

## Supplementary Materials

Article

# Eutrophication, Research and Management History of the Shallow Ypacaraí Lake (Paraguay)

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## Communication S1: Cultural significance of Ypacaraí Lake and political implications of its eutrophication in Paraguay

By Gregorio López Moreira and Luigi Hinegk

### The song of Ypacaraí Lake

*Recuerdos de Ypacaraí* (Memories of Ypacaraí) by Zulema de Mirkin (lyrics) and Demetrio Ortiz (music) is one of the most famous Paraguayan songs of all times. First interpreted in 1952, it has since been translated into other languages such as Portuguese and Italian, and recorded around the world by internationally renowned artists like Luis Alberto del Paraná, Caetano Veloso and Julio Iglesias. Over the years, the song has thus become a symbol of Paraguayan culture around the world, also among foreigners.

The song belongs to the Guaranía musical genre, created in 1925 by the renowned Paraguayan musician, José Asunción Flores. With a slow polka-inspired rhythm and characteristic melancholic melodies, Guaranía songs usually tell stories of past, lost loves. *Recuerdos de Ypacaraí* is no exception to this rule, and narrates the story of a couple who met during a warm night by the shore of the **blue** Ypacaraí Lake, but later separated, the male character singing to his *kuñatai* (young woman in Guaraní language), asking her to return.

It is likely that few Paraguayans exist that don't know the song by heart, and in fact, when someone refers to the 'blue lake' in Paraguay, everyone knows exactly which lake they are referring to.

### Festival del Lago (Festival of the Lake)

The city of Ypacaraí has hosted, since 1971, between August and September, the *Festival del Lago* (Festival of the Lake), one of the most important folklore festivals of Paraguay, which has since attracted musicians from all corners of the country, and not only. Many artists, notably from other South American countries such as Argentina, Chile, Brazil and Bolivia, have also taken part in it over the years.

The Festival was briefly interrupted during the last years of the 35-year dictatorship of General Alfredo Stroessner, after its organisers decided to give it a new direction, which was that of becoming an artistic manifestation in defence of human rights, a fact that is also telling of its importance in Paraguayan history.

### Political implications of the eutrophication of Ypacaraí Lake

The lake's eutrophication problem is a highly sensitive issue for Paraguayan citizens, who have learned about it after intense cyanobacterial blooms that occurred in 2012-2013. Since then, they are constantly demanding the intervention of local and national authorities to improve the ecological status of the lake, not only because of its cultural significance, but also because it is one of the very few summer vacation spots that are easily and rapidly accessible to people living in Greater Asunción, the metropolitan area of the capital that concentrates about 40% of the population of landlocked Paraguay. It is also frequent to see inhabitants of the basin taking the matter into their own hands, manually cleaning, for instance, the many streams that eventually discharge their waters into the lake. The national media (and not only) are also regularly reporting the ecological status of Ypacaraí Lake (Table S1), which makes it an even more politically relevant topic.

## Communication S2: Depuration efficiencies of surrounding wetland areas

By Juan Escribá and Carmen Escribá

As mentioned in the article, the Pirayú Stream, the Yukyry Stream and the Salado River are hydraulically connected to wetland areas that together cover some 116 km<sup>2</sup> of the Salado River Basin (Figure 4b), making them an important element to consider when analysing the hydrological system of Ypacaraí Lake.

From February to June 2016, the depurative roles of the Yukyry and Pirayú wetlands that surround Ypacaraí Lake were deeply investigated, both under dry and wet conditions, by INYMA Consult S.R.L., as part of the project called '*Plan de Saneamiento Integral de la Cuenca del Lago Ypacaraí*', conducted by the Italian Consortium Beta Studio S.R.L. - Thetis S.p.A. Results of these investigation highlighted the importance of preserving these ecosystems.

Specifically, a significantly high removal efficiency was measured downstream of the wetland area of the Yukyry Stream. Total nitrogen, total phosphorus and total suspended solid loads, mainly coming from the districts of San Lorenzo, Luque, Capiatá and Itauguá, were found to be largely reduced, respectively, by 65%, 73% and 95%.

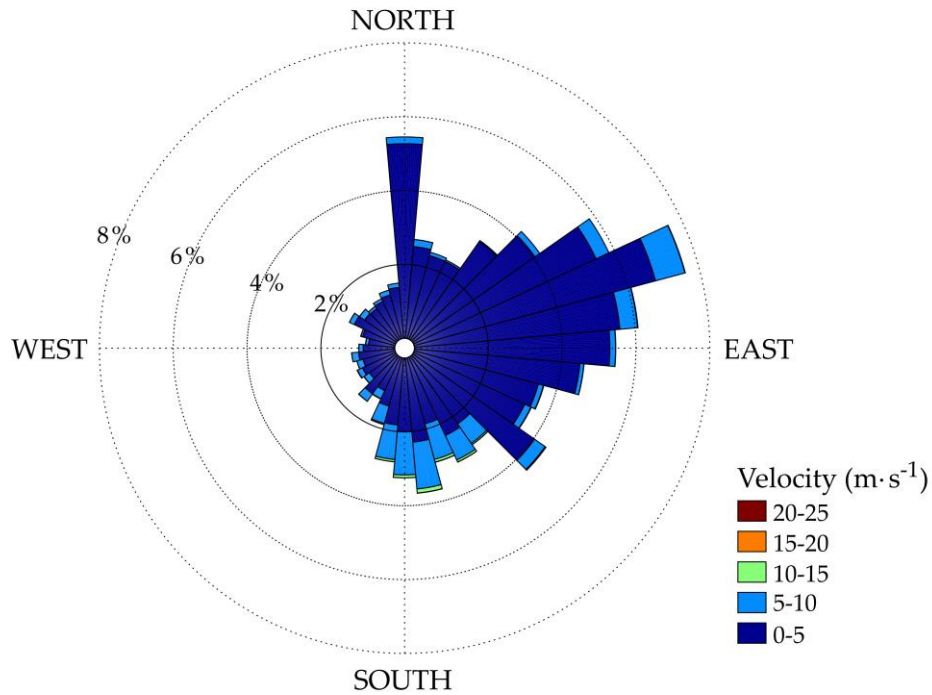
A lower abatement of upstream pollutant concentrations was observed downstream of the wetland area of the Pirayú Stream, its watercourse being heavily channelised. This reduces hydraulic retention time and, consequently, its depurative capacity. The process by which a higher hydraulic retention time provides higher nutrient removal efficiency was confirmed by concentration measurements of total phosphorus and total nitrogen along nine points of the Yukyry Wetlands, which progressively increased with distance from the lake shore.

From the hydrological point of view, the role of wetlands was observed to be crucial for understanding how much water enters and exits the lake at any given time, particularly under wet conditions. In fact, during heavy rainfalls, approximately 100 small ungauged tributaries rise in the wetland area of the Yukyry Stream and begin to directly flow into the lake, starting more than 1600 m away from the lake shore. Under these conditions, ten channels were clearly identified to be tributaries that significantly contribute to the total water input into the lake.

Increasing lake levels under wet conditions, however, can cause a backwater effect on both small ungauged tributaries and the main channel of the Yukyry Stream. The interaction between the lake and its tributaries is mainly determined by the gentle slope that defines the lake's interface with the wetlands. A kind of hydraulic short circuit may thus occur, a process that might also be verified, to a lesser extent, around the mouth of the Pirayú Stream.

**Figure S1: Wind rose for 2014-2017 wind measurements at the San Bernardino Nautical Club (CNSB)**

By Andrea Salvatore



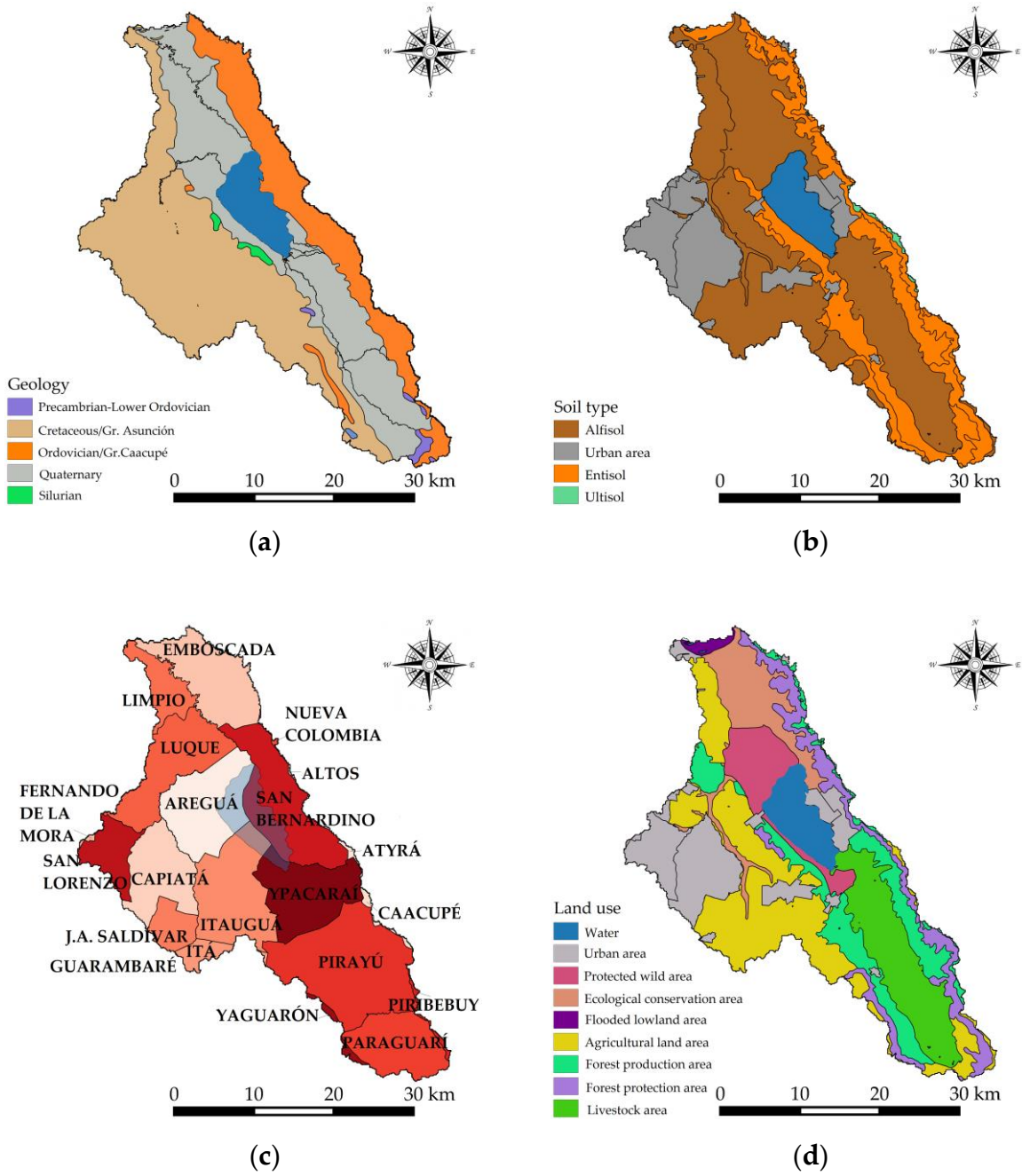
**Figure S1.** Wind rose for 2014-2017 wind data (CNSB station, 25.3142° S 57.2967° W).

**Data source**

Directorate of Meteorology and Hydrology, National Directorate of Civil Aeronautics of Paraguay (DMH-DINAC). Wind records for the San Bernardino Nautical Club (CNSB) station, 25.3142° S 57.2967° W. Database, 2014-2017.

**Figure S2: Supplementary thematic maps of the Salado River Basin**

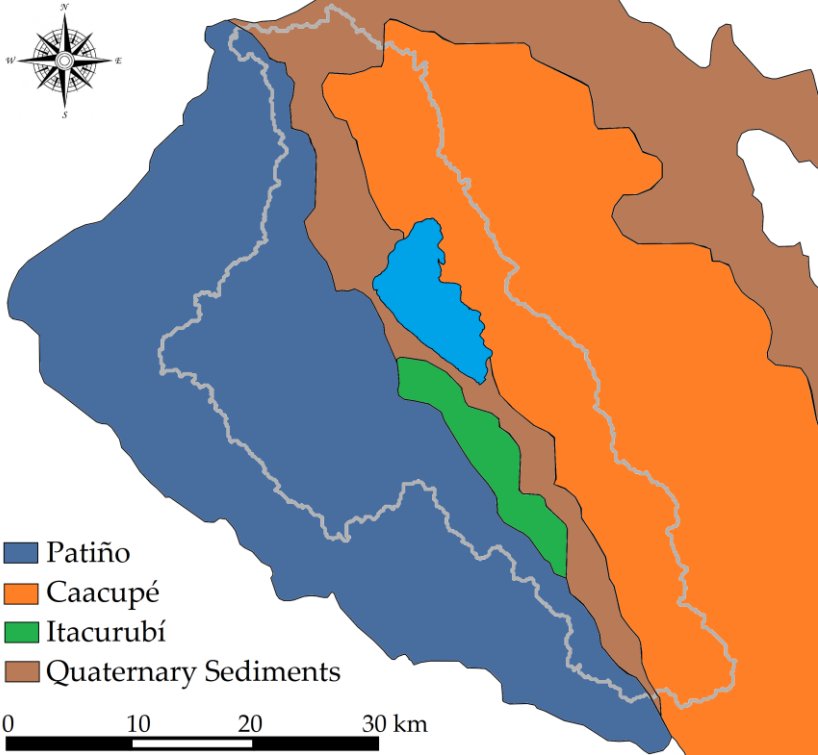
By Luigi Hinegk



**Figure S2.** Supplementary thematic maps of the Salado River Basin: (a) geology; (b) soils; (c) districts; and (d) land use.

**Figure S3: Hydrogeological map of aquifers subjacent to the Salado River Basin**

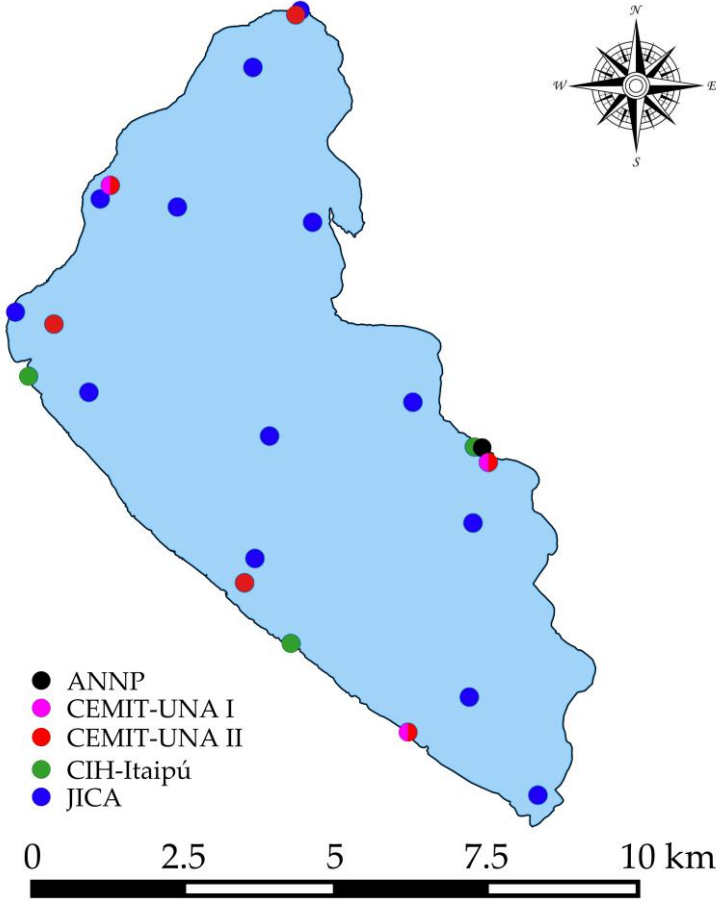
*By Luigi Hinegk*



**Figure S3.** Hydrogeological map of aquifers subjacent to the Salado River Basin.

**Figure S4: Lake sampling/measurement stations of the datasets used in this study**

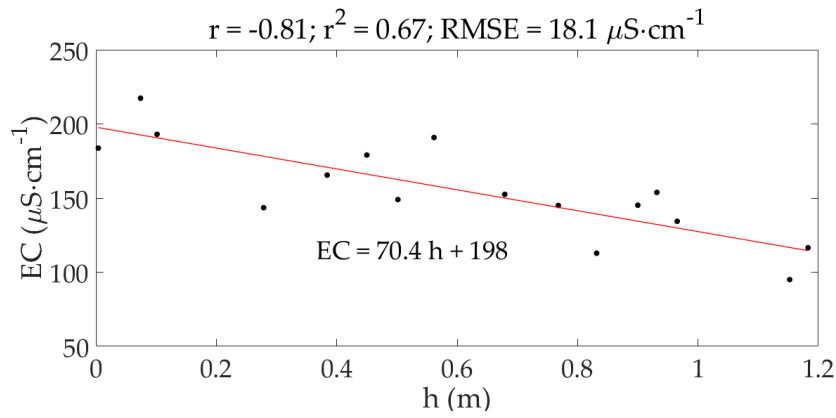
*By Luigi Hinegk*



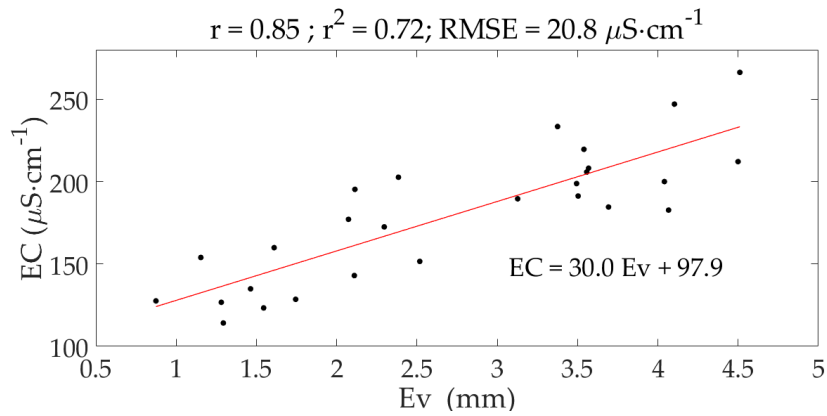
**Figure S4.** Lake sampling/measurement stations of the datasets used in this study.

**Figure S5:** Linear regressions between lake level (h) and electrical conductivity (EC), and between cumulative evaporation (Ev) and EC

By Luigi Hinegk



(a)



(b)

**Figure S5.** Linear regressions between: (a) lake level (h) and electrical conductivity (EC); and (b) cumulative evaporation (Ev) and EC.

**Table S1: Recent journalistic articles on Ypacaraí Lake**

**Table S1.** A few examples of recent journalistic articles on Ypacaraí Lake (Paraguayan and international media)

Title	News agency	Date	Link
Peligroso baño en aguas contaminadas del lago	ABC Color (PY)	15 January 2018	<a href="http://www.abc.com.py/edicion-impres/locales/peligroso-bano-en-aguas-contaminadas-del-lago-1664854.html">http://www.abc.com.py/edicion-impres/locales/peligroso-bano-en-aguas-contaminadas-del-lago-1664854.html</a>
Triste panorama en playa de Areguá	ABC Color (PY)	20 October 2017	<a href="http://www.abc.com.py/edicion-impres/interior/triste-panorama-en-playa-de-aregua-1642166.html">http://www.abc.com.py/edicion-impres/interior/triste-panorama-en-playa-de-aregua-1642166.html</a>
El lago se tiñó de verde	ABC Color (PY)	15 June 2017	<a href="http://www.abc.com.py/edicion-impres/interior/el-lago-se-tino-de-verde-1620419.html">http://www.abc.com.py/edicion-impres/interior/el-lago-se-tino-de-verde-1620419.html</a>
Calor y contaminación en el Lago Ypacaraí	ABC Color (PY)	2 February 2017	<a href="http://www.abc.com.py/fotos/calor-y-contaminacion-en-el-lago-ypacarai-1567040.html">http://www.abc.com.py/fotos/calor-y-contaminacion-en-el-lago-ypacarai-1567040.html</a>
Descenso histórico del Lago Ypacaraí	ABC Color (PY)	4 October 2016	<a href="http://www.abc.com.py/nacionales/descenso-historico-del-lago-ypacarai-1524801.html">http://www.abc.com.py/nacionales/descenso-historico-del-lago-ypacarai-1524801.html</a>
Agua negra del lago en la playa de Areguá	ABC Color (PY)	22 September 2016	<a href="http://www.abc.com.py/edicion-impres/ciudadano-digital/agua-negra-del-lago-en-playa-de-aregua-1520946.html">http://www.abc.com.py/edicion-impres/ciudadano-digital/agua-negra-del-lago-en-playa-de-aregua-1520946.html</a>
Más “proyectos” para recuperar el lago Ypacaraí	ABC Color (PY)	31 August 2016	<a href="http://www.abc.com.py/nacionales/mas-proyectos-para-recuperar-el-lago-1514091.html">http://www.abc.com.py/nacionales/mas-proyectos-para-recuperar-el-lago-1514091.html</a>
Cianobacterias, basura y coliforms fecales comprometen uso del lago	ABC Color (PY)	28 December 2015	<a href="http://www.abc.com.py/edicion-impres/locales/cianobacterias-basura-y-coliforms-fecales-comprometen-uso-del-lago-1439670.html">http://www.abc.com.py/edicion-impres/locales/cianobacterias-basura-y-coliforms-fecales-comprometen-uso-del-lago-1439670.html</a>
Dead fish wash up on shore as lake turns a toxic-greens forcing residences to wear masks to disguise the unbearable stench	Daily Mail (UK)	2 February 2013	<a href="http://www.dailymail.co.uk/news/article-2272629/Ypacarai-Lake-turns-toxic-green.html">http://www.dailymail.co.uk/news/article-2272629/Ypacarai-Lake-turns-toxic-green.html</a>
Paraguayan ‘Jewel’ Lake Loses Its Lustre	IPS (IT)	7 October 2010	<a href="http://www.ipsnews.net/2010/10/paraguayan-jewel-lake-loses-its-lustre/">http://www.ipsnews.net/2010/10/paraguayan-jewel-lake-loses-its-lustre/</a>



**Table S2: Fish species of Ypacaraí Lake (2008-2012 sampling campaign)**

By Mario Insaurrealde, Luigi Hinegk and Gregorio López Moreira

**Table S1. Fish species of Ypacaraí Lake observed during the 2008-2012 sampling campaign.**

Order	Family	Genus	species	Common name (English)	Common name in Paraguay (Spanish or Guaraní)
Beloniformes	Belonidae	<i>Strongylura</i>	sp.	Needlefish	Pez aguja
Characiformes	Acestrorhynchidae	<i>Acestrorhynchus</i>	<i>pantaneiro</i>	Smallscale pike characin	Dientudo
	Anostomidae	<i>Leporinus</i>	<i>pellegrinii</i>	Headstander characin	Boga
	Characidae	<i>Astyanax</i>	<i>asuncionensis</i>	Paraguayan astyanax	Mojarra
			<i>bimaculatus</i>	Twospot astyanax	Mojarra
			<i>eigenmanniorum</i>	Astyanax	Mojarra
			<i>Gymnocorymbus</i>	<i>ternetzi</i>	Black tetra
		<i>Moenkhausia</i>	<i>dichrourea</i>	Bandtail tetra	Piky
			<i>intermedia</i>	Tetra	Piky
		<i>Oligosarcus</i>	<i>oligolepis</i>	Characin	Dientudo
	<i>Tetragonopterus</i>	<i>argenteus</i>	Characin	Mojarrita	
	Curimatidae	<i>Cyphocharax</i>	<i>platanus</i>	Toothless characin	Sabalito plateado
			<i>voga</i>	Toothless characin	Sabalito
		<i>Potamorhina</i>	<i>squamoralevis</i>	Toothless characin	Blanquillo
		<i>Steindacherina</i>	<i>brevipinna</i>	Toothless characin	Sabalito
	Erythrinidae	<i>Hoplerethrinus</i>	<i>unitaeniatus</i>	Aimara	Tarey'i jhú
		<i>Hoplias</i>	<i>malabaricus</i>	Trahira	Tarey'i pará
	Gasteropelecidae	<i>Thoracocharax</i>	<i>stellatus</i>	Spotfin hatchetfish	Pechito
Lebiasinidae	<i>Pyrrhulina</i>	<i>australis</i>	Pencilfish	Piky	
Prochilodontidae	<i>Prochilodus</i>	<i>lineatus</i>	Streaked prochilod	Carimbatá	
Serrasalmidae	<i>Metynnis</i>	<i>maculatus</i>	Spotted metynnis	Palometa	
		<i>Serrasalmus</i>	<i>marginatus</i>	Spotted piranha	Piraña
	<i>Serrasalmus</i>	<i>nattereri</i>	Red-bellied piranha	Piraña	
		<i>spilopleura</i>	Speckled piranha	Piraña	
Triportheidae	<i>Triportheus</i>	<i>paranensis</i>	Tetra	Pirá guyrá	

**Table S2 (continued).** Fish species of Ypacaraí Lake observed during the 2008-2012 sampling campaign.

Order	Family	Genus	species	Common name (English)	Common name in Paraguay (Spanish or Guaraní)	
Clupeiformes	Pristigasteridae	<i>Pellona</i>	<i>flavipinnis</i>	Yellowfin river pellona	Lacha	
	Engraulidae	<i>Lycengraulis</i>	<i>grossidens</i>	Atlantic sabretooth anchovy	Anchoa de río	
Gymnotiformes	Apteronotidae	<i>Apteronotus</i>	<i>albifrons</i>	Black ghost (knifefish)	Morenita	
	Gymnotidae	<i>Gymnotus</i>	<i>carapo</i>	Banded knifefish	Morena	
	Hypopomidae	<i>Brachyhypopomus</i>	<i>brevirostris</i>	Bluntnose knifefish	Morenita	
	Ramphichthyidae	<i>Ramphichthys</i>	<i>rostratus</i>	Sand knifefish	Morenita	
	Sternopygidae	<i>Eigenmannia</i>	<i>virescens</i>	Glass knifefish	Morenita	
Myliobatiformes	Potamotrygonidae	<i>Potamotrygon</i>	<i>brachyura</i>	Short-tailed river stingray	Raya común	
			<i>motoro</i>	Ocellate river stingray (a.k.a. peacock-eye stingray)	Raya común	
Perciformes	Cichlidae	<i>Aequidens</i>	<i>tetramerus</i>	Saddle cichlid	Pirá mbokajá	
			<i>Bujurquina</i>	<i>vittata</i>	Banded acara	Pirá mbokajá
			<i>Crenicichla</i>	<i>lacustris</i>	Pike cichlid	Juanita
				<i>lepidota</i>	Pike cichlid	Juanita
			<i>Gymnogeophagus</i>	<i>balzani</i>	Argentine humphead	Chanchita
			<i>Hypselecara</i>	<i>temporalis</i>	Emerald cichlid	Pirá mbokajá
	Sciaenidae	<i>Oreochromis</i>	<i>niloticus</i>	Nile tilapia	Tilapia	
			<i>Pachyurus</i>	<i>bonariensis</i>	La Plata croaker	Corvina
	<i>Plagioscion</i>	<i>ternetzi</i>	Freshwater croaker	Corvina		
Pleuronectiformes	Achiridae	<i>Achirus</i>	<i>lineatus</i>	Lined sole	Lenguado de río	
Siluriformes	Aspredinidae	<i>Bunocephalus</i>	<i>doriai</i>	Banjo catfish	Guitarrita	
	Auchenipteridae	<i>Aucheipterus</i>	<i>nuchalis</i>	Driftwood catfish	Pirá bicicleta	
	Auchenipteridae	<i>Tracheylopterus</i>	<i>galeatus</i>	Driftwood catfish	Apretador	
	Callichthyidae	<i>Callichthys</i>	<i>callichthys</i>	Cascarudo (armored catfish)	Cascarudo	
			<i>Corydoras</i>	<i>paleatus</i>	Peppered corydoras	Tachuela
	<i>Hoplosternum</i>	<i>littorale</i>	Atipa	Cascarudo		

**Table S2 (continued).** Fish species of Ypacaraí Lake observed during the 2008-2012 sampling campaign.

Order	Family	Genus	species	Common name (English)	Common name in Paraguay (Spanish or Guaraní)	
Siluriformes (continued)	Doradidae	<i>Ossancora</i>	<i>eigenmanni</i>	Thorny catfish	Armado	
		<i>Platydoras</i>	<i>costatus</i>	Raphael catfish	Armado	
		<i>Rhinodoras</i>	<i>dorbignyi</i>	Thorny catfish	Armado	
		<i>Trachydoras</i>	<i>paraguayensis</i>	Thorny catfish	Armadito	
	Heptapteridae	<i>Pimelodella</i>	<i>gracilis</i>		Graceful pimelodella	Mandi'i (bagrecito)
			<i>laticeps</i>		Three-barbeled catfish	Mandi'i (bagrecito)
		<i>Rhamdia</i>	<i>quelen</i>	South American catfish	Ñurundi'a	
	Loricariidae	<i>Hypoptopoma</i>	<i>gulare</i>		Armored catfish	Vieja de agua
		<i>Hypostomus</i>	<i>albopunctatus</i>		Armored catfish	Vieja de agua
			<i>borellii</i>		Armored catfish	Vieja de agua
			<i>niceforoi</i>		Armored catfish	Vieja de agua
			<i>plecostomus</i>		Suckermouth catfish	Vieja de agua
			<i>robinii</i>		Teta	Vieja de agua
		<i>Loricaria</i>	<i>cataphracta</i>		Armored catfish	Vieja de agua
		<i>Loricariichthys</i>	<i>labialis</i>		Armored catfish	Vieja de agua
			<i>maculatus</i>		Armored catfish	Vieja de agua
		<i>Paraloricaria</i>	<i>vetula</i>		Armored catfish	Vieja de agua
		<i>Pseudohemiodon</i>	<i>laticeps</i>		Armored catfish	Vieja de agua
		<i>Pterygoplichthys</i>	<i>anisitsi</i>		Armored catfish	Vieja de agua
		<i>Rhinelepis</i>	<i>aspera</i>		Armored catfish	Vieja
<i>Rineloricaria</i>		<i>parva</i>		Armored catfish	Vieja de agua	
<i>Sturisoma</i>		<i>robustum</i>		Armored catfish	Vieja de agua	
Pimelodidae		<i>Hypophthalmus</i>	<i>edentatus</i>		Highwaterman catfish	Bagre Rosado
	<i>Iheringichthys</i>	<i>labrosus</i>		Long-whiskered catfish	Bagre trompudo	
	<i>Pimelodus</i>	<i>maculatus</i>		Long-whiskered catfish	Mandi'i (bagre)	
		<i>ornatus</i>		Long-whiskered catfish	Mandi'i (bagre)	

**Table S3: Phytoplankton of Ypacaraí Lake**

By Antonio Benítez, Claudia Ávalos, Inocencia Peralta, Luigi Hinegk and Gregorio López Moreira

**Table S3a.** Green algae of Ypacaraí Lake

Division	Class	Order	Family	Genus	species	
Chlorophyta	Chlorophyceae	Chlamydomonadales/Chlorococcales	Chlorococcaceae	<i>Chlorococcum</i>	sp.	
			Sphaeropleales	Hydrodictyceae	<i>Pediastrum</i>	<i>duplex</i>
						sp.
				Neochloridaceae	<i>Golenkinia</i>	sp.
				Scenedesmaceae	<i>Scenedesmus</i>	<i>quadricauda</i>
						sp.
				<i>Tetradesmus</i>	sp.	
		Tetrasporales	Selenastraceae		<i>Ankistrodesmus</i>	sp.
					<i>Monoraphidium</i>	<i>contortum</i>
						sp.
Trebouxiophyceae	Chlorellales	Tetrasporales	Palmellaceae/Sphaerocystidaceae	<i>Sphaerocystis</i>	<i>schroeteri</i>	
			Chlorellaceae	<i>Actinastrum</i>	<i>aciculare</i>	
						sp.
		<i>Chlorella</i>		sp.		
				<i>Dictyosphaerium</i>	sp.	
			Oocystales	Oocystaceae	<i>Oocystis</i>	sp.
Charophyta	Conjugatophyceae	Zygnematales	Closteriaceae	<i>Closterium</i>	<i>macilentum</i>	
						<i>moniliferum</i>
						sp.
			Desmidiaceae	<i>Cosmarium</i>	sp.	
				<i>Staurastrum</i>	sp.	
				<i>Stauroidesmus</i>	sp.	
	Mesotaeniaceae	<i>Netrium</i>	sp.			

Table S3b. Diatoms of Ypacaraí Lake

Phylum (Subphylum)	Class	Subclass	Order	Family	Genus	species var. variety		
Ochrophyta (Khakista)	Bacillariophyceae	Bacillariophycidae	Bacillariales	Bacillariaceae	<i>Nitzschia</i>	sp.		
			Cymbellales	Cymbellaceae	<i>Cymbella</i>	sp.		
				Gomphonemataceae	<i>Gomphonema</i>	sp.		
			Eunotiales	Eunotiaceae	<i>Eunotia</i>	sp.		
			Naviculales	Naviculaceae	<i>Navicula</i>	sp.		
				Pinnulariaceae	<i>Pinnularia</i>	sp.		
				Stauroneidaceae	<i>Stauroneis</i>	sp.		
			Surirellales	Surirellaceae	<i>Cymatopleura</i>	<i>solea</i>		
					<i>Surirella</i>	<i>angustata</i>		
			Coscinodiscophycidae	Aulacoseirales	Aulacoseiraceae		<i>Aulacoseira</i>	<i>ambigua</i>
								<i>distans</i>
								<i>granulata</i> var. <i>angustissima</i>
								<i>granulata</i> var. <i>granulata</i>
Fragilariophycidae	Fragilariales	Fragilariaceae			<i>Cyclotella</i>	sp.		
					<i>Fragilaria</i>	sp.		
					<i>Synedra</i>	<i>ulna</i>		

Table S3c. Cryptophytes of Ypacaraí Lake

Phylum	Class	Order	Family	Genus	species
Cryptophyta	Cryptophyceae	Cryptomonadales	Cryptomonadaceae	<i>Cryptomonas</i>	<i>obovata</i>
					<i>reflexa</i>
					sp.
		Pyrenomonadales	Pyrenomonadaceae	<i>Rhodomonas</i>	sp.
			Chroomonadaceae	<i>Chroomonas</i>	sp.
			Geminigeraceae	<i>Plagioselmis</i>	<i>nannoplanctica</i>

Table S3d. Cyanobacteria of Ypacaraí Lake

Class	Subclass	Order	Family (Subfamily)	Genus	species f. forma				
Cyanophyceae	Nostocophycideae	Nostocales	Nostocaceae	<i>Anabaena</i>	<i>affinis</i>				
					<i>circinalis</i>				
					<i>crassa</i>				
					<i>spiroides</i>				
					sp.				
					<i>Anabaenopsis</i>	<i>elenkinii f. circularis</i>			
					<i>Aphanizomenon</i>	sp.			
				<i>Cylindrospermopsis</i>	<i>raciborskii</i>				
				<i>Raphidiopsis</i>	<i>curvata</i>				
				Oscillatoriophycideae	Chroococcales	Chroococcales	Chroococcaceae	<i>Chroococcus</i>	<i>turgidus</i>
							Gomphosphaeriaceae	<i>Gomphosphaeria</i>	sp.
							Microcystaceae	<i>Microcystis</i>	<i>aeruginosa</i>
								<i>flosaquae</i>	
								<i>novacekii</i>	
				<i>panniformis</i>					
				<i>protocystis</i>					
				<i>wesenbergii</i>					
	Oscillatoriales	Oscillatoriales	Oscillatoriaceae	<i>Lyngbya</i>	sp.				
				<i>Oscillatoria</i>	sp.				
			Phormidiaceae (Phormidioideae)	<i>Phormidium</i>	<i>foveolarum</i>				
Synechocophycideae	Synechococcales	Synechococcales	Merismopediaceae (Merismopedioideae)	<i>Aphanocapsa</i>	<i>delicatissima</i>				
					sp.				
					<i>Merismopedia</i>	<i>convoluta</i>			
					<i>tenuissima</i>				
					sp.				
			Pseudanabaenaceae (Pseudanabaenoideae)	<i>Pseudanabaena</i>	<i>limnetica</i>				
					<i>mucicola</i>				
					sp.				
			Synechococcoideae	<i>Synechococcus</i>	sp.				

Table S3e. Other phytoplankton groups of Ypacaraí Lake

Phylum (Subphylum/Infraphylum)	Class (Subclass)	Order	Family	Genus	species
<b>Dinoflagellates</b>					
Myzozoa (Dinozoa/Dinoflagellata)	Dinophyceae	Gonyaulacales	Ceratiaceae	<i>Ceratium</i>	<i>furcoides</i> sp.
		Gymnodiniales	Gymnodiniaceae	<i>Gymnodinium</i>	sp.
<b>Euglenids</b>					
Euglenozoa	Euglenoidea (Euglenia)	Euglenida	Euglenaceae	<i>Euglena</i>	<i>sanguinea</i> sp.
				<i>Strombomonas</i>	sp.
			Phacaceae	<i>Trachelomonas</i>	sp.
				<i>Phacus</i>	sp.
<b>Synurids</b>					
Ochrophyta (Phaeista)	Chrysophyceae	Synurales	Mallomonadaceae	<i>Mallomonas</i>	sp.

**Table S4: Zooplankton of Ypacaraí Lake**

By Antonio Benítez, Claudia Ávalos, Inocencia Peralta, Luigi Hinegk and Gregorio López Moreira

**Table S4.** Zooplankton of Ypacaraí Lake

Phylum (Subphylum)	(Superclass) Class (Subclass/Infraclass)	(Superorder) Order (Suborder)	Family	Genus	species
<b>Cladocerans</b>					
Arthropoda (Crustacea)	Branchiopoda (Phyllopoda/Diplostraca)	Cladocera (Anomopoda)	Chydoridae	<i>Alona</i>	<i>cambouei</i>
				<i>Leydigia</i>	<i>propinqua</i>
			Bosminidae	<i>Bosmina</i>	<i>freyi</i>
					sp.
			Daphniidae	<i>Ceriodaphnia</i>	<i>cornuta</i>
					<i>quadrangula</i>
				<i>Daphnia</i>	<i>magna</i>
					<i>pulex</i>
					sp.
			Macrothricidae	<i>Macrothrix</i>	sp.
			Moinidae	<i>Moina</i>	<i>micrura</i>
					<i>minuta</i>
					<i>rostrata</i>
<i>Moinodaphnia</i>	<i>macleayi</i>				
Sididae	<i>Diaphanosoma</i>	sp.			
		<i>Sida</i>	<i>crystallina</i>		
<b>Copepods</b>					
Arthropoda (Crustacea)	(Multicrustacea) Hexanauplia (Copepoda)	(Gymnoplea)	Unidentified	<i>Unidentified</i>	sp.
		Calanoida			
		(Podoplea)	Cyclopidae	<i>Cyclops</i>	sp.
		Cyclopoida			



Table S4 (continued). Zooplankton of Ypacaraí Lake

Phylum	Class (Subclass)	(Superorder) Order	Family	Genus	species subspecies			
<b>Rotifers</b>								
Rotifera	Eurotatoria (Monogononta)	(Gnesiotrocha) Flosculariaceae	Trochosphaeridae	<i>Filinia</i>	<i>longiseta limnetica</i> <i>terminalis</i> sp.			
			(Pseudotrocha) Ploima	Asplanchnidae	<i>Asplanchna</i>	<i>herricki</i> sp.		
		Brachionidae				<i>Brachionus</i>	<i>calyciflorus</i> sp.	
						<i>Keratella</i>	<i>americana</i> <i>cochlearis</i> <i>quadrata</i> sp.	
							<i>Platyias</i>	<i>quadricornis</i>
							Gastropodidae	<i>Ascomorpha</i>
						Nommatidae		
		Synchaetidae				<i>Polyarthra</i>	<i>dolichoptera</i> <i>remata</i>	
						Trichocercidae	<i>Trichocerca</i>	<i>cylindrica</i> sp.
			Eurotatoria (Bdelloidea)	Bdelloida	Philodinidae	<i>Philodina</i>	sp.	

**Table S5: Reviewed studies on Ypacaraí Lake and other water bodies of its hydrological system**

By Gregorio López Moreira and Luigi Hinegk

**Table S5.** Reviewed studies on Ypacaraí Lake and other water bodies of its hydrological system

Study	Authors/Agency	Year
Investigaciones Analíticas en el Lago Ypacaraí	F. S. Facetti Villasanti	1945
Investigaciones de trazas de Elementos en Lago Ypacaraí	J. F. Facetti-Masulli and F. S. Facetti Villasanti	1965
Aspectos bioecológicos del lago Ypacaraí	N. González Romero	1973
Calidad de agua en el lago Ypacaraí. Informe a SENASA.	J. F. Facetti Masulli, C. López Rogelio López, F. J. Schade	1978
Algunos peces del lago Ypacaraí	N. González Romero and G. Arzamendia Gómez	1979
Interpretación geofísica y geológica del Valle de Ypacaraí (Paraguay) y su formación	J. M. DeGraff, R. Franco, D. Orué	1981
Estudios Hídricos en el lago Ypacaraí –Informe al Municipalidad de San Bernardino.	J. F. Facetti Masulli and Hydroconsult taskforce.	1984
Estudio Limnológico del lago Ypacaraí. Proyecto y presupuesto para el saneamiento.	PROSER (Spanish consultant company)	1983
Estudio Limnológico del Lago Ypacaraí	D. G. Torres and N. G. Romero	1986
Estudio Limnológico del Lago Ypacaraí	Barbara Ritterbusch	1988
The Study on Water Pollution Control Plan for the Lake Ypacaraí and its Basin: Main and Supporting Reports I-V	JICA	1988-1989
Environmental Evaluation of the Lake Ypacaraí Watershed and the Bay of Asunción	Dames & Moore, Inc.	1995
Estudios de Evaluación del Impacto de la instalación de un Umbral de Restitución en el Lago Ypacaraí	J. F. Facetti-Masulli, F. Lozano, F. Flores	1995
Misión de identificación para la gestión ecológica de la cuenca del lago Ypacaraí-Paraguay. Detención y reversión del proceso de deterioro de la cuenca del lago Ypacaraí.	G. Bendoricchio for ARPA-Veneto (Italy)	2000
Estructura institucional para la gestión integrada de la cuenca del Lago Ypacaraí	M. C. Barboza for GTZ	2000
Estudios Hídricos en el Lago Ypacaraí	J. F. Facetti-Masulli et al.	2005
Hydrological Aspects of Lake Ypacaraí, Eastern Paraguay. A case of study.	J. F. Facetti-Masulli et al.	2006
Hydrological Aspects of Lake Ypacaraí, Eastern Paraguay. A case of study.	J. F. Facetti Masulli	2006
Proyecto de “Control y mejoramiento de la calidad de las aguas de la cuenca del Lago Ypacaraí y Río Paraguay”	JICA-SEAM-DIGESA	2006
Balance Hídrico Integrado del Acuífero Patiño	R. Monte Domecq and J. Báez	2007
Levantamiento Hidrotopográfico del Lago Ypacaraí	J. M. Sekatcheff Snead	2007

**Table S5 (continued).** Reviewed studies on Ypacaraí Lake and other water bodies of its hydrological system

Study	Authors/Agency	Year
Interacción Agua superficial-subterránea en la Cuenca del Arroyo Yukyry y el Sistema Acuífero Patiño	R. Monte Domecq, A. Wehrle and A. Zaldívar	2008
Planificación y Manejo de la Cuenca del Ypacaraí en relación al Área Metropolitana de Asunción	K. Spezini Stanley	2009
Aspectos Geológicos y su Relación con la Gestión Sustentable de la Cuenca del Lago Ypacaraí	A. Castillo Clerici for DOSAPAS-SENASA	2012
Monitoreo de Calidad de Agua por Campañas de Muestreo en el Lago Ypacaraí: Serie de informes	CEMIT-UNA for the Itaipú Binational Entity	2012-ongoing
Reflexiones sobre el Estado Ambiental de la Cuenca del Lago Ypacaraí. Alternativas de solución	J. F. Facetti	2013
Manual técnico para la gestión del saneamiento ambiental (Tomo 1)	J. F. Facetti	2013
Aspectos Limnológicos del lago Ypacaraí. Estudios Hídricos III	J. F. Facetti-Masulli et al.	2014
Plan de Saneamiento Integral de la Cuenca del Lago Ypacaraí: Diagnóstico de la situación actual del Lago Ypacaraí y su cuenca	Beta Studio-Thetis for MOPC-BID	2015
Servicio de apoyo a los trabajos de batimetría en el Lago Ypacaraí	R. Monte Domecq	2015
Determinación de la Línea de Ribera del Lago Ypacaraí	R. Monte Domecq	2015
Plan de Saneamiento Integral de la Cuenca del Lago Ypacaraí: Modelación matemática e identificación de acciones y medidas de mitigación	Beta Studio-Thetis for MOPC-BID	2016
Informe de Evaluación de Nutrientes y Eficiencias de Depuración de los Humedales del Lago Ypacaraí	J. Escribá Ticoulat and C. Escribá (Beta Studio - Thetis for MOPC-BID)	2016
Reserva de Recursos Manejados Lago Ypacaraí y el Sistema de Humedales Adyacentes. Plan de manejo 2007-2017	MOPC	2017
Estudio del comportamiento del viento en San Bernardino	S. Méndez	2017
Influencia de factores físico-químicos sobre la biodiversidad de cianobacterias en el Lago Ypacaraí durante el periodo 2012-2014	G. Benítez Rodas, G. Villalba Duré, C. Ávalos de Enciso et al.	2017
Primer reporte de floración por Ceratium furcoides (Levander) Langhans en el Lago Ypacaraí – Departamento Central, Paraguay	G. Benítez Rodas, M. Dos Santos, A. Núñez et al.	2017
Caracterização das ondas no lago Ypacaraí (Estudo Exploratorio) / Waves characterization in the Ypacaraí Lake (Exploratory Study)	F. Bock, F. Facetti and M. Pereira	2017
Hydro-thermodynamic modelling of the shallow Lake Ypacaraí (Paraguay)	A. Salvadore	2018
Water and nutrient balance of Lake Ypacaraí and Salado River Basin (Paraguay): Data analysis and modeling	L. Hinegk	2018

**Table S6: Sampling/measurement dates and variables of the JICA, CEMIT-UNA I and CEMIT-UNA II datasets**

By Luigi Hinegk

**Tables S6a-c.** Existence (✓) or not (✗) of data of nine limnological variables considered in this study, for each sampling/measurement date of the campaigns conducted by: (a) JICA; (b) CEMIT-UNA I (funded by UNA); and (c) CEMIT-UNA II (funded by Itaipú).

<b>6a) JICA (16 February 1988 to 3 March 1989)</b>									
Date	Tw	h*	SS	SD	TP	TN	DO	Chl-a	Turbidity
16/02/1988	✓	✓	✓	✓	✓	✗	✓	✓	✗
02/03/1988	✓	✓	✓	✓	✓	✗	✓	✓	✗
22/03/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
20/04/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
31/05/1988	✓	✓	✗	✓	✓	✗	✓	✓	✗
21/06/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
08/07/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
18/08/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
27/09/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
27/10/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
06/12/1988	✓	✓	✓	✓	✓	✓	✓	✓	✗
10/01/1989	✓	✓	✓	✓	✓	✓	✓	✓	✗
15/02/1989	✓	✓	✓	✓	✓	✓	✓	✓	✗
03/03/1989	✓	✓	✓	✓	✓	✓	✓	✓	✗

\* Indicates data owned by ANNP (from 16 February 1988 to 6 April 2016) or CIH-Itaipú (from 22 June 2016 to 26 September 2017).

<b>6b) CEMIT-UNA I (5 October 2012 to 29 April 2014)</b>									
Date	Tw	h*	SS	SD	TP	TN	DO	Chl-a	Turbidity
05/10/2012	✓	✗	✗	✓	✓	✓	✗	✗	✓
16/10/2012	✓	✗	✗	✓	✓	✓	✗	✗	✓
25/10/2012	✓	✗	✗	✓	✓	✓	✗	✗	✓
13/11/2012	✓	✗	✗	✓	✓	✓	✗	✗	✓
16/01/2013	✓	✗	✗	✓	✓	✓	✗	✗	✓
06/03/2013	✓	✓	✗	✓	✓	✓	✗	✗	✓
17/05/2013	✓	✗	✗	✓	✓	✓	✗	✗	✓
28/08/2013	✓	✓	✗	✓	✓	✓	✗	✗	✓
19/11/2013	✓	✓	✗	✓	✓	✓	✗	✗	✓
25/03/2014	✓	✓	✗	✓	✓	✓	✗	✗	✓
29/04/2014	✓	✓	✗	✓	✓	✓	✗	✗	✓

\* Indicates data owned by ANNP (from 16 February 1988 to 6 April 2016) or CIH-Itaipú (from 22 June 2016 to 26 September 2017).

<b>6c) CEMIT-UNA II (1 December 2014 to 26 September 2017)</b>									
<b>Date</b>	<b>Tw</b>	<b>h*</b>	<b>SS</b>	<b>SD</b>	<b>TP</b>	<b>TN</b>	<b>DO</b>	<b>Chl-a</b>	<b>Turbidity</b>
01/12/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓
09/02/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓
07/04/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓
03/06/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓
11/08/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓
21/10/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓
16/12/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓
04/02/2016	✓	✓	✓	✓	✓	✓	✓	✓	✓
06/04/2016	✓	✓	✓	✓	✓	✓	✓	✓	✓
22/06/2016	✓	✓	✓	✓	✓	✓	✓	✓	✓
17/08/2016	✓	✓	✓	✓	✓	✓	✓	✓	✓
28/10/2016	✓	✓	✓	✓	✓	✓	✓	✓	✓
26/12/2016	✓	✓	✓	✓	✓	✓	✓	✓	✓
27/03/2017	✓	✓	✓	✓	✓	✓	✓	✓	✓
29/06/2017	✓	✓	✓	✓	✓	✓	✓	✓	✓
26/09/2017	✓	✓	✓	✓	✓	✓	✓	✓	✓

\* Indicates data owned by ANNP (from 16 February 1988 to 6 April 2016) or CIH-Itaipú (from 22 June 2016 to 26 September 2017).