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Nova Scotian Institute of Science

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Volume 47, Part 1 • 2012

Continued

Proceedings of the Nova Scotian Institute of Science (2011)
Volume 47 Part 1, pp. 1-2

EDITORIAL

Another Notable Anniversary
Rachel Carson's 'Silent Spring' and its Influence

As we celebrate the 150th anniversary of the NSIS, it is worth reflecting again on other anniversaries of 2012. We of course share our anniversary year with the Bedford Institute of Oceanography, theirs being a 50th, soon resulting in a major celebratory book "Voyage of Discovery" (see the Ad in this issue).

Another very notable 50th anniversary in 2012 is that of *Silent Spring*, written by Rachel Carson, and that is the subject of this article. The date of publication was September 27th, 1962. Three excerpts had appeared in *The New Yorker* that summer. There was great public interest and growing anticipation in the government departments responsible for agriculture, wildlife conservation, and water and food quality. President John F. Kennedy, already a reader of the author's previous best-selling books on the seas (e.g. *Under the Sea Wind*; *The Sea Around Us*), was interested in seeing action taken immediately by his officials. Angst was felt by the chemical industry and rebuttals and law suits were being planned.

Rachel Carson, already renowned as a marine scientist and writer, was celebrated as a visionary and hero after *Silent Spring* was published. The book was a heartfelt, brilliantly researched and wonderfully written expose on the impacts of pesticides and other toxic chemical substances on the environment and its wildlife. It became an instant best seller, and selected as Book of the Month for October that year. *Silent Spring* is still in press, having sold over 2 million copies, in countless languages worldwide. It is considered one of the most influential books of the 20th century, and has been the subject of many books and articles. Among the most notable is Linda Lear's *Rachel Carson – Witness for Nature*.

Silent Spring led to discussion and debate about chemicals that resulted in new environmental legislation, new government departments (e.g. Environment Canada came into being a few years later), and most importantly a new public awareness of the health and environmental risks of living in a chemically dependent society. Why note this anniversary? Does *Silent Spring* still have lessons for us? Is it still worth reading? The answers of course lie with each reader and perspective. But the view of many in conservation and the environmental sciences is that *Silent Spring* is a landmark in society's collective efforts to care for the environment, and it deserves revisiting. Its basic message - that chemicals can harm both wildlife and human health if not tested adequately prior to use and mishandled during use - is very valid today. The book's description of ecological processes was an early, accurate and eloquent attempt to describe ecology in a readily understood way. The book and its author have become icons in the struggle to protect and conserve natural environments, and protect human health from exposures to persistent toxic chemicals.

Carson's book, though dated in places, is as beautifully written as her other classics. She gave us a literary masterpiece that has inspired a generation of scientists and environmentalists. Its primary message is that we need to understand the implications of living in our chemical world to protect ourselves, our children, and our living landscapes, oceans and wildlife. Clearly, science has a huge responsibility to ensure this understanding and protection.

Of special note is a new biography of Rachel Carson titled: *On a Farther Shore: The Life and Legacy of Rachel Carson,* the author being William Souder. It sheds further light on the interplay between conservation and industrial interests. So, if interested, read this new book and read or re-read *Silent Spring*, while we continue to celebrate the NSIS 150th and communicate scientific advancements in the region.

Peter G. Wells, Editor

150th Anniversary AGM Attendees

Front row (l-r): Michelle Paon, Elaine McCulloch, Anne Mills, Linda Marks, Suzuette Soomai.

2nd row: Heather Cook, Leigh-Ann Bishop, Sharon Longard, Angelica Silva, Peter Wells.

3rd row: Bob Cook, John Young, Henry (Hank) Bird, Eric Mills.

Back row: Truman Layton, John Rutherford, David Richardson, Archie McCulloch, Alan Ruffman, Stuart Grossert.

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COMMUNICATING KNOWLEDGE TO NEW AUDIENCES: VICTORIAN POPULARIZERS OF SCIENCE[1]

BERNARD LIGHTMAN*

York University

ABSTRACT

In the past historians have tended to explain the existence of a cult of science from about 1850 to 1890 as the result of the work of elite scientists such as Darwin, Huxley, and Tyndall. But this explanation leaves out two crucial factors: the role of popularizers who were not practitioners of science and the occurrence of a communications revolution in the second quarter of the 1800s that established the conditions necessary for what happened in the second half of that century. Once these factors are added to our account of the cult of science, a very different picture emerges, one that forces us to reconsider the standard story of the dominance of the scientific scene by figures like Darwin, Huxley, and Tyndall.

Just before Christmas Day, 1862, John Henry Pepper invited a small group of literary and scientific friends, and members of the press, to his Royal Polytechnic Institution on Regent Street in London, England, to see a performance of a play. His plan to surprise his visitors with a preview of a new optical illusion worked better than he could possibly have imagined. The audience was so startled by the ghost illusion that Pepper took out a provisional patent the following day, sensing its almost unlimited potential (Figure 1). When he started showing the ghost illusion at the Polytechnic, a periodical described it as a "real veritable spectre, so real that the spectator hardly believes the Professor when he states that it is a mere illusion, a fact, however, which he establishes by walking clean through it" (University of Westminster Archives). Pepper's ghost caused a sensation and drew thousands of visitors to the Royal Polytechnic Institution.

Pepper wasn't the only lecturer on science who attracted the attention of Victorian audiences in 1862. On November 10th, Thomas Henry Huxley delivered the first of six weekly lectures to an audience

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[1] This paper is based on an invited lecture given on May 7th, 2012, at the University of King's College, Halifax, NS, on the occasion of the 150th anniversary of the NSIS.

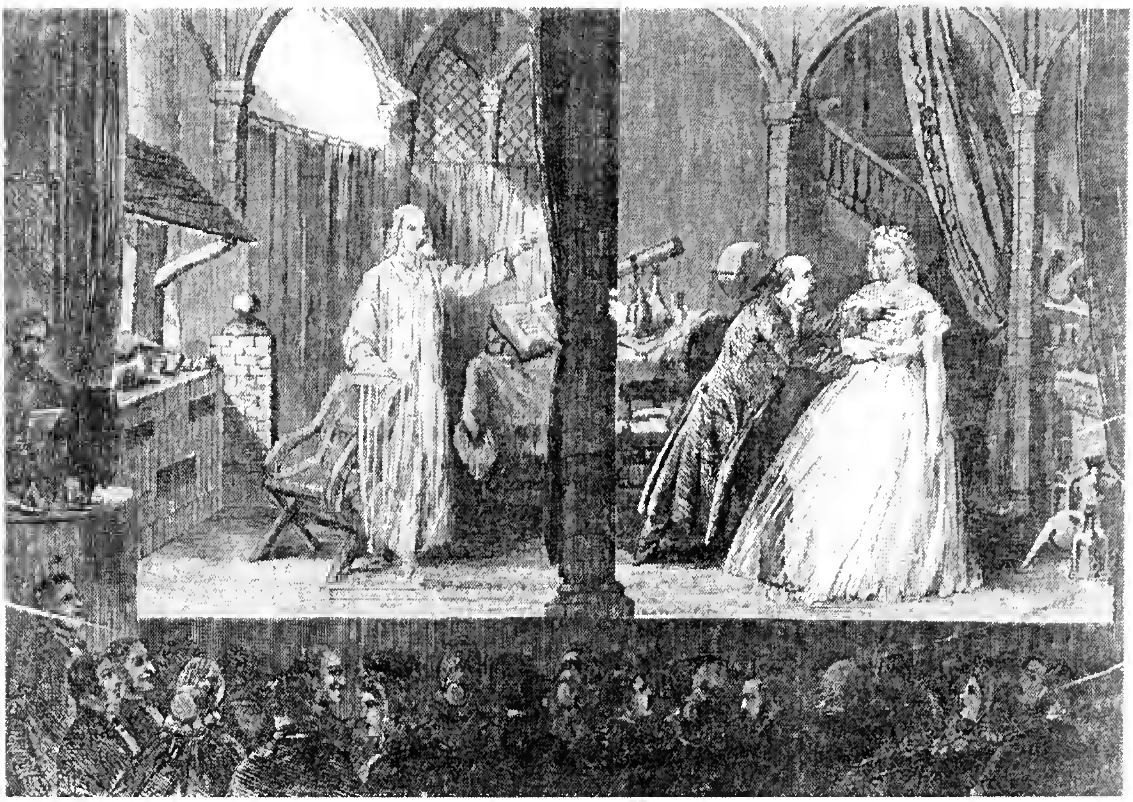


Fig 1 Pepper's Ghost haunts the stage at the Polytechnic Institution. Source: "Spectre Drama at the Polytechnic Institution," *Illustrated London News* 42 (May 2, 1863), 486.

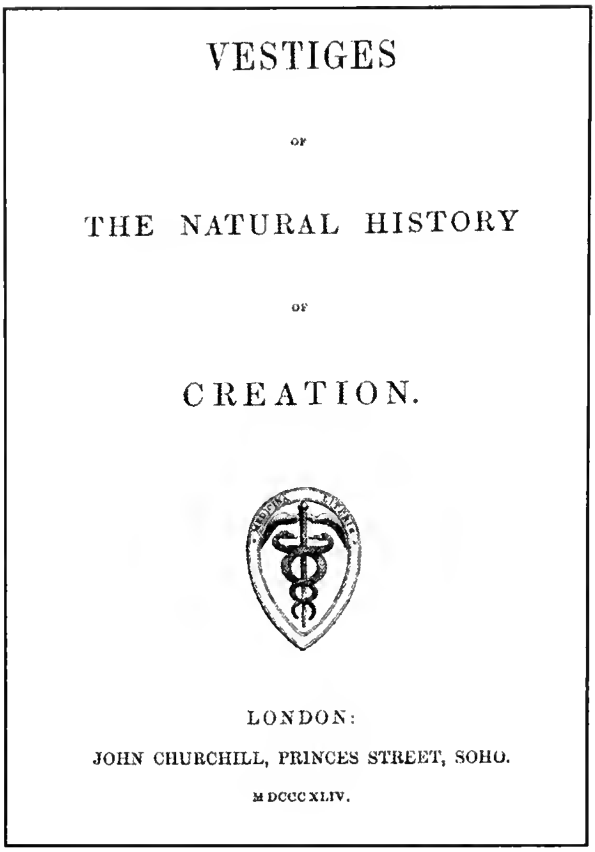
of workingmen. Now known as "Six Lectures to Working Men," one historian of science has described them as "plebeianizing the *Origin*" (Desmond 1997, 310). To Huxley's astonishment, when they were published, they sold well and not only in England. In the same year, over at the Royal Institution on Albemarle Street, Huxley's friend John Tyndall, a physicist, was also lecturing to an excited audience. Whereas Huxley lectured to workers, Tyndall's audience was composed of the well to do. Tyndall had the chairman presiding over his spring lecture light a cigar at the invisible focus of a beam of infrared radiation (McMillan and Meehan 1980, 49). The year 1862 is also memorable for the publication of Charles Kingsley's *Water Babies* in serial form in *Macmillan's Magazine*. Kingsley, a Christian socialist, novelist, and liberal Anglican cleric, wrote a charming book for children that introduced evolution in a nonthreatening way. In 1862, popularizers of science wrote and lectured for every type of audience in Britain.

But if we traveled across the Atlantic Ocean from Britain to Canada that same year, we would witness another notable event. I refer, of course, to the founding of the Nova Scotian Institution of Science. I have grouped the establishment of the NSIS together with lectures by Pepper, Huxley, and Tyndall, as well as with the publication of Kingsley's *Water Babies*, to illustrate the point of my lecture: that there was a profound connection between the various efforts to disseminate scientific knowledge in 1862. For some time now, historians have referred to the period between 1848 and 1890 as the age of the worship of science, or sometimes, the cult of science. By this they mean that during this period, at least in the Anglo-American and European world, there was a fascination with science. In Britain in the 1850's, this fascination manifested itself in a series of natural history crazes, as the marine aquarium and fern collecting became widespread fads. Science captivated the Victorians right up to the end of the century. They came into contact with science through witnessing the spread of dazzling new technologies, such as cable telegraphy, through encounters with exotic animals and plants from around the world, and through experiencing heated debates over the validity of new scientific theories, such as Darwin's theory of natural selection. For some, the fascination with science operated at an even deeper level. For them, science provided the basis for making sense of themselves and their place in the universe, either in conjunction with revised Christian notions or completely on its own terms.

In the past historians have tended to explain the existence of a cult of science as the result of the work of elite scientists like Darwin, Huxley, and Tyndall. But this explanation leaves out two crucial factors: the role of popularizers who were not practitioners of science and the occurrence of a communications revolution in the second quarter of the 1800s that established the conditions necessary for what happened in the second half of that century. Once these two factors are added to our account of the cult of science, a very different picture emerges that forces us to reconsider the standard story of the dominance of the scientific scene by figures like Darwin, Huxley, and Tyndall. I will outline the major features of the new picture by discussing three modes of popularizing science, in print, in oral form, and in display.

I. The Communications Revolution

Published in 1844, a book titled the *Vestiges of the Natural History of Creation* became the focal point of a huge controversy that reverberated for the rest of the century (Figure 2). In the book the author presented evolutionary theory, previously linked to working-class radicalism, in a favorable, appealing light to middle class readers. The book was attractive to a general audience because it combined


VESTIGES

OF

THE NATURAL HISTORY

OF

CREATION.

LONDON:

JOHN CHURCHILL, PRINCES STREET, SOHO.

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Fig 2 Title page of the first edition of the *Vestiges of the Natural History of Creation* (1844). Source: [Robert Chambers], *Vestiges of the Natural History of Creation* (London: John Churchill, 1844).

astronomy, anthropology, psychology, physiology, geology, and theology into a vast synthesis that covered the evolution of the universe from the beginning to the present. The *Vestiges* provided its readers with a dramatic evolutionary epic, from monad-to-human. Members of the Victorian public were also drawn to the *Vestiges* because of the mystery surrounding its author. Published anonymously, the author managed to hide his, or her, identity for decades despite efforts to remove the mask. Guessing became a popular game. Some thought the author was Ada Lovelace, who was the only legitimate daughter of Lord Byron, the poet. Others suspected Whig politician Henry Brougham, who championed the publication of cheap books. There was a long list of scientific suspects, including Charles Babbage, the inventor of a calculating engine; Charles Lyell, the eminent geologist; and Charles Darwin, at that time the author of a well-known travel book about his experiences while on *HMS Beagle* (Secord 2000, 20-21).

Selling 39,000 copies by 1890, the *Vestiges* was an extraordinarily successful scientific steady seller. To put the book's sales into context, let us compare them with the sales of Darwin's *Origin of Species*, published in 1859. Darwin's *Origin* reached the 56,000 mark by 1899, surpassing the *Vestiges*. But in terms of the immediate impact of the two books, the *Vestiges* outsold the *Origin*. Whereas the *Vestiges* sold 21,250 copies within a decade of its first publication, the *Origin* sold only 10,000 copies (Lightman 2007a, 33-34). There is no doubt that Darwin's book had an enduring impact, unlike the *Vestiges*. But from the point of view of the Victorian reader in the middle of the century, the two books were almost on a par in terms of influence. So who was the author of the *Vestiges*? The answer to the question is quite revealing. The author was not a practitioner of science—he was a publisher and a writer. Robert Chambers was one of the brothers behind the Scottish firm W. and R. Chambers that was moving in the 1840's into the world of large-scale, cheap book publishing. With their experience in periodical printing, the Chambers publishing firm was well positioned to take this new path. Due to *Chambers's Edinburgh Journal* (f. 1832), the firm had established a reputation as "publishers for the people." They aimed their publications at a new polity of consumers composed of middle- and working-class family readership. When Chambers wrote the *Vestiges* he drew on all of his experience as a publisher and journalist for this audience. This is why he was able to make evolutionary theory appealing to his readers. He knew his audience and what they liked to read.

The sales of Chambers' *Vestiges* were important to other publishers of the 1840's. They offered proof that a new reading audience existed for cheap science books. Previously, this had not been the case. Publishers had experimented with similar publishing projects earlier in the century, and the results had been mixed. Experiments in cheap educational publishing began in the second decade of the nineteenth century, in the wake of the transformation of the book trade. These ventures were crucial in the development and definition of "popular" publishing in general and "popular science" in particular. Cheap children's books published by Longman and Richard Phillips, and William Pinnock's educational catechisms, were followed by the inception of the new weekly periodicals. Relatively inexpensive literary journals such as *Literary Gazette* (1817) and *Literary Chronicle* (1819) were founded, along with the new two- and three-penny weeklies, such as the *Mirror of Literature* (1822), the *Mechanic's Magazine* (1823), the *Lancet* (1823), and the *Chemist* (1824). The children's books and the weeklies of the 1810s and early 1820s confirmed the existence of a new and profitable market for cheap publications. This led to the production in the 1820s and 1830s of publications by the Society for the Diffusion of Useful Knowledge (SDUK), and by John Murray and Longman with the designation "popular science." These ventures had limited success.

But for cheap science books and periodicals to reach sales of the magnitude of the *Vestiges* consistently, the conditions had to be right. First, there had to be readers who would buy the books. In this context, it is useful to examine literacy rates in Britain. The size of the British reading audience grew, as literacy rates increased dramatically over the course of the last sixty years of the century. Whereas the number of literate and illiterate Britons was roughly equal at the end of the 1830s, by the close of the century illiteracy had fallen to 1 percent (St. Clair 2004, 13; Vincent 1989, 22). Starting in the 1830s, then, publishers could reach out to a growing reading audience as new segments of the population became literate, especially members of the middle class and the wealthier working class. It is difficult today, when we are bombarded with print on a daily basis, to imagine a western society where the ability to read was so restricted. But it would be fair to say that a mass reading audience, as we know it, did not exist in Britain at the end of the eighteenth century. And that is why we cannot really speak of the existence of "popular science" before the beginning of the nineteenth century.

If the nature and size of the reading audience was evolving in the first half of the nineteenth century, so was the technology of publishers. The new steam powered publishing technologies under development would eventually allow publishers to reach the rapidly growing reading audience. Many steam-printing technologies developed in the early nineteenth century had been used by newspaper and penny periodical publishers who saw the advantages of faster production, but not book publishers, who relied on hand-press technology. In the 1840s, some book publishers decided to attempt to reach the audience of the penny periodicals and began to adopt steam-print technologies. The growth of the British railway system provided a better transportation system for publishers and the reduction of the cost of paper and the "taxes on knowledge", an intricate system created to prevent radicals from publishing, made it even more possible to produce cheap publications. James Secord, an eminent historian of science who has written extensively about Chambers and the *Vestiges*, has argued persuasively that all of these developments combined to create a communication revolution. He asserts that this revolution represented the "greatest transformation in human communication since the Renaissance" that led to "opening the floodgates to a vastly increased reading public" (Secord 2000, 2).

Let us not forget that during the second quarter of the nineteenth century, an important period for the communications revolution, was also the time when the mechanics' institutes really took off. The Whig politician Henry Brougham's *Practical Observations upon the Education of the People* (1825) was one of the catalysts. In his *Political Observations, Brougham* set down a general plan for establishing and managing such institutes throughout Great Britain. He was also involved in the vast publishing experiment known as the Society for the Diffusion of Knowledge. His plans to set up a Society to publish cheap science books are of a piece with the idea behind the mechanics institutes. Institutes began to appear in many large British towns by the 1840's. By 1851 there were over seven hundred literary and mechanics institutes in Great Britain and Ireland with over 120,000 members. This year was the high point of their expansion. Organized by interested members of the middles classes for artisans and operatives, the belief was that scientific education would result in the moral improvement of these members of the working class and that it would lead to their acceptance of the new industrial society (Shapin and Barnes, 1977, 33-37). The NSIS was a direct descendant of the Halifax Mechanics' Institute (1831-1860) and of the Halifax Literary and Scientific Society (1839-1862). So the intertwined stories of mechanics institutes and the communications revolution during that period are important for understanding the early history of the NSIS.

II. Scientific Authors

Even with the increase in the literacy rate leading to the growth of new reading audiences for science, and the development of new printing technologies by the publishers, a third requirement was needed to make possible the production of cheap science books. Someone had to write them. In the past, historians have concentrated on the science books written by practitioners, the men who did science. For the second half of the nineteenth century this would mean looking at the Huxleys and the Tyndalls, members of the scientific elite bent on professionalizing science. But these men had a specific agenda to pursue that affected their popularizing activities. When Huxley's generation of scientific practitioners arrived on the scene at the mid-point of the century, a changing of the guard took place within the scientific leadership, though it was not without friction. Many of the middle-class "Young Turks" of science, including Huxley and Tyndall, came from outside the Oxbridge environment. Where the earlier generation of British scientists had insisted that knowledge was to be conceived within a religious framework, the aims of this new group included the secularization of nature, the professionalization of their discipline, and the promotion of expertise. Huxley coined a catchy name for this new vision of a science emancipated from theology: scientific naturalism. Huxley argued that proper science excluded any reference to a divine being—scientists should stick to studying observable causes and effects in nature. The scientific naturalists aggressively pushed for a redefinition of science in the latter half of the nineteenth century. In addition to Huxley and Tyndall, the ranks of the scientific naturalists included the philosopher of evolution Herbert Spencer, the mathematician William Kingdon Clifford, the founder of eugenics Francis Galton, the statistician Karl Pearson, the anthropologists John Lubbock and Edward Tylor, the biologist E. Ray Lankester, the doctor Henry Maudsley and a group of journalists, editors and writers such as Leslie Stephen, G. H. Lewes, John Morley, Grant Allen and Edward Clodd.

The scientific naturalists were not just aiming at a reform of scientific theories and institutions. They were also interested in transforming British culture as a whole. They put forward new interpretations of humanity, nature and society derived from the theories, methods and categories of empirical science, especially evolutionary science. They chose to challenge the cultural authority of the Anglican aristocratic establishment by claiming that they provided the best intellectual leadership of a modernized and industrialized Britain. When they wrote books, articles or lectures for the Victorian public, they defended the agenda of scientific naturalism.

But by focusing only on the practitioners of science when trying to understand how science was communicated to a general audience, we completely miss another large group of popularizers, the scientific journalists and writers. These men and women usually had no formal scientific training. Often they were self-taught. Many of them were trying to establish a career for themselves as science writers, taking advantage of the new market conditions and the need of publishers for authors. This was the beginning of science journalism as a profession. From the point of view of the scientific naturalist, these popularizers presented a problem. They did not have the expertise needed to speak on behalf of science. Many of them did not share the agenda of the scientific naturalists. But the scientific naturalists had little control over who publishers and editors hired to write about science. They would have been particularly concerned about the large number of Anglican clergymen and women who were churning out science books. Due to their naturalistic approach to science, Huxley and his allies were committed to eliminating the clergymen-scientists who saw the study of nature as a handmaiden to natural theology or as subordinate to theology and religious authority. As for women, in the eyes of the scientific naturalists they were doubly disqualified from real participation in science, including the role of popularizer. Not only were they more easily seduced by the lure of Christianity, they were considered not to possess the required intellectual power to engage in genuine scientific research. By nature they were religious, emotional, and subjective, according to the scientific naturalists. Darwin's *Descent of Man* (1871) provided an evolutionary rationale for the alleged inferiority of women. Writing to the geologist Charles Lyell on March 17th, 1860, T. H. Huxley declared, "five sixths of women will stop in the doll state of evolution, to be the stronghold of parsondom" (Imperial College, Huxley Papers, 30.34).

It is therefore somewhat surprising to find that there were a large number of Anglican clergymen and women engaged in popularizing science in the second half of the century. Among the Anglican parsons were Ebenezer Brewer, Charles Alexander Johns, Charles Kingsley, Thomas William Webb, Francis Orpen Morris, George Henslow, William Houghton, and Henry Neville Hutchinson. These men drew on their authority as clergymen of the Church of England to speak in public about their views on science. They established themselves as trusted writers in a wide range of scientific areas, from astronomy to botany, entomology, geology, and ornithology. Through their work the Church of England maintained an active presence in the British scientific world, and they kept the relevance of religious themes to contemporary science before the minds of the public, even after the appearance of Darwin's *Origin of Species*.

Let us take Ebenezer Brewer as an example of this group of popularizers. Brewer was a graduate of Cambridge (Figure 3). He was ordained Deacon in 1834 and priest in 1836, but he never seems to have held an ecclesiastic post. Although headmaster of King's College

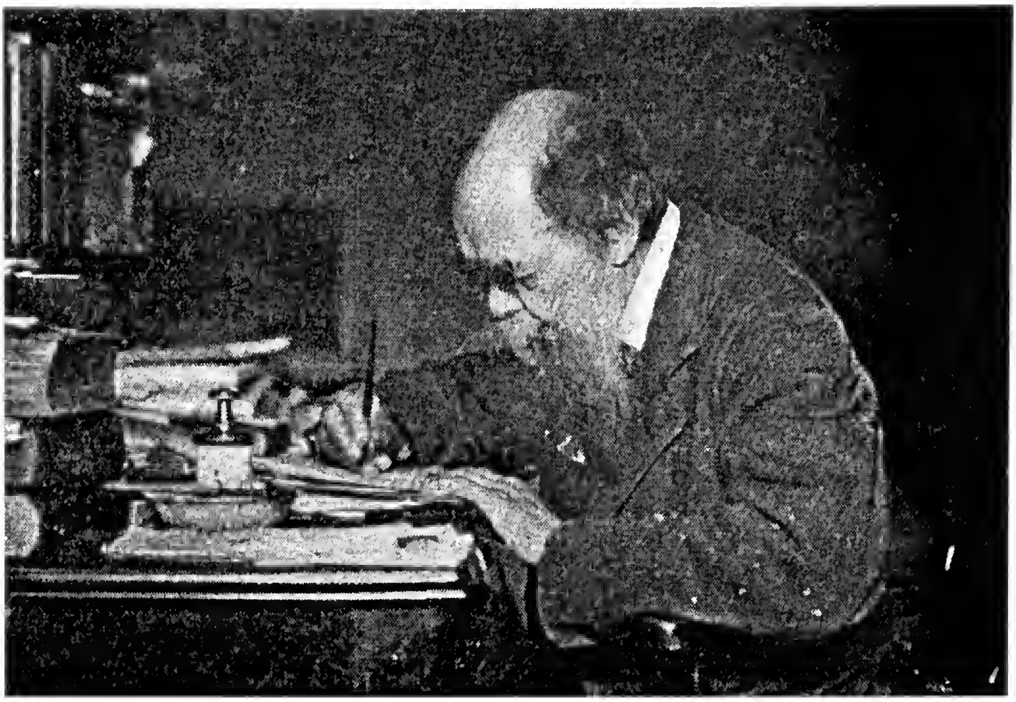

Fig 3 Brewer at work at his desk. Source: *The House of Jarrolds, 1823-1923: A Brief History of One Hundred Years* (Norwich: Jarrold Publishing, 1924), opposite p. 41.

School, Norwich, he dedicated himself to writing books on a wide range of topics, including the literary, social, and political history of Europe, book-keeping, dictionaries of phrases and fables, school textbooks, and scientific works aimed at a popular audience. Brewer's *Guide to the Scientific Knowledge of Things Familiar* (1847) holds the record for largest number of copies sold of a science book published in the second half of the nineteenth century. By 1892, when the book had reached its forty-fourth edition, 195,000 copies had been printed (Lightman 2007a, 66). That is over three times the number of copies of Darwin's *Origin* sold by 1899. The book used a question and answer format familiar to audiences through their reading of religious catechisms. Here are some samples of his questions and answers. "Q. Show the wisdom of God in making AIR a BAD conductor." The correct response was, "If air were a good conductor (like iron and stone), heat would be drawn so rapidly from our body, that we should be chilled to death." Many of his questions challenged the reader to link established scientific facts to divine wisdom or goodness. "Q. Show the WISDOM of GOD in making grass, the leaves of trees, and ALL VEGETABLES, excellent radiators of heat" (Brewer 1874, 184, 215).

Women also distinguished themselves as popularizers of science in the second half of the nineteenth century. They wrote about virtually every aspect of the natural sciences, though natural history topics tended to dominate. Lydia Becker, Phebe Lankester, Anne Pratt, Elizabeth Twining, and Jane Loudon all explored the world of botany. Arabella Buckley and Alice Bodington wrote primarily on evolutionary biology, while Margaret Gatty was more interested in marine biology. Other women, such as Mary Roberts, Anne Wright, Sarah Bowdich Lee, Annie Carey, Eliza Brightwen, and Elizabeth and Mary Kirby, moved across topics in natural history, from geology, to conchology, ornithology, and entomology. A smaller number of women tackled natural philosophy. Agnes Clerke and Agnes Giberne concentrated on astronomy. Some women were knowledgeable enough to range over both the physical and life sciences. Mary Ward covered astronomy in one book and the use of the microscope to study livings things in the other. Rosina Zornlin penned works on electricity, geology, geography, astronomy, and hydrology. Mary Somerville began with astronomy, but also dealt with other physical sciences and the life sciences in later books.

Margaret Gatty is an example of one of the women (Figure 4). Gatty, a devout evangelical, was married to a Yorkshire clergyman. She wrote a number of widely read books on zoological topics. Her *British Sea-Weeds* (1863), an introductory book to the topic, established her credentials as a knowledgeable collector, but her series of didactic and scientifically informed short stories, *Parables from*

Fig 4 Margaret Gatty, an evangelical popularizer of science. Source: "The Late Mrs. Alfred Gatty," *Illustrated London News* 63 (October 18, 1873), 379.

Nature (1855-71), became an international bestseller that made her a household name in Britain. Reaching an eighteenth edition in 1882, it was reissued many times by different publishers right up to 1950. Gatty's *Parables* contained a mixture of science, morality, and religion that was considered to be appropriate Sunday reading for Victorian families. Gatty's evangelicalism was reflected in her stories, and she was fiercely opposed to Darwin. Women like Gatty, and Anglican clergyman like Brewer, had much in common. Their authority to speak out on the religious significance of science was being questioned by the scientific naturalists. They both emphasized the moral and religious lessons to be learned through an understanding of nature, and they stressed the sense of wonder to be experienced when faced with its beauty. Together, they formed a formidable group whose common agenda could frustrate the goals of scientific naturalists.

III. Scientific Lecturers

John George Wood, popularizer and Anglican clergyman, delivered the Lowell Lectures in Boston in 1883. He startled his audiences with a carefully managed spectacle. To illustrate the key points of his lecture he drew "rapid improptu sketches" of creatures that gradually took shape before the eyes of those attending. Audiences were particularly impressed by their magnitude. The sheet of black canvas that he used to draw on was stretched on a wooden frame that gave him a surface of eleven feet by five feet six inches. Close up, the drawings looked coarse and clumsy, but when viewed from thirty or forty feet away they were elegant pictures that were clearly visible in every part of the largest hall. The impact on the audience was electrifying. In one of his Lowell Lectures Wood spoke on the whale to a packed room. "When I opened the lecture by drawing the whale, eleven feet long, in two strokes," he wrote to his family, "there was first dead silence, and then such a thunder of applause that I had to wait." Then Wood drew a little sailor on the whale's back to illustrate its gigantic size, and the crowd "laughed and cheered in the heartiest manner" (T. Wood [1890], 203). Wood's larger-than-life sketches catered to the popular audience's taste for spectacle. He realized that if science lectures were to become a popular form of entertainment, and if he were to succeed as a public lecturer, he had to satisfy the craving for visual images that was the hallmark of mass culture in this period.

Wood was among the most well known popularizers in the second half of the century. He lectured and published extensively. He turned his lectures into spectacles and incorporated a multitude of visual images in his books. In this section I will examine Wood as a representative showman of science. Many science lecturers capitalized on the pictorial turn in British culture. In addition to Wood, the natural historian Frank Buckland, son of the eminent Oxford geologist William Buckland, and Richard Proctor, a prolific popularizer of astronomy, exploited their audience's hunger for spectacle and visuality. Appealing to the eyes of their audience gave them a competitive edge and provided them with a powerful vehicle for presenting a vision of science set within a religious framework. They demonstrated the potential of science to attract vast, new audiences by incorporating visual spectacle. Their blend of instruction and amusement was a hallmark of popular science in this period. But some were able to make a good living from their lecturing while others struggled. Wood was one of those who struggled.

Wood, like Brewer, is another one of those figures who were well known to Victorian audiences but who have been forgotten by historians, until recently. A reviewer in the *Saturday Review*, who was by no means well disposed towards Wood, acknowledged that he "had a thousand readers where Darwin had but one and Professor Huxley not more than a dozen" ("Rev. J. G. Wood" 1890, 479). The phenomenal sales of Wood's books confirm that he had a large reading audience. His *Common Objects of the Country* (1858) became one of the best-sellers of the second half of the century. Within a decade of the book's first appearance, 64,000 copies had been printed, and by 1889, the number was 86,000 copies (*Archives of George Routledge & Co. 1853-1902*, 1973, Publication Books, vol. 2, 424; vol. 3, 87, 96; vol. 5, 324; vol. 6, 96). This far exceeded the sales of Darwin's *Origin of Species*. When the Victorian reading public thought about science, they were as likely to recall books by Wood, as they were to refer to Darwin's *Origin*. It was a sign of Wood's popularity when *Punch* poked fun at his Wood's *Common Objects of the Seashore* (1857) and those who read it by depicting them as if they were the common objects of the sea when they combed the shore for marine flora and fauna (Figure 5). Wood received his B.A. from Oxford in 1847 and was ordained as priest in 1854 (Figure 6). But already his interest in natural history was leading him away from a clerical career. After several of his natural history books had been well received by

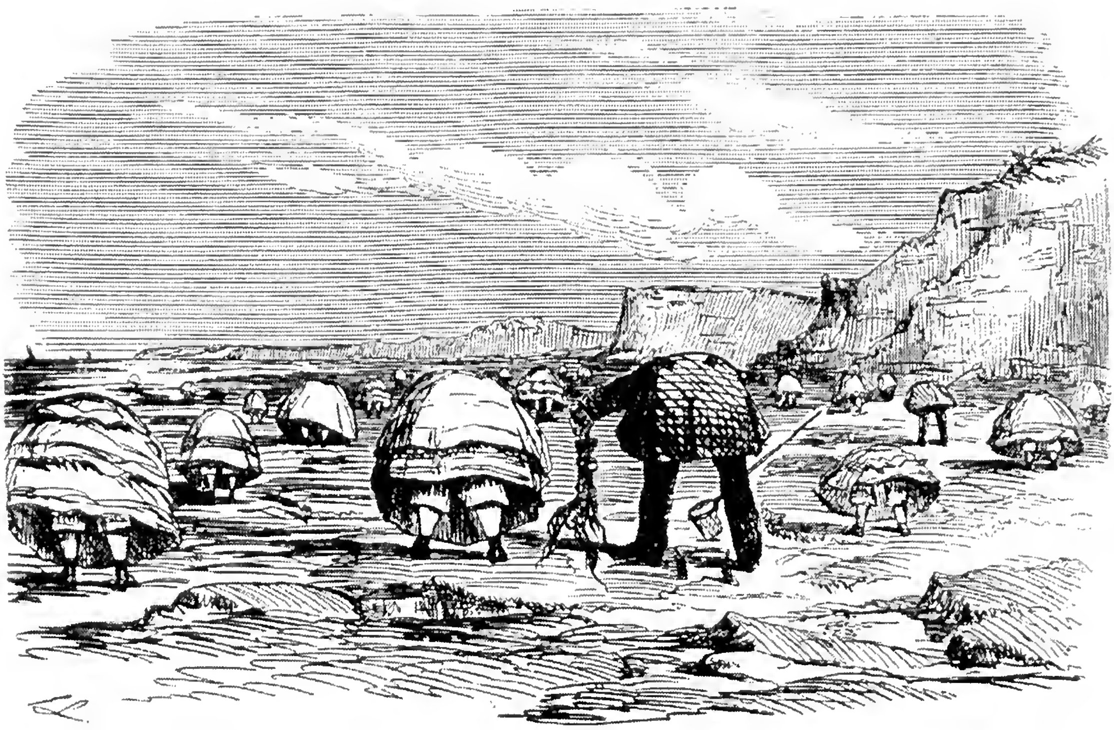

Fig 5 *Punch* lampooning Wood's readers. Source: "Common Objects at the Sea-Side—Generally Found upon the Rocks at Low Water," *Punch* 35 (August 21, 1858), 76.

Fig 6 The Reverend J. G. Wood, Anglican clergyman turned popularizer of natural history. Source: Theodore Wood, *The Rev. J. G. Wood: His Life and Work* (New York: Cassell Publishing Company, 1890), frontispiece.

Victorian readers, Wood resigned in 1862 from all paid clerical duties and began to build a career as a scientific writer. Leaving the security of a clerical position for writing was a risky move, particularly in the early 1860s. Wood could only make it work by churning out articles and books at an astounding rate. He published over two dozen natural history books over the course of his career as a popularizer.

Wood was known for his lavishly illustrated books. In *Insects at Home* (1872), for example, there were seven hundred figures drawn by a team of illustrators. *Insects Abroad* (1874) contained six hundred illustrations produced by the same team. Wood's illustrations played an important role in his presentation of a theology of nature that would have been opposed by the scientific naturalists. In the preface to *Insects Abroad*, he stated his two objectives. First, in keeping with the goodness of divine design, he hoped "to show the great and important part played by Insects in the economy of the world, and the extreme value to mankind of those insects which we are accustomed to call Destructives." The creatures most detested by humans—mosquitoes, ants, and wood-boring beetles and termites—were actually among our greatest benefactors. According to Wood, insects were "working towards one purpose, namely, the gradual development of the earth and its resources." Insects were not just good in the larger scheme of things; they were also beautiful. The second objective of *Insects Abroad* was to encourage readers to "note the wonderful modifications of structure which enable the insects to fulfill their mission, and the surpassing beauty with which many of them are endowed" (J. Wood 1883, v, 5). *Insects at Home* also emphasized this theme. "We find among insects," Wood asserted, "a variety and brilliancy of colour that not even the most gorgeous tropical flowers can approach, and that some of our dullest and most insignificant little insects are, when placed under the revealing lens of the microscope, absolutely blazing with natural jewellery" (J. Wood 1872, 2).

Throughout both books, Wood drew the reader's attention to the beauty of insect bodies and wings, making good use of his many illustrations. The illustrations in the insect books presented their subjects in a natural setting filled with lush vegetation and teeming with life. This was the vision of nature so central to natural theology. The striking frontispiece to *Insects at Home*, rendered in vivid color, presented a variety of different insects, including one of Wood's favorites, the Great Green Grasshopper. This is Wood's happy world of beautiful insects. It was no challenge for Wood to highlight the beauty of some butterflies, moths and beetles. But he was not satisfied unless he could persuade his readers that nearly every insect was aesthetically pleasing in some way. As Wood turned to insects commonly seen as ugly and disgusting, he found something attractive and wonderful to praise (Figure 7). A giant earwig, on the right near the bottom of

Fig 7 Finding wonder in the insect world. Source: John George Wood, *Insects at Home* (London: Longmans, Green, 1872), 228, plate VII.

Plate VII of *Insects at Home*, was described as a "fine insect," while the common earwig, on the right near the top, was shown with "its beautiful wings extended." In this illustration Wood also includes a field cockroach and its egg case (bottom right), a field cricket (just below the center of the illustration), and a mole cricket (center bottom, below the field cricket). In some cases Wood was forced to turn to the microscope for help in finding the element of beauty he wanted his readers to see in all insects. As "dull and colorless as the Gnat may appear to the unaided eye," Wood announced, "it has only to be placed under the revealing glass of the microscope to blaze out in a magnificence which would pale all the fabled glories of Aladdin's fairy palace" (J. Wood 1872, 226, 230, 602).

Wood found that he could not always make enough money to support his family just by publishing books. In the later 1870's, when the state of the book trade had deteriorated, Wood began to consider lecturing as a possible means of supplementing his income. From 1879 until his death in 1889, Wood conducted ambitious lecturing tours of England, averaging about ninety lectures in a season. During his most extensive tour during the 1881-82 season, Wood gave more than 120 lectures. Wood was in competition with professional scientists like John Tyndall who had tremendous reputations as powerful speakers and great showmen. Wood's use of his "rapid impromptu sketches" of battling ants, gigantic whales, and other creatures won him scores of invitations to lecture. Wood used color pastels imported from Paris that positively glowed on the large, black canvas-drawing surface that he had specially designed. Unfortunately, none of the sketches have survived. We can only try to get a glimpse of what they looked like from contemporary reports. A reporter for the *Altrincham and Bowdon Guardian* was deeply impressed by Wood's sketches, which were "not mere diagrams, but finished pictures in colours of great beauty." In his estimation, "Mr. Wood's method of lecturing is in fact we believe, unique" ("Lectures for Altrincham and Bowdon" 1881, 5). According to Wood's son, the sketches were "always perfectly exact in every particular," and "no line was ever rubbed out or alteration ever made." Wood's seemingly spontaneous sketches were the outcome of long and careful prior preparation. First, he made a tracing of the object he wished to draw from some trustworthy woodcut. He would copy this two or three times upon a slate, always attempting to do so with the fewest possible lines. Next, he would make a very careful sketch in color upon the back of a small paper strip. Then, finally, he would stand before his black canvas and practice drawing the sketch over and over until he could execute it without hesitation and without mistake. Wood's command of his pastels in the accurate depiction of the natural world served as proof of his scientific expertise (T. Wood [1890], 154, 159).

Wood's innovative speaking style won him the invitation to give the prestigious Lowell Lectures in Boston. The trip was a success in terms of the enthusiastic response Wood received from his audiences. But Wood's failure to hire an agency to organize engagements in addition to the Lowell Lectures doomed the enterprise financially, and he would have made just as much had he stayed in England. His second transatlantic tour in 1884-5 was a disaster and was cut short. This time he had hired an agent, but an incompetent one who lied to Wood about the number of firm engagements. After that experience Wood decided never again to undertake another trip across the Atlantic.

The circumstances surrounding Wood's death also underlined the risk involved in trying to make a living off scientific lecturing. Once Wood started lecturing, the physical demands of the circuit took its toll on his health. Wood caught a severe chill while on a lecturing tour and then died shortly thereafter, on March 3, 1889. "The poor fellow literally died in harness," one of Wood's friends wrote in the *Times*. The friend was making a plea on behalf of Wood's family, whom he had left totally unprovided for. Donors were asked to send money to the "J. G. Wood Fund." Shortly thereafter, Wood's widow wrote to the Royal Literary Fund for help. "So impossible did he find it to maintain his family by his pen alone," she explained, "that in 1879 he adopted public lecturing as a supplementary profession and yet after working almost without a days' holiday for nearly 37 years, he has been able to leave behind him nothing but the proceeds of his life insurance policy" (Whitehead 1889, 15; Cambridge University Library, Royal Literary Fund, File No. 1982, Letter 24). Although Wood's unhappy demise demonstrated the riskiness of embarking on a career of popularizing science, he was nevertheless highly influential with the public. His influence owed a great deal to his use of visual images in both his popular lectures and his best-selling books. He offered a theology of nature, depicted in images of harmonious animal life, that countered the secularized vision of nature propounded by scientific naturalists like Huxley and Tyndall.

IV. Museums and Exhibitions

In 1851 London was the site of an international exhibition. The Great Exhibition of the Works of Industry of All Nations was a significant indicator of a change in attitude toward science evident to many mid-nineteenth-century observers. Historians have presented it as proof of the beginning of the age of the cult of science. The Exhibition was housed in an immense glass and iron building of unique architectural design, earning it the nickname "Crystal Palace." Never before had an industrial exhibition drawn such huge crowds. T. H. Huxley, then an aspiring young biologist, wrote to his future wife in 1851 that visitors to the Crystal Palace approached it with awe and reverence, as if they were on a sacred pilgrimage to a holy shrine. "The great Temple of England at present," Huxley told her, "is the Crystal Palace—58,000 people worship there every day. They come up to it as the Jews came to Jerusalem at the time of the Jubilee" (Huxley to Heathorn, September 23, 1851, letter no. 165-66, Imperial College, Huxley Papers, Huxley/Heathorn Correspondence). If the success of the *Vestiges* indicated to publishers that there was a market for cheap science books, the throng of visitors to the Crystal Palace seemed to show that exhibitions that featured science and industry could be popular draws.

The nineteenth century was also a period of museum growth. Existing museums were expanded and new museums were founded, especially after the Museums Act of 1845 in Britain enabled civic museums to be established throughout the provinces. As well as such great national museums as the National Gallery (founded in 1824) and the South Kensington Museum (1857), which was the precursor of the both the Victoria and Albert Museum and the Science Museum, two hundred metropolitan, provincial, and university museums were founded in Britain (Rupke, 1994, 13-15). Among them were important science museums, such as the Museum of Practical Geology (1851) and the British Museum (Natural History) in South Kensington (1881). In addition to these museums of public education, there was a wide range of more commercial enterprises, ranging from the relatively long-term—such as the Adelaide Gallery (1832-45) and the Polytechnic (1838-81)—to such ephemeral shows as the exhibitions of the so-called Aztec children who took London and Dublin by storm in the summer of 1853. At the start of the century, access to most museums had been governed by gentlemanly conventions of politeness, and some collections remained in gentlemen's private cabinets located in country houses, where they were accessibly only to polite or respectable classes of society. But by the end of the Victorian era, most museums had been opened up, from the country houses, which welcomed hordes of day-trippers, to the national and municipal museums, which were open to all at no cost and even began to open on Saturdays and evenings. The formation of a mass reading public in Britain, therefore, took place at about the same time that museums and exhibitions became accessible to a mass visiting public. Of course, these publics were virtually one and the same.

The world of Victorian science exhibitions and museums is fascinating. A number of examples illustrate their significance. Wyld's Globe, constructed in 1851 as a companion to the Great Exhibition, is one candidate. Located in the heart of Leicester Square, London, visitors could walk into a massive globe that contained a huge map of the earth on the inside. The purpose of the Globe was to educate the public in the science of geography, and lecturers were stationed at various points to inform visitors about that particular part of the globe. Later, new attractions were added, including a panorama of China, dioramas of India and of the Australian gold fields, models of the Arctic and of the Crimean War, and an Oriental Museum. The Globe stayed open for ten years, drawing large crowds. Another candidate is the Royal Panopticon, also in Leicester Square, which was built in 1854 and closed two years later. It featured an immense organ, a large fountain, a gigantic electrical apparatus, industrial machines, scientific instruments, sculpted statues, tradesman's stalls, a laboratory, an apparatus room, a photography gallery, and lecture halls. But I will focus on a third intriguing scientific institution, the Royal Polytechnic Institution. That will allow us to return to John Henry Pepper and his ghost illusion. What all three had in common was an emphasis on entertainment and instruction, which was also a feature of the books and lectures we have discussed.

Pepper became manager of the Royal Polytechnic in 1854 (Figure 8). Educated at King's College School, he later studied analytic chemistry at the Russell Institution. In 1840 he was appointed assistant chemical lecturer at a private school of medicine. His relationship with the Royal Polytechnic Institution began in 1848, when he was hired as a lecturer and analytic chemist. Pepper was manager for eighteen years, with some short interruptions. But he resigned for

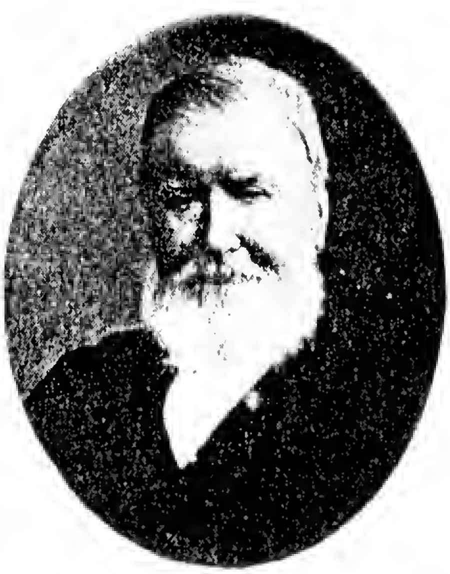

Fig 8 John Henry Pepper, showman of science. Source: "Personal," *Illustrated London News* 116 (April 14, 1900), 503.

good in 1872 after a quarrel with the board of directors over the extent of his autonomy. During his time at the Polytechnic, he published five science books for the public, including *The Boy's Playbook of Science* in 1860. After leaving the Polytechnic, he tried to re-create his form of science entertainment at the Egyptian Hall in Piccadilly but lost money on the venture, and he went on tour in the United States, Canada, and Australia from 1874 to 1881. He accepted the post of public analyst in Brisbane, Australia, in 1881, stayed there until 1889, and then returned to England, where he remained until his death in 1900 (Boase 1965, 386-87; Cane 1974-75, 116-28; Secord 2002, 1648-49; Brock 2004, 1572-73).

When Pepper took over the reins of the Polytechnic in 1854, the big question for the manager of this institution was how to attract customers whose expectations had been raised by their experiences exploring the Crystal Palace on shilling days. The Polytechnic's offerings must have seemed meager in comparison. When it was first established in 1838, the Polytechnic seemed vibrant and novel. It was equipped with a laboratory, a lecture theater, industrial tools and machines, and a large display room, known as the Great Hall, where the main exhibits were housed. Among the main exhibits were the diving bell and diver, an oxyhydrogen microscope, large electrical machines, and model boats floating in a long canal (Figure 9). The diving bell provided a unique experience for visitors. Four to five persons could fit inside while it was submerged. Given the diversity of its attractions, the Polytechnic was part museum, part laboratory, part lecture theatre, part exhibition hall, and even part amusement park. But Pepper transformed the Polytechnic in an effort to attract more visitors in the competitive post-Crystal Palace era. He added features associated with the London entertainment scene. In the 1850's he added dramatic readings—mainly from Shakespeare—and then experimented with scenes of plays and then entire plays.

Pepper took the theatrics of science to a whole new level when he came across a new scientific principle for generating surprisingly realistic optical illusions suggested by the inventor Henry Dircks. Pepper had already been lecturing on "Optical Illusions" in 1856 and on "Remarkable Optical Illusions" in 1857 and saw this as an area that could attract a substantial audience. Dircks' invention, improved by Pepper, gave him an almost unlimited source of new illusions that attracted vast crowds to the Polytechnic. The ghost illusion was used in various scenes accompanying Pepper's lectures while the

Fig 9 The Diving Bell at the Polytechnic, at left in the picture. Source: University of Westminster Archive, R Illust 10. Reproduced with permission of University of Westminster Archive Services.

"Spectre Drama" played in the morning and the evening. Special written permission was obtained from Charles Dickens to mount a production of his "Haunted Man" as a vehicle for exhibiting the ghost illusion. To satisfy the craving for novelty, Pepper was constantly modifying his illusions so he could present a variety of startling effects. In 1865, visitors to the Polytechnic could see the disembodied head of Socrates deliver a rhymed speech and Sir Joshua Reynold's cherubs singing a choral song. To the disembodied head of Socrates he added Shakespearean creations including the floating and speaking heads of Hamlet and Lear. Pepper's theatrical use of the ghost in his lectures and the dramatic productions at the Polytechnic were, to him, completely in line with the scientific aims of his institution. Pepper's lectures stressed the optical science behind his illusions. Though entertaining and spectacular, his lectures were intended to be instructive (Lightman 2007b, 111-124). The public never seemed to tire of his optical illusions (Figure 10). In 1866, the *Illustrated London News* claimed that 109,000 visitors had seen them ("Royal Polytechnic" 1866, 511).

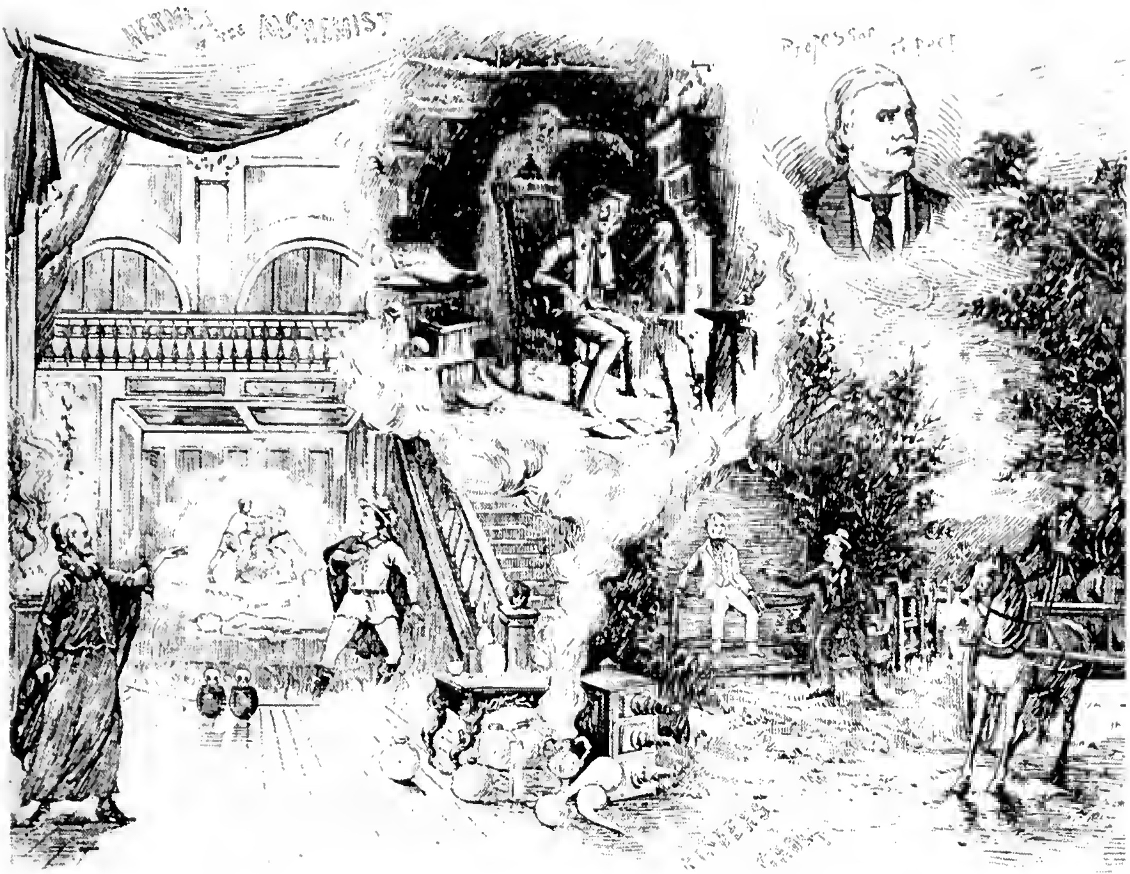

Fig 10 Pepper's Ghost Illusions. Source: "Professor Pepper and His Ghosts," *Pall Mall Budget* (January 16, 1890), 85.

Besides the impressive figures on the number of visitors who went to the Royal Polytechnic Institution, we can also gauge the Polytechnic's impact by looking at cultural references to it from outside the scientific world. During the 1860s, a humorous song about the Polytechnic began to circulate. It was titled "Laughing Gas or A Night at the Polytechnic." The song tells a story about a young man from rural England, Humphrey Brown, who has come to London to visit all of the popular London entertainments, including the Polytechnic (Nash [1860]). Exhausted by his busy day, Brown falls asleep in the lecture room and awakens to find that he is locked in for the night. Afraid of meeting one of Pepper's ghosts, he shores up his courage by swallowing the contents of a container marked "Improved Laughing Gas." He begins to feel light headed, as if he were drunk, and laughs uncontrollably. Then he explores the Polytechnic in this peculiar condition, playing with all of the exhibits. He sees Cherubs floating about in the air; puts on a diving suit, and gets a huge shock from one of the electrical apparatus. Pepper returns and finds him, and tells him that that he has ingested so much gas that he'll laugh until he dies.

The composer and singer of the song, John Nash, was a well-known music-hall artist and comedian. He performed at the South London Music Hall in 1860 and then at the Oxford Music Hall the following year. He toured the United States in 1874 and in 1876 and later formed his own touring company that he took across the Atlantic in 1886. He was the first music-hall artist to perform at royal command. In the *Cambridge Guide to Theatre*, Nash is described as "a specialist in silly walks" and in the *Oxford Companion to Popular Music* as one who "pioneered the laughing song" (Gammond 1991, 415-16; Banham 1995, 777-78). Nash liked to refer to himself as "Jolly John Nash," and to prove he deserved the nickname, he composed and published a song in the 1890s titled "I'm such a jolly Man." Nash's selection of the Polytechnic as an appropriate topic for a music-hall song is indicative of its popularity in the 1860s. Nash assumes that everyone will get the jokes, and they depend on a widespread knowledge of the Polytechnic.

One final point about Pepper, which links him to the other science popularizers we have looked at who were not practitioners. Pepper's attitude towards scientific naturalism was somewhat complicated. Like Huxley and his allies he rejected spiritualism—indeed, he used his ghost illusion to dismiss spiritualism. But at some point in his life Pepper converted to Roman Catholicism, a decision normally fraught with serious consequences in Protestant England and usually an indication of strong religious convictions. According to one contemporary, Pepper was a sincere Christian who "never let slip an opportunity of impressing upon his hearers that the man of science by endeavoring to penetrate deeply into the hidden secrets of nature was guilty of no irreverence, and that the idea that science and unbelief go hand in hand was totally devoid of foundation." Pepper ended his astronomical lectures with arms and eyes raised, and with a quotation from the Psalms "The Heavens declare the Glory of God, and the firmament showeth His handiwork" (Boase 1965, 386; Wilkie n.d., 74). Pepper's conception of science as framed by religious themes is less obvious in his work than in Brewer, Gatty, or Wood's, but it is there.

V. Conclusions

One of the hallmarks of science from about 1830 was the proliferation of its sites. More and more science periodicals began to appear, accompanied by a huge explosion of books, museums, exhibitions, and lectures. In older stories about the formation of the worship of science from about 1850 to 1890, historians tended to credit elite scientists such as Darwin or Huxley for the tenacious hold that science seemed to have on the hearts and minds of Victorians. But as scientific naturalists began to cultivate the strategy of professionalization, it committed them to privileging select spaces in which to practice legitimate science, such as the laboratory above all else. They were also selective about the sites in which they would communicate the results of their research and their views on the broader implications of scientific discoveries, whether it be in the *Nineteenth Century*, *Nature*, or other respectable periodicals, in elite scientific institutions such as the Royal Institution or the annual meeting of the British Association for the Advancement of Science, or on carefully organized lecture tours abroad. By pursuing professionalization as a route to reforming science, scientific naturalists left huge cultural spaces open to popularizers such as Brewer, Gatty, Wood, and Pepper. It was their religiously tinged agenda that members of the Victorian public encountered when they came into contact with science, just as much as the agenda of scientific naturalism.

I have tried to show how the roots of the cult of science of the second half of the nineteenth century can be traced back to earlier in the century, when the communications revolution took place and when there was an explosion of mechanics institutes in Britain. My account emphasizes the connections between the publication of cheap science books, the proliferation of scientific lectures, and the rise of scientific museums and exhibitions. These connections are embodied in the activities of some of the popularizers that were examined. Wood was both a scientific author and a lecturer. Pepper wrote science books, lectured extensively in Britain and elsewhere, and ran the Royal Polytechnic Institution. No doubt the details of the Canadian story differ from the British one. But the larger contours of the story must be similar, if only because what happened in Britain in the nineteenth century had a tremendous impact on developments in Canada and its founding provinces. Chambers' *Vestiges of the Natural History of Creation* caused a sensation in Canada, just as it did in Britain. Canadians read Gatty and Brewer. Scientific lecturers like Wood spoke about science to appreciative Canadian audiences. Though Canada as a young country did not experience a growth of science museums in the nineteenth century on the same scale as

Britain, scientific societies in the provinces flourished. As we celebrate the 150th anniversary of the establishment of the NSIS, we should recall its crucial connection to the many modes in which science was popularized in the nineteenth century in its mother country.

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BIOBLITZ OF THE LAKE ROSSIGNOL WILDERNESS AREA

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ABSTRACT

The Lake Rossignol Wilderness Area is a 4100 ha protected area in Queens County, Nova Scotia. In July, 2006, the Protected Areas Branch of Nova Scotia Environment invited 34 scientists, students and volunteers to conduct a four day bioblitz of this little studied protected area. Surveys were conducted for reptiles, fish, vascular plants, fungi, lichens and bryophytes. Physical and biological attributes of peatlands and dendrochronological studies were also conducted. A total of 294 species were identified during the survey, 285 of which are new records for the Wilderness Area. Dendrochronological analysis suggests trees at the site have been growing in place for at least the last 350 years.
Keywords: Lake Rossignol Wilderness Area, bioblitz

INTRODUCTION

The term bioblitz was first used during an event held at the Kenilworth Aquatic Gardens in Washington, D.C. in 1996 (Shorthouse 2010). Since then, the bioblitz has become a useful technique for scientists to rapidly assess the biodiversity of protected areas, establish new species records and in some cases identify new species to science. A new species of fungus, *Trifoliellum bioblitzii*, was found in 2009 during a bioblitz of the Blue Mountain-Birch Cove Lakes Wilderness Area in Nova Scotia. Other events have also revealed significant new

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species. For example Harper et al. (2009) described two species of a newly identified genus as a result of a marine bioblitz in New Zealand (2009). In addition to establishing new species records (for example see Lewington and West 2008, Karns et al. 2006) the bioblitz can lead to the discovery of biodiversity hotspots (Graham et al. 2010). Some bioblitzes are taxa specific such as the annual Biological Survey of Canada insect blitz (Shorthouse 2010), the Tuckerman workshop survey for lichens and bryophytes (Lendemer and Hodkinson 2009) or the more specific exotic herpeto-faunal bioblitz in Barnacle Historic State Park in 2005 (Meshaka et al. 2008).

There are several reasons for conducting bioblitzes in Nova Scotia. Foremost is to increase knowledge about the biota found in little studied protected areas of Nova Scotia. The opportunity for scientists of different disciplines to interact and learn about other specialities has often been cited by participants as an important part of the survey event. The survey can also be a useful learning experience for students and volunteers who participate.

In 2004 the Protected Areas Branch of Nova Scotia Environment, in conjunction with the Biology Department of St. Francis Xavier University, conducted the first multi-disciplinary bioblitz in Nova Scotia at Canso Coastal Barrens Wilderness Area. Ten scientists and students conducted an inventory of a variety of species groups over a single day. Since then, the Protected Areas Branch has conducted three more bioblitzes in other protected areas (Scatarie Island, Lake Rossignol, Tangier Grand Lake) ranging from two to four days.

In 2006, the Protected Areas Branch invited 34 scientists, students and volunteers to a bioblitz in the Lake Rossignol Wilderness Area. Participants conducted inventories between 26 and 29 July 2006 in a variety of disciplines. Some sampling was also conducted in 2007 and 2008.

The Lake Rossignol Wilderness Area is a 4100 ha protected area in Queens County, Nova Scotia. The area was designated in 1998 under the provincial Wilderness Areas Protection Act. This Act restricts activities such as development, forestry, mining and destruction or removal of natural materials. The Lake Rossignol Wilderness Area was designated in part to protect representative ecosystems of the LaHave Drumlins and Lake Rossignol Hills Natural Landscapes (Cameron 2004, Lynds and LeDuc 1995).

Historical human impacts to North Queens County have included forestry and agriculture. Forest was cleared for agriculture with about 4.4 % of North Queens under agriculture in 1870, although this declined to about 1.1% by 1966 (Telfer 2004). Forestry in the area was historically limited to small patches and individual trees but more recently has included larger clearcuts and conversion of mixed forest to plantations (Telfer 2004). Lake Rossignol was dammed in the 1920's by forestry companies which considerably enlarged the lake converting previous forest to lake (Davis and Browne 1996). Lake Rossignol Wilderness Area is relatively remote and has seen little recent human activity. However, there has been some recent forest harvesting and road construction around the Wilderness Area (Cameron 2004). There is also some evidence of past forest harvesting and farming in the Wilderness Area (R. Cameron pers. comm.). Atmospheric deposition of non-marine SO_4 and NO_3 between 1977–1980 has led to the acidification of lakes in southwest Nova Scotia (Underwood et al. 1987). Although SO_4 and NO_3 have declined in the last several decades, deposition has continued to exceed critical loads for upland forest soils and aquatic ecosystems (Ouimet et al. 2006, Environment Canada 2004). The susceptibility to acid precipitation is largely due to the low buffering capacity of acid bedrock and soils in that part of Nova Scotia (Davis and Browne 1996).

Although the Lake Rossignol Wilderness Area was designated to protect representative ecosystems, there have been no systematic biological surveys of the area with the exception of some vegetation surveys collected in 1992 and 2003 (Cameron 2004). These data collections were confined to forest ecosystems and no study had been conducted in the large area of wetland in the southern portion of the protected area (Davis and Browne 1996).

Lake Rossignol Wilderness Area was considered a likely candidate to provide habitat for a variety of rare species. Two lakes within the Wilderness Area and six lakes that border it provide potential habitat for coastal plain flora, eastern ribbon snake (*Thamnophis sauritus*) and Blanding's turtle (*Emydoidea blandingii*). Large wetlands in the Wilderness Area are also potential habitat for coastal plain flora.

METHODS

Study Area

The Lake Rossignol Wilderness Area is between 44°18′ and 44°11′ north latitude and 65°8′ and 64°59′ west longitude in Queens County, Nova Scotia (Figure 1). The Wilderness Area is in the north temperate forest region with high annual precipitation (1200 to 1400 mm) and relatively warm summer temperatures (average July temperature of 18°C). Underlying geology is mainly quartzite overlain with stony or silty till, silty till drumlins and organic material. Mature mixed forests dominate much of the protected area but large wetlands are found in the south-eastern portion. There are three lakes within the protected area, Big Rocky, Little Rocky and Moccasin Lakes with an area of 263 ha, 51 ha and 73 ha respectively (Cameron 2004).

Adjacent to Lake Rossignol Wilderness Area is property owned by Bowater Mersey and under conservation easement with the Nature Conservancy of Canada. This area was visited on 27 July 2006 by the survey participants. Data from this area are included in this study.

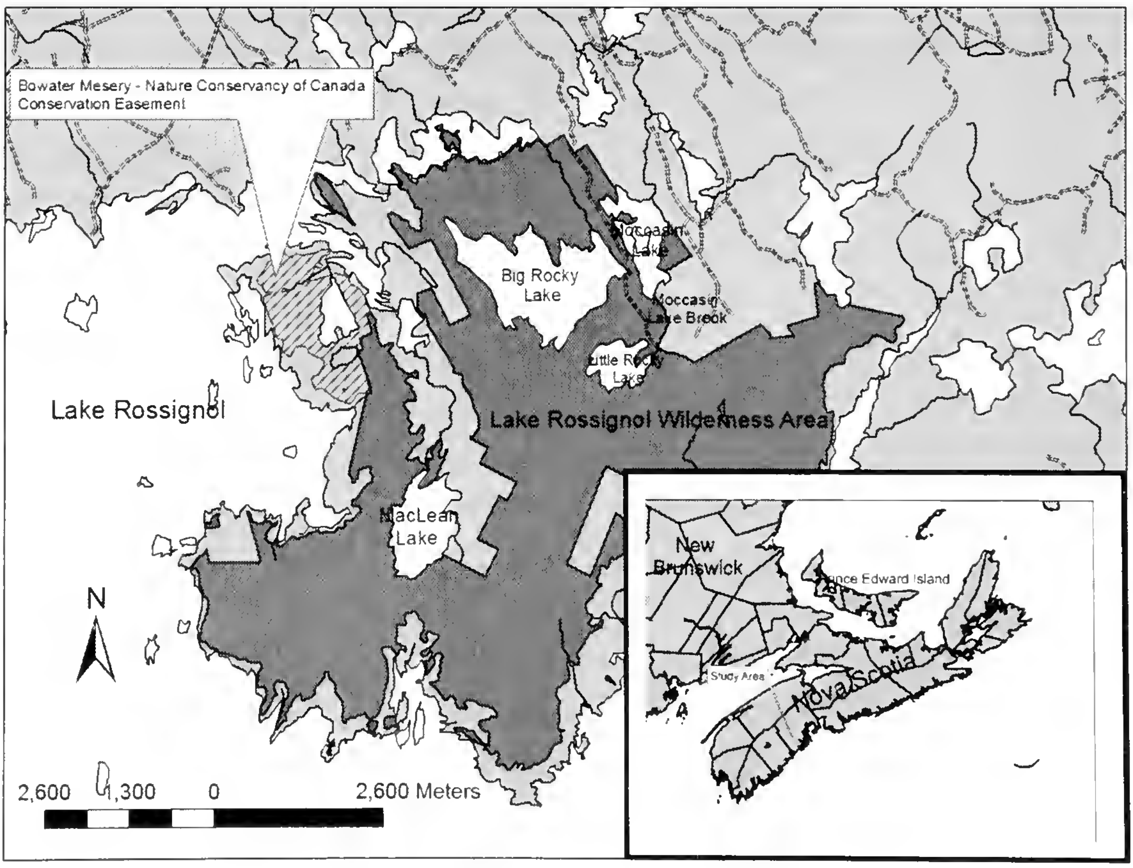

Fig 1 Map of Lake Rossignol Wilderness Area, Nova Scotia showing general location and major features.

Biological Sampling

Fish

Standard minnow traps and fyke nets (length 3 m; mouth 0.40 m^2; mesh size 1.5 cm) were set between 26 and 28 July in three lakes within the Wilderness Area – Big Rocky Lake, Moccasin Lake, and Apple Tree Lake. Minnow traps were baited with beef liver. Captured fish were identified to species, measured for length and either returned unharmed to the water or sacrificed (two fish) to be archived in the collection at St. Francis Xavier University, Antigonish, Nova Scotia.

Turtles

A combination of visual surveys and live-trapping was employed. Visual surveys were conducted each day for about 2 hours, while setting, checking, and removing aquatic hoop-net live-traps baited with sardines. On July 26, 2007, 12 live-traps were set and baited along the length of Moccasin Lake Brook, in suitable turtle habitat (stillwaters with dense aquatic vegetation). The traps were checked once a day, for three days, and were removed on July 29, 2007. Setting 12 traps for 3 nights yielded a total of 36 trap-nights, and about 8 hours of visual survey time. All trap-captured turtles were identified and released immediately after capture.

Snakes

Visual surveys were conducted on July 28 and 29, 2006, along the shore of Lake Rossignol, Moccasin Lake Brook, and in a swamp adjacent to Lake Rossignol. These surveys involved observers walking or canoeing in parallel transects through the wetland with 1-10 m between each observer. Attempts were made to catch eastern ribbon snakes when observed; all snakes were released at the point of capture. A total distance of 6009 m was covered by walking, 499 m covered by canoe, and 9.7 hr of observer effort was exerted.

Vascular Plants

Vascular plants were identified and collected between 26 and 28 July, 2006. Five to seven observers with one recorder visited different areas of the Wilderness Area each day and a separate species list was generated for each day. If a plant species was encountered on more than one day, duplicate specimens were not collected. Digital photos and Global Positioning System (GPS) coordinates were taken at collection sites with rare or unusual species or particularly rich sites. Collections were made of each species encountered and were later pressed and deposited at the E.C. Smith Herbarium at Acadia University or the Nova Scotia Museum of Natural History Herbarium. Nomenclature follows Zinck (1998).

Fungi

The collections of fruiting bodies of fungi were made on 26 July, on the west facing hillside in the north eastern end of the Wilderness Area and on 27 July in the Bowater Mersey - Nature Conservancy of Canada conservation easement.

Photographs were taken of the cap, gills, and stipe of each specimen. Specimens could not be preserved, but spores were kept when spore prints were produced. Measurements of cap diameter and of stipe length and diameter were recorded. Identification to species was done in the field and later with photographs and spore prints.

Lichens

Two habitat types were selected for intensive survey; a small unnamed brook connecting Carrigan Lake and Big Rocky Lake and a treed swamp south of Little Rocky Lake. These habitat types are commonly targeted by the authors for surveys because of the high diversity of macrolichens expected to be found on both hardwood and coniferous species. Although most of the surveying occurred in these two habitats, observations were not limited to them and opportunistic collections were also made in other locations. Identifications were made in the field. Those species that could not be identified in the field were collected and later identified in a labratory using various keys. Collections were made of thirty-nine specimens which were later deposited in the Nova Scotia Museum of Natural History.

Bryophytes

Bryophytes were identified or collected between 26 and 29 July, 2006, and 22 April, 2008. Species identified in the field were recorded by substrate on which they occurred. Species that could not be identified in the field were collected and later identified in the laboratory using Ireland (1982). Collected specimens were deposited at the Nova Scotia Museum of Natural History. Searches for bryophytes were conducted such that a variety of habitats and substrates were visited. Habitat types visited included mature mixedwood and hemlock forest, treed fen, brook and lake riparian zones.

Dendrochronology

Standard dendrochronology practices were used to sample 24 eastern hemlock (*Tsuga canadensis*) trees at the Bowater Mersey - Nature Conservancy of Canada conservation easement. Two cores were taken at breast height for each tree. Cores were taken at 180° to one another since the trees were found growing on a slope. This was done to acquire cores that could be used together to derive the average growth of the tree species at the site.

All cores taken were transported back to the Mount Alison Dendrochronology Labratory, air dried, and glued into slotted mounting boards. The cores were then sanded to a 600 grit polish. The ring widths of each sample were measured using a WinDendro computer software system and a high resolution flatbed scanner. All ring widths were measured to 0.001 mm. Ring width patterns for each species were cross dated both visually and statistically using program COFECHA (Holmes et al., 1986). COFECHA correlations were derived using 50 year segments lagged successively by 25 years. Tree patterns that exhibited correlation coefficients greater than 0.3281 were significant to the 99% level. Each data set was then analyzed with program ARSTAN (Cook 1999) with a single detrending method to derive a master average chronology that illustrated the unified growth signal of all trees.

Intensive focus of a Peatland

The diversity of four different taxonomic groups was surveyed within the peatland using standardized methods:

Odonate Sampling – Sampling took place as observers moved through the study site in a semi-random fashion. Upon entering a bog, a random direction was chosen from all possible directions that led away from the edge of the bog. This direction represented a linear transect which was walked by the observer until an adult odonate was encountered. Odonates encountered were captured using white 33 cm diameter aerial insect nets with a 1.5 or 0.6 m handle. When possible, odonates were identified in the field and released after adding a small mark to their wing using a waterproof pen to prevent double counting. However, when field identification was not possible, specimens were collected and preserved for later identification. After capture, a new random direction was chosen and this process was continued. When observers encountered the bog edge during transects, a new random direction was chosen that led away from the edge of the bog.

Collected specimens were defatted using a 24-36 hour acetone bath and then air dried for preservation. Odonates were identified using a standard dissecting microscope and a range of taxonomic keys.

Tabanids (horse and deerflies) of the family Tabanidae were sampled by hand netting and with modified Manitoba traps. Manitoba traps are plastic and wooden cones that were baited with a suspended beach ball covered by a garbage bag and Octanol, a tabanid attractant. Female tabanids attracted to the trap tend to fly upwards, funneled by the cone shape of the trap, into the collecting head. A 2 cm^3 cube of Vapona (Scotts Canada Ltd.) was placed in the collecting head to act as an insecticide. Males were captured by aerial net as they are not attracted to traps. A trap was placed in an open area of the bog, approximately 10 m from the tree-line for approximately 3 hours. Typically, sampling occurs for longer trap sessions and for a minimum of three periods during the summer; late May-early June, early-mid July, and early-mid August. The extended trapping time was not done in this study because of the short duration of the survey.

Collected specimens were initially frozen. Individual specimens were prepared and pinned within three weeks and subsequently identified to species with a binomial key. Individuals of the genus *Atylotus* were not identified due to a small number of specimens to examine, and lack of access to reference material.

Vegetation – Woody vegetation and *Sphagnum* moss diversity was surveyed using three 2 X 50-m belt transects. Each transect was established in random directions from the peatland edge in different sub-habitats within each bog (e.g. lag swamp, open bog, shrub bog, treed bog, poor fen). All species of woody vegetation under 2-m and *Sphagnum* mosses that were encountered within the belt transect were recorded and relative abundance scored. Habitat and habit of each recorded *Sphagnum* species was noted (e.g. hummock, hollow, lawn, submerged, etc.).

Other Species – All observations of orchids, reptiles and amphibians were recorded during other activities. Additional time was spent around pools searching for amphibians.

RESULTS AND DISCUSSION

Turtles

Two snapping turtles (*Chelydra serpentine* L.) and twelve painted turtles (*Chrysemys picta* Sch.) were captured in the aquatic live-traps. No turtles were seen during visual surveys.

Two of the four species of freshwater turtle known to exist in Nova Scotia were confirmed to reside in the Lake Rossignol Wilderness Area. Even though no wood or Blanding's turtles were seen or captured, we cannot prove their absence, and more time and effort would be required to be conclusive. The nearest Blanding's turtle population is in Kejimkujik National Park, roughly 9 km northwest of Lake Rossignol Wilderness Area (McMaster and Herman 2000). Wood turtles are better known from northern Nova Scotia and southern Cape Breton Island (Gilhen 1984), although there are some records for Annapolis County in the Atlantic Canada Conservation Data Centre Records.

Snakes

Although surveys were targeted for the eastern ribbon snake (*Thamnophis sauritus*), a threatened species in Nova Scotia under the Nova Scotia Endangered Species Act, three of the other four snake species found in this province were also observed (Table 1). The eastern ribbon snake is a cryptic species making sightings infrequent. There were two observations of eastern ribbon snakes – at Moccasin Lake Brook and Little Rocky Lake. Although these two sightings provide us with little information on the density of eastern ribbon snakes in this area, it does provide us with more information on the distribution of the species.

Eastern garter snakes (*Thamnophis sirtalis*), eastern smooth green snakes (*Opheodrys vernalis*), and redbelly snakes (*Storeria occipitomaculata*) are fairly common throughout their range (Gilhen 1984). During the survey 2 eastern garter snakes, 4 smooth green snakes,

Table 1 Species and number of snakes observed during the 2006 Lake Rossignol Wilderness Area Bioblitz.

Snake Species	Number Observed
Eastern Ribbonsnake (Thamnophis sauritus) L.	2
Eastern Garter Snake (Thamnophis sirtalis) Allen	2
Smooth Green Snake (Opheodrys vernalis) Harlan	4
Redbelly Snake (Storeria occipitomaculata) Storer	1

and 1 redbelly snake were observed. Although our surveys were not targeted for these species, multiple observations suggest that these populations may be healthy.

Fish

From a total of 327 trap-hours (32% at each of Apple Tree and Moccasin Lakes, 36% at Big Rocky Lake) and 80 fyke net-hours (all at Big Rocky Lake), 30 individual fish were captured (Table 2). Within Apple Tree Lake, American eel (*Anguilla rostrata* Lesueur) and yellow perch (*Perca flavescens* Mitchell) were captured. In Moccasin Lake, yellow perch and golden shiner (*Notemigonus crysoleucas* Mitchell) were collected while in Big Rocky Lake, American eel, white perch (*Morone americana* Gmelin) and brown bullhead (*Ameiurus nebulosus* Lesueur) were captured in the fyke nets.

Captured fish, except American eel, were selectively measured (not every individual measured) and displayed mean size (+SD; sample size) of 19.0 cm (+3.6; N=4) for white perch, 7.45 cm (+2.4; N=10)

Table 2 Fish sampling results from three lakes within the Lake Rossignol Wilderness Area between 26 and 28 July, 2006.

Date	Location(s) [1]	Gear type and effort	Species captured	Number captured
26-27 July	Apple Tree Lake	Minnow traps (X3); 37.5 trap-hours	American eel	3
	Big Rocky Lake	Minnow traps (X3); 57 trap-hours	–	0
		Fyke net (X1); 19 hour soak time	White perch	4
			Brown bullhead	1
	Moccasin Lake	Minnow traps (X2); 39 trap-hours	Yellow perch	2
			Golden shiner	2
27 July	Apple Tree Lake	Minnow traps (X2); 24 trap-hours	Yellow perch	3
27-28 July	Apple Tree Lake	Minnow traps (X2); 42 trap-hours	Yellow perch	1
	Big Rocky Lake	Minnow traps (X3); 63 trap-hours	–	0
		Fyke net (X1); 21 hour soak time	White perch	5
			American eel	2
	Moccasin Lake	Minnow traps (X3); 64.5 trap-hours	Yellow perch	7

[1] Geographic coordinates of sampled locations:

Apple Tree Lake	4905500N	336500E
Big Rocky Lake	4903400N	337000E
Moccasin Lake	4903400N	337300E

for yellow perch, and 7.75 cm (+0.35; N=2) for golden shiner. Eels were not measured but length of sampled eels were estimated at ~40 cm. The sole brown bullhead was 13.5 cm (TL).

This survey of the three lakes found only five fish species. Alexander et al. (1986) list 14 fish species found in 58 lakes in Queens County, of which eight species were found in more than 5 of the 58 lakes. In addition to the five species presented here, the other three species listed by those authors were brook charr (*Salvelinus fontinalis*), white sucker (*Catastomus commersoni*), and banded killifish (*Fundulus diaphanous*). Peterson and Martin-Robichaud (1989) attempted to define fish assemblages in lakes of Nova Scotia and the sampled lakes reported here would likely fall within their Assemblage 3 (white sucker, brown bullhead, yellow perch; also containing golden shiner, pumpkinseed sunfish (*Lepomis gibbosus*), and chain pickerel (*Esox niger*)). Alexander et al. (1986) also reported significant positive correlations between presence of yellow perch and each of golden shiner and brown bullhead, and between brown bullhead and each of golden shiner and white sucker. Thus, we suspect that the community of these lakes most closely resembles Assemblage 3 of Peterson and Martin-Robichaud with the sampling missing the presence of the white sucker. Alexander et al. (1986) also showed significant negative correlations for presence between brook charr and each of yellow perch and golden shiner, therefore, their absence in the sample results is expected. Big Rocky Lake, with its presence of white perch, may represent a slightly different fish assemblage, or the capture of this species may simply reflect the different sampling methods (fyke net rather than minnow traps).

Future sampling in this area should include multiple methods (fyke net, beach seine, minnow traps, angling) in each lake and the collection of basic water chemistry data (pH, color, Secchi depth).

Vascular Plants

One hundred species of vascular plants were found (Table 3). Plant species were typical of the various habitats visited and no at-risk species were encountered within the Protected Area. An unusual hybrid was collected in the bog on July 28th : *Platanthera blephariglottis* X *dilitata*. This hybrid was later confirmed by M. Zinck, botanist at the Nova Scotia Museum of Natural History and the specimen is now held in the museum collection. An incidental collection of downey rattlesnake plantain (*Goodyera pubescens*), was made just outside

Table 3 Vascular plants recorded during the Lake Rossignol Wilderness Area bioblitz in 2006. Plant species are recorded by the day they were observed during the bioblitz.

Plant Species Day 1	Plant Species Day 2	Plant Species Day 3
Abies balsamea (L.) Mill.	*Abies balsamea*	*Acer pensylvanicum*
Acer saccharum Marshall	*Acer pensylvanica* L.	*Acer rubrum*
Aralia nudicaulis L.	*Acer rubrum* L.	*Amelanchier sp.* Medicus
Betula papyrifera Marshall	*Betula papyrifera*	*Antennaria neglecta* E. Greene
Clintonia borealis (Aiton) Raf.	*Clintonia borealis*	*Aralia nudicaulis*
Coptis trifolia (L.) Salisb.	*Corallorhiza maculata*	*Aronia sp.* Medicus
Corallorhiza maculata (Raf.) Raf	*Cornus canadensis*	*Betula alleghaniensi* Britton
Cornus canadensis L.	*Cypripedium acaule*	*Betula papyrifera*
Cypripedium acaule Aiton	*Dryopteris marginalis* (L.) A. Gray	*Chamaedaphne calyculata* (L.) Moench
Diphasiastrum tristachyum (Pursh) Holub	*Epigaea repens* L.	*Chimaphila umbellate* (L.) Barton
Epigaea repens L.	*Eriocaulin aquaticum* (Hill) Druce	*Coptis trifolia*
Gaultheria hispidula (L.) Muhlenb. ex Bigelow	*Gaultheria procumbens* L.	*Cornus canadensis*
Gaultheria procumbens L.	*Gaultheria hispidula*	*Diervilla lonicera* Miller
Gaylussacia baccata (Wang.) K.Koch	*Gaylussacia baccata*	*Epigaea repens*
Goodyera tesselata Lodd.		*Eriophorum virginicum* L.
Hamamelis virginiana L.	*Goodyera tesselata*	*Fagus grandifolia* Ehrh
Ilex glabra (L.) Gray	*Hamamelis virginia*	*Fragaria sp.* L.
Iris versicolor L.	*Huperzia lucidula* (Michuax) Trevisan	*Galium mollugo* L.
Kalmia angustifolia L.	*Ilex glabra*	*Gaultheria hispidula*
Linnaea borealis L.	*Kalmia angustifolia*	*Gaultheria procumbens*
Lycopodium annotinum L.	*Ledum groenlandicum* Oeder	*Gaylussacia baccata*
Medeola virginiana L.	*Linnea borealis*	*Goodyera tesselata*
Mitchella repens L.	*Lobelia dortmanna* L.	*Gymnocarpium dryopteris* (L.) Newman
Monotropa hypopythis L.	*Lycopodium clavatum* L.	*Hamamelis virginiana*
Monotropa uniflora L.	*Medeola virginiana*	*Hieracium paniculatum* L.
Myrica pensylvanica Mirbel.	*Mitchella repens*	*Ilex glabra*
Osmunda cinnamomea L.	*Monotropa hypopithys*	*Kalmia angustifolia*
Osmunda regalis L.	*Monotropa uniflora*	*Kalmia polifolia* Wangenh.
Pinus strobes L.	*Nymphea odorata* Aiton	*Lobelia inflate* L.
Platanthera clavellata (Michx.) Luer	*Picea rubens* Sarg.	*Medeola virginiana*
Polypodium virginianum L.	*Pinus resinos* Aiton	*Mitchella repens*
Prenanthes sp. L.	*Pinus strobes* L.	*Monotropa hypopythis*
Pteridium aquilinum (L.) Kuhn	*Polyganum cilinode* Michx.	*Monotropa uniflora*
Pyrola eliptica Nutt.	*Polypodium virginianum* L.	*Myrica gale* L.
Rubus sp. L.	*Pontedaria cordata* L.	*Myrica pensylvanicum*
Spirea alba Duroi	*Populus tremuloides* Michaux	*Nemopanthus mucronata* (L.) trel.

Table 3 *Continued*

Plant Species Day 1	Plant Species Day 2	Plant Species Day 3
Spirea tomentosa L.	*Pteridium aquilinum* (L.) Kuhn.	*Nymphea odorata*
Thelypteris palustris Shott.		*Osmunda cinnamomea*
Toxicodendron sp. L.	*Pyrola elliptica* Nutt.	*Osmunda regalis*
Triadenum virginicum (L.) Raf.	*Quercus rubra* L.	*Oxalis stricta* L.
Trientalis borealis Raf.		*Picea sp.* Dietr.
Trillium undulatum Willd.	*Spirea tomentosa*	*Pinus strobus*
Tsuga Canadensis (L.) Carriere	*Thelypteris noveboracensis* (L.) Nieuwl.	*Plantago major* L.
Viburnum cassinoides L.	*Trientalis borealis*	*Platanthera hookeri* (Willd.) Lindley
	Tsuga Canadensis (L.) Carrière	*Pontedera cordata*
	Vaccinium macrocarpon Aiton	*Populus sp.* L.
	Vaccinium sp. L.	*Prenanthes sp.* L.
	Populus grandidentata Michaux	*Prunella vulgaris* L.
	Acer pensylvanicum	*Pteridium aquilinum*
	Vaccinium angustifolium Aiton	*Pyrola eliptica*
	Achillea millefolium L.	*Quercus rubra*
	Actaea sp. L.	*Ranunculus repens* L.
	Aster accuminatus Michx.	*Rhododendron canadense* (L.) Torr.
	Aster macrophyllus L.	*Rosa sp.* L.
	Dennstaedtia punctolobula (Michaux) T.Moore	*Sagittaria latifolia* Willd.
	Luzula multiflora (Retz.) Lej.	*Sium suave* Walter
	Melampyrum lineare Desr.	*Smilax rotundifolia* L.
	Phegopteris connectilis (Michaux) Watt	*Spirea tomentosa*
	Polystichum acrostichoides (Michaux) Schott	*Toxicodendron radicans* (L.) Kuntz(L.) Kuntse
	Streptopus amplexifolius (L.) DC.	*Trifolium repens* L.
		Vaccinium macrocarpon
		Veronica officinalis L.
		Veronica serpyllifolia L.
		Viburnum cassinoides
		Viola sp. L.

the protected area. This orchid is currently designated red (at-risk or may be at-risk) by Nova Scotia Department of Natural Resources. A subsequent visit to the site of this orchid, revealed it to be present in abundance (about 200 plants).

Fungi

Thirty-four species of fungi were identified (Table 4). Most of the fungi were mycorrhizal and common. One identification is still in question and may not be common. Ten specimens on day one and 15 specimens on day two produced spore prints to help with identification.

Lichens

Sixty-one macrolichen species were recorded (Table 5). The most significant species observed along the brook site was *Anzia colpodes,* which is known from most of eastern North America (Brodo 2001) but has been reported from only eight counties in Nova Scotia (Anderson, in prep.) and is not considered widespread in those areas. Cyanolichens of interest observed included *Coccocarpia palmicola* and *Leptogium corticola*, both designated Yellow or Sensitive species by Nova Scotia Department of Natural Resources (Anderson 2007).

The treed swamp selected for the survey proved less interesting due to immaturity of tree species and soil dryness, however *Fuscopannaria ahlneri* listed as Red or At Risk or May Be At Risk was observed on rock. No specimen was collected at the time due to its rarity.

Bryophytes

Forty-eight species of bryophytes were identified and collected (Table 6). All species were mosses with the exception of four liverworts. All species are relatively common in the province (Ireland 1982) with the exception of *Buxbaumia aphylla* and *Sphagnum torreyanum* which are considered S2 (May be vulnerable to extirpation due to rarity or other factors, 6 to 20 occurrences or few remaining individuals) and *Mnium stellare* and *Sphagnum angustifolium* which are considered S1 (Extremely rare—may be especially vulnerable to extirpation, typically 5 or fewer occurrences or very few remaining individuals) by the Atlantic Canada Conservation Data Centre. Thirty-six species are terricolous, eight species are epiphytic, two species were found on rotted wood, one was found on rock and one species on rock in water.

Table 4 Fungi species identified during the Lake Rossignol Wilderness Area bioblitz 2006. Species are organized by area in which they were found and whether a spore print was produced.

Species Rossignol Wilderness Area	Spore Prints	Species Bowater Abitibi Conservation Easement, Lake Rossignol	Spore Prints
Amanita brunnescens G.F.Atk.	No	*Austroboletus gracilis* (Peck) Wolfe	Yes
Amanita ceciliae (Beck&Broome) Bas	Yes	*Boletus cf minato-olivaceus* Frost	No
Amanita frostiana Peck	Yes	*Cantharellus ignicolor* R.H.Petersen	No
Boletus subglabripes Peck	Yes	*Craterellus fallax* A.H.Sm.	No
Hygrocybe irrigata (Pers.) Bon	No	*Hygrocybe irrigata* (Pers.) Bon	No
Hygrocybe miniata (Fr.) P. Kumm.	No	*Leotia lubrica* (Scop.) Pers.	No
Hygrophorus marginatus var. concolor A.H. Sm.	No	*Lactarius uvidus* (Fr.) Fr.	No
Hygrophorous marginatus var marginatus Peck	No	*Ramaria stricta* (Pers.) Quel.	No
Lactarius camphoratus (Bull.)Fr.	No	*Nolanea strictia* (Peck) Largent	Yes
Lactarius cinereus Peck	No	*Pluteus salicinus* (Pers.) P. Kumm.	
Lactarius subvellereus Peck	Yes	*Hydnellum caeruleum* (Hornem.) P.Karst.	No
Pluteus salicinus (Pers.) P.Kumm.	Yes	*Russula claroflava* Grove	No
Russula silvicola Shaffer	Yes	*Russula brunneola* Burl.	No
Russula variata Banning	Yes	*Russula fragilis* Fr.	No
Strobilomyces strobilaceus (Scop.) Berk.	Yes	*Russula heterophylla* (Fr.) Fr.	Yes
Suillus pictus (Peck) A.H.Sm.&Thiers	No	*Russula variata* Banning	Yes
Tylopilus felleus (Bull.) P. Karst	No	Suillus americanus (Peck) Snell	No
Xanthoconium affine (Peck) Singer	No	*Tapinella atrotomentosa* (Batsch) Sutara	Yes
		Tylopilus chromapes (Frost) A.H. Sm. And Thiers	No
		Xanthoconium affine (Peck) Singer	Yes

Dendrochronology

Thirty-eight of the 42 cores collected during the Bio-Blitz project illustrated a radial growth pattern and were averaged into a master chronology for the site. The chronology illustrates a similar growth trend to other eastern hemlock found in the region (Robichaud and Laroque 2008, Campbell and Laroque 2007) and spans the time frame from 1661 to 2006, a 346 year interval.

In general, during the last ~100 years, radial growth changed from a low at the end of the 19th century, to its best growth during the 1930s and 1940s. From that period until the mid-1970s radial growth was reduced, but it has since taken a marked upturn and is again exhibiting some wide radial growth in the last 30 years, coinciding with recent warming trends in the climate.

Table 5 **Lichen species identified during the Lake Rossignol Wilderness Area bioblitz 2006 with substrate on which they were found. Position is Universal Trans Mercator Zone 20 T.**

Species	Position	Substrate	Habitat
Anaptychia palmulata (Michx.)Vain.	20 T 336701 4903825	White Ash	inlet to Big Rocky Lake
Anaptychia palmulata (Michx.)Vain.	20 T 336394 4904440	Red Maple	
Anaptychia palmulata (Michx.)Vain.	20 T 336016 4905052	Red Maple	
Anaptychia palmulata (Michx.)Vain.	20 T 336015 4905359	Red Maple	
Anaptychia palmulata (Michx.)Vain.	20 T 336183 4904871	Red Maple	
Anzia colpodes (Ach.) Stizenb.	20 T 335905 4904016	Red Maple	
Anzia colpodes (Ach.) Stizenb.	20 T 336374 4904415	Red Maple	
Anzia colpodes (Ach.) Stizenb.	20 T 336506 4904197	Red Maple	
Anzia colpodes (Ach.) Stizenb.	20 T 336473 4904231	Red Maple	
Anzia colpodes (Ach.) Stizenb.	20 T 336461 4904291	Red Maple	
Anzia colpodes (Ach.) Stizenb.	20 T 336212 4904841	White Ash	
Arctoparmelia incurva (Pers.)Hale	20 T 336150 4904331	rock	
Cetrelia chicitae (W.L.Culb.)W.L.Culb & C.F.Culb.	20 T 336701 4903825	rock	inlet to Big Rocky Lake
Coccoarpia palmicola (Sprengel) Arv. & D. J. Galloway	20 T 336405 4904363	Red Maple	
Coccoarpia palmicola (Sprengel) Arv. & D. J. Galloway	20 T 336415 4904310	Red Maple	
Coccoarpia palmicola (Sprengel) Arv. & D. J. Galloway	20 T 336418 4904327	Red Maple	
Coccoarpia palmicola (Sprengel) Arv. & D. J. Galloway	20 T 336381 4904337	Red Maple	
Coccoarpia palmicola (Sprengel) Arv. & D. J. Galloway	20 T 336352 4904482	Red Maple	
Coccoarpia palmicola (Sprengel) Arv. & D. J. Galloway	20 T 336472 4904196	Red Maple	
Collema nigrescens (Hudson) DC.	20 T 336495 4904151	Red Maple	
Collema subflaccidum Degel.	20 T 336093 4904317	Red Maple	at edge of treed swamp, RM, WA, Yellow Birch
Collema subflaccidum Degel.	20 T 336192 4904519	White Ash	
Collema subflaccidum Degel.	20 T 336092 4904351	White Ash	
Collema subflaccidum Degel.	20 T 336425 4904382	Red Maple	
Collema subflaccidum Degel.	20 T 336205 4904860	Red Maple	
Dendriscocaulon intriculatum (Nyl.) Henssen	20 T 336095 4904326	White Ash	

Table 5 *Continued*

Species	Position	Substrate	Habitat
Dendriscocaulon intriculatum (Nyl.) Henssen	20 T 336093 4904317	Red Maple	at edge of treed swamp, RM, WA, Yellow Birch
Heterodermia neglecta Lendemer, R. C. Harris & E. Tripp (Lendemer et al. 2007)	20 T 336374 4904415	Red Maple	
Heterodermia neglecta Lendemer, R. C. Harris & E. Tripp (Lendemer et al. 2007)	20 T 336592 4904091	Red Maple	
Hypogymnia incurvoides Rass. (McCune et al. 2006)	20 T 336588 4904093	Red Spruce	
Hypogymnia physodes (L.) Nyl.	20 T 336449 4904284	White Pine	
Imshaugia aleurites (Ach.) S. F. Meyer	20 T 336422 4904248	Red Maple	
Leptogium corticola (Taylor) Tuck.	20 T 336689 4903918	Red Maple	
Leptogium corticola (Taylor) Tuck.	20 T 336487 4904246	Red Maple	
Leptogium corticola (Taylor) Tuck.	20 T 336327 4904470	Red Maple	
Leptogium corticola (Taylor) Tuck.	20 T 336201 4904864	Red Maple	
Leptogium cyanescens (Rabenh.) Körber	20 T 336182 4904532	White Ash	
Leptogium laceroides (B. de Lesd.) P. M. Jørg.	20 T 336093 4904317	Red Maple	at edge of treed swamp, RM, WA, Yellow Birch
Leptogium laceroides (B. de Lesd.) P. M. Jørg.	20 T 336473 4904231	Red Maple	
Leptogium laceroides (B. de Lesd.) P. M. Jørg.	20 T 336461 4904291	Red Maple	
Leptogium laceroides (B. de Lesd.) P. M. Jørg.	20 T 336182 4904532	White Ash	
Lobaria pulmonaria (Mull) Ag.	20 T 336636 4904042	Red Maple	
Lobaria pulmonaria (Mull) Ag.	20 T 336461 4904291	Red Maple	
Lobaria pulmonaria (Mull) Ag.	20 T 336182 4904532	White Ash	
Lobaria pulmonaria (Mull) Ag.	20 T 336240 4904711	Red Maple	
Lobaria pulmonaria (Mull) Ag.	20 T 336235 4904726	Red Maple	
Lobaria pulmonaria (Mull) Ag.	20 T 336473 4904231	Red Maple	
Lobaria pulmonaria (Mull) Ag.	20 T 336096 4904358	White Ash	
Lobaria quercizans Michaux	20 T 336636 4904042	Red Maple	
Lobaria quercizans Michaux	20 T 336182 4904532	White Ash	
Lobaria scobiculata (Scop.) DC.	20 T 336701 4903825		inlet to Big Rocky Lake

Table 5 *Continued*

Species	Position	Substrate	Habitat
Lobaria scobiculata (Scop.) DC.	20 T 336636 4904042	Red Maple	
Lobaria scobiculata (Scop.) DC.	20 T 336436 4904273	Red Maple	
Lobaria scobiculata (Scop.) DC.	20 T 336415 4904310	Red Maple	
Lobaria scobiculata (Scop.) DC.	20 T 336275 4904537	Red Maple	
Lobaria scobiculata (Scop.) DC.	20 T 336235 4904726	Red Maple	
Lobaria scobiculata (Scop.) DC.	20 T 336240 4904711	Red Maple	
Menengazia terebrata (Hoffm.) A. Massal.	20 T 336705 4903898	Yellow Birch	
Nephroma helveticum Ach.	20 T 336701 4903825	rock	inlet to Big Rocky Lake
Nephroma helveticum Ach.	20 T 336031 4904341	Red Maple	
Nephroma lavaiegatum Ach.	20 T 336689 4903918	Red Maple	
Nephroma sp	20 T 336015 4905359	Red Maple	
Nephroma sp	20 T 336615 4904042	Red Maple	
Normandina pulchera (Borrer) Nyl.	20 T 336352 4904482	Red Maple	
Fuscopannaria ahlneri (P. M. Jørg.) P. M. Jørg.	20 T 337130 4900894	rock	
Pannaria conoplea (Ach.) Bory	20 T 336096 4904358		
Pannaria conoplea (Ach.) Bory	20 T 336592 4904091	Red Maple	
Pannaria conoplea (Ach.) Bory	20 T 336461 4904291	Red Maple	
Pannaria conoplea (Ach.) Bory	20 T 336490 4904357	Red Maple	
Pannaria conoplea (Ach.) Bory	20 T 336394 4904440	Red Maple	
Pannaria conoplea (Ach.) Bory	20 T 336352 4904482	Red Maple	
Pannaria conoplea (Ach.) Bory	20 T 336235 4904726	Red Maple	
Pannaria conoplea (Ach.) Bory	20 T 336130 4904905		
Pannaria conoplea (Ach.) Bory	20 T 336477 4904227	Red Maple	
Pannaria rubiginosa (Ach.) Bory	20 T 336592 4904091	White Ash	
Parmelia squarrosa Hale	20 T 336449 4904284	White Pine	
Parmeliella tryptophylla (Ach.) Müll. Arg.	20 T 336304 4904576	Red Maple	
Parmeliella tryptophylla (Ach.) Müll. Arg.	20 T 336182 4904532	White Ash	

Table 5 *Continued*

Species	Position	Substrate	Habitat
Parmeliella tryptophylla (Ach.) Müll. Arg.	20 T 336638 4903942	Red Maple	
Parmeliella tryptophylla (Ach.) Müll. Arg.	20 T 336636 4904042	Red Maple	
Parmotrema crinitum (Ach.) M. Choisy	20 T 336031 4904341	Red Maple	
Parmotrema crinitum (Ach.) M. Choisy	20 T 336705 4903898	Yellow Birch	
Peltigera aphthosa (Ach.) M. Choisy	20 T 336592 4904091	White Ash	
Peltigera evansiana Gyelnik	20 T 336506 4904197	Red Maple	
Platismatia glauca (L.) W. L. Culb.. & C. F. Culb.	20 T 336449 4904284	White Pine	
Protopannaria pezizoides (Weber) P. M. Jørg. & S. Ekman (Jørgensen 2000c)	20 T 336095 4904326	White Ash	
Protopannaria pezizoides (Weber) P. M. Jørg. & S. Ekman (Jørgensen 2000c)	20 T 336472 4904196	Red Maple	
Pseudocyphellaria perpetua McCune & Miadl. (Miadlikowska et al. 2002)	20 T 336636 4904042	Red Maple	
Pseudocyphellaria perpetua McCune & Miadl. (Miadlikowska et al. 2002)	20 T 336436 4904273	Red Maple	
Pseudocyphellaria perpetua McCune & Miadl. (Miadlikowska et al. 2002)	20 T 336461 4904291	Red Maple	
Pseudocyphellaria perpetua McCune & Miadl. (Miadlikowska et al. 2002)	20 T 336415 4904310	Red Maple	
Pseudocyphellaria perpetua McCune & Miadl. (Miadlikowska et al. 2002)	20 T 336192 4904519	White Ash	
Pseudocyphellaria perpetua McCune & Miadl. (Miadlikowska et al. 2002)	20 T 336235 4904726	Red Maple	
Pyxine soridiata (Ach.) Mont.	20 T 336487 4904246	Red Maple	
Ramalina roesleri (Hochst. ex Schaerer) Hue	20 T 336031 4904341	Red Maple	
Tuckermanopsis orbata (Nyl.) M. J. Lai	20 T 336449 4904284	White Pine	
Usnea strigosus (Ach.) Eaton	20 T 336449 4904284	White Pine	

Table 6 Bryophytes identified during the Lake Rossignol Wilderness Area bioblitz, 2006.

Species
Anomodon rostratus (Hedw.) Schimp.
Atrichum alteroristatum
Bazzania trilobata
Bryum argentums
Buxbaumia aphylla Hedw.
Ceptialozia lunulifolia
Dicranum flagellare Hedw.
Dicranum fuscescens Turn.
Dicranum polysetum Sw.
Dicranum scroparium Hedw.
Dicranum viride (Sull. & Lesq. *ex* Sull) Lindb.
Diphyscium folusom
Fontinalis novae-angliae
Hylocomium splendens (Hedw.) B.S.G.
Leocobryum glaucoma (Hedw.) Ångstr. *ex* Fries
Leucodon brachypus var. *andrewsianus* Crum & Anderson
Metzgeria conjugate
Mnium hornum Hedw.
Mnium stellare
Neckera pennata Hedw.
Pallavicinia lyellis
Pleurozium schreberi (Brid.) Mitt.
Pohlia nutans (Hedw.) Lindb.
Polytrichum commune
Polytrichum juniperinum
Polytrichum strictum Brid.
Porella platyphylloidea
Ptilium cilare
Ptilium crista-castrensis (Hedw.) De Not.
Rhacomitrium aciculare
Rhizomnium appalachiam
Rhizomnium punctatum
Rhytidiadelphus triquetrus (Hedw.) Warnst.
Sphagnum angustifolium
Sphagnum capifolium
Sphagnum cuspidatum Ehrh. *ex* Hoffm.
Sphagnum fuscum
Sphagnum girgensohnii Russ.
Sphagnum magellanicum Brid
Sphagnum russowii
Sphagnum squarrosum Crome
Sphagnum torreyanum
Thuidium delicatulum (Hedw.) B.S.G.
Tortella tortuosa (Hedw.) Limpr.
Ulota crispa (Hedw.) Brid.
Ulota coarctata
Ulota hutchinsiae

Table 7 Species documented in a treed peatland near Little Rocky Lake, Lake Rossignol Wilderness Area, Nova Scotia. Note: Coastal Plain species are noted with an asterisk (*).

Taxon	Species Observed in Bog
Odonates	Variable Darner *(Argia fumipennis* **Burmeister***)*
	Calico Pennant *(Celithemis elisa* Hagen*)*
	Petite Emerald *(Dorocordulia lepida* Hagen*)*
	Hagen's Bluet *(Enallagma hageni* Walsh*)*
	Orange Bluet *(Enallagma signatum* Hagen*)*
	Eastern Forktail *(Ischnura verticalis* Say*)*
	Sphagnum Sprite *(Nehalennia gracilis* Morse*)*
	Cherry-faced / Ruby Meadowhawk *(Sympetrum internum/ rubicundulum* Montg.*)*
	Band-winged Meadowhawk *(Sympetrum semicinctum* Say*)*
Tabanid Flies	*Chrysops delicatulus* Osten Sacken
	Chrysops vittatus Weideman
	Hybomitra microcephala Osten Sacken
	Hybomitra pechumani Teskey and Thomas
Sphagnum Mosses	*Sphagnum angermanicum* Melin
	Sphagnum angustifolium (Russ) J. Jens
	Sphagnum austinii
	Sphagnum capillifolium
	Sphagnum cuspidatum
	Sphagnum fallax Klinggr.
	Sphagnum flavicomans (Card.) Warnst.
	Sphagnum flexuosum Dozy & Molk.
	Sphagnum fuscum
	Sphagnum girgensohnii
	Sphagnum magellanicum
	Sphagnum majus (Russ) J. Jens
	Sphagnum quinquefarium (Lindb. *ex* Braithw.) Warnst.
	Sphagnum warnstorfii Russ.
Woody Vegetation (in Peatland)	Larch (*Larix laricina* (DuRoi) K.Koch)
	Black Spruce (*Picea mariana* (Mill.) BSP.)
	White pine (*Pinus strobus*)
	Red Maple (*Acer rubrum*)
	Red Chokeberry (*Aronia arbutifolia* (L.) Ell.)*
	Black Chokeberry (*Aronia melanocarpa* (Michx.) Ell.)
	Huckleberry (*Gaylussacia baccata*)
	False Holly (*Nemopanthus mucronata*)
	Lambkill (*Kalmia angustifolia*)
	Bog Laurel (*Kalmia polifolia*)
	Blueberry (*Vaccinium angustifolium*)
	Wild Raison (*Viburnum cassinoides*)
	Labrador Tea (*Ledum groenlandicum*)
	Sweet gale (*Myrica gale*)
	Rhodora (*Rhododendron canadense*)
	Common Juniper (*Juniperus communis* L.)
	Leatherleaf (*Chamaedaphne calyculata*)
	Large Cranberry (*Vaccinium macrocarpon*)
	Small Cranberry (*Vaccinium oxycoccos* L.)
	Serviceberry (*Amelanchier sp.*)

Table 7 *Continued*

Taxon	Species Observed in Bog
	Tea berry (*Gaultheria procumbens*)
	Black Crowberry (*Empetrum nigrum* L.)
Woody Vegetation (from Lagg)	Speckled Alder (*Alnus incana* (L.) Moench)
	Inkberry* (*Ilex glabra*)
	Bayberry* (*Myrica pensylvanica*)
	Steeplebush (*Spirea tomentosa*)
	Poison Ivy* (*Toxicodendron radicans*)
Other Species	Orchid hybrid (*Platanthera blephariglottis X P. dilatata* (Wild.) Lindl.)
	Rose Pogonia (*Pogonia ophioglossoides* (L.) Ker-Gawler)
	White-fringed Orchid* (*Platanthera blephariglottis* (Wild.) Lindl.)
	Pink Lady Slipper (*Cypripedium acaule*)
	Round-leafed Sundew (*Drosera rotundifolia* L.)
	Pitcher Plant (*Sarracenia purpurea* L.)
	Bog Goldenrod (*Solidago uliginosa* Nutt.)*
	Marsh St Johns-wort* (*Triadenum virginicum* (L.) Raf.)

The data collected at the Bio-Blitz site contributes to understanding the protected area. Trees at the site have been growing in place for at least the last 350 years.

Peatland

The peatland had vegetation suggestive of a fen such as sedges and grasses. However, it also contained several plant species that are more typical of poor-nutrient ombrotrophic bogs, including black crowberry (*Empetrum nigrum*) and lambkill (*Kalmia angustifolia*) (Crum 1992).

Plant species richness of the Lake Rossignol Wilderness Area was high compared to other peatlands in the region (D. Hurlburt, unpublished data) (Table 7). Fourteen *Sphagnum* species (44 % of Nova Scotia total) and 22 woody vegetation species (14 % of Nova Scotia total) were observed. However, tabanid and odonate diversities were lower than expected with only nine species of odonates and four species of tabanid flies recorded. It is suspected that the overcast, wet and cool weather on the sampling day was not amenable to insect emergence and flight.

Seven of thirty-five species of vascular plants found are of a Coastal Plain Distribution. All of these species are both locally and globally secure (Zinck 1998).

CONCLUSION

The scientific usefulness of the bioblitz was clearly demonstrated. A total of 294 species were identified during the survey, 285 of which are new records for the Wilderness Area. The identification of sites of five species-at-risk will enable protected areas managers to tailor management plans to ensure their conservation. These findings also highlight the importance of protected areas to species-at-risk conservation. The data from this study can also provide a base from which to build a more complete inventory of the Wilderness Area. Another area where bioblitzes can be useful is the identification of invasive species which require monitoring or control (Meshaka et al. 2008, Karns et al. 2006). Although this study did not result in the identification of invasive species in the Wilderness Area, more intensive surveys may be needed. This bioblitz brought together scientists from a variety of disciplines that might not normally interact and may result in further collaborations among disciplines and agencies.

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THE USE OF *ALOE* CONSTITUENTS IN SELF-ADMINISTERED CANCER TREATMENT

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ABSTRACT

Complementary and alternative medicines (CAMs) include many different biologic substances that may be ingested or applied topically in an effort to mitigate disease. One source of such substances is the *Aloe*, a plant that has been used since antiquity to treat a multitude of conditions, and which is now being touted as a potential natural aid in the fight against cancer. There are many different classes of nutrient and modulatory chemicals isolated from *Aloe*, and some have now been investigated for their anticancer activities. This review will focus on the anticancer properties of four main *Aloe* components – aloe-emodin, aloin, acemannan and β-sitosterol – in relation to their activities against cells in human cancers and potential abilities to interfere with conventional chemotherapeutics. We build upon this background to consider the validity for *Aloe* in cancer care. It is evident, after considering both *in vitro* and *in vivo* findings, that there needs to be further independent studies examining the safety and efficacy of ingestion of *Aloe* products for human use, proper standardization of product content, and systematic identification and characterization of the wide variety of *Aloe* constituents.

Aloe is a genus of perennial succulent plants that thrive in hot, dry climates (Choi et al., 2002; Molassiotis et al., 2005). As with many plants, its cosmetic and health-related potentials have been explored since antiquity, and it finds current use in a multitude of cosmetic, dermatologic and other healthcare products (Reynolds and Dweck, 1999; Ulbricht et al., 2007). However, more recently it has fallen into that group of biologics that have found favour in the popular view as a natural remedy for chronic diseases such as cancer. In this review we explore the emerging issue of 'natural medicines', the anticancer activities reported for *Aloe* itself, and provide a perspective on whether *Aloe* has a place in rational support of the cancer patient.

Keywords: Natural products, alternative medicine, aloe, aloe-emodin, aloin, acemannan, cancer.

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COMPLEMENTARY AND ALTERNATIVE MEDICINE

The group of agents and practices that falls outside of conventional western medicine is usually referred to as complementary and alternative medicine (CAM). There is varied opinion as to what practices and ideas fall under this broad term (Tascilar et al., 2006). According to the National Center for Complementary and Alternative Medicine (NCCAM), a division of the National Institutes of Health in the United States, CAM is "a group of diverse medical and health care systems, practices and products that are not generally considered part of conventional medicine" (NCCAM, 2011). NCCAM refers to conventional medicine as that which is practiced by individuals with either medical doctor or doctor of osteopathy degrees, along other health care professionals such as nurses, physiotherapists and psychologists (NCCAM, 2011).

The Canadian Cancer Society (CCS) makes a clear distinction between the 'complementary' and 'alternative' components of CAM (CCS, 2010). It defines complementary medicine similarly to NCCAM as "any practice, therapy or product that is not considered conventional medicine for cancer care" (CCS, 2010). Although many Canadian medical schools offer some training in complementary medicine practices, these practices are not conventionally used to treat cancer. Nevertheless, complementary medicine practices may be combined with standard patient care treatments to help alleviate side effects caused by cancer treatment (CCS, 2010). However, alternative medicine by this definition is used instead of conventional, standard patient care treatments (CCS, 2010). CCS emphasizes the fact that alternative therapies are often based on observations lacking any scientific base (CCS, 2010). Regardless, most definitions of CAM refer to the same general principle of practicing wellness while being treated for a disease, and not necessarily adopting practices employed by conventional medicine.

The varied definitions assigned to CAM make interpretation of surveys on the use of these therapies difficult (Tascilar et al., 2006). Nevertheless, many statistics have been published as to the prevalence of CAM in society worldwide. In a key systematic literature review of this topic, Harris and Rees reported that only three of the 12 studies they surveyed produced reliable prevalence data (Harris and Rees, 2000). In a population survey, MacLennan and colleagues determined that nearly 50% of all South Australian residents used at least one non-medically prescribed CAM, whereas approximately 20% had sought help from a naturopath or other CAM practitioner (MacLennan et al., 1996). This substantial prevalence of CAM is seen amongst all developed nations and has been increasing since the latter part of the 20th century. Between 1990 and 1997, the number of Americans that used CAM increased from 32 to 42%. Over the same period, patient inquiries about CAM to both medical doctors and CAM practitioners increased from 8 to 14% (Eisenberg et al., 1998; Eisenberg et al., 1993). Currently, almost 4 out of 10 adults say they have used CAM in the past 12 months (Barnes et al., 2008). This activity involves substantial expenditure that is also rising. Over the period 1997-2007, money spent on CAM-related therapies in the United States increased from just over $21 billion to nearly $34 billion (Eisenberg et al., 1998; Nahin et al., 2009). Because Canadian statistics commonly mirror those of the United States, it is evident that many individuals seek benefit from CAM-related therapies (McFarland et al., 2002).

Cancer patients are no less likely to use CAM. In a worldwide systematic review of 26 studies in 1998, approximately 31% of adult cancer patients were found to have used CAM therapies at some point after being diagnosed (Ernst and Cassileth, 1998). This may be an underestimate for the more developed nations. The data are very variable depending upon geographical location, but more recent data from North America suggest that between 25 and 84% of cancer patients in the United States have used some sort of CAM therapy after their diagnosis (Tascilar et al., 2006).

Arguably, the potential impact of ingested natural materials may be greater for cancers of the gastrointestinal tract. Tough and colleagues studied CAM use among colorectal cancer patients in Alberta (Tough et al., 2002). The overall prevalence was 49% and the form of CAM use included psychological and spiritual therapies (65%), vitamins and minerals (46%) and herbal supplements (42%) (Tough et al., 2002). Thus, although noninvasive practices (e.g., psychosocial and spiritual therapies) are most frequently associated with CAM, ingestion or topical application of biological substances accounts for a large portion of CAM use. The use of biological products in cancer has also risen significantly since the early 1990s (Cassileth and Deng, 2004; Cauffield, 2000; Molassiotis et al., 2005). Because each of these substances has the potential to interact with conventional chemotherapeutic agents, it is important to analyze the consequences of using CAM-related biological substances while receiving chemotherapy.

ALOE: ITS HISTORY AND USE IN MEDICINE

Aloe is a genus of perennial succulent plants that thrive in hot, dry climates (Choi and Chung, 2003; Molassiotis et al., 2005). Although there are nearly 400 species within the *Aloe* genus, only *A. barrbadensis* (also known as *A. vera*) and *A. aborescens* are used in therapeutic preparations (Moghaddasi and Verma, 2011).

Aloe grows in temperate or tropical areas throughout the world (Moghaddasi and Verma, 2011). It is a common and popular ornamental plant that can survive indoors or in gardens with scarce water supply. Large, agricultural-scale crops of *Aloe* are usually restricted to favored geographic areas such as Mexico, Africa, India, Australia and some parts of the United States (Florida, along with southern areas of Texas and California) (Moghaddasi and Verma, 2011).

Originally described in the Ebers Papyrus, an ancient Egyptian book of remedies, *Aloe* was used in antiquity for treating skin infections and constipation (Ulbricht et al., 2007). In 74 AD, the Greek physician Dioscorides documented *Aloe* as being useful for treating wounds, hair loss, genital ulcers and hemorrhoids (Ulbricht et al., 2007). Several hundred years later on, Arab traders brought *Aloe* to Asia, and the Spanish introduced it to the Americas in the 16th Century (Ulbricht et al., 2007). The popularity of *Aloe* rose dramatically in the 1930s as it became used as topical treatment for various forms of dermatitis (Reynolds and Dweck, 1999; Ulbricht et al., 2007). Since the 1930s, *Aloe* has been incorporated in a multitude of cosmetic, dermatologic and other healthcare products (Reynolds and Dweck, 1999; Ulbricht et al., 2007). However, it is also sold on its own as a therapeutic product, largely due to its roots in traditional medicine.

Following its established record of its use in folk medicine, *Aloe* is used for a variety of (sometimes contradictory) purposes. Based upon its use in traditional Chinese, Indian (Ayurvedic) and Arab medicine, *Aloe* is often used to treat constipation (Ulbricht et al., 2007). However, Ayurvedic medicine also indicates that *Aloe* can be used to regulate menstruation, treat hemorrhoids, rid the body of parasitic worms, and when combined with licorice root, *Aloe* can be effective against eczema and psoriasis (Ulbricht et al., 2007). Traditional Arab medicine, meanwhile, claims *Aloe* to be effective in the treatment of headaches, fevers, wounds and various forms of infection (Ulbricht et al., 2007). *Aloe* is a truly versatile plant, if history is our guide.

THE DIFFERENT COMPONENTS OF *ALOE*

As evident in Fig. 1, *Aloe* is a succulent plant with long, fleshy leaves. Parenchymal gel from the center of each leaf can be dried (resulting in *Aloe* concentrate) or can be diluted with water to make juice products. A sticky, latex-like liquid may also be extracted from the tubules that line each leaf (Moghaddasi and Verma, 2011). Until 2002, when the United States FDA deemed it to be a class III substance such that a prescription or license is needed for legal possession, aloin (responsible for *Aloe*'s laxative effects, due to aloin's anthraquinone moiety (Patel et al., 1989)) was used in many over-the-counter laxatives. Today, manufacturers commonly remove aloin from *Aloe* preparations due to its potential side effects and insufficient safety data (NCCAM, 2011; Ulbricht et al., 2007).

Fig 1 An *Aloe vera* plant. Note the long, fleshy leaves and the pendulous flowers on a central spike. Modified from (Bianchi, 1997).

Given the consumer demand and commercial potential for *Aloe* products, researchers have begun to investigate the biological activity of *Aloe* leaf components. In part, such investigations seek to validate the claims made by CAM practitioners and the companies producing *Aloe* products, that *Aloe* is effective against a variety of diseases. Even a simple online search with "*Aloe* products" as the keyphrase will identify a variety of websites selling *Aloe* products for both internal and external use. In this review, our interest focuses on the potential use against cancer. Therefore, we will focus on the particular components of the plant that have been investigated for their anticancer activities.

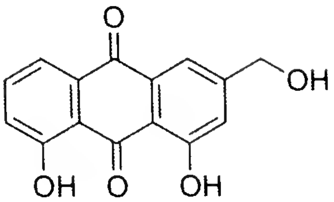
Aloe contains many different classes of nutrient and modulatory chemicals (Table 1). Attention has particularly focused on the anthraquinones, a class of agents renowned for their various bioactivities (Choi and Chung, 2003). In cancer research, the most widely studied pharmacologically active anthraquinones are aloe-emodin and aloin (Choi and Chung, 2003; Manitto et al., 1990; Reynolds and Dweck, 1999). Both of these compounds can be isolated from the latex leaf lining of *Aloe* plants (Moghaddasi and Verma, 2011). Aloin and aloe-emodin are structurally related (Fig. 2 A, B). Whereas aloe-emodin's structure has two carbonyl (C=O) groups, the replacement of one carbonyl group with a glucose residue leads to the structure of aloin. Aside from the anthraquinones, some anticancer studies have investigated the saccharide components of the *Aloe* plant. These have primarily focused upon acemannan, a hydrophilic sugar polymer (Fig. 2 C). Acemannan is a polymer of 3-O-acetyl-β -D-mannopyranose (acetyl-mannose) units linked by β -1→4 glycosidic bonds. Amongst

Table 1 Major families of biologically-active chemicals in *Aloe*.

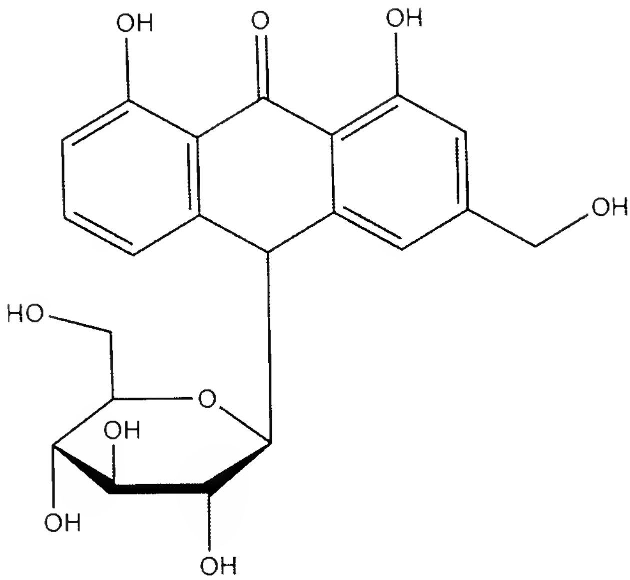
Chemical family	Examples
Anthraquinones	Aloe-emodin, aloin, aloetic acid
Carbohydrates	Acemannan, galactan, xylan
Chromones	Neoalosin A, isoabaichrome, 8-C-glucosyl-noreugenin
Enzymes	Amylase, catalase, superoxide dismutase
Ions	Calcium, iron, potassium
Organic compounds	Lignins, salicyclic acid, potassium sorbate
Proteins	Lectin, lectin-like substance
Saccharides	Acemannan, mannose, glucose, aldopentose
Vitamins	Folic acid, vitamins A, B12, C and E
Hormones	Auxins, gibberellins, β-sitosterol

Modified from (Moghaddasi and Verma, 2011).

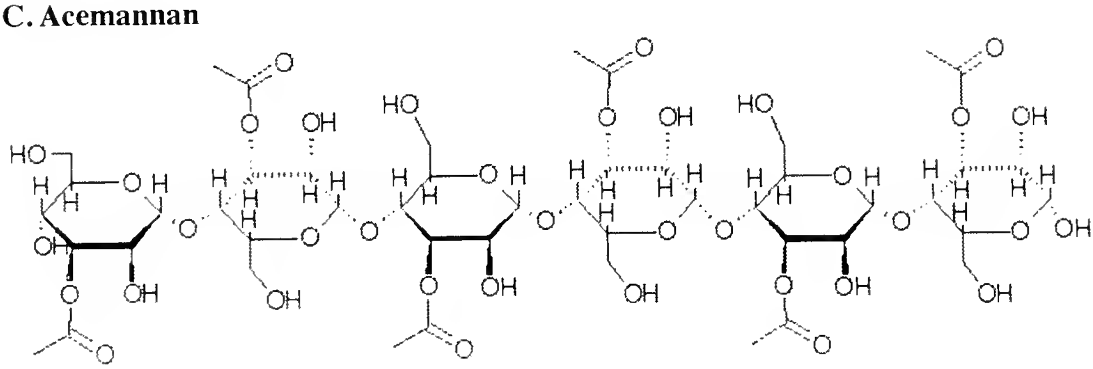
A. Aloe-emodin



B. Aloin



C. Acemannan



D. -sitosterol

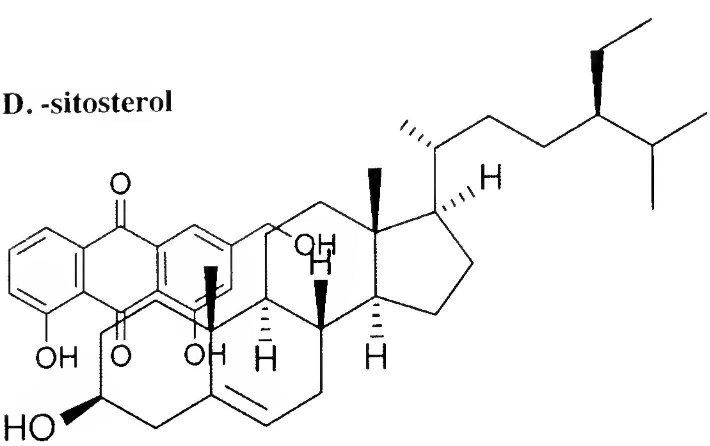


Fig 2 Chemical structures of the key bioactives in Aloe vera.

the low-molecular-weight substances that have been identified within *Aloe* is β-sitosterol, one of several phytosterols (plant sterols) that has a structure very similar to that of cholesterol (Fig. 2 D). This review will focus upon the reported anti-cancer activities of these four principal components: *Aloe*-emodin, aloin, acemannan and β-sitosterol. Many different potential cellular effects have been noted in an array of experimental systems; some of the more significant recent findings are summarised in Table 2. There is a great diversity in terms of available information (e.g. the cellular sources studied and the assays used) and considerable disparity in the amount of data for different *Aloe* constituents (e.g. there are 18 different studies on aloe-emodin, and just a single relevant study for acemannan). There is also substantial variability in the sources of the materials tested, the degrees of purity and the active concentrations tested. It is therefore important to understand the full picture of activities that have been identified (Table 2).

POTENTIAL ACTIVITIES OF *ALOE* COMPONENTS IN CANCER

1. Activities of Aloe-emodin

Aloe-emodin has been heralded as a novel potential chemotherapeutic drug due to its ability to modulate the cell cycle and cell proliferation, effects that are mediated by the action of aloe-emodin on protein kinases C (PKC) a family of 10 signaling enzymes that are important in the release of hormones, cell division and tumor growth (Acevedo-Duncan et al., 2004; Blobe et al., 1994). Human glioma cells exposed to aloe-emodin were unable to progress through the DNA synthesis phase (S phase) of the cell cycle and cell proliferation was inhibited (Acevedo-Duncan et al., 2004). The activity of all PKC isozymes except PKC- ι (the isozyme related to protection of a cell against apoptosis) decreased upon exposure of the cells to aloe-emodin. Aloe-emodin concurrently increased the tendency of cells to enter apoptosis (a form of programmed cell death) by modulating the balance of peptidases that promote apoptosis (e.g., caspase-7) and the apoptosis inhibitor survivin (Acevedo-Duncan et al., 2004).

Investigations in cells from a variety of neoplasias show a consistent action of aloe-emodin in inhibiting cell proliferation and enhancing apoptosis through pathways involving PKC. In human lung squamous

Table 2 Potential anti-cancer activities of the key biologically-active compounds in *Aloe vera*.

Compound	Type of cancer	Experimental Model*	Potential Anticancer Action(s)
Aloe-emodin	Oral cavity	KB cell line	G2/M cell cycle arrest; enhanced alkaline phosphatase (ALP) activity (Xiao et al., 2007).
	Tongue	SCC4 cell line	Enhanced apoptosis and S-phase cell cycle arrest (involvement of mitochondrial death pathways, caspase cascades and the Fas/death-receptor) (Chiu et al., 2009).
		SCC4 cell line	Decreased cell migration and invasion (suppression of MMP-9 gene expression; decreased protein levels and activity of MMP-2, but no change in MMP-2 gene expression) (Chen et al., 2010a).
		SCC4 cell line	Increased DNA damage and decreased DNA repair (inhibition of DNA repair genes - MGMT, ATM, ATR, BRCA1, 14-3-3sigma, DNA-PK) (Chen et al., 2010b).
	Pharynx	NPC-TW039 and NPC-TW076 nasopharyngeal carcinoma cell lines	Increased apoptosis (caspase-8 activation of mitochondrial death pathways); enhanced G2/M phase cell cycle arrest (increased CyclinB1/Cdc2 binding) (Lin et al., 2010).
	Stomach	MCG803 and SGC9071 cell lines	G2/M cell cycle arrest; decreased cell proliferation/migration (possibly through protein kinase-c and c-myc inhibition) (Guo et al., 2008).
		AGS and NCI-N87 cell lines	Enhanced apoptosis (mitochondrial release of apoptosis-inducing factor and cytochrome c, subsequent caspase-3 activation); reduced phosphorylation of pro-apoptotic BH3 interacting-domain death agonist, BID (Chen et al., 2007).
	Liver	Huh-7 hepatoma cell line	Decreased proliferation; induced apoptosis (decreased expression of calpain-2 and ubiquitin-protein ligase E3A) (Jeon et al., 2012).
		HepG2, HCCM and Hep3B hepatocellular carcinoma cell lines	Induced apoptosis (increased oxidative stress and decreased intracellular reduced glutathione (GSH); prolonged activation of c-Jun N-terminal kinase (JNK) and involvement of apoptosis signal-regulating kinase-1) (Lu et al., 2007a).
	Colon	WiDr cell line	Angiogenesis inhibitor (suppressed vascular endothelial growth factor (VEGF) expression and migration/invasion of endothelial cells); reduced mRNA levels of matrix metalloprotease-2/9 and RhoB; decreased nuclear translocation and DNA binding of transcription factor (NF-KB) responsible for VEGF and MMP-2/9 expression (Suboj et al., 2012).
	Cervix	HeLa cell line	G2/M cell cycle arrest (reduced cyclin 2 And CDK2 levels; Increased cyclin B1 and CDK1 levels); reduced PKC-alpha and c-myc expression (Guo et al., 2007).

Table 2 *Continued*

Compound	Type of cancer	Experimental Model*	Potential Anticancer Action(s)
	Bladder	T24 cell line	Enhanced G2/M cell cycle arrest (decreased cyclin-dependent kinase 2 and cyclin B1 levels); apoptosis (increased p53 expression, p21 and caspase-3 activation; enhanced Fas/APO1 receptor and Bax expression) (Lin et al., 2006).
	Skin	B16-F10 murine melanoma cell line	Inhibited proliferation, migration; decreased invasion (suppressed MMP-9 secretion); enhanced cell differentiation, adhesion and aggregation (Tabolacci et al., 2010).
		A431 epidermal carcinoma cell line; SCC25 head and neck squamous cell carcinoma cell line	Increased apoptosis (upregulation of tumor necrosis factor (TNF)-alpha and Fas ligand, their respective receptors and adaptor domains; caspase-8 activation, among other molecular events associated with apoptosis); aloe-emodin combined with 5-fluorouracil enhanced cell death by activation of multipie caspases (Chou and Liang, 2009).
	Lung	H460 large-cell lung carcinoma cell line	Photoactivated aloe-emodin induced anoikis (cell death occuring when anchorage-dependent cells detach from the extracellular matrix) (Lee et al., 2010).
		H460 large-cell lung carcinoma cell line	Induced apoptosis; detected a change in 11 proteins (e.g., vimentin, ATP synthase and endoplasmic reticulem chaperones); caspase-3 apoptotic pathway activation (Lai et al., 2007).
	Lymphoma	U937 cell line	Enhanced transglutaminase activity resulting in differentiation of cells to mature monocytes, highlighting aloe-emodin's potential to be used for monocytic differentiation in leukemia therapy (Tabolacci et al., 2011).
	Pharynx, liver, bone	FaDu pharyngeal squamous cell carcinoma cell line; Hep3B hepatoma cell line; MG63 osteosarcoma cell line	S-phase cell cycle arrest (cyclin-Cdk2-p21 complexes resulted from extracellular signal-related kinase (ERK) activation); promotes apoptosis by caspase-8-mediated activation, independent of p53 involvement (Lin et al, 2011).
Aloin	Breast, ovary	T47D breast cancer cell line; primary ovarian adenocarcinoma cell line	Induced S phase cell cycle accumulation; no effect on DNA synthesis (Esmat et al., 2005).
	Cervix	HeLaS3 cell line	Induced S phase cell cycle arrest and apoptosis while altering the activities of numerous antioxidant enzymes (Nifaiforovifa et al., 2007)

Table 2 *Continued*

Compound	Type of cancer	Experimental Model*	Potential Anticancer Action(s)
Acemannan	Leukemia	Feline-leukemia virus-infected cats	Intraperitoneal administration to clinically symptomatic cats resulted in enhanced survival and quality of life (Sheets et al, 1991).
β-sitosterol	Colon	COLO 320 DM, human colon cancer cell line; male Wistar rats	Inhibited growth, promoted apoptosis and decreased the expression of both beta-catenin and proliferating cell nuclear antigens (cell line); decreased aberrant crypt formation in 1,2-dimethyl hydrazine-initiated rats (Baskar et al., 2010).
	Stomach	SGC-7901 cell line	increased cytotoxity and decreased cellular proliferation; induced apoptosis (DNA damage, morphological changes, increased expression and activation of pro-caspase-3; Increased bax expression; decreased bcl-2 expression) (Zhao et al., 2009).
	Liver	HepG2 hepatocellular carcinoma cell lines	Oxidative products of beta-sitosterol decreased cell viability (Koschutnig et al., 2009).
	Breast	MCF-7 and MDA-MB-231 cell lines	Combined treatment of beta-sitosterol with tamoxifen (antiestrogen agent) increased cytotoxicity of tamoxifen by enhancing intracellular ceramide (pro-apoptotic signal) levels (Awad et al., 2008).
	Leukemia	U937 and HL60 cell lines	Enhanced caspase-3 activation and increased DNA fragmentation; induced cell cycle arrest and endoreduplication (nuclear genome replication without cell division); increased polymeric alpha-tubulin levels and microtubule polymerization (effects mediated by PI3K/Akt and Bcl-2 signaling pathways) (Moon et al., 2008).
	Breast	MDA-MB-23 cell line	Beta-sitosterol and TNF-related apoptosis-inducing ligand combination treatment induced sensitized cells to apoptosis (Park et al., 2008a).
	Connective tissue	MCA-102 murine fibrosarcoma cell line	increased apoptosis (ERK activation; Inactivation of PI3K/Akt signaling pathway) (Moon et al., 2007).
	Breast	MCF-7 and MDA-MB-231 cell lines	Promoted apoptosis (enhanced Fas levels and caspase-8 activity) (Awad et al., 2007)
	Breast	MCF-7 cell line; ovariectomized athymic mice	Increased *in vitro* cell proliferation; no stimulation of MCF-7 tumor growth *in vivo*; decreased serum estrogen levels *in vivo* (Ju et al., 2004).

Table 2 *Continued*

Compound	Type of cancer	Experimental Model*	Potential Anticancer Action(s)
	Connective tissue	Transformed Rat1 and Rat2 fibroblast cell lines	Inhibition of H-Ras(v12)-induced DNA synthesis (Park et al., 2003).
	Breast	MDA-MB-231 cell line	Prevented tumor cell invasion through Matrigel; decreased adhesion of cells to plates coated with collagen I, collagen IV, fibronectin and laminin; prevented cell growth; induced G2/M cell cycle arrest (Awad et al., 2001).
	Prostate	LNCaP cell line	Increased activation of the sphingomyelin cycle (enhanced protein phosphatase 2 activity, without changes in its protein levels); possible activation of membrane-bound enzymes (Awad et al., 2000).

* Human, unless otherwise indicated.

(Awad et al., 2008; Awad et al., 2007; Awad et al., 2000; Awad et al., 2001; Baskar et al., 2010; Chen et al., 2007; Chen et al., 2010a; Chen et al., 2010b; Chiu et al., 2009; Chou and Liang, 2009; Esmat et al., 2005; Guo et al., 2008; Guo et al., 2007; Jeon et al., 2012; Ju et al., 2004; Koschutnig et al., 2009; Lai et al., 2007; Lee et al., 2010; Lin et al., 2006; Lin et al., 2010; Lin et al., 2011; Lu et al., 2007a; Moon et al., 2008; Moon et al., 2007; Niciforovic et al., 2007; Park et al., 2008a; Park et al., 2003; Sheets et al., 1991; Suboj et al., 2012; Tabolacci et al., 2010; Tabolacci et al., 2011; Xiao et al., 2007; Zhao et al., 2009).

carcinoma and non-small cell carcinoma cell lines, aloe-emodin provoked apoptosis alongside a decrease in expression of two PKC isozymes (δ and ε) and an increase in the apoptosis effector caspase, caspase-3 (Lee, 2001). Similarly, emodin isolated from rhubarb (*Rheum palmatum*) and structurally similar to aloe-emodin induced apoptosis in a human leukemia cell line by means of a mechanism that depended on caspase-3 (Chen et al., 2002). Therefore, aloe-emodin initiates PKC-dependent signalling pathways that lead to cell death in a variety of cancer cell lines.

Interestingly, aloe-emodin was able to hinder cell proliferation in one human liver cancer cell line (HepG2) and induce apoptosis in another (Hep3B) (Kuo et al., 2002). Further dissection of the mechanism identified p53 and p21 as major players. In the HepG2 cell line, aloe-emodin exposure resulted in p53 expression that led to increased p21 expression. The protein p21 is a cyclin-dependent kinase inhibitor and interacts with cyclin-dependent kinases that regulate cell cycle progression at the G1 phase (Kuo et al., 2002). The G1 checkpoint is when the cell interprets a number of incoming signals that determine whether or not it divides (Massague, 2004). Consequently, increased p21 expression in HepG2 cells causes G1 cell cycle arrest. Additionally, aloe-emodin prevents DNA synthesis by upregulation of both p16 and retinoblastoma protein, two important tumor suppressor proteins (Lu et al., 2007b).

However, Hep3B cells do not express p53 to trigger this cascade of events leading to G1 cell cycle arrest (Kuo et al., 2002). In these cells, apoptosis was induced by increased expression of Bax, a pro-apoptotic protein that is regulated by p21 in a p53-independent manner (Kuo et al., 2002).

Aloe-emodin has effects on other molecular targets in HepG2 cells. It upregulates proteins associated with oxidative stress and increases the amount of intracellular reactive oxygen species (Lu et al., 2007b). Furthermore, aloe-emodin inhibits cell migration by upregulating nonmetastastic gene 23, an important metastasis inhibition factor (Lu et al., 2007b). Upregulation of the Fas receptor, a member of the tumor necrosis factor (TNF) receptor family, on HepG2 cells has been documented as well (Jiang et al., 1999; Kuo et al., 2002). Fas modulates apoptosis upon binding FasL, its endogenous ligand (Jiang et al., 1999; Kuo et al., 2002). This response leads to mechanisms that overlap with those triggered by conventional chemotherapeutic drugs.

The data on selective toxicity of aloe-emodin against different cancers are somewhat contradictory because they demonstrate activity of aloe-emodin against some experimental cancer cell lines within a tumour type, but not others. Some studies are highly encouraging. In one study for example (Pecere et al., 2000), aloe-emodin was found to be active against neuroectodermal tumor cells in both tissue culture and animal models, and caused cell death (e.g., cell shrinkage, membrane blebbing and nuclear fragmentation were observed – all of which are morphological features of apoptotic cells). However, growth of human hematopoietic progenitors and normal fibroblasts was not inhibited by aloe-emodin (Pecere et al., 2000). In fact, hematopoietic cells were not affected at concentrations more than 100 times higher than those required to inhibit neuroectodermal tumor cell growth (Pecere et al., 2000). This observation is especially important because high-dose chemotherapy is often associated with neutropenia, a dose-limiting toxicity (Lyman et al., 2005). In severe combined immunodeficiency (SCID) mice, there was no evidence of acute or chronic toxicity of aloe-emodin injected subcutaneously at the highest concentration that could be dissolved in an aqueous solution (50 mg/kg/day) (Pecere et al., 2000). Unfortunately, in the same study, it was also found that aloe-emodin failed to inhibit the growth of epithelial and blood-derived tumor cell lines (e.g., T-cell leukemia, colon adenocarcinoma and cervix epithelial carcinoma cells), suggesting that any selectivity is based upon cell type rather than whether the target cell is normal or malignant (Pecere et al., 2000).

Of significant concern are observations that in certain circumstances, aloe-emodin may enhance tumor cell growth. For example, it was found to increase the growth of colorectal carcinoma cells (Schorkhuber et al., 1998). After chemical modification by intestinal bacteria, aloe-emodin becomes a strong laxative (Schorkhuber et al., 1998). Continued use of laxatives containing aloe-emodin has been associated with many adverse side effects, including the risk of developing colon cancer in experimental models (Muller et al., 1996; Schorkhuber et al., 1998). It has been suggested that one detrimental action of aloe-emodin might be its ability to increase secretion of urokinase, an enzyme that can digest extracellular matrix, which can increase cell proliferation and, in the context of neoplasia, could also promote metastasis from the colon (Schorkhuber et al., 1998).

Whereas *Aloe* components (most notably aloe-emodin) have been shown by Ames testing to possess mutagenic and possible carcinogenic potential *in vivo*, animal studies have not yet unanimously demonstrated these findings (Brusick and Mengs, 1997; Mueller et al., 1998). It has also been suggested that aloe-emodin might be genotoxic by hindering the interaction of topoisomerase II with DNA (Muller et al., 1996). Although topoisomerase II inhibition as such is a cytotoxic mechanism exploited by anti-cancer drugs such as etoposide, improper topoisomerase II function may lead to mutations and chromosomal translocations as have been observed in some forms of leukemia (McClendon and Osheroff, 2007; Muller et al., 1996; van Maanen et al., 1988).

Although many researchers believe that laxatives containing aloe-emodin may increase an individual's risk of developing colorectal cancer, other data from human studies show no significant risk of long-term (up to 20 years) laxative use (Nusko et al., 2000). Therefore, it is not conclusive that aloe-emodin-containing laxatives may increase the risk of developing colorectal cancer. Indeed, it is possible that they may instead play a protective role through their suppressive effects on N-acetyltransferases (NATs). NATs are responsible for catalyzing metabolic cascades induced by acrylamine compounds, such as those found in cooked meat (Chung et al., 2003). Through their bioactivation (involving N-acetylation reactions) and detoxification pathways (involving O-acetylation reactions), these enzymes create intermediate metabolites capable of forming adducts with DNA, which can lead to various forms of cancer (Chung et al., 2003). Aloe-emodin decreases NAT activity, likely by binding to the enzyme-substrate complex inhibiting NAT activity as a possible non-competitive inhibitor. The net effect is to hinder the formation of DNA adducts after acrylamine exposure (Chung et al., 2003).

Several studies have tried to quantify the levels of aloe-emodin that can be attained within the human body and therefore interact with cells following ingestion. Therapeutic doses of laxatives containing aloe-emodin administered repeatedly in 10 healthy volunteers resulted in aloe-emodin being undetectable in blood samples collected within 96 h of receiving the first dose (Krumbiegel and Schulz, 1993). A kinetic study using two *in vitro* intestinal models – an everted rat gut sac and a monolayer of differentiated and absorptive cells similar to those in the small intestine (Caco-2 cells) also tried to determine the fate of aloe-emodin when ingested (Park et al., 2009). Uptake of aloe-emodin by intestinal epithelial cells was demonstrated by both approaches. After incubation with 5 to 50 μM of aloe-emodin, the rate of aloe-emodin absorption was similar between the two models, and reached saturation near the 50 μM treatment. The percentage of aloe-emodin that was absorbed ranged from 6.6% to 11.3% (Park et al., 2009) This ready uptake is likely due to aloe-emodin's relatively high affinity for phospholipid membranes (Park et al., 2008b). In addition, aloe-emodin may interact with certain transporters, such as the sodium dependent glucose transporter-1 that could transport aloe-emodin into the cell unchanged (Park et al., 2008b). Additionally, Caco-2 cells may metabolize aloe-emodin by phase II metabolic reactions involving glucuronidation or sulfation and in this context it has been found that nearly 19% of glucuronidated or sulfated aloe-emodin was absorbed (Park et al., 2009). Metabolism *in vivo* is mostly in the liver, and aloe-emodin can be converted to 2-hydroxyemodin by cytochrome P450 1A2 (Mueller et al., 1998; Park et al., 2008b).

Whereas aloe-emodin has been studied for its ability to regulate cell cycle and proliferation through its interaction with a variety of molecular targets, literature underlining aloe-emodin's potential carcinogenic effects make it unclear as to whether or not this compound can be used for its anticancer properties. However, research associated with aloin, and anthraquinone similar to aloe-emodin, has also been conducted.

2. Activities of Aloin

Aloin (Fig. 2 B) is a mixture of two diasteromers, aloin A and aloin B, which differ depending on whether the sugar moiety is above (aloin A) or below (aloin B) the plane of the anthroquinone (Park et al., 2008b). Because aloin can be converted to aloe-emodin anthrone by intestinal bacteria in humans, these two compounds share similar biological effects after ingestion, such as their abilities to act as potent laxatives (Akao et al., 1996) (Choi and Chung, 2003). Whereas the majority of anticancer research has focused on the pharmacological effects of aloe-emodin, several anticancer properties of aloin have also been investigated.

Just as for aloe-emodin, aloin has been linked with the ability to trigger apoptosis. Using Jurkat T-lymphocytes, aloin was shown to disrupt cell membrane integrity and interfere with mitochondrial membrane potential, both of which are hallmarks of apoptosis (Buenz, 2008). Using DNA-staining techniques, aloin was also found to increase the proportion of cells at the G2 cell cycle phase that precedes cell division (Buenz, 2008). These apoptotic and antiproliferative effects required large doses within the range of 100 - 1000 μg/ml. The huge variabiity in doses of aloin (or other agents) may reflect the absence of enzymes that may convert aloin to active metabolites, which are often found in the liver. However, more studies are required to not only determine, but also characterize aloin metabolites *in vivo* and *in vitro* (Buenz, 2008).

Aloin has been shown to be cytotoxic in two human breast cancer cell lines (MCF-7 and SKBR-3) (Esmat et al., 2006). Similar to aloe-emodin, there seems to be a link with topoisomerase II, and also with the HER-2/Erb-2 oncogene, which specifies an aberrant growth factor receptor. Topoisomerase IIα and HER-2/Erb-2 genes are often coamplifed in breast cancer, and the amplification of topoisomerase IIα together with HER-2/Erb-2 relates to the effectiveness of aloin action (Esmat et al., 2006). MCF-7 cells (with no overexpression of either Erb-2 or topoisomerase IIα) were more sensitive to the cytotoxic effects of aloin (half-maximal inhibitory concentration (IC_{50}) 60 μg/ml, compared with 150 μg/ml) than SKBR-3 cells (with coamplification of Erb-2 and topoisomerase IIα) (Esmat et al., 2006). The effect of aloin in MCF-7 cells was to disrupt the cell cycle and induce apoptosis by inhibiting cyclin B1 (a regulatory protein in mitosis) expression, following inhibition of topoisomerase IIα expression (Esmat et al., 2006). SKBR-3 cells exhibited a lesser effect consistent with the slight decrease in topoisomerase IIα expression. Clearly, the effect of aloin on breast cancer cells depends on the precise phenotype of the cancer cells. It also appears that this compound exerts its action through a variety of mechanisms.

The intestinal epithelial absorption of aloin in everted rat gut sac and Caco-2 cell models is similar to that of aloe-emodin, even though there is no bacterial conversion to the latter in these systems. The absorption of aloin was between 5.5% and 6.6%, with approximately 18.2% being absorbed if in the glucuronidated or sulfated form (Park et al., 2009). To assess aloin's bioavailability *in vivo*, plasma, tissue and urine concentrations of aloin were measured in rats that were given 11.8 g/kg of aloin by gavage (Park et al., 2008b). This dose was chosen based on previous studies that had established 11.8g/kg as the lowest observed adverse effect level. Aloin was detected in the plasma, with its peak concentration (59.1 ng/ml) being reached after 1h. Aloin reached its peak liver and intestine concentrations in 30 min, with the liver concentration being approximately 78 ng/ml and that of the intestine being roughly 100 ng/ml. The peak kidney concentration (nearly 13 ng/ml) occurred after 5h and the amount of aloin that had accumulated in the urine over a 24-h period was estimated to be 0.03% of the initial dose (Park et al., 2008b). Metabolism appears to be primarily hepatic (Park et al., 2008b).

The studies using both aloe-emodin and aloin show a substantial disparity between the concentrations that are tested *in vitro* to identify putative anti-cancer effects, and those that are attainable *in vivo* even with generous oral dosing. The work of Park and colleagues (Park et al., 2008b), with oral dosing that would equate to a daily intake of 0.83 kg of aloin per day in the standard 70kg human, yielded systemic levels of no more than 100 ng/ml. Yet some of the *in vitro* studies with cancer cell lines have used concentrations in culture as high as 1000 μg/ml (Buenz, 2008), that is 10,000-fold higher than are readily attainable. While the use of anthraquinones at such high concentrations in culture may reveal useful activities of molecular motifs that could be refined to eventually produce a worthwhile drug, it has very little value in informing us of the value of *Aloe* itself if ingested by an actual cancer patient. More focused efforts on the application of *Aloe* components are underway: investigations are being conducted to compare aloin's cardiotoxicity to that of commonly used chemotherapeutic agents such as doxorubicin, an anthracycline that often induces cardiotoxicity (Esmat et al., 2006); and researchers are attempting to modify aloin's chemical structure in order to heighten its cytotoxic effects (Kumar et al., 2010).

3. Activities of Acemannan

Acemannan, which is isolated from the gel of the *Aloe* plant, has been shown to activate macrophages both *in vitro* and *in vivo* (Djeraba and Quere, 2000; Moghaddasi and Verma, 2011; Zhang and Tizard, 1996), and might therefore potentially promote the action of tumour-associated macrophages. Acemannan binds to protein receptors on the macrophage cell surface (Djeraba and Quere, 2000; Zhang and Tizard, 1996), facilitating the internalization of acemannan, which in turn results in macrophage activation. Such activation is associated with the release of cytokines that have many actions, including the enhancement of T-cell proliferation and increased T-cell-mediated cytotoxicity (Djeraba and Quere, 2000; Karaca et al., 1995; Zhang and Tizard, 1996).

Macrophage activation is often measured in terms of nitric oxide (NO) production (Djeraba and Quere, 2000; Karaca et al., 1995; Zhang and Tizard, 1996). NO regulates major histocompatibility cell (MHC) surface antigens that are required for antigen presentation and the recognition of foreign antigens, such as those that may be present on a cancer cell (Djeraba and Quere, 2000; Zhang and Tizard, 1996). Furthermore, release of NO has been shown to inhibit the DNA synthesis of tumor cell lines (Drapier and Hibbs, 1988).

Although mechanisms of acemannan action are still being investigated, it appears that acemannan principally functions to enhance immune mechanisms (e.g., macrophage activation, immune system stimulation and enhanced release of anticancer cytokines) (de Visser et al., 2006; Harris et al., 1991; Peng et al., 1991). This has proven sufficient grounds for it to be used in the treatment of cancer in animals such as cats and dogs (Harris et al., 1991; VPL, 2011). The compound is typically administered by subcutaneous or intramuscular injection, and it is uncertain whether oral doses would be as effective (VPL, 2011). Oral acemannan needs to be broken down by gut flora so that mannose receptors lining gut epithelial cells can transport it into the bloodstream for distribution throughout the body (Flint et al., 2008).

4. Activities of β-sitosterol

Aloe plants contain numerous other components that may exert effects on cell cycle and proliferation. For example, *Aloe* gel also yields β-sitosterol, which is partly responsible for *Aloe*'s wound healing properties and has been demonstrated to be a potent inducer of angiogenesis (Choi et al., 2002; Lee et al., 1995). This is thought to occur by the ability of β-sitosterol to increase pro-angiogenic proteins such as vascular endothelial growth factor (VEGF), Flk-1 (a receptor for VEGF), von Willebrand factor and blood vessel matrix laminin (Choi et al., 2002). Because angiogenesis is an essential step in tumour progression since tumors require a blood supply to grow larger or spread to other organs, there is a possibility that β-sitosterol may promote tumor growth in animal models (Carmeliet and Jain, 2000).

USE OF *ALOE* IN TREATMENT OF HUMAN CANCERS

Aloe use, whether for topical purposes or by ingestion, has been a well-established practice in different cultures for many years. Therefore, it is no surprise that even with conflicting reports as to the proposed biological activities of *Aloe* components and suggestions of interactions of these components with anticancer drugs, cancer patients will continue to use *Aloe* or its components. This may be for hoped-for anti-cancer properties, or to alleviate symptoms of conventional therapies. For example, at the time of writing one website for a company that markets *Aloe* products makes these comments "Courses of chemotherapy tend to make people feel thoroughly rotten. This particular treatment tends to cause bouts of nausea that negates what little appetite they might have. Drinking gel before, during and after chemotherapy may alleviate these symptoms." (FLAP, 2010).

1. Evidence for Anti-cancer Activity

There have been several clinical studies that have looked at possible effects of *Aloe* in addition to standard chemotherapy. One focused study looked at its use in lung, colorectal, gastric and pancreatic cancer patients in addition to a base of standard-of-care chemotherapy appropriate for the clinical characteristics of each metastastic, solid tumor (Lissoni et al., 2009). A comparison was made between patients who received *Aloe* in addition to their chemotherapy and patients who did not receive *Aloe* with their chemotherapy. For patients that received *Aloe*, an oral dose was given three times each day, beginning six days before the onset of chemotherapy. *Aloe* administration was continued during chemotherapy and each dose consisted of 300 g of fresh *Aloe* leaves together with 500 g of honey. It was found that *Aloe* given in conjunction with chemotherapy significantly increased tumor regression and disease control, while also prolonging survival (Lissoni et al., 2009). Furthermore, quality of life increased in patients that received both *Aloe* and chemotherapy because of decreased asthenia (loss of strength) and increased energy levels (Lissoni et al., 2009). However, this study was not blinded – and it would be hard to blind such a treatment – so that confounding influences such as altered patient behaviour in the treatment group are hard to exclude.

The same investigators also conducted a controlled clinical trial on patients with numerous advanced solid tumors that were refractory to established treatment (Lissoni et al., 1998). In this case, patients were given either melatonin (an immunomodulating hormone produced by the pineal gland) or a combination of melatonin and *Aloe*. Improvements were reported for the combination of melatonin and *Aloe* compared with melatonin alone, in partial response (8% vs 0%), stable disease (50% vs 27%) and one-year survival rates (Lissoni et al., 1998).

There is thus some evidence of a beneficial effect of *Aloe* in advanced cases of human cancer (Lissoni et al., 1998; Lissoni et al., 2009). However, it will be necessary to carry out blinded and randomized trials with at least partially-purified extracts before the evidence is fully convincing.

2. Possible Interactions with Conventional Drugs

Because numerous chemotherapeutic drugs (e.g., cisplatin, 5-fluorouracil (5-FU), adriamycin, mitoxanthrone and etoposide) have been found to induce apoptosis in solid tumors and some types of leukemia, some researchers believe it is possible that aloe-emodin may be useful in enhancing their apoptotic response (Fenig et al., 2004; Hickman, 1992; Jiang et al., 1999). However, data relating to this belief are somewhat contradictory because some studies document a cytoprotective effect of aloe-emodin. For example, aloe-emodin reduced cisplatin's ability to trigger apoptosis in certain fibrosarcoma and glioma cell lines (Mijatovic et al., 2005). In these cells, aloe-emodin in fact interfered with cisplatin's ability to activate the extracellular signal-related kinase (ERK) pathway that can promote apoptosis or cell cycle arrest (Cagnol and Chambard, 2010; Mijatovic et al., 2005). The cytoprotective action of aloe-emodin was further examined in comparable fibrosarcoma and glioma cell lines (Harhaji et al., 2007). It was determined that aloe-emodin reduced the cytotoxic effects of TNF, a proinflammatory cytokine, by decreasing TNF-initiated ERK activation (Harhaji et al., 2007). Therefore, the possibility exists, that aloe-emodin can interfere with conventional drug therapy in addition to having the potential to enhance anti-cancer drug action. This poses something of a dilemma in terms of arguments for a therapeutic effect of ingested aloe-emodin in cancer patients.

3. Assessment for Dermatologic Benefit

Perhaps more inherently logical given the wide utility of *Aloe* in skin care products is the possibility of using *Aloe* to address dermatological problems incurred during cancer treatment. *Aloe* gel has been evaluated as a possible agent to prevent dermatitis caused by radiation therapy (Williams et al., 1996). In a first Phase II randomized clinical trial, these investigators tracked the status of skin dermatitis (e.g., severity of dermatitis, time until severe dermatitis occurs and how long severe dermatitis would persist) in female patients receiving chest or breast radiation treatment. It compared the topical application of *Aloe* to a placebo gel and found no significant differences between the treatment groups. A second trial was conducted with a similar patient cohort to eliminate the possibility that the gel itself might be efficacious, and compared an *Aloe* gel group against a 'no treatment group'. However, this trial also failed to demonstrate an effect of *Aloe*, indicating that the dermatitis resulting from radiation therapy (which has a large component of direct cellular damage) is not alleviated by *Aloe* product. Therefore, these studies would suggest that *Aloe* is ineffective for dermatological problems associated with cancer treatments.

FUTURE PROSPECTS FOR *ALOE* IN CANCER TREATMENT

1. Is *Aloe* Useful for Cancer Treatment?

The situation with *Aloe* is similar to that of many natural products that have garnered an active following in the general population that arises out of a long history of use extending back to before the emergence of western medicine. It has proven extremely challenging to show effects that will satisfy the demands of evidence-based medicine. Bench science using experimental models has revealed promise for bioactivity of individual components of *Aloe*, but the evidence is often flawed by the use of doses that are many orders of magnitude above those attainable in the human patient. Research in both cellular and animal models has also suggested possible negative actions of these compounds, leading to toxicities or perhaps even increased cancer risk. This research again may be compromised by the experimental doses, but it is an inevitable truth that any substance that has useful bioactivity will carry a risk of 'off-target' side effects as a result of its activity; there is no assurance that just because something 'is natural' it cannot also be harmful.

Whether or not natural components of *Aloe* have genuine activity against cancer (or potentially may promote aspects of the disease) is unclear based on both the *in vitro* and clinical data presented in this review. However, it is evident that – as for many natural sources – the native molecules do have activities against cellular pathways that if appropriately extended, could lead to useful agents to manipulate the cellular response.

Identifying the chemicals within *Aloe* that might have potential for further study or development will require thorough studies that characterize the wide variety of potentially biologically active compounds of the plant. Each of these compounds must be assessed for their effects on cell cycle proliferation. Furthermore, it is likely that interactions between these compounds also influence their respective biological activities.

2. Safety in Use of *Aloe*

Aloe is a popular biologic used by the public in CAM-related approaches to disease treatment, and there are many companies producing *Aloe* products. It is important for the public to recognize that the composition of these products is highly variable, especially when *Aloe* extracts are obtained from plants of different geographic origins (Choi and Chung, 2003; Reynolds and Dweck, 1999). There are often poor manufacturing techniques and quality control mechanisms in place to ensure standardized forms of *Aloe* preparations (Choi and Chung, 2003; Moghaddasi and Verma, 2011; Reynolds and Dweck, 1999). Additionally, poor regulation of *Aloe* products has prevented CAM practitioners from agreeing on a standard dose that can be efficacious without inducing undesirable side effects (Marcus and Grollman, 2002).

These again are common challenges in the use of whole natural products to self-treat disease. Understanding the biological activities of *Aloe* constituents, their interactions with conventional medicines, and proper standardization of product content, are essential for the safety of those who take these preparations, irrespective of the contribution they make to alleviating disease.

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BEACHED BIRD SURVEYS ON SABLE ISLAND, NOVA SCOTIA, 1993 TO 2009, SHOW A DECLINE IN THE INCIDENCE OF OILING

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Sable Island, located about 160 km southeast of the landmass of Nova Scotia, Canada, is far offshore and provides a platform for beach surveys to monitor oil pollution in Scotian Shelf waters. Sporadic beach surveys conducted there during the 1970s and 1980s indicated that oiled birds and beached tar were common occurrences. During a survey program from January 1993 to December 2009, more than 10,800 bird corpses were found in 171 surveys covering a total of >13,500 km of shoreline. Sixty-four species were recorded, of which 52 were seabirds and waterfowl. The numbers of beached birds and species composition exhibited large fluctuations, which reflected both the seasonal distribution of species and the effects of weather and beach conditions. The oiling rate of corpses for all seabirds and waterfowl combined was 28.6%, and ranged from a high of 69.9% in 1996 to a low of 1.4% in 2009. Alcids had the highest rates of oiling (averaging 54.3%), while lower rates were observed for shearwaters (1.9%) and *Larus* gulls (2.4%). The results of the 1993-2009 surveys, as well as those of earlier studies in the 1970s and 1980s, indicate a declining trend in the oiling rate of beached birds on Sable Island.

Keywords: oil pollution, marine pollution, seabird oiling rate, beached bird survey, Sable Island

INTRODUCTION

Millions of seabirds of more than 20 species breed along the coasts and islands of Atlantic Canada (Brown et al. 1975, Lock et al. 1994). In offshore waters of Nova Scotia, the seabirds are predominantly non-breeding individuals of species that breed in boreal and arctic waters of the North Atlantic, and they are especially abundant in the winter (Lock et al. 1994). In addition, a number of pelagic species that breed in the Southern Hemisphere migrate to the northwest Atlantic during the northern summer (Lock et al. 1994). Consequently, there is a large and varied seabird fauna in waters of the Scotian Shelf and its slope at all times of the year. These birds are highly vulnerable to oil pollution from shipping and ship-based activities in their marine environment.

The continental shelf averages about 200 km wide off Nova Scotia, and Sable Island is located near its outer edge (Sable Island Station: 43.9330° N, -60.0055° W). The island is the emerged portion of the Sable Island Bank and is about 160 km southeast of mainland Nova Scotia, 53 km west of a large submarine canyon known as the Gully, and 40 km north of the upper edge of the continental slope (Fig 1a). The region is influenced by the northeasterly flow of the Gulf Stream passing south of Sable Island, the southwesterly flow of the Nova Scotia Current passing to its west, and the southern flow of the Labrador Current (Sutcliffe et al. 1976). A large and persistent anti-clockwise gyre is formed among these currents, and is roughly centered on Sable Island (Hannah et al. 1996, 2001). The gyre entrains floating materials such as plastic litter, petroleum residues, seaweed, bird and seal corpses, and other debris, some of which eventually washes ashore on the island.

Sable Island is located in an area with frequent marine traffic among ports in eastern Canada (the Atlantic Provinces and the St. Lawrence

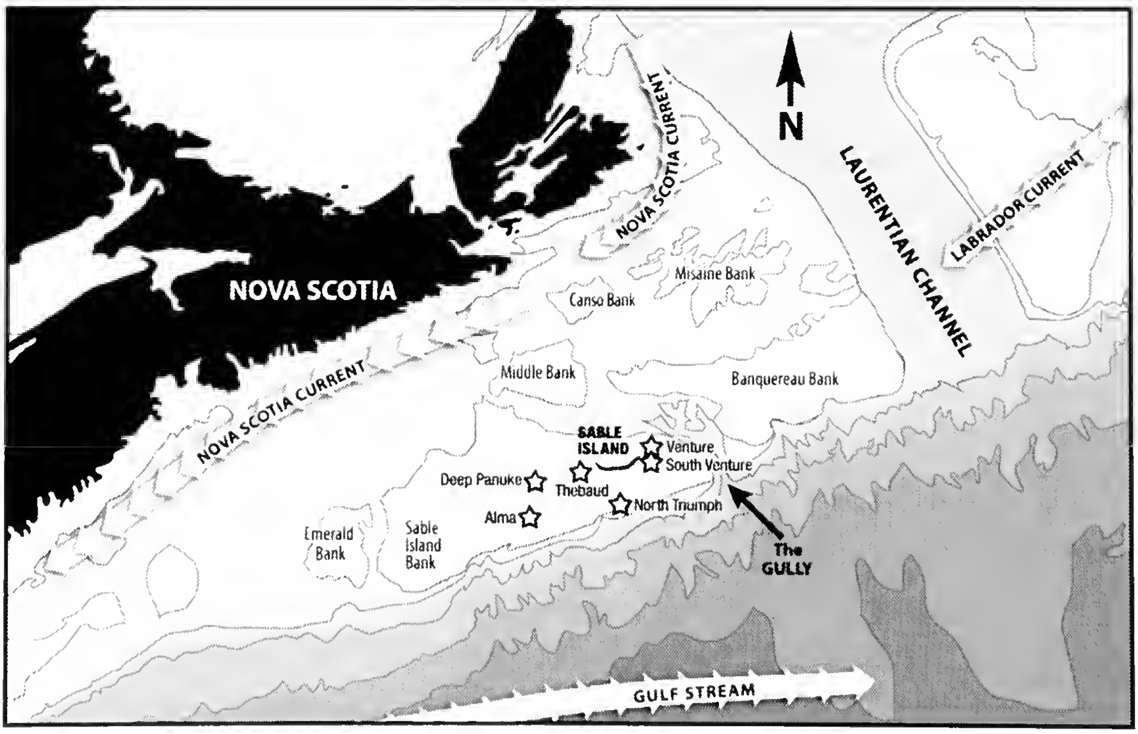

Fig 1a Nova Scotia and the Scotian Shelf region. Locations of present offshore energy installations near Sable Island are indicated by star symbol.

Seaway), the USA, and Europe. Some of this shipping activity has been responsible for discharges of petroleum into regional waters (Chardine 1991, Cook et al. 2006, Percy & Dewis 2006). In addition, the Sable Island Bank is at a centre of production of offshore fossil fuels. Production platforms are located to the east, south, and southwest of the island (Fig 1a). Because Sable Island is an isolated offshore location, it has been used as a monitoring station for marine litter (Lucas 1989) and beached marine mammals (Lucas & Hooker 2000, Lucas & Daoust 2002, Lucas & Natanson 2010).

The earliest published reports of oiled birds on Sable Island were in 1970 following the mid-winter grounding of the coastal tanker *Arrow*, which released bunker-C into Chedabucto Bay, Nova Scotia (Brown et al. 1973). This observation was followed by sporadic surveys by Environment Canada personnel for beached seabirds during the 1970s (Brown et al. 1973) and early 1980s (Lock 1992), and by Zoe Lucas in 1984 and 1985-86. Since 1993, however, there has been a continuous program of beached bird surveys on Sable Island as part of the Environmental Effects Monitoring Program associated with oil and gas activity in the Sable Island Bank region. Generic identification of petroleum residues collected from the beach and feathers of bird corpses found on the island during 1996 to 2005 was reported by Lucas and MacGregor (2006). The primary goals of the present study are to establish the patterns of occurrence of beached birds at Sable Island, and to monitor long-term trends. Here we report the incidences of oiling for seabirds and waterfowl recorded during surveys on Sable Island.

METHODS

Study Site

Sable Island is approximately 45 km long and up to 1.5 km wide, and is oriented roughly west-east, with its ends curving northwards (Fig 1b). The shoreline comprises an uninterrupted sand beach. Beach width during summer varies from about 10 m to more than 50 m on the north side, and from 10 m to 700 m on the south side. The greatest width of beach on the south side occurs in two areas, one (known as the sandy plain) about 9 km long and up to 700 m wide, and another 2.5 km long and 450 m wide, both on the western half of the island. During the winter all beach areas are generally narrower, and occasionally sections are only a few meters wide at low tide. Such

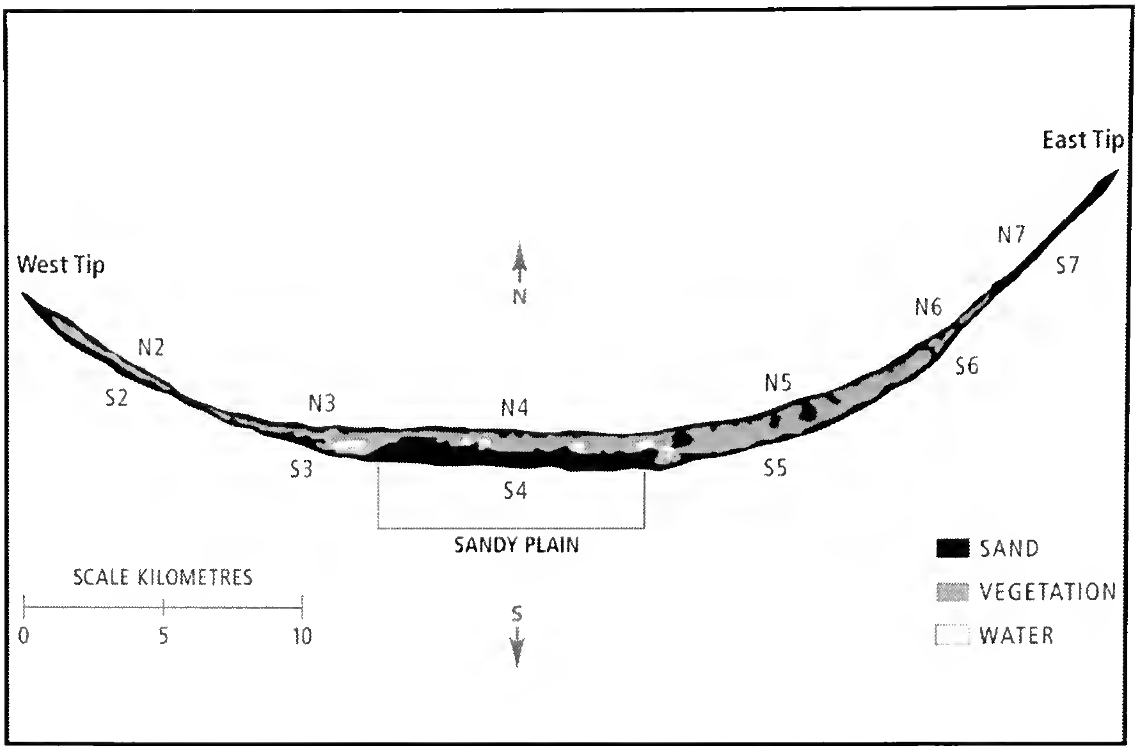

Fig 1b Sable Island. Six survey areas were established along the north and south sides. These areas roughly correspond to variations in the orientation of the beach according to the inner and outer curves of the island.

reductions in width also occur during storms throughout the year.

For the purposes of this survey the island was divided into six sections along the north and south sides (Fig 1b). These areas roughly correspond to variations in the orientation of the beach according to the inner and outer curves of the island. Between January 1993 and May 1994, only the north and south beaches backed by vegetated dunes were included in the survey program (i.e., sections s3 to s6 and n3 to n6, totalling 56 km of shoreline). Beginning in June 1994, the north and south sides of the west spit (sections s2 and n2) were added, increasing the shoreline in the study to 72 km. In June 1998 the north and south sides of the east spit were added (sections s7 and n7), so that the entire shoreline of Sable Island (92 km) was included in the study site.

Search Protocol

The beach was examined from the low tide line to the upper reach of storm waves, which in most areas extend to the base of the vegetated dunes. Where storm waves wash into large unvegetated breaks between dunes, and along the sandy plain, the area surveyed extended approximately 30 m above the high tide line.

All surveys were conducted by the first author, once every 25-45 days as weather and beach conditions permitted. The interval between surveys exceed 45 days on 29 occasions, which is 17% of the total surveys. The longest of these were a 96-day interval between surveys in January and April 1994, and an 81-day interval in October and December 2000. Conditions that affected the timing of surveys included narrow beach profiles and flooding after winter and tropical storm events, snow and ice cover, and grey seal (*Halichoerus grypus*) breeding colonies that occasionally impeded travel on, and search of, the beach.

Surveys were conducted by travelling slowly back and forth between the water's edge and the upper reach of storm waves on an all-terrain vehicle. At the start of each survey, the beach was examined to determine the position of highest water since the last survey. Depending upon visibility and beach conditions, each survey took three to five days to complete. In some cases the beach was flat and clear of debris. At other times, however, the beach was littered with debris, seaweed wrack, and chunks of eroded peat, with irregular topography caused by high winds and waves.

Examination and Reporting of Bird Corpses

All bird corpses and fragments found during the surveys were examined, and either marked with coloured wire or removed from the beach. Corpses of young gulls from the island's Herring Gull (avian binomials are given in Table 1) and Great Black-backed Gull colonies still being fed by parents, were not included because this age group is not likely to be exposed to pollution at sea. Separated right and left wings of the same species and age found in the same section of beach were counted as one corpse. Species identification, corpse condition (completeness and freshness), any obvious external injury, presence and extent of oiling or entanglement, and scientific markings such as leg bands were recorded for each corpse.

The presence of oil was recorded using a protocol similar to that employed in studies in other regions (Chardine & Pelly 1994, Camphuysen 1998, Wiese & Ryan 1999, Žydelis et al. 2006). The oiling rate was calculated using only complete or largely intact corpses (i.e., having 75% of all feather groups present for examination). The presence and degree of oiling of complete corpses was recorded as a code using a four-point scale: (0) clean plumage; (1) slight surface oiling, or <10% of the body oiled; (2) moderate oil, penetrating to the

Table 1 List of 52 species of seabird and waterfowl represented by corpses recovered during beach surveys on Sable Island, 1993-2009.

Family and Species	Percent of total	Total corpses[1]
Gaviidae	0.2	
Red-throated Loon *(Gavia stellata)*		2
Common Loon *(Gavia immer)*		19
Podicipedidae	0.1	
Red-necked Grebe *(Podiceps grisegena)*		15
Procellariidae	21.1	
Northern Fulmar *(Fulmarus glacialis)*		510
Cory's Shearwater *(Calonectris diomedea)*		14
Greater Shearwater *(Puffinus gravis)*		1,304
Manx Shearwater *(Puffinus puffinus)*		3
Sooty Shearwater *(Puffinus griseus)*		455
Hydrobatidae	0.4	
Leach's Storm-petrel *(Oceanodroma leucorhoa)*		29
petrel species[2]		15
Phaethontidae	0.1	
Red-billed Tropicbird *(Phaethon aethereus)*		2
White-tailed Tropicbird *(Phaethon lepturus)*		4
Phalacrocoracidae	0.1	
Great Cormorant *(Phalacrocorax carbo)*		8
Double-crested Cormorant *(Phalacrocorax auritus)*		2
cormorant species[2]		1
Sulidae	2.5	
Northern Gannet *(Morus bassanus)*		269
Anatidae	0.4	
Canada Goose *Branta canadensis*		4
Snow Goose *(Chen caerulescens)*		1
Wood Duck *(Aix sponsa)*		3
Mallard *(Anas platyrhynchos)*		1
American Black Duck *(Anas rubripes)*		9
Blue-winged Teal *(Anas discors)*		1
Ring-necked Duck *(Aythya collaris)*		1
Common Eider *(Somateria mollissima)*		4
Long-tailed Duck *(Clangula hyemalis)*		2
Black Scoter *(Melanitta nigra)*		1
White-winged Scoter *(Melanitta fusca)*		1
Red-breasted Merganser *(Mergus serrator)*		16
scaup species[2]		4
Rallidae	<0.1	
American Coot *Fulica americana*		1
Laridae	14.3	
Long-tailed Jaeger *(Stercorarius longicaudus)*		1
Parasitic Jaeger *(Stercorarius parasiticus)*		1
Pomarine Jaeger *(Stercorarius pomarinus)*		5
jaeger species[2]		2
South Polar Skua *(Stercorarius maccormicki)*		3
Great Skua *(Stercorarius skua)*		3
Bonaparte's Gull *(Larus philadelphia)*		2
Laughing Gull *(Larus atricilla)*		5
California Gull *(Larus californicus)*		1

Table 1 *Continued*

Family and Species	Percent of total	Total corpses[1]
Herring Gull *(Larus argentatus)*		271
Iceland Gull *(Larus glaucoides)*		73
Glaucous Gull *(Larus hyperboreus)*		5
Lesser Black-backed Gull *(Larus fuscus)*		1
Great Black-backed Gull *(Larus marinus)*		759
Black-legged Kittiwake *(Rissa tridactyla)*		386
Sandwich Tern *(Sterna sandvicensis)*		2
Common Tern *(Sterna hirundo)*		28
Arctic Tern *(Sterna paradisaea)*		1
Sooty Tern *(Sterna fuscata)*		1
Black Skimmer *(Rynchops niger)*		2
tern species[2]		3
Alcidae	60.8	
Common Murre *(Uria aalge)*		221
Thick-billed Murre *(Uria lomvia)*		2,024
Razorbill *(Alca torda)*		112
Dovekie *(Alle alle)*		1,888
Black Guillemot *(Cepphus grille)*		13
Atlantic Puffin *(Fratercula arctica)*		538
large alcids[2]		1,810
Total Corpses		**10,862**

[1] Includes total number of specimens, both complete and partial corpses.
[2] Specimens not identified to species.

base of feathers, 10-25% oiled; (3) heavy oil, >25% oiled. Incomplete corpses, with less than 75% of the plumage present, were categorized as Code 4. We recorded the presence of oil on incomplete corpses, but except where noted the oiling rates presented are based on complete and largely intact corpses, so they are comparable with protocols and results reported in other published studies of this type.

On Sable Island, corpses may be rapidly buried by windblown sand, and then exposed again days to months later. Consequently, some corpses recorded during surveys were up to several months old, having been buried and missed during previous surveys. When possible, the month of beaching was estimated based on the freshness of tissues, degree of scavenging, effects of sandblasting on feathers, or marking of corpses between surveys. Except for fresh specimens, most corpses found in surveys conducted during the first week of the month were considered to have beached during the preceding month (e.g., a bird found during a survey done on May 4th would be considered to be an April corpse).

For corpses of large alcids that were comprised of only wings and few or no other body parts, or largely intact corpses missing the head and/or tail feathers, it was not practical to distinguish among Razorbill, Common Murre, and Thick-billed Murre, and these were recorded as “large alcids”.

In addition to oil on bird corpses, the occurrence and distribution of oil on the beach was recorded during surveys between 2006 and 2009. Events occurring prior to 2006 were reported by Lucas & MacGregor (2006).

Earlier Studies

Prior to the 1993-2009 program, three short-term beach surveys were conducted in response to particular oiling events. These were: January 1975; February-March 1984 during the *Shell-Uniacke G72* gas well blowout; and late December 1986. Also, the beach was surveyed in February, June, and October of 1985; and in February, April, May, June, September, and December of 1986. These surveys were restricted to areas within sections s3 to s6 and n3 to n6 (Fig 1b). Although the intervals between surveys in 1985-1986 varied from five weeks to several months, and *Larus* gull corpses were not recorded, the beach survey methods were otherwise similar to those of the 1993-2009 program.

Collection and Analyses of Oil Residues

Samples of petroleum residues were collected from corpse plumage and from the beach to represent pollution occurring on various locations of the island’s shoreline (i.e., the north and south sides, and east and west ends), and on various species and/or groups of birds. Samples were packaged in aluminum foil or in glass jars with foil covers, kept frozen, and delivered to a laboratory for gas chromatographic analysis (MacGregor & Associates, Halifax, NS).

Statistical analysis of annual trends

To assess annual trends in corpse density (oiled and unoiled) and oiling rate, data from individual species were pooled for shearwaters, gulls, and alcids. Northern Fulmars were analyzed separately because, unlike the other species, they had adequate sample sizes for analysis but could not be readily pooled into any of these taxonomic categories. Annual trends were first analyzed with generalized linear models (with Poisson links for densities and binomial links for oiling rate), but yielded excessive overdispersion even after corrections. Conse-

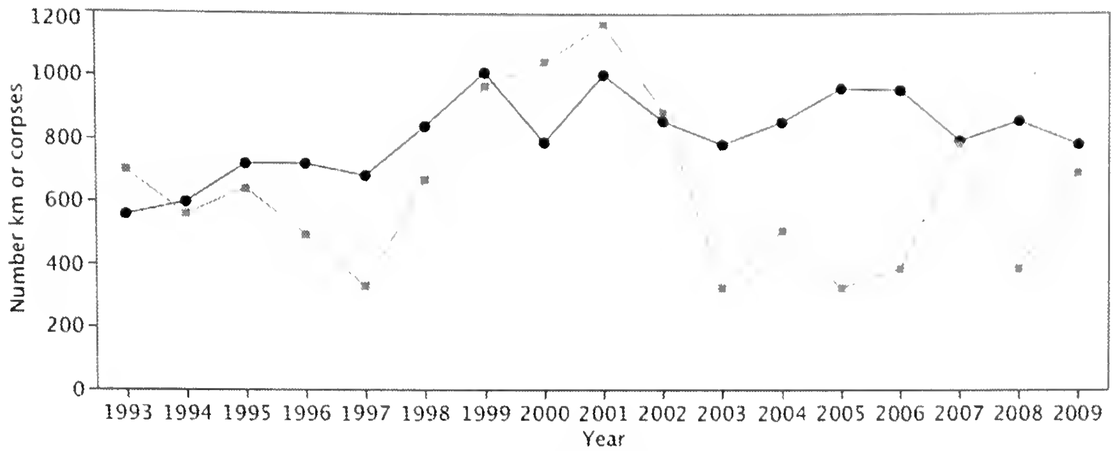

Fig 1c Total number of linear kilometres surveyed per year (black line), and total number of seabird and waterfowl corpses (all species and codes combined) recovered per year (grey line).

quently the data were transformed (log transformation for densities, arcsine transformation for oiling rate) and analyzed by least squares regression. Transformation yielded residuals with acceptably normal distributions (Shapiro-Wilk tests, $P > 0.05$).

RESULTS

Numbers of Corpses

A total of 171 surveys covering 13,770 linear km of beach (Fig 1c) was conducted between January 1993 and December 2009, and 10,884 bird corpses, representing 64 species, were found. Of these, 12 species (totalling 22 specimens) were landbirds or herons, which are birds not likely exposed to marine petroleum in the study area and are not considered further. The remainder (Table 1) was comprised mostly of three families: fulmar and shearwaters (Procellariidae), jaegers, gulls, and terns (Laridae), and alcids (Alcidae). The species with the highest frequencies of occurrence were Northern Fulmar, Herring Gull, and Great Black-backed Gull, being found in 75%, 67%, and 89% of surveys, respectively.

Fifty-two percent of seabird and waterfowl corpses recovered were complete (having >75% of all feather groups remaining). Complete corpses comprised 69% of shearwater specimens, 75% of *Larus* gulls, and 43% of alcids (Table 2). Of the 1,835 of corpses that could not be identified to species, 99% were large alcids and the rest were cormorants, storm-petrels, scaups, jaegers, and terns. Of 2,357 corpses of large alcids identified to species, 85.8% were Thick-billed Murre, 9.4% Common Murre, and 4.8% Razorbill. If it is assumed that these species occurred in a similar proportion among the 1,810 unidentified "large alcids," then the total estimated number of Thick-billed Murres found during the surveys was 3,578, Common Murres 391, and Razorbills 198. Thus, overall, Thick-billed Murres would have comprised 33% of all corpses recovered during the 1993-2009 survey.

Seasonal Trends

The seasonal average linear density of bird corpses for all species combined (complete and incomplete) across the 17 year sampling period, was 1.306/km-month in late autumn and winter (November-April), and 0.389/km-month in late spring and summer (May-October). Monthly variations in corpse numbers showed strong seasonal trends for some bird groups and species. Of the three main groups, 82% of shearwaters (Fig 2a) occurred in June and July, 50% of *Larus* gulls (Fig 2b) in January through April, and 98% of alcids (Fig 2c) in December through May.

Within gull and alcid groups, however, there were species-specific patterns. Herring Gulls showed some seasonality in occurrence, with 67% found during the March-July period when this species is establishing nests and raising young on the island. Great Black-backed Gulls also nest on the island, but 61% of corpses occurred in December

Fig 2 Seasonal occurrence of selected bird groups and species. All corpses (Codes 0 – 4), grey line; and complete corpses (Codes 0 – 3), black line.

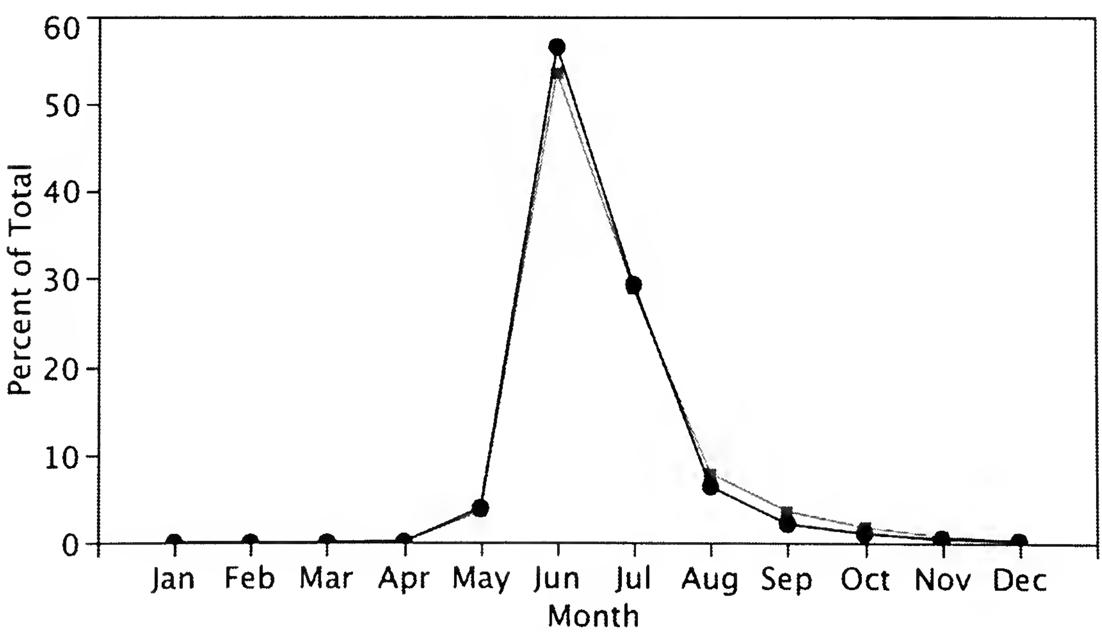

Fig 2a Shearwaters (Sooty, Cory's, and Greater). All corpses (n=1,773); and complete corpses (n=1,231).

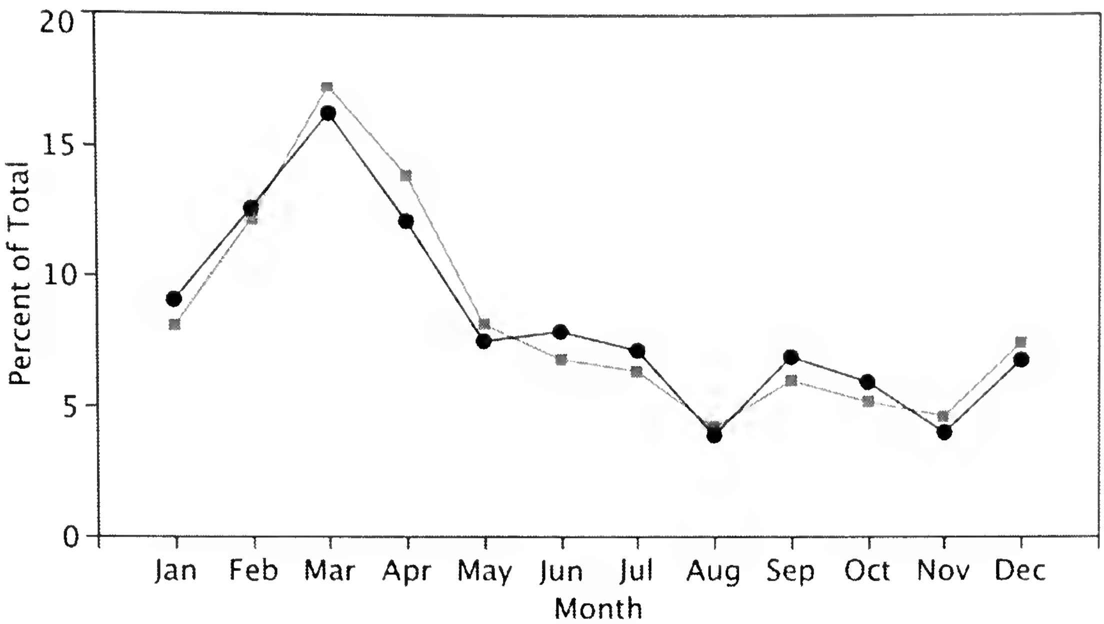

Fig 2b Larus gulls (Iceland, Herring, and Great Black-backed). All corpses (n=1,103); complete corpses (n=826).

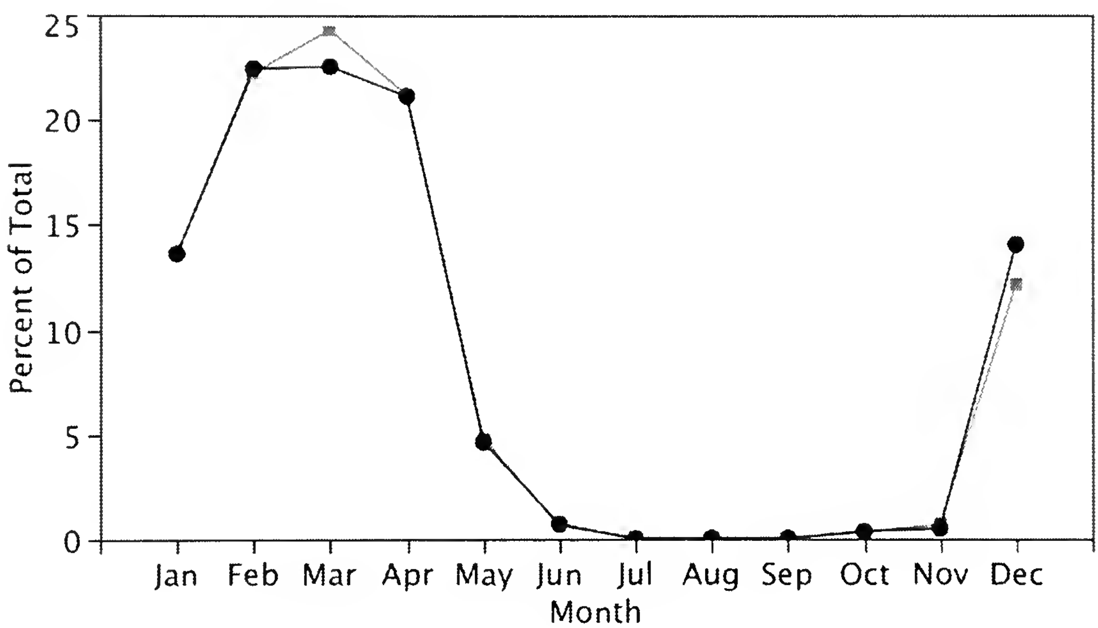

Fig 2c Alcids (Common & Thick-billed Murres, Razorbill, unidentified large alcids, Dovekie, and Atlantic Puffin). All corpses (n=6,593); and complete corpses (n=2,821).

through April. Most Black-legged Kittiwakes occurred during late fall through to early spring. The seasonal occurrence of large alcids was dominated by Thick-billed Murre, which greatly outnumbered Razorbill and Common Murre. Dovekie and Atlantic Puffin corpses peaked earlier in the winter. Although Northern Fulmar was recorded throughout the year, 69% of corpses were found in February through June (Fig 2d), and 71% of Northern Gannet corpses in October-December (Fig 2e). Only 5 of the 52 seabird and waterfowl species occurred in all months of the year during the 1993-2009 surveys:

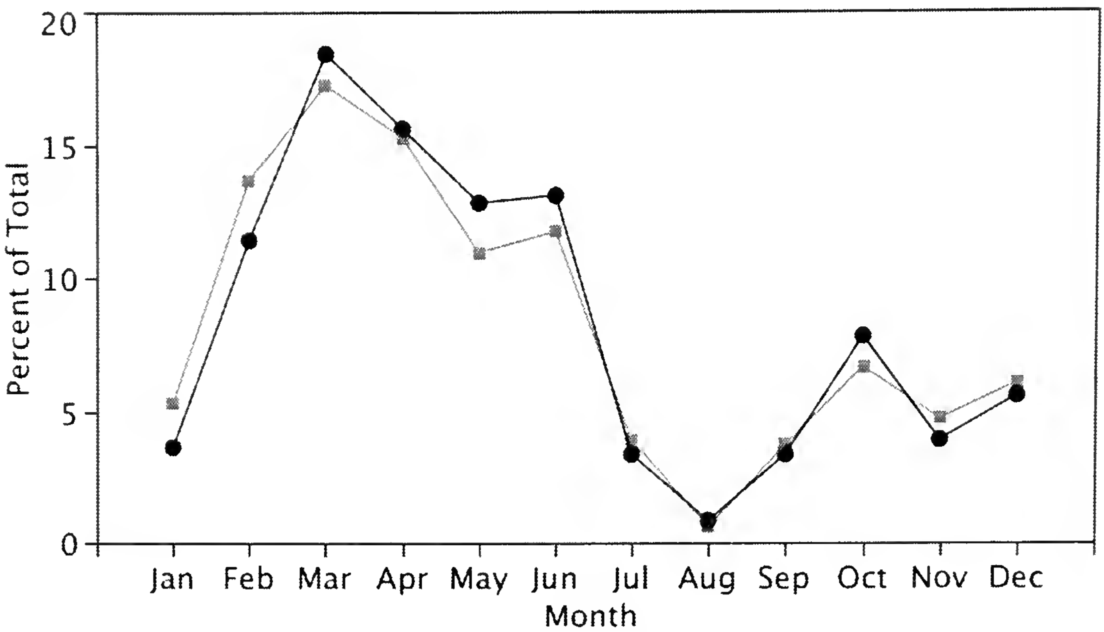

Fig 2d Northern Fulmar. All corpses (n=510); complete corpses (n=358).

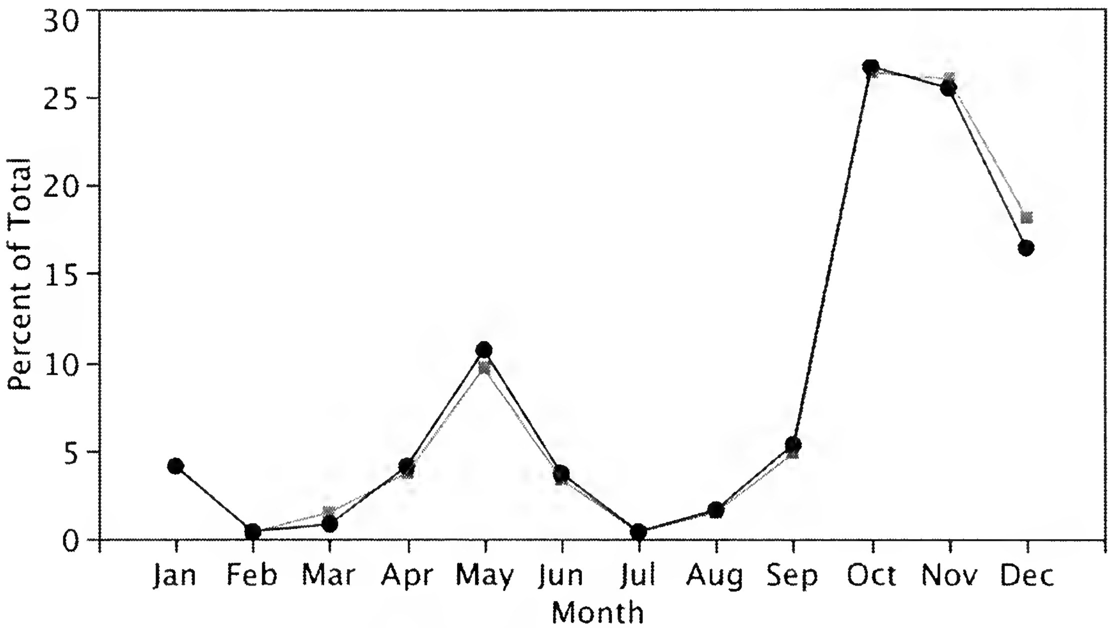

Fig 2e Northern Gannet. All corpses (n=269); and complete corpses (n=243).

Northern Fulmar, Northern Gannet, Herring Gull, Great Black-backed Gull, and Black-legged Kittiwake.

Linear Density of Corpses

The total corpse density (complete and incomplete corpses combined) averaged over the 17-year study period was 0.790 per km-year, with the annual density ranging from a low of 0.338/km in 2005 to a high of 1.322/km in 2000. The 17-year average corpse densities for the most abundant groups and species were:

- shearwaters 0.129/km (annual range 0.022 to 0.365/km) (Fig 3a)
- *Larus* gulls 0.080/km (0.039 to 0.156/km) (Fig 3b)
- alcids 0.479/km (0.105 to 1.047/km) (Fig 3c)
- Northern Fulmar 0.037/km (0.006 to 0.081/km) (Fig 3d)
- Northern Gannet 0.020/km (0.005 to 0.042/km)
- Black-legged Kittiwake 0.028/km (0.005/km to 0.054/km)

Except for alcids (Fig 3c), the annual density of total corpses and complete corpses did not show significant trends within the main bird groups (Figs 3a, 3b & 3d).

Fig 3 Annual density of selected bird groups and species, oiled and unoiled corpses combined. Tests of annual trends (on transformed data; see text). All corpses (codes 0-4, grey line); complete corpses (codes 0-3, black line).

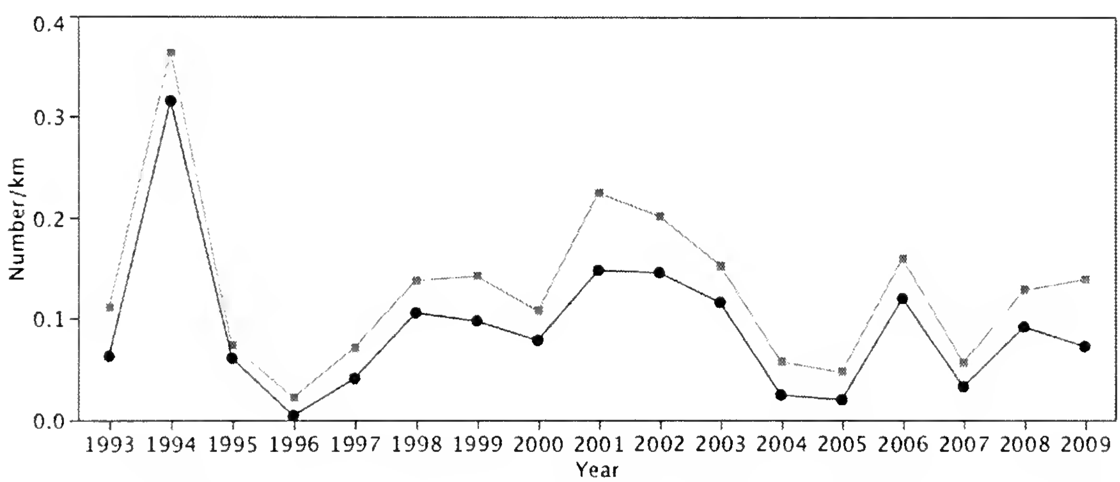

Fig 3a Shearwaters. Tests of annual trends: all Corpses, $F_{1,15}$=0.32, P=0.58; complete corpses, $F_{1,15}$=0.68, P=0.42.

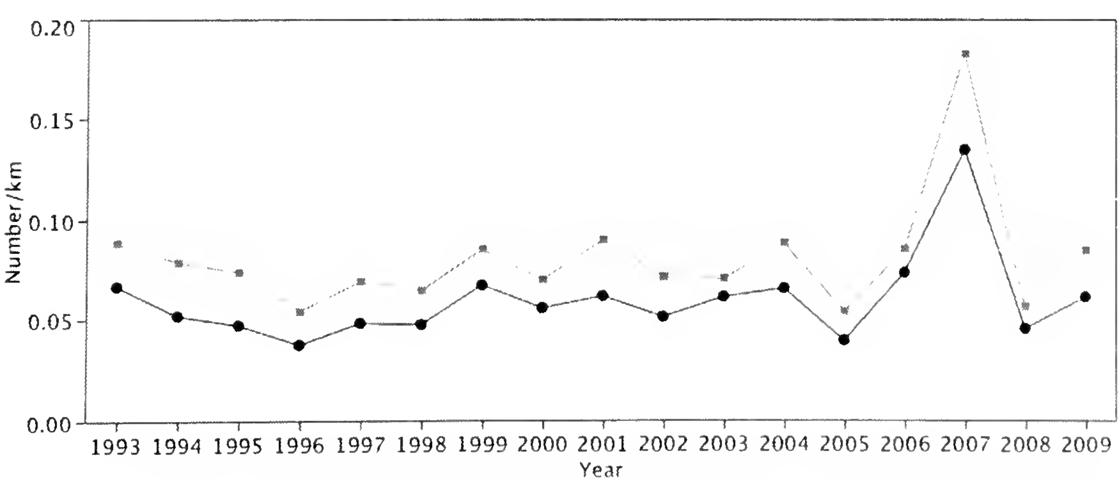

Fig 3b Larus gulls. Tests of annual trends: all corpses, $F_{1,15}$=1.03, P=0.33; complete corpses, $F_{1,15}$=2.11, P=0.17.

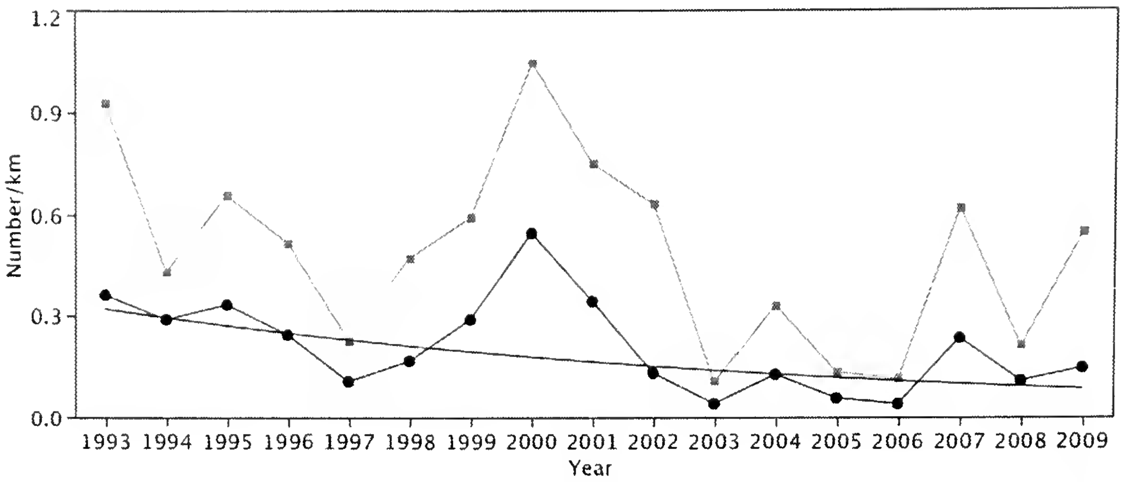

Fig 3c Alcids. Tests of annual trends: all corpses, $F_{1,15}$=3.01, P=0.10; complete corpses, $F_{1,15}$=6.18, P=0.03. Trend line fitted to transformed data (see text).

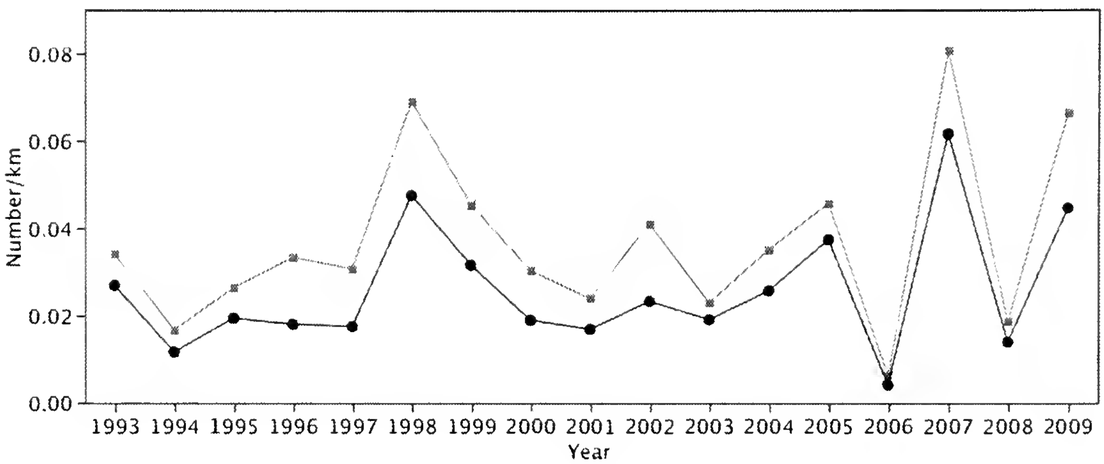

Fig 3d Northern Fulmar. Tests of annual trends: all corpses, $F_{1,15}$=1.28, P=0.28; complete corpses, $F_{1,15}$=0.90, P=0.36.

Spatial Distribution of Corpses

Fifty-nine percent of all corpses recovered during 1993-2009 were found on the north beach and 41% on the south. The linear density of corpses was 0.956/km and 0.628/km on the north and south beaches, respectively. However, when bird groups were examined separately, there were larger differences in corpse density of shearwaters and alcids between the north and south sides of the island. More than 75% of shearwaters occurred on the south side, while 71% of alcids were on the north. Razorbill was the only alcid species that did not occur more often on the north beach, with 47% recovered from the north side. Among other species, 54% of fulmars were found on the north beach, as were 47% of gannets, 56% of *Larus* gulls, and 64% of kittiwakes.

Incidence of Oil Contamination

Oiled corpses were recorded for 15 of the 52 seabird and waterfowl species found in the 1993-2009 surveys (Table 2). Of the 37 species not oiled, 30 were represented by ≤5 specimens and some are only incidental in the study region (e.g., Red-billed Tropicbird, White-tailed Tropicbird, California Gull, Lesser Black-backed Gull, Sandwich Tern, and Black Skimmer) (Table 1). Sooty Shearwater was the only species found in large numbers (i.e., 455 corpses) of which none were oiled.

Oiled corpses, complete and incomplete combined, occurred in all months, but 96% were in winter (November through April), and only 4% in summer (May through October) (Fig 4a). The preponderance of alcids in winter and early spring resulted in this seasonal peak of oiled corpses.

The proportion of oiled corpses (based on complete corpses, Codes 0 - 3), all species combined, was 29%, ranging from 70% (165 of 236) in 1996 to 1.4% (4 of 277) in 2009. Shearwaters (Fig 5a) and *Larus* gulls (Fig 5b) had the lowest overall oiling rate (3% of complete corpses were oiled), while alcids showed the highest rate (54% of complete corpses, Table 2, Fig 5c).

The extent of oiling on each corpse varied across species. As a group, alcids were typically moderately to heavily affected, with 55% being oiled on >25% of the body surface (Fig 4b). Some

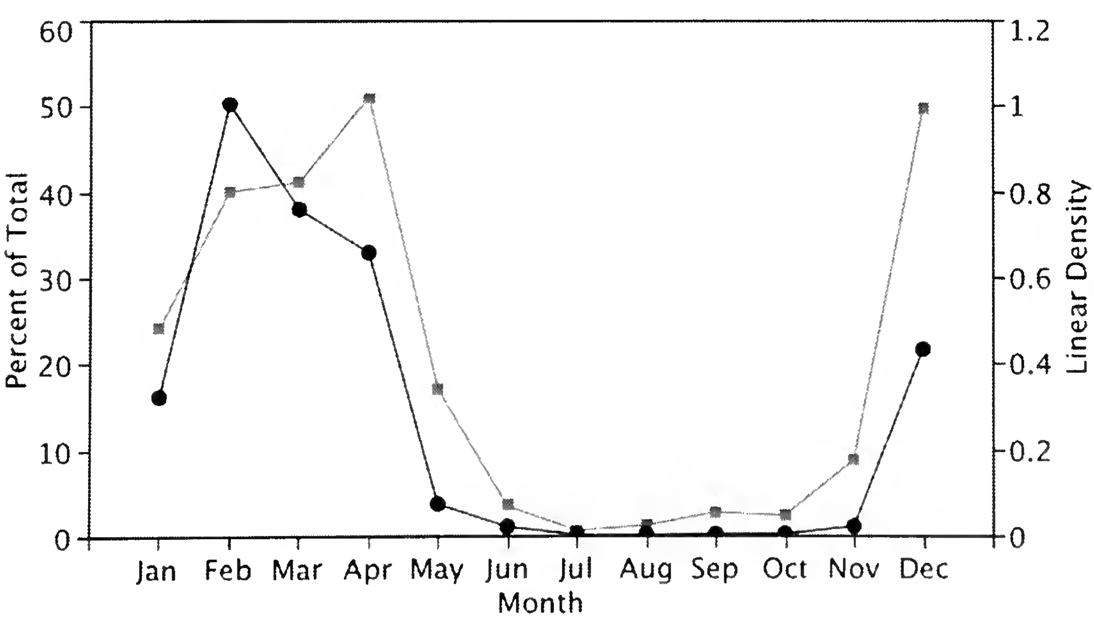

Fig 4a Seasonal incidence of oiling for species found oiled and represented by ≥10 corpses, complete and incomplete combined (see Table 2). Proportion of total corpses oiled (percent, grey line), and number of oiled corpses per kilometre (linear density, black line).

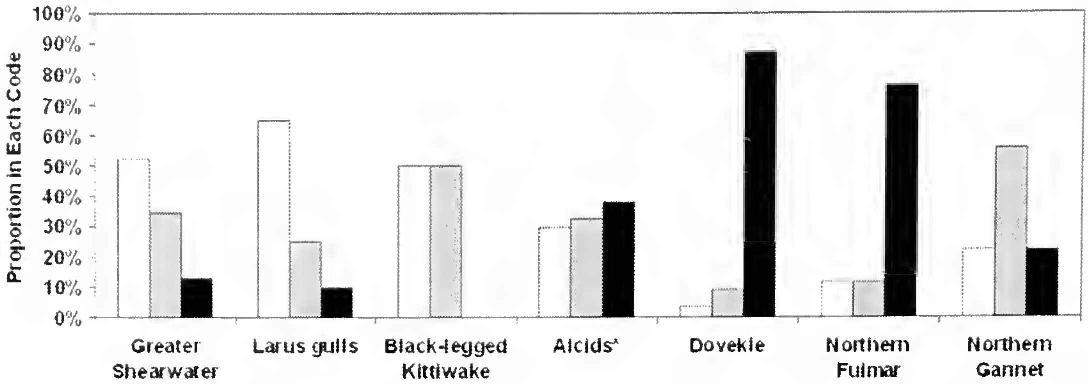

Fig 4b Proportions of the total samples of 7 taxa of oiled birds in 3 categories of oiling (proportion of body surface area oiled). Code 1 (<10%) white; Code 2 (10-25%) grey; Code 3 (>25%) black. *Alcid group does not include Dovekie.

Fig 5 Annual incidence of oiling for selected bird groups and species (complete corpses). Oiling rate (proportion of corpses oiled, grey line) compared with linear density of oiled corpses (number of oiled corpses/km, black line). For significant trends and those approaching statistical significance, trend lines were fitted with transformed data (see text).

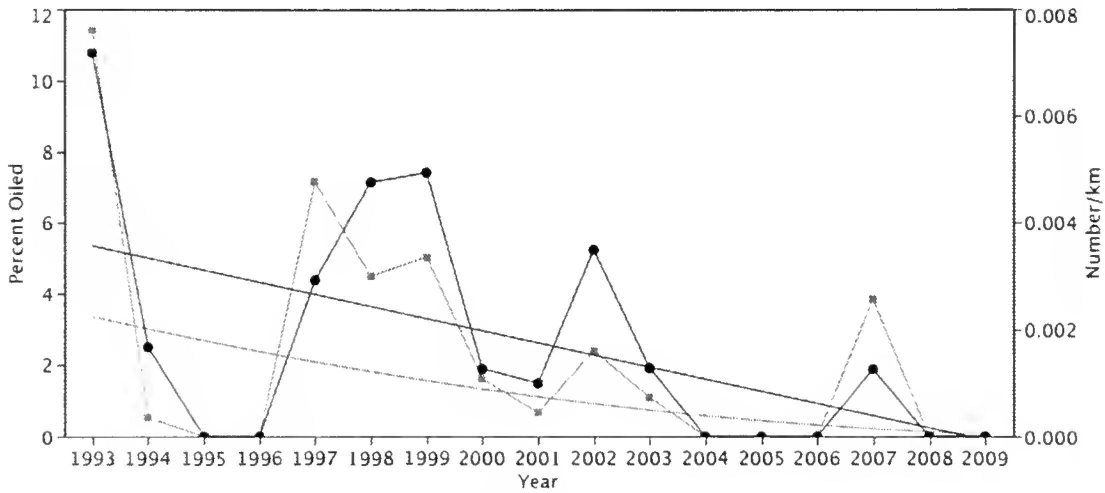

Fig 5a Shearwaters (n=1231). Oiling Rate $F_{1,15}$=3.67, P=0.07; Linear Density $F_{1,15}$=5.76, P=0.03.

complete corpses were entirely covered in a thick coating of heavy oil, usually with a harder outer crust that indicated weathering at sea. Of the 285 such corpses, 99% were Dovekies. Of non-alcid species, only Northern Fulmar tended to be heavily oiled, with 13 of 17 oiled complete corpses having oil on >25% of the body, and three of these were entirely coated. The proportion of corpses covered in a heavy coating of oil declined from an average of 24% in the 1990s, to 1.9% in 2000 and 8.3% in 2001, and none found afterward.

The annual proportion of unoiled complete corpses (Code 0) for the three main bird groups did not show a significant change over the 17 years of the study (all P > 0.05; Fig 6). Both the density of oiled corpses and oiling rate, however, declined significantly for alcids and

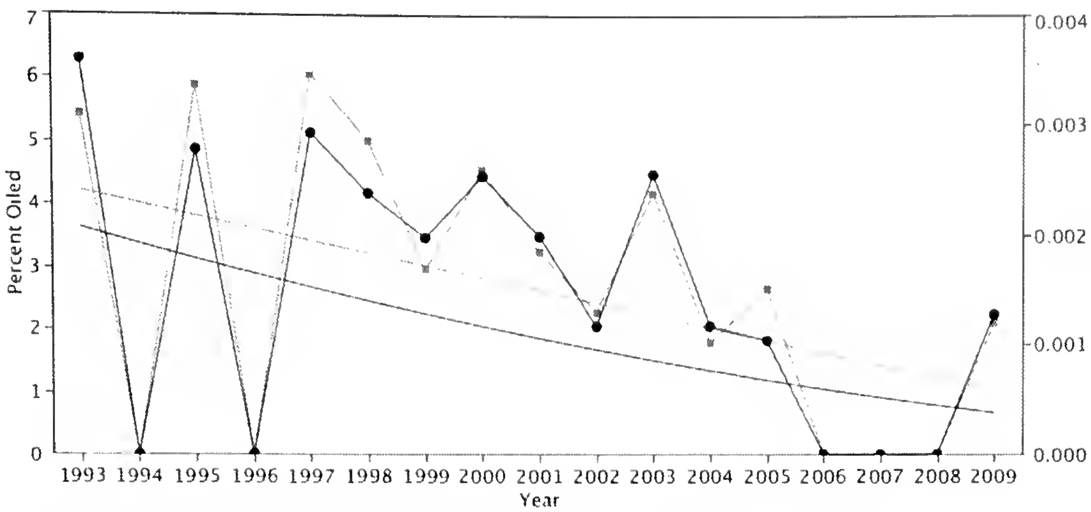

Fig 5b Larus gulls (n=826). Oiling Rate $F_{1,15}$=2.21, P=0.16; Linear Density $F_{1,15}$=4.46, P=0.05.

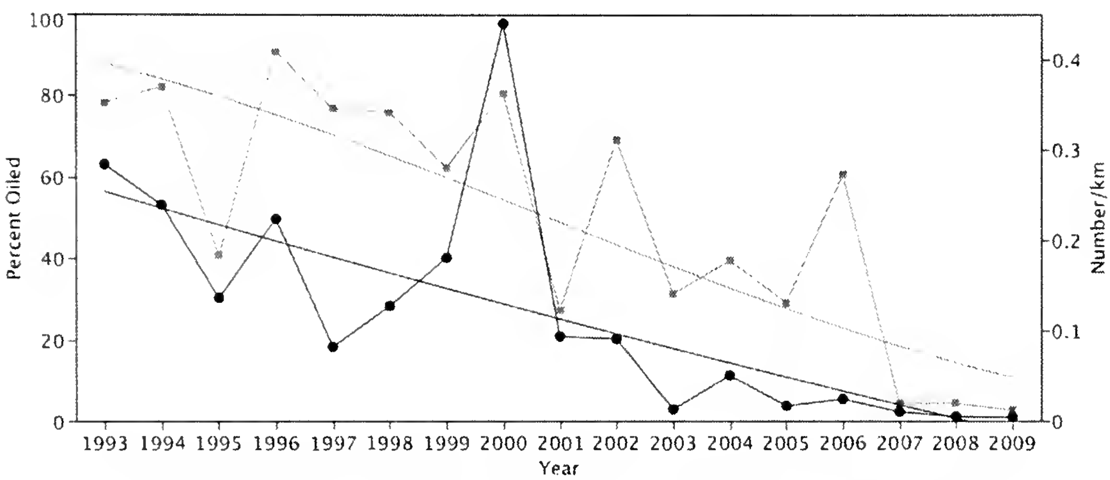

Fig 5c Alcids (n=2,821). Oiling Rate $F_{1,15}$=25.34, P=0.0001; Linear Density $F_{1,15}$=16.94, P=0.0009.

fulmars (Figs 5c & 5d), and in shearwaters and gulls the trends showed a weak tendency ($P \leq 0.16$) toward a decline (Figs 5a & 5b). Species-specific changes in the oiling rate, although not showing statistically significant negative trends, were evident in Razorbill, Common and Thick-billed Murre, Dovekie, Atlantic Puffin, and unidentified large alcids (Figs 5e, 5f, 5g, 5h, 5i & 5j). Further, the average species specific oiling rates for the most abundant species (Table 2) during the last five years of the study were markedly lower than the long-term annual averages. Similarly, the overall average oiling rate for all species combined (Table 2) during the last five years was 4.4% compared with 28.9% for the 17 years of the survey program.

No oil slicks were observed during the survey program, and no beached oil in the form of pelagic tar particles was recorded during surveys conducted in 2006 through 2009.

Table 2 Nineteen species represented by ≥10 complete corpses, plus the group of unidentified large alcids, listed in order of total corpses (complete and incomplete combined) recovered during the 1993-2009 beached bird survey program. The last column shows oiling rates, and numbers of complete corpses in brackets, for the last five years of the program. Oiling rates given as percentage.

Species	All Corpses Codes 0-4	All Corpses oiling rate	Incomplete Corpses Code 4	Incomplete Corpses oiling rate	Complete Corpses Codes 0-3	Complete Corpses oiling rate 1993-2009	Complete Corpses oiling rate 2005-2009
Thick-billed Murre	2,024	45.7	658	40.7	1,366	48.0	8.5 (271)
Dovekie	1,888	51.1	1,132	38.6	756	69.8	8.2 (97)
large alcids	1,810	55.1	1,608	53.2	202	70.3	33.3 (21)
Greater Shearwater	1,304	2.1	374	1.1	930	2.5	0.5 (207)
Great Black-backed Gull	759	3.0	161	4.4	598	2.7	0.5 (213)
Atlantic Puffin	538	21.0	307	15.3	231	28.6	9.6 (52)
Northern Fulmar	510	5.9	152	8.6	358	4.7	0 (136)
Sooty Shearwater	455	0	165	0	290	0	0 (84)
Black-legged Kittiwake	386	4.9	344	4.9	42	4.8	0 (8)
Herring Gull	271	1.9	96	2.1	175	1.7	1.4 (70)
Northern Gannet	269	3.4	26	0	243	3.7	4.3 (70)
Common Murre	221	53.9	43	58.1	178	52.8	17.1 (35)
Razorbill	112	48.2	24	33.3	88	52.3	25.0 (20)
Iceland Gull	73	1.4	20	0	53	1.9	0 (19)
Leach's Storm-petrel	29	0	11	0	18	0	0 (6)
Common Tern	28	0	18	0	10	0	0 (4)
Common Loon	19	57.9	1	100.0	18	55.6	0 (3)
Red-breasted Merganser	16	0	4	0	12	0	0 (6)

Table 2 *Continued*

Species	All Corpses Codes 0-4	All Corpses oiling rate	Incomplete Corpses Code 4	Incomplete Corpses oiling rate	Complete Corpses Codes 0-3	Complete Corpses oiling rate 1993-2009	Complete Corpses oiling rate 2005-2009
Red-necked Grebe	15	6.7	1	0	14	7.1	0 (6)
Cory's Shearwater	14	0	3	0	11	0	0 (5)
Total	10,741	30.7	5,148	32.7	5,593	28.9	4.4 (1333)

NB. Black Guillemot was the only species found oiled but represented by <10 complete corpses during 1993 to 2009. Of the 13 specimens recovered, 3 were complete, and 1 was oiled.

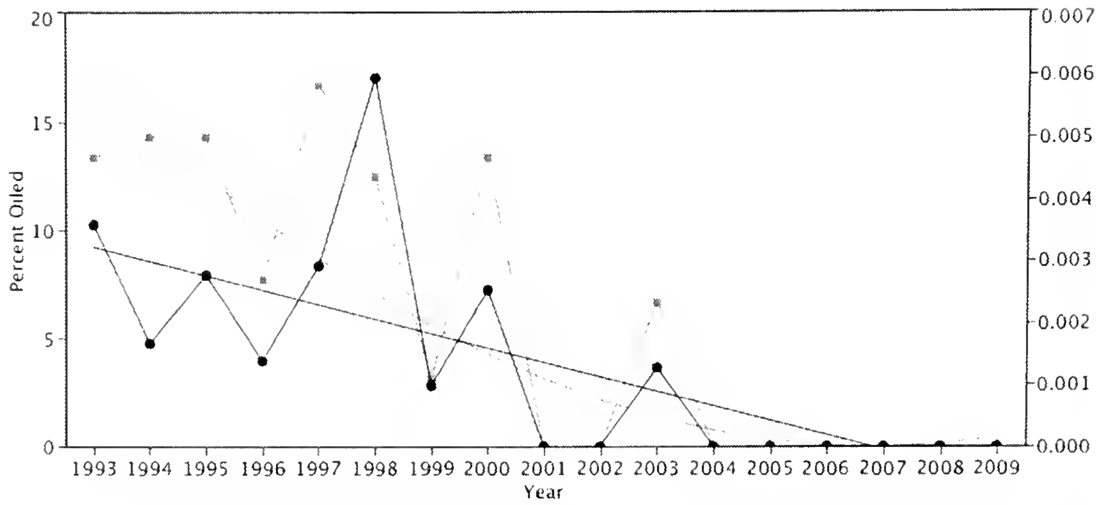

Fig 5d Northern Fulmar (n=358). Oiling Rate $F_{1,15}$=37.56, P=0.00001; Linear Density $F_{1,15}$=13.71, P=0.0021.

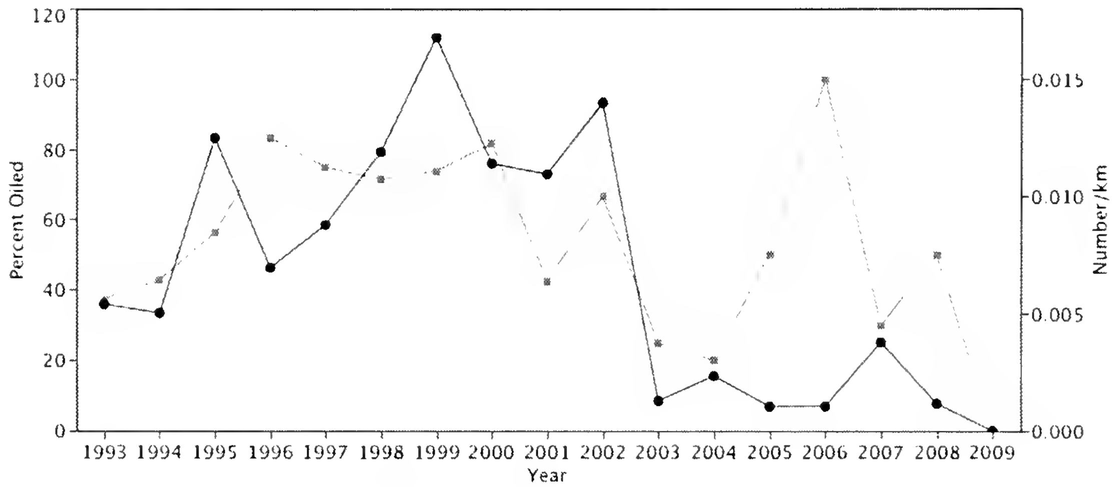

Fig 5e Common Murre (n=178).

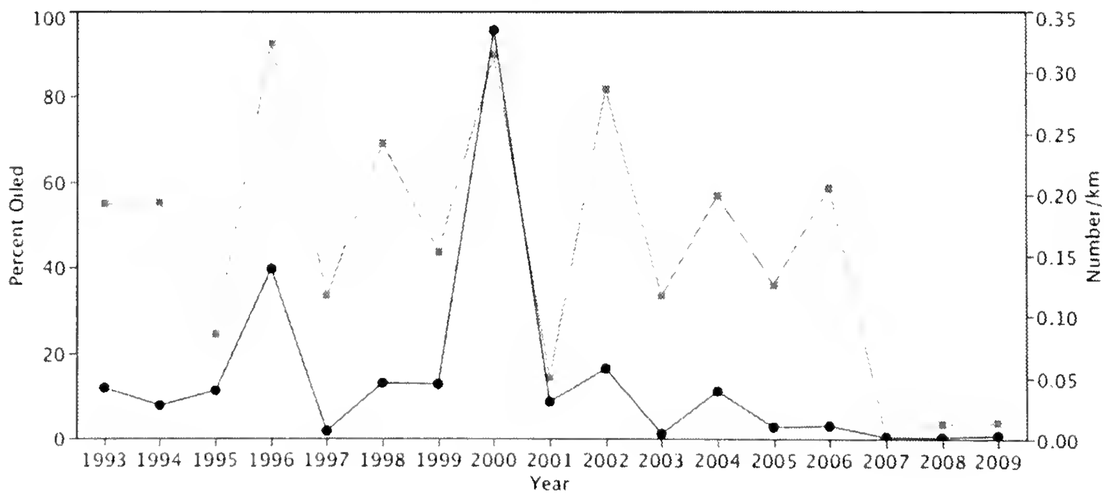

Fig 5f Thick-billed Murre (n=1,366).

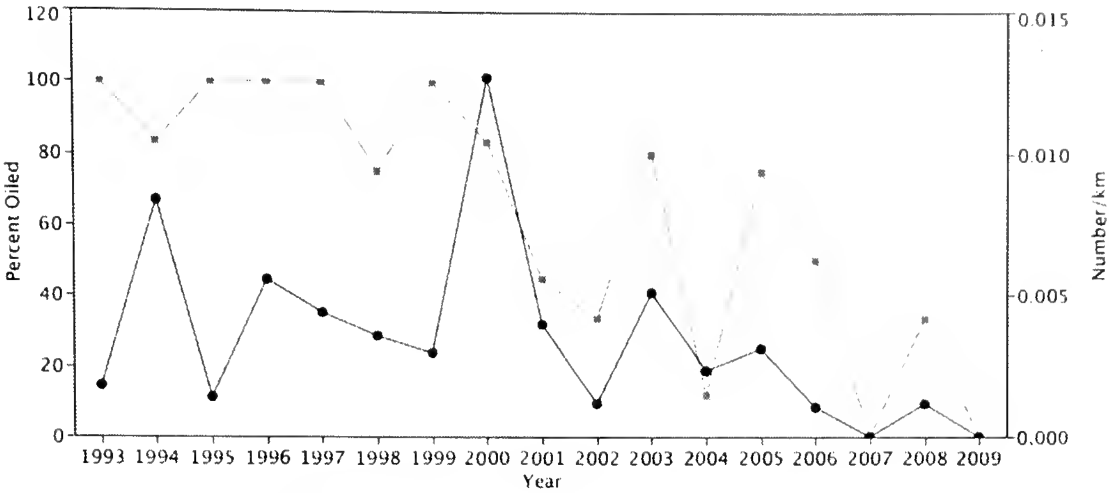

Fig 5g Razorbill (n=88).

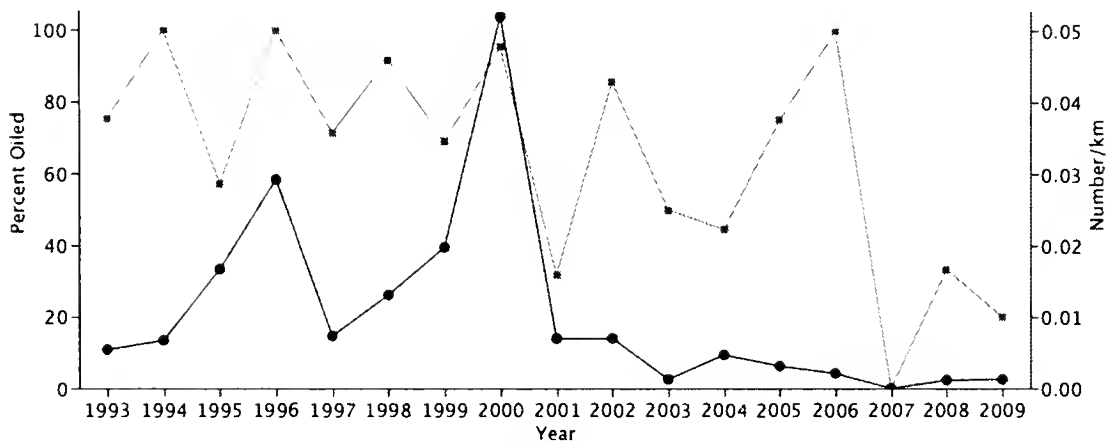

Fig 5h Large unidentified alcids (n=202).

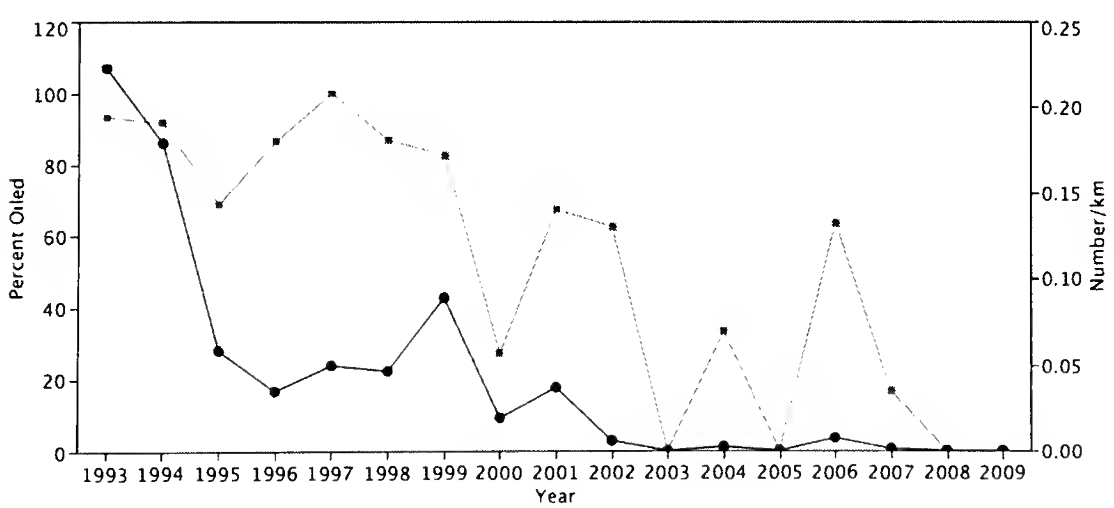

Fig 5i Dovekie (n=756).

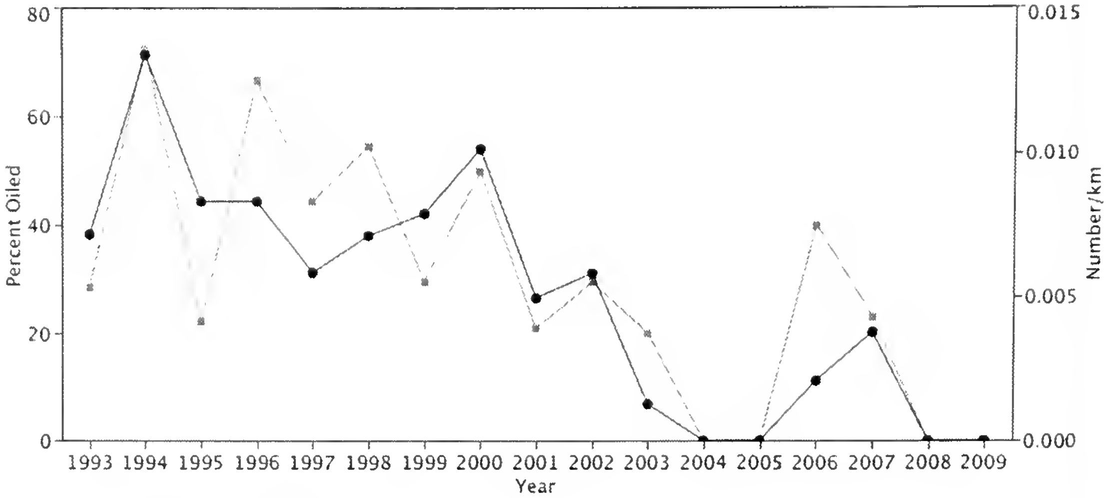

Fig 5j Atlantic Puffin (n=231).

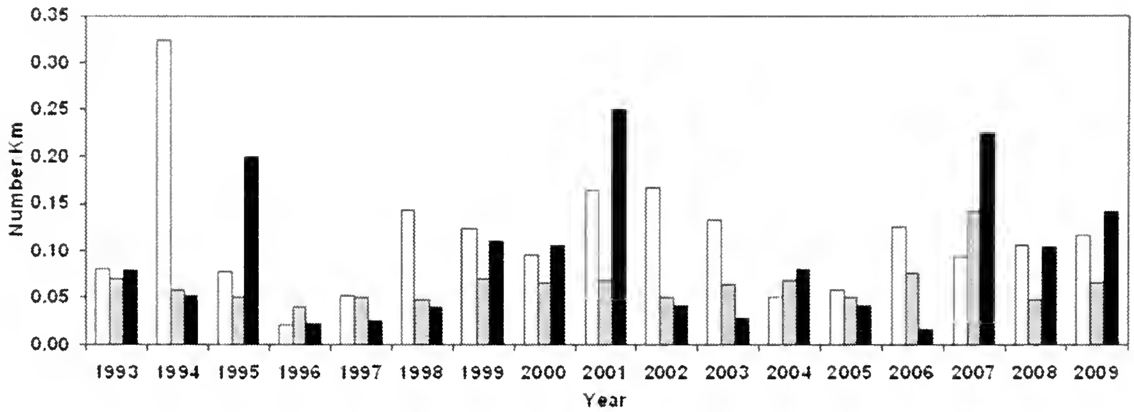

Fig 6 Annual density of complete unoiled corpses (code 0) for the three main bird groups. Fulmars and shearwaters (n=1,552, white); skuas, gulls and terns (n=881, grey); alcids (n=1,291, black).

Additional Observations—Beaching of Shearwaters in July 1994

One week after completion of the June 1994 beached bird survey, a large number of shearwaters came ashore along the south side of the island. Most were recently dead, or dying, while others appeared to have been dead and floating in the ocean for a longer time. A between-surveys count found that of 274 intact corpses (261 Greater, 12 Sooty and 1 Cory's), 1.8% were oiled; four Greater Shearwaters were lightly oiled and the single Cory's Shearwater was heavily oiled. None of the shearwater corpses were removed from the beach, and 64 were marked with coloured wire. Recovery of 40% of the marked birds during the scheduled survey three weeks later suggested that 400 or more birds may have beached in the interval between surveys. This incidental observation was not used to adjust the 1993-2009 survey data, which are based on corpses found during the actual survey periods.

Table 3 Summary of observations from three beached-bird events at Sable Island.

	Jan 21-Feb 02 1975	Feb 27-Mar 06 1984[1]	Dec 22-30 1986
South beach survey (km)		28	30
North beach survey (km)	3	28	28
Survey duration (days)	10	8	9
Total corpses	482	757[2]	2,607
Distribution	95% on north	99% on north	96% on north
Corpses/km (north)	161	26.9	83.6
Oiling rate[3]	100%	<6%	100%
Bird groups/species	% of corpses	% of corpses	% of corpses
Northern Fulmar	0.0	0.3	0.4
Gulls	0.0	0.4	0.1
Alcids	100.0	99.3	99.5
Large alcids	22.2	3.7	3.0
Dovekie	75.5	95.6	94.5
Atlantic Puffin	2.3	0.0	2.0

[1] Beach survey conducted during *Uniacke G-72* gas blowout reported in Shell Canada Resources (1984).
[2] Few specimens were fresh or intact, and most may have beached during January.
[3] Proportion of all corpses found (i.e., complete and fragments).

Additional Observations—Previous Beached Bird Surveys, 1970s and 1980s

A number of comparable surveys of beached birds were conducted by the first author prior to the 1993-2009 monitoring program. These earlier surveys included investigations of three oiling events (origin of oil not identified) in January 1975, February 1984, and December 1986 (Table 3), and a series of nine additional surveys carried out between February 1985 and December 1986 (Table 4).

On January 21 1975, a large number of oiled bird corpses washed ashore on the eastern quarter of the north side of the island. It was only possible to survey a short section of beach, but between January 21 and February 2, 482 corpses were collected, all of them alcids and all oiled (Table 3). The density of oiled birds on this section of beach was 161/km. The corpses were not evenly distributed along the north side of the island, and there were very few on the south side. Therefore, the corpses found in this limited survey cannot be used to accurately estimate the total number beached on the island during this event, although it is likely that >1,000 oiled birds had washed ashore.

On February 22 1984, a gas blowout occurred at the *Shell Uniacke G-72* well located 20 km north of the eastern tip of Sable Island (Shell

Table 4 Comparison of oiling rate (%, complete corpses) for selected species and groups recorded in beach survey programs in Newfoundland and Sable Island. Total number of corpses (complete and incomplete combined) in brackets.

Species & Groups	NFLD [1,2] 1984-2006 winter	NFLD [1,2] 1984-2006 summer	Sable Is [3] 1985-1986 year-round	Sable Is [3] 1993-2009 year-round	Sable Is [3] 1993-2009 winter	Sable Is [3] 1993-2009 summer
Common Loon			0.0 (3)	55.6 (19)	58.8 (18)	0.0 (1)
Red-necked Grebe			0.0 (1)	7.1 (15)	7.7 (14)	0.0 (1)
Northern Fulmar	22.2 (18)	8.3 (22)	4.8 (21)	4.7 (510)	6.7 (318)	2.0 (192)
Greater Shearwater		6.8 (183)	0.0 (37)	2.5 (1,304)	33.3 (15)	2.3 (1,289)
Sooty Shearwater			2.8 (88)	0.0 (455)	0.0 (4)	0.0 (451)
storm-petrels			0.0 (3)	0.0 (44)	0.0 (10)	0.0 (34)
Northern Gannet	15.8 (31)	6.3 (142)	16.7 (6)	3.7 (269)	5.6 (145)	1.7 (124)
Common Eider	46.4 (71)	52.2 (66)	0.0 (1)	0.0 (4)	0.0 (4)	0
Long-tailed Duck	45.5 (15)		0	0.0 (2)	0.0 (2)	0
Ring-billed Gull		8.7 (30)	0	0	0	0
Herring Gull	12.2 (142)	6.6 (426)	nr[4]	1.7 (271)	3.8 (135)	0.0 (136)
Great Black-backed Gull	14.8 (55)	8.6 (22)	nr[4]	2.7 (759)	3.7 (497)	0.9 (262)
Black-legged Kittiwake		3.8 (770)	3.7 (27)	4.8 (386)	5.9 (324)	0.0 (62)
Razorbill			0.0 (3)	52.3 (112)	50.0 (100)	52.6 (12)
Common Murre	65.0 (163)	27.8 (328)	50.0 (4)	52.8 (221)	54.2 (206)	30.0 (15)
Thick-billed Murre	79.6 (472)	63.6 (112)	45.9 (98)	48.0 (2,024)	50.2 (1,859)	22.2 (165)
Dovekie	53.6 (386)	23.2 (213)	48.6 (140)	69.8 (1,888)	70.8 (1,850)	25.0 (38)
Black Guillemot	18.5 (77)	7.5 (124)	0.0 (1)	33.3 (13)	3.3 (12)	0.0 (1)

Table 4 *Continued*

Species & Groups	**NFLD [1,2] 1984-2006 winter**	**NFLD [1,2] 1984-2006 summer**	**Sable Is [3] 1985-1986 year-round**	**Sable Is [3] 1993-2009 year-round**	**Sable Is [3] 1993-2009 winter**	**Sable Is [3] 1993-2009 summer**
Atlantic Puffin	47.6 (25)	34.5 (34)	17.5 (40)	28.6 (538)	28.6 (517)	28.6 (21)
total alcids			41.9 (415)	54.3 (6,606)	56.0 (6,219)	26.5 (387)
large alcids[5]			40.3 (129)	51.1 (4,167)	53.2 (3,840)	26.6 (327)
All species combined	**69.0**		**29.6**	**28.6**	**42.7**	**3.5**

[1] Source Wilhelm et al. 2009.
[2] Although Wilhelm et al. 2009 report that for the Newfoundland program, linear density of oiled birds is a more reliable index, in their Table 1 the incidence of oiling for species is given as the oiling rate. Also, only "most common species" are listed, thus bird group and/or species identification for 213 corpses found in winter, and 127 found in summer, are unknown.
[3] Source, this paper.
[4] Larus gulls were not recorded as per the 1983-1984 survey protocol used by the Canadian Wildlife Service (Lock 1992).
[5] Common & Thick-billed Murres, Razorbill, and unidentified large alcid corpses combined.

Canada Resources Limited 1984). Monitoring of the north and south beaches began on February 27, with daily surveys until March 6. A total of 757 beached corpses was collected (Table 3), with visible oil residue occurring on <6% of them. Species oiled were Northern Fulmar, large alcids, and Dovekie. Few corpses were complete, and many were not fresh and had been on the beach or in the water for some time. An unknown proportion of the birds collected was probably beached in January, prior to the blowout, because on January 22 about 300 unoiled Dovekie corpses had been counted on a 12 km section of the north beach. Although oiled birds collected offshore after the February incident were found to be oiled with condensate from the blowout, gas chromatographic analyses of residues collected from bird corpses found on the beach during this eight-day period indicated that they were composed of Bunker-C rather than gas condensate (Shell Canada Resources Limited 1984).

Nine beached bird surveys were conducted in 1985-1986 (Table 4). A total of 415 alcid corpses was recovered, of which 42% were oiled, accounting for 98% of all oiled birds. Sooty Shearwaters comprised 70% of the shearwater corpses, of which two (both Sooty) were oiled.

On December 21 1986, only three days after the completion of the above series of surveys, a large number of heavily oiled corpses washed ashore. The shoreline was surveyed again, and between December 22 and 30, a total of 2,607 oiled corpses was recovered from the north and south sides of the island (Table 3). Most occurred on the north side, and those on the south washed ashore about five days after corpses had beached on the north side. About 98% of the oiled corpses were enveloped in heavy oil, and the rest had patches and smears of oil on wings and underparts.

DISCUSSION

The results of 171 beached bird surveys conducted between 1993 and 2009 on Sable Island, combined with limited observations from as early as 1975, indicate a markedly declining trend in the incidence of oiling. This decrease in both the oiling rate and the linear density of oiled corpses is consistent with both the lack of beached pelagic tar events observed after 2003 (Lucas & MacGregor 2006), and the absence of corpses entirely coated in oil after 2001.

Seasonal Distribution

Of the 38 pelagic and coastal seabird species commonly found offshore in Atlantic Canada (Brown et al. 1975, McLaren 1981, Lock et al. 1994), 27 were recorded in the 1993-2009 surveys on Sable Island. Of the 52 species of seabird and waterfowl recovered (Table 1), 15 are frequently seen flying or feeding near Sable Island, including those nesting on the island, while 12 are only occasionally sighted (1 to 5 individuals per year) and others are rare vagrants (McLaren 1981).

There were species-specific variations in the numbers of beached corpses. The differences reflected local abundances associated with the phenology of reproduction, feeding, migration, and wintering. During the summer and winter there is a large influx of non-breeding birds into the north Atlantic Ocean, including in the study region, with the greatest densities occurring near the edge of the continental shelf and on shallow banks (Brown et al. 1975, Lock et al. 1994). Post-breeding Dovekie, Thick-billed Murre, Black-legged Kittiwake, and Northern Fulmar are particularly abundant in the region during September through March. During the summer millions of other birds migrate north from the Southern Hemisphere to spend their non-breeding season in the northwest Atlantic. Greater and Sooty Shearwaters are on the Scotian Shelf in May through September (Chardine 1995), and flocks of as many as 5,000 birds have been observed sitting on the water near Sable Island (McLaren 1981). Corpses of Northern Fulmar were most abundant in March through May, somewhat earlier than might be expected based on their seasonal peak abundance reported by Lock et al. (1994), and with a lesser high in October-November. Corpses of Northern Gannet occurred most frequently in October through December, during the period when this species disperses southward from its breeding colonies north of the study area, to overwintering habitat between New England and the Gulf of Mexico (Mowbray 2002). Bird corpse numbers peaked in winter, and alcids comprised the majority recovered, reflecting the predominance of arctic-breeding birds, such as Thick-billed Murre and Dovekie, which overwinter in the region (Brown 1985, Lock et al. 1994).

Bird corpses afloat in the open ocean are strongly influenced by wind speed and direction, with reported rates of drift ranging from 2.2% to 4.6% of the wind speed (Hope Jones et al. 1970, Bibby & Lloyd 1977, Bibby 1981, Flint & Fowler 1998). In the Sable Island Bank region there is a prevalence of winds from westerly quadrants at all seasons, in winter particularly from the northwest, and in summer and early autumn more so from the southwest. In late autumn and spring the westerlies are more variable. Moreover, the frequent passage of cyclonic systems through the region can result in strong winds, usually of short duration (a few days), from easterly quadrants (Environment Canada 1984). Prevailing winds, as well as seasonal abundance, largely account for differences between bird species and groups in corpse density on the north and south sides of the island. For example, the greater number of shearwater corpses found in summer reflects both their seasonal distribution and the predominance in summer of southerly and southwesterly winds that would move their corpses towards the island from areas of their greatest abundance to the west and south (Lock et al. 1994).

Oiled Seabirds and Waterfowl

It has been reported that bird corpses at sea lose buoyancy and sink after about eight days (Wiese 2003), and because they would not wash ashore, they account for an unknown proportion of birds oiled at sea that are not recovered in beach surveys. However, on Sable Island, scavenged corpses (Code 4) floating just below the surface or moving along the sea bottom are commonly seen within the surf zone and washing ashore (ZL unpublished observations). This may account for the higher proportion of incomplete corpses (48%) found on Sable Island compared with the 30% reported from surveys in southeastern Newfoundland (Wilhelm et al. 2009).

The relatively larger number of incomplete corpses found on Sable Island likely explains some survey results for which the oiling rate based on all corpses is higher than that based only on complete corpses (Table 2). The oiling rate expressed as a proportion of total corpses (complete and incomplete combined, Codes 0 - 4) is generally within four percentage points of the oiling rate as a proportion of complete corpses (Codes 0 - 3), and in some cases slightly exceeds the coded oiling rate. For example, the overall oiling rate for 1993-2009 based on complete corpses of the most abundant species (Table 2) is 28.9%, while for the same group of species the rate is 32.7% if based only on incomplete corpses (Code 4). The oiling rate for complete Common Murre corpses is 5.3 percentage points lower than that for incomplete corpses (Table 2). However, in the small alcids (Atlantic Puffin and Dovekie), the coded oiling rate markedly exceeds the rate for complete and incomplete corpses combined by 7.6 and 18.7 percentage points, respectively. Overall, these results suggest that for many species the indices of oiling based on total corpses are roughly comparable to those based on complete corpses.

On Sable Island the seasonal and annual variations in numbers of oiled birds were largely a reflection of the proportions of oiled alcids. Seabird species differ in their vulnerability to oil pollution, with the most susceptible being those that spend much of their time on the water roosting, swimming, and diving. Such birds, considered to be "primarily aquatic", include loons, grebes, cormorants, ducks, and alcids (Chardine 1995, Camphuysen & Huebeck 2001). The generally less vulnerable "aerial" species, which spend more time flying, include fulmar, shearwaters, storm-petrels, gannet, jaegers, skuas, gulls, and terns. Some of the latter are less susceptible than others. For example, Great Black-backed and Herring Gulls are surface-feeding seabirds that commonly roost on land; Northern Fulmars are also surface-feeding birds, but they generally roost on the water. This may account for the somewhat higher oiling rate for fulmars compared with *Larus* gulls at Sable Island, 4.7% and 2.5%, respectively. Similarly, Wilhelm et al. (2009) report winter oiling rates for fulmars that are higher than those for *Larus* gulls.

Seasonal variations in the occurrence of beached oiled corpses also reflected prevailing winds. If wind is the primary force directing the movements of floating bird corpses, it is likely that many oiled corpses found on Sable Island in winter represent birds that had encountered the pollution northwest through northeast of the island. Most of those found in summer may be birds affected in areas to the southwest through southeast of the island. However, some corpses are likely transported past Sable Island and then drift back towards the island when a change in wind direction occurs.

The higher proportion of oiled alcid corpses on the north beach in winter is consistent with the predominance of these birds in the region in winter, the prevalence of strong northerly winds, and the location of areas of heavy marine traffic to the north and northwest of the island. Fewer alcids are in these offshore waters during the summer, and this is reflected in the much lower proportion of oiled birds recorded on Sable Island during that season.

Shearwaters spend less time on the sea surface than alcids do, and are thus less exposed to oil pollution. Nevertheless, the relatively low oiling rate observed for shearwaters suggests that they do not often encounter oil in waters around Sable Island during the summer.

The small number (<0.5% of total birds recorded) of live oiled birds seen on Sable Island (Lucas & MacGregor 2006) contrasts with findings in some Newfoundland surveys, where 50-65% of oiled birds were found alive (Chardine & Pelly 1994). These authors suggested that because oil kills birds quickly in cold waters as a result of hypothermia, many of the birds found in coastal Newfoundland likely encountered the pollution relatively close to shore. Thus the low numbers of live oiled birds found at Sable Island may indicate that birds do not encounter the pollution close to the island.

Five species of seabird (two gulls, two terns, and one storm-petrel) and four of waterfowl regularly breed on Sable Island, albeit in relatively small numbers compared with the millions of non-breeding individuals that summer and winter in Scotian Shelf waters. However, the species that nest on the island, as well as those that overwinter there (e.g., Great Black-backed and Iceland Gulls, and Red-breasted Merganser), forage in or otherwise spend some time on waters surrounding Sable Island, and so would be exposed to any oil pollution in the vicinity. Nevertheless, there is a relatively low rate of oiling in these species.

Comparison with Earlier Surveys on Sable Island

The intervals between the nine surveys conducted in 1985-1986 ranged from 37 to 122 days, and the program covered less than two years, and so the observations are not fully comparable with those of the 1993-2009 program. The earlier results do, however, indicate similar trends in species composition and seasonal distribution of beached birds, and some useful comparisons can be made (Table 4). All 16 species found during 1985-1986 also occurred in 1993-2009. The proportions of the most frequently observed species were similar, although shearwaters were an exception. In 1985-1986, 70% of the shearwaters recovered were Sooty Shearwaters, but in 1993-2009 the proportions were reversed, with 74% being Greater and these outnumbered Sooty Shearwaters in all years during the latter program. The seasonal distributions of species in the surveys of 1985-1986 and 1993-2009 were broadly similar: most alcid corpses were found in winter and early spring, and most shearwaters in mid-summer.

The average oiling rate for all species combined was 29% in both the 1985-1986 and the 1993-2009 survey programs, and is higher than the 11% found in a program of 14 beach surveys carried out by Environment Canada on Sable Island between May 1983 and July

1984 (Lock 1992). However, Dovekie corpses, most of which (92%) occurred in a January 1983 "wreck" of that species, predominated in the Environment Canada surveys, comprising 74% of all birds found, of which only 3% were oiled. When Lock (1992) excluded the Dovekie corpses, the overall oiling rate for the 1983-1984 surveys was 34%. Also, Lock (1992) noted that an overall high proportion of oiled Northern Fulmars and shearwaters was the result of a single oiling incident in May-June 1984. The surveys of 1983-1984 (Lock 1992) and 1985-1986 were both of short duration, each undertaken for less than two years. The results of relatively short-term programs are more likely to be skewed by large events.

Although some of the annual and species-specific oiling rates from the first decade of our 1993-2009 monitoring program are higher than those found in earlier surveys on Sable Island, there were no large oiling events on the island during the 17 years of our study, comparable to those of January 1975 and late December 1986.

Comparison with Survey Results from Other Areas of Atlantic Canada

Campbell and Bredin (2007) reported on beach surveys conducted in Cape Breton, Nova Scotia, between 2001 and 2005. They found an overall oiling rate of 37.7%, with murres being the most frequently oiled. However, although Cape Breton is within 200 km of Sable Island, the total number of seabird and waterfowl corpses recovered (129) was very low compared with that of Sable Island, and of the 14 species recorded, only four were represented by >10 specimens (complete and incomplete corpses combined). Campbell and Bredin (2007) suggested that the predominance of offshore winds in winter explained the relatively small numbers of bird corpses observed in Cape Breton.

Although the decline in the level of seabird oiling observed at Sable Island during the latter half of the 1993-2009 is generally consistent with declines reported from Newfoundland (Wilhelm et al. 2009), the overall incidence of oiling was lower than that reported for southeastern Newfoundland (Wiese & Ryan 1999, Wilhelm et al. 2009). Also, there were differences in the seasonality of occurrence and species-specific oiling rates (Table 4) and in the proportions of species found, with Black Guillemot, Common Eider, and Black-legged Kittiwake being more frequently recorded in Newfoundland (Wilhelm et al. 2009). A much higher proportion of corpses, particularly those of alcids, was recovered at Sable Island during the winter (Table 5).

Oiling Rate and Linear Density of Oiled Corpses as Indices of Long Term Trends

The oiling rate is an international standard for presenting data from beached bird surveys (Camphuysen 1998). However, it is recognized that changes in non-oil related causes of bird mortality, such as extremely low temperatures, avian diseases, or starvation, can influence oiling rates by changing the 'background level' of clean corpses found in beached bird surveys.

Wilhelm et al. (2009) suggested that the oiling rate may not be a reliable index of long-term trends for vulnerable species in southeastern Newfoundland. They re-evaluated the use of the oiling rate because of a discrepancy in seasonal trends, and concluded that it was unreliable for assessing oil pollution in that region because they had observed a decline in mortality from other causes, such as birds drowning in fishing nets or killed or injured during the annual murre hunt (Wiese & Ryan 2003) which would have resulted in fewer unoiled birds found in the beach surveys. Consequently, they considered the linear density of oiled birds, rather than the conventional oiling rate, to be a more representative measure for quantifying trends in oil pollution in the Newfoundland region.

During 1993-2009, there was not a similar decline of unoiled murre corpses on Sable Island. Moreover, the Sable Island region is unlikely to be affected by changes in mortality factors associated with the murre hunt or coastal gillnetting, as occur in Newfoundland and Labrador. However, a change in natural mortality was detected on Sable Island in 2007, when the linear density of unoiled corpses of Great Black-backed Gull was more than double the long-term average (Fig 3b). This coincided with an outbreak of avian cholera in open-ocean seabirds in Atlantic Canada (McBurney et al. 2007). In this case, the increased natural mortality was not reflected in a 'decreased oiling rate' because no oiled gull corpses were recovered between 2006 and 2008.

Thus, even though the methods show similar trends, results from the Sable Island program generally indicate that beach survey data provide a better understanding of trends when the oiling rate is presented in the context of the linear density of bird corpses.

Table 5 **Comparison of proportions (%) of total corpses found in winter and summer in Newfoundland and Sable Island beach survey programs. Number of corpses in brackets.**

Beached Bird Corpses	NFLD[1] 1984-2006 winter	NFLD[1] 1984-2006 summer	Sable Is 1993-2009 winter	Sable Is 1993-2009 summer
Total Corpses (Codes 0 – 4)	45.7 (2,566)	54.3 (3,049)	72.2 (7,838)	27.8 (3,024)
Complete Corpses (Codes 0 – 3)	52.2 (1,796)	47.8 (1,646)	64.0 (3,617)	36.0 (2,033)
Aerial birds[2]	13.0 (246)	87.0 (1,640)	37.0 (1,538)	63.0 (2,622)
Alcids	62.4 (2,021)	37.6 (1,216)	94.1 (6,219)	5.9 (387)

[1] Source: Wilhelm et al. 2009.
[2] Fulmar, shearwaters, gannet, and Larus gulls, and includes storm-petrels at Sable Island.

Oil Contamination

Generic identification of oil residue specimens collected between 1996 and 2005 (Lucas & MacGregor 2006) indicated that they likely represented 74 marine oil discharge events, of which 77% were crude oils, 15% were bunker-fuel oils, and 8% were bilge-oil mixtures (Lucas & MacGregor 2006). An additional 42 samples were collected during 2006 to 2009, and the proportion of presumed discharge events involving crude oil was lower (59%) (Lucas & MacGregor, unpublished data).

The results of laboratory analyses suggest that in some cases, oiled birds found during a particular survey appeared to have encountered pollution from several different discharge events (Lucas & MacGregor 2006). This is consistent with the findings of other studies. For example, based on analytical data, Levy (1980) concluded that seabirds collected from the Nova Scotia mainland coast in 1976 were not victims of the then-recent *Argo Merchant* spill (Powers & Rumage 1978), but of a variety of other spills (e.g., weathered and unweathered fuel oil, and discharges of various oils that routinely occurred as a consequence of marine shipping and oil industries). Furness and Camphuysen (1997) suggested that chronic oil pollution is a constant process in which variable numbers of seabirds are exposed under variable conditions. Camphuysen (2010) states that the source of chronic pollution within the North Sea area has been comprised of ships' fuel oils rather than crudes, deliberately discharged with bilge waters.

Possible Reasons for a Decline in Incidence of Oiling Observed at Sable Island

The results of 50 years of beached bird surveys in the Netherlands showed significant declines in the oiling rates for most species and groups, indicating a reduction of chronic oil pollution in the southern North Sea (Camphuysen 1998, Camphuysen & Huebeck 2001, Camphuysen 2010). For example the oiling rate for Northern Fulmar declined from 71% in the 1960s to 21% in the 2000s, and for Razorbill, down from 99% in the 1960s to 64% in the 2000s (Camphuysen 2010). The decline in the linear density of oiled birds in southeastern Newfoundland reported by Wilhelm et al. (2009), and the decrease in the incidence of oiled birds at Sable Island (expressed as both oiling rate and linear density), suggest that there has been a similar reduction of oil pollution in the Northwest Atlantic.

These declines are likely due to a combination of initiatives, such as increased and more effective surveillance to detect illegal dumping of oily wastes, the routine use of onshore oil reception facilities, the ongoing retirement of single-hulled tankers, an increasing proportion of vessels with segregated ballast, the strengthening of laws providing for investigation and charging of suspected polluters, and education of ships' officers and crews about the consequences of illegal dumping. Increased public awareness about the environmental impacts of the exploration, production, and shipping of fossil fuels has supported the implementation and enforcement of legislation by governments of marine states worldwide (Camphuysen 2010).

In Canada, the Integrated Satellite Tracking of Oil Polluters (I-STOP) system became an enforcement tool in 2003, and Bill C-15, passed in May 2005, amended the Migratory Birds Convention Act of 1994, and the Canadian Environmental Protection Act of 1999. These amendments clearly establish that the Acts are enforceable within the 200 nm (320 km) limit of the exclusive economic zone of Canada, and they increase the accountability of ships' officers for oil discharges and enable authorities to impose heavier penalties. The timing of these changes in awareness, procedure, and enforcement is consistent with the recent declines in seabird and waterfowl oiling observed in southeastern Newfoundland and Sable Island.

SUMMARY

1. Although there were marked fluctuations in annual densities of bird corpses, as has also been reported from Newfoundland (Wiese & Ryan 2003) and the North Sea (Camphuysen 2010), beached bird surveys on Sable Island between 1993 and 2009, combined with observations from earlier surveys, indicate a declining trend in the incidence of oiling.
2. The decrease in the incidence of oiled bird corpses at Sable Island was evident in both the annual oiling rate and the linear density of oiled corpses.
3. This decline is consistent with a lack of beached pelagic tar events on Sable Island after 2003, and the marked reduction in the proportion of heavily oiled and entirely coated bird corpses, and likely indicates a diminishing intensity of oil pollution in the region's waters.
4. Results from the Sable Island program indicate that beach survey data provide a better understanding of trends when the oiling rate is presented in the context of the linear density of bird corpses.
5. For most species found as corpses at Sable Island, the oiling rate expressed as a proportion of total corpses (complete and incomplete combined) is roughly comparable with the oiling rate as a proportion of complete corpses only (i.e., coded oiling rate).
6. Generic identification of oil samples collected between 2006 and 2009 indicated that, as reported for 1996 to 2005 (Lucas & MacGregor 2006), most oil residues represented three categories of presumed discharge events: crude oils, fuel oils, and bilge oils. However, in 2006-2009, the proportion of discharge events involving crude oil was 59% compared with 77% in the earlier period.
7. While Sable Island serves as an excellent platform to monitor trends in the numbers and oiling rates of seabirds in the wider Scotian Shelf region, its seasonally resident seabirds and waterfowl provide an especially good indication of oil pollution in adjacent waters. The relatively low rate of oiling found in seabird species that commonly forage near Sable Island, and the small proportion of live oiled birds, suggest that the intensity of local oil pollution is not greater than occurs more generally in the Scotian Shelf region. This is in spite of the fact that offshore exploration and

production activities for natural gas have occurred close to Sable Island since the 1970s.

8. The long-term beach survey program on Sable Island provides useful information on trends in rates and generic sources of oil pollution, and in the species composition and seasonal distribution of affected birds. The data presented here provide a baseline against which future surveys can be compared. During the winter, Sable Island is generally downwind of areas where seabirds likely encounter most oil pollution, so the island is a useful platform for monitoring bird mortality in the region. Moreover, because Sable Island is roughly centered in an area of offshore oil and gas production, with generally increasing ship traffic, the island is important for continued monitoring of environmental impacts associated with these industrial activities.

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GROWTH AND OVERPOPULATION OF YELLOW PERCH AND THE APPARENT EFFECT OF INCREASED COMPETITION ON BROOK TROUT IN LONG LAKE, HALIFAX COUNTY, NOVA SCOTIA

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A fish survey was conducted on Long Lake, Woodens River, Halifax County, Nova Scotia during May 2005. A total of 2711 yellow perch were captured over a twelve day period and were the most abundant fish. Fifty-eight yellow perch were sampled for length, weight, scales, and sex. Total length of yellow perch ranged from 81mm to 276 mm with a mean of 133mm. Ages determined from scale analysis ranged from 2 to 13 years but 95% were younger than 8 years of age. Age at maturity was 2 years. The Von Bertalanffy growth relationship for yellow perch described slow growth and suggested stunting which is consistent in crowded populations. Increased abundance of yellow perch and reduced abundance of brook trout has been reported by anglers in the Woodens River system and was evident from our catches. The apparent effect of increased, intraguild competition on the brook trout population is discussed.

Keywords: yellow perch, brook trout, overpopulation, stunting, intraguild competition.

INTRODUCTION

Long Lake is located in Halifax County, Nova Scotia and is part of the Woodens River system. This watershed includes 19 connected lakes and flows southwest into Woodens River, eventually empting into St. Margaret's Bay for a total watershed area of 65 square kilometers (Fig. 1; WRWEO 2009). The underlying geology of the Woodens River drainage is characterized by shallow soils and exposed granite bedrock with limited groundwater, productivity, and natural buffering capacity against acid precipitation.

Located approximately 20 kilometers west of the Halifax city core, Woodens River watershed is impacted by a number of disturbances

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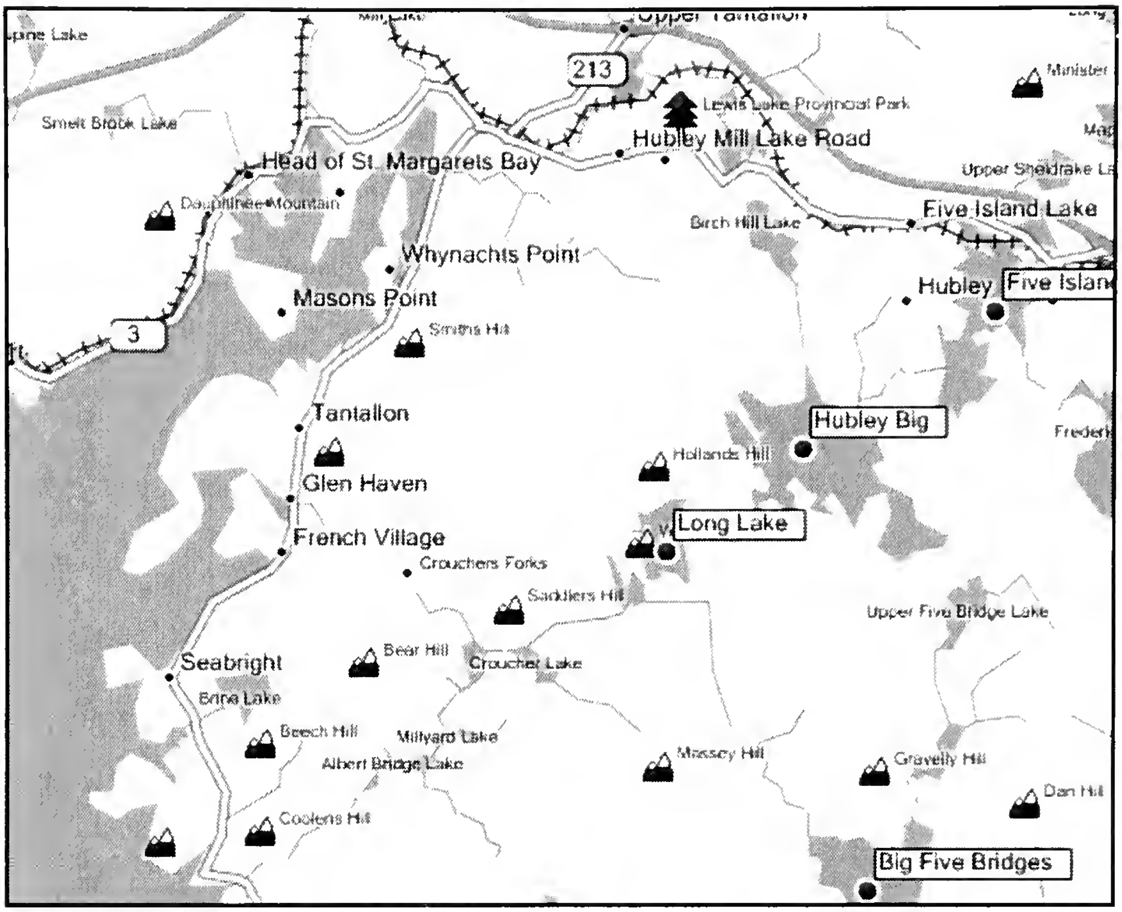

Fig 1 Map of study lake (Long Lake, 44.647233° 63.800773°) and surrounding Woodens River Watershed, Halifax County, Nova Scotia.

influencing the environment. In October of 1994 the Nova Scotia Department of Health announced that polychlorinated biphenyl (PCB) contaminants had been found in Five Island Lake in the watershed and in the tissue of resident fish captured (CCME 1994-95). This resulted in the issuance of a health advisory regarding local fish consumption. Land use such as high density residential development, commercial forestry operations and a heavy highway traffic use have also impacted water quality in the watershed.

In 2001 the Nova Scotia Department of Fisheries and Aquaculture designated the Woodens River system as a Special Management Area. The Woodens River Special Trout Management Area has been under catch-and-release only regulations. Seven fish species have been documented in Long Lake: American eel, *Anguilla rostrata (*Lesueur, 1817), banded killifish, *Fundulus diaphanous (*Lesueur, 1817), brook trout, *Salvelinus fontinalis (*Mitchill, 1815*),* alewife, *Alosa pseudoharengus* (Wilson, 1811*),* golden shiner, *Notemigonus crysoleucas (*Mitchill. 1814), white sucker, *Catostomus commersonii* (Lacepède, 1803*)* and yellow perch, *Perca flavescents* (Mitchill, 1814) (Stantec 2008).

Historically this system has been popular for its recreational brook trout fishing. An indication of a decline in the brook trout population of the Woodens River system was documented during the 1984 spring creel census conducted on Big Hubley Lake (O'Brien 1984). It was noted by recreational anglers to be the poorest capture season for brook trout ever. Anglers stated acid rain and extreme fishing pressure were to blame (O'Brien 1984). The specific reason for the decline in the brook trout population was not clear and was probably due to a combination of factors.

Inverse to the declining brook trout numbers has been an extreme increase in the population of yellow perch. It appears that this large population of yellow perch may have stunted growth characteristics commonly associated with overpopulation (Scott and Crossman 1973). Our work presents yellow perch sampling data that was conducted in Long Lake in 2005. These data are used to discuss the potential aquatic community shift and its impact on the brook trout population.

METHODS

Fish sampling was conducted in Long Lake between the 4th and 19th May, 2005. Ten small fyke nets and one large fyke net were used to collect fish. Each small net consisted of two hoop nets that were attached with a 0.5m x 5m lead. Each hoop net had a 0.5m circular opening that directed fish into a series of 6 circular hoops with funnels and finally to the bag end. The large fyke net had a lead (50m x 1m) and two (20m x 1m) wings that were attached to a $1m^2$ square opening that was framed with 3cm diameter hollow aluminum conduit. The net opening led to a series of framed funnels and to a bag end. Mesh size for small and large fyke nets was 1 cm^2. Nets were set perpendicular to the shoreline at a depth of less than 3m and for a minimum time of 1 or 2 nights. The total effort was 23 net-nights.

All fish collected were identified to species, enumerated and with the exception of 58 yellow perch samples, were returned live to the lake. The sample of yellow perch was frozen for later analysis.

In 2006, the yellow perch were measured for total length (TL mm) and, total weight (g). The yellow perch weight - length relationship was described from a power function as:

$$W = aL^b,$$

where W is the weight of the fish in g, L is the total length of the fish in mm, and a and b are constant parameters (Ricker 1975).

Fish were dissected to determine sex. Scale samples were collected from each fish and mounted on microscope slides. Scales were magnified (40x) using an overhead projector and a photocopy of the magnified scale was used to age perch. Two fisheries researchers determined ages and annulus marks on each scale. Total scale length and distances between focus and annuli were determined for the purpose of back-calculation of length at age for individual yellow perch.

A modification of the Fraser-Lee equation was used to determine the back-calculated length at age. This modification of the Fraser-Lee equation (Schreck and Moyle 1990) described the body-scale relationship as a regression:

$$L_i = a + (L_c - a)(S_i - S_c)$$

where L_i, the length in mm at age *i* is determined by inputting the known measurements of: length of fish at capture (L_c), distance from scale focus to scale annulus (S_i), total scale length and (S_c), and the intercept of the body-scale regression (*a*).

Growth was described by the Von Bertalanffy growth equation:

$$L_t = L_{inf}\,[1 - e^{K(t - to)}],$$

where L_t is the TL at time *t*, *to* is the size of the fish at age 0, and K the rate of growth (Schreck and Moyle 1990, Lackey and Nielsen 1980). The L_{inf} is calculated by dividing the y intercept (of the regression of L_t by L_t+1) by 1 - k (slope of the regression of L_t on L_t+1).

RESULTS

A total of 2786 fish were captured from Long Lake during this field study. Species captured included brook trout, yellow perch, white sucker, American eel and golden shiner (Table 1). A total of 2711 yellow perch were captured for a catch-per-unit-effort (CPUE) of 117.09 /net night, the highest of the study. Only one brook trout and one white sucker were captured for a CPUE of 0.04 /net night. Fifty-eight yellow perch were collected for detailed analysis of which 36 were female, 19 were male and 3 were unknown (Fig 2). Mean total length and standard deviation (SD) were 133±39 mm and TL ranged from 81mm to 276mm. Mean weight and SD were 39±18 g

Table 1 Fish species, number captured and catch-per-unit-effort (CPUE) in Long Lake, Woodens River system, Halifax County, Nova Scotia, during field sampling 4th to 19th of May, 2005. The CPUE is based on 23 net- nights of sampling.

Fish Species	Scientific Name	Number Captured	CPUE (Catch-per-unit-effort)*
American eel	*Anguilla rostrata*	69	3.00
Brook trout	*Salvelinus fontinalis*	1	0.04
Golden shiner	*Notemigonus crysoleucas*	4	0.17
White sucker	*Catostomus commersonii*	1	0.04
Yellow perch	*Perca flavescens*	2711	117.09

and weights ranged from 7g to 255g. The weight-length relationship for yellow perch was $Wt = 0.0001TL^{3.03}$ ($r^2 = 0.965$; Fig 3).

The mean age of yellow perch was 4.53 yr and age ranged from 2 to 13 yr (Fig 4). Seventy-six percent of the fish sampled were 5 years of age or less. Mean TL at age was 95mm for 2+ years, 110mm for 3+ years, 124mm for 4+, and 134mm for 5+ years (Table 2). The yellow perch Von Bertalanffy growth equation, $L_t = 349(1 - e^{-0.078(t + 0.74)})$ with a K of 0.078, illustrates extremely slow growth. Mean TL at age versus the calculated von Bertalanffy growth relationship was similar until age 6. At age 6 the mean TL made a sharp upward jump until age 8 when length change between year intervals slowed. The von Bertalanffy curve shows gradual length growth each year towards a plateau at the calculated asymptotic TL of 349mm (Fig 5).

DISCUSSION

Sampling bias associated with method of capture and time of sampling can influence the catchability of certain fish species and the size of the fishes captured. Ricker (1975) suggests the use of fyke nets will tend to select for faster growing and larger individuals in a population. For this reason, the rate of growth and mean size of yellow perch in our study may be slightly greater than the true population characteristics. Time of year is also a consideration as water temperature and seasonal influences can impact behavior and habitat usage of fish in a lake (Hayes and Livingstone 1955). By

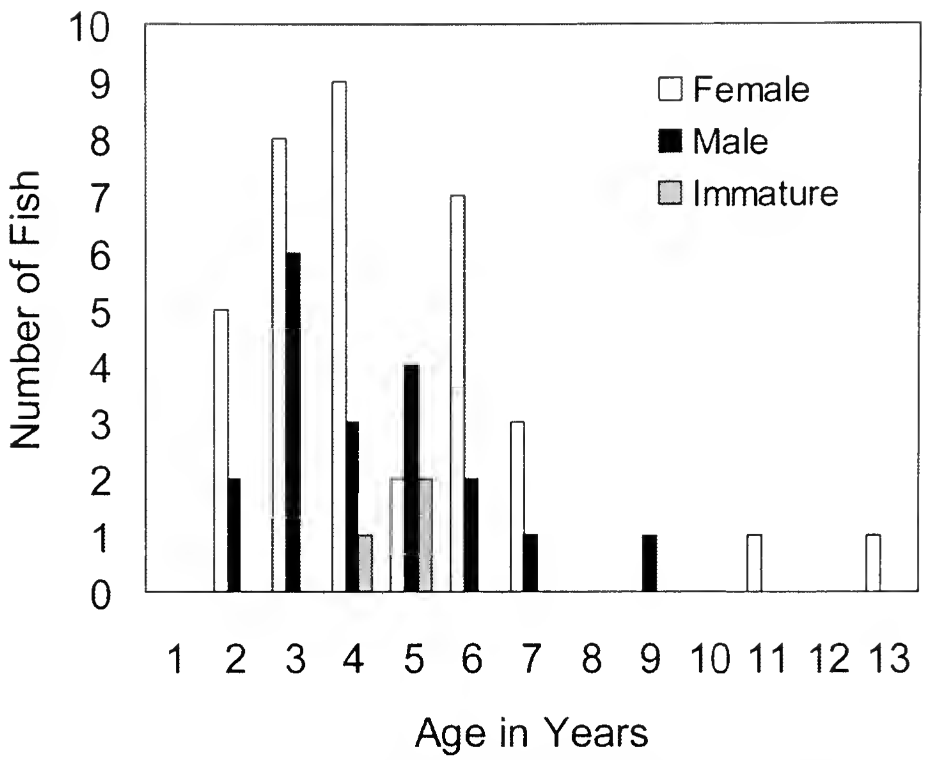

Fig 2 Age and sex structure of yellow perch captured in Long Lake, Halifax County, Nova Scotia, 2005.

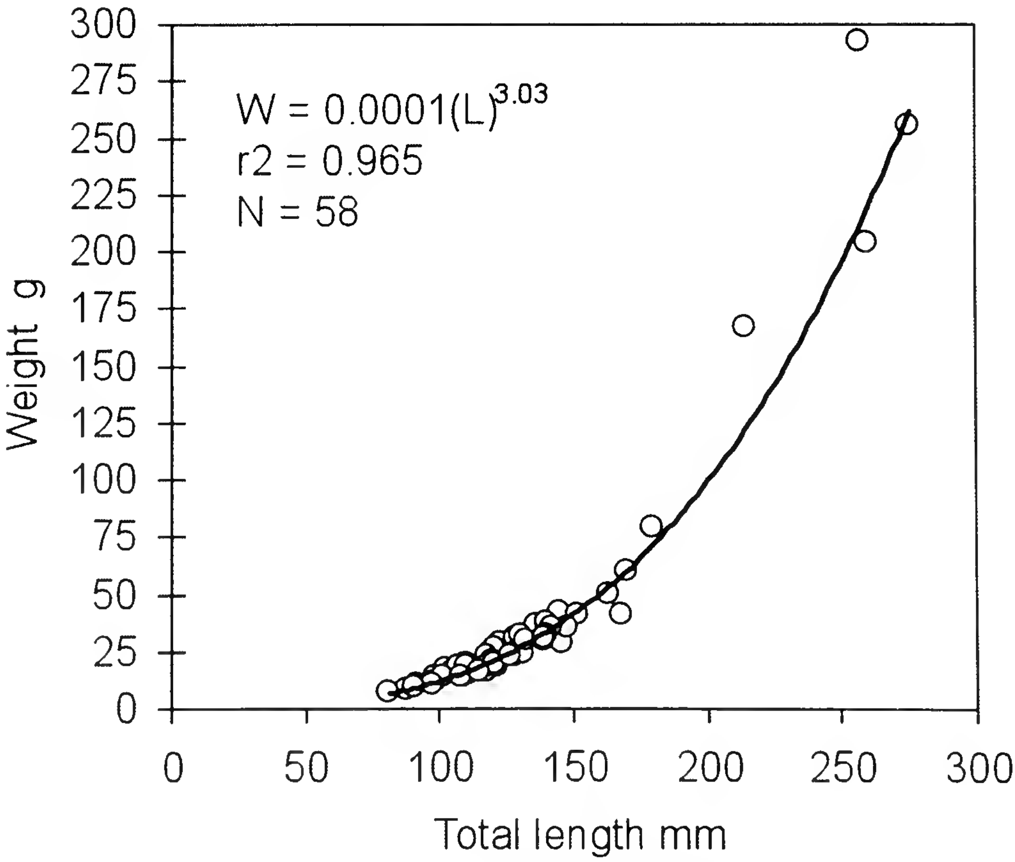

Fig 3 Weight - length relationship of yellow perch captured in Long Lake, Halifax County, Nova Scotia, 2005.

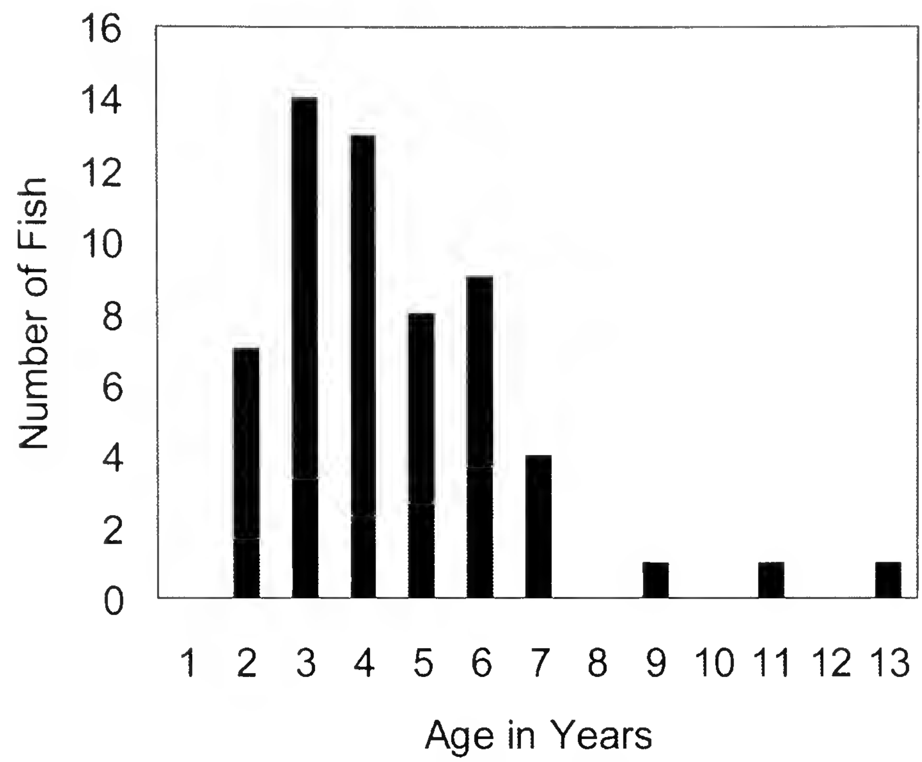

Fig 4 Age structure of yellow perch captured in Long Lake, Halifax County, Nova Scotia, 2005.

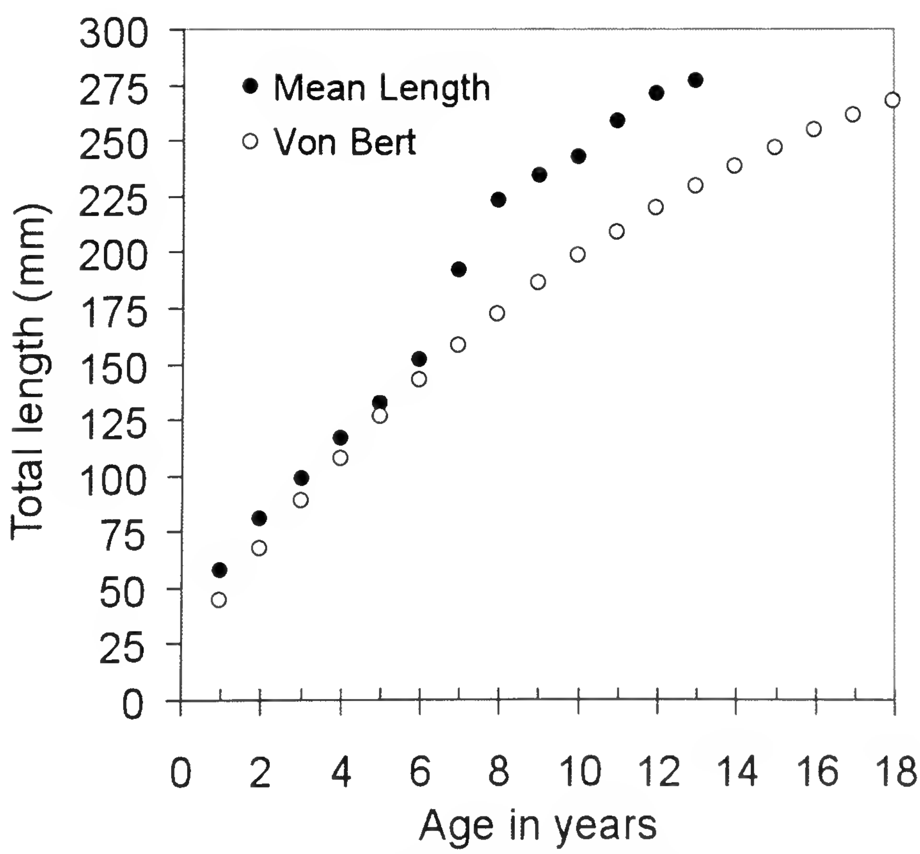

Fig 5 Mean total length vs age of yellow perch captured in Long Lake in relation to the calculated Von Bertalanffy relationship.

Table 2 **Average total length in relation to year class of yellow perch captured in Lake Jesse, Nova Scotia (Smith 1939) and Long Lake, Nova Scotia, 2005.**

	Average Total Length (mm)	
Year class	Lake Jesse (Smith 1939)	Long Lake (2005)
2+	92	95
3+	108	110
4+	125	124

sampling during May, sampling bias was minimized as yellow perch and brook trout are similarly active in shallow, littoral areas during this time of year and therefore the likelihood of capture was similar. During May, yellow perch are spawning and brook trout are actively feeding in the littoral zone, allowing us to interpret fyke net CPUE as an index of population density in Long Lake.

Growth of yellow perch is highly variable and limited documentation is available on the general population characteristics of stunted yellow perch in Nova Scotia. Smith (1939) described the stunted population of yellow perch in Lake Jesse, Nova Scotia as having a mean TL of 92mm at 2+; 108mm at 3+; 125mm at 4+. The mean TL at age observed by Smith (1939) in Lake Jesse were similar than those found in Long Lake in 2005. Scott and Crossman (1973) state that adult yellow perch found in crowded populations rarely exceed 152mm in TL. The mean capture TL of adult yellow perch (3+ years) found during our study was 110mm, with only 16% of the fish sampled exceeding 152mm TL.

The inability of brook trout to compete successfully with other species has been commonly noted (Fraser 1978; East and Magnan 1991; Flick and Webster 1992; Quinn *et al.* 1994). In lakes, the density of brook trout declines with an increase in competitive species. In a study of 16 Nova Scotia lakes it was found that in lakes with only one competitor species, the mean catch/net night of brook trout was 2.8, however, when three or more competitor species were present the mean catch/net-night declined to only 0.1 (NSDFA, unpublished data). Our catch of 0.4 trout/net-night in this study, suggests the population density in Long Lake may be similar to other lakes where the intraguild competition with other fish species is significant (Polis *et al.* 1989). As well, Quinn *et al.* (1994) also documented that brook trout density decreased with community complexity in Algonquin Provincial Park, Ontario.

White sucker, American eel, and yellow perch are found in Long Lake and all are considered to be direct competitors of brook trout (MacMillan *et al.* 2008). Yellow perch were found to be the most abundant fish present in Long Lake and are likely the most significant competitor with brook trout. Yellow perch are able to adapt and utilize a wide variety of habitats (Scott and Crossman 1973). Additionally, their high reproductive potential and effective feeding capacity make them highly competitive, leading to overpopulation and stunting (Scott and Crossman 1973). Recent research conducted by Browne and Rasmussen (2009) demonstrates that the intraguild predation between brook trout and yellow perch can result in a feeding niche shift which is unfavorable to brook trout abundance. In non-perch lakes juvenile brook trout were found to feed primarily in the littoral zone of lakes, however, in lakes containing yellow perch their feeding was predominately on pelagic prey, including larval perch (East and Magnan 1991; Browne and Rasmussen 2009). This documented niche shift corresponded to a decline in CPUE of brook trout (Browne and Rasmussen 2009). It is suggested that a shift to pelagic resource use at an earlier developmental stage for brook trout may result in a decrease in recruitment to larger-size classes, but Browne and Rasmussen (2009) comment that further research is required to test this hypothesis.

Brook trout shift to a piscivorous diet at approximately 250mm TL (Fraser 1978; Tremblay and Magnan 1991), at which time they are no longer competing for food with yellow perch. Brook trout, however, may experience reduced growth rates in the first two years due to competition with yellow perch and the above discussed niche shift. Browne and Rasmussen (2009) also found that the mean size of prey fish consumed by brook trout in non-perch lakes were smaller than that in perch lakes. This indicates that brook trout in perch lakes may have to grow to a larger size before shifting to a piscivorous diet due to limits on the size range of available prey.

Brook trout and yellow perch can naturally coexist. Yellow perch, especially the nektonic larvae, can be an important prey item for brook trout (East and Magnan 1991). The natural balance of these two species may be affected by numerous other factors. These include but are not limited to: habitat quality and quantity, recreational fishing pressure, competitive species, acidification, and global warming. Individual and combined effects of these factors may have altered the natural balance of yellow perch and brook trout in Long Lake.

The significance and implication of competition between yellow perch and brook trout is not clear. There are potentially additional factors impacting brook trout abundance within the Woodens River system. We suggest further research is required to quantify the factors inhibiting brook trout production. In the presence of these unknowns and to prevent further degradation of the resource, continued application of special management regulations is advisable.

Acknowledgements This project was partially funding through the Nova Scotia Freshwater Fisheries Research Cooperative. We thank Tara Marshall who participated in the data collection component of this project and Susan Wren who assisted in the aging and graphical presentation of the data. We also thank the current Director of Inland Fisheries, Don MacLean and his predecessor, Murray Hill, for providing resources for this survey.

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Proceedings of the Nova Scotian Institute of Science (2012)
Volume 47, Part 1, pp. 143

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[1] These papers were unavailable in usable format at the time of publication and may be published at a later date.

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Robert Paul[1]:

"The elusive causal association between gastro-esophageal reflux disease (GERD) or colon inflammation and atrial fibrillation (AFIB) and atrial flutter: A review of the literature and new case study."

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TURBIDITY CURRENTS: A UNIQUE PART OF NOVA SCOTIA'S AFRICAN GEOLOGICAL HERITAGE

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ABSTRACT

Four hundred million years ago, when the supercontinent Pangea was torn apart, a piece of the continental crust from material that is now part of Africa broke off on the North American side. That piece of Africa became southern Nova Scotia. The African rock was made of material deposited by ancient turbidity currents. Created by submarine landslides, turbidity currents still happen today. Whether evaluating these sedimentary rocks for oil and gas deposits or for building a city, or studying the possibility of future turbidity currents along the coast to be prepared for a tsunami, turbidity currents are studied by scientists because they have an impact on Nova Scotians.

Keywords: turbidite, turbidity current, Grand Banks earthquake, Meguma Group

'Late in 1929, many banks failed. Most of them were on Wall Street, but one was already under water, off Newfoundland.' (Nisbet and Piper 1998)

The events of November 18, 1929

As Newfoundlanders were sitting down for supper, just after 5pm on November 18, 1929, the ground beneath them started to shake. The earthquake on the Grand Banks of Newfoundland, only 265 kilometres from the Burin Peninsula, on the south coast of the Island of Newfoundland, measured 7.2 on the Richter scale and was felt on the Atlantic coast reaching from Newfoundland to New York (Heezen and Ewing 1952, Ruffman and Hann 2006).

The earthquake itself did little damage on land because the epicentre was about 20km below 2,000 m of water. It did, however, shake loose the sediment above and a great underwater landslide, or slump, occurred. When the sediment shifted downward, so did all the water directly above it. The surface displacement generated a high energy wave that propagated outward as a tsunami that was felt on the coast of the Avalon Peninsula and in parts of Nova Scotia, but was only devastating at the closest land, the south coast of the Burin Peninsula. The bays of the south coast of the peninsula are deep and become narrow near shore, which worked together to focus the wave energy. Consequently, the waves could grow and push far up onto the land. Unknown to Newfoundlanders, catastrophe was traveling toward them at the tremendous speed of approximately 144km/hr (Ruffman 1996).

The rumbling subsided and the sun went down on a calm ocean and clear, windless sky. Announcing its imminent arrival, about two and a half hours after the earthquake, the tsunami caused the water to drain from harbours around the Burin Peninsula. Then three large waves hit the coast within half an hour, rising up out of the lowered seas to pummel the land. The waves were perfectly timed to arrive with the high of a spring tide, the highest of tides. Wind waves would have added to the impact of the tsunami; fortunately, there were none. Most people were able to save themselves, but that night 26 people drowned as the waves swept inland and destroyed homes and fish houses (Ruffman 1996).

At the time the tsunami was generated, the earthquake was causing a very different event at the bottom of the ocean. The epicentre of the earthquake was in a region crossed by many transatlantic submarine cables and when the ground shifted, six cables immediately broke. That was no surprise. What confused scientists was the sequence of cables that broke over more than 13 hours in increasing water depth and increasing distance from the site of the epicentre. How could the earthquake cause cable breaks so far from its origin and in a sequence (Heezen and Ewing 1952)?

On December 21 of 1929, J. W. Gregory published a letter in Nature. It was the first attempt to explain the cable breaks of 1929, as he said, a total of '12 cables broken in 28 places.' Gregory explained the breaks by describing faults along the submarine canyon off the Cabot Strait, now known as the Laurentian Channel. He was the first of a series of scientists to attempt an explanation, although none were correct. That is, until Heezen and Ewing came along.

Twenty-three years after the event that David Piper, a geologist and turbidite expert at the Bedford Institute of Oceanography, calls '1929', American scientists Heezen and Ewing attributed the breaks to a giant turbidity current that flowed across the ocean floor breaking cables as it passed. Later, Piper et al. (1988) found that the current reached speeds of up to and greater than 67km/h, basing their estimate on the distance between the cables and the time between breaks.

As Dr. Piper said, '1929 was a big draw.' The 1929 turbidity current has been well studied and drew the interest of scientists because so much was known about it. Happening out of view and being as difficult to predict as earthquakes, turbidity currents tend to go unnoticed. But, in Piper's words: 'In terms of earthquake-triggered turbidity currents, until 1979, 1929 was I think, the only one that was particularly monitored and particularly understood. And it was monitored because all these cables got broken.' The method of monitoring is described by Heezen and Ewing (1952): 'The instants of the cable interruptions were accurately recorded by automatic machines which record the telegraphic messages, and the locations of the breaks were determined by resistance measurements from the shore ends of the cables.' The result was a unique set of data on turbidity currents.

What is a 'turbidity current'?

Turbidity currents are one type of a group of phenomena called gravity currents. A familiar example of a gravity current is a cold front moving in, often accompanied by thunderstorms. Cold air is denser and therefore heavier than warm air, so it presses horizontally under the warmer air.

A second example, more akin to a turbidity current, is an avalanche. When a mountainside of snow becomes unstable, it can start to accelerate downhill: its rumble will echo through the mountain range. The destruction can be devastating. If the avalanche is made of powder snow mixed with the air above, then it is a gravity current, and not a slide, like a mud slide. Turbidity currents are the submarine big brothers of powder avalanches, but instead of snow it is mud and sand that make up the excess density of the water they inhabit. The dense, sediment-laden water flows down the side of the continental slope to the deep sea.

To initiate a slump-induced turbidity current, a submarine landslide mixes sediment up into the water column. The particles of sediment are more dense than the water around them and have a tendency to settle out, but before this happens the muddy water may start to flow downslope. Once the current begins to flow, it quickly becomes violent. The sediment is turbulently mixed vertically through the full height of the current, maintaining it in suspension. Larger currents even dig up sediment as they go, giving themselves more driving energy. The largest in the world are sometimes energetic enough to gouge great canyons into the sides of continental slopes (Choux et al. 2005, Parker et al. 1986).

Upon reaching the deep ocean, turbidity currents find themselves on relatively flat ground and start to lose momentum. At this point 'the sediment will deposit and the current, having lost its raison d'être, must vanish' (Parker 1982).

And they do vanish, leaving behind great fan shapes of sediment. Nisbet and Piper (1998) found that when the 1929 current deposited sediment, it could have covered Texas in waste-deep mud and sand. In a turbidity current the sand is more dense and sinks faster. It will form the bottom layers and the mud slowly rains down on top. The current subsides and what remains is a sequence of sedimentation called a turbidite. As will become clear in the next section, turbidites can maintain recognizable form over geologic time, becoming sedimentary and sometimes becoming metamorphosed rock.

Halifax was built on a current

Turbidites are formed at the bottom of the ocean, but Southern Nova Scotians live on top of one. How did sedimentary rock from the bottom of the ocean come to be on land?

Five hundred million years ago, in place of the Atlantic was another ocean, the Rheic Ocean. Mostly due to water action, such as rivers, sediment from the Saharan Shield was displaced and swept onto the continental shelf of the Rheic Ocean. When the sediment became unstable, turbidity currents were generated that uprooted the sediment and deposited it as turbidites in the deep ocean. Four hundred million years ago the Rheic Ocean grew old and closed. The crust and mantle of the bottom of the ocean were subducted, forced downward, under the North American plate until the Rheic Ocean was no more and the equatorial supercontinent Pangea was born.

When what are now the North American plate and the African plate collided, the turbidites were in the form of sedimentary rock, created by the compression of sediment during the previous millions of years. As the Rheic Ocean closed, the more dense oceanic crust was subducted under the less dense North American plate. The turbidites, made of crustal material, were either pulled down with the oceanic crust, or forced upward, folding up onto the continent. According to Barrie Clarke, Professor in the Department of Earth Sciences at Dalhousie University, when they were on the bottom of the ocean, the turbidites were 11 km thick and the lateral extent was about the distance from Halifax to Montreal. 'But they've now been accordioned. They've been shortened.' Upon their ascension onto the continent, a new mountain range was born. As Clarke said, 'We used to have something like the Himalayas here. ... This would have been a good place for ... eco-tours 400 million years ago.' The mountains are gone now, worn down by glacial erosion.

At the time of the great mountains, Nova Scotia was far from the ocean. But supercontinents are unstable; heat from the centre of the Earth builds up underneath them. Enormous convection cells in the mantle are what cause plate tectonics. The energy trapped under Pangea caused the convection cells in the mantle to change and the result was that the North American plate was torn from the African plate. The crust began by cracking, searching for the weakest point at which to break. Most cracks became failed rifts and scarred the landscape, forming, for instance, the Bay of Fundy. The successful break happened at the edge of the continental shelf, now 200m underwater (Choyce 1996). The Atlantic Ocean was born, and so was Nova Scotia, on what Clarke calls 'a chip of Africa'.

The joining line between the African turbidites and the North American plate goes laterally from the Bay of Fundy to just south of Cape Breton Island, at Chedabucto Bay. Clarke said: 'I thought the department of tourism should set up a Bedouin tent on the north side of this fault, just as you're coming into Truro. ... Get a couple of students and a camel and welcome people to Africa. ... Whenever you tell people this story about, geologically you've come to Africa, they find it quite interesting. But,' he said, 'nobody ever took me up on it. I guess it was the renting a camel part that was hard.'

The African turbidites are called the Meguma Group and in the 1960s Dalhousie geologist Paul Schenk was studying them. Barrie Clarke was a contemporary of Dr. Schenk. Dr. Clarke explained that geologists can look at rocks and decipher the paleo-current, that is, in which direction the rocks flowed. When Schenk looked at the local turbidites he found something he wasn't anticipating. As Clarke explained the problem, 'The curious thing was that the sediments were coming from off-shore. ... The source had to be southeast. ... [Y]ou can't wash sediment out of the ocean onto the land, so there had to be another source ... this source was [Africa] and of course now it's 3000 km away. ... Paul made this correlation across the Atlantic ocean'.

There is still some controversy about whether or not the Meguma Group came from Africa. Another candidate is South America. When asked, Barrie Clarke's thoughts were: 'is it Morocco? It sure looks like it.' He was with Paul Schenk on an expedition to Morocco, where he was studying granites (igneous rocks), while Schenk examined the turbidites. As he described it, the two men felt at home because the geological landscape was the same as that of Nova Scotia. Because of Schenk's remarkable insight into the link between Nova Scotia and Africa, a plaque dedicated to him is outside the Killam Library (Fig 1).

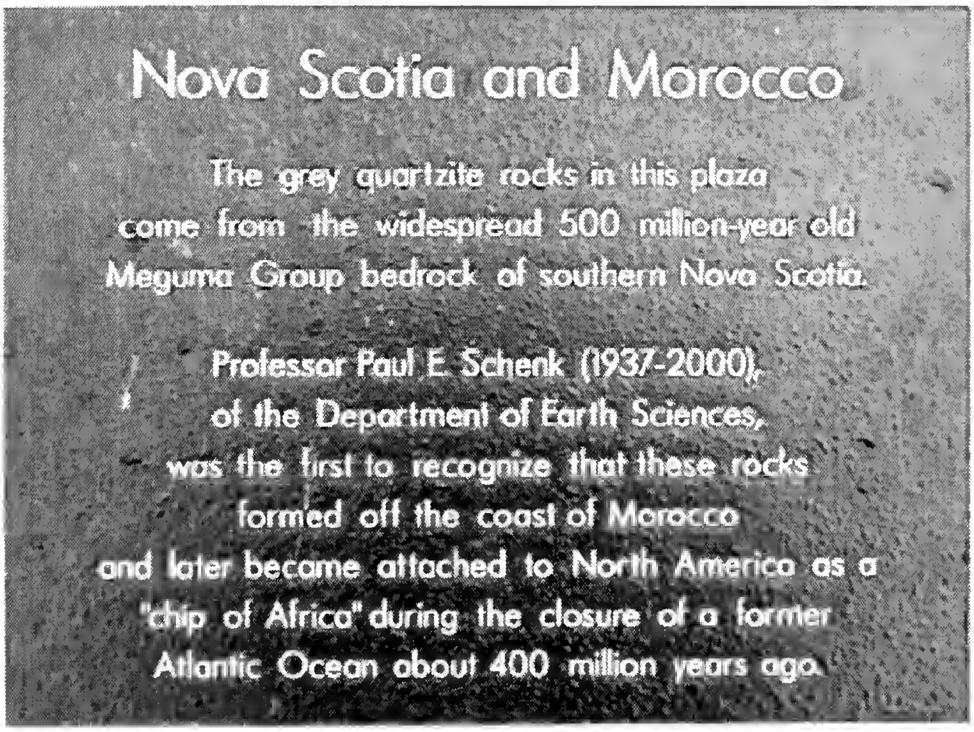

Fig 1 Plaque in honour of Geologist Paul Schenk, outside the Killam Library on the Dalhousie University campus.

Nova Scotia today

Cities are built using local rock. For Halifax, that means Meguma. For instance, at Dalhousie, the Sir James Dunn Science Building is made from the sandy, bottom layers of the Meguma turbidite, while the stone wall around campus is made of slate that was once the muddy top layers of the turbidite. At the beginning of a field trip Dr. Clarke pointed out the building and wall and explained: 'All of this stuff was quarried down in Purcell's Cove.' In front of us were the two main parts that make up the Meguma Group. 'There you have it! There's your turbidite.'

As we drove north on the Veteran's Memorial Highway (Hwy 102) toward Kearney Lake Rd., where the entrance is found to the Gateway Material Limited quarry, Clarke gestured at the trees on our left. 'The quarry begins here. ... It's huge. Absolutely huge quarry. And you can't see it. You drive along here and you think, "oh, nice countryside." There's a great big hole over there. It's colossal! And what they're quarrying here is the turbidites.' We turned off the highway and drove a short way into the quarry, far enough to see massive piles of pulverized rock.

The next stop was Larry Uteck Drive, off the Bedford Highway. Blasting of the rock to put in the road left a vertical section of open rock face about 3m high where the layers of Meguma can be seen. The coarse and heavy sands were deposited first and then the lighter muds. The sequence repeated over and over as the turbidites built up one on top of the next off the Saharan Shield (See Fig 2). Deposits from three or four consecutive turbidity currents were visible in the rock wall.

Fig 2 Exposed Meguma Group turbidite along Larry Uteck Drive. The transition from the top of one layer of turbidite to the bottom of the next is indicated by the horizontal line near the top of the toonie (2$ coin). Darker material below is the muddy top layer. Light material above is the sandy bottom layer of the next turbidity current deposit.

There are thin lines of differently coloured rock in the Meguma on Larry Uteck Drive that don't seem to belong. They are quartz veins, but they can contain gold. When the turbidite was compressed and folded, in places it cracked and mineral-rich water seeped in, depositing its dissolved load that eventually became quartz. Barrie Clarke commented, 'Right where this curvature is the greatest on the fold, where you're really bending these rocks, that's where they'll fracture ... and that's where you find the gold.' In Nova Scotia, all gold districts are in the form of vein deposits in the Meguma (Bates 1987).

Turbidites on the bottom of the ocean may not contain gold, but could hold a bright future in oil and gas. Grant Wach is a Professor of Petroleum Geoscience in the Department of Earth Sciences at Dalhousie University. In a recent interview Professor Wach explained the connection between turbidites and oil and gas exploration, saying that 'turbidites ... can be oil and gas bearing reservoirs.' The sandy part of a turbidite is porous and can form a reservoir for oil or gas, as long as a seal forms above it. Gas seeps up into the sandy rock and becomes trapped by the upper muddy layer, which over time has become shale. Turbidity current deposits that are 80 to 100 million years old, from the Cretaceous Period, are the right age to contain such deposits; 'that's likely when the gas was formed.' As for the Meguma Group, it lost its porosity when it was compressed as Africa collided with North America. There are, however, off-shore turbidites that show promise.

In a document entitled 'Deep Water Post-Drill Analysis: 1982-2004', wells such as the Annapolis and Crimson are described. The wells are found in the region basinward of the Sable Delta, an ancient river delta. Chevron drilled the Annapolis well in the spring and summer of 2002. Wach said, 'The objective was deep water turbidite sands and they found some gas', 'so they looked down deeper at the Crimson well.' In 2004 Marathon drilled the Crimson, about 9km from the Annapolis well, and was unsuccessful in finding hydrocarbons. When asked whether gas has been found in off-shore turbidites, Grant Wach's response was: 'Not yet. But, the potential is still there and companies are on the lookout (CNSOPB 2011).

As discussed above, turbidites are of interest to Nova Scotians, but turbidity currents are also important. Nova Scotia exists in a region of some seismic activity. To understand the local risks of catastrophic natural events, as Wach told me, scientists 'plot out earthquakes and seismicity and they try to see the periodicity of that seismicity.' When will another event like that of 1929 happen again? According to David

Piper, in an email: 'We have evidence that a failure the size of 1929 takes place only every 100 000 years in that area.' It doesn't sound like much to worry about, but, he says, tsunamis that could hit Nova Scotia, caused by submarine landslides in locations such as the Scotian Shelf, occur on the order of every 10,000 years.

Grant Wach suggested that this essay be subtitled: 'Can you tread water?', adding 'we're at risk here.' Mosher (2009) examined the possibility of landslides and tsunamis along the Canadian coastline, concluding that on the east coast, large volumes of sediment have accumulated on the Scotian Shelf and they have the potential to fail, starting a submarine landslide. If this were to happen, a tsunami would be generated that could reach the coast of Nova Scotia within a few short hours, leaving little time for local people to react. In the meantime, Nova Scotians go about their lives on 'a chip of Africa'.

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THE USE AND INFLUENCE OF SCIENTIFIC INFORMATION IN ENVIRONMENTAL POLICY MAKING: LESSONS LEARNED FROM NOVA SCOTIA

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ABSTRACT

Governmental organisations produce vast quantities of scientific information on the state of the marine and coastal environment which is often intended to guide policy-making to mitigate or reverse the declining trends in the health of the environment. How scientific information is used and how it influences environmental policy and decision making are however not well understood. The apparent disconnect between the knowledge and information produced by scientists and that used by policy makers is attributed to problems at the science-policy interface. Based on a multidisciplinary literature review, this paper describes how policy makers seek out and use scientific information within the context of policy design in the 21st century. Best practices for increasing information flows across the science-policy interface are drawn from a study of the awareness, use, and influence of *The 2009 State of the Nova Scotia Coast Report* in coastal policy making in Nova Scotia.

Strategic or rational approaches to policy making can increase the two-way flow of information across the science-policy interface as it facilitates collaboration among multiple actors in information generation, transmission, and use. The production, use, and influence of *The 2009 State of Nova Scotia's Coast Report* in coastal policy making in Nova Scotia demonstrates the strategic approach to policy making whereby coastal policy is being developed through (i) intergovernmental partnerships, (ii) the use of best available information, (iii) linkages between the policy process and policy output, and (iv) public participation.

INTRODUCTION

Given the complex nature of modern environmental problems (e.g., the effects of climate change, overfishing, and pollution), it is essential that policy makers and their advisors receive relevant information

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to develop policies to mitigate these environmental crises (Ascher, Steelman, & Healy, 2010; Lubchenco, 1998). Making sound environmental policy decisions requires input from scientific information from various disciplines which is available from diverse sources (e.g., academic institutions, governmental agencies, and non-governmental organisations), in different genres (e.g., technical report and journal series), and in different formats (e.g., print and digital). While marine environmental policy and decision making are complex processes, they may be further complicated due to vast quantities of information available to policy makers and their advisors.

Modern policy making prescribes the use of the best available information for policy making (Bardach, 2004; Doern & Phidd, 1992, Pal, 2010); however, the profile of scientific information in policy making typically remains low (Kahan, 2010: Likens, 2010). How scientific information is used and how it influences environmental policy and decision making are not well understood. Researchers sometimes attribute the apparent disconnect between the knowledge and information produced by scientists and that used by policy makers to problems at the "science-policy interface" (Ascher, Steelman, & Healy, 2010; Doern & Reed, 2000; Keller, 2009; Mitchell, 2010; Mitchell, Clark, & Cash, 2006; Mol, 2008).

Given the modern policy making process and the magnitude of available information, what information do policy and decision makers need to make the right policy decisions on marine environmental issues? Drawing on a literature review in the fields of public policy, information management, and resource management, this paper describes how policy makers seek out and use scientific information in the context of policy design in the 21st century. Some enablers and barriers to the flow of scientific information produced by governmental agencies within the science-policy interface will be highlighted. Best practices for increasing information flows across the interface are described based on a recent study of the awareness, use, and influence of environmental information in coastal policy making in Nova Scotia (Soomai, MacDonald, & Wells, 2011).

PRODUCTION, USE, AND INFLUENCE OF SCIENTIFIC INFORMATION

Global attention to marine environmental issues has increased substantially since the 1972 Stockholm Declaration on the Human Environment and the 1992 United Nations Conference on Environment and Development became platforms for modern environmental conservation and protection (United Nations, 1972; 1992). Vast quantities of technical publications have been produced by governmental and intergovernmental organizations in response to demands for solutions to marine environmental crises (e.g., MEA, 2005; Pew Environmental Group, 2011). Produced by governmental agencies, these publications are known as grey literature as they are not published by commercial publishers (GreyNet, 2012). Governmental agencies often see production of scientific information as one of their primary responsibilities in order to offer solutions to mitigate coastal and marine environmental problems and to inform policy decisions.

The use and influence of scientific information in environmental policy making is demonstrated in the routine workings of government. Policy analysts, through ongoing monitoring and assessment of available information, inform their ministers of emerging issues that can affect environmental policy agendas (Doern & Phidd, 1992; Lindquist, 2001; Pal, 2010). Ministers bring policy issues and policy alternatives for action to Cabinet in memoranda that summarize environmental decisions and/or in more detailed discussion papers (Doern & Phidd, 1992). In the last year of a government's term of office, detailed assessments of major trends and issues facing the country, key policy challenges and gaps, and proposed policy directions are often prepared as a "road map" for managing an overall policy agenda (Bardach, 2004; Doern & Phidd, 1992; Lindquist, 2001; Pal, 2010). Access to the "right" information by policy and decision makers is undoubtedly a critical requirement for defining policy issues and for developing appropriate policy options.

In this paper, "use and influence" in policy contexts are viewed as a single concept and can be of a direct or an indirect nature. Scientific information can be used for direct problem-solving to address an environmental issue. More often, examples of indirect use are noted; for instance, the production of information can lead to a dynamic relationship between scientists, policy makers, and other actors in the policy process, or an increase in overall knowledge, understanding and attitudes of policy makers and practitioners on environmental issues. Further, use and influence of scientific information may depend on the intended purpose of scientific publications.

POLICY DESIGN IN THE 21ST CENTURY

Modern policy making is described as a strategic or rational approach with clearly defined linkages between stages in the policy process and policy outcome. The strategic approach seeks to identify a problem, to examine policy alternatives to solve the problem, to select the best policy alternative, to implement the decision, to evaluate the degree of success of the policy choice, and to modify the policy as needed (Bryson, Crosby, & Stone, 2006; Howlett, Ramesh, & Perl, 2009; Pal, 2010). Many countries are adopting evidence-based policy making as a common strategic approach to reform and restructure the policy process (Howlett, 2005; Nutley, Walter, & Davies, 2007; Pawson, 2006). Evidence-based policy making aims to minimise policy failures by using the best available evidence from research to inform decisions about policies, programmes and projects. In the process, the experience, expertise, and judgment of policy and decision makers and scientists are integrated to formulate environmental policy alternatives (Brodhag & Talière, 2006; Head, 2008). Strategic approaches are becoming necessary due to increasing public demand for accountability and governments' recognition that transparency in public policy leads to more effective governance (OECD, 2003). The strategic approach is also believed to be essential for addressing complex environmental problems (e.g., global climate change) which require coordination of local, national, and international efforts to maximise the effectiveness of limited resources devoted to environmental protection (Chasek, Downie, & Brown, 2010; Pielke, 2007; Young, 2008).

Modern policy-making has extended beyond core government structures to include external interests and stakeholders. These wide policy communities or policy networks are characteristic of strategic governance and encourage government partnerships for joint research and the delivery of government services (Newman & Tanguay, 2002; OECD, 2003; Pal, 2010). Policy communities include government agencies, pressure groups, media, academics, and individuals who have an interest in a particular policy area. Most governments now recognize the need to engage civil society through interest groups and social movements and to use a range of tools for public consultation and citizen engagement in policy making. It is believed that the more inclusive the interests and organizations in a sector are involved, the easier it is to implement policy decisions.

Despite advances in policy making in the 21st century, elements of a less structured approach to policy making persist which can mask the existence of any overall strategic approach (Howlett, Ramesh, & Perl, 2009; Pal, 2010). Traditional policy making has been described as an incremental approach or "muddling through," whereby new policies are formed through a series of incremental changes and differ in relatively small degrees to those already in place (Dror, 1969; Lindblom, 1959; Scott, 2010). Long-term policy considerations are generally omitted on the grounds of claims of limited data and information available to policy analysts to recommend policy alternatives. The validity of the incremental approach is debatable; however, it describes the risk adverse nature of policy makers who rely on the use of a series of small iterative policy changes instead of choosing a one-off policy approach (Doern, 1993; Doern & Phidd, 1992; Doern & Reed, 1992; Howlett, Ramesh, & Perl, 2009; Hutchings, Walters, & Haedrich, 1997; Lindquist, 2001; Scott, 2010).

ENABLERS AND BARRIERS TO THE USE AND INFLUENCE OF SCIENTIFIC INFORMATION

How policy makers obtain and use information contained in scientific reports

Policy makers and their advisors commonly seek information first from personal rather than from published sources (Clark & Holmes, 2010; Holmes & Savgård, 2008; Nutley, Walter, & Davies, 2007). Personal sources include peers and scientists who may belong to boundary organizations. Boundary organisations integrate the domains of science and policy by translating scientific information for less technical audiences, and they often retain staff who actively broker links between policy advisers/policy makers and scientists (Thelwall, Klitkou, Verbeek, Stuart, & Vincent, 2010; Young, 2008). Information seeking is also facilitated by scientists who are personally motivated to communicate with advisers and policy people.

The main forms of written material used by policy makers and advisers are reviews and updates which summarize available scientific information (Clark & Holmes, 2010; Hemsley-Brown, 2004; McNie, 2007). Policy makers prefer to use reports commissioned by government departments and agencies as they contain information that is more likely to be policy-relevant than is found in purely academic research publications. Policy makers and advisors want technical reports to contain short summaries written in less technical language, giving definitive conclusions, firm recommendations, and clear directions for action (Clark & Holmes, 2010). If an author does not provide a summary, policy makers may rely on one prepared by an external body which may alter the original meaning of the information.

Policy makers seek out information on the impacts and causes of environmental issues in order to develop informed policy alternatives. While in some cases problems can be addressed at enormous costs, causes of problems are often beyond the control of policy interventions. For example, the prevalence of marine invasive species off mainland Nova Scotia and in the Bras d'Or Lakes (DFO, 2012) may be due in part to increases in international shipping activities; however, the policy answer may not lie in addressing shipping but by dealing with the consequences of the spread of the invasive species.

Using strategic approaches to policy making, policy makers seek to formulate equitable environmental policy options where effects (e.g., monetary benefits) or effort (e.g., monetary costs) are fairly or justly distributed (Howlett, Ramesh, & Perl, 2009; Patton & Sawicki, 1993). Information from various disciplines (e.g., social, environmental, and economics) is needed to make equitable policy decisions. However, policy makers may not be skilled in integrating knowledge from different scientific disciplines when developing environmental policy (Doern, 1993; Hutchings, 1997). Policy analysts (civil servants) then "translate" available scientific information into a form that can be used by policy makers (politicians) (Ouimet et al., 2010). Scientific reports are first rewritten to interpret technical details and scientific uncertainties; then the information from various disciplines are compared and filtered for use based on administrative and legal criteria (Asher, Steelman, & Healey, 2010; Keller, 2009). Policy alternatives and preferences emerge out of this filtered information and the process may be as much political as it is technical. The challenge in communicating inherently interdisciplinary information is also noted when policy makers use ambiguous terminologies to describe environmental policy decisions in legislation.

How government organisational structure and culture influence information use

The traditional hierarchical structure of government bureaucracy creates departmentalisation and centralisation which can limit communication of information and potentially cause conflict within the public service (Doern, 1993; Yang & Maxwell, 2011). In departmentalization, multiple departments share responsibility for aspects of environmental policy, each with a different functional mandate. In centralization, power and authority are located at higher management levels, i.e., the "top-down" approach. Each level of government (e.g., federal, provincial, and municipal) may have different interests or value systems (e.g., economic, social, and biological) by which they weigh the importance of environmental management and information use. For example, in Canada federal departments are the front players in policy development and the inter-departmental politics involved in environmental policy making (Doern, 1993; Howlett, Ramesh, & Perl, 2009). Jurisdictional concerns arise where ministers and senior public servants debate whether selected environmental initiatives will adversely affect or unintentionally change policy in their sphere of responsibility (Howlett & Wellstead, 2011). How information is used in different jurisdictions will vary and the process becomes more complicated when individuals operate within intra- and inter-organization arrangements.

With the increasing move toward strategic approaches to policy making, more governmental agencies now operate within complex policy making networks, which consist of formal or informal links within and across government departments and external agencies (Lindquist, 2001; Newman & Tanquay, 2002; Pross, 1992; OECD, 2003, 2001). These networks reflect wide policy communities and are comprised of a range of actors including industry, scientists, government, and interest groups. The various actors each play a unique role in information production, dissemination, and use within the policy making community.

Policy analysts now have access to information and tools to facilitate a thorough understanding of existing problems and likely impacts of policy as well as a requirement to consult with wide audiences (Scott, 2010). The tools include sophisticated databases for storage, retrieval, and analysis of relevant data; modeling and forecasting tools; information communication technologies; and social networks. The databases and information technologies themselves present limitations as they are often too technical for policy makers to take advantage of personally. Staff with expertise in using these new data and communication technologies can be employed within government agencies to assist in translation of technical information for use by policy makers.

LESSONS LEARNED FROM COASTAL POLICY MAKING IN NOVA SCOTIA

Recent coastal policy making in Nova Scotia illustrates the production, use, and influence of environmental information within a strategic policy design context. In 2009, the Government of Nova Scotia published *The 2009 State of Nova Scotia's Coast Report* in three forms – a detailed technical report, a 26-page summary document, and six four-page fact sheets (Government of Nova Scotia, 2009). The *Report* consolidates current scientific knowledge on the province's coastal areas and focuses on six priority issues: sea-level rise and storm events, public coastal access, working waterfronts, coastal water quality, coastal ecosystems and habitats, and coastal development. The *Report* was designed to reach and inform Nova Scotians about coastal issues and to encourage public participation in the development of coastal policy in Nova Scotia. The three components of the *Report* were published in print and Web-based formats, and the fact sheets and summary document were produced in English and French editions. Since its release, the Government of Nova Scotia took steps to raise public awareness of the *Report* so as to increase public participation in the review and completion of a coastal policy, the *Coastal Strategy*, a draft of which was released in October 2011 (Government of Nova Scotia, 2011a). A case study of the awareness, use, and influence of *The 2009 State of Nova Scotia's Coast Report* from the date of the release of the *Report* was conducted in collaboration with the provincial government (Soomai, MacDonald, & Wells, 2011).

The production, use, and influence of scientific information in coastal policy making in Nova Scotia demonstrates the strategic approach to policy making whereby coastal policy is being developed through (i) intergovernmental partnerships, (ii) use of best available information, (iii) linkages between the policy process and policy output, and (iv) public participation.

The Provincial Oceans Network, composed of representatives from 15 provincial departments and agencies with responsibilities and interests in coastal and ocean management, facilitated the government's new approach to coastal management (Government of Nova Scotia, 2007). Production of *The 2009 State of Nova Scotia's Coast Report* was the responsibility of representatives of the Network, i.e., experts from each provincial government department. The six priority issues were common matters facing each of the 15 departments and needed to be addressed collectively. The issues also reflected the views of community groups and the general public which had directed concerns to the relevant line agencies over several decades.

After the launch of *The 2009 State of Nova Scotia's Coast Report*, the Provincial Oceans Network conducted public consultation to promote awareness and use of the *Report* and to obtain feedback from the public about which of the six issues should be considered to be priority. This feedback was used to guide the development of the *Coastal Strategy*. Public consultation included open houses throughout the province and a multi-stakeholder meeting. In addition, a province-wide telephone survey was conducted, and the public could submit comments via the government's Web site. Subsequently, the province released a "What we Heard" report, which provided feedback on its public consultations (Government of Nova Scotia, 2011b).

The production of scientific information used in the coastal policy process was linked to the policy output. *The 2009 State of Nova Scotia's Coast Report* (Government of Nova Scotia, 2009), was seen to be both an input and an output of policy and decision making (Soomai, MacDonald, & Wells, 2011). The intended policy endpoint, the *Coastal Strategy,* was the driving factor in the production of *The 2009 State of Nova Scotia's Coast Report.* In turn, feedback from the public consultation on the *Report* was used to produce the draft *Coastal Strategy.*

Communication of *The 2009 State of Nova Scotia's Coast Report* in less technical formats facilitated the flow of information across the science-policy divide. The various components of the *Report* enabled use by multiple audiences (Soomai, MacDonald, & Wells, 2011). Email social networks played a key role in promoting awareness of the *Report* among established groups which traditionally respond to government surveys and interviews (Soomai, MacDonald, &Wells, 2011).

Many government organizations have not undertaken an analysis of the use and influence of their publications and these processes are still poorly understood. However, in the case of *The 2009 State of Nova Scotia's Coast Report*, the Government of Nova Scotia initiated the case study on awareness, use, and influence of the *Report*, signifying government's recognition of the importance of information in policy making (Soomai, MacDonald, & Wells, 2011).

DISCUSSION

The policy process filters scientific information (based on systematic analysis of trends and causal relationships by scientists in various disciplines) and political knowledge of policy makers (based on their expertise in contextual judgement and persuasion) to create new integrated knowledge. This new knowledge represents the merging of science and policy and guides the production of policy options. The increasing number of actors involved in wide policy communities can ensure that diverse sources of information (various scientific disciplines and local knowledge) are included in the filtering process. Effective flow of information across the science-policy interface depends on how well scientific and political knowledge is filtered during the policy process and how well it is utilised or interpreted in the environmental policy output.

Scientists and policy makers need to understand the strengths and weaknesses of the filters that come into play when knowledge (scientific and political) enters the policy process. Scientists need to understand the policy making process and this understanding should feed back into production of clearly presented and readily accessible information suitable for the policy process. Policy makers need to maintain diverse channels of information sources and be open to different perspectives from the various scientific disciplines. Policy makers may not be comfortable using and interpreting science and need a core group of technical support staff who can liaise with scientists. Policy makers face challenges in extracting "useful" information from scientific uncertainty and in integrating necessary information from diverse sources and multiple disciplines into policy alternatives.

The importance of boundary organisations engaged in translation of technical information for less technical audiences is apparent here.

Scientific information that enters the policy process must have the characteristics of salience, reliability and credibility (Delaney & Hastie, 2007; Holmes & Savgard, 2008; MacDonald et al., 2010; Mitchell et al., 2006). Scientists who integrate priority societal needs into their research will improve the likelihood that the research results will be useful for making policy as policy-makers respond more readily to research that affects their constituents' or clients' needs. Scientists can also consider conducting scientific research that acknowledges government's constraints in policy making and policy implementation. Selecting research questions relevant to the most pressing policy issues helps build interest and support for scientific research. Scientists can also seek input on the selection of priority research questions from policy makers. Co-production of information involving scientists and policy makers can ensure that research agendas are relevant to policy agendas as seen in the case of *The 2009 State of Nova Scotia's Coast Report*. Co-production of information can also make scientific uncertainties more visible to policy makers and scientists can answer specific questions that are important to policymakers.

Many government policies have been designed to increase economic growth and improve social benefits while policies for environmental management and sustainable development are a relatively new phenomenon. Policy makers still appear to be uncertain as to how completely new marine environmental policies will fare since there are few similar policies for comparison. Both incremental and strategic approaches to policy design are at work and must be kept in a balance. The risk adverse nature of policy makers in the environmental policy process is characteristic of the incremental approach and appears to maintain a disconnect at science-policy divide. Belief in the incremental approach may inherently jeopardize the progress of government policy making in the 21st century by promoting the now "dated" concept of insufficient information on which to base environmental policy. Weiss (1982) stated that any attempt to increase the availability of information to policy makers will increase the evidence used in decision making. Strategic approaches to policy making creates an appropriate institutional framework linking policy makers, researchers, and other stakeholders.

CONCLUSIONS

Scientists and policy makers play unique roles in facilitating the flow of information across the science-policy interface. Effective communication between scientists and policy makers, formal institutional relationships, trust, and mutual respect are critical factors in facilitating information use in policy making. Policy problems can be clearly defined if the information that policy makers receive is clearly written, with understandable technical details, and available in a summary.

Strategic approaches to policy making can increase the two-way flow of information across the science-policy interface as it facilitates collaboration among multiple actors in information generation, transmission, and use. Through strategic approaches to policy making, governments can increase their institutional capacities to share information among their agencies, anticipate scientific uncertainty, increase trust and sharing of values through dialogue and commitment building, and implement alternative delivery systems to meet policy objectives. The development of strategic plans with a clear organizational vision, mandate, strategic goals, and expected outputs provides the groundwork for increasing information use in policy development.

Recognition of the importance of using scientific information in policy making is characteristic of the strategic approach to policy making which was clearly demonstrated in recent coastal policy making in Nova Scotia. Best practices for increasing scientific information flows across the science-policy interface include: (1) use of several communication methods to reach diverse audiences; (2) production of scientific information through intergovernmental partnerships to provide current and reliable information for policy making; (3) clear linkages between the information used in the policy process and policy output; and (4) public participation in policy making. The attention given to the production of less technical versions of *The 2009 State of Nova Scotia's Coast Report* (fact sheets and summary documents) is consistent with recommendations in the scholarly literature on communication of scientific information (e.g. Clark & Holmes, 2010; McNie, 2007).

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Volume 47, Part 1, pp. 171-198

REPORTS FROM THE NSIS COUNCIL NOVA SCOTIAN INSTITUTE OF SCIENCE

PRESIDENT'S REPORT: 2011 TO 2012

The Nova Scotian Institute of Science (NSIS) celebrated its 150th anniversary in 2012. The Institute exists to provide a forum for scientists and those interested in science to learn about and discuss scientific matters. It promotes this aim through an annual public lecture and discussion series, the publication of a journal (*The Proceedings of the Nova Scotian Institute of Science*), and maintenance of a website (http://www.chebucto.ns.ca/Science/NSIS/). Through its public outreach, it draws attention to issues of societal concern that intersect the natural and social sciences, such as education, environmental and natural resource policies, and ethics. We seek to promote research and education in science by running a Mentorship Program, conducting an annual Scientific Writing Competition for university students, and supporting Regional Science Fairs. We highlight the contributions made to science and technology by Nova Scotians through our virtual Hall of Fame (http://tinyurl.com/nsis-fame), and provide information of historical interest on our website. The NSIS maintains a library in collaboration with Dalhousie University, which provides digital copies of previous volumes of the *Proceedings*.

This year's lecture programme was organized by Ron MacKay, Michelle Paon, John Rutherford, and Angelica Silva. Most of the talks were presented at the lecture theatre in the Nova Scotia Museum of Natural History. We are grateful to the Museum, and to the Museum's manager of collections and its representative on Council, Mr. David Christianson, for providing us with meeting space, the use of the theatre, and continued encouragement and support. Members of Council particularly appreciated the demonstration of the "Our Amazing World" installation by Mr. Calum Ewing. The NSIS also co-sponsored the eighth annual Sable Island Update which was held at Saint Mary's University and was attended by approximately 200 people. The 2011-2012 lecture programme was as follows:

Monday, 3 October, 2011 7:30
NS Museum of Natural History
Dr. John Calder: Nova Scotia Department of Natural Resources
Coal Age Galapagos

Monday, 7 November, 2011 7:30
NS Museum of Natural History
Dr. Heike Lotze: Department of Biology, Dalhousie University
Food, Furs and Feathers: History of Human-induced Changes in Coastal Ecosystems

Tuesday, 29 November, 2011 7:30
NS Museum of Natural History
Mr. Cameron Ells: Chair, Shubenacadie Canal Commission
There and Back Again: Along the Shubenacadie Canal in 1861

(Note: Due to popular demand, Mr. Ells kindly repeated his lecture on Monday, February 20, 2012, in the Windsor Lecture Theatre of the Art Gallery of Nova Scotia)

Monday, 5 December, 2011 7:30
NS Museum of Natural History
Dr. Martin Willison: School for Resource and Environmental Studies, Dalhousie University
From Picnic Parks to Systematic Protection of Biodiversity: A Review of the Development of Protected Areas in Nova Scotia

Monday, January 9, 2012 7:30
NS Museum of Natural History
Dr. Charlie Embree: Atlantic Food and Horticulture Research Centre, Kentville, Nova Scotia
100 Years of Research in the Orchard

Monday, 6 February, 2012 7:30
NS Museum of Natural History
Dr. Grant Wach: Department of Earth Sciences, Dalhousie University
Burning Rocks: The History of the Petroleum Industry in Canada and the Maritimes

Monday, 2 April, 2012 7:30
Windsor Lecture Theatre, Art Gallery of Nova Scotia
Dr. Jacob Hanley: Department of Geology, Saint Mary's University
A Noble Legacy: The History, Geology, and Future of Gold Mining and Exploration in Nova Scotia

Monday, 7 May, 2012 7:30
Alumni Hall, University of King's College
Dr. Bernard Lightman: Director of the Institute for Science and Technology Studies, York University, Toronto, Ontario
Communicating Knowledge to New Audiences: Victorian Popularizers of Science

(Note: Lecture co-sponsored by the History of Science and Technology Programme at the University of King's College)

The public lectures for the Anniversary Year were presented from a historical perspective, but also included the results of current research in the fields represented. The possibility of collaboration with other institutions in sponsoring speakers was, and continues to be, explored. In particular, potential co-operation with the Royal Nova Scotia Historical Society in sponsoring speakers on topics of mutual interest is being pursued. During the year, the NSIS, the Bedford Institute of Oceanography, and the RNSHS mutually advertised each other's lecture series. To further raise public awareness of our lectures this year, the NSIS talks were publicized using colour brochures and posters that were distributed both on-line and in hard copy. Attendance at lectures was gratifying; the audience typically consisted of between 70 to 80 people. These attendance numbers appear to justify a continuation of the use of high visibility promotional material in the coming year.

Through the efforts of editors Peter Wells and David Richardson and their editorial review board, two issues of the Proceedings were published in 2011. The first (Volume 46, part 1) was a special issue entitled *The Birds of Brier Island*, by Eric L. Mills and Lance Laviolette. This publication is profusely illustrated with colour photographs, and has been enthusiastically received by the public. Both volumes have benefitted by upgraded production values which include a redesigned cover format, the use of colour, and a more reader-friendly type font. The financial support of the Provincial Department of Communities, Culture and Heritage for our publishing programme is gratefully acknowledged. On January 19th, a launch celebrating the digitization of the Proceedings was held at the Killam Library. Thanks to the efforts of Michelle Paon and Sharon Longard, researchers now have on-line access all copies of the Proceedings from its beginnings in 1863 until 1984. The future of the Proceedings was discussed at a special extended meeting of Council held on March 5, 2012. Geoff Brown, of the Killam Library, was invited to address Council on the subject of on-line publishing. Mr. Brown presented a very helpful description of the Library's Journal Hosting Service, a web-based publishing application. Following the presentation, Council considered the frequency of publication of the Proceedings, the print and electronic options for publication, and the budget required to produce the journal. It was agreed to publish two issues per year, to establish a budget which would include an increase in the dues to $30.00, and to further explore the Dalhousie electronic publication option.

Through the generosity of Dr. Charles Reynes, currently living in California, and with the support and cooperation of the Killam Library, the Institute received a donation of a bound set of volumes I through IV of the Proceedings, a number of paperback journals dating through the 1930s, a number of Canadian maps ca. 1890, and an antique seal of the NSIS logo.

Our Science Writing Competition was once again organized and overseen by Bob Cook. Three students, one each in the undergraduate, graduate and honourable mention category, were awarded certificates at the April meeting of the NSIS. Congratulations are extended to:

In the undergraduate category - *William Roberts* (Acadia University) for a paper entitled, "An overview of the biology, ecology, conservation and fishing history of the seahorse, Hippocampus sp."

In the graduate category - *Suzette Soomai* (Dalhousie University) for a paper entitled, "The use and influence of scientific information in environmental policy making: Lessons from Nova Scotia"

Honourable mention – *Robert Paul* (Dalhousie University) for a paper entitled, "The elusive causal association between gastroesophageal reflux disease (GERD) or colon inflammation and atrial fibrillation (AFIB) and atrial flutter: A review of the literature and new case study"

The NSIS continued to provide financial support to the ten Regional Science Fairs in the form of a donation, for this year alone, of $150.00 in prize money, the amount reflecting the Institute's anniversary year. Various members of the NSIS Council were involved in judging projects and presenting awards.

Work was begun this year on updating the NSIS website; Susan Soomai kindly agreed to take on this responsibility. Regis Dudley was welcomed to Council as Publicity Officer.

The Anniversary Committee, ably and energetically chaired by Michelle Paon, was busy throughout the year planning events to celebrate the Institute's 150th year. At one of those events, the Anniversary Banquet held on Tuesday, May 8th at the Lord Nelson Hotel in Halifax, two distinguished Nova Scotian scientists were inducted into the Hall of Fame: Dr. Kenneth Mann, an eminent, internationally recognized marine ecologist, and Dr. Willard Boyle, recipient of the 2009 Nobel Prize in physics for his contribution to the development of the charge-coupled device. Please see the report of the Committee for further details relating to anniversary events.

In closing, I would like to thank all the members of Council for their ideas, their hard work, and their support. In particular, it is a pleasure to acknowledge Sharon Longard's long and dedicated service to the Institute; Sharon will be retiring after 17 years as the librarian representative on Council. She will be greatly missed. As well, on behalf of Council, I would like to thank Elaine McCulloch (who will continue as a member of Council) for her diligence and expertise as treasurer, and Bob Cook for his enthusiasm in promoting and overseeing the writing programme as its coordinator.

Respectfully submitted,
John Rutherford
May 8, 2012

The following motion was passed in the Nova Scotia Legislature in honour of the 150th Anniversary of the NSIS

RESOLUTION DATE: May 8, 2012

NOTICE OF MOTION

MOVED BY: David A. Wilson
Minister of Communities, Culture and Heritage
MLA, Sackville-Cobequid

I hereby give notice that on a future day I shall move the adoption of the following resolution:

WHEREAS the Nova Scotia Institute of Science celebrates its 150th anniversary in 2012 and has played an important role in supporting and promoting scientific activity in a wide variety of fields such as geology, botany, oceanography, zoology and meteorology; and

WHEREAS the Nova Scotia Institute of Science is one of the oldest such societies in Canada, created by an act of the provincial legislature in 1890, and provides a forum for debate, discussion and a better understanding of the province's connection to science and research ; and

WHEREAS science has played a significant role in the development of our province and remains vital to our future economic, social and environmental progress and is one of the keys to creating an innovative and successful Nova Scotia.

WHEREAS that all members of this House congratulate the Nova Scotia Institute of Science on this important milestone and wish them continued success in their efforts to promote the value of scientific achievement.

Mr. Speaker I request waiver of notice and passage without debate.

EDITOR'S REPORT

NSIS ANNUAL GENERAL MEETING
May 8th, 2012

Status of the Proceedings of the NSIS

Volume 46 (Parts1 and 2), 2011, of the PNSIS (*Proceedings of the Nova Scotian Institute of Science*) was successfully completed over the past calendar year.

Part One was a Special Issue or book on "*The Birds of Brier Island*" (BBI), written by Drs Eric Mills and Lance Laviolette, and printed in a new format with a spectacular cover and larger layout. This book is an essential guide for visitors to Brier Island interested in viewing the wide diversity of birds on and around the island. The Institute printed 1000 copies of the BBI and is actively marketing it throughout the Province. Members are encouraged to help in this endeavour.

The regular issue, PNSIS 46(2), was published in early 2012 in a new format – colored cover with picture, and new typeface throughout the journal. This depicts the new look that the Editors are giving the Proceedings. We hope members are pleased with it. We especially thank Gail LeBlanc (Dalhousie University, Layout and Copy) for her skilled and dedicated work on the Proceedings and its new design.

Throughout 2011, the Editorial Board across the Province worked hard to attract papers and then move them through the review process. The new reviewing process is working well and the Journal is starting to attract more papers and ones on a wide range of scientific topics. We have an excellent and enthusiastic team running the Proceedings. The Board is thanked for its work. We also thank Sarah Stevenson, Dalhousie University, stepping down as Production Editor to the NSIS.

So far in 2012, five contributed papers and four student papers are in the review process for PNSIS Volume 47(1) 2012. An editorial is being drafted. A list of prospective papers and editorials is guiding future work on the Proceedings throughout this special Anniversary year and beyond. We are seeking ideas for a Special Issue for Volume 47(2). Each Issue of the Proceedings from now on will have a unique colored cover, and the internal layout facilitating more pleasurable reading. We are making the Proceedings available in both print and electronic formats (on the website, one year after publication). All previous volumes will soon be available on our website. Eventually, with the concurrence of members, the Proceedings will only be available as e-copies.

As ever, papers of original science, review papers, commentaries and editorials are requested from all members of the NSIS and from other societies and individuals in the Province and beyond. Supported by the website, the Proceedings are the visible, written voice piece for the NSIS. We hope that members and others keep contributing to it, as it serves science and society in the Maritimes and Atlantic Region with excellence for another 150 years.

Peter G. Wells, Editor PNSIS
(Dalhousie University, Halifax, NS)

David H.S. Richardson, Associate Editor, PNSIS
(Saint Mary's University, Halifax, NS).

LIBRARIAN'S REPORT 2011/2012

Prepared for AGM May 8, 2012

The 2011/2012 year has been very productive and a number of library-related special projects have been completed.

Digitization of the *Proceedings of the Nova Scotian Institute of Science*

At the Council meeting of April 4th, 2011 a cheque for $2205.00 was received to hire a student for 140 hours to work on the digitization of Volume 19 (1934- 1938) to Volume 25 (1958-1962) of the ***Proceedings of the Nova Scotian Institute of Science.*** Nicole Radzikowski, a student from the School for Information Management at Dalhousie, was hired and completed the digitization to the end of Volume 25 in May 2011. Then, over the summer, one of the Killam Library intern students, Lora Hamilton, continued work on the digitization project and completed to the end of Volume 34, 1984. All of these volumes are now available online through DalSpace and can be viewed at http://www.library.dal.ca/collections/digitalcollections/nsis

On January 19, 2012, as part of the 150th anniversary celebrations for NSIS, there was a very successful event sponsored jointly by the Dalhousie University Libraries and NSIS to launch the digitized ***Proceedings.***

Institutional Members and Exchange Partners

There are currently 24 institutional members and 103 NSIS exchange partners. The number of institutional members has remained the same as last year. The number of exchange partners was drastically reduced this year. It was determined that of the 179 exchange partners we had, 75 had not sent any publications in exchange for receiving the ***Proceedings*** of NSIS for 2 years or more. A letter was sent to these Institutions stating that due to the high cost of postage and the lack of exchange material we were cancelling our exchange with them. Information was supplied about the availability of institutional memberships and the URL was supplied to access the back issues of the ***Proceedings*** online. One institution, Glasgow Natural History Society, cancelled their exchange with us.

Volume 46, parts 1 and 2 of the ***Proceedings of the Nova Scotian Institute of Science*** were both published in 2011. The two issues were sent to institutional members in one mailing to save on the cost of postage. The mailing to exchange partner institutions is currently being prepared. We are investigating the most reasonable rates for overseas postage.

Sales of the *Proceedings of the Nova Scotian Institute of Science*
Over the summer 27 copies of the ***Flora*** were sold to two classes, one at Acadia University and one at Dalhousie University. Sales of volumes of the ***Proceedings*** during 2011/2012, including the new title ***Birds of Brier Island,*** have generated $3,079.50 in revenue. (See Appendix A (attached) for details.)

Access Copyright
The Librarian submitted the required forms to Access Copyright for the 2011 repertoire payment to publishers in June. A cheque in the amount of $590.43 was received.

Inventory of NSIS exchange journal collection
There is a space shortage in the Killam Memorial Library and the new University Librarian at Dalhousie, Donna Bourne-Tyson, has inquired about the collection of exchange volumes stored in the basement of Killam Library. It currently occupies 304 shelves. The NSIS librarian arranged for a SIM student, David Reynolds, to complete a 100-hour practicum work project to assess the uniqueness of the material in this collection in April 2012. He listed the titles in the collection and then proceeded to determine if the journals are available electronically on-line or if they are held by other Canadian libraries. Recommendations will be brought to Council next year re: the future of this collection.

Change of mailing address:
The new mailing address reported in last year's Librarian Report has been changed again, and is:

Nova Scotian Institute of Science
c/o Killam Memorial Library
Dalhousie University
6225 University Avenue
PO Box 15000
Halifax, NS Canada B3H 4R2

Publications continue to be received regularly from our active exchange partners and this material is added on an ongoing basis to the collection. I would like to thank Carol Richardson and the Serials Department staff in the Killam Library who ensure that the NSIS Library operations continue to function smoothly.

I am taking an early retirement from Dalhousie University Libraries effective June 30, 2012. Because of this retirement, I am resigning my position as NSIS Librarian effective at the AGM in May 2012. I became the NSIS Librarian at the AGM in May 1995, and I have enjoyed being the NSIS Librarian for the past 17 years and serving as a member of the NSIS Council. I am very pleased to announce that Michelle Paon, a science librarian at Dalhousie University and a current member of the NSIS Council, has agreed to become the NSIS Librarian, effective immediately.

Respectfully submitted,
Sharon Longard
NSIS Librarian
May 2, 2012

Appendix A

Date	Title	# Sold	Institution	COST	Paid
May 17, 2011	Flora of Nova Scotia	11	Acadia University	$31.50 (reduced cost due to ordering 10 or more)	$ 346.50
May 24, 2011	v.40, pt. 1, 2 v.41 pt. 1, 2, 3, 4	1	Cheque	$47.50 ($37.50 + $10 S/H)	$ 47.50
June/July 2011	Flora of Nova Scotia	16	Biology 2601 class	$35 x 16	$ 560.00
November 8, 2011	Birds of Brier Island (v.46, pt.1)	4	Cheque	$25.00 x 4	$ 100.00
November 8, 2011	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$ 25.00
November 9, 2011	Birds of Brier Island (v.46, pt. 1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
November 9, 2011	Birds of Brier Island (v.46, pt. 1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
November 14, 2011	Birds of Brier Island (v.46, pt.1)	11	Cheque	$25.00 x 11	$ 275.00
November 15, 2011	Birds of Brier Island (v.46, pt. 1)	1	Cash	$25.00	$ 25.00
November 16, 2011	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
November 23, 2011	Birds of Brier Island (v.46, pt. 1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
November 28, 2011	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$ 25.00
November 29, 2011	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $8.00 (S/H)	$ 33.00US funds
November 29, 2011	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
November 30, 2011	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$ 25.00
December 1, 2011	Birds of Brier Island (v.46, pt.1)	3	Cheque	$75.00 + $24.00 (S/H)	$ 99.00US funds
December 5, 2011	Birds of Brier Island (v.46, pt.1)	2	Cash	$50.00	$ 50.00
December 5, 2011	Birds of Brier Island (v.46, pt.1)	2	Cash	$50.00	$ 50.00
December 6, 2011	Birds of Brier Island (v.46, pt.1)	11	Cheque	$275.00	$275.00
December 6, 2011	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$ 25.00
December 7, 2011	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$ 25.00
December 7, 2011	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$ 25.00
December 9, 2011	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
December 14, 2011	Birds of Brier Island (v.46, pt.1)	2	Cheque	$50.00	$ 50.00
December 15, 2011	Birds of Brier Island (v.46, pt.1)	5	On consignment at the Museum of Natural History	$20.00 x 5=$100.00	$ 100.00

Appendix A *Continued*

Date	Title	#	Institution	COST	Paid
December 16, 2011	Birds of Brier Island (v.46, pt.1)	2	Cheque	$50.00 + $10.00 (S/H)	$ 60.00
December 16, 2011	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $8.00 (S/H)	$ 33.00US funds
December 19, 2011	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
January 3, 2012	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $5.00 (S/H)	$ 30.00
January 5, 2012	Birds of Brier Island (v.46, pt.1)	2	Cheque	$50.00 + $10.00 (S/H)	$60.00
January 9, 2012	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $5.00 (S/H)	$30.00
January 9, 2012	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + 8.00 (S/H)	$33.00US funds
February 14, 2012	Flora of Nova Scotia v.26 pt. 2 & 4	1	Cash	$35.00	$35.00
February 15, 2012	Birds of Brier Island (v.46, pt.1)	2	Cash	$25.00	$50.00
February 15, 2012	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$25.00
March 2, 2012	Birds of Brier Island (v.46, pt.1)	3	Western Counties Regional Library	$90.00	$90.00
March 6, 2012	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$25.00
March 13, 2012	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$25.00
March 14, 2012	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$25.00
March 16, 2012	Birds of Brier Island (v.46, pt.1)	2	Cash	$25.00	$50.00
March 19, 2012	Birds of Brier Island (v.46, pt.1)	1	Cheque	$25.00 + $5.00 S/H	$30.00
March 27, 2012	Birds of Sable Island (v.31, pt.1)	4	Cash	$10.00	$40.00
March 27, 2012	v.46, pt. 2 2011	1	Cash	$10.00	$10.00
March 27, 2012	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$25.00
March 28, 2012	Birds of Brier Island (v.46, pt.1)	1	Cash	$25.00	$25.00
April 11, 2012	Birds of Sable Island (v.31, pt.1)	1	Cheque	$7.50	$7.50
Total					**$ 3079.50**

TREASURER'S REPORT

NOVA SCOTIAN INSTITUTE OF SCIENCE
MARCH 31, 2012

ASSETS:		
Bank Account	3,374.70	
Investments	52,401.46	
TOTAL ASSETS		**55,776.16**
LIABILITIES AND NET WORTH:		
Accounts Payable		
Science Fair	150.00	
		150.00
NET WORTH		**55,626.16**
TOTAL LIABILITIES AND NET WORTH		**68,742.58**

INVESTMENTS:	
Renaissance High Interest Savings Account	2,101.46
CIBC Investment	
Certificate A @5.20% (due Oct. 2012)	20,000.00
National Bank of Canada	
Certificate A@2.900% (due May 2013)	10,300.00
Montreal Trust Company	
Certificate A@3.250 % (dueJuly15 2015)	10,000.00
Laurentian Bank	
Certificate A@2.700%(dueJun15,2015)	10.000.00
TOTAL INVESTMENTS	**52,401.46**

REVENUE AND EXPENDITURES FOR 2011-2012

REVENUE			
Membership Dues			
Individuals	$3,305.00		
Institutions	625.02		
AGM (2011)	1,006.00		
Transfer from Savings	13,000.00		
Donations/Grant	110.00		
Sales/Page charges			
Proceedings	1,795.82		
Other-Flora	941.50		
Postage for Proceedings	128.00		
Income/Royalties			
Investment Income (2011 Calendar Year)		2,350.84	
Access Copyright Royalty		641.40	
Bank Interest		0.62	
			$23,904.20
EXPENDITURES			
Advertisement/Promotion	$881.09		
AGM (2010)	1,186.86		
Office supplies	19.29		
Rent	224.02		
Postage	462.40		
Donations/Prizes	2,000.00		
Proceedings Costs	19,089.44		
Correction (cheque issued to NSIS in error)	40.00		
			$23,903.10

Net gain: $1.10

Finances

The net worth of the Institute is **$55,626.16**. For this year, the Institute received $641.40 from ACCESS copyright for publication royalties. Expenditures for donations and prizes totalled $2,000.00. This included donations of $150.00 to each of 10 regional Science Fairs in Nova Scotia, and one writing competition award of $500.00 for a graduate student.

Membership

The Institute has 122 individual members including 8 life members and 3 student members. This year there were 32 new members. Dues from individual members amounted to $3,305.00 and from institutional members $625.02.

Respectfully submitted to the AGM
May 8, 2012
Elaine D. McCulloch
Treasurer

NOMINATIONS TO POSITIONS ON NSIS COUNCIL 2012-2013

President:	Michelle Paon
Vice-President:	Tom Rand*
Past President:	John Rutherford
Secretary:	Linda Marks
Treasurer:	Angelica Silva
Editor:	Peter Wells
Librarian:	Michelle Paon
Webmaster:	Suzuette Soomai
Publicity:	Regis Dudley

Councillors

Henry (Hank) Bird (Writing Competition Coordinator)
Leigh Ann Bishop* (Science Teacher's Rep)
Robert Boudreau (Mentorship)
Kevin Hewitt*
Ron MacKay§
Elaine McCulloch
Rick Singer
John Young

Student Representative

Allison Chua*

Observers

David Christianson (Nova Scotia Museum)
Vacant (Discovery Centre)

* New members on Council
§ Returning

REPORT OF THE 150TH ANNIVERSARY COMMITTEE & BANQUET COMMITTEE

Annual General Meeting - May 8th, 2012

During the 2011-2012 season, the NSIS Anniversary Committee met five times in order to plan and undertake anniversary initiatives. Publicity for and marketing of the events was also taken into consideration. In a departure from previous years, a full colour promotional brochure was produced, which included photos of the upcoming lecture speakers as well as information about the lectures and events. Copies of the brochure were supplied to NSIS members and lecture attendees and were distributed to public libraries and large public venues such as the Dalhousie Arts Centre and the New Seaport Farmers' Market.

The NSIS lecture posters were also produced in colour, including a photo of the speaker along with the location, time and lecture information. Print posters were distributed to university campus locations, public libraries, and a number of other high traffic locations. In addition, a PDF copy of each lecture poster was mounted on the NSIS website. Both the brochures and posters received a very favourable response and may have contributed to the high attendance at this year's NSIS public lectures.

Email messages about the monthly lectures were distributed to a wide range of potential audiences, including NSIS members, non-profit organizations involved in science/environmental issues/history, science teachers and science fair coordinators throughout the province, faculty members and graduate students in science, engineering and medicine, and colleagues at the Bedford Institute of Oceanography, among others. In addition, the NSIS anniversary events were made known to relevant provincial ministries, as well as deans and department chairs in science and engineering at universities throughout the province.

The NSIS lectures were held at three venues: six lectures were presented at the auditorium of the Museum of Natural History, two at the Windsor Theatre of the Art Gallery of Nova Scotia, and one at Alumni Hall at the University of King's College. Attendance at the October to April lectures far exceeded that of previous years, with an average of about 75 people per lecture. In fact, there was a full house at several of the lectures, including the lecture on the Shubenacadie Canal presented by Cameron Ells, which attracted over 100 attendees.

Several months later, Cameron very graciously repeated the lecture, which attracted another 43 attendees. Due to collaborations with the venue organizations, we have been most fortunate in being able to book the venues at very reasonable rates or free of charge.

In addition to the public lectures, several special events were organized during the year:

- NSIS worked in partnership with the Dalhousie University Libraries to officially launch the online historical Proceedings of the Nova Scotian Institute of Science. This event occurred at the Killam Memorial Library on January 19, 2012 and was attended by 30-40 people.
- The April 2012 NSIS public lecture on gold by Dr. Jacob Hanley was held at the Art Gallery of Nova Scotia auditorium. This lecture served as a prelude to an upcoming exhibit on gold that will be mounted by the gallery.
- The NSIS 150th Anniversary Lecture by Dr. Bernie Lightman was held on Monday, May 7th at the University of King's College and was co-sponsored by the History of Science and Technology (HOST) program at the university. The lecture was followed by a reception at which attendees were treated to anniversary cake and refreshments. The co-sponsorship allowed NSIS to use the lecture hall and reception room at no charge. In addition to the in-kind contribution provided by HOST, the Situating Science Atlantic Node was also very supportive of this event, providing assistance with distribution of posters and sharing the lecture announcement via Facebook®.

Throughout the coming year, a number of events have been planned to celebrate the NSIS 150th anniversary, some of which will occur in partnership with other organizations. As an example, on October 6th and 7th in Halifax, Symphony Nova Scotia will highlight the NSIS anniversary during two performances of Franz Joseph Haydn's Creation oratorio. It is hoped that these performances will draw together members of both the scientific and artistic communities in a celebration of the natural world. During the pre-concert chats, host and SNS Board of Directors member Adrian Hoffman will moderate a panel discussion on the links between science and music. He has invited NSIS members and interested scientists from throughout the province to participate as panelists in these discussions (six panelists will be chosen from among those who have volunteered their names and topics).

This past year, the Anniversary Chair attended a number of the lectures of the Royal Nova Scotia Historical Society, which afforded an opportunity to share information about the NSIS lecture season. A number of the society's members were later observed in attendance at the NSIS lectures. Further discussions with society President Bertrum MacDonald and Vice-President Claire Campbell resulted in plans to explore areas of common interest, especially related to the history of science in Nova Scotia. As a result, in November, NSIS will partner with the Royal Nova Scotia Historical Society to present a joint lecture by Dr. Suzanne Zeller of Wilfrid Laurier University. Dr. Zeller conducts research into the history of science in Canada and recently has begun to turn her attention to the early Proceedings of the NSIS. We look forward to presenting this lecture to our combined memberships and to the public.

Last year, NSIS met with representatives from the Museum of Natural History in order to propose that the museum develop an exhibit to highlight the NSIS anniversary. The idea received a warm reception, and the museum suggested the theme of "scientific collections". It appears that the museum will mount such an exhibit sometime this year.

NSIS is also looking forward to collaborations with the Bedford Institute of Oceanography (BIO) during its upcoming 50th anniversary celebrations. Our colleagues at BIO have been very supportive in terms of promoting NSIS events to BIO researchers and staff, and by distributing lecture posters and brochures.

The NSIS Banquet Committee met four times during the year to plan the May 8th banquet event. In June 2011, a brief survey was sent to NSIS members to determine the number interested in attending a banquet and to gauge potential price sensitivity to the cost of the banquet ticket. The survey indicated that there might be approximately 60 attendees and that a price point of $50 was acceptable.

Four potential venues were considered, and in the final analysis, the Lord Nelson Hotel was selected. Due to a very generous in-kind contribution by the hotel, the rental fee was waived for both the reception room (Admiral Room) and the banquet room (Georgian Lounge).

The banquet registration form and an invitation from the NSIS President were sent to members in late February 2012. Members were also given the opportunity to purchase "NSIS 150" commemorative tumblers created by Nova Scotian Crystal. The final tally of banquet registrations was 62.

A number of the Banquet Committee meetings were held in conjunction with the Anniversary Committee in order to share information and distribute tasks. The banquet event includes a reception, dinner, and the Hall of Fame inductions of Dr. Willard S. Boyle and Dr. Kenneth Mann. In addition, Dr. W. B. (Bev) Scott will be recognized as a long-standing member of the Institute. The families of both Hall of Fame honourees will be in attendance, as will the Honourable David A. Wilson, provincial Minister of Communities, Culture and Heritage, his Executive Assistant Nathaniel Smith, and Ms. Michèle Raymond, Member of the Legislative Assembly for Halifax Atlantic.

The banquet program to be distributed to attendees will include profiles of the honourees, as well as congratulatory messages from NSIS partners such as the Museum of Natural History, the Bedford Institute of Oceanography, the National Research Council, Dalhousie University Libraries, and Situating Science Atlantic Node.

The Chair expresses her sincere thanks to the members of both the NSIS 150th Anniversary Committee and Banquet Committee for their support, their creativity, and their generous commitment of time during the past year. The members of the NSIS Banquet Committee included Linda Marks, Elaine McCulloch, Angelica Silva, Michelle Paon (Chair) and John Rutherford. The members of the NSIS 150th Anniversary Committee will continue their work until the end of the 2012 calendar year. They include: Hank Bird, Bob Cook, Michelle Paon (Chair), John Rutherford, and Peter Wells.

Respectfully submitted by Michelle Paon
May 6, 2012

AGENDA

151ST Annual General Meeting – 8 May 2012
Admiral Room, Lord Nelson Hotel, Halifax, NS

1. Minutes of 150th AGM, 2011 meeting. MOVED:
   SECONDED:
2. Presidents' Annual Report (John Rutherford):
3. Treasurer's Annual Report (Elaine McCulloch)
4. Editor's Annual Report (Peter Wells)
5. Librarian's Annual Report (Sharon Longard)
6. 150th Anniversary Committee Report (Michelle Paon)
7. Nominating Committee for 2012-2013 Report (David Richardson)
8. Dues Increase
9. Lecture Programme for 2012-2013 (Draft)
10. Other Business
11. Adjournment: Moved:

MINUTES OF THE 150TH ANNUAL GENERAL MEETING

2 May, 2011

Dalhousie University Faculty Club

Council Members present: John Rutherford (Vice-President), Stuart Grossert (Past President), Mary-Jane O'Halloran (Past President), Linda Marks (Secretary), Sharon Longard (Librarian), Peter Wells (Editor), Robert Cook (Writing Contest Coordinator), Ron MacKay (Lecture Committee Coordinator), Michelle Paon (150th Anniversary Committee Coordinator)

Members present: Michael Falk, Laura MacDonald

Regrets (Council Members): David Richardson (President), Elaine McCulloch (Treasurer), Robert Boudreau (Mentorship Coordinator), Henry Bird, Angelica Silva

As the President could not be available, John Rutherford welcomed members and called to order the 150th Annual General Meeting. It was noted that the reports will be briefly summarized as all the reports have been made available to members with email prior to the meeting and that paper copies are also available.

1. **Approval of the Minutes of the 149th Annual General Meeting of 3rd May, 2010.**

   Motion to accept the minutes:
   MOVED: Robert Cook
   Seconded: Michael Falk
   No discussion. All in favour. Carried

2. **Annual Reports**

   a) President's Report (David Richardson)

   John Rutherford highlighted aspects of the President's Report (attachment # 1) on behalf of David Richardson as follows:

- The Institute had a very successful year with a well attended lecture program organized by Ron McKay with the help of Angelica Silva and John Rutherford.
- The Institute also co-sponsored the 7th Annual Sable Island meeting which was held at Saint Mary's University.
- A successful Writing Contest awarded two prizes and was organized by Robert Cook.
- Two issues of the Institute's journal the Proceedings of the Nova Scotian Institute of Science were published, thanks to the Editor, Peter Wells, and the Editorial Board, with financial assistance (in the form of a grant) provided by the Nova Scotia Department of Tourism and Heritage.
- The Institute provided financial support to ten regional science fairs.
- Dalhousie University, which houses the NSIS library, has digitized issues of the Proceedings of the Nova Scotian Institute of Science for the years 1862 – 1934.
- The Institute will celebrate its 150th Anniversary in 2012 and a committee, chaired by Michelle Paon is working on events to highlight and celebrate the event.

The Institute is indebted to the Museum of Natural History for its support and to David Christianson, the Museum's Manager of Collections for his assistance.

The President noted in his report that "The Institute has a long and proud history and will celebrate 150 years of promoting science to Nova Scotians in 2012. Few other Canadian organizations can boast this track record."

The President thaned all members of Council for their diligence and hard work during the past year.

Motion to accept the President's Report:
MOVED: Robert Cook
Seconded: Michael Falk
No discussion. All in favour. Carried

b) Editor's Report (Peter Wells / Associate Editor, D. Richardson)
Peter Wells presented the Editor's report (attachment # 2) and reported that Proceedings Vol. 45 (Parts 1 and 2) were successfully completed and that Vol. 46 (parts 1 and 2) are underway. The Editor reported that the Editorial Board has been strengthened; guidelines for manuscript flow have been developed; and that journal layout and production is supported by two Dalhousie staff members, Sarah Stevenson and Gail LeBlanc.

The Editor stressed that Institute members are welcomed to submit papers and editorials and that the Journal, supported by the Institute's Website, is an important voice for the Institute and science in Nova Scotia.

Motion to accept the Editor's Report:
MOVED: Ron McKay
Seconded: Robert Cook
No discussion. All in favour. Carried

c) Treasurer's Report
John Rutherford presented the Treasurer's report (attachment # 3) which stated that the Institute has a "net worth" of $68742.58. Revenue included a grant from the Nova Scotia Government, investment income; royalties from ACCESS copyright; the sale of the Proceedings; and membership (individual and institutional) dues. Expenditures included the printing and mailing of the Proceedings and donations; promotional materials; and prizes to the Writing Contest and province-wide Science Fairs.

The Institute currently has 106 members.

Michael Fak agreed to audit the Report. Thanks were given to the auditor.

Motion to accept the Treasurer's Report:
MOVED: Peter Wells
Seconded: Ron McKay
No discussion. All in favour. Carried

d) Librarian's Report
Sharon Longard reported highlights of her report (attachment # 4). NSIS has 179 exchange partners and 24 institutional members.

Sales of past Proceedings generated $930.50 in revenue. A project to digitize the Institute's Journal is continuing. During the summer 2010, Vols. 13 to 18 (1910-1934) of the Proceedings have been digitized through an initiative of the Dalhousie University Libraries and can be viewed at http://www.library.dal.ca/collections/digitalcollections/nsis. Council approved a request, from the Librarian, for funding for the digitization of Vols. 19 to 25 (1934-1962) of the Proceedings. This project will complete the first 100 years of the Journal.

Motion to accept the Editor's Report:
MOVED: Sharon Longard
Seconded: Michael Falk
No discussion. All in favour. Carried

S. Longard thanked Carol Richardson and the Serials Department staff in the Killam Library at Dalhousie University for ensuring that the NSIS Library continues to function smoothly.

3. NSIS Website

Stuart Grossert reported that a proposal to redesign the Institute`s website was submitted to Council in April. The present website, while well laid out, is difficult to modify due to its complexity. It has been proposed that that be contracted to work with the incoming Webmaster to produce a simpler website, which would be easier to modify. Past Webmaster, John Cordes has volunteered to assist and meetings are planned prior to October. Stuart Grossert wished to stress the importance of the website to the Institute.

4. Anniversary Committee (Michelle Paon)

Chair, Michelle Paon presented a report (attachment #5) on behalf of the Committee (John Rutherford, Hank Bird, Robert Cook, Peter Wells and Michelle Paon). Special public lectures are planned with one to be held at the Art Gallery of NS and a May Anniversary Lecture by Dr. Bernie Lightman from York University. The Committee is collaborating with Dalhousie University's School for Resource and Environmental Studies to host the Killam Memorial Lectures and along with the Institute`s Librarian, Sharon Longard, is partnering with Dalhousie University Libraries to officially launch the online Proceedings in January 2012.

A Banquet Committee (Michelle Paon, Elaine McCulloch, John Rutherford and Linda Marks) has been established to plan the Anniversary Banquet which will include a reception, dinner and a Hall of Fame presentation.

Other

In addition, the Committee is working towards collaborative initiatives with the Bedford Institute of Oceanography, which will celebrate its 50th anniversary in 2012. The Committee is also hoping that the Institute will be selected by Canada Post for a commemorative stamp.

Ron MacKay felt that the Institute should offer to cover some of the costs for the Killam Lecture Series so that we may have some influence over the lectures. John Rutherford emphasized that we do retain influence as members of the committee and can participate in the costs for refreshments. Michelle Paon may look at ideas to involve sponsors for the event.

Sharon Longard suggested that the brochure for 2011-2012 give advance notice of the banquet and Robert Cook suggested that the Premier of the Province be invited to the event.

Stuart Grossert congratulated the committee for its work and hoped that word will get out concerning these significant activities in 2012.

5. Report of the Nominating Committee and Election of Council for 2011 – 2012 (Mary-Jane O'Halloran)

Mary-Jane O'Halloran presented the nominations (attachment #6) for the 2011-2012 Council on behalf of the Committee (Stuart Grossert, David Richardson, John Rutherford and Mary-Jane O'Halloran).

There were three calls for additional nominations from the floor. As there was "no contest" to the proposed slate of officers it was declared that the nominations be elected by acclimation.

New members to Council are Suzuette Soomai (Webmaster), Richard Singer and John Young.

6. Other Business

Stuart Grossert suggested that in future the minutes from the April Council meeting be approved by the outgoing Council and not left until the following October's first meeting with a new Council. The outgoing Council could meet just prior to the AGM to discuss and approve the minutes.

Stuart Grossert expressed thanks to David Richardson for his work as President.

7. Adjournment

It was moved by Peter Wells that the meeting be adjourned at 9:55 PM.

Respectfully submitted,
Linda Marks
Secretary

Proceedings of the Nova Scotian Institute of Science (2012)
Volume 47, Part 1, pp. 199-200

HALL OF FAME INDUCTEES

Willard S. Boyle

Born: 19 August 1924, Amherst, Nova Scotia
Died: 7 May 2011, Truro, Nova Scotia
Field: Physics, Semiconductor technology

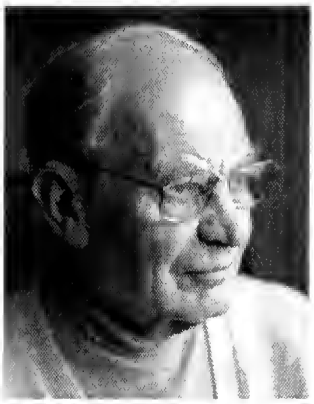
Willard Boyle moved to rural Quebec as a young boy, was home schooled by his mother, and began his formal education at Lower Canada College in Montreal at the age of 14. He joined the Royal Canadian Navy in 1943. After the war, he received his B.Sc., M.Sc and PhD (Physics) degrees from McGill University. In 1953, h joined the Bell Laboratories in Murray Hill, New Jersey, USA.

In 1962, he worked on a project which developed the first continuously operating ruby laser. He participated in space science and exploratory programs and the Apollo Space program. In 1969, in collaboration with colleague George Smith, the charge-coupled device (CCD) was created. During his time at the Bell Laboratories, he was involved in producing at least 18 patents. He retired from the Bell Laboratories in 1979 as the Executive Director of the Communication Science Division. He then lived in Wallace, Nova Scotia and maintained a residence in Lac Tremblant, Quebec.

For his contributions to science, Dr. Boyle received numerous awards, medals, and prizes. He was inducted into the Canadian Science & Engineering Hall of Fame in 2005. He was the co-recipient of the Nobel Prize in Physics in 2009 for his role in the invention of an imaging semiconductor circuit – the CCD sensor. He was made a Companion of the Order of Canada in 2010.

Photo credit: National Academy of Engineering
Text Credit: R.H. Cook

Kenneth Henry Mann



Born: 15 August 1923, Dovercourt, UK
Died: 24 January 2010, Halifax, Nova Scotia
Field: Marine Ecology

Dr. Mann was associated with the Zoology Department at Reading University (1954-1966) and his biological research soon led him to studies on aquatic ecosystems. He received a research grant to study the ecosystem energy-flow of the Thames River as a part of the International Biological Programme (IBP); this enabled him to observe web structure and function in different aquatic systems. In 1967, a year after Canada became a member of the IBP, he immigrated to Canada and accepted a position at the Bedford Institute of Oceanography (BIO), Marine Ecology Laboratory, as the Head of Biological Oceanography. His research was to measure and model marine production of multiple trophic levels from plankton and benthos to fish in St. Margaret's Bay, Nova Scotia. His research provided the first quantitative data to show that macrophytes were an important source of dissolved and particulate organic material providing energy for coastal marine food webs. He was Professor and Chairman of Biology at Dalhousie University from 1972-1980 and from 1980-1987 was the Director of the Marine Ecology Laboratory, Dept. of Fisheries and Oceans, at BIO.

Dr. Mann received a D.Sc. from the University of London (1965), and an honorary doctorate from Cape Breton University (2008). He was the first recipient of the Lifetime Achievement Award from the American Society of Limnology and Oceanography (1995). He received the Gulf of Maine Council's Visionary Award in 2003. He was a Fellow of the Royal Society of Canada.

Photo credit: The Mann Family
Text Credit: R.H. Cook

RECOMMANDATIONS AUX AUTEURS

Les auteurs peuvent soumettre leur manuscrit en anglais ou en français et doivent l'envoyer au rédacteur en chef par courriel (nsis@dal.ca et oceans2@ns.sympatico.ca). Le titre du manuscrit doit être suivi des noms de tous les auteurs, leurs adresses respectives et leurs adresses de courriel. Un résumé doit suivre qui comptera au plus 200 mots. Si approprié, il doit y avoir des sections tel que l'introduction, les méthodes, les résultats, la discussion, les conclusions et les références bibliographiques. L'orthographe doit suivre *Le Grand Robert*, et il est recommandé de se servir du Système international d'unités. Des frais de 25,00$ par page sont présentement imposés, à moins que tous les auteurs sont membres du Nova Scotian Institute of Science. (Les frais d'adhésion pour membres réguliers sont 25,00$ par an, et pour étudiants sont 10,00$ par an.) Des tableaux, des illustrations et des photos en noir et blanc peuvent être inclus et seront reproduits sans frais supplémentaires. Au format copie papier du journal, les coûts de reproduction en couleurs seront aux frais des auteurs, et seront environ 500$ par planche qui peut être une seule photo ou un collage. Chaque tableau ou illustration doit porter un titre et une légende auto-explicative.

Veuillez consulter des exemplaires du Journal pour vérifier le format du manuscrit. Chaque page doit être numérotée. Les références bibliographiques doivent être en ordre alphabétique et doivent montrer le nom complet de la revue, et si approprié, les numéros des revues, comme les exemples suivants:

Nielsen, K.J., & France, D.F. (1995) The influence of adult conspecifics and shore level on recruitment of the ribbed mussel *Geukensia demissa* (Dillwyn). *Journal of Experimental Marine Biology and Ecology* 188 (1): 89-98.

Cushing, D. & **Walsh, J.** (1976) The Ecology of the Seas. W. B. Saunders Company, Toronto.

Lee, G.F. (1975) Role of hydrous metal oxides in the transport of heavy metals in the environment. In: Krenkel, P.A. (ed.), Heavy Metals in the Aquatic Environment. Pergamon Press, Oxford, pp. 137-147.

Communication personnelle: Smith A.J. (2001, pers. comm.) in text.

Document sur un site web: Auteur (l'année de publication) titre, URL et la date de consultation.

Les auteurs sont responsables pour la revue des épreuves en placard dans les plus brefs délais. Une reproduction électronique de l'article en format PDF sera fournie gratuitement aux auteurs. Comme un des avantages d'adhésion, les membres du NSIS reçoivent chaque numéro du journal au format copie papier. Des exemplaires des numéros spéciaux de la revue sont en vente chez NSIS aux frais établis par NSIS.

NOVA SCOTIAN INSTITUTE OF SCIENCE COUNCIL 2012 – 2012

INSTRUCTIONS TO AUTHORS

Papers may be submitted in either English or French and should be sent electronically to the Editor at (nsis@dal.ca and oceans2@ns.sympatico.ca). The title should be followed by names, addresses and e-mails of all authors. An abstract of up to 200 words should follow. As appropriate, sections devoted to introduction, methods, results, discussion, conclusions and references should be included. Canadian spelling and SI units should be used wherever possible. There is currently a page charge of $25 per page but this will not be levied if all authors are NSIS members (Membership costs $25 per year for regular members and $10 year for students.) Tables, figures and black and white photographs may be included and will be published without an extra charge. Publication of colour figures in any hard copy of the journal will incur a charge that must be borne by the author and will likely be in the range of $500 per plate which may be a single photo or a collage. All tables and illustrations should have a title and a self-explanatory legend, send in separate files at 300 dpi or higher.

Refer to back issues of the Journal for general layout of a paper. Pages should be numbered. References should be in alphabetical order and give the full title of the journal and issue numbers where appropriate, thus:

Nielsen, K.J., & **France, D.F.** (1995) The influence of adult conspecifics and shore level on recruitment of the ribbed mussel *Geukensia demissa* (Dillwyn). *Journal of Experimental Marine Biology and Ecology* 188 (1): 89-98.

Cushing, D. & **Walsh, J.** (1976) The Ecology of the Seas. W. B. Saunders Company, Toronto.

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Personal Communication: Smith A.J. (2001, pers. comm.) in text.

Website Citation: Author (year) title, URL and date accessed.

Authors are responsible for correcting and returning proofs promptly. Authors will be provided with a PDF of their paper, free of charge. NSIS members receive a hard copy of the Proceedings as part of their annual membership. Copies of Special Issues of the NSIS proceedings may also be purchased from NSIS at a charge established by the NSIS. See the NSIS website http://www.chebucto.ns.ca/Science/NSIS/ for details.

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