: 10.24193/AWC2022_07

ABSTRACT. The subject proposed in this article concerns the intersection of the hydrodynamics of lakes and ponds with the economic development of their territory. It will be a question of understanding the interactions between these water bodies and territorial actors evolving on these limnic territories. Different managements are therefore imposed on each of the parties present. These managements are organized according to the limnological mechanisms specific to each environment (ponds and lakes), their temporality, their spatiality, and their risks for the human activities integrated into these water bodies. We will focus in this article on water and sediment movements not yet studied to interact with local managements. These phenomena constitute a base on which the actors around these water bodies can rely to guide the measures used to protect their activities. The purpose of this article is to provide scientific insights for decision support to actors evolving in the federation of municipalities of the Great Lakes, in the Landes, in New-Aquitaine (France).

Keywords: Limnology, Hydrodynamics, Water bodies, Actors, Management.

1.INTRODUCTION

François-Alphonse Forel, at the creation of limnology, introduced the notion that human beings are not just part of the lake's ecosystem. Through activities, human beings have the ability to interact strongly with a lake and affect its ability to provide ecosystem services (Baulaz and Dorioz, 2021). Legally speaking, French water bodies, even European ones, must be managed in the same way, on paper. In reality, it happens differently. Despite managements that has been strongly inspired by scientific knowledge, each of these managers operate according to their needs and issues. Each entity present on the banks of these water bodies is involved in the anthropization of its sector of interest.

In terms of management, the administrative structuring of water in France is

[1] PhD student, EA 1210 CEDETE - Laboratory of Geography, University of Orleans, 10 rue de Tours, 45 065 Orléans Cedex 2 (France). Email: m.bernier@ccgrandslacs.fr

[2] Senior Lecturer, EA 1210 CEDETE - Laboratory of Geography, University of Orleans, 10 rue de Tours, 45 065 Orléans Cedex 2 (France). Email: pascal.bartout@univ-orleans.fr

[3] University Professor exceptional class, EA 1210 CEDETE - Laboratory of Geography, University of Orleans, 10 rue de Tours, 45 065 Orléans Cedex 2 (France). Email: laurent.touchart@univ-orleans.fr

dictated by multiple directives such as the WFD-2000 (Water Framework Directive), Water Development and Management Master Plans, municipal decrees, etc. The objective is to achieve "good condition", theoretically considering societies living in the territory to be managed and their expectations. The reality is quite different. Society would like to think from a systemic point of view, but in fact it adopts a rigid framework, which is found in exclusively naturalistic indicators and does not take in consideration of the diversity of actor using these aquatic environments for their hobbies, by example. Gradually, the total number of actors around water bodies has diversified. To only quote a few, we find military, oil, tourism, associative, regulatory, and administrative sectors on the banks of the lakes in the federation of municipalities of the Great Lakes. The primacy of the study over the dynamics of water bodies then becomes more questionable as a reference management indicator. Important dynamic phenomena come into play on management issues (flood, navigation, filling, erosion, fauna & flora, etc.). This is why it is interesting to look at the dynamic behaviours of these water bodies. Limnology favours a territorial approach integrating all parts of interest in a complete societal system in space and time, natural or anthropogenic. More simply, it consists in linking the environmental dynamics of biocenosis, biotope and customs imposed by humans about water bodies.

In an approach of limnological geography (Bartout, 2015) which places water bodies and the diversity of approaches at the center of interactions between society and environment at different spatial and temporal scales. So, we will use dynamic limnology, a discipline that consists in understanding the physical dynamics exerted by a water body within it or towards its close environment. This dynamic approach completes physical and biocenosis approach usually prefer to study lakes or ponds, to help managements face to global change. It concerns the movements of water and sediment. The analysis of lake dynamics began with the creation of limnological sciences under Forel when he tackled the dynamics of the formation of Geneva Lake - geomorphology - or '*seiches*' (difference in altitude of the water level on the same water body) (Cvijic, 1901). To continue his work, many researchers have worked to better quantify and map it, but at very variable scales (Choffel *et al.*, 2018).We have therefore adopted the dynamic approach because it has been neglected in limnic territories (Bartout and Touchart, 2017), especially by managers. The multiplicity of spatial approaches in today limnology complicates the identification of the role of any actor in management without giving more importance to one rather than the other. To translate this complexity into the multiple regulatory issues that prioritize this or that parameter, we decided to diagnose water and sediment movements.

We propose here to produce a diagnosis of dynamic mechanisms taking place within these water bodies for a better consideration of the latter by their managers. Through the creation of a diagnosis based on dynamic phenomena applied to territories, we will try to bring new data on water bodies behaviour, easily reusable and understandable for "actors" and future "management". To do so, we produced new cartographic data at the scale of the water body studied, regardless of its nature, within the federation of municipalities of the Great Lakes, in the Landes, in New-Aquitaine, France.

2. METHODS

To create this diagnosis helpful for managers, we will study dynamics lakes based on water and sediment movements.

2.1. Presentation of studied water bodies

The sites studied in this article concern 2 water bodies located within the federation of municipalities of the Great Lakes (Fig. 1), in the department of Landes, in New-Aquitaine (France). This study is done under the direction of Pascal Bartout and Laurent Touchart via the French thesis on the subject: Can water movements (wind currents, density currents, etc.) and their effects on differentiated sediment deposits in lakes and ponds contribute to the maintenance of economic activities in their territory?

All the lakes and ponds of the Aquitaine coast are separated from the Atlantic Ocean by the wide bar of coastal dunes. The history of the establishment of these water bodies coincides, at least in part, with the history of the dunes. These lakes or pond has been specified by the dating of the periods of mobility of the dune cordon. All these data show that theses lakes were first a lagoon widely open to the ocean until around 1000 BC (Grousset, 2013). This opening was then cluttered by the sands brought by the coastal drift before being more or less obstructed in Gallo-Roman times.

The lakes of the federation of municipalities of the Great Lakes are known as ponds of Parentis-Biscarrosse and Cazaux-Sanguinet, on French soil because the study site that has long privileged the ocean nearby, abandoned them until they were given the pejorative term "pond", back then. However, these are lakes according to the definition of Laurent Touchart (2000). They are now called lakes by the locals, which is technically true if we consider that the average depth for these lakes is more than 6 meters as defined by the Ramsar convention of 1971 and that they cover more than 200 hectares, which is the criteria, according to E. Jedicke, to define a lake. Therefore, we will call them lakes, in this article. The lakes studied represent more than 9,340 hectares for a volume of 750 million litres More specifically, Lake Parentis-Biscarrosse is announced with 250 million litres. Lake Cazaux-Sanguinet, meanwhile is advertised at 500 million litres (Moreira et al., 2015).

Lake Parentis-Biscarrosse and Lake Cazaux-Sanguinet are both located in the extreme north-west of the Landes department next to the border of Gironde (French department), under the Arcachon basin and one hour southwest by car from Bordeaux. They are natural. The first is a little further south and smaller than the other, but it measures almost 3540 ha of surface at an altitude of 19 meters above sea level while its maximum depth plunges to 20.5 meters. As for Lake Cazaux-

Sanguinet, it occupies 5600 hectares of water surface, at 20 meters above sea level with a maximum depth of 23 meters (Moreira *et al.* , 2015).

These lakes also have the particularity of evolving on different communes. Lake Parentis-Biscarrosse is essentially in the Landes because of the neighbouring towns, named : Parentis-en-Born, Biscarrosse, Gastes and Sainte- Eulalie-en-Born. Its homologue, meanwhile, is divided between Biscarrosse, Sanguinet and Cazaux (township of La Teste-de-Buch, in Gironde).

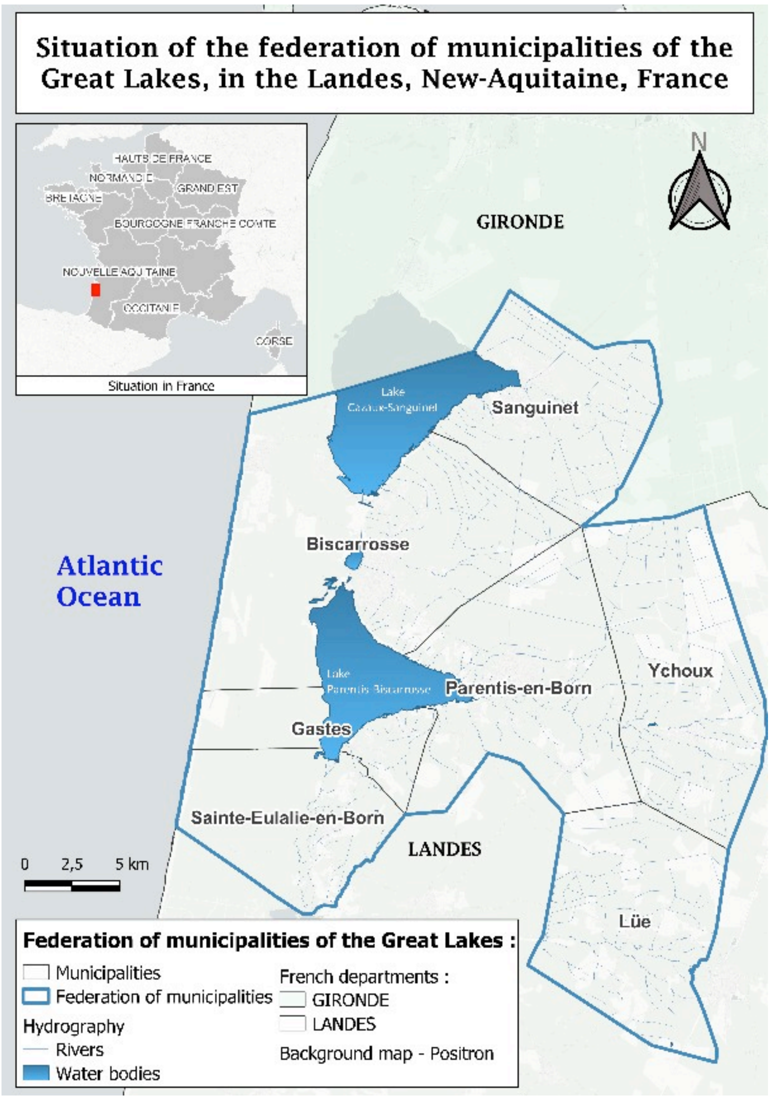

Figure 1. Situation map

To get out of the framework of limnology for naturalistic or physicochemical purposes, we have added the dynamics (Fig. 2) of these "lentic" objects for its economic/societal purposes. This diagnosis is made by considering the criteria mentioned above. Methodologies are based on a mix of surveys and field observations coupled with Geographic Information Systems (GIS).

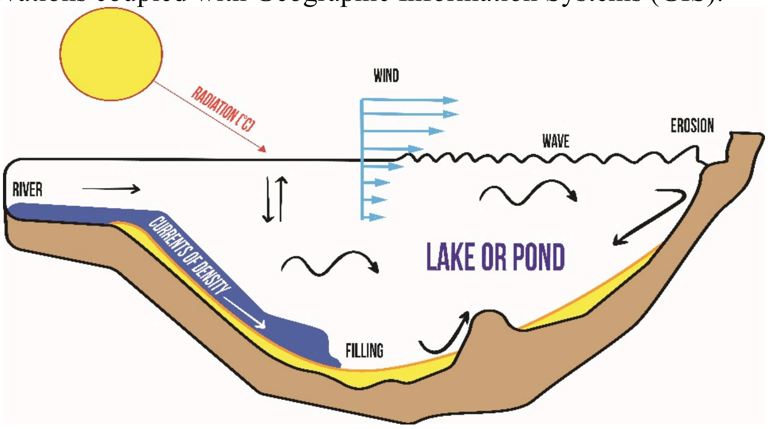

Figure 2. Representation of water and sediment movements

2.2. Bathymetries

Lakes or ponds evolve in basins. If we look at the dynamics, the bathymetry seems the ideal way to execute the initial work. The Adour-Garonne water agency carried out bathymetry on lakes studied in 2014, we will reuse their data. This bathymetry was completed with the Digital Terrain Model made by the French National Geographical Institute (IGN). The use of data previously existing on French territory makes it possible to reproduce this diagnosis on other water bodies (Fig. 3).

- Formatting of the data (about 37000 points treated for each of these Landes lakes),
- Calculate bathymetry via echo sounder surveys on the water bodies studied or via already existing data (point data), TIN interpolation.
- Cutting according to the XY right-of-way of the water body.
- Calculations in the appropriate spatial projection (EPSG: 2154).
- Assembly of bathymetric data with available digital terrain models,
- Volume calculations
- Joint with built elements and various networks (data from the IGN: BD TOPO)
- Visualization of cartographic renderings: bottoms (archaeological, sandbanks, etc.), and issues (by water levels).

This first methodological approach makes it possible to obtain results on the dynamics of the bottoms of these lakes, but also on water levels and volumes of the water body studied.

2.3. Water movements

After focusing on the depressions in which some of these movements occur, we will focus on the movements caused by the winds. The study of the winds seems to complete the previous part. The analysis of these winds (Fig. 4) is based on two distinct but complementary methods.

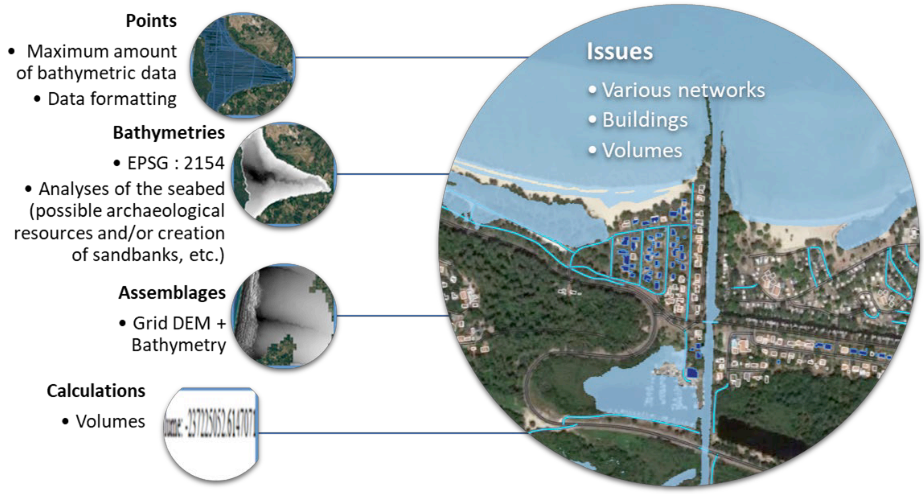

Figure 3. Sediment movement process

- Calculate potential wind races (Papon, Maleval and Nedjaï, 2005).
- Calculate effective fetch (Håkanson and Jansson, 2002) - the zone of wind momentum to raise waves - on each water body studied with the help of a regular grid.
- Calculate the height, period, and speed of the waves.
- Calculate the maximum of fetch or wind races
- Weight the winds according to an annual wind rose transmitted by MétéoFrance.
- Check in the field that the data matches; the greater the course of the winds - or fetch - the more the coast is subject to winds and erosion.

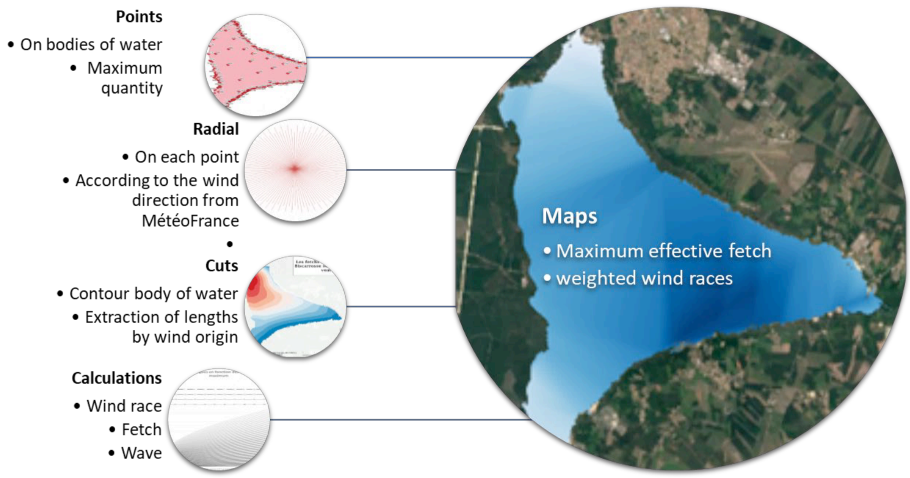

Figure 4. Water movement process

This second methodological approach makes it possible to obtain results on the dynamics of the banks and the actions of the water on its surface.

The two parts presented here in methods present some of the dynamics that we want to understand. Nevertheless, internal dynamics have not been forgotten. Tests with different equipment are underway and they will soon complement this dynamic diagnosis of water bodies.

3. RESULTS

In order to answer societal questions (floods, issues, erosion, fillings, etc.) induced by dynamic limnology, using the previous methods, we will evaluate the impacts of dynamic limnology in the two lakes of similar genesis presented at the beginning of this article.

The analysis of the bathymetry of these lakes was done under GIS. The resulting maps make it possible to visualize what is happening under the water level. With the acquisition of this data, we were able to obtain the new volumes of these lakes. The new volumes announced differ by about 5% for the same altimetry, such as Lake Parentis-Biscarrosse below (Fig. 5).

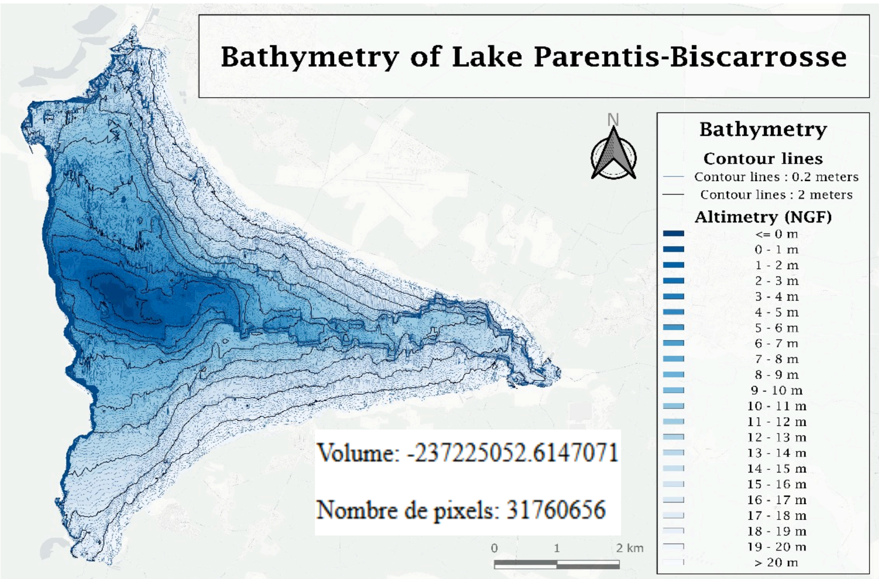

Figure 5. Bathymetry and volume by number of pixels of Lake Parentis-Biscarrosse

On these bathymetries of lakes, irregularities appear and correspond to archaeological discoveries for some and to potential archaeological discoveries for others. The lake basin was then integrated into the digital model. This last action then allowed us to change water levels to get out the issues (built and various networks). The projections of water levels (Fig. 6) were made on the histories of the most important periods of flooding or low water levels, to be compared to the water regulation (management of structures according to the altimetry of the water body) with the aim of modifying it later. These basic data will then be used to analyse the evolution of sedimentary dynamics and issues.

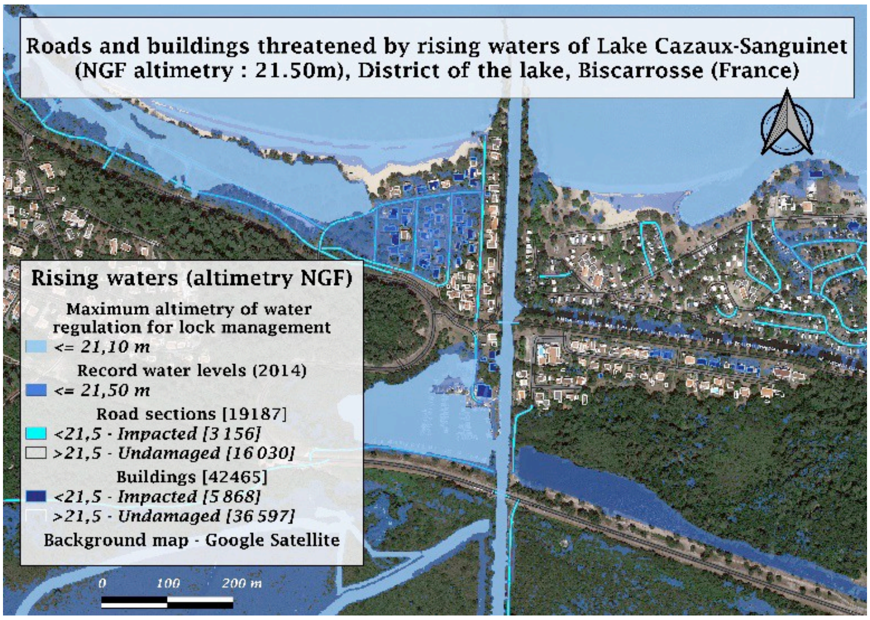

Figure 6: Issues Highlighted by GIS Visualization

The analysis of the dynamics concerning the movements of water via the winds gives us interesting results. The data obtained is presented via graphs and maps (Fig. 7 & 8). The maps make it possible to highlight the most exposed coasts (in connection with the sectoral winds) and these coincide with the eroded zones of these territories (dark blue zone). These erosions can be understood by the following graphs where we better understand the waves that hit them. On the other hand, the areas spared have visible fillings (light blue zones).

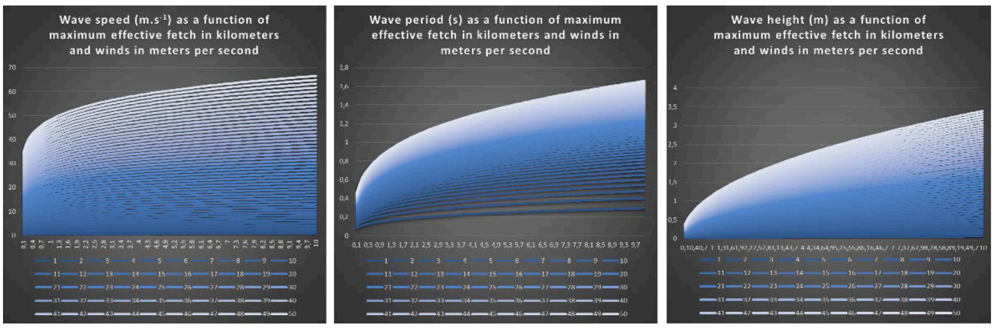

Figure 7: Graphs by fetch in kilometers

Figure 8: Wind exposure maps by lake (weighted on the left for Lake Parentis- Biscarrosse and maximum on the right for Lake Cazaux-Sanguinet)

In addition, it should be noted that the invasive exotic plants *(Lagarosiphon Major & Egeria Densa)* in these lakes have the particularity of deserting the areas where the winds and waves are the strongest.

Thus, a brief diagnosis of the dynamics of water bodies is feasible with the simple use of open-source GIS software and no equipment required. The results of these distinct methodologies can make the link with the local actors of these lakes, to escort or plan their actions on these limnic territories.

4. CONCLUSION & DISCUSSIONS

This diagnosis is a significant step forward in the integration of dynamic limnology, because it improves above all a better understanding of the behaviour of water bodies. Until now, this dynamic approach was not sufficiently emphasized by the managers because of the interests of the actors, mainly on biocenosis. Thus, these spatial criteria of the dynamics finally consider the system (including humans) of their limnic territory. Through these studies, the various actors, who had not yet understood the understanding of the movements occurring within these water bodies, can now better assimilate the territory in which they evolve. Erosion, fillings, floods, and issues can be anticipated by associating the dynamic criteria of sediments and water at the same level. This diagnosis makes it possible to produce new decision-support maps for stakeholders in their limnic areas. At the scale of water bodies, the focus on dynamics calls into question the understanding of the evolution of these aquatic environments in the future, more or less nearby. In fact, dynamic characteristics of a water body can be different from one region to another as found on these two lakes of similar genesis and shape, in the north of the Landes (France). So, this diagnosis deserves to be taken into consideration for each water body because of its ease of deployment. This would make it possible to give better ideas of support and thus to improve their management by making it easier to understand these complex environments.

With these first results, actors and managers of these lakes can understand the phenomena that impact their limnic territory. They will be able to see these lakes and ponds as living machines dependent on various mechanisms to be monitored for their proper functioning (Touchart, 1993). With this information, each of the parties present can take guidelines for the preservation of their activities. By analysing the "dynamic" movements of water and sediments within these water bodies, we will be able to bring action plans to protect the banks and infrastructures. If we better understand these dynamics, it is much easier to anticipate the evolution of water bodies. Based on this information, what will be the next measures of the actors evolving in these limnic territories?

This succinct diagnosis needs to be completed by any information available on the water bodies subject. It will be soon completed with currents.

REFERENCES

1. Alric, B. (2012) 'La vulnérabilité des lacs face au couplage du climat et des perturbations anthropiques locales: approche paléolimnologique basée sur les cladocères', p. 201.
2. Bartout, P. (2015) 'L'incompréhension de la place prise par les plans d'eau dans l'Union européenne et ses conséquences réglementaires', *Norois*, (235), pp. 17–36. doi:10.4000/norois.5608.
3. Bartout, P. and Touchart, L. (2017) 'Le territoire limnique, une alternative à la gouvernance des plans d'eau par masses d'eau ?', *VertigO* [Preprint], (Volume 17 numéro 3). doi:10.4000/vertigo.18692.
4. Baulaz, Y. and Dorioz, J.-M. (2021) 'Exploration fonctionnelle du territoire des grands lacs alpins par le prisme des services écosystémiques', p. 25.
5. Castagnos, E. and Dutartre, A. (2001) 'Evolutions récentes des peuplements de plantes aquatiques exotiques dans les lacs et les étangs landais', p. 229.
6. Choffel, Q. *et al.* (2018) 'Le centre thermique, nouvel outil de compréhension du bilan thermique et de l'évolution spatio-temporelle de la température d'un étang ?', *Norois*, (246), pp. 57–73. doi:10.4000/norois.6350.
7. Dutartre, A. (2004) 'De la régulation des plantes aquatiques envahissantes à la gestion des hydrosystèmes', p. 14.
8. Filliol, J. (1955) 'Aspects physiques de la région des étangs landais d'Arcachon à Soustons', *Revue géographique des Pyrénées et du Sud-Ouest*, 26(1), pp. 28–43. doi:10.3406/rgpso.1955.1397.
9. Grousset, F. (2013) 'Chapitre 2 : Du climat du passé au climat du futur', in Le Treut, H. (ed.) *Les impacts du changement climatique en Aquitaine*. Presses Universitaires de Bordeaux, pp.41–60. doi:10.4000/books.pub.621.
10. Håkanson, L. and Jansson, M. (2002) *Principles of Lake Sedimentology*. doi:10.1007/978-3-642-69274-1.
11. Lemmin, U. *et al.* (2016) *Dans les abysses du Léman*. Lausanne: Presses polytechniques et universitaires romandes.
12. Maleval, V. (2000) 'L'étude de l'érosion des berges du lac de Saint-Pardoux : méthodologie et résultats.', in *6ème Conférence Internationale des Limnologues*

d’Expression Française. Clermont-Ferrand, France, p. 70. Available at: https://hal.archives-ouvertes.fr/hal-00924331 (Accessed: 28 October 2021).

13. Moreira, S. *et al.* (2015) ‘Rapport d’activité du suivi scientifique des plans d’eau de Carcans-Hourtin, Lacanau, Cazaux-Sanguinet et Parentis- Biscarrosse’, p. 106.
14. Nedjai, R., Messaoud, N.N. and Bensaid, A. (2016) ‘Evolution de la dynamique hydrosédimentaire des étangs de moyenne montagne sous la double influence urbaine et agricole : cas de l’étang de Haute-Jarrie (Isère : France)’, *Revue Géographique de l’Est*, 56(1–2). doi:10.4000/rge.5695.
15. Papon, P., Maleval, V. and Nedjaï, R. (2005) ‘Le bilan sédimentaire en lac : l’influence de la course du vent sur l’érosion (Lake sedimentary balance : the fetch influence on the erosion)’, *Bulletin de l’Association de géographes français*, 82(2), pp. 213–223.doi:10.3406/bagf.2005.2456.
16. Parpaite, G. (2015) ‘ADLFI. Archéologie de la France - Informations, Nouvelle-Aquitaine’, p.5.
17. Pinay, G. *et al.* (2018) *L’eutrophisation*. éditions Quae. doi:10.35690/978-2-7592-2757-0.
18. Thi, A.D.L. *et al.* (2012) ‘Structure thermique et courantologie du Léman’, *ARCHIVES DES SCIENCES*, p. 15.
19. Touchart, L. (1993) ‘La machine lacustre : l’exemple du Léman’, *Annales de Géographie*, 102(573), pp. 449–471. doi:10.3406/geo.1993.21169.
20. Touchart, L. (2016) ‘Le bilan thermique des étangs : réflexion épistémologique et application aux étangs limousins’, *Annales de géographie*, 708(2), p. 143. doi:10.3917/ag.708.0143.