The development of limnology history essay

Limnology is the study of inland waters. Inland waters include running and standing waters, fresh and saline, natural and man-made, and the study of lakes, rivers, streams, ponds and wetlands. The word limnology derives from the Greek: Î›Î¯Î¼Î½Î· or limne meaning lake and Î» ÏŒÎ³Î¿Ï, or logos meaning knowledge. It is often regarded as a division of ecology and environmental science. It covers all aspects including the biological, chemical and geological characteristics of inland waters. The definition of Limnology as the study of inland waters is true to a degree, as it encompasses many dimensions of inland water science. However, a better way of saying it is that Limnology is the study of inland water ecological systems (Lewis, 1995). This requires the use of information on all components of the system. Limnology thus might be considered an umbrella discipline supported by information from all other disciplines contributing to the science of inland waters. Limnology has strong affinities with fisheries science, hydrology, oceanography, and some branches of geology, botany, zoology, and environmental engineering.

It is not a new science, but has in fact been around in some form or other since about the early nineteenth century(Melvin, 2010). The development of Limnology was hampered in the early days, by the fact that most work was being done was on the oceans, rather than on lakes. However this in some way benefited Limnology as advancements being made in oceanography could also be applied to the study of fresh water bodies. This essay will consider the developmental history of limnology from the writer’s point of view.

While many believe Peter Erasmus Muller is credited with starting the foundations of limnological research by his plankton discoveries in fresh water, and while it appears that Anton Fritsch began investigations in the Bohemian Forest as early as 1871, it is still F. A. Forel (1841-1912) who is credited as the founder of limnological studies(Egerton, 1962). A professor in the University Of Lausanne, Switzerland, his works included: in 1869, Intruction & l'ètude de la fauna profonde du Lac Lèman; between1874-1879, Materiaux pour servir a I'etude de la fauiie profonde du lac Le'man. Between1892-1904, he published his Le leman, monographie limnologigue in three volumes, which was the first book of its kind. In 1885 appeared his La fauna profonde des lacs Suisses for which he was awarded a prize. Then, in 1901, he published the Handbuch der Seenkunde Allgemeine Limnologie, that is considered the first general presentation of limnology from the modern point of view. Forel studied Lake Geneva from a physical, chemical and biological view that has to some degree been the most commonly used method of study thus far. While in the USA, another early pioneer that should take some of the credit is Stephen Alfred Forbes (1844-1930). Forbes was the first Chief of the Illinois Natural History Survey, a founder of aquatic ecosystem science and a dominant figure in the rise of American ecology. His publications are influential for their extensive field observations with conceptual insights. Forbes believed that ecological knowledge was fundamental for human well-being. While already famous as an economic entomologist, Forbes undertook studies of massive fish mortality in Lake Mendota, Wisconsin. He showed the connection of algae blooms and lake physics to fish kills, and embarked on a remarkable research program into the ecology of lakes and rivers. Many of his insights about lake ecology were collected in an influential paper, “ The Lake as a Microcosm” (Forbes, 1887). Forbes’ work foreshadowed the ecosystem concept as well as modern ideas of behavioral ecology and food web dynamics. However, it should be mentioned that before Forbes had published any papers a few important advancements had been made. In 1865, Pietro Angelo Secchi (1818-1878) created the Secchi disk to measure water transparency, a very low tech piece of equipment which is still used today. Lagos Winkler in 1888 developed a field test for ascertaining the amount of dissolved oxygen in a sample of water.

During these early days of Limnology, Forel and many other scientists were only describing the physical, chemical, and biological aspects of a single lake. It was not until 1905 when C Wesenberg-Lund released a paper that changed the way limnologists studied the inland water systems. His paper was a comparative study of lakes in Scotland and Denmark, as well as some pioneering work on plankton and littoral animals. But despite some major advancement in the field, World War 1 broke out and effectively bought an end to this era.

Post World War, a new generation of Limnologists in Europe, USA, USSR and later in Japan led the advancements in the field of Limnology. In Europe there were two main individuals that made great strides to making up for the lost years while war raged across Europe. They were August Friedrich Thienemann (1882-1960) and Einar Christian Leonard Naumann (1891-1934), who in 1922 formed the International Society of Limnology (SIL). The aim of SIL was (and still is) to study and understand all aspects of limnology. The main way they achieved this was by the organization of triennial congresses, to promote scientific collaboration among those pursuing “ real” research, and those who were more concerned with practical fishery, pollution, and water-supply problems. August Thienemann was an ecologist, whose area of study was around individual insects but he was also one of the pioneers in the area of functional groupings. This lead Limnology towards ecological understandings of aquatic systems (Kalff, 2002; Strom, 1929). His study of insects was used to try and determine the aquatic ecosystem based on the chironomid found. He focused on the society of organisms. Strom (1929) agrees with this focus, but goes on to say that the study should be extended further into the investigation of the single organism, including morphology, physiology and genetics (Figure 1)

Figure 1 shows how Strom would expand the study of subjects to clarify the ecosystem, in comparison to Thienemann (Strom, 1929)

Lindeman (1942) released an paper based on Thienemann’s ideas, and the idea of nutrient cycling within lakes and food web structure, showing that the idea put forward by Thienemann in 1925 has withstood the test of time. Reynolds (1999) suggests food web theory in the community structure found within a ecosystem, continued to be a dominant concern as late as the 1980/90’s. While Thienemann and a great number of other scientists believed that lakes were closed systems, Naumann (1891-1934) saw them as open systems (Kalff, 2002). His intuition was that the input of phosphorus, nitrogen and calcium into the system, had a direct effect on the amount and composition of phytoplankton. There has since been hundreds of papers published on the phosphorus relationship to lake function and structure (Prairie, 2008). Naumann believed that phytoplankton is an indicator of nutrient conditions, however technology was not available to directly test this theory. This led him to classify lakes based on their nutrient levels: oligotrophic (poorly nourished), eutrophic (well nourished) and later added mesotrohic (medium nourished). These terms are still used today. Naumann's classification was accepted by Thienemann, however Thienemann modified it to include dystrophic (defectively nourished) to account for the lakes high in colored organic matter. This fourth group is solely based on water color as opposed to nutrient content. Because Naumann was alone in thinking that lakes were open systems he is not accredited with as much influence as Thienemann in the study of Limnology for this era, and this meant lakes were studied as closed units of organizations well into the 1960's and maybe even to some extent till today.

In the USA there were two limnologists that influenced the direction Limnology was heading, and this was in a different direction to their colleagues in Europe (Kalff, 2002). Edward Birge (1851-1950) and Chancey Juday (1871-1944) from their Wisconsin School were moving away from the simplex notion of Limnology to more order and logic. The Wisconsin Natural History Survey paid for the comparative study of hundreds of lakes, while their university connections allowed them to call on chemists, biologists, bacteriologists and instrument makers, to new levels. With this group of people they made many new instruments and developed many new techniques (Spoolman, 2003). Their access to many lakes of different size and morphometry that lay in different basins, led them to dispute any possibility of generalization on a narrow band of lakes as was being carried out in Europe by Thienemann. Unlike in Europe, Birge and Juday were defining many different classifications of lakes such as allotrophic and autotrophic (Kalff, 2002), as well as other concepts regarding how lakes retrieved nutrients by different processes depending on in and out flows. Birge and Juday were also developing more quantitative comparative methods than their European coworkers, however they did not have even the most simple techniques for seeing the statistical difference. Another major step Birge and Juday bought to Limnology, in 1925, was the lake cauterization of having phosphorus present which to this day is a principal proxy used to predict lake functioning. This led them to setup the Trout Lake Station, funded by the University of Wisconsin. Birge believed that the only real way to study lakes was from the field, meaning out on the water observing in its natural habitat, not from a laboratory (Spoolman, 2003). The trout lake station allowed a group of scientists to live and work in that environment. Birge hired Juday to lead the field team, while he took care of the fundraising side. Spurred on by Forbes' 1887 paper " The Lake as a Microcosm" he believed that in order to understand the parts and processes of a lake, you have to collect enough data over a longer period of time. 1911-1916 saw Birge and Juday and a team of graduates undertake filtering of some 2000 tons of water and 200 tons of foodstuffs of fish. From these findings he is quoted as saying " Here we had for the first time a definite notion of the total quantity of food and eaters handled by the lakes in the process of their housekeeping…. After nearly 20 years of experience in the study of lakes we had learned to ask the question: how does a lake keep house?"(Spoolman, 2003, p. 21) This was a defining moment for Birge and many of the people who followed him (Spoolman, 2003).

Limnology changed again with the work done by George Evelyn Hutchinson (1903-1991). Hutchinson was a product of a more modern era of science and could see the need to bring mathematics into the equation. He is best known for his studies into lake metabolism, biogeochemistry, paleolimnology, lake classification and plankton diversity all published in his Treatise on Limnology in three volumes (Kalff, 2002). Unlike his predecessors, he agreed with Naumann and did not see lakes as a single unit, instead he hoped to be able to describe each component of the complete ecosystem, building a whole from the individual parts. The idea that biological interactions happening under the water line were the most important factors in determining the behavior of lakes, fits well with the models put forward by earlier work (Kalff, 2002). After his career as a researcher Hutchinson primarily turned to the development of ideas based around, determinants of community composition and the development of ecological theory based on evolutionary principles, put forward by Charles Darwin (Kalff, 2002). The ideas that Hutchinson developed about lake interactions being linked to chemical/physical environment has formed the basis of many further studies.

Between 1939-1945, the Second World War raged across many parts of Europe, this effectively bought an end to an era of Limnology, and it was not till the mid to late 1950’s that the science started again. With technological advancements made during the war, new instruments using isotopes were created and with the ever growing number of computers available for statistical tests, and easier international travel, Limnology grew rapidly. Between 1960 and 1980 the major changes of limnology happened. Until this time most of the study areas were based around improving water quality or dealing with waste water, and many projects were conducted by single person, or at best with help from a couple of students. A new scheme was setup creating the International Biological Program, where teams were formed in economically strong countries and were able to study whole lakes or streams. This ecosystem ecology led to new insights into relationships between organisms in the ecosystem, and with huge data sets this led to new quantitative models being developed to explain the results found. Reynolds(1999) sums up the history thus far as " a deepening appreciation of the constraints the aquatic environment imposes on the selection and survival of its inhabitants" (p. 12). The slowing down of new discoveries in the 1980 and 90's has had detrimental effect on limnology in terms of funding for further research. Despite now knowing more than ever, we are seeing a shift away from free study by scientists and more towards government pushed problem solving (Kalff, 2002). Most papers on Limnology are pre World War II, and since then it is difficult to find any paper that has really defined real change or advancements in the field. Most advancement seems to have been made in technological ways, with more accurate measuring methods and computers to run huge data sets. However G. Harris' (1999) paper aptly named This is not the end of limnology (or of science): the world may well be a lot simpler than we think has presented evidence that ecosystems (and freshwater ecosystems in particular) may well be a lot simpler than we think. Buried deep within a very complex world there are some general modes of behaviour, determined by fundamental principles, which impart certain kinds of high level order and predictability. Thus there is a need for further research into the field of Limnology (Harris, 1999).

Conclusion

Despite most credit in the early development of Limnology going to F. A. Forel for his many published works, credit must be paid to P Muller and A Fritsch for their early efforts in the field of Limnology. C Wesenberg-Lund’s comparative study of lakes in Scotland and Denmark, was the first to compare results from more than one location. World War I broke out in 1914 and lasted till 1918, bringing a hasty end to this early progression. Post World War I, A Thienemann and E Naumann made an important contribution formed the SIL publication and did some of the first works on ecosystem dynamics. Naumann believed that lakes were open systems, but as this view was not shared by others at the time, it did not have the impact the notion deserved. In the USA it was Birge and Juday and the Wisconsin school that changed the direction of Limnology, towards studying more lakes and collecting more data than anyone to date. They also setup the Trout Lake station, to study and observe all on site, without the need to take back to the lab. Most of the breakthroughs within the field happened in this era, prior to World War II. Post World War II most advancement seems to be made in the way of technology, with continually improving measurement tools using isotopes. The new organization of the International Biological Program led to a change in the way the studies was carried out. Until this time most studies were conducted by one or at the most three people. This program allowed a team to be setup to carry out bigger study areas. Later in the century new advancements were slowing, so Limnology shifted once again moving away from new study, towards more government pushed problem-focused study. It is suggested that there are still new breakthroughs to be made in Limnology, if we are prepared to look.