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Autor: Vincent, Warwick F.
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François Alphonse FOREL in Japan

Warwick F. VINCENT*

In July 2012, the Association for the Sciences of Limnology and Oceanography (ASLO) held its Aquatic Sciences Meeting at Otsu, on the shores of Lake Biwa, Japan. This was the first time an ASLO meeting had been held in Asia, and it attracted over 1000 participants from more than 40 countries. Given that 2012 marked one century since the death of F.A. FOREL, and 120 years since he founded the science of limnology as the 'oceanography of lakes', the ASLO meeting in Japan provided an ideal opportunity to commemorate F.A. FOREL internationally, and to celebrate his remarkable accomplishments.

ASLO-Japan began on 8 July 2012 with a public symposium convened and chaired by Dr. Michio Kumagai, President of the Limnological Society of Japan, entitled "Follow the water: From Mother Lake to Mother Earth". This symposium was simultaneously translated in Japanese and English, and like many sessions through the rest of the week, it was held in the elegant Lake Biwa Opera House. The opening lecture was by Dr. Yukiko Kada, the Governor of Shiga Prefecture (the governance region that encompasses Lake Biwa and its watershed) who talked about the "Mother Lake" water management strategy of the prefecture based on the concept of "seeking harmonious co-existence with lake ecosystems via the paths of water research, knowledge exchange and wise management of aquatic resources". This lake is a precious resource that provides the drinking water for 14 million people including the residents of Otsu, Kyoto and Osaka. Prior to being elected to public office, Dr Kada was a research sociologist and deputy director of the Lake Biwa Museum, and she has a special interest in the relationship between people and lakes. Those interests brought her several years earlier to Lake Geneva, a similar sized lake to Lake Biwa, where she visited the Forel Documentation Centre at the Lake Geneva Museum (Musée du Léman), Nyon, to inspect the original manuscripts of Forel and to work with the museum staff (Fig. 1) to arrange a display about Forel and Lake Geneva for her museum in Japan.

The ASLO public symposium continued with lectures by the President of ASLO (Prof. John Downing) on the water cycle (*Follow the water: from rain to lakes to rivers to the sea*); a representative of the World Lake Student Meeting (Andrew Mehring) on *The world water crisis*; myself as an ASLO scientist on the subject *Our changing Mother Earth: Messages from the Arctic*; and the well known artist and resident of the Lake Biwa region, Brian Williams, who spoke on the subject *Natural beauty: The signature of ecosystem health*. My lecture allowed

Fig. 1. Governor Yukiko Kada (centre), her team and Swiss hosts during her visit to the Lake Geneva Documentation Centre of the Musée du Léman at Nyon, Switzerland (www.museeduleman.ch). 2nd to the left of Dr. Kada is C. Bertola, to the right (4th) is Mme Jacqueline Porret Forel, the grand-daughter of F.A. FOREL, and 3rd to the right, Mr. François D.C. Forel. Photograph courtesy of Dr. Carinne Bertola, Musée du Léman.

* Centre d'études nordiques (CEN: Centre for Northern Studies) & Département de biologie, Université Laval, Québec City, Québec, Canada

me to introduce F.A. FOREL to the Japanese public, and to talk briefly about some of his visionary perspectives on lake ecosystems. Trained in medicine and as the son of a distinguished archaeologist, F.A. FOREL considered humans to be an natural component of the lake biota, and a species that benefits from lake ecosystem services such as transport, safe water and fisheries (which he quantified in economic terms), while at the same time exerting a powerful influence on the lake environment and its plant, animal and microbial communities. In many respects, these perspectives mirror the "Mother Lake" concept of Shiga Prefecture, and it is a perspective that we increasingly need to scale up to a planetary level, to achieve "harmonious coexistence" with the hydrosphere and biosphere during this era of rapid anthropogenic change.

The ASLO Scientific Conference was convened by Drs Jotaro Urabe, Kazuhiro Kogure and Michio Kumagai, and it was officially opened that evening by Governor Kada, who in collaboration with ASLO President John Downing and Past President Deborah Bronk, performed the ceremonial breaking open of a barrel of sake, which the governor then helped serve to all participants. This was followed by a tasting of many sakes from breweries throughout the Shiga Prefecture. The Forel family has a long history of vineyard cultivation, and in his memoirs, F.A. FOREL relates the story of his father taking him as a boy up onto one of the Swiss glaciers, and pouring drops from a gourd of red wine onto the ice to reveal the crystalline structure of the glacier. F.A. FOREL would likely much approve of the use of the Japanese equivalent of wine to launch a week of international symposia on limnology and oceanography.

Our special session entitled *Light, Transport and Mixing in Lakes: 100 Years after Forel*, was one of the first scientific symposia of the meeting, and was held on 9 July 2012 with an excellent attendance of limnologists and oceanographers from many nations. This session was convened by Prof. Sally MacIntyre from the University of California, Santa Barbara, USA, Prof. Alfred Johny Wueest, from the EAWAG Swiss Federal Institute of Aquatic Science and Technology, Kastanienbaum, Switzerland, and Warwick F. Vincent, Laval University, Québec City, Canada. The symposium aimed to review many of the limnological contributions of F.A. FOREL, followed by papers presenting current research in physical limnology, with emphasis on hydrologic optics, stratification, currents and mixing regimes.

The session began with a tutorial by W.F. Vincent and C. Bertola (*From lake physics to ecosystem services: Forel's limnology*) that gave an overview of F.A. FOREL's pioneering research in limnology over more than five decades. This talk described the way F.A. FOREL developed and applied new technologies to observe and record all aspects of the lake environment, his passion for collecting information from disparate sources, and his ability combine this information with his own detailed observations to produce a unified synthesis. This talk was based on the information published in Vincent and Bertola (2012, this volume).

The next papers focused on underwater light and lake color, subjects that were of great interest to F.A. FOREL. Prof. Geoff Schladow et al. (*Toward an understanding of the causes of clarity decline in Lake Tahoe*) explained how correspondence between F.A. FOREL and the American pioneer limnologist John Le Conte documents the time when Lake Tahoe (California-Nevada, USA) exhibited exceptional clarity. This clarity has declined markedly over the last few decades, an effect that was originally attributed to algal particulates and more recently to inorganic particulates derived from urban runoff. Most recently, measurements of backscattering to total scattering ratios of particulates suggest that the shift in phytoplankton community structure towards small cell diatoms has played a role in the decline of Lake Tahoe's clarity. F.A. FOREL was also fascinated by the legendary blueness of Lake Tahoe. The next paper by S. Watanabe et al. (*Quantifying the blueness of Lake Tahoe: spatial and long term variations in lake color*) described their hyperspectral radiometric profiling in the lake, combined with laboratory measurements of absorption and scattering for discrete water samples. The radiometric data were converted into color coordinate axis values to quantify the variations in blueness with depth and among sites. Comparison of these results with studies on Lake Tahoe in the 1970's implied that there has been considerable change in color throughout the water column. Decreased water clarity has also been observed in ultra-oligotrophic Lake Mashu in northeastern Hokkaido. H. Kobayashi et al. (*Evaluation of optical factors limiting transparency of Lake Mashu, one of the clearest lakes in the world*) undertook field measurements with underwater radiometers and an in situ spectrophotometer, and combined this with modeling of radiative transfer processes. The results indicated that the decline in clarity is the result of scattering by algal particulates, and changes in the volume scattering function.

In his classic description of lake currents, F.A. FOREL noted that Lake Geneva was "simply an enlarged river", with net transport of water through the lake from the upper Rhone River inflow to the Rhone River outflow. The next two papers in the F.A. FOREL symposium focused on a more fluvial system of con-

nected lakes, the Saint Lawrence River, Canada. J.-J. Frenette et al. (*Colorful niches of phytoplankton shaped by the spatial connectivity in a large river ecosystem: a riverscape perspective*) showed how inflowing tributaries inject chromophoric dissolved organic matter (CDOM) and non-algal material, which selectively absorb wavelengths in a gradient from blue to red wavebands, in turn affecting phytoplankton community structure. F.A. FOREL would be pleased to hear the author's conclusion that water color as measured by spectral underwater radiation represents a key integrating and structural property of large river ecosystems. P. Massicotte and J.-J. Frenette then presented a mechanistic model coupled with a fine scale hydrodynamic model to describe dissolved organic carbon (DOC) fluxes in Lake Saint Pierre, a fluvial lake on the Saint Lawrence River (*Mechanistic modeling of DOC dynamics: understanding interactions between kinetic processes and mass transport in a large fluvial lake*). The results showed that semi-labile DOC is strongly controlled by hydraulic residence time, whereas labile DOC from primary production was the principal source of energy for heterotrophic bacteria, which consumed nearly 99% of this pool during its transit in the system.

One of F.A. FOREL's greatest passions in limnology was the study of surface seiches. He was also very interested in earthquakes, and he corresponded with a colleague in Japan about the effects of earthquakes on lakes. F.A. FOREL would therefore be especially interested in the paper by M. Iwaki and M. Kumagai et al. entitled *The surface seiche of Lake Biwa, Japan*. Field investigations were carried out on Lake Biwa from 2010 to 2012 using a water level instrument that had a resolution of 1 mm, and a sampling interval for the data logger of 2 min. Using Fourier spectral analysis, the authors separated the effect of inherent oscillations on water level, and showed how the massive 2011 earthquake in Japan (the Tohoku Earthquake) caused changes in lake water level, both through the earthquake motion itself and via a long period Rayleigh wave.

Two of the papers in the symposium brought us to Lake Geneva, Forel's "natural laboratory and aquarium". J. Halder et al. (*Mixing and stratification: a chemical approach based on stable O and C isotope profiles*) noted how F.A. FOREL was one of the first to argue that the Rhone River entered the lake as a density current. Their study measuring stable isotopes of H and O in water quantified the fraction of Rhone water within the interflow, its extension throughout the lake and its vertical mixing. The analysis of C isotope profiles gave insights into the sources of dissolved inorganic carbon and its mixing within the water column. These isotopic approaches also provided an approach toward validation of circulation models. A.D. Le Thi et al. presented a three-dimensional thermal and circulation model to conduct numerical experiments for Lake Geneva (*Application of finite-element modeling to predict the thermal regimes and circulation patterns of Lake Geneva and their relationship to geomorphology*; Fig. 2.). The modeling results showed how geomorphology (size and bottom topography) and wind patterns influenced the circulation patterns, with the dominant wind stresses from the northeast and southwest sustaining the cyclonic (counterclockwise) central gyre of the Grand Lac basin.

Fig. 2. Presentation by Mme A. D. Le Thi from the Institute F.-A. Forel and Institute for Environmental Sciences, University of Geneva (www.unige.ch/forel), at the F.A. Forel Symposium, ASLO, in Otsu, Japan. Photograph by Prof. Vera Slaveykova.

A paper by B. Boehrer and colleagues, including K.A. Chikita from Hokkaido University, focused on the thermobaric stratification that can occur in very deep lakes under a climate regime with cold winters (*Thermobaric stratification of Norwegian fjord lakes and Japanese caldera lakes in comparison*). In two steep caldera lakes, the temperature profiles in the deep water indicated two layers, and the profiles could be explained by stability arguments and horizontal homogeneity. In contrast, comparative profiles from fjord lakes showed a

continuous gradient throughout the water column. These results have implications for the renewal of deep water in thermobarically stratified lakes.

The F.A. FOREL Symposium concluded with a tutorial by S. MacIntyre entitled *Mixing dynamics in lakes: will changes in climate alter contemporary patterns?* Using newly analyzed data from Toolik Lake in the Arctic and Lake Victoria in tropical Africa, the author showed their commonalities in internal wave dynamics, and examples of interannual variability in surface energy budgets, internal wave dynamics, and lake thermal structure that is determined by large scale atmospheric cycles and the dipoles in adjacent oceans. She illustrated the consequences of internal wave motions and large scale eddies in the mixed layer on oxygen dynamics and light climate, and thereby brought together the subjects of hydrodynamics, biogeochemistry and hydrologic optics, three of the fundamental subdisciplines of F.A. FOREL's limnology.