Advanc. Limnol. **65**, p. 309–319
Freshwater Phytoplankton of Argentina

# Phytoplankton from natural water bodies of the Patagonian Plateau

Irina Izaguirre* & Juan F. Saad

With 3 figures and 2 tables

**Abstract:** The Patagonian Plateau is one of the most arid regions of Argentina, where mean annual rainfall ranges between 100 and 200 mm. This region contains different types of water bodies: large artificial lakes, permanent natural lakes, rivers and temporary ponds. In comparison with the Andean lakes, the available information on phytoplankton from the natural water bodies of the steppe is scarcer. In general, most lakes in this region range from mesotrophic to eutrophic. Limnological regional studies have shown that nutrient concentrations and algal biomass of the lakes located in the ecotone zone (pre-Andean) and in the Patagonian Plateau are higher compared with those registered in the Andean lakes. The dominant algal groups in most of the surveyed water bodies of the steppe are usually Chlorophyceae, Bacillariophyceae and Cryptophyceae. Cyanobacteria seem to be more abundant in some lakes of the steppe with fish introduction.

**Keywords:** Phytoplankton, lakes, shallow lakes, Patagonian Plateau, fish introduction

## Introduction

The Argentinean Patagonia is a region delimited by the Colorado River to the North, the Atlantic Ocean to the East, the Andes to the West and parallel 54° to the South. This large region may be divided into two major subregions: Andean Patagonia and Patagonian Plateau (Díaz et al. 2000).

The Patagonian plateau or Patagonian steppe is a complex landscape mainly characterized by a basaltic plateau and tectonically uplifted pebble fans (Iriondo 1989). It encompasses different types of water bodies, including reservoirs, permanent natural lakes and temporary ponds. Most natural lakes were originated by tectonic activity or by eolic erosion, and are shallower than the Andean lakes. They are usually rounded or oval and have poorly developed coastal profiles. Compared with the Andean lakes, those located in the steppe are char-

**Authors' address:**
Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, IEGEBA (UBA-CONICET), C1428EHA, Buenos Aires, Argentina.
*Corresponding author: iri@ege.fcen.uba.ar

DOI: 10.1127/1612-166X/2014/0065-0048 1612-166X/2014/0065-0048 $ 3.00

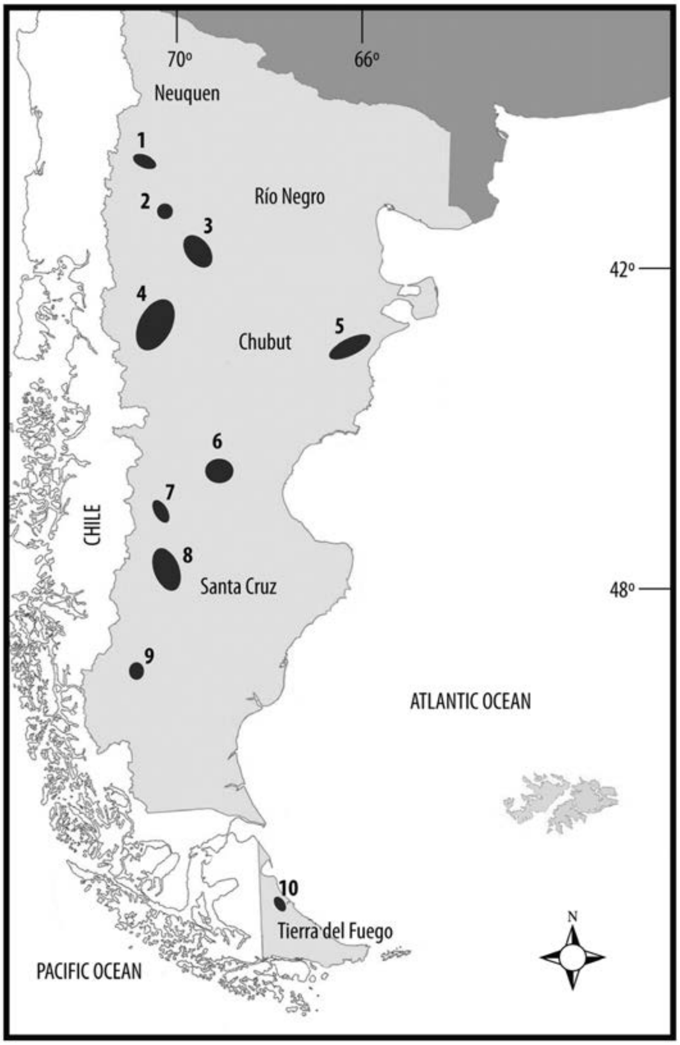


**Fig. 1.** Geographic location of the aquatic systems studied in the Patagonian steppe. 1: Northern area of Laguna Blanca and surroundings (lakes Blanca, Jabón and El Burro); 2: Central area of the Nothofagus forest-Patagonian steppe ecotone (lakes El Chancho and Los Juncos); 3: Central steppe area (lakes Ñe Luan, Carrilaufquen Chica, Carrilaufquen Grande and NF1); 4: Lakes Chultas, Rosario, Esquel, Zeta, Brecham; 5: Florentino Ameghino Reservoir and shallow lake Cacique Chiquichano; 6: Lakes Musters and Colhue Huapi; 7: Lake Ghio and surroundings; 8: Lakes Cardiel, Del Mie, Volcán 2-4, shallow lakes of the Strobel Plateau, P. Moreno 1-4; 9: shallow lakes near El Chalten; 10: shallow lakes near Rio Grande.

acterized by higher concentrations of total phosphorus and chlorophyll *a* (Quirós & Cuch 1985), ranging from mesotrophic to eutrophic (Quirós & Drago, 1999).

From the Andes to the steppe there is a decreasing gradient of moisture, changing the climate from "Andean humid cold" in the West to "Patagonian arid" towards the East. In the steppe the annual rainfall ranges from 100 to 200 mm, being one of the most arid regions of Argentina (Cabrera 1976). The soils are typically alkaline with high salt contents (Speck et al. 1982).

The aim of this article is to gather the existing information on phytoplankton from natural water bodies of the Patagonian steppe. The location of the systems mentioned in this article is shown in Fig. 1.

## Phytoplankton studies for the region in the 20th century

Studies conducted in the water bodies from the Patagonian Plateau are comparatively much less numerous than those of the Andean lakes. With the exception of the investigations carried out in the reservoirs, that in some cases involved various consecutive yearly cycles (see Casco et al. 2014), the available information about phytoplankton of the natural lakes located in the Patagonian steppe is rather fragmentary.

The first sampling-trips carried out through Patagonia in the 20th century gave rise to many floristic papers, but most of these surveys were mainly restricted to the phytoplankton composition of Andean lakes (e.g. Thomasson 1959, 1963). A previous floristic report published by Seckt (1950–56) also included algal species collected in some lotic systems and many shallow lakes (some of them in the steppe zone).

Izaguirre et al. (1990) carried out the first comparative analysis of the phytoplankton structure (net size fraction: > 20 µm) of 20 Patagonian lakes, among which 8 are in the pre-Andean and Patagonian plateau region (Fig. 1): Lakes Rosario, Musters, Colhue Huapi, Chultas, Esquel, Zeta, Brecham and the Florentino Ameghino Reservoir. This study showed that the phytoplankton abundance was significantly lower in the Andean lakes than in the steppe ones. A cluster analysis based on the abundance of the phytoplankton species allowed distinguishing two groups of lakes: the oligotrophic Andean lakes and meso-eutrophic lakes from the Pre-Andean zone and Patagonian steppe, whose algal assemblages were characteristic of the trophic state of each one of these two groups. In the Patagonian Plateau the dominant algal classes were Bacillariophyceae and Chlorophyceae. The average species diversity was lower in the steppe lakes than in the Andean lakes (Izaguirre 1991).

Later on, Izaguirre (1993) analyzed phytoplankton samples (net fraction) collected every three months from 1984 to 1985 in six of the water bodies included in the previous study (Chultas, Musters, Colhue Huapi, Rosario, Esquel and Florentino Ameghino). In this research deep phytoplankton samples were also analyzed for the deeper lakes (Chultas, Musters and Rosario). Bacillariophyceae and Chlorophyceae were the dominant algal classes in lakes Musters, Rosario and Florentino Ameghino. Chlorophyceae predominated all along the year in lakes Colhue Huapi and Esquel. Lake Chultas showed the highest variation in its algal structure during the study period, with dominance of Cyanobacteria, Bacillariophyceae or Chrysophyceae, depending on the season and the depth. Abundance of phytoplankton > 20 µm varied along the year from < 10 to 870 ind. $ml^{-1}$, registering the highest values in deep layers; algal biomass ranged between less than 10 mg $m^3$ to 5300 mg $m^3$. The dominant species differed in the lakes: *Pediastrum kawraskyi* (Syn: *Pseudopediastrum kawraskyi*) in Lake Colhue Huapi; *Gomphosphaeria lacustris* in Lake Chultas; *Chlamydomonas* spp. in Lake Esquel; *Aulacoseira granulata* in the reservoir F. Ameghino; *Asterionella formosa*, *Stephanodiscus niagarae* and *P. kawraskyi* in Lake Musters; *Asterionella formosa* and *Aulacoseira granulata* in Lake Rosario. Interestingly, studies based on numerical taxonomy by Tell & Mataloni (1990) demonstrated that the species identified in lakes Musters and Colhue Huapi as *P. kawraskyi* were actually three different linked taxa (namely complex: *kawraskyi – mustersii – patagonicum*). The algal assemblages registered in the lakes are typical of mesotrophic and eutrophic systems (*sensu* Reynolds 1998, Reynolds et al. 2000 and cites therein).

From 1987 to 1992 summer samples were taken in 21 Patagonian lakes by Díaz et al. (2000), including two sallow lakes located in the Patagonian steppe of Rio Negro Province (Carrilaufquen Grande and Carrilaufquen Chica). In this study, net and nano-phytoplankton size fractions were analyzed. Regarding chemical features, the steppe lakes differed from those located near of the mountains by their higher conductivity values and ammonia values. In agreement with the previous results obtained by Izaguirre et al. (1990), this study showed that the steppe lakes exhibited higher net phytoplankton densities and lower species diversities than the Andean lakes. Besides, as the study conducted by Díaz et al. (2000) included both net and nanoplankton size fractions, as well as algal taxa biomass, a more detailed grouping was obtained, which enabled the differentiation of the Andean oligotrophic lakes. The most representative phytoplankton taxa reported in this paper for the two steppe shallow lakes were: *Anabaena* spp., *Chroococcus* spp., *Planktolyngbya limnetica*, *Oscillatoria* spp., *Dictyosphaerium pulchellum*, *Franceia* spp., *Monoraphidium* spp., *Pediastrum boryanum*, *P. duplex*, *Planctonema lauterbornii*, *Scenedesmus* spp., *Tetraedron minimum*, *Lepocinclis* spp., *Trachelomonas* spp., *Cryptomonas* spp., *Asterionella formosa*, *Aulacoseira granulata*, *Navicula* spp. and *Fragilaria crotonensis*.

Different studies were conducted from 1989 to 1992 in the Florentino Ameghino Reservoir (see Casco et al. 2014) (e.g. Sastre et al. 1991, Sastre et al. 1994), and along the Chubut River from the reservoir to its mouth in the Atlantic Ocean (e.g. Sastre et al. 1991, Ayestarán & Sastre 1995, Otaño & Santinelli 1997), registering many chlorococcalean and diatom species. At the stretch of the Chubut River near the estuary the community was dominated by Bacillariophyceae and Dinophyceae, with some typical marine taxa (Santinelli & Estevez 1993). In particular, algal blooms of *Aulacoseira granulata* were reported for the lower stretch of the river (Sastre el al. 1994).

## Phytoplankton studies for the region in the first decade of 21th century

From 2001 to 2004, the impact of fish introduction on planktonic food webs was studied in 18 lakes of the Patagonian Plateau by Reissig et al. (2006). The lakes were located in four areas: Northern area of Laguna Blanca and surroundings (lakes: Blanca, Jabón and El Burro); Central area of the *Nothofagus* forest-Patagonian steppe ecotone (lakes El Chancho and Los Juncos); Central steppe area (lakes Ñe Luan, Carrilaufquen Chica, Carrilaufquen Grande and NF1); Southern area in Santa Cruz Province (lakes Cardiel, Del Mie, Volcán 2, Volcán 3, Volcán 4, P. Moreno 1, P. Moreno 2, P. Moreno 3 and P. Moreno 4) (Fig. 1). Zooplankton and phytoplankton composition and abundance were analyzed discriminating among lakes with fish introduction, lakes with endemic fish fauna and fishless lakes. Phytoplankton was analyzed to the genus or species level, quantifying densities and biovolumes for each lake. This study showed that fish introduction changed the zooplankton structure in the studied lakes, leading to a narrower size spectrum because of the disappearance of *Daphnia* and large centropagid copepods, and changes in zooplankton seemed to cascade down to phytoplankton. Regarding phytoplankton abundance, values ranged from 102642 cells. $ml^{-1}$ to 5493620 cells. $ml^{-1}$ in lakes with introduced fishes, with a complete preponderance of net phytoplankton over nanoplankton (Nano:Net ratio 0.0003–0.0338). In the lake with native fish total phytoplankton abundance was 4816 cells. $ml^{-1}$ and the Nano:Net ratio 0.5135. In lakes without fish total phytoplankton varied from 226 cells. $ml^{-1}$ to 7603 cells. $ml^{-1}$, with a higher relative importance of the nanoplankton fraction in the community (Nano:Net ratio 0.6964–2.3037). The abundance and biovolume of Cyanobacteria clearly prevailed in those lakes where fishes were introduced, with the following dominant taxa: *Aphanocapsa delicatissima*, *Anabaena flos-aquae* (Syn: *Dolichospermum flos-aquae*), *Anabaena* spp., *Microcystis aeruginosa* and *Oscillatoria tenuis*. In the lake with native fish Chlorophyceae (Chlorococcales) was the dominant algal group, mainly represented by *Pediastrum boryanum*. In the fishless lakes different algal groups were dominant depending on the water body (Cryptophyceae, Chlorophyceae, and Zygnematales). The results of this study provide very valuable information for the conservation of freshwater systems of Patagonia, since it evidenced the effects of the fish introduction on planktonic communities, and particularly on the proliferation of Cyanobacteria. In line with these investigations, Lancelotti (2009) examined 32 shallow lakes from the "Lake Strobel Meseta", a basaltic plateau located on the Southern Patagonian steppe; based on a multivariate analysis, the lakes were classified in turbid without macrophytes, small vegetated with a significant macrophyte cover, large non-vegetated and large vegetated (Lancelotti et al. 2009). In vegetated water bodies the dominant macrophyte is usually *Myriophyllum quitense*, which shows a great seasonal variation, covering in some cases up to 95 % of the total bottom surface. The food webs of lakes stocked and devoid of trout were analyzed. The phytoplankton biomass was estimated by measurements of chlorophyll *a*. In nine lakes the community structure and trophic relationships were characterized by means of stable isotope analysis (nitrogen and carbon), and the results showed that the pelagic and benthic trophic pathways appear uncoupled in the studied lakes (Lancelotti et al. 2009). The investigations showed that the two large non-vegetated fishless lakes analyzed were the only sites in which amphipods exploited the pelagic zone.

From 2005 to 2006 the plankton communities of the eutrophic shallow lake Cacique Chiquichano, located within the city of Trelew, were monitored (Gonçalves et al. 2011). In this study the authors analyzed the changes in photosynthetic parameters as a result of exposure to UVR, the taxonomic composition of phytoplankton and the grazer abundance. The eutrophic condition of the lake was evidenced from the high chlorophyll *a* (chl-*a*) values (with a peak of 799 $\mu g\ L^{-1}$), and the pico-nanoplankton fraction accounted for the bulk of total Chl-*a* during almost the whole year. Phytoplankton showed an alternation of Cyanobacteria and diatoms throughout the year, corresponding these periods to low transparency phases and clear water periods respectively. Among the Cyanobacteria the dominant taxa were *Micro-*

*cystis* spp., *Synechocystis* sp. and *Lyngbya* sp., whereas diatoms were mainly represented by *Navicula* spp., *Nitzschia* sp., *Cyclotella* sp. and *Surirella* sp.

More recently, within the framework of a biogeographic survey focused on the microbial plankton communities of Austral Patagonia, 33 lakes were sampled on spring 2007 and 2008, covering a latitudinal transect from the south of Chubut Province (45.37°S) to Tierra del Fuego Province (63.41°S). The study involved different types of water bodies from deep to shallow lakes, with a wide range of trophic states (Schiaffino et al. 2011, Tell et al. 2011). Among the studied water bodies, 15 are located in the steppe: 4 in Chubut Province (Lake Musters, Lake Colhue Huapi and 2 semi-permanent ponds), 9 in Santa Cruz Province (Lake Ghio, Lake Cardiel, 3 shallow lakes from the "Strobel Meseta", and 4 shallow lakes and ponds), 2 in Tierra del Fuego (shallow lakes San Luis and Laguna de los Cisnes). The main physical and chemical data measured in these water bodies are summarized in Table 1. Total phytoplankton abundance varied from 102 ind. $ml^{-1}$ to 70211 ind. $ml^{-1}$ (mean value 10700 ± 22980 ind. $ml^{-1}$), registering the highest densities in two shallow lakes from the Strobel plateau (unpubl. data). In most of the lakes the dominant algal classes were Chlorophyceae and/or Cryptophyceae. Bacillariophyceae were also very abundant in Lake Cardiel and in Laguna de los Cisnes (Fig. 2). Lake Ghio and two semi-permanent ponds showed a higher contribution of Chrysophyceae. Contrarily to that observed in the oligotrophic Andean lakes sampled, the lakes from the steppe completely lacked Haptophyceae and Dictyochophyceae. Table 2 shows the more abundant phytoplankton taxa registered in the water bodies of the Patagonian Plateau sampled, the main functional groups to which they belong according to the classification proposed by Reynolds et al. (2002) and updated by Padisák et al. (2009), and the mean phytoplankton densities. The most representative taxa en terms of abundance, and recurrent in many lakes, were: several species of *Monoraphidium* (codon X1), *Chlamydomonas* spp., *Plagioselmis lacustris* and *P. nanoplanctica* (codon X2), and several species of *Cryptomonas* (codon Y). Some diatom species were also abundant in particular lakes, among them, *Fragilaria construens* (codon MP) and *Nitzschia acicularis* (codon D). In general, Cyanobacteria were not well represented in terms of density in the water bodies surveyed, except in particular ponds. In some lakes (e.g., Ghio and Cardiel) and in some ponds Chrysophyceae were also abundant, which were mainly represented by species of the genus *Ochromonas*.

Current investigations at the Strobel Plateau (Santa Cruz) by Izaguirre and coworkers are being developed. Twelve shallow lakes with and without fish introduction were analyzed, and important differences among phytoplankton structure (biomass and dominant algal groups) were found (Fig. 3). Highest total phytoplanktonic biovolume was registered in lakes with fish introduction (lakes 8 to 12), and in these water bodies Cyanobacteria were the dominant phytoplankton group reaching up to 84% of the total algal biovolume (lake 11). On the other hand, fishless clear water bodies (lakes 3 to 7) with submerged macrophytes presented the lowest biovolumes, and the dominant algal group varied in the different lakes. Natural turbid inorganic environments (lakes 1 and 2) showed intermediate total biovolume and were dominated principally by Chlorophytes (Order Chlorococcales), reaching up to 92% of total biovolume (lake 1). These results seem to indicate that fish introduction affects the trophic web structure due to a cascade effect.

**Table 1.** Geographic position and main limnological characteristics of the water bodies of Austral Patagonia surveyed in 2007 and 2008 (Tell et al. 2011). wd: without data.

| | Coordinates | Temp. (ºC) | pH | Cond. (µS $cm^{-1}$) | Chl *a* (µg $L^{-1}$) | $PO_4$ (mg $L^{-1}$) | DIN (mg $L^{-1}$) | DOC (mg $L^{-1}$) | Kd ($m^1$) |
|---|---|---|---|---|---|---|---|---|---|
| Lake Musters (Chubut) | 45°32'S 69°08'W | 12.6 | 7.84 | 310 | 2.62 | 0.38 | 0.23 | 10.80 | 1.15 |
| Pond a (Chubut) | 45°34'S 69°06'W | 15.5 | 8.40 | 490 | 4.75 | 0.06 | 0.41 | 19.30 | 2.53 |
| Pond b (Chubut) | 45°33'S 69°00'W | 14.1 | 8.05 | 110 | 9.68 | 0.20 | 0.42 | 13.50 | 2.27 |
| Lake Colhue Huapi (Chubut) | 45°22'S 68°57'W | 10.0 | 8.68 | 1350 | 47.01 | 1.78 | 0.28 | 8.20 | 28.52 |
| Pond a (Santa Cruz) | 47°20'S 70°59'W | 27.0 | 8.30 | 1810 | 17.02 | 14.10 | 0.10 | 17.00 | 1.17 |
| Lake Ghio (Santa Cruz) | 47°16'S 71°30'W | 12.8 | 8.20 | 4760 | 0.11 | 0.84 | 0.04 | 42.00 | 0.34 |
| Pond b (Santa Cruz) | 47°12'S 71°35'W | 20.7 | 8.20 | 4110 | 18.35 | 15.80 | 0.05 | 64.10 | 3.42 |
| Shallow Lake a (Strobel plateau – Santa Cruz) | 48°41'S 71°09'W | 10.1 | 8.20 | 560 | 19.56 | 0.18 | 0.06 | 33.70 | 7.04 |
| Shallow Lake b (Strobel plateau – Santa Cruz) | 48°40'S 71°07'W | 13.6 | 8.20 | 4600 | 5.43 | 0.10 | 0.03 | 43.50 | 1.73 |
| Shallow Lake c (Strobel plateau – Santa Cruz) | 48°37'S 71°08'W | 17.3 | 8.30 | 230 | 36.67 | 0.10 | 0.18 | 44.00 | wd |
| Lake Cardiel (Santa Cruz) | 48°59'S 71°07'W | 11.0 | 9.30 | 4360 | 0.76 | 1.39 | 0.10 | 11.80 | 0.23 |
| Pond c (Santa Cruz) | 49°35'S 72°17'W | 12.3 | 8.15 | 380 | 3.87 | 0.26 | 0.34 | 5.40 | 0.42 |
| Pond d (Santa Cruz) | 49°35'S 72°18'W | 13.6 | 8.30 | 560 | 3.17 | 0.15 | 0.17 | 11.70 | 0.54 |
| San Luis (Tierra del Fuego) | 53°55'S 67°35'W | 10.7 | 8.10 | 313 | 0.29 | 0.17 | 0.08 | 17.10 | 2.06 |
| Laguna de los Cisnes (Tierra del Fuego) | 53°47'S 67°46'W | 12.7 | 8.98 | 25800 | 0.31 | 0.40 | 0.13 | 6.90 | 2.73 |

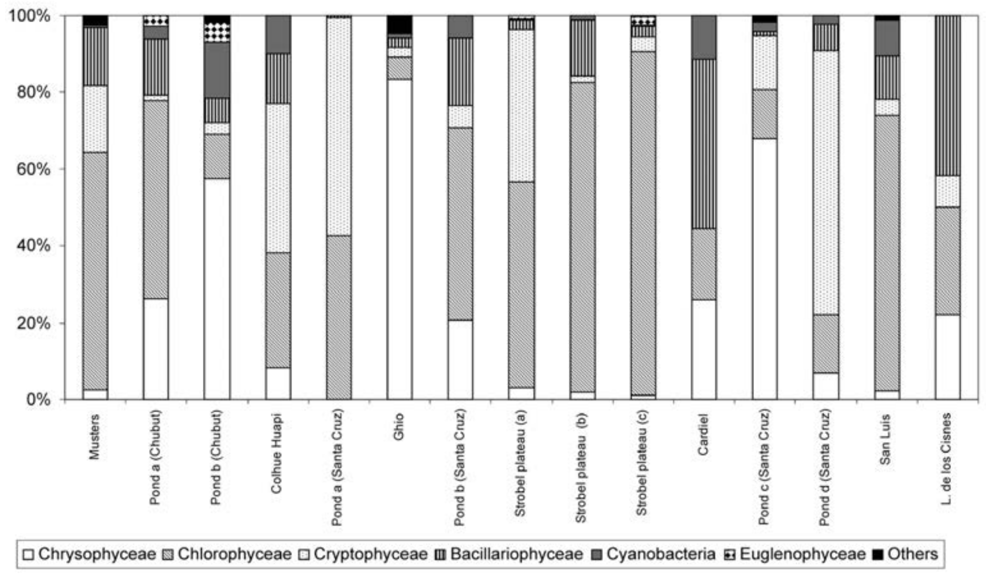


**Fig. 2.** Proportion of the different algal groups registered in the Patagonian lakes surveyed in spring 2007 and 2008.

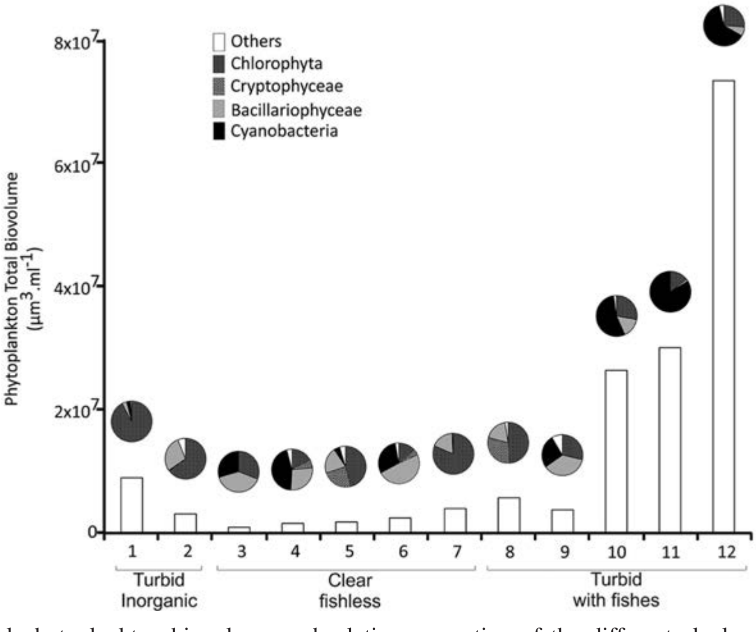


**Fig. 3.** Total phytoplankton biovolume and relative proportion of the different algal groups in the studied lakes of the Strobel Plateau (Santa Cruz Province) – Sampling period: December 2011.

**Table 2.** More abundant taxa (in density) in the Patagonian lakes surveyed in spring 2007 and 2008, main functional groups according the classification of Reynolds et al. (2002) and the revision of Padisák et al. (2009) and mean phytoplankton density (MPhD).

| | More abundant taxa | Main Functional Groups | MPhD (ind. $ml^{-1}$) |
|---|---|---|---|
| Lake Musters | *Monoraphidium circinale, Monoraphidium contortum, Monoraphidium griffithii, Plagioselmis lacustris* | X1, X2 | 2175 |
| Lake Colhue Huapi | *Chlamydomonas* sp., *Plagioselmis nanoplanctica, Cryptomonas* sp., *Fragilaria construens, Coelosphaerium* sp. | X1, X2, Y, MP, L0 | 1678 |
| Ponds (Chubut) | *Chlamydomonas* sp., *Monoraphidium arcuatum, Monoraphidium circinale, Monorahidium contortum, Monoraphidium griffithii, Monoraphidium subclavatum, Monoraphidium tortile, Chroomonas* sp., *Plagioselmis lacustris* cf., *Chromulina* sp., *Ochromonas* sp., *Nitzchia acicularis*, *Dolichospermum* sp., *Leptolyngbya fragilis* | X1, X2, D, H1, S1 | 3676–7312 |
| Lake Ghio | *Ochromonas* sp. | X2 | 193 |
| Lake Cardiel | *Oocystis lacustres, Chromulina* sp., *Nitzschia sigma* | X2, F, D | 308 |
| Lakes Strobel plateau | *Chlamydomonas* sp., *Pteromonas* sp., *Monoraphidium arcuatum, Monoraphidium contortum, Monoraphidium griffithii, Monoraphidium komarkovae, Monoraphidium pusillum, Scenedesmus acuminatus, Cryptomonas* spp., *Plagioselmis lacustres, Ochromonas* sp., *Gomphonema* sp., *Nitzschia acicularis, Aphanocapsa delicatissima* | X1, X2, J, Y, MP, D, K | 4170–70211 |
| Ponds (Santa Cruz) | *Bothryococcus braunii, Monoraphidium circinale, Monoraphidium contortum, Oocystis lacustres, Chlorella* spp., *Chlamydomonas* spp., *Plagioselmis lacustres, Plagioselmis nanoplanctica, Cryptomonas marsonii*, *Dinobryon divergens, Ochromonas* sp. | F, X1, X2, Y, E | 109 – 2417 |
| San Luis | *Chlorella* sp., *Monoraphidium circinale, Monoraphidium contortum, Monoraphidium griffithii, Oocystis parva, Tetrastrum* sp., *Willea* sp., *Aphanocapsa delicatissima* | X1, F, J, K | 2208 |
| Laguna de los Cisnes | *Chlamydomonas* sp., *Cryptomonas* sp., *Aulacoseira granulata* | X2, Y, P | 208 |

## Final remarks

The lakes located in the Patagonian Plateau have received comparatively less attention than those of the Andean region. In spite of the great number of water bodies that host some areas of the steppe, like the "Lake Strobel Plateau" and other basaltic plateaus of Santa Cruz Province, the information about phytoplankton composition and ecology is fragmentary. Particularly, studies involving different periods of the year are mainly restricted to the reservoirs. This is probably due to the remoteness of the environments, which in some cases are rather inaccessible. Studies conducted in lakes from this region coincided in the characterization of most of the lakes of the steppe as mesotrophic to eutrophic, with higher algal biomass than the Andean lakes. Dominant algal classes are usually Chlorophyceae, Cryptophyceae and Bacillariophyceae, whereas Cyanobacteria seem to be favored in some lakes with fish introduction. Most of the dominant phytoplankton functional groups are typical of shallow water bodies of mesotrophic to eutrophic conditions. Some diatoms are associated with shallow turbid waters, and others are meroplanktonic species that are drifted to the plankton. Some areas of the Patagonian steppe are characterized by a great variety of environments with contrasting limnological characteristics, most of which have not been explored from the point of view of their phytoplankton communities.

## References

Ayestarán, M. G. & Sastre, A. V. (1995): Diatomeas del curso inferior del río Chubut (Patagonia, Argentina). Pennales I: Naviculaceae. – Bol. Soc. Argent. Bot. **31**: 57–68.
Cabrera, A. (1976): Regiones Fitogeográficas Argentinas. – In: Enciclopedia Argentina de Agricultura y Jardinería, II (I). Acme, Kugler WF, Buenos Aires.
Casco, M. A., Labollita, H. A. & Cano, M. G. (2014): Phytoplankton of the reservoirs of Central and North Patagonia. – Adv. Limnol. **65**: 000–000.
Diaz, M., Pedrozo, F. & Baccala N. (2000): Summer classification of Southern Hemisphere temperate lakes (Patagonia, Argentina). – Lakes Reserv.: Res. Manage. **5**: 213–229.
Gonçalves, R. J., Villafañe, V. E., Medina, C. D., Barbieri, E. S. & Helbling, W. E. (2011): Plankton dynamics and photosynthesis responses in a eutrophic lake in Patagonia (Argentina): influence of grazer abundance and UVR. – Lat. Am. J. Aquat. Res. **39**: 117–130.
Iriondo, M. (1989): Quaternary lakes of Argentina. – Paleogeogr. Paleoclimat. Paleoecol. **70**: 81–88.
Izaguirre, I. (1991): Fitoplancton de distintos ambientes acuáticos continentales de la República Argentina: estructura, dinámica y tipificación. – Tesis Doctoral, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires.
Izaguirre, I. (1993): Comparative analysis of the phytoplankton of six lentic environments from the Province of Chubut (Argentina). – Physis B **48**(114-115): 7–23.
Izaguirre, I., del Giorgio, P., O´Farrell, I. & Tell G. (1990): Clasificación de 20 cuerpos de agua Andino-Patagónicos (Argentina) en base a la estructura del fitoplancton estival. – Cryptogamie Algol. **11**: 31–46.
Lancelotti, J. L. (2009): Caracterización limnológica de lagunas de la Provincia de Santa Cruz y efectos de la introducción de Trucha Arco iris (Oncorhynchus mykiss) sobre las comunidades receptoras. – Tesis Doctoral, Universidad Nacional del Comahue, Centro Regional Universitario Bariloche.
Lancelotti, J. L., Pozzi, L. M., Yorio, P. M., Diéguez, M. C. & Pascual, M. A. (2009): Fishless shallow lakes of Southern Patagonia as habitat for waterbirds at the onset of trout aquaculture. – Aquat. Conserv: Mar. Freshw. Ecosyst. **19**: 497–505.

Otaño, S. H. & Santinelli, N. H. (1997): Chlorophyta del río Chubut (Patagonia, Argentina) I. Chlorococcales. – Physis B **53**: 124–125.

Padisák, J., Crossetti, L. O. & Naselli-Flores, L. (2009): Use and misuse in the application of the phytoplankton functional classification: a critical review with updates. – Hydrobiologia **621**: 1–19.

Quirós, R. & Cuch, S. (1985): Relaciones entre visibilidad, fósforo total y concentración de clorofila en 32 lagos patagónicos, Argentina. – Actas XII Congreso Nacional del Agua, Mendoza, I, Estudios de aguas superficiales y subterráneas, pp. 1–30.

Quirós, R. & Drago, E. (1999): The environmental state of Argentinean lakes: An overview. – Lakes Reserv.: Res. Manage. **4**: 55–64.

Reissig, M., Trochine, C., Queimaliños, C., Balseiro, E. & Modenutti, B. (2006): Impact of fish introduction on planktonic food webs in lakes of the Patagonian Plateau. – Biol. Conserv. **132**: 437–447.

Reynolds, C. S. (1998): What factors influence the species composition of phytoplankton in lakes of different trophic status? – Hydrobiologia **369/370**: 11–26.

Reynolds, C. S., Dokulil, M. & Padisák, J. (Eds.) (2000): The Trophic Spectrum Revisited. The influence of trophic state on the assembly of phytoplankton communities. – Hydrobiologia **424**: 1–152.

Reynolds, C. S., Huszar, V., Kruk, C., Naselli-Flores, L. & Melo, S. (2002): Towards a functional classification of the freshwater phytoplankton. – J. Plankton Res. **24**: 417–428.

Santinelli, N. & Esteves, J. L. (1993): Características químicas y fitoplanctónicas del estuario del rio Chubut (Patagonia, Argentina). – Naturalia Patagónica **1**: 22–34.

Sastre, A. V., Santinelli, N. H. & Sendin, M. E. (1991): Floración de Aulacoseira granulata (Ehr.) Simonsen (Bacillariophyceae) en el curso inferior del río Chubut. – Biol. Acuática **15**: 98–99.

Sastre, A. V., Santinelli, N. H., Otaño, S. H., Ivanissevich, M. E. & Ayestarán, M. G. (1994): Diatom blooms and their relation to water supply. – Verh. Internat. Ver. Limnol. **25**: 1974–1978.

Schiaffino, M. R., Unrein, F., Gasol, J. M., Massana, R., Balagué, V. & Izaguirre, I. (2011): Bacterial community structure in a latitudinal gradient of lakes: the roles of spatial versus environmental factors. – Freshwater Biol. **56**: 1973–1991.

Secky, H. (1950–1956): Estudios hidrobiológicos hechos en las agues de la Cordillera del Sud. – Bol. Acad. Nac. Cienc. Córdoba **39**: 290–339.

Speck, N. H., Sourrille, E. A., Wijnhoud, S., Munist, E., Vofkheimer, W. & Menendez, J. A. (1982): Sistemas fisiográficos de la zona de Ingeniero Jacobacci-Maquinchao. – Colección Científica INTA, Buenos Aires.

Tell, G. & Mataloni, G. (1990): Systematic studies on the *Pediastrum kawraiskyi-mustersii-patagonicum* complex (Chlorophyta): two new species and morphological variations in two Patagonian lakes (Argentina). – Nova Hedwigia **50**: 159–180.

Tell, G., Izaguirre, I. & Allende, L. (2011): Diversity and geographic distribution of Chlorococcales (Chlorophyceae) in contrasting lakes along a latitudinal transect in Argentinean Patagonia. – Biodivers. Conserv. **20**: 703–727.

Thomasson, K. (1959): Nahuel Huapi. Plankton of some lakes in the Argentine National Park, with notes on terrestrial vegetation. – Acta Phytogeogr. Suec. **42**: 1–83.

Thomasson, K. (1963): Araucanian Lakes. Plankton studies in North Patagonia with notes on terrestrial vegetation. – Acta Phytogeogr. Suec. **47**: 73–103.