

SIL news

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The International Association of Theoretical and Applied Limnology (Societas Internationalis Limnologiae Theoreticae et Applicatae, SIL) promotes and communicates new and emerging knowledge among limnologists to advance the understanding of inland aquatic ecosystems and their management.



Fig. 1. Map showing the original water way of the Danube in the mid-19th century in Vienna (upper right) and the situation as it appears in 2004.

Alternative stable states, resilience and hysteresis during recovery from eutrophication - A case study

by

Karl Donabaum, Karin Pall, Katrin Teubner and Martin T. Dokulil

continued on next page

The concept of alternative stable states has been developed during the last 15 years. Several field observations supported the theory, summarized in Scheffer (1998) and Dokulil and Teubner (2003). The hypothesis proved useful especially for shallow lake ecosystems in the form of bistability when a clear water, macrophyte-dominated stage alternates with a turbid, algal-dominated phase. These two situations may be seen as alternative stable equilibria where macrophyte domination occurs at low nutrient levels while algal domination prevails at elevated nutrient quantities. At intermediate nutrient concentrations both stable states are possible. The switch from one to the other can occur as a catastrophic shift, or an ecosystem may oscillate between the two equilibria over prolonged periods of time. Alternative stable states can also be used as a conceptual basis for successfully managing shallow lake ecosystems (Moss *et al.* 1997).

Rapid changes in a shallow, urban lake in Vienna (Austria) from macrophyte domination to a turbid state, characterized by high biomass of filamentous cyanobacteria (Dokulil and Mayer 1996), have been interpreted as a shift to a new equilibrium. An integrated lake management concept was developed to reverse these eutrophication effects (Donabaum *et al.* 1999; Dokulil *et al.* 2000).

Regulation of the River Danube at Vienna in 1875 resulted in the isolation of parts of the main river channel (Fig. 1). The remaining backwater, known as 'Old Danube', became almost entirely dependent on groundwater seepage and precipitation because there was no natural surface inflow or outflow. The lake soon developed into a famous recreational resort and has progressively been engulfed by the city. The nearby River Danube and especially the impoundment New Danube, which was built to protect the city from flood events, both influence the direction and dynamics of the groundwater. Today, Old Danube is a shallow urban lake within the city of Vienna and a very popular recreational area (Fig. 1 and Table 1).

Table 1. Morphometric data for Old Danube.

Altitude	157 m a.s.l.
Area	1.583 km ²
Volume	3.697 x 10 ⁶ m ³
Maximum depth	6.8 m
Mean depth	2.33 m
Mean theoret. retention time	190 days

Prior to 1990 the water was clear with high Secchi-disk transparencies, frequently down to the bottom. Large areas were covered with submerged macrophytes substantially influencing nutrient dynamics by their storage capacity. The dominant species were *Myriophyllum spicatum* L. and *Potamogeton pectinatus* L. The Charophytes *Nitellopsis obtusa* (DESV. IN LOIS) J. GROVES, *Chara tomentosa* L. and *Chara hispida* WOOD were also abundant. Over the years organic-rich

sediments have accumulated in several areas on top of the fluvial deposits as a result of internal processes. Parts of these sediments became anoxic because of respiration and reduced water exchange (Löffler 1988).

The first symptoms of severe water quality deterioration were detected during routine monitoring in the late 1980s. The filamentous cyanobacteria *Limnothrix redekei* (VAN GOOR) MEFFERT was first recorded in water quality samples in 1992. By early 1993 the lake had shifted to a turbid state dominated by the filamentous, cyanobacterial species *Cylindrospermum raciborskii* (WOLOSZ) SEENAYYA ET SUBBA RAJU, which potentially can fix atmospheric nitrogen. This species also can produce cyanotoxins harmful to people and may also affect trophic interactions (Dokulil and Mayer 1996; Mayer *et al.* 1997). In 1993 and 1994 only remnants of the macrophyte and charophyte populations remained (Dokulil and Janauer 1995).

Substantial nutrient flux from non-point sources, such as leaking septic tanks and elution from a near-by former dump site, were believed to be responsible for the rapid shift from clear water to turbid water state. Nutrient inputs originating from the excretion of waterfowl and from recreational activities probably had a minor influence. Due to large stocks of benthivorous (Cyprinids) and planktivorous fish in Old Danube, background turbidity was high and abundance of larger zooplankton species was low. The zooplankton was dominated by rotifers, small cladocerans and copepods.

The triggering factor for the shift, however, was the water level dynamics in the second half of the 20th century (Fig. 2). The reduction in water level fluctuation and a permanent higher water level since the late 1970s in combination with nutrient influx, were assumed to be the main reasons for the disappearance of the macrophytes, similar to observations by Blindow *et al.* (1993).

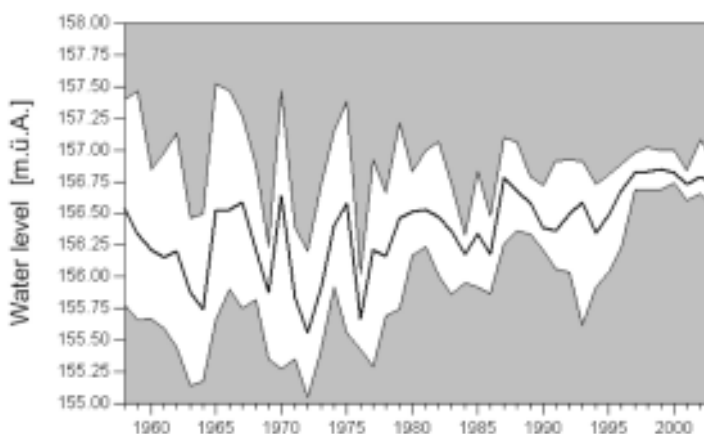


Fig. 2. Water level dynamics in Old Danube for the years 1958-2003. The bold line indicates the average annual water level. Annual ranges are given by the white area around the average.

Because of the high awareness by the citizens of Vienna, a sound restoration concept quickly had to be developed and implemented, including external as well as internal measures. As a first internal countermeasure, flushing was applied by exchanging half the basin volume with water of lower nutrient concentrations from the impoundment New Danube in the winter of 1993. External measures included expansion and repair of the sewerage network as well as proper instructions for the pumping wells installed in the area of the former dump site to keep nutrient enriched ground water away from the lake.

After careful consideration of several restoration techniques commonly used, the Riplox-method was selected as the main internal restoration measure (Ripl 1976). It was implemented in the spring of 1995 and 1996 (Fig. 2). FeCl_3 , buffered with limestone, was added to remove phosphorus and suspended material by chemical and mechanical flocculation. In a second step, $\text{Ca}(\text{NO}_3)_2$ was added to the sediments to enhance nitrate oxidation. Nitrate is reduced to elemental nitrogen by anaerobic denitrification. Organic mud is oxidized to carbon-dioxide and water. Consequently, the oxygen deficit caused by heterotrophic metabolism decreases. Thus, prolonged anoxic conditions near the sediment surface can be avoided and internal loading reduced.

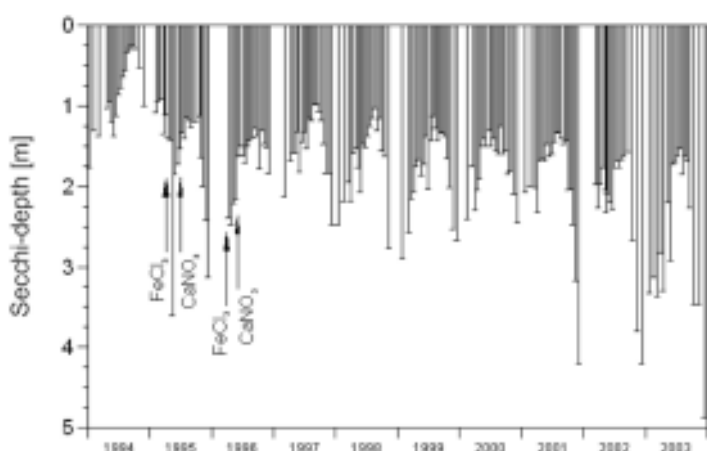


Fig. 3. Development of Secchi-depth in Old Danube from 1994-2003. The periods of experimental impacts are indicated by arrows.

Immediately after the Riplox treatment, which can be seen as a whole lake experiment, Secchi-depth significantly increased (Fig. 3) and concentrations of total phosphorus and chlorophyll-a dropped considerably. The composition of the phytoplankton assemblage shifted from cyanobacteria towards diatoms and green algae, accompanied by an increase in the relative biomass contribution of heterotrophic bacteria (Kirschner *et al.* 1998) and zooplankton. This re-structured plankton community had an enhanced phosphorus accumulation efficiency and acted as a sink for phosphorus in a reduced total pool size (Teubner *et al.* 2003). The period of intermediate nutrient concentrations from 1997-2000 was characterised by the continued abundance of filamentous cyanobacteria, poor growth of macrophytes and slow increase in the abundance of larger species of zooplankton.

This time period can be seen as the resilient phase of the ecosystem during recovery. It may also be seen as a unstable situation where shifts in any direction are possible.

To push the system further in the desired direction, biomanipulation was attempted. For several reasons, large-scale fish removal was not possible in Old Danube, but predators like *Aspius aspius* L. and pike perch (*Stizostedion lucioperca* L.) were stocked to reduce bleak (*Alburnus alburnus* L.) and other planktivorous fish. We tried to enhance macrophyte growth by planting submerged macrophytes but light was still the limiting factor. To enhance the underwater light intensity in areas where macrophytes grow, the water level was artificially lowered by 30 cm between February and May from 2002 onwards. Within two years this treatment resulted in a dramatic increase of macrophyte coverage, mainly consisting of *Myriophyllum spicatum* L. (Fig. 4). Annual total phosphorus further decreased to $19 \mu\text{g l}^{-1}$, chlorophyll-a to $8 \mu\text{g l}^{-1}$, and Secchi-depth increased to 2.6 m in 2003. Phytoplankton became dominated by chrysophytes in spring and by a mixture of green algae, coccal cyanobacteria and cryptophyceans in summer.

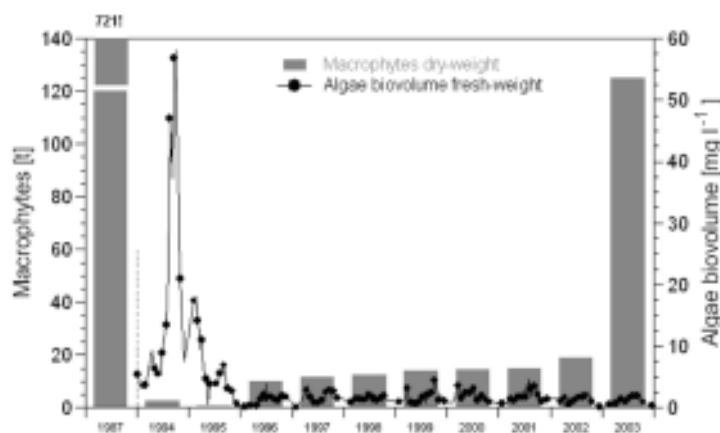


Fig. 4. Sequence of annual changes of macrophyte biomass as dry matter and phytoplankton biovolume as mg fresh weight per litre for the year 1987, and from 1994-2003.

The hysteretic response of Old Danube to environmental changes is summarised in Fig. 5. The path during deterioration is significantly different from that during the recovery phase back to macrophyte domination indicating the resilience of the system against perturbations. Results are overlaid on observations from a number of other lakes. A range of deep stratifying oligotrophic to hypertrophic shallow polymictic lakes (shaded sigmoid in Fig. 5) follow the typical forward and backward pattern expected for this relationship. Annual average long-term data from a macrophyte-dominated water body (Neue Donau, ND) and a turbid lake (Neusiedlersee, NS), marked individually by elliptical envelopes, deviate from these expectations and can be delineated by a line of 3 TP to 1 Chl-a (Dokulil and Teubner 2003). These lakes and situations are, therefore, characterized by low Chl-a:TP ratios. Overlap to the 'regular' pattern or transition to another stable state

is seen, especially in Old Danube. The macrophyte dominated years from 1987-1990 were characterized by low Chl-a:TP ratios, while the following years of eutrophication and restoration coincided with the typical expectations for Chl-a to TP. Although Old Danube is now back to the macrophyte-dominated stable state (Figs. 4 and 5), Chl-a to TP ratios are not back to what was typical before the shift or what is common in other macrophyte-dominated lakes. For further discussion and other examples see Dokulil and Teubner (2003).

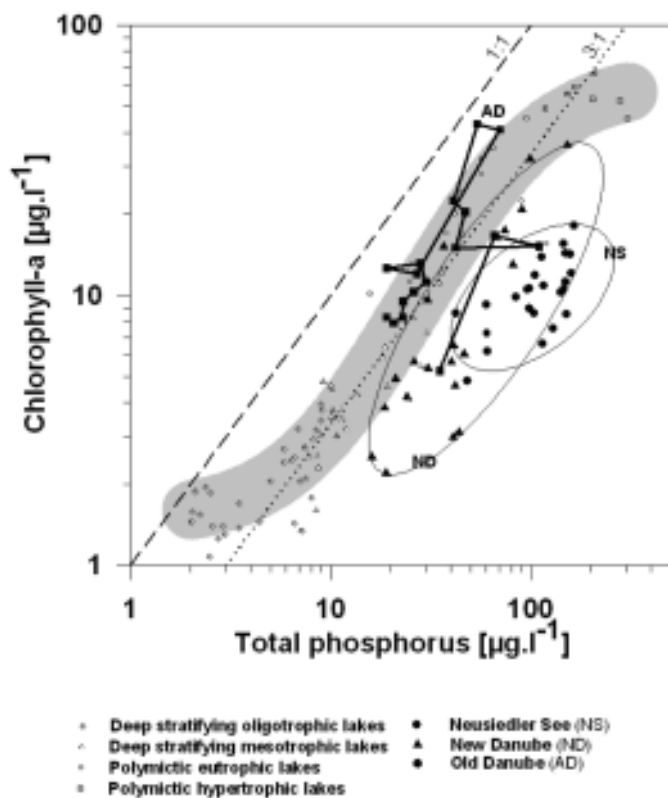


Fig. 5. Conceptual log-log plot of TP versus Chl-a indicating the time sequence of events in Old Danube overlaid on observations from many lakes covering deep oligotrophic to shallow polymictic lakes from Austria and Germany (shaded area). Elliptic envelopes surround data from the macrophyte-dominated New Danube (AD) and the turbid shallow Neusiedlersee (NS) for comparison.

All in all, the Old Danube case study has once more verified the theory of alternative stable states which was used successfully for the recovery of this urban lake. Moreover, long-term investigations indicated significant resilience of the system against changes and hysteretic behaviour during the recovery phase.

Acknowledgments:

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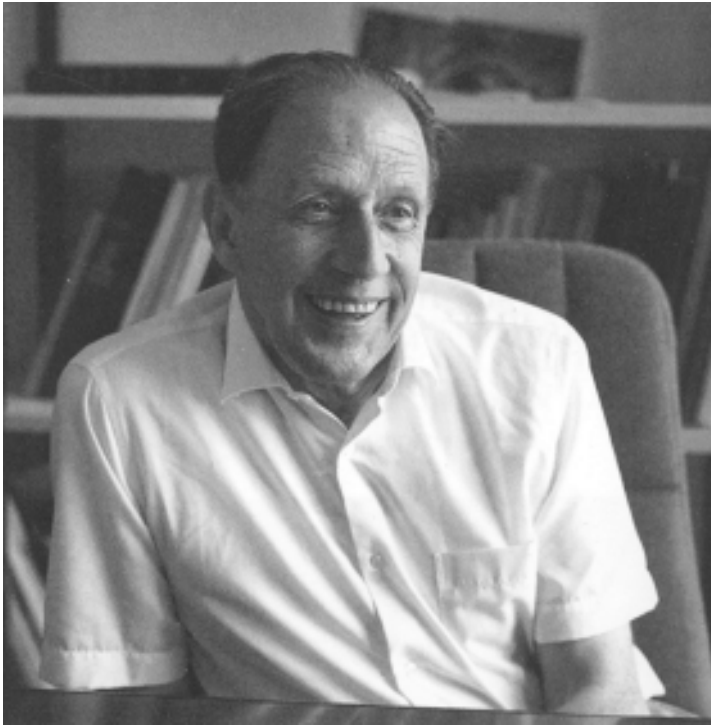
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Professor Ramón Margalef in his office at the Department of Ecology, University of Barcelona, November 1987.

Ramón Margalef **1919 - 2004**

“To speak of Ecology is to speak about Margalef, but to speak of Margalef is certainly more than to speak of Ecology”. These were the first words used by Spanish Oceanographer, Josefina Castellvi upon introducing Margalef on the reception of the last award Margalef received; the Gold Medal of the Catalan Government on October 7, 2003. And I obviously think that these were the fairest words to describe the career of Margalef, extending from his contributions to Ecology to the human being who will be never forgotten by the many people who had the good fortune to interact with him.

Margalef will be remembered by his many contributions to limnology and oceanography, but also to ecological theory (e.g., *Perspectives in Ecological Theory* 1968). Overall, he published more than 400 papers and 12 books. His contributions to teaching were outstanding. He wrote the book *Ecología*, first published in 1974, and later *Limnología* in 1983, which advanced the teaching and the development of ecology and limnology not only in Spain, but also in other Spanish-speaking countries.

Margalef was a pioneer. He was the first ecology professor in Spain, as well as the first Spaniard to attend and participate in SIL meetings in the fifties and sixties. He was also the first ecologist to connect information theory with ecological theory. He had many other firsts as well. This was being done with few resources and a lot of enthusiasm and intelligence. He used to say that “In the University pond there is enough interest for a thesis to be done”, and he was not a preacher of empty words. As an example, he built his own microscope from spare parts in post-war Spain of the 40s. Equipped with a bicycle, a net and a bag filled with empty aspirin tubes, he sampled many waterbodies throughout Spain for the first time.

He received many awards during his long career. I will only include in this long list two which could be the most important for those involved in aquatic ecology. These were the Huntsman Prize of Biological Oceanography (1980) and the Naumann-Thieneman Medal of the International Society for Limnology (1989). However, he did not like receiving prizes, reasoning that “It is related to age” and “Criticism is more stimulating than recognition”. Those who interacted with him are unanimous in feeling that Margalef had unusual generosity and humility; two exceptional virtues among scientists. Many stories have been related these days that involved his openness in listening to someone coming to him with a question, or asking him for help. He always had a refreshing, unique view of the situation when replying to these questions. Many times, even without catching the complete meaning of his reply, the interaction resulted in the encouragement and formulation of other related questions that were even more stimulating than the first one. That was the way that Margalef saw his role as a professor.

Margalef had an encyclopaedic knowledge on the organisms inhabiting fresh and marine waters. This is impressively demonstrated in his book, *Limnología*. To him, the organisms were not static, but were part of a unified entity that also included the physical and chemical environment. He described the mechanisms of plankton succession and the role of physical processes in structuring plankton communities, contributing not only to the expansion of limnology, but also of oceanography.

Professor of professors, Margalef supervised 36 doctoral theses between 1971 and 1990. Many of his former students are now spread in universities and research centers throughout Spain and Latin America. He also helped to train many non-academic ecologists, who also feel somewhat orphaned without him. Moreover, he stimulated the formation of the Spanish Society for Limnology in 1981 by encouraging a group of young and enthusiastic limnologists to take the Society in their own independent direction. This was yet a further indication of his way of leading science and life.

Ramón Margalef passed away on May 23, 2004. He died quietly, just as he carried out his research and taught his many students. His beloved wife, Maria Mir, also a biologist with whom he had four children and published several joint scientific contributions, survived him only seven days. May the two of them rest in peace.

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Environmental Issues

Ubiquity and Cosmopolitanism of Protists Questioned

This brief article is based on a recent review that contained a detailed discussion of ubiquity and cosmopolitanism of protists and literature evidence (Foissner 2004). Further, this review commented on bacteria and microfungi for which, due to new molecular methods, there now seems to be a restricted distribution of certain taxa.

As early as 1913, Beijerinck, a Dutch microbiologist, formulated his famous metaphor “in microorganisms, everything is everywhere, the environment selects”. Quickly this phrase became a fundamental paradigm in microbial and protistan ecology, likely driven by the intuitive view that such minute organisms must have simple ecologies. Although this was soon disproved, Beijerinck’s view survived, especially among ecologists. The few taxonomists who opposed an overall cosmopolitanism of protists were largely ignored, in spite of the good evidence they presented. Only when biodiversity research became fashionable did the problem actually become new, especially because newly developed molecular methods showed that many morphospecies of small organisms, such as bacteria, protists, rotifers and microcrustaceans, are composed of several species with sometimes distinct areals.

Why is endemism so difficult to prove in protists?

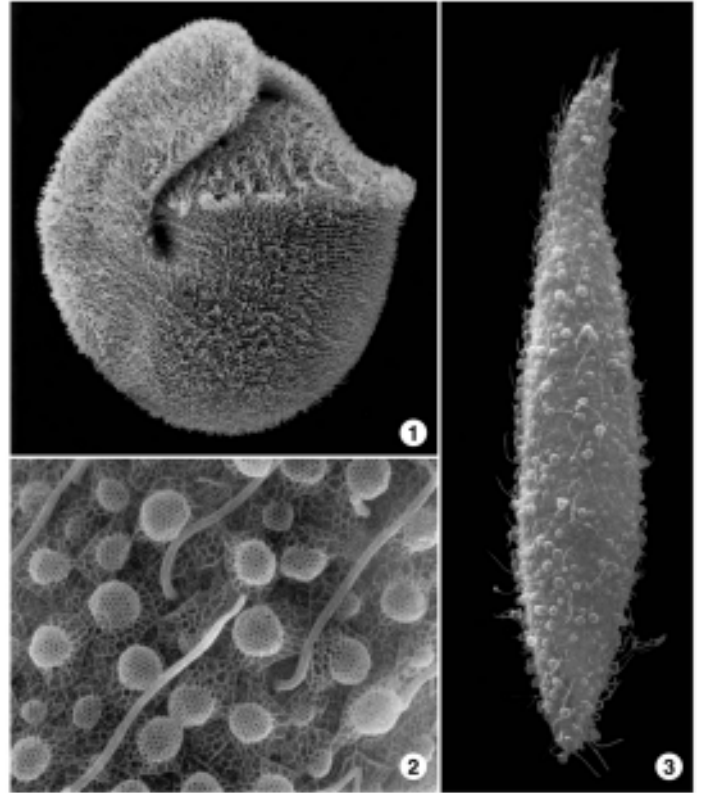
A lot of drawbacks make endemism difficult to prove in protists: (i) compared to higher plants and animals, they are extremely difficult to recognize due to their microscopic size; (ii) many species are dormant (encysted) most of their life, only when appropriate conditions set in do they excyst and become visible; (iii) compared to macroscopic organisms, most protists have few distinct morphological features which, additionally, are often difficult to recognize; (iv) protistology was never a mainstream science and thus few people contributed; and (v) the use of holarctic identification literature for species from other biogeographical regions classifying “minor” differences as “site variations”.

These and other problems, such as the widespread occurrence of misidentifications, cause (i) reliable distribution data being scant; (ii) rare and possibly locally distributed species being heavily undersampled; and (iii) more than 50% of the actual diversity being undescribed in many protistan groups. In other words, we know mainly the euryoecious species, which are more abundant and widely distributed.

Contrasting views

Today, a “cosmopolitanism school”, represented mainly by Fenchel and Finlay (2003), and a “moderate endemism school”, represented, inter alia, by myself and Ralf Meisterfeld, fight for the best arguments. Fenchel

and Finlay argue that the small size and high abundance of microorganisms favor global dispersal and thus low rates of allopatric speciation. They explain the lack of certain microorganisms in certain areas as a result of uneven sampling efforts.



Figs. 1–3. Flagship ciliate species with restricted geographic distribution. Fig. 1: *Bresslauides discoideus* is a long, rapacious moss and soil ciliate, up to 600 μm long, occurring only in Laurasian areas. Figs. 2 & 3: I discovered this still undescribed trachelophyllid ciliate in a salt marsh on the north coast of Venezuela. It is a slender species about 200 μm long covered with nicely faceted, 3–5 μm -sized lepidosomes. The unique, hat-like shape of the lepidosomes shows that this species represents a new genus likely restricted to South America or Gondwanan areals.

The moderate endemism model refers to the many eye-catching “flagship” species which have never been found in other well investigated areas, and emphasizes that most protists are much older than multicellular organisms and, thus, had sufficient time to acquire considerable diversity. This is supported by the continuous discovery of new flagship species showing our ignorance about even conspicuous taxa (Figs. 1-3). However, the most convincing argument for a restricted distribution of microorganisms comes from the data presented under the next heading.

Minuteness and high abundance do not necessarily cause global distribution: evidence from macrofungi, mosses, and ferns

Macrofungi, mosses and ferns often have larger areals than flowering plants and large animals. But few are true cosmopolitans and many of them have rather restricted areals, although their main dispersal means (spores) are usually in the size (5–50 µm) of large bacteria and small protists and are produced in astronomical numbers. This simple fact, which has been completely ignored by the cosmopolitanism model, shows that there is no ecological or other reasons to assume global distribution of all protists.

Conclusion: not everything is everywhere

Flagship species, reliable distribution data, and molecular investigations show that restricted geographic distribution of microorganisms occurs in limnetic, marine, terrestrial, and fossil ecosystems. The data available suggest a multifactorial model in which diversity, dispersal, and provincialism of microorganisms are determined by historic events (split of Pangaea etc.), time, small size, high individual numbers, and limited cyst viability. I estimate that about one third of the free-living protists, described and undescribed, have restricted distribution.

Key literature

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Working Groups

The African Great Lakes

SIL's African Great Lakes Group has had an important role in stimulating international research on the three largest East African lakes, the very deep rift valley lakes Tanganyika and Malawi and the huge (69,000 km²) but shallower Lake Victoria. This group was initiated in 1987 at the SIL Congress in New Zealand in response to reports that drilling for oil had started on the shores of Lake Tanganyika, which could endanger the priceless faunas, fisheries and water supplies of the four riparian countries: Tanzania, Zambia, Burundi and the Democratic Republic Congo. All three lakes support fisheries of vital importance for their rapidly rising human populations. They are also well known as biodiversity hotspots with spectacular endemic faunas including flocks of cichlid fishes unique to each of the lakes of international significance as they offer special opportunities to investigate how new species evolve and coexist.

The group's first task was to organize an international 'Symposium on Resource Use and Conservation of the African Great Lakes' on Lake Tanganyika at the University of Burundi in 1989 (Lowe-McConnell, *et al.* 1992). The widely circulated recommendations from this and subsequent meetings were then used to help obtain international funds for fisheries and biodiversity projects.

The 1990s saw a veritable explosion of research on all three lakes which are now facing serious threats caused by the rapid rise in human populations, leading to over fishing and pressures on their unique faunas from sedimentation and pollution following changes of land use in the lake basins. International projects, involving well over a hundred scientists, have concentrated on limnological conditions affecting fish production, the ecology of the communities, and underwater observations of behavior, spawning a huge bibliography of papers and widely scattered reports. Their findings, together with those from papers given at fisheries conferences and international symposia organized by specialist groups (IDEAL - International Decade of East African Lakes, SIAL - Speciation in Ancient Lakes, PARADI - Biological Diversity of African Fresh and Brackish Waters, and GLOW - Great Lakes of the World) have been collated and assessed as 'Recent Research in the African Great Lakes: fisheries, biodiversity and cichlid evolution' (Lowe-McConnell 2003). Published as a Special Issue of *Freshwater Forum* this can be obtained from the Freshwater Biological Association (contact: info@fba.org.uk) or the author (ro.mcconnell@virgin.net).

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Book Reviews

The Endemic Fishes of Lake Baikal

by Valentina G. Sideleva
270 pp., 2003, hardbound
Backhuys Publishers, Leiden
ISBN 90-5782-133-8
Euro 112.00

Valentina Sideleva is the authority on the 33 species of endemic cottid fishes of Lake Baikal, Siberia. She introduces the entire fish fauna of 55 native species and subspecies and five introduced species in Chapter 1, with synonymies, biogeography, and a review of previous work on Baikal and its life. Chapter 2 surveys habitats available in the lake's waters, with maps, charts and tables. Chapter 3 covers digestive anatomy and diets. Life histories, Chapter 4, range from *Cottocomephorus grewingkii* with a five-year life cycle and fast growth, to slow-growing *Asprocottus herzensteini*, a deep, benthic species 5 cm long, with fecundity of 11 eggs. At the other extreme, the two species of *Comephorus*, 10-21 cm long, bear thousands of live young. Chapters 5, 6, and 7 explore physiological adaptations to pressure, vision, and hemoglobin variation. Lateralis and neuromast anatomy are illustrated in Chapter 8. Chapters 9, 10, and 11 review karyotypes, otoliths, and mid-water adaptations; 12 synthesizes the trophic system of sculpins, Baikal seals, and other organisms.

Systematics is treated in Chapter 13, with distribution maps, tables of character data, vertical distributions, ratios, drawings, and keys. In Chapter 14, phylogenies are labeled with three pre-cladistic families: Cottidae, Comephoridae, and Abyssocottidae. Molecular analyses cited show the flock to be cladistically within the genus *Cottus*. Assumed rates of molecular evolution place origin of this diversity in the Pleistocene, but actual rates are probably slower. None of the phylogenies that include data from sculpins outside the lake show the Baikal sculpins to be monophyletic. Chapter 15 discusses the rich literature on Baikal speciation. Radiation of the diversity from two colonists in shallow waters to specialized species in deep and pelagic habitats, is hypothesized to follow a pattern of allotropic and allochronic isolation, with transitions to deep benthic and pelagic habitats.

In summary, this is a remarkable monograph on the most interesting example of rapid fish evolution in northern-hemisphere fresh waters. It will be studied as the premier description of a temperate species flock.

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The Lakes Handbook: Volume 1 Limnology and Limnetic Ecology

Edited by P.E. O'Sullivan & C.S. Reynolds
712 pp., 2004, hardcover
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This is the first of a two part set and provides the limnological and ecological basis for the second volume that will cover lake restoration and rehabilitation. The Editor's goals with the handbooks were to convey something of the extraordinary diversity of lakes basins and their ecologies, to reveal the common constraints that link the properties of water and to identify the fundamental knowledge required to support the management of quality and biotic outputs from lakes and reservoirs.

Volume 1 contains contributions from 19 scientists and starts with Reynolds' chapter on Lakes, limnology and limnetic ecology: towards a new synthesis. He points out that the whole concept of the ecosystem health of lakes, as well as the way that they are managed in order to achieve and maintain a sustainable condition, must now undergo careful revision in light of our new understanding on how lake ecosystems work. Seven chapters follow on the chemical and physical features of lakes. In the next chapter Colin Reynolds provides the general context for the remainder of the book that reviews the broad structure and general organization of limnetic communities (phytoplankton and macrophytes to pelagic microbes and fish) and their roles in energy flow and material processing in lakes. Here he raises the interesting point that there is still a tendency among researchers that have studied in great detail community function in a particular lake to believe that all lakes behave in more or less the same way. Reynolds makes the important point that while these types of studies are still needed, the 'true' limnologist needs to see a wider picture, to recognize the role of component processes in the behavior of a whole system. The final two chapters examine the Self-regulation of Limnetic Ecosystems and Paleolimnology.

The goal to provide a contemporary and accurate reflection of our current understanding of how lakes function was an ambitious one. The book (both volumes) took more than five years from conception to distribution. Some of this delay the editors accept while some was due to contributors that were unable to keep to the schedule, in some cases forcing their replacement. Four tragic events also contributed to this delay, the deaths of SIL members, Werner Stumm, Tommy Edmondson, Milan Straskraba and Bill Williams. Fortunately, their chapters have been included with minimal editing and additions by others. To try and reduce the impact of the delays, the editors were able to give contributors an opportunity to update their chapters. This has been variably successful in different chapters, but for the most part the reviews end in about 1998/99. Some may see this as a significant weakness of the handbook.

However, there are several good reasons to want to own the handbook. First, the editors have done an excellent job and all the chapters are well written, easy to read and well illustrated. With a book of this size it would be surprising not to find the occasional typographical error, as these can slip by the most careful scrutiny, such as the misspelling of 'ecosystems' in the title of Chapter 11. Second, it seems that contributors were not significantly restricted in the length of their contributions. As a result readers will appreciate the depth and detail of information in most chapters. In the case of the physical properties of lakes, there are three chapters devoted to different aspects. This is not to say that there are not omissions; for example, I found little about benthic microbial ecology or the role of lipids in lake processes. Third, the contributors provide a diverse and interesting array of examples from around the world to illustrate the points that they discuss.

With the cost of the book being higher than recent limnological textbooks, individuals may hesitate to purchase The Lake Handbook. However, the Editors and their contributors have provided a treasure chest of information. So while researchers may shy away from purchasing this book, they would be well advised to recommend it to their librarians.

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Antarctic Biology in a Global Context – Proceedings of the VIIIth SCAR International Biology Symposium, 2001, Amsterdam

Edited by H.L. Huiskes, W.W.C. Gieskes, J. Rozema,
R.M.L. Schorno, S.M. van der Vies and W.J. Wolff
352 pp., 2003
Backhuys, Leiden
ISBN 90-5782-079-X, Euro 120.00

This publication is the proceedings of the latest in the series of biology symposia sponsored by the Scientific Committee on Antarctic Research (SCAR). Such meetings are unusual in being focussed on a geographical region rather than topic, and as such cover a broad spectrum of biology from terrestrial to marine, pollutants to climate change, molecules to whales. The linking feature is the strong physical forcing by low temperature and ice/snow cover shared by all organisms and environments, and this is evident in many of the six themes into which the volume is divided. Those themes are; “The role of Antarctica in global patterns and processes”; “Climate change and increases in UV-B: Impacts and Responses”; “Adaptation and Evolution in Extreme Environments”; “Antarctic and Arctic Ecosystems, Poles Apart?”; “Biogeography and Biodiversity in Antarctic and Sub-Antarctic Systems”; “Antarctic Research, Human Impacts and Environmental Policy”. The final section, “Outlook”, which contains a single review of polar limnology may have been better placed within the other sections.

The nature of this book lends itself to purchase by institutions rather than individual specialists, few of whom are likely to find more than one or two of the papers of direct use. As an institutional resource, some of the overview chapters, which start most of the sections, do a good job of summarizing the current state of understanding of areas of Antarctic Biology. Three that stand out are those written by Karentz, “Environmental change in Antarctica: ecological impacts and responses”; the introductory chapter by Clarke on “Evolution, adaptation and diversity: global ecology in an Antarctic context”; and de Broyer *et al.*'s paper on “Biodiversity patterns in the Southern Ocean: lessons from Crustacea”. These papers draw on multiple threads to provide new insights to Antarctic issues.

Some of the sections work better than others. The first, “The role of Antarctica in global patterns and processes” contains just four papers, none of which really address the theme. Instead we have three papers on distribution of organisms (ice algae, whales and vegetation/permafrost) and one on carbon oxidation in lakes. These papers could perhaps have been better re-distributed in other sections of the volume, as they do not deliver on the theme. The second section is more focussed, containing three papers on UV impacts and two on climate change after Karentz's introduction. The UV papers address mechanisms for tolerating UV stress, an interesting development in this area where for many years there was a focus on the deleterious impacts of UV on organisms. Two interesting examples showing how Antarctic communities can respond quickly to artificial (Convey) or natural climate change (Gerighausen *et al.*) complete this section. An increased interest in long term observations and experiments is a welcome feature of several papers in this volume.

The third section, on adaptation and evolution, contains the greatest number of contributions. Di Prisco provides

a comprehensive overview, and a series of papers on various aspects of the physiological, structural and behavioural adaptations to extreme environments by fish, birds and plants. A number of papers in this section seemed strangely out of place – notably papers dealing with iceberg scour communities and the trophic links amongst amphipods, petrel breeding strategies and the use of lipid markers to identify krill diets.

Section four is an interesting attempt at a bipolar perspective. An overview chapter reviews the similarities and differences in the two polar regions, then Vincent and Belzille compare the UV climate (one wonders why this paper is not in the strong UV and climate change section where it would fit excellently), and McMinn and Hegseth show striking similarities between sea ice algae from the two regions. Verde *et al.* compare cold adaptation of haemoglobin systems in Arctic fish with those of southern fish, and infer different evolutionary pathways – this paper links well with the evolution section of the volume.

The biogeography and biodiversity theme is something of a catch-all. Here we have papers on use of GIS approaches to model the distribution of larval fish and papers on seals, skuas, worms, cyanobacteria and fungi, with an interesting (unanswered) conundrum from Lewis-Smith on why two apparently unspecialized angiosperms have been the only ones to colonize the Antarctic in the Holocene. Good question.

The final main section addresses that unique Antarctic preoccupation – in a continent supposedly occupied for science, what impact are scientists having on the continent? In the most part the papers in this section deal with localized impacts – we need to look at the sections on climate change to consider more overarching impacts of human activities on Antarctica. The general conclusion is that human presence inevitably impacts on terrestrial, lacustrine and marine communities. Contaminants and altered community composition or population structure are reported in all of these papers. The point is made that contaminants (including invasive species) are often legacies of past modes of action, and that environmental protection is ever improving. Only one paper attempts to place impacts in any context, with Waterhouse advocating the use of state of the environment reporting as a framework for assessment.

The selection of the central theme for this conference shows how Antarctic Science has come to recognize that it must reach out of its political basis and become relevant in a global context. The volume begins to address this need, but few contributions really do focus on Antarctica in a global context. Instead the lasting flavour is of a summary of the breadth of work that is currently ongoing by national Antarctic research programmes, organized into, rather than structured around, a series of themes. One wonders whether the need to bring together scientists to address critical Antarctic questions could be better served by shifting the format for at least some SCAR meetings from presentation to workshop. Having said that, this volume is very well presented with a good index (though no author index), contains some genuinely interesting and innovative research and should be a useful addition to academic library shelves.

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Towards a Theory of the Functioning of Aquatic Ecosystems

by Alexander F. Alimov
130 pp., 2003
Backhuys Publishers, Leiden
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Euro 42.00

The ecosystem concept has experienced several decades of evolution and maturation. The complex nature of an ecosystem makes examination and quantifying of functional interrelationships among the many changing components most challenging. Many studies yield only pieces of the ecosystem analyses; others evaluate the dynamics of dominant components. Attempts to find order and consistency among relationships are perennial challenges, but also opportunities for understanding.

In this small book Alexander Alimov presents a succinct summary of major elements of a quantitative functional theory for aquatic ecosystems. Portions of these constructs were developed in an earlier book on production hydrobiology (Alimov 1989). The clear objective was to model interactions that result in observed production of biomass and biodiversity under various natural and anthropogenically modified environmental conditions. From these correlations, a degree of prediction may emerge toward the direction of potential changes in ecosystems as environmental conditions change.

The initial chapter addresses the abundance and dynamics of communities of organisms in aquatic ecosystems. Organism abundance, biomass, and diversity are related to each other and many habitat and system environmental parameters of broad range (e.g., drainage basin size, BOD, phytoplankton production, etc.). The second chapter addresses the dynamics of biomass of populations, communities (trophic levels), and ecosystems, almost entirely restricted to phytoplankton, zooplankton, and zoobenthos. Productivity of lakes and reservoirs is addressed in the third chapter. Although the bias toward pelagic production prevails, some attention is given to macrophytes and periphyton, although based largely on old and outdated data from the International Biological Programme (IBP). Within these limitations, many of the correlations of productivity with other parameters (temperature, latitude, nutrients, respiration, diversity, etc.) are useful and indeed often insightful.

The fourth chapter addresses biotic balances and energy flows in ecosystems in which fluxes and efficiencies of transfers among pelagic biota and benthic animals are evaluated, based almost entirely on Russian and IBP data. Expectations for balance and implications when the values do not balance are not discussed adequately, particularly in relation to the importance of allochthonous organic matter inputs and especially their utilization. The data do support, however, the conclusion formed decades ago that lakes are net heterotrophic and a major portion of their material and energy derives from external sources.

The subject of cycling of nutrients ('flows of matter') in the fifth chapter is much more controversial. Predation by macrozooplankton and benthic animals are considered the dominant pathway for phosphorus (P) recycling from and for phytoplankton. Bacterial and protistan recycling is considered small and negligible without any support data or consideration of non-predatory mortality (genetically programmed death, viral lysis, extracellular exudations, etc. or other sources of mortality; e.g., Wetzel 1995, 2001). Alimov is correct in stating that the data on such matter flows in ecosystems are very difficult to quantify. The data presented, however, are misleading quantitatively and conceptually, highly biased to macroanimals, and do not allow the author to draw such major conclusions of ecosystem operation. The concluding statement that fish control high diversity of aquatic ecosystems is totally unsubstantiated. The section on information flows evaluates negentropy in relation to nucleotides as carriers of information and changes in entropy. This interesting subject, buried in roots particularly by Patten (1985) and Odum (1983), needs much further elaboration by Alimov in this section to be convincing, particularly in relation to his theme of biodiversity and flows of phosphorus by animals. The essential differences between P-mass and P-turnover rates in animals are not treated and these components are not compared to the other multiple elemental turnover rates within the entire ecosystem.

The sixth chapter addresses stability and resilience ('steadiness' or constancy) of aquatic ecosystems in response to natural or anthropogenic

environmental alterations. Alimov's primary index to quantify responses is variability of dynamics of biomass, because 'all functional and structural characteristics of ecosystems ... are related to biomass'. Some statements of correlation (e.g., water transparency inversely to community and ecosystem stability) are functionally simplistic and misleading. In the end, the author states that stability, particularly in relation to biodiversity, is coupled to the adaptive capabilities of organisms, which has long been known to be within the genetically determined physiological tolerances of the individual species.

Functional biological patterns are treated in the final chapter. Because of ecosystem complexity, a systems approach is invoked to analyze functional patterns using simple ecosystem models. Basic rate constants were set for processes without explanation and components were based on phosphorus, assuming a constant mass of phosphorus per energy content of organic matter. Model outcomes were determined among phytoplankton, zooplankton, macrozoobenthos, and fish under different theoretical states of eutrophication, purported community simplification, and changed stability. Examples were given of the predation-based alterations of community structure from Russian studies.

A number of relationships are discussed as novel but in reality have been developed long ago in many uncited works. Common to much Russian scientific literature, productivity is reported in terms of energy fluxes ($\text{kcal m}^{-2} \text{yr}^{-1}$), which is a bit awkward as conversions to the usual carbon values is variable and not direct. A large number of ambiguous undefined words and phrases are used (e.g., lake capacity, specific production, vegetation season, etc.) without any or adequate explanation. Often equation parameters are undefined or defined many chapters earlier in the book, which makes interpretations difficult. Some excellent ideas, such as 'internal stabilizing mechanisms', are never pursued in sufficient detail to gain an appreciation of their validity.

Perhaps my greatest difficulty is the presentation of many correlations among different components and their dynamics. The causes underlying these relationships are rarely discussed, often implied or assumed, and never treated in detail. As a result, I would be enthusiastic in using this book in a seminar discussion series with graduate students, but many of the relationships will need to be discussed in detail with full explanations and with a historical background that is not presented in the book. Interpretations and support data are strongly biased to Russian works, and many seminal studies and data are not included. Many of these other studies would have greatly strengthened some of Alimov's arguments, and in some cases would have demonstrated quite different conclusions. For example, the statement that biomass turnover rates are low in aquatic ecosystems (P/B coefficients = ca. 1) is wrong, because all of these ecosystems are totally dominated in species, energy, and material fluxes by organisms less than 100 μm in size with much higher P/B ratios.

In summary, Alimov's treatment presents many interesting and most useful relationships in a concise direct form. Many conclusions are drawn without substantiation or from a strictly predation-based perspective. Although the latter is very useful among trophic levels, it ignores major components of energy and material fluxes and their regulation and does not adequately reflect the operation of aquatic ecosystems. The book provides many insights but must be read carefully and critically.

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2005 International Symposium of the North American Lake Management Society.
8 - 11 November 2005
Madison, Wisconsin, USA
Contact: Dr. Jeffrey A. Thornton, Chair
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