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ABOUT THE COVER IMAGE

Raymond Lindeman in 1939. In this issue Bob Sterner's biography explains the story, the context, and the consequences of Lindeman's work.

RAYMOND LAUREL LINDEMAN AND THE TROPHIC DYNAMIC VIEWPOINT

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INTRODUCTION

With its presentation of the Raymond L. Lindeman Award, The Association for the Sciences of Limnology and Oceanography recognizes each year an outstanding paper written by an author no older than 35 years of age. Raymond Lindeman was an intellectually daring, determined young man whose insightful paper, "The Trophic Dynamic Aspect of Ecology" (Lindeman 1942) has inspired many others and serves as a cornerstone of ecosystem ecology. The gift to establish this ASLO award came from Lindeman's graduate school friend and colleague, the late Charles B. Reif, whose recollections of the young Ray Lindeman (Reif 1986) are a vivid personal account. The now-famous story behind the rejection and ultimate publication of Lindeman's Trophic Dynamic paper was told by Cook (1977) and is not repeated here. The main focus here is on the Minnesota years, on Raymond Lindeman the graduate student, because that part of the story has so far been relatively neglected. My main focus in delving into the Raymond Lindeman story was to clarify his scientific breakthroughs and to seek to understand how he came to them, who or what influenced him, and how his work departed from the prevailing practices. Background includes the aforementioned works as well as several other biographical and historical and interpretive studies (Lindsey 1980, McIntosh 1985, Kingsland 1991, Hagen 1992, Sobczak 2005, Brady 2008). This telling builds upon those previous works by the use of archived files of Lindeman's and others, as well as recent interviews of individuals who knew Raymond Lindeman.

Raymond Lindeman photographed in 1939.

Raymond Lindeman's graduate work began with a traditional examination of different forms of one species of rotifer. By the time he was writing his thesis, however, Lindeman's work departed greatly from the scholarship of the era and embraced the entirety of the aquatic ecosystem. We remember Raymond Lindeman today for his quantitatively based, conceptually driven study of an ecosystem in its entirety, including plants, animals, and other living compartments as well as the nonliving compartments. Lindeman's postdoctoral advisor, G. Evelyn Hutchinson (after whom ASLO has also named an award), referred to Raymond Lindeman as "one of the most creative and generous minds yet to devote itself to ecological science" (Hutchinson Addendum to Lindeman 1942). Today, we aquatic scientists continue to be inspired by Raymond Lindeman's story while we build upon the science that he was so instrumental in creating. The presentation of the Lindeman Award is occasion to recall a life story both compelling and tragic.

Although Raymond Lindeman lived only a short time he "produced more of scientific importance in his brief life than most people have produced in a normal life span."(D. Lawrence letter to Robert E. Cook, January 11, 1975, Lawrence papers, University of Minnesota Archives). His 1942 Trophic Dynamic paper is widely celebrated but the breadth of his accomplishments may sometimes be overlooked. Raymond Lindeman is best known for developing and advocating a conceptual approach, but he knew his organisms, and as we'll remember here, he built his theory on a solid foundation of his knowledge of

Publications by Raymond L. Lindeman.

Lindeman, R. L. 1939. Some affinities and varieties of of the planktonic rotifer *Brachnionus havanaensis* Rousselet. Transactions of the American Microscopical Society 58:210-221.

Lindeman, R. L. 1941. The developmental history of Cedar Creek Bog, Minnesota. American Midland Naturalist 25:101-112.

Lindeman, R. L. 1941. Ecological dynamics in a senescent lake. University of Minnesota, Minneapolis, MN. PhD thesis.

Lindeman, R. L. 1941. Seasonal food-cycle dynamics in a senescent Lake. American Midland Naturalist 25:636-673.

Lindeman, R. L. 1942. Experimental simulation of winter anaerobiosis in a senescent lake. Ecology 23:1-13.

Lindeman, R. L. 1942. Seasonal distribution of midge larvae in a scenescent lake. American Midland Naturalist 27:428-.

Lindeman, R. L. 1942. The trophic-dynamic aspect of ecology. Ecology 23:399-418.

Unpublished works.

Intra-specific variation in the rotifer *Brachionus diacanthus* Schmarda (*B. angularis* Gosse). Submitted to the Transactions of the American Microscopical Society, November 18, 1938. Retracted March 26, 1939.

Microfossils in the sediments of a senescent lake, and their successional significance: a preliminary report. With Eleanor Lindeman.

natural history and paleoecology. Raymond Lindeman, born and raised on a Minnesota farm, showed early academic aptitude, and did his graduate work at the University of Minnesota with Dr. Samuel Eddy as his major professor. From there he moved to Yale to work as a Postdoc with Dr. G. Evelyn Hutchinson. His famous trophic dynamic paper took form at Minnesota, was finished at Yale, and was submitted to *Ecology* where it initially was rejected for publication. After several well-established scientists from Minnesota and Yale wrote in support of the manuscript it eventually was published. Raymond Lindeman's life came to a tragic early end before the paper actually appeared.

Lindeman the scientist and ASLO the society had nearly contemporaneous beginnings. Raymond Lindeman began his graduate student training in 1936, the same year in which the Limnological Society of America was formed. The LSA was an affiliate society of the American Association for the Advancement of Sciences, and it was the forerunner society to ASLO (Lauff 1963). The LSA became ASLO in 1948 (Redfield 1956). Lindeman attended the 3rd annual LSA meeting in Indianapolis in 1936, his second year in graduate school, and he joined the society shortly thereafter—annual dues were $1 (P.S. Welch letter to RL, February 26, 1938, Lindeman papers, Yale University). At

Chronology of events in the life of Raymond L. Lindeman.

Date	Event
July 24, 1915	Born, Redwood Co., MN
1927	Entered High School
1932	Entered Park College
1935	Attended summer session, University of Minnesota, Itasca field station
Fall, 1936	Received B.A. from Park College, graduated second in class
Summer, 1936	Entered Graduate School University of Minnesota
December 21, 1936	First sampling trip to Cedar Bog Lake undertaken
Date uncertain	Hospitalized with jaundice
December, 1937	Attended LSA/AAAS meeting in Indianapolis, IN
February 26, 1938	Joined Limnological Society of America (ASLO forerunner).
Summer, 1938	Wed to Eleanor Hall
Summer, 1939	Attended Friday Harbor Summer Session with Eleanor
December, 1939	Met Hutchinson at LSA/AAAS meeting in Columbus, OH
June 24, 1940	Last sampling trip to Cedar Bog Lake
Summer, 1940	Attended Hydrobiology Symposium at Madison, WI and met Deevy.
November 11, 1940	First letter to Hutchinson
November, 1940	First draft of trophic dynamic paper
December, 1940	Attended LSA/AAAS meeting in Philadelphia, PA, gave paper entitled, Food Chain Dynamics in a Senescent Lake and met Hutchison
February, 1941	Date on his PhD thesis
April, 1941	Awarded Sterling Fellowship to work at Yale
Summer, 1941	Instructor of five-week Field Biology summer course at St. Mary's College, Winona, MN
August, 1941	Arrived at Yale
September, 1941	Cover date on first draft Trophic Dynamic paper to include quantification of trophic levels in energy terms
October, 1941	Trophic Dynamic paper submitted
November, 1941	Trophic Dynamic paper rejected
December, 1941	Attended LSA/AAAS meeting in Dallas, TX and gave a paper with Hutchinson (see text box).
Christmas, 1941-April 1942	Illness, little work accomplished including hospitalization for 3 weeks shortly after returning from Dallas.
March, 1942	Revised Trophic Dynamic paper was submitted and acceptance was received
April-May, 1942	Hepatic attack with hypertrophy and visceral edema
June 15, 1942	Underwent exploratory surgery
June 29, 1942	Passed away
October, 1942	Trophic Dynamic paper published in Ecology

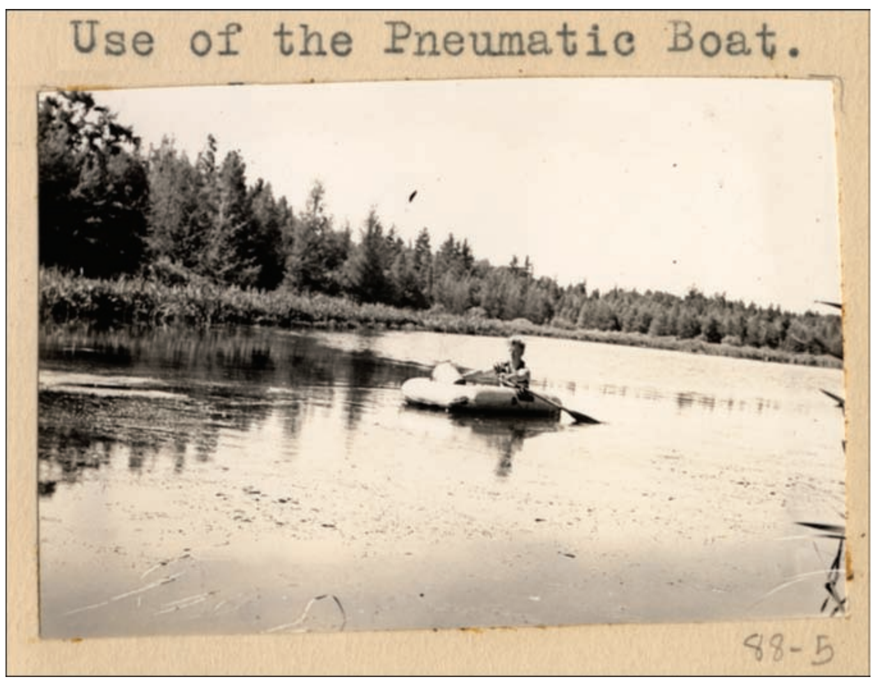
this time LSA membership was ~300 individuals (Lauff 1963). He also attended the 1939 LSA meeting in Columbus, Ohio, and it was there that he met Hutchinson for the first time. Lindeman also attended a third LSA meeting in Dallas, Texas in 1941 where he gave a talk that he co-authored with Hutchinson. Scientific societies were important then like they are today – not just for communicating science but for allowing individuals to make new contacts and explore career opportunities.

LINDEMAN'S LIFE

Raymond Laurel Lindeman was the eldest child of Otto and Julia Lindeman, nee Ash. Friends and family called him Ray but we will refer to him here by his full first name. The family rented and farmed property near Clements, Minnesota (FM Interview). Raymond had three siblings. A brother, Myrl Arlo, was two years Raymond's junior. His two sisters were named Ethel B. and Lila Mae (nicknamed Pat). Another member of the Lindeman household was Floyd Mertz, a hired hand. The pursuit of knowledge ran strong in the agrarian Lindemans. Both parents attended an agricultural school (PL Interview) and Otto was sometimes the first of his neighbors to introduce new practices to the farm (FM Interview). Myrl obtained a Bachelor of Mechanical Engineering with high distinction in 1941 and a Master of Science in Mechanical Engineering in 1942, both from the University of Minnesota (University of Minnesota, Registrar records). Myrl died, like Raymond, from problems associated with his liver (FM Interview). Ethel specialized in bookkeeping and financial analysis (PL Interview). Ethel helped type Raymond's thesis. Pat's education included a BS with distinction from the University of Minnesota in 1950 (University of Minnesota registrar records). She taught nutrition in community colleges in California for more than 30 years. The family provided direct support to Raymond's research; Pat recalls the Lindeman family helping process his mud samples using tweezers and white bowls (PL Interview). On two occasions Floyd Mertz accompanied Raymond into the field for the regular Cedar Bog Lake sampling (FM Interview). A photograph of Raymond on the lake in his inflatable boat derives from one of these occasions. Raymond was close to his mother. Julia was with him and his wife in New Haven in his final days.

As a boy, Raymond had few friends his own age, and he had an early, avid scientific interest, keeping a large butterfly collection in his bedroom (PL Interview). Raymond attended a "country school with eight grades in one room" (PL Interview). His teacher had him take 8th grade tests in 6th grade and Raymond passed them all (PL Interview). Raymond entered Redwood Falls High School in 1927 at age 12 and graduated in 1932. A common and recurring theme among those who recalled Raymond was his intense and not easily satisfied curiosity about the natural world. From multiple sources, we get some inkling about the way Raymond Lindeman threw himself into the subject. He was a "nice fellow but all business," (FM Interview). "Ray was always a very serious and intense worker," said Don Lawrence (D. Lawrence letter to Robert E. Cook, January 11, 1975, Lawrence papers, University of Minnesota Archives). According to Reif (1986), "In all social situations Ray was always polite, serious, and proper, " and "once Ray decided on a course of action his awareness of time was switched to hold." His work habits approached relentlessness, perhaps to the point of degrading his already compromised health. For example, Don Lawrence recalled that "he and his wife would work intensively in the field and in the lab for several weeks until he began vomiting blood. Then he would spend some weeks in the hospital on bland diet and then go to work again."(D. Lawrence letter to Robert E. Cook, January 11, 1975, Lawrence papers, University of Minnesota Archives). Alec Hodson, another faculty member during Raymond's graduate school years said, "If it weren't for his wife, who was always around to help him with his work and to see that he got some food into his stomach, I seriously think he would have forgotten to eat."(Finley 1977). Raymond often skipped class to work on his own ideas, but his grades did not suffer (Reif 1986).

An appetite for hard work apparently did not spill over to all life's endeavors. Floyd Mertz recalls that Raymond seldom was involved in the work of the farm, and he never saw Raymond get on a tractor (FM Interview). Raymond was clearly capable of spending long hours outdoors, but from these observations of Floyd Mertz it seems his energy was focused on natural history, not agriculture. From brief comments in his correspondence it seems Raymond had mostly suspicion when it came to orga-



Raymond Lindeman using his "Pneumatic Boat" to sample in July, 1937. The date was indicated on a copy of this photo in the collection of Mr. Floyd Mertz, who sampled the lake with Lindeman on two occasions (FM interview). The photograph from the Raymond Laurel Lindeman Papers, Manuscripts and Archives, Yale University Library.

nized religion. For example, one letter when discussing potential prospects related to a job opening at a Catholic University, Lindeman wrote, "I would like to be able to teach the Truth as I see it and not as some holy so-and-such sees it for me…" (RL letter to C. Reif, August 20, 1940, Lindeman papers, Yale University Archive). Reif (1986) comments that Raymond's political views were left of his own.

Raymond graduated second in his class from Park College, Missouri (Reif 1986). At Park, he was a member of the Chorus, Glee Club, and the manager of the Student Book Exchange (Application for Fellowship for Study in Scandinavian Countries, approximately March 15, 1939, Lindeman papers, Yale Archives). Raymond's enjoyment of singing was also noted by his graduate student friend and officemate (Reif 1986). Apparently Raymond first met his eventual graduate school advisor, Samuel Eddy, while Raymond was doing summer undergraduate studies at the Lake Itasca field station in 1935. An undated, handwritten draft of a letter from Lindeman to Eddy accepts an assistantship to attend graduate school and thanks Eddy for his interest, referring to Itasca in 1935 (Letter from RL to Eddy, Lindeman papers, Yale Archives). A group photograph of Raymond at Itasca survives. University of Minnesota Registrar records confirm he attended during summer, 1935 before he graduated from Park. It is interesting today to note that even back in the mid-1930s summer programs such as field stations had a strong influence on the career trajectories of young ecologists. A poem Raymond wrote at Itasca even seems in some ways to foreshadow the trophic dynamic approach, what with its "hunting and hunted microbes" and its "dynamic worlds." The poem's central theme is the search for understanding amid nature's splendor. This desire ran strong in Raymond Lindeman.

Raymond met his bride-to-be, Eleanor Hall, at Park College. She was a partner in science as well as life. Eleanor's father was a Professor of Political Science at Albion College (Reif 1986). They were wed in Michigan in the summer of 1938. She apparently then transferred to Minneapolis; attending the University of Minnesota from Fall 1938 through Winter 1941. She received a Bachelor of Arts in Zoology with a minor in French on the same date Raymond received his PhD (University of Minnesota, Registrar records). Raymond's sister Pat described Eleanor as a "very, very loving person" (PL Interview). Eleanor is often described as being with Raymond in the field as well as during long hours in the lab. Don Lawrence wrote, "It is certain that Ray could not have accomplished what he did without the devoted help of his wife. They had no children so she spent all her available time on his projects." (Letter from Don Lawrence to Robert Cook, January 11, 1975, Lawrence papers, University of Minnesota Archives). She was the algal specialist of the pair. Raymond mentions her expected contributions to their anticipated future work in his NRC fellowship application written during his postdoctoral year at Yale , "My wife will work jointly with me in this research. She is a competent diatom taxonomist, and her quantitative analyses of these microfossil indicators will enable us to extend the scope and value of this research beyond that which I could accomplish if working alone" (Application for National Research Fellowships in the Natural Sciences, National Research

This group photograph hangs at the Itasca Biological Station. It was taken either in 1935 or, more likely, 1937 when Raymond penned the poem presented elsewhere. RL is the second from the right in the back row. Other individuals are not identified.

MINNESOTA'S LAKE, ITASCA,

Hears the great pines bend and sway,
Hears the wild deer's muted whistle
Greet its mate at close of day;
To us now who watch and listen
Cascades through both ear and lens
Fragments of primeval secrets
To o'erwhelm our narrowed kens!
Here we search the placid waters,
Find a microcosmic sea
Wherein hunting, hunted microbes
Eat and live and die, as we.
Here we wander through the forest
Magnitude past all belief;
Yet one shrub is universal
To the aphid in its leaf.
Here beside the lake, Itasca
We have found a rendezvous;
With all Nature's prized beauty
Here about our feet astrew.
To whom Fortune does so favor
That we revel here discern
Dynamic worlds are set before us
Let us humbly seek to learn.

—Raymond Lindeman

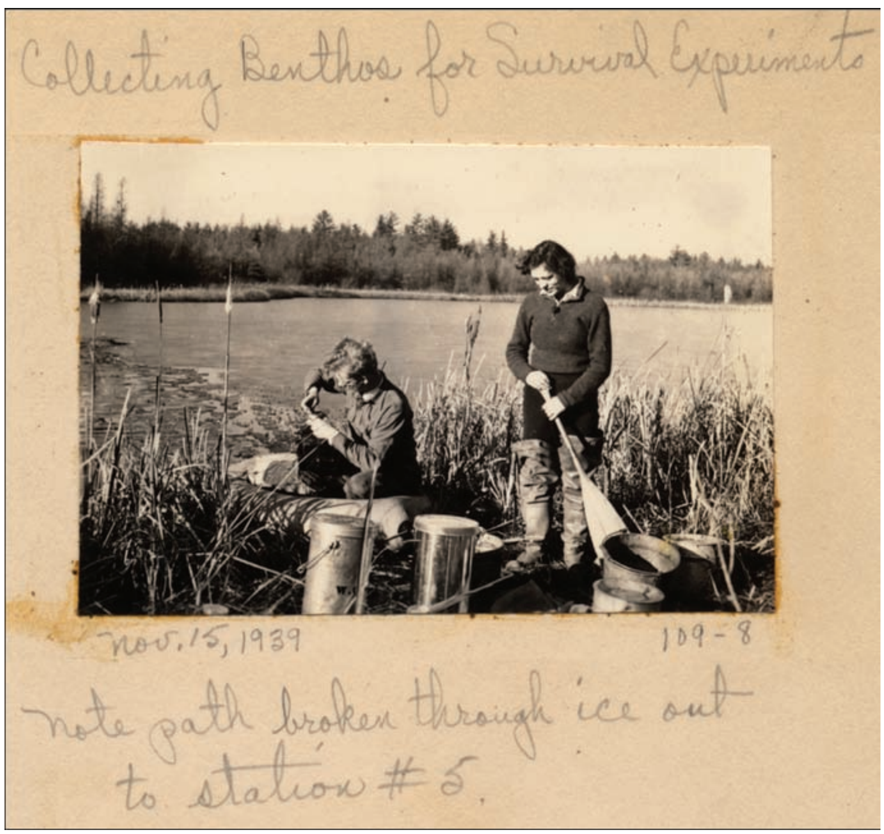
Poem by Raymond Lindeman.
From http://www3.cbs.umn.edu/itasca/about/poem.shtml.

Council, February 17, 1942, Lindeman papers, Yale Archives). Late in November 1941, Eleanor consulted with Dr. Ruth Patrick on some difficult diatom species identifications, receiving confirmation of most of her IDs (letter from RL to Ed Deevy, December 2, 1941, Lindeman papers, Yale Archives). With Lindeman, Hutchinson and Patrick at once at Yale, this was a confluence of three scientists after whom ASLO has named awards. After leaving Minnesota the Lindemans attempted to publish a manuscript based on Eleanor's algal data, but they were thwarted when Samuel Eddy withheld permission to utilize the associated basic limnological survey data (Various RL letters to Chuck Reif and Samuel Eddy, Lindeman papers, Yale Archives). Following Raymond's death, Eleanor returned to the University of Minnesota and attended graduate school from Fall, 1942 through Spring, 1944 (records of the University of Minnesota registrar—the field of study is not recorded). Eleanor remarried to a medical researcher, had children, and did extensive traveling with her husband and family especially in South America, eventually living in northern California (PL Interview).

Raymond and Eleanor Lindeman lived what sounds like a Spartan existence even given the circumstances of Depression-era graduate-student life. The young couple first resided in a trailer on private property at 410 Harvard St., SE (Application to American Scandinavian Foundation, approximately March 15, 1939, Lindeman papers, Yale Archives), a few minutes by foot from Room Z11 of the Zoology building, an office Raymond shared with Charles Reif (Reif 1986). The plumbing for the trailer was located in the basement of a home next door and an extension cord furnished their power (letter from D. Lawrence to Robert E. Cook, January 11, 1975, Lawrence papers, University of Minnesota Archives). Today, the location where Lindeman's trailer once sat is occupied by a Superblock of University dormitories, and hundreds of students reside there year after year. The Lindemans later moved to an apartment farther from campus (Reif 1986). Raymond and Eleanor did not own a car, which necessitated monthly transportation arrangements through friends and family to permit the Cedar Bog Lake sampling. Six individuals in addition to Eleanor are acknowledged in Lindeman's thesis as providing help in the field. Eleanor kept canaries in the trailer (PL Interview and letter from Chuck Reif to RL, July 5, 1938, Lindeman papers, Yale Archives). Raymond's annual stipend at the University of Minnesota was $600. Money obviously was tight, and there are many references to the toughness of the economic times in the Lindeman correspondence.

As will be covered in more detail below, near the end of Raymond's graduate studies, he met Hutchinson and Deevy (one of Hutchinson's students), and then applied for and received a Sterling Fellowship to work at Yale. In between, in the summer of 1941, Raymond was a summer instructor at St. Mary's College, Winona, Minnesota. St. Mary's was a four-year, liberal arts men's college run by the De La Salle Christian Brothers, a Roman Catholic teaching congregation. Sometime late in August, 1941 the Lindemans arrived at New Haven. Shortly after arriving, Raymond wrote to his former advisor:

> "Sorry not to have written before, but I've been awfully busy revising again, with Hutchinson's help, my essay on the trophic-dynamic viewpoint in ecology. I think a copy will reach you in a week or so, and would like to have your reactions to it. We arrived in New Haven about a month ago, and are now very nicely located. The department is very interesting: the offices and equipment (with exceptions) are not as good as at Minnesota but there are many more full-time technicians around. I guess they put their money into high salaries and technicians rather than equipment, which is better from some points of view. I can't praise Dr. Hutchinson too highly – he's the most congenial, unassuming and friendly sort of fellow imaginable – and without reservation the most incredibly brilliant. He knows the European literature like a book and comes around for a chat every day with Tommy Edmondson (working on rotifers), Tom Austin (working on zooplankton – has published with Tressler) and myself. There's lots to be learned here just by keeping one's ears



Raymond and Eleanor collecting benthos at Cedar Bog Lake for their winter anaeorbiosis survival experiment. November 15, 1939. A path through the ice is apparent. Raymond Laurel Lindeman Papers, Manuscripts and Archives, Yale University Library.

open. We're organizing a general ecology seminar group, from as many fields as we can find fellows interested – soils, botany, oceanography, etc., and hope to have some spiraited [sic] discussions"

(letter from RL to Samuel Eddy, September 28, 1941, Lindeman papers, Yale Archives).

By October even the financial situation had improved: "By the way, about two weeks from now you'll be receiving a little financial 'present' from us if we have any left by the time we get down to the R's on our debtor list!" (letter from RL to Chuck Reif, October 22, 1941, Lindeman papers, Yale Archives). The stipend at Yale was $1800/year, triple his graduate school salary. Professionally, the time at Yale was occupied with further sample analysis by Eleanor and him, revisions of the Trophic Dynamic paper along with submission, rejection and resubmission followed by acceptance (Cook 1977), attendance of the Dallas meetings, then shortly afterward declining health.

Had he been blessed with robust health, Raymond Lindeman would be in his mid-90s as I write this, but sadly, his story unfolds differently. Several serious ailments afflicted him and altered the course of events. The first was an injury which occurred when he was young when he accidentally spilled iodine into his right eye, which resulted in corneal corrosion and meant this eye was capable only of distinguishing dark from light (Reif 1986). This would have had some impact on his work. When applying for a Sterling Fellowship at Yale, Raymond listed his equipment needs this way, "50x dissecting microscope, monocular preferred" (RL letter to Hutchinson, February 17, 1941, Lindeman papers, Yale archives). A discoloration of the right eye socket is apparent in one portrait presented in this article but not another and according to Reif (1986) his favoring of his left eye often imparted to him a kind of quizzical look when he was in conversation. His other ailments more significantly affected his work and ultimately led to his early death. In addition to these being debilitating they also were a factor relative to the WWII draft, which was drawing many equal-aged young men of his time into global combat. Raymond suffered both from chronic colitis, or sometimes it is said, stomach ulcers. Raymond's digestive problems plagued him often and sometimes greatly restricted his activities. According to Don Lawrence, Raymond subsisted entirely on a bland diet (Finley 1977). Reif (1986) recalls them sharing meals, including corn and eggs, cooked over a Bunsen burner in the lab, and that when given a chance to select the menu for a home-cooked meal Raymond requested salmon cakes. Raymond spent one summer ill in his bedroom on the farm, where the family took food to him (PL Interview).

Date unknown but this portrait was included in Lindeman's application for an NRC Fellowship, which was dated February 17, 1942. In contrast to the better known portrait shown in Figure 1, this one shows little overt sign of the boyhood injury to his right eye save perhaps a slight narrowing. The photograph does not appear to be retouched. Raymond Laurel Lindeman Papers, Manuscripts and Archives, Yale University Library.

As problematic as his digestive issues were, it was pathologies of his liver that ultimately proved most serious. Raymond suffered from a form of hepatitis that resisted both clear diagnosis and treatment. It led to episodes of jaundice in 1937 and early 1942. In a lighthearted passage to his close friend, Reif wrote, "They'll be cooping you up as an alien if you don'[t] change your color scheme soon" (Letter from Chuck Reif to RL, February 13, 1942, Lindeman papers, Yale Archives). Early in March, Raymond was reporting "I've been out of the hospital for two weeks, but haven't yet gotten back to normal routine. The attack was quite serious and left me with a good bit of cirrhosis and hypertrophy (considerably enlarging my midriff), so that I'll have to be rather careful from now on" (letter from RL to Chuck Reif, March 3, 1942, Lindeman papers, Yale Archives). The most medically complete description of his fatal illness seems to be from an April 13, 1942 letter Raymond penned to Don Lawrence: "The trouble is obscure – hepatic cirrhosis of unknown etiology, with a possibility that it may become progressively worse in spite of everything" (Letter from RL to Don Lawrence, April 13, 1942, Lawrence papers, University of Minnesota Archives). Just a month later during his downhill slide of 1942, he wrote this to Reif, "confidentially, there is a better than even chance I won't survive the summer. My liver trouble has gotten irregularly worse, in spite of the best doctors, and after 4 months is beginning to show visceral oedema. I expect to have an exploratory operation soon in the more or less desperate hope that they can find out what the cause is and then try for a cure. Eleanor is working at the Yale Library and s[h]ould be able to continue if worst follows worse" (Letter from RL to Chuck Reif, May 16, 1942, Lindeman papers, Yale Archives, underlines original). Today, we know that the causes of hepatic cirrhosis include alcoholism, hepatitis B and C and fatty liver disease, as well as other unknown causes. From all reports, Raymond Lindeman was a teetotaler whose work habits left little room for dalliances, so it seems safe to rule out the first of these causes. The end came on June 29, 1942. Raymond Lindeman donated his body to the Department of Anatomy, Yale.

INFLUENCES

The conceptual advances of his 1942 Trophic Dynamic paper are why Raymond Lindeman's name is celebrated today, but this famous paper is part of a fascinating journey of intellectual growth and transformation. What influences and inspirations eventually led to this breakthrough? Looking into this background lets us appreciate that the conceptually elegant Trophic Dynamic Viewpoint was advanced in full knowledge of the messiness and complexity of natural ecosystems.

According to his NRC postdoc application (Yale archives), Raymond's coursework at Minnesota consisted of: Protozoology (Turner), Animal Behavior – physiology (Minnich), Animal Ecology – terrestrial (Eddy), Aquatic Ecology (Eddy), Entomology (Mickel), Parasitology (Riley), Histology (Pliske), Ichthyology (Eddy), Biostatistics (Treloar), Rotifer Problems (research) (Eddy) and Research in Aquatic Biology (Eddy). Notably missing from this list of coursework is the name of W.S. Cooper, an individual as we will see who was a big influence on Raymond Lindeman.

Raymond Lindeman's advisor at the University of Minnesota was Samuel Eddy (1897-1972), Professor of Zoology and Curator of Fishes at the Bell Museum of Natural History. Eddy worked to document the fish species of Minnesota (Eddy and Surber 1943), and later of all of North America (Eddy 1957). He also published multiple works on vertebrate anatomy. He taught courses in ecology, anatomy and fishing (in Physical Education). Eddy's hometown was Decatur, IL. He attended James Millikin University where he was introduced to aquatic invertebrates. He left school for a time to pursue farming and then returned to finish his Bachelor's degree. He received a Ph.D. from the University of Illinois in 1930 with a thesis entitled, "A Study of Freshwater Plankton Communities." From there he went to the Illinois Natural History Survey, published a number of studies on plankton in Lake Michigan and elsewhere, and subsequently joined the University of Minnesota Zoology faculty in 1929.

Eddy was what we'd likely call today a traditional zoologist. His interests were in species identification, anatomy, and biogeography. "My principal hobby in high school was to dissect every animal I could collect and to keep careful notes on my dissections. I read every book in our public library." (Eddy 1961, p. 122). Eddy led an extensive survey of Minnesota lakes, which was performed during 1929-34 under the WPA and CCC auspices. Charles Reif, Raymond's close friend and fellow Eddy student, spent his summers at these camps in the northern part of the state, collecting data for his thesis and helping to manage the survey. Leadership of the survey was later transferred to someone else, which from correspondence between Lindeman and Reif seems to have been a serious blow to Eddy. Eddy's writings around the time when Lindeman was in his lab indicate a keen interest in fish growth rates and productivity, a clear overlap with the energetics approach being taken by Lindeman. The letters Eddy wrote to Lindeman at Yale are short and professional and lacking in personal exchanges, with more than one letter from Eddy asking Lindeman if Raymond had brought one or more laboratory items from Eddy's lab to Yale. From this distance, we can guess that Samuel Eddy's influences on Lindeman included a deep knowledge of the natural history of lake organisms, a respect for scientific rigor, and professionalism.

Eddy was clearly supportive of Lindeman, for example in writing recommendation letters for postdoctoral applications (RL letters to Samuel Eddy, 1942, Yale archives), but Lindeman's conceptual orientation seemed to have little overlap with the intellectual style of his major professor. In the year after Lindeman left Eddy's lab, Eddy was finishing his book with Surber (Eddy and Surber 1943), which contains an extensive introduction on lake dynamics. The section begins, "Fishes represent the end of a long cycle through which the elements of fertility pass from raw substances in the water and lake bottoms to food for the higher forms of fish life," a verbal parallel to Lindeman's food cycle diagram (see below). But, there is nothing of substance from Lindeman's thesis in this section, perhaps because its intended audience was the public. Lindeman's papers are cited in Eddy's much later (1966) account of lakes in the north central U.S. as examples of studies of productivity relations. The trophic dynamic theory is mentioned here but not otherwise remarked upon. From this great distance, it is hard to discern any significant intellectual influence that Eddy had on the conceptual and theoretical advances associated with Lindeman's most famous Cedar Bog Lake studies, or that Lindeman's theoretical advances made much of an impact on Eddy's thoughts.

Raymond's publication list is short but the topics included are broad, including biogeography, paleolimnology, succession, and trophic dynamics. His first publication (Lindeman 1939) was a classical zoological work describing several new forms of the rotifer *Brachionus havanaensis.* This style of work is unmistakably in the footsteps of Eddy. Lindeman worked through some of Eddy's own plankton samples for this paper, and the taxonomic-autecological approach taken there was closely aligned with the fish studies Eddy was doing at the time. In the publication Raymond credits Eddy's inspiration for the study and in correspondence Lindeman also says that Eddy had begun work on a monograph of *Brachionus* but had abandoned it due to pressures of other duties, opening up the chance for Lindeman to take over (RL letter to E. Ahlstrom, February 17, 1939, Yale archives). This 1939 paper of Lindeman's is actually one of two he submitted to the Transactions of the American Microscopical Society on the forms of *Brachionus.* The other (see list of publications) was submitted in November of 1938, but after acceptance Raymond withdrew it in March of the following year because he became aware of a larger study by D.E.H. Ahlstrom on the entire genus. As Editor, J.E. Ackert invited Raymond to send a substitute manuscript. Raymond declined. It seems apparent that Raymond's efforts by now were being devoted fully to the Cedar Bog Lake study. None of the rotifer work made it into Lindeman's thesis. The record does not permit us to see clearly how the rotifer work fit into his thinking when he was forming his research directions in the early part of his graduate school years. Was it ever seriously considered as his main topic, or was it an opportunistic foray that presented itself to him? Raymond began his regular sampling of the Cedar Bog Lake ecosystem in December of 1936, only six months into his graduate work, which seems to clearly indicate that he saw the study of the whole lake ecosystem not just the rotifers as his main interest right from the beginning.

William S. Cooper was a significant influence. Cooper was a student of Henry Chandler Cowles at the University of Chicago, receiving his Ph.D. in 1911. Cooper came to Minnesota in 1915 by way of Stanford when F.E. Clements was the Head of the University of Minnesota Botany Department (Lawrence 1979). Clearly, succession was a topic often discussed during Lindeman's graduate school years. Cooper's research interest in Minnesota centered on the postglacial history of the Anoka Sand Plain, the geological feature on which Cedar Bog Lake is located (Cooper 1935, Lawrence 1979). In the words of Don Lawrence, "I think Dr. Cooper was more real help to Raymond than Eddy because Cooper had recently advised another student [Russell Artist] in a pollen analysis study of the bogs of the Anoka Sand Plain, another of which (Cedar Bog Lake) Lindeman was studying." Further, in a letter to E.S. Deevy in November, 1939, Raymond wrote, "Dr. Cooper has been promoting as much cooperative work as possible on this beautiful natural area, and my own work is largely in response to his suggestion" (Yale archives). Cooper, Lawrence and others, including Raymond, were freely mixing their scientific interests with preservationist goals, and Lindeman's project was undertaken at an early stage of maintaining the site for future generations (Hodson 1985).

The creek and bog as well as the water body now called Cedar Bog Lake were an exciting find and judged to be a valued location for research. Cooper was the first scientist to "discover" Cedar Bog Lake while on an aerial reconnaissance trip on April 6, 1930 only six years before Raymond performed his first sampling. The bog and lake were first referred to as "Decodon Bog" and "Decodon Lake" respectively owing to the extensive growth of this plant in the lake margins. Since at least Lindeman's writings the lake has been called Cedar Bog Lake. By 1937 the Minnesota Academy of Science had formed a committee to investigate the preservation of this site. About 200 hectares—or about one tenth of the currently preserved area—around Cedar Bog Lake were purchased with private funds around 1940. Lindeman's published papers and his correspondence make it clear that his main interest in this particular ecosystem had to do with its dystrophic state. He often referred to the lake as being in "late successional state" and one of the major questions he wished to answer was the pattern of productivity associated with the succession from open water to land. Raymond had the overall goal of connecting long-term changes in productivity relations to his measurements of energy in and out of ecosystem components. Thus, the extensive bog around the lake was one of its major values as a study area. The preserved land was transmitted to University of Minnesota ownership in 1942, and has since grown to 2200 hectares (for a more complete history, see http://www.cedarcreek.umn.edu/about/history/historylong.shtml). The area was then known as "Cedar Creek Forest." For many years the land was called the "Cedar Creek Natural History Area." Today it is named the Cedar Creek Ecosystem Science Reserve, and a laboratory building there is named in Lindeman's honor (see Recognitions below). The synergisms of scientific investigation and conservation that are part of this story are ones that continue to be strong defining characteristics of modern ecology.

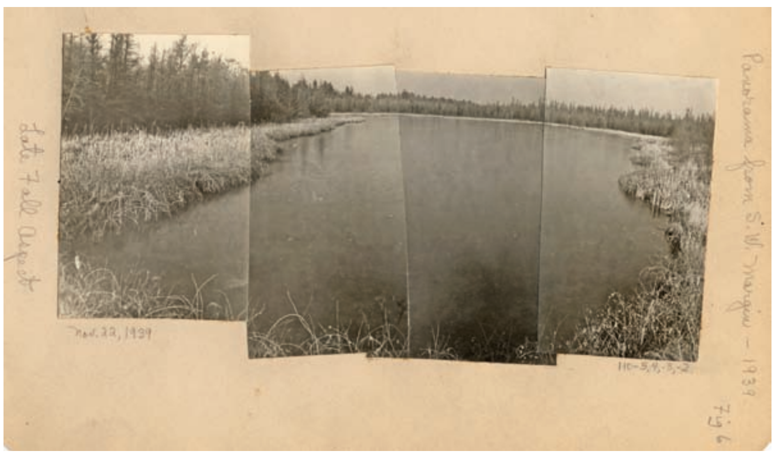
Cooper was a popular teacher. Perhaps Cooper's most important influence on Raymond was his regular seminar held at the Cooper home, which seems to have been a forum where wide-ranging discussions about many ecological topics occurred. For example, in February of 1941, Raymond wrote to Hutchinson that, "The theoretical section on the 'ecosystem' has been undergoing more or less constant revision. Our joint bio-ecology "seminar" group meeting weekly at Dr. Cooper's home is providing much stimulation and helpful criticism, all of which is tending to clarify the concept and principles."

There is one other highlight of Lindeman's graduate school years that is preserved in the historical record. In the summer of 1939 Raymond received University support in the form of a Sigerfoos Fellowship to attend a summer program at Friday Harbor. He and Eleanor made the trip out west. Near the end of the summer, he collected some samples for Don Lawrence of Mount Saint Helens ash deposits from several Seattle-area lakes. He received credit for a course in Marine Plankton and a course in Marine Research.

There is a rich correspondence between Raymond and Edward S. Deevy through the years 1939-1942 (Yale archives). Deevy was Hutchinson's second PhD student, receiving his degree in 1938. His work "converted the field of paleolimnology into a quantitative science" (http://www.nap.edu/readingroom.php?book=biomems&page=edeevey.html). Deevy's interactions with Lindeman arose indirectly out of the Columbus LSA meeting (see Timeline). This was where Raymond first met G. Evelyn Hutcinson, who read Deevy's paper there because Deevy was unable to attend. Lindeman and Deevy finally met in 1940. Through their progressively less and less formal correspondence, Deevy advised Raymond on his application for a Sterling Fellowship to work at Yale. Deevy told him to stress the "zoological" rather than "ecological" aspects of his application because he thought the department would be more receptive that way. The correspondence between Raymond and Deevy clearly shows the strong interest that Raymond had in the field of paleolimnology and lake succession.

No list of influences on Raymond would possibly be complete without mention of G. Evelyn Hutchinson, his Postdoctoral Advisor. Raymond would have been aware of Hutchinson's work through his reading and training as a graduate student. His personal introduction was facilitated by Ed Deevy, His first letter to Hutchinson was written on November 11, 1940 about the time of the first preserved draft of the Trophic Dynamic paper (see Timeline) and there are a total of eight other preserved letters in the correspondence between them. These seem to be a complete record of the correspondence undertaken at this time of fertile intellectual activity by Lindeman. Raymond described his interests in this first letter as being "centered around senescent lakes and lake succession" rather than stressing energetics or food cycle relationships. He also lists plans for future study, and they indicate Raymond's focus on combining paleo- and modern time scale studies. Raymond says his plans include: spectroscopic analysis of sediments, pollen analysis for chronology, microfossil analysis, analysis of chlorophyll, phosphorus and nitrogen to better understand the food cycle, and population dynamics (paraphrased from the original letter RL to Hutchinson November 11, 1940, Yale archives). In a later letter (November 26, 1940), Raymond states, "my primary research interest is at present in food cycles and community dynamics". Raymond and Hutchinson met the following month at an LSA meeting.

They corresponded back and forth during the following nine months, during which Raymond's thesis was completed and accepted by his committee. At the same time his Trophic Dynamic paper was being revised. He and Eleanor moved to New Haven in August. The scientific content of their letters emphasizes two things. First, they compare thoughts on spectroscopy for measuring nutrients; both of them are planning to utilize this technique in their upcoming work and the technical details were of mutual interest. Second, they stake out contrasting positions on the nature of productivity and succession in climax lake communities. Hutchinson's correspondence refers to his paper with Wollack (1940) and Raymond's viewpoint is spelled out in his correspondence as well as his thesis (Lindeman 1941a, pp. 175-179). Their argument concerns patterns of organic matter accumulation – Hutchinson's work on Lindsay Pond suggested to him that lake succession rather quickly reaches a point where this accumulation is fairly constant with time, that lakes reached a kind of equilibrium, whereas Raymond's Cedar Bog Lake studies convinced him that no such equilibrium was reached. What seems most notable in correspondence between Raymond and Hutchinson is an absence of discussion of the developing Food Cycle ideas that are core to the famous Trophic Dynamic paper. This manuscript was submitted to Ecology only 1-2 months after Raymond and Eleanor arrived at New Haven, and thus Hutchinson's greatest input might have occurred during this brief window.



A panoramic view of Cedar Bog Lake assembled by Raymond Lindeman. This view looks north.


An aerial photo of Cedar Bog Lake taken in 1966 by Don Lawrence. This view looks SW. Cedar Creek meanders across the top half of the photo. http://www.cedarcreek.umn.edu/about/history/Lawrence1966Photos/.

Now that we have insight into the persons Raymond Lindeman encountered and learned from in his graduate career and later, it is time to attempt to put Lindeman's studies into a broader scientific context.

THE TROPHIC DYNAMIC VIEWPOINT

Historians have often noted Lindeman's work and its position in the development of ecology. McIntosh (1985) stressed Lindeman's focus on the concept of succession, and he wrote about the work's role in the adoption of energy-based principles by later ecologists. Kingsland (1991) discusses the way Lindeman attempted to connect short-term, observable dynamics to longer-term patterns of succession. Hagen (1992) provided an overview of Lindeman's writings and emphasizes the connection with Hutchinson. Golley (1993) paid particular attention to how Lindeman's work related to early formulations of the ecosystem concept, "Lindeman concluded the lake was an ecosystem. He was the first to implement Tansley's concept explicitly in a quantitative effort to define the system and describe and understand its dynamic behavior (p.50)." This same theme also was touched upon by Kingsland (1995). Kohler (2002) emphasized the way Lindeman advanced the trophic level concept of Elton and takes special note of the detailed knowledge of Cedar Bog Lake that Lindeman brought to his synthesis.

Now we will consider how Lindeman used his Cedar Bog Lake data in relation to the literature of the time to generate a two-part breakthrough. Part one was the formalized description of the system as represented in the well-known Food Cycle diagram with OOZE in the central spot, the kind of "wiring diagram" that Lindeman thought was appropriate. Breakthrough part two was the quantification of stocks and rates that layered on top of that diagram.

The seminal trophic dynamic paper (Lindeman 1942) was initially rejected in part because reviewers thought its conclusions went too far beyond the data, especially in that Cedar Bog Lake was just one lake of many. This criticism may lend the impression that Raymond Lindeman was a theorist unacquainted with natural history detail. However, Raymond's Cedar Bog Lake study was remarkable in its scope and meticulous in its detail. Raymond Lindeman got his hands and feet dirty. Between December 21, 1936 and June 24, 1940, Raymond (or when he was ill, assistants) made 28 sampling trips to Cedar Bog Lake, amassing a data set on water column temperature and oxygen, the macrobenthic community, net and nannoplankton, pond weeds, and swimming predators including fish. He utilized a transect of sites across the long dimension of the lake. He did not measure nutrients or estimate bacterial abundance though from his writings it's clear he placed great importance on these. Fish and other swimming predators were estimated from samples taken after winter kill. Intensive sampling of one or another of these different categories of organisms was not at all unusual for the day, but to attempt a comprehensive accounting of all of these interacting players all at once was. He used this painstakingly gathered information to create a composite accounting of the biomass of organisms within various ecosystem components. Mostly, he utilized wet centrifuged mass of collected samples to convert to dry mass and eventually to convert these to g-cal. This effort yielded a record of the seasonal patterns associated with these major groups (Lindeman 1941b, a). Perhaps the most detailed subset of his data concerned the macrobenthos. In his thesis, he presented counts of these organisms from a total of 286 samplings for which he, Eleanor and other helpers sieved and then hand-sorted organism. In his thesis, he crunched his data to present individual populations and groupings of populations into $g\ m^2$. It was but one lake, but Raymond Lindeman knew Cedar Bog Lake intimately.

Lindeman's accomplishments hinge on the way that he organized the potentially unruly raft of data into an elegant "Food Cycle." Raymond's thesis contains a fascinating 10-page section he called the "History of Food Cycle Concepts" where he describes the way his newly gained point of view arose from a lineage that started with Möbius (1877) and extended through some of the well-known forerunners of modern ecology and limnology. In these thesis pages it is possible to gain some appreciation for how Lindeman viewed those authors who influenced him and the departure he wanted to make from the past. Lindeman felt that Möbius was the first to enunciate the two "fundamental concepts" of productivity and community. On the other hand, according to Lindeman, Möbius failed to discuss the role of predation or of the "food-cycle." The concept of food-cycle was extremely important in Lindeman's writings. By this he meant the cycling of nutrients in and among the dissolved phase, autotrophs, microbes, and larger organisms, or in other words the integration of biotic and abiotic matter. From here, Lindeman considered "The Lake as a Microcosm" of Forbes (1887), and he quotes from there the entire paragraph that begins, "As one example of the varied and far-reaching relations into which the animals of a lake are brought in the general struggle for life, I take the common black bass." Forbes's articulation of what we might today call the food web linkages of the bass, its prey and the species supporting those prey is in fact quite similar to a large fraction of Lindeman's writings, which concern themselves with placing each species of Cedar Bog Lake into the context of what it eats and what eats it. The gap Lindeman perceived in Forbes was the lack of discussion of plants. Lindeman also somewhat mysteriously included the following text referring to Forbes's microcosm, "nor did he fully enlarge upon the potent significance of his title." Lindeman, unfortunately, does not himself enlarge upon this thought and it not at all clear what he had in mind here and what aspects of "microcosm" he felt needed amplification beyond Forbes. The last sentence in Lindeman's paragraph about Forbes will be of interest to modern limnologists who have made the degree of autotrophy vs. heterotrophy an active research question, "The fact that Forbes did recognize lakes as relatively autotrophic microcosms represents a distinct contribution to the development of our concepts of nutritive cycles and of productivity." Lindeman had nothing but praise for F.A. Forel, whose Le Leman he next quotes and dis-

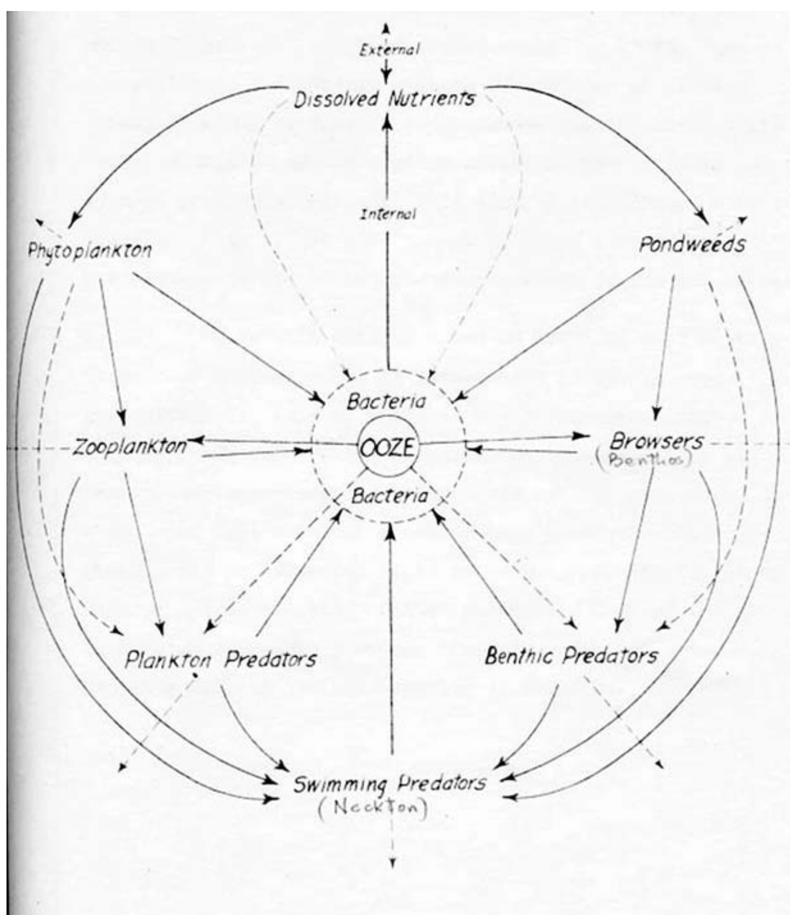
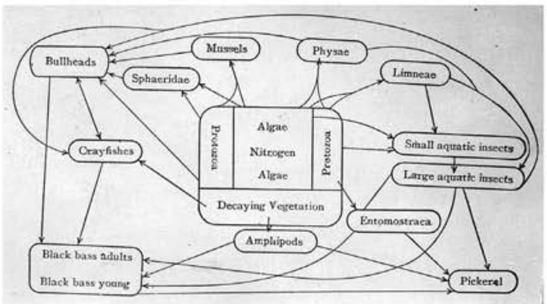


Fig. 7. The primary food-cycle of Cedar Bog Lake

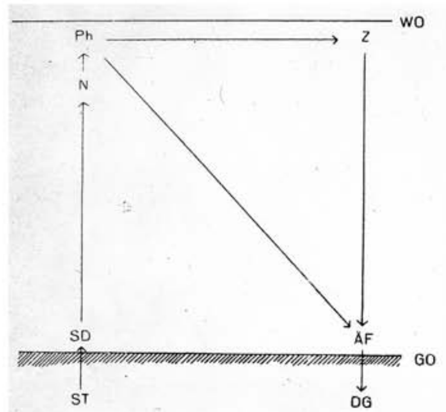
cusses. In Lindeman's view, Forel provided a "brilliant exposition of the general nature of food cycles" which "will serve even today as an introductory account of trophic relationships."

The remainder of Lindeman's "History of Food Cycle Concepts" section is organized around a set of diagrams from previous authors (Lindeman 1941b has a much-abridged version of this section). This discussion then leads to the presentation of the thesis version of Lindeman's impactful "OOZE" Food Cycle Diagram. The six forerunner diagrams that Lindeman reprinted and commented upon in his thesis illustrate in a powerful way what he absorbed from previous writings. They are arranged chronologically and begin with Shelford (1918) and continue through Alsterberg (1924), Thienemann (1926) based on Naumann (1924), Strøm (1928), Rawson (1930) and Wassmund (1930). These all were attempts at formalizing the workings of the lake ecosystem, and through this thesis section we get some insight into how Lindeman himself thought his own approach differed from these others.

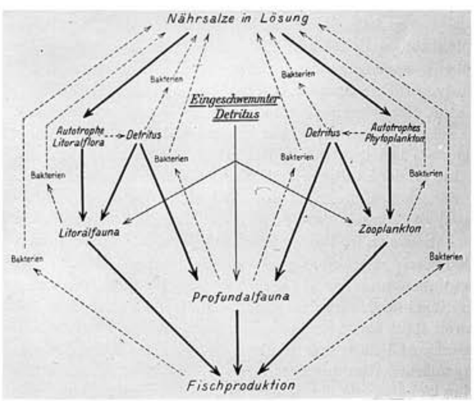
Working his way through these diagrams one after the other, features or perceived failings he noted included: the representation of only food chains with no feedback cycles through detritus (Shelford), the inclusion of allochthonous inputs (begins with Thienemann), an overemphasis on fish (Rawson), the central position of detritus (Strøm) and the inclusion of human influences (Wassmund). Looking carefully at all these six forerunning diagrams, it is Thienemann's that is the closest to Lindeman's. In fact, the correspondence is striking. Both show separate and symmetric cycles, one for open water and one for the littoral zone. Both begin with dissolved nutrients and end with fish. Lindeman collected the ooze and bacteria into a single central position whereas Thienemann represented detritus and bacteria in multiple places, but the functional connections through these pools are essentially the same. There are some differences in that Lindeman shows all pools feeding into the bacteria/ooze complex whereas in Thienemann's diagram detritus comes solely from the autotrophs. Lindeman's view of lake ecosystems, on which his theoretical advances all rested, was strikingly similar to what Thieneman had suggested years earlier. Lindeman's depiction is more elegant in its simplicity and it seems more than an artistic stroke



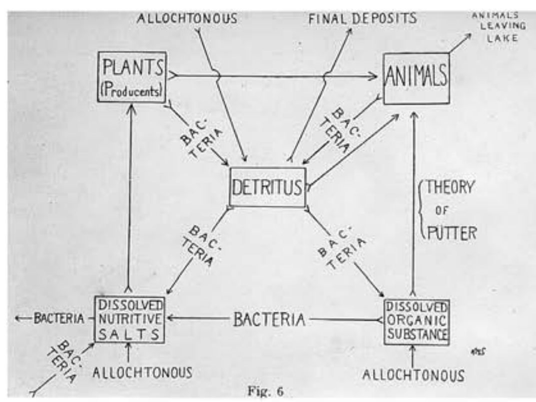
A. Shelford 1918



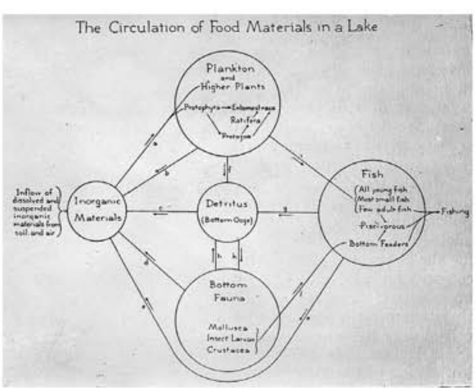
B. Alsterberg 1922, 1924



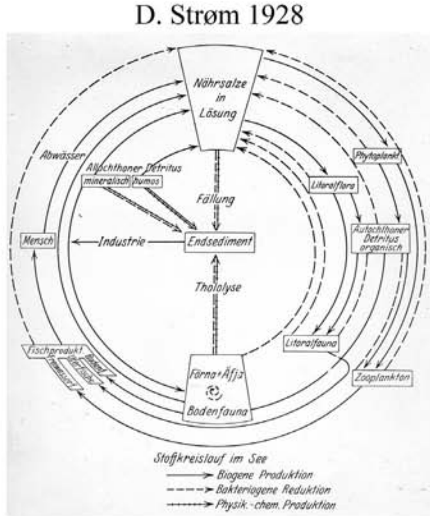
C. Thienemann 1926



D. Strøm 1928



E. Rawson 1930



F. Wassmund 1950

that he moved detritus to a central position, akin to Strøm's representation, and thus emphasized the essential connection of life and nonlife. Lindeman was at least strongly considering working with Strøm as a Postdoc because his papers contain an application for a fellowship to the American Scandinavian Foundation that mentions an intention to work in Strøm's laboratory (Yale archives).

By his choosing to include and comment upon these different representations of aquatic ecosystems, we can see today that Raymond was grappling with the intellectual challenge of representing the complex and messy natural world—many details of which he knew all too well—as a clean, abstract concept amendable to further calculation, analysis and comparisons. His interpretation imposes a severe symmetry and an almost artistic formality on the ecosystem. Visually, it emphasizes the essential unity and interdependence of the biotic and abiotic realms. Lindeman published two versions of the Food Cycle Diagram in addition to the one in his thesis. In Lindeman (1941b) there are minor wording differences ("plankers" instead of "plankton"). In his Trophic-Dynamic paper (1942), Lindeman took one more step, adding the input of solar radiation explicitly (into Phytoplankters and Pondweeds) and noting trophic levels with Greek Lambdas and subscripts. The mathematical connotations of the Greek letters, added to the existing scaffolding of the Food Cycle Diagram is a clear illustration of how his work grew in quantitative directions when he moved to Yale.

The grasping of the entire ecosystem at once was one part of the Lindeman breakthrough. From noting the design and initial date of his sampling program, it seems to have been his goal almost from his first days in the Eddy lab. We can therefore see his Food Cycle diagram as a vital and important step, one which was taken after many trips to the field in all seasons, after hours of picking organisms out of ooze, after serious contemplation of observations of change on short and long time scales, and after reading and thinking about the works of those who came before him. The second part of the Lindeman breakthrough was his quantifying those observations in a way that corresponded with his diagram. Others were writing about the entire ecosystem and thinking about organizing different components into a logical and coherent fashion, but Raymond was the first to provide a quantitative accounting of all of these components in a single ecosystem, which allowed him to search for pattern within them.

At the writing of his thesis late in 1940 and early in 1941, the Cedar Bog Lake data was being presented in units of grams per unit surface area. He had moved part way to distilling the essence of the data he had painstakingly collected, but he knew more could be done,

> "The energy relationships within the ecosystem can thus potentially be expressed by a series of mathematical formulae. Although the present author feels utterly incapable of applying such lofty principles of analysis to the aquatic ecosystem, Haskell's approach is presented, with a keen appreciation of the potential power of the "energy-availing" perspective to open new horizons of ecological thought, in the hope that it may guide future workers toward a more fundamental concept of ecological processes."
>
> (Lindeman 1941a, pp. 164-165)

At this time he was just beginning to express the ecosystem in energetic terms. His Seasonal Food Cycle paper (Lindeman 1941b) contains tables both in mass and in energy terms. He acknowledges Juday, Hutchinson, Deevey and Hodson for comments on this manuscript. In the first half of 1941 he was continuing to develop the Trophic Dynamic viewpoint (called "Trophodynamic as late as February 1941). Two early versions of his manuscript (February and March, 1941) show little further progress in the analysis and presentation of data. By the next surviving draft (September, 1941), just a few weeks after his and Eleanor's arrival at Yale, the Quantitative Food Cycle Relationships section of his manuscript had greatly matured, and the whole manuscript was about a month away from submission. Now trophic levels were represented by Greek Lambdas. He was taking pains to separate standing stocks from rates and to distinguish gross from net production. Also by this time he had "interpolated" (his term) the biomass values into gram-calories per square centimeter. Hutchinson's influence in this maturation of quantitative approaches to the data and adoption of energetics seems undeniable, but the record is silent on how much each of them contributed. The surviving correspondence between the two is absent of any discussion whatsoever about quantifying trophic levels or thinking in energy terms.

No matter how the Trophic Dynamic viewpoint came together, it did a remarkable thing:

> "This paper was the first one to indicate how biological communities could be expressed as networks or channels through which energy is flowing and being dissipated, just as would be the case with electricity flowing through a network of conductors. Though the concept is now regarded as both basic and obvious, like the principle of competitive exclusion, it roused extraordinary suspicion."
>
> (Hutchinson 1979, pp. 246-247)

Hutchinson's and Lindeman's continuing discussions regarding the patterns of productivity associated with succession formed the basis of a joint oral paper, presented at the December LAS meeting in Dallas. The confluence of energetics and succession theory would occupy many ecologists in the future. The young Raymond Lindeman's Trophic Dynamic Viewpoint truly changed the way ecologists think:

> "During his long days on the water collecting his data and mulling over what they meant, he saw that by combining the stage-setting with the biotic community it supported, and treating it as an integrated unit through which energy from the sun is utilized and dissipated in gradual steps, he could reduce all the biological happenings to energy terms."
>
> (Lindsey 1980, p. 5)

RECOGNITIONS

In addition to the ASLO award which is the impetus of this essay, Lindeman's achievements have been formally recognized in several other ways. Raymond Lindeman's name is associated with several sites on the University of Minnesota properties.

A small seminar room (Room 200) of the Ecology Building on the St. Paul campus is named in his honor, and a plaque hangs at the entrance to the room. This is an appropriate recognition when we consider the great importance that the W.S. Cooper seminars had to the young Raymond Lindeman. The University of Minnesota Minneapolis campus includes a Scholars Walk, where pedestrians pass by a series of graphical presentations representing notable works of science, art and other forms of scholarship that arose from work at the University (http://www.scholarswalk.umn.edu/discovery/wall_names.html). Lindeman's Food Cycle Diagram and associated text is displayed there. Many years ago there was some discussion about renaming the now-gone zoology building for him, but that didn't occur (Lawrence papers). The Lindeman Research and Discovery Center was dedicated at the Cedar Creek Ecosystem Science Reserve in 2007, and it houses dry labs, faculty and staff offices, meeting rooms and meeting space. Years ago there was discussion about renaming Cedar Bog Lake "Lindeman's Pond" but that did not occur, some thinking that the name Cedar Bog Lake was already strong associated with Lindeman (Lawrence papers). Finally, the annual Raymond Lindeman Memorial Seminar in the Department of Ecology, Evolution and Behavior brings notable speakers to the campus in remembrance of the young, dedicated graduate student from Redwood County.

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GORDON & BETTY MOORE FOUNDATION ANNOUNCES THE 2012 MMI INVESTIGATOR COMPETITION

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THE 2012 MMI INVESTIGATOR COMPETITION

The Gordon and Betty Moore Foundation's (GBMF) Marine Microbiology Initiative (MMI) has sponsored research in marine microbial ecology since 2004. An important strategy for MMI has been to support the research of an influential group of individual investigators. As its current investigator program is ending in 2012, MMI is initiating another investigator program that will support 10–15 outstanding scientists who are current or emerging leaders in the field. They will be chosen based on their potential to conduct cutting-edge research that supports MMI's objectives to uncover the principles that govern the interactions among marine microbes and that govern microbially mediated nutrient flow in marine ecosystems.

The forthcoming MMI Investigator awards will run from 2013–2018 and seek to support the research of an influential group of individual researchers who will be selected based on the significance of their past research, the quality of their current research, the potential for continued groundbreaking science in the future, and the probability that their future work would contribute to the success of the Initiative. It is anticipated that the awards will range from approximately $200,000 to $500,000 per year in direct costs for an aggregate amount of approximately $25M over five years. MMI expects that the pool of successful candidates will be at varying career stages and represent a variety of scientific backgrounds to enhance the diversity of tools and approaches used to address outstanding questions in the field. Applicants may include microbial ecologists, biogeochemists, modelers, evolutionary biologists, bioinformaticians, and others.

Information about the 2012 MMI Investigator competition including eligibility requirements can be found at http://www.moore.org/mmi–investigators. The competition is open from 2 April to 4 June 2012.

BACKGROUND

The world's oceans are experiencing unprecedented stresses due to human impacts such as increased nutrient runoff, over-fishing, and increased emissions of greenhouse gases that are causing pervasive changes in ocean chemistry and temperature. The scientific community needs the knowledge and tools to predict how these changes will affect critical ocean ecosystems upon which society relies for many important functions. The long-term goal of MMI is to enable a comprehensive understanding of marine microbial communities, including their genetic diversity, composition, function; their ecological role in the oceans; and their contribution to ocean health and productivity.

Since it was launched in 2004, MMI has transformed the field of microbial oceanography by investing in the application of emerging DNA sequencing and biological sensor technologies as well as computational modeling approaches to reveal the immense diversity and critical activities of microorganisms in the ocean. MMI is now tackling another great need identified by the scientific community as both a challenge and an opportunity: to uncover the principles that govern the interactions among microbes (who interacts with whom, how, when, where, and the consequences thereof) and that govern microbially mediated nutrient flow in the marine environment (who consumes and excretes what, where, how much, when, and the consequences thereof).

MMI will achieve these goals by enabling breaking barriers in the field and catalyzing new science through conceptual breakthroughs and advances in technology. MMI seeks to overcome interdisciplinary barriers that currently hinder scientists from identifying and quantifying nutrient pools in the in the ocean, from deciphering the genetic and biochemical bases of microbial metabolism, and from understanding how microbes interact with one another. MMI supports research that identifies and fills gaps in the development of experimental model systems required to investigate archetypal microbial interactions, and the development of key technologies, methods, computational modeling techniques and theory needed to advance our understanding of microbial interactions and the mediation of biogeochemical cycles. The initiative targets crosscutting needs, such as bioinformatics, investigation of microbial processes at small time and space scales, and developing microbial probes and sensors to further transform the field and enable new ways of inquiry.

To accomplish these strategies for making high scientific impact, the MMI employs four grant-making approaches – single Investigator Awards (MMI Investigator portfolio) that support individual current and emerging leaders in the field; Multi-disciplinary Team Research Projects that support collaborations to address interdisciplinary challenges; Community Resource Projects that fund development of tools and infrastructure of broad utility to the entire research community; and Instrumentation and Technology Development grants that advance the community's capabilities through development of novel technology.

The Limnology and Oceanography

Bulletin

The Association for the Sciences of Limnology and Oceanography is a membership-driven scientific society (501(c)(3)) that promotes the interests of limnology (the study of inland waters), oceanography and related aquatic science disciplines by fostering the exchange of information and furthering investigations through research and education. ASLO also strives to link knowledge in the aquatic sciences to the identification and solution of problems generated by human interactions with the environment.

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Views expressed in this publication do not necessarily reflect official positions of the Association for the Sciences of Limnology and Oceanography unless expressly stated.

The *L&O Bulletin* publishes brief articles of broad interest to the ASLO membership, Letters to the *Bulletin* (typically responses to articles), and ASLO News on a quarterly basis. Information on the preparation and submission of articles and letters can be found on the ASLO Web site (www.aslo.org). It is recommended that you contact the editors before preparing an article or letter.

ASLO NEWS

MESSAGE FROM THE PRESIDENT

Deborah A. Bronk, *Dept. Physical Science, Virginia Institute of Marine Sciences, The College of William & Mary, Gloucester Point, VA USA; bronk@vims.edu*

This is a bittersweet column to write because it is my last as president. One of the main activities I have undertaken while in office was an overhaul of our operations manual. We have done a lot of rethinking while we undertook the revising. The experience has reinforced what I had been thinking for a while – ASLO is in a real state of transition. In the last 15 years we have launched five new publications – *L&O Methods*, *L&O Bulletin*, *L&O Fluids and Environments*, *L&O e-Lectures*, and *L&O e-Books*. We now have over a dozen contractors as staff, have doubled the number of awards we present, have an annual operating budget of approximately a million and a half U.S. dollars and have expanded internationally, which adds an additional layer of complexity to everything as we grapple with exchange rates and membership spanning virtually all time zones.

As an acknowledgment of ASLO's growing complexity, the board approved the hiring of an outside consultant to under take ACE – ASLO's Comprehensive Evaluation. This activity will be an all-encompassing look at ASLO's overall business model and the business models of all of its publications. This work is underway under the able guidance of Paul del Giorgio.

In reflecting on the past couple of years ASLO has had a number of successes. The Consortium of Aquatic Scientific Societies is firmly established and has been passed into the capable hands of our new ASLO representative, Mike Vanni. *L&O Fluids and Environments* is off to a great start thanks to editor Joe Ackerman. The passion of editor Jennifer Cherrier has converted *L&O e-Lectures* from a good idea to a fully operational peer-reviewed publication! We more than doubled the ASLO Endowment Fund and have set up new membership categories to help it to continue to grow in the future. We fully subsidized daycare for ASLO members in San Juan and Salt Lake City, and I'm happy to say we are learning a lot and it is picking up momentum! We've also had a great run of successful meetings with a very exciting one coming up in Japan! Last, but not least—we have a new name!

Figure 1. Dr. President Deborah Bronk and Hans Paerl in San Juan February 2011.

As I close I want to offer my heartfelt thanks to the entire ASLO board and our wonderful Business Office (Fig. 2)! They are a dedicated, hard working, talented group of people, and ASLO is lucky to have them. I am especially grateful to Helen Schneider Lemay and Adrienne Sponberg for their support and wisdom over the years. I also give particular thanks for the help, brainstorming over wine, and coordination of gift cards for massages from President-elect John Downing. I am very happy that I get to pass the torch into the hands of such a wonderful human being. Finally, I extend a special thanks to Claudia Benitez-Nelson for my lovely Dr. President beauty pageant sash, which she gave me in San Juan (Fig. 1). I still put it on if I'm having a bad day and it always makes me smile!

Thank you for the opportunity to serve this great society! It has been an honor, a labor of love, and a wonderfully fun ride!

SOMETHING TO THINK ABOUT: ARE ALL THESE LETTERS OF REFERENCE NECESSARY?

Writing letters of reference is a critically important part of being a scientist today. It is also a large time sink. Writing the first letter for a colleague or student can take hours. It can also be nerve wracking because much can be riding on it. I am happy and honored to commit this time for students or colleagues that are being seriously considered for a position. A practice that seems to be becoming more common, however, is for search committees to request that letters of reference be included with the initial application package. My question is – are all these letters necessary? It is not uncommon these days to get over 40 applications for an academic position and at times the numbers are much higher. If each applicant includes three letters that is over 120 letters! What does this represent in terms of science time? Even the most cursory review of applications will eliminate many candidates outright and closer examination will narrow it even further. I suggest that it is only after these initial reviews have been completed that letters should be requested. When we request letters at this point we can do so knowing that our colleagues' time will be well spent because they are informing the search committee about a serious candidate.

Deborah A. Bronk
ASLO President

Figure 2: The 2011-2012 ASLO Board at Salt Lake City: Standing, from left to right: Lucille Doucette, Paul Kemp, Luana Pinho, Robin Anderson, Jennifer Cherrier, Allison Fong, John Downing, Uta Passow, Tom Bianchi, Anya Waite, Carlos Duarte, Helen Schneider Lemay, Paty Matrai, Joe Ackerman; Kneeling, from left to right: Lisa Campbell, Paul del Giorgio, Deidre Gibson, Debbie Bronk, Roxane Maranger, Lihini Aluwihare, Adrienne Sponberg.

MESSAGE FROM THE BUSINESS OFFICE

Helen Schneider Lemay, *ASLO Business Office, 5400 Bosque Blvd., Suite 680, Waco, TX 76710-4446; Tel.: 254-399-9635 or 800-929-2756, Fax: 254-776-3767; business@aslo.org*

Dear ASLO Member:

Membership is the key to every scientific society, so we hope that you have renewed your ASLO membership and have reminded others to do the same!

This was the year of the Ocean Sciences Meeting. Almost 4,000 scientists attended in February. Salt Lake City provided a great location with easy access to skiing, time to hear scientists-turned-musicians at Lumpy's during the JAM session, and the convenience of a wonderful convention center, even if the beer was "3.2". This July, ASLO ventures to Asia for our meeting in Japan. We are excited about working with many scientists (both old and new members) from the Pacific Rim area. A special thanks to all ASLO members who have served on the committees for both of these meetings.

Be sure to submit your proposals for Emerging Issues Workshops at ASLO meetings. This is a great way to fund stimulating discussions on scientific issues that are on the horizon.

ASLO continues to support our students and early career professionals. Childcare grants are available for ASLO meetings as well as travel grants for students. New categories also have been added for our senior members and an all new, Life Membership.

Be sure to read through the *Bulletin*. Each issue will keep you up to date on important ASLO news and information.

Helen Schneider Lemay
ASLO Business Manager

MESSAGE FROM THE PUBLIC AFFAIRS OFFICE

Adrienne Sponberg, *ASLO Public Affairs Director, 10410 Kensington Parkway Suite 216, Kensington, MD 20895, sponberg@aslo.org*

The 2012 Ocean Sciences Meeting marked the third time ASLO has met in Salt Lake City. As I was on the plane reviewing the list of events for the week, I couldn't help but compare the 2012 OSM with the previous two meetings (the 2003 and 2005 Aquatic Science Meetings). At the 2003 meeting, there were two workshops pertaining to outreach and one contributed session focused on education. At the 2012 meeting, there were 19 contributed sessions having to do with education or policy and management. There were also 15 workshops and special events devoted to policy, education, and outreach. While the Ocean Sciences meetings are typically larger than the Aquatic Science meetings, this is also an indication of the change in the scientific community. The demand for these events (as evidenced by the sometimes packed rooms in the workshops) has increased. Gone are the days when having an undergrad in your lab for a summer counted as "broader impacts" for your NSF grant. More and more graduate students are openly admitting that they want to do something with their degree other than work in a research setting.

ASLO is committed to providing opportunities for its members to learn more about how to be effective in outreach. Workshops and special events at ASLO conferences are one way the society accomplishes that goal. And while some events are hard to capture for those who are unable to attend in person, we strive to make as much of the content available after the meetings as possible. Below I will recap two of the OSM activities I was involved with that are available to those who missed them. A summary and video recording of the third event – the evening panel discussion about public acceptance (or not) of climate change moderated by NPR's Richard Harris – will be available by the time the next issue of the *Bulletin* goes to press.

"BEST OF COSEE HANDS-ON ACTIVITIES" CD AND WEBSITE

In the 2008 and 2010 COSEE surveys on education and outreach, the top request from ASLO respondents was for more examples of hands-on activities that members can use for outreach (e.g., visits to local schools). Through our partnership with the NSF COSEE program, we took a big step towards answering that call this year through the production of the "Best of COSEE hands-on activities" CD that was distributed to over 3800 OSM attendees. The CD (also available on the web at http://www.cosee.net/best_activities/) is searchable by topic, activity duration, and grade level. Physical copies of the CD have been going fast; they were also distributed at the National Science Teachers Association meeting and at the USA Science & Engineering Festival. Our goal is to collect even more hands-on activities for version 2 of the CD that will be distributed at the 2013 Aquatic Sciences Meeting in New Orleans.

S FACTOR VIDEO WORKSHOP WITH RANDY OLSON

ASLO has been very fortunate to develop a working relationship with marine biologist turned filmmaker Randy Olson. This partnership has been facilitated and nurtured by ASLO member Jon Sharp. Thanks to Jon's leadership and to funding from NSF, Randy's film workshops have become a regular feature at ASLO meetings. This year's film workshop was the best yet (I'm not the only one who felt that way, check out Randy's blog post about it here: http://thebenshi.com/?p=3559). What better way to capture a film workshop than through film? Randy and his team have created a summary video of the entire event and have also posted each of the analyzed films along with a clip of the panel's critique. You can watch those videos at: http://www.sfactorpanels.org/sf2.html. Randy has also summarized his "Top Ten" notes from the event in a separate article in this issue of the *Bulletin* (see p. 57). While the workshop does focus on filmmaking, there is a lot of great advice that could apply to any form of science communication, even your own science talks at ASLO conferences!

GETTING TO KNOW YOUR *L&O:F&E* ASSOCIATE EDITORS

Limnology and Oceanography: Fluids and Environments (*L&O:F&E*) is ASLO's newest journal devoted to the interface of fluid dynamics with biological, chemical, and geological processes in aquatic systems. Navigating interdisciplinary research can be a difficult task especially for an Associate Editor (AE) whose role is that of an impartial judge—to fairly assess the reviewers' comments and guide the author's next steps. Once an AE is assigned a new manuscript, his or her first task is to select reviewers, which is a delicate job that requires profound knowledge of the interdisciplinary topic as well as the politics (the often conflicting relationships among people in a society). When the reviews are received, the AE digests that input along with his or her own assessment of the manuscript to arrive at a decision. It is unfortunately quite common for reviewers to recommend very different fates for a paper, which puts the AE in the uncomfortable position of having to make at least one of the reviewers and perhaps the author unhappy. The AE's final job is to help edit accepted manuscripts, suggesting wording and organizational changes to improve clarity for the reader. Being an *L&O:F&E* AE is a very demanding job, and we are extremely fortunate that these people devote so much time to the ongoing challenge of making *L&O:F&E* a leading journal in the aquatic sciences. ASLO acknowledges the important work that these people do for the society and features them periodically in the *Bulletin.*

BERNIE BOUDREAU

Bernie Boudreau is currently the Dean of Graduate Studies at Dalhousie University (Halifax, Canada), holds a Faculty of Science Killam Professorship and is a Fellow of the Royal Society of Canada (The National Academies). Bernie is well recognized for his contributions to the modeling of diagenetic processes in sediments and bottom boundary layer dynamics. He has contributed extensively to our understanding of the pH of marine waters, the mixing of sediments by organisms, the formation and movement of gas in near-surface sediments and the effects of boundary layers on solute and suspended solid exchange between sediments and the overlying waters. As part of his AE duties for *L&O:F&E*, Bernie encourages papers on flow and mass transport in and over sediments and their consequences to the biology, chemistry and physics of the bottom. In addition he would also like to motivate the submission of papers that deal with unusual flow and transport phenomena that occur in the oceans.

ALFRED J. WÜEST

Johny Wüest is head of the department "Surface Waters - Research and Management" at the Swiss Federal Institute of Aquatic Science and Technology (EAWAG), Kastanienbaum, Switzerland, and he is an adjunct professor in Aquatic Physics at the Swiss Federal Institute of Technology (ETH), Zürich. As part of his post-doc and sabbaticals he worked at IOS and UBC in British Columbia, at APL-UW in Seattle and at UNZA in Zambia. His research interests focus on small-scale physical phenomena (such as microstructures, boundary layers, double diffusive layering, etc.) and on anthropogenic influences on biogeochemical and physical processes in natural waters. He has persued several interdisciplinary and problem-oriented projects. As Associate Editor for *L&O*: F&E, he handles articles with a focus on the interaction of small-scales physical processes with biogeochemical or planktonic phenomena in stratified waters.

OUTSTANDING *L&O* REVIEWERS

Everett Fee, *Limnology & Oceanography Editorial Office, 343 Lady MacDonald Crescent, Canmore, AB T1W 1H5, Canada; lo-editor@aslo.org*

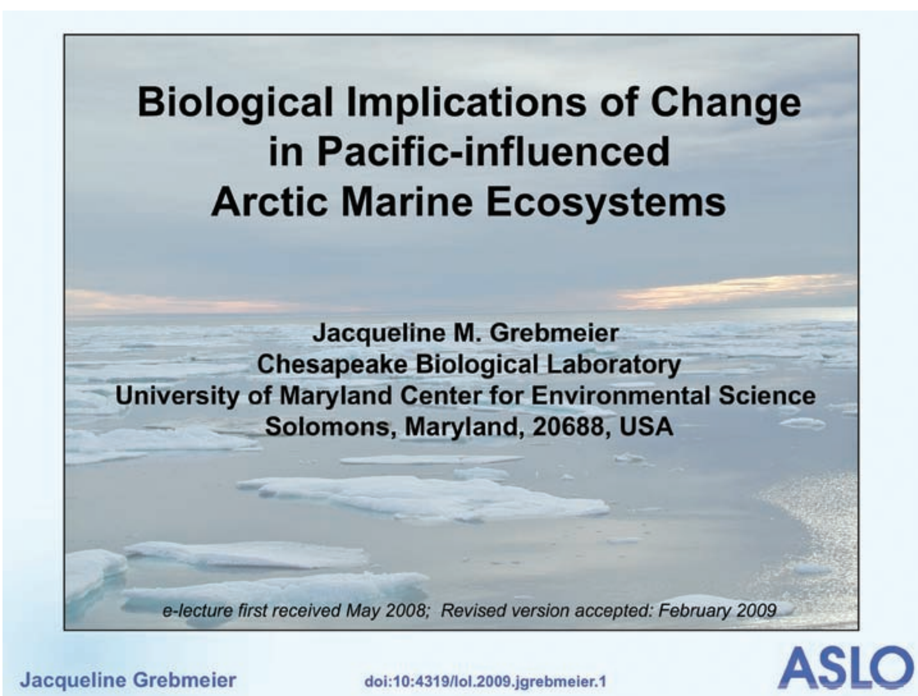
Peer review is a crucial component of modern science. The fact that *L&O* is able to utilize the services of the best scientists as reviewers allows it to be a leading journal in the aquatic sciences. However, these individuals seldom get the recognition they deserve for this selfless work. Therefore, the *Bulletin* cites outstanding reviewers that Everett Fee, *L&O* Editor, feels deserve special recognition for their overall reviewing efforts. The ASLO membership extends its sincerest appreciation and thanks these outstanding scientists.

PATRICK NEALE

Pat Neale leads the Photobiology-Solar Radiation Lab at the Smithsonian Environmental Research Center in Maryland, USA. Research there concerns the effects of solar UV and PAR irradiance on aquatic ecosystems, as well as the bio-optics of UV radiation and dynamics of Chromophoric Dissolved Organic Matter (CDOM). A particular focus is defining the spectral dependence of UV effects to assess the impacts of stratospheric ozone depletion on phytoplankton and other aquatic organisms. Pat did his doctoral studies at UC Davis and held postdoctoral positions at UC Berkeley and Bigelow Labs before joining SERC. He studies both freshwater and marine systems ranging from the Ross Sea, Antarctica, to Lake Titicaca, Peru/Bolivia.

GERTRUD NÜRNBERG

Gertrud Nürnberg is head of Freshwater Research (www.fwr.ca), which focuses on the modeling and restoration of eutrophic lakes and reservoirs. She founded this company in 1984, after completing her Ph.D. on the availability of phosphorus from anoxic hypolimnia to epilimnetic plankton with honors at McGill University in Montreal, Quebec, under guidance of the late Robert Peters and Frank Rigler. Her main interest is still focused on the determination and quantification of internal phosphorus loading from bottom sediments. She has published comparative research and empirical lake models on phosphorus, iron and anoxia and on lake management techniques in numerous scientific journals, while working with lake associations, governmental agencies, NGOs, engineering companies and the private sector in the US, Canada, and Europe. She has been involved with the North American Lake Management Society (NALMS) as an associated editor of the journal Lake and Reservoir Management since 1996 and is a past director of the Eastern Canada Region for NALMS.



Title slide of Jackie Grebmeier's *L&O e-Lecture* entitled "Biological Implications of Change in Pacific-Influenced Arctic Marine Ecosystems

FEATURED *L&O* E-LECTURE: CLIMATE CHANGE IN THE ARCTIC BY JACKIE GREBMEIER

Grebmeier, Jacqueline M. *2009. Biological Implications of Change in Pacific-influenced Arctic Marine Ecosystems. Limnol. Oceanogr. e-Lectures, doi:10:4319/lol.2009.jgrebmeier.1*

Jackie Grebmeier's *L&O e-Lecture* is entitled "Biological Implications of Change in Pacific-Influenced Arctic Marine Ecosystems" (doi:lo:10:4319/lol.2009.jgrebmeier.1). This lecture provides an overview of climate and biological changes in Pacific-influenced Arctic marine ecosystems. It reviews and examines the major contributing factors to these changes including changing conditions of sea ice, freshwater input, and the alteration of marine ecosystems. Examples of these factors are provided to illustrate the potential impacts that will have broad-reaching implications for long-term ecosystem structures. This lecture also reviews the progress of various programs undertaken during recent years (i.e. Bering Sea Research Program, Canada's Three Oceans, the Russian/US Long-term Census of the Arctic Ocean, and the Western Arctic Shelf-Basin Interactions) which have provided insights into the key processes influencing ecosystem function and change in the northern Bering and Chukchi shelf regions. Data sets from these programs are included in this *L&O e-Lecture* in the context of biological response to sea ice changes in the Pacific Arctic region, with accompanying discussion by the *L&O e-Lecture* author.

**Descriptive information is provided for all lecture slides to facilitate usage and each L&O e-Lecture is accompanied by an instructor/student supplementary reading list.*

ABOUT THE E-LECTURE AUTHOR

Dr. Jacqueline Grebmeier is a Research Professor at the Chesapeake Biological Laboratory University of Maryland Center for Environmental Science. Her research is focused on pelagic-benthic coupling on continental shelves in the Arctic, benthic ecology, invertebrate zoology, contaminant distributions, and high latitude oceanography. She has participated in over 40 oceanographic cruises on both US and foreign ships, many as Chief Scientist. She is the current U.S. Delegate and Vice-President of the International Arctic Science Committee and member of the Arctic Ocean Sciences Board.

GREBMEIER'S THOUGHTS ON THE *L&O* E-LECTURE SERIES:

The *L&O e-Lectures* provide a valuable tool for conveying ongoing research results in support of teaching concepts within relevant environmental courses. The summary lectures allow students to visually learn how results from field science are summarized and conveyed to bring a natural process or set of findings to the public, be it in the classroom or public forum. Literature citations from these e-lectures allow both the student and teacher to explore more detailed results or topics that excite the interest and/or imagination of participants in an educational mode. As an active field scientist, I am honored to have my research highlighted in this informative educational lecture series.

MEETING HIGHLIGHTS

2012 OCEAN SCIENCES MEETING, SALT LAKE CITY

Mary I. Scranton, *Stony Brook University, Stony Brook NY 11794 mary.scranton@stonybrook.edu*

In February 2012, ASLO, The Oceanography Society and the American Geophysical Union jointly sponsored the 16th Ocean Sciences Meeting in Salt Lake City. Total registration for the meeting was 3,985 (preliminary), although if we counted the children in the day care program, we may have hit the 4000 mark! Of these, 1057 were students and 493 were "early career" participants. We also had 53 students and teachers attending from local high schools, and 106 participants from non-developed countries. A total of 51 countries were represented, with 2850 from the US, 175 from Japan, and more than 100 participants each from Canada, the UK, China, Germany, and France.

The Salt Lake City Convention Center was spacious but our space was relatively compact, and there was plenty of room for posters, oral presentations and meetings. The program committee (see box) was committed to seeing that this be a truly joint meeting, and from all reports they succeeded. Traditionally, meetings of the different societies have different "personalities" but the program committee worked to develop an interdisciplinary meeting that might become the model for future Ocean Sciences Meetings.

In early discussions, the planning committee agreed that a great meeting should be stimulating but not exhausting and that there should be plenty of opportunity to learn something totally new and outside one's field as well as to interact with colleagues and friends. To this end, plenary lectures were grouped on Wednesday morning, allowing for a break in the week. Topics for the plenaries included shark conservation biology, biogeochemical modeling, a study of the consequences of heterogeneity of organism in the ocean, graduate education in the ocean science and academia's contribution to studies of the Deep-Horizon oil spill. One TOS Award and award talk (the Munk Award Lecture by William Kuperman) and two AGU awards and award talks were given (the Rachel Carson Award Lecture by Nancy Rabalais and the Sverdrup Award Lecture by Deborah Steinberg).

One hundred and fifty concurrent oral sessions were held with 1264 talks presented. Poster sessions for 2271 posters were grouped together in the late afternoon and at the same time as the beer hour, and did not conflict with any oral sessions. Food and beverages were plentiful and poster sessions were full of lively discussion. As has been the case for several recent ocean related meetings, there was a film workshop on the Sunday before the Ocean Sciences Meeting with Randy Olson, marine biologist turned filmmaker (see next article, p57). NPR Science Correspondent Richard Harris was at OSM as well to moderate a panel discussion about why the public does not always accept scientific consensus.

The meeting included many programmed town halls, and mentoring and early career support activities as well as a student social mixer and an early career mixer. And Tuesday night, ocean scientist-musicians filled a local watering hole with music at the Music Jam! Salt Lake City was surprisingly warm although some participants did take advantage of the meeting location to ski.

Overall, informal reports from meeting attendees were highly positive. The venue, food and internet connectivity earned high praise. And the program committee concluded the meeting feeling that our goals were well met. As always the professional staff members who organized the logistical details of the meeting are humbly thanked.

2012 Ocean Sciences Meeting

Co-Chairs:

Mel Briscoe (TOS)
Consortium for Ocean Leadership

Mary Scranton (ASLO)
Stony Brook University

Eric Itsweire (AGU)
National Science Foundation

Committee:

Kay Bidle
Amy Burgess
Regina Easley
Ken Golden
Peter Huybers
Kimberly Keats
Suzanne Keeley
Jim Lerczak
Jim McManus
Jenny Ramarui
Helen Schneider-Lemay
Julie Vanderhoff
Brenda Weaver
Cheryl Ann Zimmer

TOP TEN NOTES FROM THE SALT LAKE CITY S FACTOR PANEL

Randy Olson, *Prairie Starfish Productions, Raleigh Studios, 5254 Melrose Ave., Los Angeles, CA USA*

When we ran the first S Factor Panel at AGU in December several people said to us afterwards, "Why were you so easy on the videos?" The answer was simple, "Because we've been there."

Jason Ensler, Sean Hood, and I (the first panel members) were film school classmates at USC. We had to share our student films with our fellow classmates and sit quietly as everyone tore them to shreds. We know the pain.

But at the same time, the first rule they drilled into our heads in film school is that "film is a collaborative medium." It's not the same as writing. Good films take a lot of editing and shaping and revising to get them to the point where a large audience can enjoy them. A crucial part of that process is "test screenings" after which you engage the audience in detailed discussion of what worked and what didn't work in the film. This is essentially the same process we are offering with the S Factor events.

For S Factor 2, here is a summary (but not an exhaustive list) of some of the more prominent points we offered up in our commentary. Each of the videos, and a clip of the panel critique, may be viewed at: http://www.sfactorpanels.org/sf2.html

1. WRITE AND DEVELOP A SCRIPT—Never thought I'd see myself writing this. I entered film school thinking I was talented enough that I could take any lousy bunch of footage and make it into a fascinating film. I've learned over the years, the very hard way, that ain't true. It helps A LOT to invest time up front before you start filming. A lot of the videos we get with the S Factor events are people who shot footage on a research cruise, then when they got home started trying to put it together into "something." Which is okay. But once you've mastered that level, its time to start thinking about some sort of script BEFORE you take off on the cruise. Which leads to coming up with scenes. Which leads to writing out the scenes and even the dialogue that will make them work. Which leads to walking through the scenes and rehearsing them. Which leads to making films that work better and are smoother. For this event it seemed to be the number one comment we had -- invest time in planning, scripting, and pre-production.

2. GRAB INTEREST—The first thing you want to do is grab the interest of the audience. About the best way to do this is to pose an interesting question for which the viewer wants an answer which can be used to keep their interest until nearly the end of the video (which is what telling a story is about). The basic dictum I cite in my book is, "Arouse and Fulfill" (which comes from a communications professor who says there's almost a century of theory around this simple principle). The term "arouse" may conjure up sexual thoughts, but in this case it's really just referring to stimulating the interest of the audience. For the "fulfill" part you need to make sure you meet the expectations you generated with the arousal. The "Octopus Ballet" and "Southern Ocean Hydrography" videos both did amazing jobs of opening with immediately engaging visuals, but neither of them ever progressed into telling much of a story, which causes most of the audience to eventually waiver in their interest. The "Dead Zone" video opens with a large amount of information. It would have benefitted by first posing a clear question, then presenting the information as part of the answer to the question.

The S-factor 2 crew (left to right): Jon Sharp, Adrienne Sponberg, Brian Palermo, Dorie Barton and Randy Olson.

3. THE "WHY?"/WHAT'S AT STAKE—Panel member Brian Palermo hit on this several times. The more the audience is able to understand why you went to all the trouble to make a video, the more they are likely to be drawn in to what is being communicated. One simple and important question to ask, over and over again, is, "What's at stake with this problem?" and more specifically, "What is going to happen if something isn't done?" The "Dead Zone" video could benefit from this line of thought. The video talks about the large problem of nutrients being flushed down the Mississippi River into the Gulf of Mexico creating the seasonal dead zone, but it doesn't go far enough in addressing this fundamental question of why its important. It needs to tell us in as exact terms as possible, what is at stake with the human populations of the region -- how much wildlife will be lost, how much industry will be impacted, what is going to happen if we don't do something to curtail these dead zones? "Flat Stanley," would also benefit from addressing this -- we love the Flat Stanley narrative device, but what's the actual research being done with the vehicle and why is it important?

4. POWER OF ONE—It's an odd dynamic of storytelling, but the scaling of numbers of subjects vs. impact is kind of reversed. If you tell an interesting story about one person, wouldn't you think it would be four times more interesting if it was the story of four people? It turns out to be the opposite. Storytelling is at its most powerful completely stripped down to the story of the single individual (and ideally told BY the individual, i.e. in the first person). There's a famous expression, "The death of one person is a tragedy, the death of a million is a statistic." People are drawn in and moved by stories of tragedy, but much less so by just statistics. The "NASA Develop" video is an example of this dynamic. It would be more effective to have it tell the story of a single person's experiences rather than a bunch of snippets from many folks. Conversely, the "Jellyfish" and "Coral Hybrid" videos did a good job of using a single person to embody the subject matter being conveyed.

5. ON SCREEN TITLES—As much fun and powerful as videos can be, when it comes to simply wanting to educate an audience on a topic, you should seriously consider using primarily still images with supporting narration and music scoring. Moving images (i.e. video) present a large amount of information to the viewer, which is definitely stimulatory, but more often than not is insufficiently precise in hitting the point being made to not be distracting. For example, if you're wanting to talk about oil pollution on mud flats and you have footage of mud flats covered with oil, but in the distance is a sailboat passing by, a lot of the audience will end up watching the sailboat rather than listening to the narration. But if you only present a still image of the scene, the audience will quickly take it in, relax their eyeballs, then actually listen to the narration and let it guide them in absorbing what is being communicated. And this can be further enhanced by putting short phrases

of text on the screen to add a visual element to what is being said. At the end of the "Dead Zone" video are some nice examples of on screen text with still images. In the "Tiny Life of Oysters" they did a nice job of presenting interesting opening exposition all building to a single point, that "Today there's just 3/10 of one percent" of what the oyster reefs used to be. That's a powerful factoid that would benefit from being written out on the screen as it's said.

6. POWER OF HUMOR—S Factor panelist Brian Palermo, a veteran comic actor and improv instructor (he was the computer science professor in the movie, "The Social Network") says in his comments on the Penguin video, "When they're laughing, they're listening." That's a nice little rule about the power of humor. The big challenge is whether you're able to make it work. The best and almost only way to determine this is through lots and lots of "test screenings" starting with a few trusted friends and then eventually audiences with some strangers. There's a humorous element to "Flat Stanley" that makes it work very well. Even the "Octopus Ballet" has a lightly humorous undertone to it (at least it did for me). And the Penguin video is just plain hilarious.
7. MUSIC SCORING—Remember the old saying, "It's not what you say but how you say it"? This is the basic dynamic of music scoring. Your visual images can say one thing, but you can change or enhance what they are saying through the use of this second channel of communication, music. If you have a photo of a fisherman holding up an enormous fish with the climax music score from "The Natural" when Robert Redford hits a home run you will be saying something very different to your audience than if you show the same photo and have a piece of ominous score from a "Batman" movie. Same photo, different message. Music scoring allows you to do this throughout your video. You can create a "temp score" by using music from your favorite movie scores, then eventually hire a professional composer to create an original score using your temp score for a guide. For a short video like these you can easily find a good composer willing to do this (use Craigslist) for just a few hundred dollars or sometimes even for free if they like the subject matter and issue.
8. PROFESSIONAL VOICEOVER—The professionalism of the narrator ends up being an important element of authority in making a video. It's often nice to let the scientist do the narration -- as mentioned before, there's nothing more powerful than first person narration. But at the same time, the very best narrators can bring a voice so powerful your audience will automatically be drawn in. This means you have to realize there is a professionalism to voiceover. Trained actors and voiceover artists have an ability to lend just the right amount of dramatic performance to the material -- not so much as to be hammy, but not so little as to be dull and monotoned. A great resource for finding voiceover talent for very little money is www.voice123.com
9. IT'S A VISUAL MEDIUM—More than anything else, you must keep in mind the first and foremost rule of filmmaking, which is that it's a visual medium. When people tell me they have a very limited budget and ask what they should spend money on, I tell them the highest priority is to hire a professional cameraman who has a good "eye." If you make a film full of stunning visuals, everything else can be pretty mediocre and you'll still do okay. Your starting point as a filmmaker needs to be "how can we tell our story without ANY voiceover or interviews?" If you can manage that, you'll probably have the most powerful possible version of the film you want to make. However, if you consider your story, look at what you have for visuals, then decide you just can't convey exactly what you need to with what you've got, then that is when you begin thinking about bringing in a narrator or conducting interviews. This is one of the fundamental mistakes that gets made -- too many productions begin by deciding who their on camera host will be and who they are going to interview. That's backwards. See if you're good enough to tell stories without a host or narrator (I'm usually not, but the good filmmakers are).
10. LESS IS MORE—Video is not a very effective medium for transmitting information. People can't really retain more than two or three pieces of information from a video. It is much more effective as a motivational medium, using the power of human emotion to get people more connected with a subject. Towards this end, if you can tell a compelling (and sometimes even emotive) story with a good structure to it that ends up conveying a single, very important selected piece of information it will be much more effective than trying to pack the video with a whole shopping list of information. At some point people just glaze over when presented with too much detail. S Factor Panelist Dorie Barton, who is an actor and script analyst, offers up a very good quote on this problem of too much information for the "Dead Zone" video when she says, "Data is not necessarily details." That's a good one to take to heart.

MEMBER NEWS

DEBBIE BRONK NAMED SECTION HEAD OF NSF OCEAN SCIENCES

John Downing, *ASLO President-elect*

Congratulations to Debbie Bronk! Our ASLO President for the past two years has accepted the position of Section Head of the Division of Ocean Sciences at the U.S. National Science Foundation effective August 2012. The Ocean Section includes biological, physical, and chemical oceanography as its core disciplines plus lots of other special initiatives and programs. As Section Head, Debbie will serve as a member of the Division leadership team and as the Directorate's principle spokesperson in the area of oceanographic research. She will report to the Director of the Division of Ocean Sciences (David Conover). As Section Head, she will be responsible for overall planning, management and commitment of budgeted funds for the Section. She tells us that she is excited about this opportunity to serve the scientific community and her country; she also stipulated that her NSF appointment would not impede her vigorous contributions to ASLO as Past-President. This will be a two to three year temporary appointment. She will reside primarily in Washington, D. C. over this time. Thanks to her experienced long-term lab group, her research at the Virginia Institute of Marine Science at the College of William & Mary will continue full steam ahead! The entire ASLO family wishes Debbie best wishes for an exciting time at NSF. How wonderful it is to have an advocate for the aquatic sciences as strong and effective as Debbie in such a pivotal and influential position.

JEAN-PIERRE GATTUSO AWARDED AGU'S VERNADSKY MEDAL

Jean-Pierre Gattuso (CNRS, Villefranche-sur-Mer) has been awarded the Vladimir Ivanovich Vernadsky Medal 2012 by the European Geophysical Union "for creative and scholarly contributions to biogeosciences at the interface between microbial ecology, coral ecology, biogeochemistry and chemical oceanography." The medal was established by the Division of Biogeosciences in recognition of the scientific achievement of Vladimir Ivanovich Vernadsky. It is reserved for scientists who have made exceptional contributions to biogeosciences in general.

ASLO'S LIFETIME & SUSTAINING MEMBERS

ASLO would like to thank the following who have generously decided to become Lifetime and Sustaining Members.

LIFETIME MEMBERS

Deborah Bronk
College of William and Mary/VIMS, Physical Sciences

John Downing
Iowa State University, Ecology, Evolution, and Organismal Biology

Kunshan Gao

Roxane Maranger
Université de Montréal, Biology

Milla Rautio
Université du Québec à Chicoutimi,
Département des Sciences Fondamentales

Johan Schijf
UMCES/Chesapeake Biological Laboratory

Dennis Swaney
Cornell University, Ecology and Evolutionary Biology

SUSTAINING MEMBERS

Daniel Conley
Lund University, Dept. of Geology

Katie Droscha
MSU Limnology Lab, Michigan State University

James Elser
Arizona State University, School of Life Sciences

Jian Gao
Jinan University

Nancy Grimm
Arizona State University, Life Sciences

Robert Heath
Kent State University, Biological Sciences

Nafisat Ikenweiwe
Federal Univ of Agric. Abeokuta, Nigeria,
Dept. of Aquaculture & Fish.Mgt.

James Kitchell
University of Wisconsin - Madison

Tomohiro Komorita

Joseph Montoya
Georgia Institute of Tech, Biology

Sybil Seitzinger
International Geosphere-Biosphere Programme

David Siegel
University of California - Santa Barbara, ICESS & Geography

A. Wood
University of Oregon, Institute of Ecology and Evolution

2012 ASLO AWARDS

G. EVELYN HUTCHINSON AWARD TO JAMES J. ELSER

*Cited by **James P. Collins,** School of Life Sciences, Arizona State University, Tempe, Arizona 85287-4501 USA; jcollins@asu.edu*

James J. Elser is an outstanding scientist whose contributions to research, education, and service fit the ideals of the G. Evelyn Hutchinson Award. Jim couples innovation and a passion for discovery to make—as Hutchinson asked of recipients of this award—"considerable contributions to knowledge" that ensure a "legacy of scientific excellence."

Elser is a pioneer in developing and testing the theory of ecological stoichiometry. In 2002 he joined with Robert W. Sterner to publish their seminal *Ecological Stoichiometry: The Biology of Elements from Molecules to the Biosphere.* In their book they explain and integrate diverse observations while opening an array of new questions in ecology and evolution. Ecological stoichiometry is a powerful body of theory advancing our understanding in areas as diverse as behavioral ecology and aquatic ecology while blending mechanistic (functional or biochemical) and evolutionary approaches. The book has been used in seminars and courses worldwide.

In his research Jim has teamed with colleagues in the U.S. and internationally to improve our understanding of nutrient limitation, trophic dynamics, biogeochemical cycling, and the linkages between evolutionary and ecosystem processes. He has applied a set of basic principles from the molecular level in individual cells to regional and global ecosystems. Jim Elser's work is centered in limnology and ecology, but he has creatively extended ecological stoichiometric ideas to areas as far reaching as understanding human nutrition and the development of cancer. His research is synonymous with innovative experimental design and discovery. As one colleague observed, Elser "has great curiosity and enormous talent for science."

A rich diversity of topics characterizes Jim's publications: nutrient limitation of algae, of bacteria, of zooplankton; cascading trophic interactions; comparative ecology of freshwater, marine, and terrestrial ecosystems; evolution of life history traits in zooplankton; benthic ecology in streams and lakes; effects of global change and eutrophication on aquatic food webs; cyanobacteria blooms; consumer-driven nutrient recycling; stromatolites and the Cambrian explosion; genetics and ecophysiology of RNA production. Regarding such breadth one observer noted: "A striking feature with his [J. Elser's] scientific merits is his innovative thinking and the ability to link processes 'from genes to ecosystems.' " Jim is a superb example of an integrative thinker with a vision unlimited by disciplinary boundaries.

Elser's distinguished publication record includes papers in leading scientific journals, but also in Foreign Policy on the science and policy implications of phosphorus use and limitation in human systems. This research bridges the gap between scientists, non-scientists, and policymakers bringing international attention to phosphorus limitation as it applies to agriculture, run-off in streams and coastal areas, as well as wastewater reclamation.

Jim Elser integrates research and teaching while mentoring the next generation of aquatic and terrestrial ecologists. He has guided many undergraduate and graduate students as well as postdoctoral associates in his laboratory. Jim's many accomplishments of course confer a stature that for some faculty members would lead to avoiding large undergraduate courses in favor of smaller upper-division undergraduate courses and graduate seminars. But this is not Jim Elser's style. He is a role model for junior and senior colleagues as he regularly and enthusiastically teaches introductory biology for non-majors. By now he has taught an estimated 10,000 students in a way that makes a difference in their ability to reason carefully and understand the natural world. In recognition of his many accomplishments in research, teaching, and service Jim holds Arizona State University appointments as both a Regents' Professor and a President's Professor, the latter recognizing truly exceptional contributions to teaching. Holding both professorships is a rare accomplishment on our campus.

Professor Elser is an innovative, broad thinker whose ideas are changing biology by adapting, modifying, and creating theory to explain a broad range of phenomena. Ecological stoichiometry has the potential to be among a handful of unifying theories in biology as a result of the rigor and imagination Jim brings to his research. His drive to expand scientific collaborations beyond institutional boundaries and scholarly silos results in novel approaches to long-standing scientific questions while providing fertile ground for the questing intellect of the next generation of researchers and citizen scientists.

James J. Elser deserves this year's G. Evelyn Hutchinson Award for work already completed, promise of work to come, and the living legacy that Jim is building through sustained and generous investment in his research, colleagues, and students.

RAYMOND L. LINDEMAN AWARD TO STUART JONES

*Cited by **Jay T. Lennon,** W.K. Kellogg Biological Station, Department of Microbiology and Molecular Genetics, Michigan State University, 3700 East Gull Lake Drive, Hickory Corners, Michigan, USA; lennonja@msu.edu*

The winner of the Lindeman award this year (2012) is Stuart Jones. Dr. Jones is currently an Assistant Professor in the Department of Biological Sciences at the University of Notre Dame. The work discussed in his paper:

Jones, S.E. and Lennon, J.T. (2010) Dormancy contributes to the maintenance of microbial diversity. Proceedings of the National Academy of Sciences of the United States of America 107: 5881-5886

was completed as part of his postdoctoral research at Michigan State University.

Dormancy is a bet-hedging strategy used by various organisms to overcome unfavorable environmental conditions. By entering a reversible state of low metabolic activity, dormant individuals become members of a seed bank, which can determine community dynamics in future generations. Stuart's article used a unique combination of traditional limnological techniques, mathematical modeling, and cutting-edge molecular approaches to make the case for the importance of inactivity or dormancy in freshwater lake microbial communities. Stuart's findings made links between environmental characteristics, including lake trophic status, and the prevalence of microbial dormancy. Importantly, the study demonstrates that our estimates of biodiversity are likely to be strongly influenced by the molecular tools that are used to characterize microbial communities. Finally, the paper informs the recent debate about the ecological and functional importance of rare organisms (i.e., the "rare biosphere") by identifying a perhaps counter-intuitive relationship between abundance and activity of different microbial taxa. Already, Stuart's paper has made a large impact on a number of fields, including limnology, oceanography, ecology, and microbiology. His study provides a theoretical framework for understanding the complexity of natural systems, but also has implications for predicting disease dynamics and the resiliency of managed ecosystems. Stuart's keen intellect, creative ability, and interdisciplinary training make him a worthy recipient of the Raymond L. Lindeman Award.

A.C. REDFIELD LIFETIME ACHIEVEMENT AWARD TO Z. MACIEJ GLIWICZ AND WINFRIED LAMPERT

*Cited by **Nelson G. Hairston, Jr.,** Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY 14853 USA, ngh1@cornell.edu*

Winfried Lampert and Maciej Gliwicz are recognized jointly this year (2012) with ASLO's Alfred C. Redfield Lifetime Achievement Award. It is the first time ever that the association has honored two colleagues simultaneously, and it is highly fitting. Separately, Gliwicz and Lampert have each contributed extraordinary amounts to the depth and breadth of our understanding of the roles that zooplankton play in the dynamics of lake ecosystems. Indeed each was fittingly nominated independently for this year's Redfield Award, but like so many things about these two singular individuals, their paths crossed. Together they, their students, and their research collaborators have led the way in studies of *Daphnia,* an ecologically critical taxon in many lake ecosystems. Their studies of the responses of this genus to its physical environment, food resources, competitors and predators have been instrumental in establishing its key position in the ecological dynamics of the limnetic zone. The body of work provides much of the foundation that makes it possible to declare the *Daphnia pulex* genome the first in the field environmental genomics.

The convergences in Lampert's and Gliwicz's careers are remarkable. They received their doctorate degrees four years apart (1967 at the University of Warsaw, and 1971 at the University of Freiburg, respectively). Gliwicz's first publication (1969) on *Daphnia* concerned its feeding selectively using a remarkably inventive method based on particle size distributions. Lampert's first publication on *Daphnia* (1974) also concerned feeding selectivity and reported a novel dual-isotope label technique. From these beginnings, each has gone on to study the metabolic, morphological and behavioral adaptations of *Daphnia* and other zooplankton taxa to accumulating food resources while coping with competitors and avoiding predators. As members of the influential Plankton Ecology Group (PEG) in the 1980s, they were coauthors on one of the most highly cited papers in limnology (Sommer, Gliwicz, Lampert and Duncan. 1986. The PEG-model of seasonal succession of planktonic events in fresh waters. Arch. Hydrobiol. 106: 433-471). Critical to this contribution was Lampert's seminal recognition that spring clearing events in lakes (the "clear-water phase") are caused by seasonal increases of *Daphnia* populations with a prodigious capacity to graze down the spring phytoplankton bloom, and Gliwicz´s observation that this promotes summer blooms of inedible or toxic algae and cyanobacteria, a topic to which both colleagues contributed further important research, separately and together.

As their careers blossomed, Gliwicz joined the faculty of the University of Warsaw in 1976, while Lampert joined the faculty of the University of Frankfurt in 1977. In 1984 Lampert was elected Director at the Max-Planck-Institute for Limnology (MPIL) in Plön, Germany, while in that same year, Gliwicz was made Head of the Department of Hydrobiology at the University of Warsaw, and promoted to Professor of Natural Science in 1986. At MPIL, Lampert assembled one of the most remarkable facilities for studying the vertical distribution of plankton anywhere in the world – his four-story high plankton towers with the possibility to construct vertical gradients in temperature, light, oxygen and phytoplankton density, and to manipulate the presence or absence of predators or their kairomones. These towers served as a research platform for some of the most rigorous tests of the mechanisms underlying zooplankton vertical migration behavior. The plankton towers were only one of many reasons to visit MPIL. For twenty-two years (1984-2006), Winfried Lampert maintained one of the most stimulating research environments anywhere in limnology: there were always interesting students, postdocs, and research scientists present, exchanging ideas and carrying out studies, while Lampert himself was ever present providing encouragement, critiques, and new ideas as needed. Though keeping MPIL running smoothly was clearly a full-time job, Lampert maintained his own active research program showing, among many other things, how *Daphnia* acquire and grow in response to different food resources, and how its vertical distribution matches closely the position in the water column that maximizes fitness both for feeding and for predator avoidance.

During these years, Maciej Gliwicz established his parallel research group at the University of Warsaw where he trained his own creative group of plankton ecologists. And, Gliwicz came frequently to Plön to join the mix of limnologists there, and to float and test new hypotheses. Like Lampert, his best known studies have expanded our knowledge of zooplankton interactions and of vertical migration as a predator avoidance adaptation. They are coauthors on four publications in addition to the PEG paper. A hallmark of both Gliwicz and Lampert has been their forceful insistence on the importance of adaptive evolutionary processes as the foundation for understanding the ecological dynamics of freshwater plankton. It is a perspective each pursued starting in the 1970s at a time when broad biogeochemical and energetic patterns were dominant perspectives in limnology, and this more intimate view of biological interactions is now an integral part of our understanding.

Both have received the Nauman and Thienemann medal of the International Society of Limnology, and both have been chosen for the Ecology Institute Prize in Limnetic Ecology (as a result of which each has published an extremely interesting book for the Excellence in Ecology series). Lampert has been elected a foreign member of the Polish Academy of

Sciences, and is a recipient of the Winberg Medal of the Russian Hydrobiological Society. Gliwicz is an Honorary Member of the Ecological Society of America. It is a genuine pleasure for ASLO to recognize each of them – and both of them together – for their lifetimes of achievement.

PATRICK AWARD TO PENNY CHISHOLM AND JOHN CULLEN

*Cited by **Philip Boyd,** NIWA Centre of Chemical & Physical Oceanography Department of Chemistry University of Otago, Dunedin, New Zealand*

Around two decades ago, John Martin made a prophetic remark outside the Redfield Laboratory in Woods Hole. His seminal quote - in jest - "Given me a ½ a tanker of iron and I'll give you an ice age" succinctly illustrated several significant issues that became pivotal in driving a new research field from 1988 onwards. They included the potent link between ocean biogeochemistry and global climate in the geological past, and the disproportionately important role of trace metal supply on the ocean's carbon cycle. The other issue this quote could allude to is how ocean iron fertilization might be used to geoengineer our climate.

The prospect of the detrimental effects of geo-engineering on the Ocean Commons is an environmental problem at least on the scale of acid rain, or the ozone hole. Our joint awardees have steadfastly and clearly communicated the issues, pitfalls, and dangers of ocean iron fertilization for twenty years. It is highly likely that without such dedicated efforts - much of it done in the early mornings, weekends and evenings - we would likely be faced with a barely recognizable ocean - in which the biogeochemistry and ecology had been purposefully modified by geo-engineers.

Chisholm and Cullen have walked a tightrope between developing both an appraisal of our scientific understanding of the role of iron biogeochemistry, and a critique of the very selective use of scientific advances in this field by commercial interests. Indeed, their recognition of this confounding 'muddying of the waters' between science and geo-engineering had helped the wider scientific community and the media to tease apart these issues. The breadth of their vision as to the wider implications of geo-engineering of the Ocean Commons led to the recognition of a policy vacuum in this area, and they have helped to release this vacuum.

Their eloquent debate at meetings and symposia has both raised general awareness of this potential environmental problem and galvanised other scientists to become involved in this issue. The example they set in pursuing commercial interests in ocean iron fertilization was an inspiration to the community of coastal ecologists who lobbied and successfully publicised the harmful effects that would result from proposed urea fertilization of the coastal ocean, in pristine regions such as the Sulu Sea.

Our co-awardees have kept a resolute finger on the pulse of developments by geo-engineers and challenged them at public meetings. They were also proactive in promoting debate with commercial interests in ocean fertilization. Chisholm and Cullen co-chaired an ASLO-sponsored meeting between scientists, policy and commercial stakeholders in 2001 in Washington, DC. I took part in this meeting and can vouch that it took all of the scientists "out of our comfort zone." Nevertheless, Penny and John steered us through this confrontational gathering, and in turn helped build a community of scientists who together kept their "ears to the ground." This facilitation led to discussions of how to counter the wide range of ploys that geoengineers use to publicise their unsubstantiated claims regarding low financial costs, investment opportunities and environmental benefits (for both carbon sequestration and fisheries productivity!!) of ocean fertilization.

For 20 years Penny Chisholm and John Cullen have been at the forefront of their research interests in algal physiology. In contrast to the widespread recognition for advancing their respective fields, of cyanobacterial physiology and algal bio-optics, their selfless efforts in halting commercial exploitation of the Ocean Commons has received little attention. I recently looked through my email archives from both of them. There were hundreds of emails, informing, encouraging, and cajoling me on this issue. I can only surmise at how much time and energy both co-awardees have put into preventing this environmental problem.

To date, their efforts have so far prevented any geo-engineering of the coastal or open ocean, stimulated policy formulation (such as the London Convention) on this thorny issue. Their tenacity has helped dissuade several commercial ventures that ocean fertilization of the Ocean Commons will be always be challenged by a well-informed community of scientists. Their inspiration has encouraged many scientists - including myself - to become more involved at the policy interface, for example leading to the publication of the UNESCO/IOC Ocean Fertilization - A summary for policy makers. One of their nominees clearly summed up why they should be worthy winners of the Ruth Patrick award - the best way to solve an environmental problem is to prevent its creation. This award is a small token of thanks by our community for the efforts of Penny and John in averting the widespread environmental ramifications of ocean fertilization.

JOHN MARTIN AWARD TO RIK WANNINKHOF

*Cited by **Liqing Jiang,** National Oceanographic Data Center, NOAA/NESDIS/NODC E/OC1, SSMC-3, Rm 4603, 1315 East West Highway, Silver Spring, MD 20910-3282, USA, liqing.jiang@noaa.gov*

Wanninkhof, R., 1992. Relationship between gas exchange and wind speed over the ocean. J. Geophys. Res. 97, 7373-7381.

One of the fundamental challenges in study of biogeochemical cycles is to make the leap from concentrations to rates. This holds true for a large number of interfaces and processes, ranging from sedimentation rates, particle settling in oceans and lakes, primary production to atmospheric deposition. Estimating sea-air transfer of gases is another rate that confounded quantification in the 1980s. Despite clear evidence of strong impact of wind on air-water gas transfer in controlled laboratory settings, many studies of gas transfer in the ocean, most notably the large number of gas transfer rates determined by the ^{222}Radon-^{226}Radium disequilibrium in the surface ocean did not show convincing correlations with environmental forcing (Peng et al., 1979; Smethie et al., 1985).

The need to establish a means of quantifying fluxes of gases across the interface had never been greater in light of increasing appreciation of the role of the ocean in sequestering or releasing climate relevant gases. While fluxes can be estimated by a variety of means, using a bulk flux equation analogous to Fick's first law has great merit for estimating sea-air fluxes on regional to global scales. That is, gas fluxes across the aqueous interface can be determined from the air-water concentration difference, ΔC, and a parameter called the gas transfer velocity or piston velocity, k: $F = k\ \Delta C$. While concentration differences could be readily measured or estimated, quantifying the gas transfer velocity was more challenging. Most efforts went into determining relationships of gas transfer velocity and wind speed. One of the first convincing field results that the gas transfer was related to wind was from a novel experiment adding a purposeful tracer to a small lake (Wanninkhof et al. 1986). The results from this study were extrapolated, aided by wind wave tank results from, Broecker et al. (1978) in the first widely used gas exchange-wind speed relationship for the natural environments (Liss and Merlivat, 1985).

The seminal paper "Relationship between gas exchange and wind speed over the ocean" was not merely an iteration of the initial parameterizations but was based on fundamental insights to establish a relationship that could be applied to global sea-air exchange with emphasis on the uptake of excess carbon dioxide from the atmosphere. The relationship was bound by the global constraint of uptake of bomb ^{14}C (Broecker et al., 1985). It addressed the impact of variability of winds on gas transfer. It provided a speculative assessment of the role of chemical enhanced CO_2 exchange at the interface. The manuscript included a comprehensive listing of basic physicochemical properties of relevant gases as a function of seawater temperature such that the derived gas exchange-wind speed relationship could be used for a variety of gases over a wide range of ocean environments.

The importance of the paper and utility of the relationship is reflected by a citation count of over 1500. The so-called "Wanninkhof gas exchange relationship" is incorporated in many of the ocean biogeochemical global circulation models used to predict future CO_2 levels in authoritative works such as the IPCC (2007). It has become the standard to evaluate gas transfer estimates in field studies, and those based on theory. Our knowledge of gas transfer relationships with wind speeds have improved greatly over the past two decades. However, the enduring qualities of the work are the empirical and theoretical underpinning that is as relevant now as 20-years ago.

It is the simplicity and ability to distill complex physical phenomena into a simple characterization that gives the work its staying power. It was not considered the definitive final word on gas transfer. As mentioned in the conclusion of the paper, "Many uncertainties regarding the relationship between gas transfer and wind speed remain. It is not clear whether wind speed can be used by itself to estimate gas transfer velocities." Rather the paper has served as the framework and foundation of the exciting and critical developments in this field.

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MARGALEF EXCELLENCE IN EDUCATION AWARD TO JOHN P. SMOL

*Cited by **Brian Cumming,** Queen's University, Kingston, Ontario, Canada; cummingb@queensu.ca*

"To my students, past and present." These are the words John P. Smol used in the opening dedication of his highly acclaimed textbook *Pollution of Lakes and Rivers* (now in its second edition) and summarize John's motivation for his legendary work ethic and dedication to excellence in teaching. In John's world, the students come first.

Founder and co-director of the Paleoecological Environmental Assessment and Research Lab (PEARL) at Queen's University, Smol leads a group of approximately 30

Photo by Sandra Murray.

students and other researchers in studying a wide range of limnological issues. His prowess in scientific research has been well recognized (he has published over 440 journal papers and chapters, and 19 books), and he has won over 35 research awards and fellowships, including the Herzberg Gold Medal as Canada's top scientist or engineer, and is a previous winner of the ASLO Hutchinson Award. He also holds the Canada Research Chair in Environmental Change and is Editor of the journal *Environmental Reviews.*

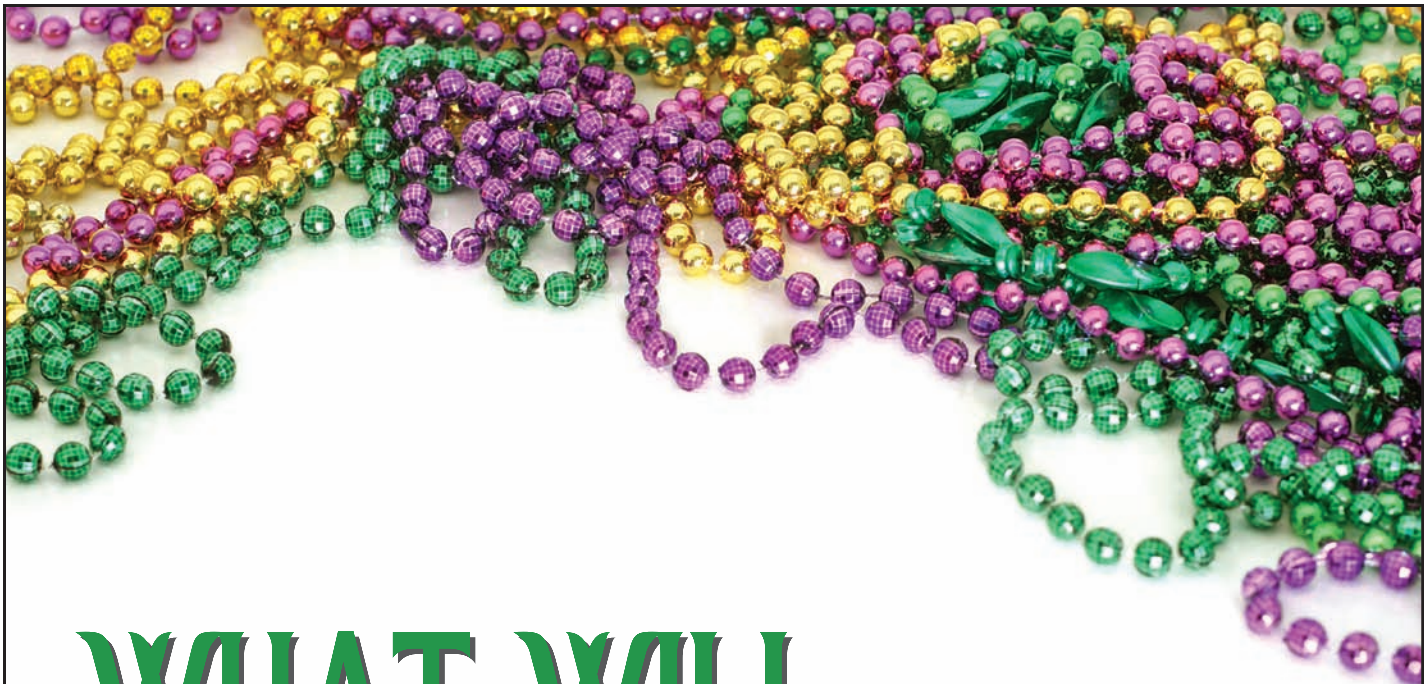
I purposely begin with this brief summary of Smol's outstanding research record, as it is this same determination and hard work, coupled with a strong social commitment that has also driven John to develop an internationally renowned teaching program. He has done this by recognizing the importance of excellent, highly organized and innovative lecturing approaches, combined with "hands-on" laboratory skills development, coupled with an appreciation for the need of field-based experience. A recurring phrase used to describe John's inspirational style is his "contagious enthusiasm." A common thread throughout his research and teaching is the development and employment of strong communication skills – and not just communicating to other students or colleagues, but also communicating to policy makers, the media, and to the public-at-large. Smol accomplishes this by constant vigilance in honing and refining his students' communication skills, and repeatedly showing by example the importance of effective communication, whether it be to a senior government politicians, to a local groups of retired citizens, or to his participation in the mentorship program and lecturer at science camps, to kindergarten and elementary school-aged children (e.g., Love Your Lake Day at a provincial park).

Independent evidence of John's excellence in education can be gathered from many sources. He has already been recognized by eight teaching-related awards. For example, he was the winner of our inaugural Award for Excellence in Graduate Supervision. John's success with over 60 graduate students and over 20 post-doctoral fellows is legendary, with his graduates filling faculty and research positions in the best universities and research institutes. In 2009, John was named a 3M National Teaching Fellow, considered by many to be Canada's top undergraduate teaching award. Perhaps most notably, following a nation-wide search, the editors of Nature named John Canada's Top Mid-Career Science Mentor. As noted by Dr. P. Campbell (Editor-in Chief of Nature), John's nomination "…stood apart in a 'class of its own', according to the judges, who were particularly moved by the student testimonials..."

Due to his international reputation as a mentor and educator, John has hosted students, post-doctoral fellows and other university staff from across Canada, the USA, as well as visitors from South America, Europe, Asia, and Australia. Smol has lectured on all seven continents, but he is also in very high demand to lecture on teaching methods and approaches, including several keynotes at education conferences and lectures on mentoring at learned societies and student groups (such as his numerous "Advice to Young Scientists" talks he has given in many venues, including a previous ASLO conference). As recent evidence of the trust and respect colleagues have for John, he was named Research Integrity Advisor for our entire university – making himself available to students and others who have concerns about integrity issues.

His reputation is equally high for his energy and effectiveness in educating those in authority and the public-at-large in the implications of his and others research findings. His press releases on new results are eagerly awaited, and he is a frequent commentator on environmental issues for radio, television, and the print media. The straight-forward language that he uses in explaining science and the obvious passion he brings to his concerns for human sustainability are well-known to the media and to all who turn to him for clarification of issues in science and the environment. Not surprisingly, John was also awarded the T. Geoffrey Flynn Advancement Champion Award -- our highest award for service in recognition of his outreach teaching and public education. The list can go on.

In summary, John P. Smol is an outstanding scientist, with an equally remarkable record of teaching, student mentorship, and communication.



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