AN ABSTRACT OF THE DISSERTATION OF

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This dissertation focuses on the life of Dixy Lee Ray as it examines important developments in marine biology and biological oceanography during the mid twentieth century. In addition, Ray's key involvement in the public understanding of science movement of the 1950s and 1960s provides a larger social and cultural context for studying and analyzing scientists' motivations during the period of the early Cold War in the United States. The dissertation is informed throughout by the notion that science is a deeply embedded aspect of Western culture. To understand American science and society in the mid twentieth century it is instructive, then, to analyze individuals who were seen as influential and who reflected widely held cultural values at that time. Dixy Lee Ray was one of those individuals. Yet, instead of remaining a prominent and enduring figure in American history, she has disappeared rapidly from historical memory, and especially from the history of science. It is this very characteristic of reflecting her time, rather than possessing a timeless appeal, that makes Ray an effective historical

guide into the recent past. Her career brings into focus some of the significant ways in which American science and society shifted over the course of the Cold War.

Beginning with Ray's early life in West Coast society of the 1920s and 1930s, this study traces Ray's formal education, her entry into the professional ranks of marine biology and the crucial role she played in broadening the scope of biological oceanography in the early 1960s. The dissertation then analyzes Ray's efforts in public science education, through educational television, at the science and technology themed Seattle World's Fair, and finally in her leadership of the Pacific Science Center. I argue that Ray was ideally suited to promote a dominant conception of a socially useful and instrumental form of science that lay at the core of the public understanding of science through the 1960s. These efforts in the public understanding of science reflected a broad endeavor among scientists to spread knowledge about and values of modern science from elite American society to a broader public. The dissertation concludes with a short examination of Ray's neutral gendered identity which, considered within the largely masculine context of science, played a significantly role in the successes of her professional career.

Dixy Lee Ray, Marine Biology, and the Public Understanding of Science in the United States (1930-1970)

by
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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Erik Ellis, Author

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the Ford Foundation; the Rockefeller Archives; and the archives of the Seattle School District.

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ARCHIVE KEY

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Menzel: Donald H. Menzel papers (HUG 4567.18), Century 21 Exposition (Seattle) – Correspondence. Harvard University Archive, Cambridge MA.

DLR: Dixy Lee Ray Collection (Accession No. 82106). Hoover Institution Archive, Stanford University, Palo Alto CA.

Edmondson: W. T. Edmondson Papers (Accession 2024-003). University of Washington Archives and Special Collections, Seattle WA.

Guggenheim: Dixy Lee Ray file, 1952 awardee. John Simon Guggenheim Memorial Foundation, New York NY.

Magnuson: Warren G. Magnuson Papers (Accession 3181-4). University of Washington Archives and Special Collections, Seattle WA.

McCarthy: Joseph L. McCarthy Papers (Accession 3331-84-34). University of Washington Archives and Special Collections, Seattle WA.

Museum of Science: Private archive (inquire with museum staff). Museum of Science, Boston MA.

NAS: Ad hoc committee on Marine Biology, Division of Biology and Agriculture. National Academy of Sciences Archive, Washington DC.

NASCO: National Academy of Sciences Committee on Oceanographic Research, Earth Sciences Division, Central Files series. National Academy of Sciences Archive, Washington DC.

NSF Gen: General Records, 1949-63 (Waterman's Subject File), Record Group 307, National Science Foundation. National Archive and Records Administration, College Park MD.

Turner: Ruth Dixon Turner, Museum of Comparative Zoology, Mollusk Department. Harvard University, Cambridge MA. (As of July 2004, Turner's collection was not processed.)

SIO: Scripps Institution of Oceanography Library Archives. University of California at San Diego.

Smithsonian: various collections (listed as "Accession Number: Title"). Smithsonian Institution Archives, Washington DC.

Weiss: Paul A. Weiss Collection, Record Group W436, Rockefeller Archive Center, Sleepy Hollow, New York.

Dixy Lee Ray, Marine Biology, and the Public Understanding of Science in the United States (1930-1970)

Introduction

Dixy Lee Ray, Biography, and Science as Culture

On the second day of January, 1994, Dixy Lee Ray died at her home on Fox Island, just a few miles across Commencement Bay from Tacoma Washington, where her life began nearly eighty years earlier. By all accounts hers had been an eventful life. Editors at the *Seattle Post-Intelligencer* described her as full of "eccentricities and challenges to conventional wisdom." While she made "her most significant...contributions in science" and had served as chairman of the Atomic Energy Commission, the editors concluded that Ray would "long be remembered as one of Washington state['s] most interesting and outspoken chief executives."[1]

Undoubtedly Ray gained her greatest public exposure as Washington state's first woman governor. Indeed, in 1976 Dixy Lee Ray joined Connecticut's Ella Grasso as the United States' second woman governor to be elected on her own merit rather than following a husband into office.[2] In recognition of this remarkable event, an artist's

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[1] Editorial, "Dixy Lee Ray," *Seattle Post-Intelligencer*, 4 Jan 1994. For a short analysis of Ray's years as governor and her political style, see Kurt Kim Schaeffer, "Right in the Eye: The Political Style of Dixy Lee Ray," *Pacific Northwest Quarterly*, Spring 2002, 93(2):81-93.

[2] Ella Grasso was elected governor of Connecticut in 1974 and again in 1978. Three earlier women had been elected as state governors, yet each earned their offices through their husbands.

rendering of Ray appeared on the cover of *Time* magazine following the election.[3] This event alone makes Dixy Lee Ray interesting for Washington state history, for American political history, and more broadly for women's history. Yet, as noted by the editors of the *Seattle P-I*, Ray built her career as a scientist, and throughout her professional life she was identified as a marine biologist. Inn tracing Ray's scientific career from the 1930s into the early 1970s, this dissertation is concerned with issues related to women's involvement in the sciences; efforts to educate the general public about the methods, concepts, and values of science; and the development of the marine sciences. As a history of science, the aim of this study is to understand some of the ways in which science constituted a fundamental part of American culture and, on the individual level, to analyze how a person came to identify herself as a marine biologist in the mid twentieth century, with the particular set of practices, ideals, and goals that constituted the culture of American science.

As an historical figure, Dixy Lee Ray provides a compelling case study for examining how the cultures of science changed through much of the twentieth century. Ray began her scientific training in the height of the Great Depression and embarked on

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In 1924 two women were elected governors of their respective states. Nellie Tayloe Ross became governor of Wyoming for a single term after her husband, William B. Ross, died near the end of his first term. The second woman, Miriam Amanda Ferguson ('Ma' Ferguson), won the Texas governorship in 1924 after her husband had been impeached and was not allowed on the ballot. She won a second two-year term in 1932. Finally, in 1966 Lurleen Wallace, wife of George Wallace, successfully ran in his stead because the Alabama state constitution did not allow governors to run for consecutive terms. Lurleen Wallace died in office in 1968. See *Biographical Directory of the Governors of the United States, 1789-1978* (Westport, CT: Meckler Books, 1978).

[3] The sketch is of Ray's head on the body of a Goldfinch, the state bird, with iconic images of salmon, Mt. Rainier, and a Boeing jet in the background. *Time*, 12 Dec 1977.

her professional career immediately at the end of the Second World War. During the 1950s and 1960s she established herself as an influential marine biologist and advocate of the public understanding of science. Yet, by the time of Ray's death, less than fifty years after her formal career began, many scientists (especially within marine biology) would have agreed with the conservation biologist who wrote to *The Seattle Times,* following Ray's death: "As a fellow zoologist and political activist, her platforms were consistently disappointing for me. To [*The Seattle Times'*] description of her as 'unpolitical, unique, and uncompromising' should be added the characteristic 'unscientific,' despite her impressive list of academic credentials. It appears she failed to understand the hypothetical-deductive method which is the foundation of real science."[4]

In a similar vein but with greater sophistication, Daniel Botkin, a plant ecologist and nature writer,[5] had suggested a few years earlier that Ray's scientific values no longer represented those of her professional community. In a *New York Times* review of Ray and Lou Guzzo's book *Trashing the Planet*, Botkin correctly described the authors' motivation as stemming from "bewilder[ment] that we have lost faith in science and technological progress." Botkin dismissed the relevance of Ray and Guzzo's book by claiming that the authors failed "to understand that today our society genuinely questions the 19th century idea of progress and is concerned by negative effects of the machine

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[4] James Bergdahl ("Pacific Northwest Biodiversity Institute"), letter to the editor, *Seattle Times*, 12 Jan 1994.

[5] Botkin's scientific research centers on pine forest ecology, and from the 1980s onward he has written extensively on broader issues at the heart of the modern environmental movement, such as in his 1990 book, *Discordant Harmonies: A New Ecology for the 21st Century* (New York, NY: Oxford University Press, 1990).

age."[6] Botkin's criticism encouraged readers to associate Ray's opinions with a bygone era which had long been superceded by more complex and advanced scientific views.

In contrast, this dissertation argues that Ray derived her scientific values from the dominant views of the early post World War Two American scientific community.[7] Botkin exaggerated by suggesting that Ray's scientific values were rooted in the previous century, instead of the previous decades. Her fortunes as a scientist rose with her generation's ascendance, and likewise the views espoused by Ray – her kind of faith in the power of science – gradually fell out of favor during the cultural shifts that marked the emergence of a younger generation in the 1960s and 1970s.[8] It is in the very tumultuous cultural revolutions that emerged in the latter part of Ray's life, rather than

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[6] Daniel B. Botkin, review of *Trashing the Planet: How Science Can Help Us Deal with Acid Rain, Depletion of the Ozone, and Nuclear Waste (Among Other Things)*, by Dixy Lee Ray with Lou Guzzo. *The New York Times*, 30 Sep 1990, Book Review section, 29. Interestingly, Botkin concluded his review by dismissing the book with the very language Ray often employed to discredit opponents. The few positive aspects of the book, Botkin wrote, "are lost in emotionalism, rhetoric and unfair selection of facts."

[7] Ronald Walters makes the point that it was not until the late decades of the twentieth century that scientists felt their authority to be seriously under attack in the United States. It was this sense of threat that motivated Ray's later science education efforts as well as those who criticized her for misrepresenting science, such as Paul Ehrlich. Ronald G. Walters, "Uncertainty, Science, and Reform in Twentieth Century America," 1-10, *Scientific Authority & Twentieth Century America*, edited by Ronald G. Walters (Baltimore, MD: Johns Hopkins University Press, 1997).

[8] The most prominent scientific attack on her late-life viewpoints can be found in Paul R. Ehrlich and Anne H. Ehrlich, *Betrayal of Science and Reason: How Anti-Environmental Rhetoric Threatens Our Future* (Washington, DC: Island Press, 1996). The Ehrlichs, like most of Ray's critics from the late 1980's onward, took aim at her arguments that large-scale environmental problems could be dealt with through technological fixes, or as in the case of global warming, that it was primarily a natural climatic fluctuation. She stated these positions in two books (both with Lou Guzzo): *Environmental Overkill: Whatever Happened to Common Sense?* (Washington, DC: Regnery Gateway, 1993); and *Trashing the Planet: How Science Can Help Us Deal with Acid Rain, Depletion of the Ozone, and Nuclear Waste (among other things)* (Washington, DC: Regnery Gateway, 1990).

the nineteenth century, that we can best understand the mixed reception Ray received as a scientist over the course of her career.

Late in Ray's life she upset many in the scientific community, especially within the life sciences, with her views regarding the uses of nature and exemplified in her staunch support of nuclear energy. What, if any, historical legacy she has retained is as a idiosyncratic political figure.[9] Yet through the majority of her life she was a formidable force in American science, particularly marine biology, oceanography, and in efforts to improve the public understanding of science. The underlying historical questions, then, revolve around how Dixy Lee Ray fashioned a successful scientific career and in what ways she embodied the values and perspectives of the larger scientific community.

In a biography of Morris Cohen, a well-known early twentieth century American intellectual, David Hollinger wrote that although Cohen was largely forgotten soon after his death, "he would not have attained eminence had he not been able to offer something then in demand." Cohen, like Ray, "turned out to be much more of a 'period piece' than did some of his contemporaries."[10] And as Hollinger shows in his study of Cohen, this kind of individual is perfectly suited to provide historical insights into the sometimes subtle differences that mark succeeding generations. Rather than focusing only on those scientists who exemplify a kind of 'timelessness' and whose achievements resonate with

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[9] The previously cited essay by Kurt Kim Schaeffer, "Right in the Eye," discusses Ray's political style and blunders with the press corps as Washington State governor. Tellingly, as regional political history, it remains the only scholarly work on Ray.

[10] David A. Hollinger, *Morris R. Cohen and the Scientific Ideal* (Cambridge, MA: The MIT Press, 1975), ix.

current modes of thinking, portraits of scientists who have been forgotten and whose ideas have fallen out of fashion, such as Ray, draw attention to the ways in which science constituted part of a larger intellectual, social, and cultural reality derived from a different time and place.

Biography

This dissertation traces Dixy Lee Ray's life with the aim of situating her scientific career within a larger social and cultural context. As such this narrative ends with Ray's appointment to the Atomic Energy Commission, when her career took on a far more explicitly political dimension. While important themes connect the latter part of her career with the former, concluding this dissertation in the early 1970s emphasizes the coherence of the scientific world in which Ray flourished, with only intimations of the social, cultural, and intellectual shifts that took place over the latter years of her life. Focusing on Ray's early career undoubtedly places her in the best possible light. At the time of her nomination to the Atomic Energy Commission, Ray embarked on a slightly different and more explicitly political phase of her career, and I have chosen to end this dissertation at that point.

One of the fundamental criticisms of biography is that it tends to create heroes out of ordinary humans. This misses the point of modern historical scholarship, the critics contend, in which societies, cultures, intellectual traditions are to be understood on their own terms and not simply as morality tales for our own times. In a criticism of biography, one historian recently stated that "the biographical exercise seems designed to

provide models of human excellence for reflective people and to reveal history's uses as a pep-talk for life instead of as a repository of cultural knowledge."[11] Yet, this sort of skepticism toward the scholarly value of biography may be gradually eroding. For example, social and cultural historians have argued that biography presents a valuable tool for grounding their studies within the variety and complexity of lived experience.[12] Similarly, for those who study the history of sexuality and gender, biography offers a fine-grained approach to understanding the construction of personal identities. In a work that has particular resonance with this dissertation, Jo Burr Margadant argues that biography of prominent women can best expose "unsuspected fissures" in the social fabric that allow marginalized individuals to construct unconventional but socially significant identities.[13]

Yet, if much of professional history is rediscovering the value of biography, history of science has long defended its usefulness. More than two decades ago Charles Rosenberg argued that biography presents the historian with an "organic and unassailably coherent sample of historical data." While the life of any one person is necessarily "idiosyncratic," that individual's life can not have been randomly constructed. "Every

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[11] Bruce Kuklick, "Biography and American Intellectual History," *The Journal of the Historical Society*, 2004, 4(2):252.

[12] See for example, Nick Salvatore, "Biography and Social History: An Intimate Relationship," *Labour History* (Australia), 2004, 87:187-192; and Jill Lepore, "Historians Who Love Too Much: Reflections on Microhistory and Biography," *Journal of American History*, 2001, 88:129-144.

[13] Jo Burr Margadant, "Introduction: Constructing Selves in Historical Perspective," *The New Biography: Performing Femininity in Nineteenth-Century France* (Berkeley, CA: University of California Press, 2000), 1-32. Quotation from 3.

life course reflects a specific configuration of social options – those chosen… or unchosen," Rosenberg stated. "To follow the choices made by a particular actor is necessarily to transcend the sterile categories of internal and external, social or intellectual."[14]

Debates over 'internal' and 'external' approaches to the history of science animated the discipline at the time Rosenberg argued for the usefulness of biography. More recently historians of science have shifted the terms of biography's utility, while noting the continued popularity of the genre. Michael Shortland and Richard Yeo have suggested that biographies can provide a positive tension, between explorations of uncommon individuality (genius, etc.) and analyses of the social, political, and other contextual factors which construct the individual. The tensions between these two necessary levels of historical analysis provide impetus for continued scholarship.[15]

Much exemplary literature in the history of science has drawn on the utility of biography to address these various levels of analysis. Frederic L. Holmes dedicated his

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[14] Charles E. Rosenberg, "Science in American Society: A Generation of Historical Debate," *Isis*, 1983, 74:364. Thomas L. Hankins took up the cause of biography a few years earlier in his essay "In Defense of Biography: The Use of Biography in the History of Science," *History of Science*, 1979, 17:1-16.

[15] Michael Shortland and Richard Yeo, "Introduction," *Telling Lives in Science: Essays on Scientific Biography* (Cambridge, England: Cambridge University Press, 1996), 36. There are a number of pertinent essays on biography and the history of science in Ramesh S. Krishnamurty, ed., *The Pauling Symposium: A Discourse On the Art of Biography* (Corvallis, OR: Oregon State University Press, 1996), especially Frederic L. Holmes, "Historians and Contemporary Scientific Biography, " 197-212. See also, Thomas Söderqvist, "What's the Use of Writing Lives of Recent Scientists?" Paper presented to Oregon State University History of Science colloquium, 8 April 2005. Available at http://oregonstate.edu/dept/history/lunchbunch_soderqvist.htm (viewed 30 Sept 2005).

historical scholarship to the question of how scientific knowledge came into being, deconstructing simplistic notions of genius by examining and reconstructing the daily research lives of numerous prominent scientists. In his recent book *Investigative Pathways*, he urges historians of science to scrutinize, when possible, an individual's moment-to-moment development of scientific ideas as a product of material and experimental processes. The minute details of scientific investigation can then highlight the often unexpected intellectual conclusions that become codified as scientific knowledge. These are, to Holmes, the "investigative pathways" which elucidate the complex production of new knowledge and that lie at the heart of the history of science.[16]

Where Holmes primarily studied the individual to address issues of scientific knowledge production, a recent study of Dmitrii Mendeleev uses his wide-ranging life to portray the broader history of Imperial Russia in the late nineteenth century. As Michael Gordin's study of Mendeleev has shown, a person's historical legacy – in this case the formulation of a periodic table of elements – is often isolated from the totality of a person's life, thereby obscuring how the accomplishment blended into larger social, political, or other endeavors of the era. In Gordin's biography, Mendeleev's well-known achievement is described alongside his many other efforts on behalf of science and state. Gordin argues that Mendeleev's construction of a periodic table of the chemical elements should not be seen simply as a tool to understand regularities within chemical elements.

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[16] For an explanation of his methodological approach see Frederic Lawrence Holmes, *Investigative Pathways: Patterns and Stages in the Careers of Experimental Scientists* (New Haven, CT: Yale University Press, 2004); and as an example of his approach, *Hans Krebs: Vol 1, The Formation of a Scientific Life, 1900-1933* and *Vol 2, Architect of Intermediary Metabolism, 1933-1937* (New York, NY: Oxford University Press, v.1, 1991 & v.2, 1993).

Rather, the table is an outcome of far-reaching impulses to bring order and control in a Tsarist Russia struggling to impose stability on an increasingly restive society.[17] In this sense, the best biographies construct a thorough contextualization of time and place, bringing into stark relief the ways in which knowledge is fundamentally built into the social order.

While Holmes's and Gordon's scholarship may not fall within the main tradition of biography, others hue more closely to the genre's norm, such as those whose primary aim is to explore the social, political, or other contexts of science. Here Adrian Desmond's biography of Thomas Henry Huxley provides a good example, with its focus on how class, religious, and political issues in Victorian era Britain shaped, and were shaped by, this important scientist.[18] Of course, Desmond's biography of Huxley is but one of many, reminding us that the writing of history necessarily reflects the concerns of the present.[19] Just as this dissertation is interested in how Dixy Lee Ray constructed her

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[17] Michael D. Gordon, *A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table* (New York, NY: Basic Books, 2004).

[18] Adrian Desmond, *Huxley: From Devil's Disciple to Evolution's High Priest* (Reading, MA: Addison-Wesley, 1994). Some other recent biographies that similarly exemplify a sophisticated scholarly approach are Janet Browne's two volume biography *Charles Darwin: Voyaging* (Princeton, NJ: Princeton University Press, 1995) and *Charles Darwin: The Power of Place* (New York, NY: Alfred A Knopf, 2002); Mary Jo Nye, *Blackett: Physics, War, and Politics in the Twentieth Century* (Cambridge, MA: Harvard University Press, 2004); Nathaniel Comfort, *A Tangled Field: Barbara McClintock's Search for the Patterns of Genetic Control* (Cambridge, MA: Harvard University Press, 2001); Allan A. Needell, *Science, Cold War, and the American State: Lloyd V. Berkner and the Balance of Professional Ideals* (Amsterdam, the Netherlands: Harwood Academic, 2000); Marilyn Ogilvie and Clifford J. Choquette, *A Dame Full of Vim and Vigor: A Biography of Alice Middleton Boring, Biologist in China* (Amsterdam, the Netherlands: Harwood Academic, 1999).

[19] This point was well illustrated by Janet Browne in her 2005 History of Science Society Distinguished Lecture, "Making Darwin: Biography and Character" (Minneapolis, MN).

identity as a marine biologist, Huxley's newest biographer, Paul White, explores the multiple layers of meanings that made Huxley an embodiment of the Victorian "man of science."[20]

Thus, it is well established that a broadly biographical perspective can provide new insights and fresh material for scholarship while addressing important and broad historical questions. While not denying that positive and negative moral lessons will continue to be drawn from Dixy Lee Ray's life, the ultimate aim of this dissertation is to illuminate, through her life and scientific career, some of the social roles, cultural practices, and intellectual ideals that wove science into the fabric of mid twentieth century American life.

Science as Culture

Where the methodological approach of this dissertation derives from biography, an underlying theme has to do with how science represented an important cultural touchstone of modern American society. Historians of science have long been interested in showing how science, as an intellectual enterprise, is deeply embedded within larger cultural values and practices. Recently, this effort is receiving renewed emphasis. Kathryn Olesko has urged historians of science to actively pursue the kinds of social and cultural questions in which the broader profession of historians, as well as the general

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[20] Paul White, *Thomas Huxley: Making the "Man of Science"* (Cambridge, England: Cambridge University Press, 2002).

public, can readily participate. In this vein a recent edition of *Osiris* explicitly addressed how the practices and values of science partook in the construction of modern civil society in the Western world.[21] From the ways in which women's discussions of mathematics reflected larger efforts to engage and broaden public discourse in eighteenth century England, to the problems of bringing science into Cold War American civic life, the array of issues revolving about the reciprocal dependence of science and culture in the modern Western world are being analyzed by a wide range of historians and provide much of the motivation for this dissertation.[22]

A central theme informing this dissertation stresses how science participated in public discourse and in the construction of common (but authoritative and elite) knowledge. Much of Dixy Lee Ray's life took place in rather more public spaces than did most of her colleagues. From her early efforts in non-commercial television to her successful guidance of a public science education center, and her selection to the Atomic

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[21] Kathryn Olesko, "History and the History of Science *Redux*: A Preface," vii-x, *Science and Civil Society,* edited by Lynn K. Nyhart and Thomas Broman, *Osiris*, 2002, 2nd Series, vol. 17.

[22] *Science and Civil Society*, edited by Lynn K. Nyhart and Thomas Broman. See especially Shelley Costa, "The *Ladies' Diary*: Gender, Mathematics, and Civil Society in Early-Eighteenth-Century England," 49-73, and Jessica Wang, "Scientists and the Problem of the Public in Cold War America, 1945-1960," 323-347. Much of the best literature on these themes come from studies of the modern and early modern period: Steven Shapin and Simon Schaffer, *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, NJ: Princeton University Press, 1985); Jan Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820* (Cambridge, England: Cambridge University Press, 1992); Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago, IL: University of Chicago Press, 1994); Margaret C. Jacob, *Scientific Culture and the Making of the Industrial West* (New York, NY: Oxford University Press, 1997). Yet twentieth century American history has not been ignored, such as in Gregg Mitman's work: *The State of Nature: Ecology, Community, and American Social Thought, 1900-1950 (*Chicago, IL: University of Chicago Press, 1992), and *Reel Nature: America's Romance with Wildlife on Film* (Cambridge, MA: Harvard University Press, 1999).

Energy Commission, this dissertation examines some of the many ways in which science participated in the larger American social and political life through the midst of the twentieth century.

Inasmuch as this dissertation attempts to situate Ray's life in a larger cultural context, Chapter One begins by sketching the early explorers' and settlers' visions for the region in which she was born and raised. With remarkable speed settlers, drawn by the explorers who described Puget Sound, established the civil and cultural institutions they deemed necessary for the permanent establishment of a modern society. Whereas academic institutions in Europe and on the East Coast had long been virtually closed to women, advocacy of women's higher education in the nineteenth century greatly influenced the creation of co-educational universities. These new, more inclusive, institutions sprang up across the nation and dominated in the Western states. In this way women began to have greater access to formal training in the sciences, particularly in those areas deemed appropriate to women, such as the life sciences and preparation for elementary or high-school teaching. This social and institutional milieu, becoming more open to women's participation in the sciences, provided an important context for the early years of Ray's life. The remainder of the Chapter One sketches some pertinent aspects of her childhood, from the family's socio-economic background to Ray's personal characteristics, interests, and primary education.

In Chapter Two I explore the role of education and mentoring in the construction of a scientist, with the aim of understanding how the transmission of scientific practices

and broader cultural ideals contributed to this process. In this case, the construction of a young woman into a credible marine biologist required careful training in experimental techniques and in appropriately scientific ways of thinking and communicating. In addition, from her mentors Ray absorbed a philosophical outlook in which science formed more than just a set of practices for the laboratory or the field; science encompassed a model for how to live the good life. Throughout Ray's formal education, she gradually came to understand the contours of her science – marine biology – and the ways in which it fit within the larger system of scientific disciplines. Taking up her identity as a scientist, and joining a fraternity of generally like-minded individuals, prepared Ray for later missions to redefine her discipline as well as to delineate and promote science within the broader American society.

In Chapter Three the biographical thread runs from Ray's entry into the professional scientific ranks as a zoology professor at the University of Washington through her efforts to redefine marine biology and biological oceanography in the early 1960s. Ray solidified her identity as a marine biologist, skilled in basic laboratory techniques, with her work on the nutritional physiology of a common wood-boring organism. Ray's research addressed empirical, non-theoretical issues. By making significant additions to the store of knowledge, Ray confirmed her identity as a solid and uncontroversial participant in the scientific enterprise. With a secure identity as a marine biologist by the late 1950s, Ray moved on to redefine the geographical and conceptual range of the marine sciences. As the study and practice of oceanography rapidly expanded in the early Cold War, those who studied marine life (primarily at the seashore)

saw an opportunity to attract greater resources to a disciplinary field that had traditionally been seen as part of zoology. Ray, with a handful of others, pushed aside the notion that biological oceanography primarily entailed the deep-water study of plankton and broadened its scope to include all life within the marine environment. Ray did more than most in this reorientation by forcefully promoting a broad vision of biological oceanography on the National Academy of Sciences Committee on Oceanography and through her work to fund biological oceanography at the National Science Foundation.

The needs of any particular scientific discipline often absorbed much of an influential scientist's time, and as Ray's advocacy of marine biology illustrates, this often pitted scientists from various disciplines against each other. Yet, belief in an essential unity of methods, values, and ultimate goals within the scientific enterprise bound scientists to a common cause along with much of the American intellectual and social elite. Chapter Four details Ray's efforts in popular science education and in the public understanding of science, as scientists strove to increase American knowledge and appreciation of science during the Cold War. Non-commercial television came into being through the work of citizens who shared a deep dissatisfaction over the common and often anti-intellectual content of commercial television. Funded largely through the Ford Foundation, non-commercial television represented an effort to promote an ever more enlightened American civil democracy. Science, among other intellectual and high-culture activities, was expected to play an important part in reforming American society through television. In making a television program about Puget Sound marine organisms for her local non-commercial television station, Ray discovered an opportunity to

combine her training in marine biology with her skills at public performance. Then, in the early 1960s Ray's career squarely addressed the public understanding of science when she assumed leadership of Seattle's newly established Pacific Science Center. In this role Ray epitomized the scientist-citizen. Embodying the modernist vision of bringing the values of science to the general public, she not only ran a highly successful regional public science education center but also became increasingly involved in issues that spanned science and public policy.

In Chapter Five I analyze Ray's identity as a scientist from the perspective of her gendered image. I argue that as a non-traditional female, cultivating certain habits deemed unfeminine by the standards of her time, Ray eased her entry into the male-dominated professional world. The way in which Ray built her scientific persona was, of course, unique and idiosyncratic. Yet, since other women rose to prominence in the sciences, too, Ray's strategies remind us of the variety of ways women of this era dealt with the obstacles to professional life. The novelty of a highly successful woman in the scientific community during this period suggests that these women all had to fashion unconventional identities that, as Margadant says, exploited the fissures in the gendered social system. The image of science as a domain of disembodied knowledge, especially in the United States, fostered the sense that anyone could participate. But science, though it may have assumed the mantle of universality, was nevertheless a community dominated by men and masculine traditions. Ray built a successful scientific career by taking full advantage of the openings afforded by a progressive educational system, and by constructing an identity that rebuffed the normative pressures of femininity. Ray's life

suggests that, in a post war society deeply committed to a traditional ideal of male and female roles, she rose to high levels of authority and power precisely because she was unconcerned about adopting practices and habits regarded as potentially unfeminine.

Ray's life in science, as this dissertation aims to show, presents us with a complex picture of social forces and strong individuality at play in constructing the career of an influential and public-minded marine biologist. She reflected the values of her time, of her scientific community, and of an American elite culture that had great faith in the power of science; at the same time Dixy Lee Ray was, in the enduring tradition of American myth, a determined individual who carved her own path and shaped the world in which she wanted to live.

Chapter 1

Science, Institutions, and Women: Creating a Culture of Science on the West Coast

> While dinner was getting ready on the point I ascended this Bank with one of the Gentlemen & strolled over an extensive lawn, where solitude rich pasture & rural prospects prevaild – It presented an uneven surface with slight hollows & gentle risings... & rendered the Western side of this arm a pleasant & desirable tract of both pasture and arable land where the Plough might enter at once without the least obstruction.... [The land appeared capable of] yielding luxuriant Crops of the European Grains or of rearing herds of cattle who might here wander at their ease over the extensive fields of fine pasture, though the only posessors of it we saw at this time were a few gigantic Cranes of between three & four feet high who strided over the Lawn with a lordly step.[1]

These words, recorded by the Scottish botanist Archibald Menzies, naturalist attached to Captain George Vancouver's 1792 exploration of Puget Sound,[2] paint the picture of an abundantly fertile land, un-peopled and apparently waiting for civilized development. As an envoy of Enlightenment European society, the naturalist, much like the missionary, embodied the lofty goals of Western expansion: to discover and order the wild bounty of the natural world. As such the naturalist had become a standard member on missions of exploration in order to record the wonders of the new world for the savants of the old.[3]

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[1] Archibald Menzies, *Journal of Vancouver's Voyage, April to October, 1792* (Victoria, BC: W. H. Cullen, 1923). Citation is from journal entry, 7 May, 1792.

[2] Captain George Vancouver named the body of water explored during this voyage after Lieutenant Peter Puget.

[3] The work of the naturalist on British ships in the nineteenth century is epitomized by Charles Darwin's five year journey on the Beagle, recorded in his popular 1839 account *Journal of*

Along the northern stretches of the Pacific Coast achievement of the grand ideals of the Enlightenment took place in rather mundane routines near the shores of a place that would soon take the name of Tacoma. On 20 May, Menzies wrote that after meeting with some local Indians at what is now Fox Island[4] and exchanging "buttons beads & bits of Copper" for a meal of clams "still fresh in the shell," he returned to his primary interest – the identification of local flora: "Here I found some small trees of both the American & Mountain Ash neither of which I had before met with on this side of the Continent...."[5] Menzies's observations provide us with the first example of 'science' being practiced in Puget Sound. These notes on the flora and fauna of the region were

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Researches into the Geology and Natural History of the Various Countries Visited by HMS Beagle.

[4] Tacoma is the birthplace of Dixy Lee Ray's parents, less than one-hundred years after this event; and property on Fox Island became their family retreat by the 1930s.

[5] Menzies, *Journal*, 20 May, 1792. It is significant to note that Lewis and Clark's overland expedition to the West Coast in 1805/6 similarly found much of its meaning through documentation of the region's natural history. See for example Gerald Holton's essay on the linkage of science and nationhood at the time of President Jefferson, "On the Jeffersonian Research Program" *Archives Internationale d'Histoire des Sciences*, 1986, 36:325-336; and James P. Ronda, "Exploring the American West in the Age of Jefferson" in *North American Exploration, Volume 3: A Continent Comprehended*, edited by John Logan Allen (Lincoln, NE: University of Nebraska Press, 1997), 9-74. Ronda portrays an inextricable link between the expansion of science, empire, and wealth, illustrating his point with the words of the prominent fur-trader Alexander Ross: "The progress of discovery contributes not a little to the enlightenment of mankind; for mercantile interest stimulates curiosity and adventure, and combines with them to enlarge the circle of knowledge. To the spirit of enterprise developed in the service of commercial speculation, civilized nations owe not only wealth and territorial acquisitions, but also their acquaintance with the earth and its productions." See page 12.

also contextualized within a larger and distinctly Anglo-American vision of social development that would rapidly come into being over the following decades.[6]

This chapter sketches the congealing of a frontier society, its creation of cultural institutions, over a remarkably short period of time in the nineteenth century. While drawing on deep traditions and values of Western society, the cultural institutions and outlook that developed on the West Coast were at the same time somewhat more fluid than those on the East, and provided a unique identity to persons who grew up in the rapidly changing cities and towns of the region.[7] Moreover, this chapter sets the stage for the main focus of the dissertation, namely the scientific career of Dixy Lee Ray. As a prominent American marine biologist and public (and controversial) advocate of science through the middle decades of the twentieth century, she was a product of the West Coast institutions described in this chapter. In turn, Ray played an influential role in shaping these institutions as well as the larger public discourse about science, the environment, and the human attitude toward the natural world.

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[6] Two general sources for the history of the region are: Murray Morgan, *Puget's Sound: A Narrative of Early Tacoma and the Southern Sound* (Seattle, WA: University of Washington Press, 1979), and the more broadly focused work by Carlos Schwantes, *The Pacific Northwest: An Interpretive History* (Lincoln, NE: University of Nebraska Press, 1996, revised edition).

[7] A recent book by David Livingstone argues that science should be seen as being produced not just by savants, but also by geographical regions and particular places. This dissertation, in certain ways, draws on this conception of science. See David N. Livingstone, *Putting Science in its Place: Geographies of Scientific Knowledge* (Chicago, IL: University of Chicago Press, 2003).

'Discovering' a Place & Building Culture

The story of European settlement along the West Coast of North America predates the nineteenth century, yet the 1840s and 1850s marked the beginning of the modern transformation of the region as significant populations of settlers of European origin began to establish institutions emblematic of Western society. The treaty of Guadalupe-Hidalgo in 1848 ceded land in the Southwest, including California, from Mexico to the United States; during the same year Congress gave formal recognition to the immense and lightly populated Oregon Territory as part of the growing nation. With the discovery of gold in central California setting off massive migration to the West Coast, the new and predominantly Anglo residents of the West, along with expansionist politicians on the East Coast, began to find ample reason to clamor for full integration of the territories at the edge of the continent. The State of California entered the Union in 1850, followed by Oregon in 1859. In comparison to California and Oregon, the relatively delayed population boom taking place in the Washington Territory through the decade of the 1880s (from 75,000 in 1880 to nearly 350,000 in 1890), resulted in statehood by 1889. For the region as a whole, the population totaled roughly 105,000 for California and the Oregon Territory in 1850. By 1890, the populations of the West Coast states had boomed to over 1,800,000. It is within this massive and remarkably abrupt transformation of society on the West Coast, following Native American societies' precipitous decline as a result of contact with Europeans over the previous two centuries, that individuals created the institutional frameworks of science alongside other cultural foundations.

Fundamental to the American sense of a civilized society has been the establishment of higher educational institutions, sites where citizens could build and expand upon the basic knowledge gained in elementary and secondary schools. These institutions defined and promoted the higher intellectual and social qualities expected in a modern democratic society. In this regard the college or university played an important function in keeping at bay the potentially de-civilizing environment encountered in the New World. Similarly, Americans believed higher education helped to develop and solidify an egalitarian social order within the emerging republican society that disavowed the imposed order of aristocratic, old world Europe. As historians of science have pointed out, the study of natural philosophy, or science, formed a cornerstone of nineteenth century education and, with the marked proliferation of these institutions, women gained new opportunities to participate in scientific endeavors.[8] Larry Owens has argued that science became ever more important in the latter half of the nineteenth century as Americans looked to unify a deeply divided country. In an examination of connections between culture, science, and university education in post-civil war America, he writes that the tumult of a reconstructing society "demanded [a] pluralism of ideas and a student marked by openness of mind and a commitment to truths sought through

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[8] See the studies of American science education by Lawrence Veysey, *The Emergence of the American University* (Chicago, IL: University of Chicago Press, 1965); Stanley M. Guralnick, "Sources of Misconception on the Role of Science in the Nineteenth-Century American College" (1974) and Sally Gregory Kohlstedt, "Parlors, Primers, and Public Schooling: Education for Science in Nineteenth-Century America" (1990), both reprinted in *The Scientific Enterprise in America: Readings from Isis*, edited by Ronald Numbers and Charles Rosenberg (Chicago, IL: University of Chicago Press, 1996); and Nathan Reingold, "American Indifference to Basic Research: A Reappraisal," 54-75, *Science, American Style* (New Brunswick, NJ: Rutgers University Press, 1991).

rational inquiry." These demands could be fully met through study of the sciences. Illustrating the underlying value of science for American society, Owens quotes the president of research-oriented Johns Hopkins University as saying, "the essential value of the university does not depend on the discoveries it makes, or the knowledge it accumulates and imparts, but in the character which it develops."[9] For those living in the far western reaches of the country, in what American settlers often imagined as a wild, untamed environment, the need for careful and deliberate development of character was even more keenly felt.

The civilizing project within which higher education participated gradually came to include women, but not without strong protest from some who saw women's education as a potential source of destabilization of the "natural" social order. Despite objections, as Margaret Rossiter has detailed, the expansion of colleges and universities in the nineteenth century included numerous exclusively women's institutions as well as co-educational private and public schools. Vassar College, opened in 1865 in New York State, soon to be joined by Smith College, Wellesley College, and Bryn Mawr, all opening in the 1870s and 1880s, and providing both high-quality educational opportunities for women and future places of employment for those who earned degrees

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[9] Larry Owens, "Pure and Sound Government: Laboratories, Playing Fields, and Gymnasia in the Nineteenth-Century Search for Order" *Isis,* 1985, 76:182 & 193; and Robert E. Kohler, "The Ph.D. Machine: Building on the Collegiate Base," (1990) reprinted in *The Scientific Enterprise in America*, 98-122. Kohler makes in important comparative note between European and American science in the research oriented university setting, which points out the broad importance of science for betterment of the society as a whole: "The remarkable growth of the American system of higher learning has given rise to much research about its distinctive organization and mores:... [including] the tendency to treat scientific research as a professional pursuit for the many rather than as a calling for a few."

in the rapidly professionalizing sciences.[10] In a faint echo of the founding of East Coast women's colleges, a Young Ladies Seminary was founded near San Francisco in 1852. Cyrus and Susan Mills, Presbyterian missionaries returning from years spent in the Pacific Islands, purchased the fledgling institution thirteen years later, zealous to build up a prominent school exclusively for the education of women. While initially little more than a place to nurture spiritual virtues through the study of theology, edifying literature, history, and the arts, a gradual evolution of the institution resulted in its becoming a formally incorporated, non-sectarian, degree-granting college by 1889. With prominent trustees such as Stanford University's President David Starr Jordan, Mills College soon became recognized as a progressive and quality educational option for ambitious young women who did not, or could not, pursue higher education at the more prominent women's colleges on the East Coast. In 1889 Mills College became the first institution west of the Mississippi to award the B.A. degree to women.[11]

More broadly the passage of the Morrill Land Grant Act of 1862 opened the flood-gate for creation of public higher education institutions such as Cornell University and the University of Michigan. These institutions provided men and women with access to, most often, very practical kinds of courses for application to industry, for the refinement of elementary school educators, or for agricultural knowledge, but they did not ignore the loftier goals of personal ennoblement. In the spirit of democratic

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[10] Margaret Rossiter, *Women Scientists in America, Volume 1: Struggles and Strategies to 1940* (Baltimore, MD: Johns Hopkins University Press, 1982), 9-10.

[11] Elias Olan James, *The Story of Cyrus and Susan Mills* (Palo Alto, CA: Stanford University Press, 1953), 178-212.

education for his citizenry Isaac Stevens, first governor of the newly established Washington Territory, directed the legislative body to draft a land-grant petition for a public university. Confident that the Territory would soon be peopled by many more than the few thousand residents currently scratching out a meager existence, Stevens declared

> the subject of education already occupies the minds and hearts of the citizens of this Territory, and I feel confident that they will aim at nothing less than to provide a system, which shall place within the means of all the full development of the capacities with which he has been endowed. Let every youth, however limited his opportunities, find his place in school, the college, the university, if God has given him the necessary gifts.[12]

In this most unlikely location Seattle residents created the University of Washington in 1861, the first public university on the Pacific Coast. Research oriented institutions such as Johns Hopkins University and the University of Chicago, modeled on the highly successful German institutions, also soon opened their doors to men and women who would become members of an American scientific elite. This proliferation of colleges, opening up higher-education opportunities to large sections of American society, gradually transformed the United States into one of the leading nations for scientific research. The creation of America's higher education system, with its nascent prestige in

[12] Charles M. Gates, *The First Century at the University of Washington, 1861-1961* (Seattle: WA: University of Washington Press, 1961), 7-8. President Franklin Pierce soon accepted this 1854 proposal, thereby making provision for two universities in the territory that could draw their financing from resources of these significant land grants. So while the 1862 Morrill Act is most often seen as the origin of land grant institutions, a number of such public universities already existed by that time, including the University of Washington.

science and technology, represented a significant component in the American dream of constructing a civilized, rational, scientific and Enlightened society.

New Institutions: Science & Education for All

Given this brief background to the place of science and education in nineteenth century America, attention should be directed to particular institutions figuring prominently in later chapters of this study.

The University of Washington traces its origins to 1861, one year before the passage of the Morrill Land Grant Act began to dramatically expand the opportunities for higher education in the United States. While the establishment of the University of Washington illustrates the mapping of Euro-American social and cultural values onto the Western landscape, the University itself was in reality little more than a dream.[13] Western pioneer civic leaders desperately wanted to counteract the wild and potentially corrupting environment of the West with the culture, civility, sophistication, progress, and edification that higher education represented. The first university president, William E. Barnard, a graduate of Dartmouth and a man of strict morals, initiated his leadership by decrying the prevalence of "drunkenness, licentiousness, profanity, and Sabbath

[13] Keith Benson states that public colleges of California, Oregon, and Washington, established between the 1860s and 1880s, "were actually no more than glorified secondary schools and academies in their early years, [but] they all eventually participated in the higher education reforms that swept across the United States" in the following decades. "Marine Biology or Oceanography: Early American Developments in Marine Science on the West Coast" in *Oceanographic History: The Pacific and Beyond*, edited by Keith Benson and Philip Rehbock (Seattle, WA: University of Washington Press, 2002), 298-302; quotation page 298.

desecration" and instituted strict moral standards for University of Washington students. Frequenting saloons or theaters would not be tolerated, the President declared, and students were expected to participate in daily reading of scripture and weekly attendance at church and chapel services.[14] However, in a young society that cared more for practical and secular values required for building wealth, Barnard received little support and soon departed for the relative civility of the East Coast. As for co-education, apparently little or no discussion occurred: admittance of women took place from the University of Washington's origin and by all indications matriculated in roughly equal proportion to men from at least the turn of the century.

Photographs from the period at the University of Washington show that female students composed a significant segment of zoology course participants.[15] In the lecture hall or the field, zoology (or botany, it can be assumed) appealed to women who wanted to pursue higher levels of education, a point well illustrated through historical images.[16]

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[14] Gates, *The First Century,* 31-32.

[15] While women appear as participants in zoology course pictures, an image of a mining course of the same period at the University of Washington (not shown) is composed only of men. This suggests the gendered differences in "acceptable" coursework. See Gates, *The First Century,* images follow pages 18 and 74.

[16] For the use of images as historical evidence, see Robert M. Levine, *Insights into American History: Photographs as Documents* (New York, NY; Prentice Hall, 2003). Much has been written on nineteenth century botany and the fact that women were prominent participants (at least until the professionalization), for example Elizabeth Keeney, *The Botanizers: Amateur Scientists in Nineteenth-Century America* (Chapel Hill, NC: University of North Carolina Press, 1992), 69-83; and Ann B. Shteir, *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760-1860* (Baltimore, MD: Johns Hopkins University Press, 1996).

In the following images, the first from 1905 and the second from 1916, half or more of the students are women.

Property of MSCUA, University of Washington Libraries. Photo Coll 700

Property of MSCUA, University of Washington Libraries. Photo Coll 700 [17]

The creation of a respectable biology program at the University of Washington can be traced to the turn of the century, at a time of rising interest in natural history and "nature study," especially where scientific education included women.[18] The arrival of T. C. Frye, a botanist trained at the University of Chicago with interest in marine algae,

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[17] Original photos come from University of Washington Campus Photographs Collection held at University of Washington Library Special Collections, (negative #s: UW20329z & UW20331z). Viewable online at http://content.lib.washington.edu/imls/kcsnapshots/index.html (search term "zoology").

[18] Kim Tolley, *The Science Education of American Girls: A Historical Perspective* (New York, NY: RoutledgeFalmer, 2003). This study for the most part addresses education at the primary level, but chapters 5, 6, and 7 argue that in American society and its educational system, natural history and the nature study movement received great attention in the late 19th and early 20th century due in part to their appropriateness for women's education.

served to bring teaching and research in the biological sciences up to a respectable standard amongst his colleagues around the nation.[19]

The establishment of a marine research station in 1904 at Friday Harbor in the San Juan Islands marks an important development in elevating the biological sciences at the University of Washington. Over the course of the previous two decades, marine stations had become vibrant sites for biological teaching and research, as many historians have shown.[20] Anton Dohrn's Zoological Station at Naples, followed by the Woods Hole Marine Biology Laboratory in Massachusetts, represented the best of these stations. Charles Atwood Kofoid, the influential invertebrate zoologist from Berkeley (and one of the key individuals in founding the Scripps Institution of Oceanography and the Western Society of Naturalists, mentioned below), reported to American colleagues in 1910 on the

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[19] Alongside the academic science coming into being during the final decades of the nineteenth century in Seattle, Keith Benson has documented the creation of a natural history society in Puget Sound beginning in 1879. The Young Naturalists Society formed itself out of the interest of local naturalists in creating a "society that would stand the test of time and become a perpetual source of pleasure and instruction." The Young Naturalists' Society eventually merged its museum collection with the University of Washington. For the intertwined history of the YNS and the UW, see Keith Benson, "The Darwinian Legacy in the Pacific Northwest: Seattle's Young Naturalists' Society, P. Brooks Randolph, and Conchology" *Darwin's Laboratory: Evolutionary Theory and Natural History in the Pacific,* edited by Roy MacLeod and Philip F. Rehbock (Honolulu, HI: University of Hawaii Press, 1994), 212-238. Quotation, page 221.

[20] A useful overview of marine research stations, including an analysis of writings about them can be found in Keith Benson's "Summer Camp, Seaside Station, and Marine Laboratory: Marine Biology and Its Institutional Identity," *Historical Studies in the Physical and Biological Sciences,* 2001, 32(1):11-18. For cultural aspects see Philip J. Pauly, "Summer Resort and Scientific Discipline: Woods Hole and the Structure of American Biology, 1882-1925," in *The American Development of Biology*, edited by Ronald Rainger, et al., 121-150. Numerous useful essays can be found in "The Naples Zoological Station and the Marine Biological Laboratory: One Hundred Years of Biology," *Biological Bulletin*, 1985, 168 (supplement). Robert Kohler includes a section on the MBL and other 'hybrid' research sites in his recent work on the nineteenth and twentieth century history of field and laboratory sciences, *Landscapes and Labscapes: Exploring the Lab-field Border in Biology* (Chicago, IL: University of Chicago Press, 2002), 35-48.

marine stations of Europe and practically gushed over the potential for research to be found at Naples:

> ...inspiring in its history and unparalleled in its growth, unsurpassed in its contributions to biological science, profound in its influence upon the course of development of modern biology, and powerful in its stimulus to the establishment of biological stations elsewhere stands the Zoological Station of Naples, the peer and leader of them all.[21]

With the Naples station leading the way in the 1870s, American scientists began to envision seaside stations along their own coastlines. C. O. Whitman, first director of the Woods Hole Marine Biology Laboratory, answered in his first annual report the question of why seaside research held such attraction for naturalists:

> To this we may reply, that the ocean is the home of the lowest as well as the oldest forms of life, and it is in such forms that the mysteries of life can presumably be most nearly approached. Then there are abundance and variety, and certain important groups that do not occur in fresh water. To the luxuriance of the fauna and flora of the shore, is added that vagrant, pelagic life, which is collected by ocean currents, tides, and winds, and laid at one's feet as freely as if all nature pleaded for investigation. Moreover the study of marine life has long been inadequately provided for, its advantages not having been generally recognized until within the last fifteen or twenty years.[22]

Within this climate of exuberance over the promise of seaside establishments – for teaching, for research, and as an escape from the urban setting of many university

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[21] Charles Atwood Kofoid, *The Biological Stations of Europe* (Washington, DC: United States Bureau of Education, Bulletin No. 4, 1910), 8.

[22] "Report of the Director" in the *Annual Report of the Marine Biological Laboratory, Woods Hole* (1888), 16. Archive of the Marine Biological Laboratory, Woods Hole, MA.

laboratories - the University of Washington purchased land in the San Juan Islands and founded the Puget Sound Biological Station.[23]

Further down the coast, on the southern tip of Monterey Bay in California, the young Leland Stanford Jr. University was in the vanguard of this movement, having opened its own marine station a decade earlier than their colleagues in Puget Sound. Accepting its first students in 1893, the Hopkins Marine Station (which had officially opened in 1891 as the Hopkins Seaside Laboratory) set the model for a university-attached research institution aimed at exposing students to the plentiful and unique organisms found in the marine environment and training them in the modern laboratory techniques by which plants and animals could be studied. These places were, quite simply, convenient sites to wed field and laboratory practices for the training of students in a pleasant and stimulating natural setting.[24] However, while Stanford University's seaside research station became an early and successful training site for those interested in botany, zoology, and other biological sciences it also helped to establish certain social norms within this small group of naturalists. Significantly, Stanford's policy of co-education, established at its founding in the mid 1880s, ensured women access to the

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[23] For essays on the origins of American marine stations and their orientation toward secondary-education teacher training, research, or summer retreats respectively, see Keith Benson, "Why American Marine Stations?: The Teaching Argument"; Jane Maienschein, "History of American Marine Laboratories: Why Do Research At the Seashore?" both in *American Zoologist*, 1988, 28(1):7-25; op. cit., Philip Pauly, "Summer Resort and Scientific Discipline" 123-125, specifically.

[24] Benson, "Summer Camp, Seaside Station" 14. Here Benson argues that the student-oriented marine laboratory, as an outpost of a university, originated on the West Coast, primarily at Hopkins and Friday Harbor.

Hopkins Marine Station's resources. Stanford's founders, Leland and Jane Stanford, believed "that the education of both sexes shall be equally full and complete, varied only as nature dictates. The *rights* of one sex, political and otherwise, are the same as those of the other sex, and this equality of rights ought to be fully recognized." Thus, in the first year's enrollment, women comprised 130 of 555 students, nearly one-quarter of the student body.[25] The key phrase, "only as nature dictates," alluded to a deep-seated belief that men had been endowed by nature with a greater capacity than women for the mental as well as physical rigors of education. Consequently, belief in coeducation at the West Coast's preeminent private university had to be limited in practice, through the institution of enforced male-to-female ratios, in an effort to ensure the masculine dominance of academic culture.[26] At both Hopkins and Friday Harbor, reflecting the norms of the parent institutions and the wider society, women could participate fully in zoological research as undergraduates and even graduate students, yet always with the understanding that women would not enter into leadership positions at these institutions.[27]

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[25] Susan Wels, *Stanford: Portrait of a University* (Palo Alto, CA: Stanford Alumni Association, 1999), 23-24. Italics in original. For a more sophisticated history of Stanford, see Rebecca S. Lowen, *Creating the Cold War University: The Transformation of Stanford* (Berkeley, CA: University of California Press, 1997). Although it does not address the specific issues discussed here, the first two chapters describe the university's overall research atmosphere up through World War Two.

[26] Ibid., 24. Within the first ten years of existence, Jane Stanford capped female enrollment at 500 in response to the large number of qualified female applicants. This was followed by an admission system in which the ratio of women to men could not exceed 45:55. This policy ended during the Great Depression as overall enrollment declined; by the height of World War II women outnumbered men by 2:1 at Stanford.

[27] Again, Rossiter's study shows that, across the United States, women's opportunities in science were strictly limited. While gaining greater access to education, women's employment opportunities were, at the same time, restricted to faculty positions in women's colleges

Some evidence is available to shed light on the question of who performed research at these stations. For the Hopkins laboratory, research deemed worthy of publication in their own journal series took the form of traditional natural history. This is not surprising considering the influential presence of Stanford's President, David Starr Jordan, who maintained a somewhat defensive view of Natural History in the face of experimental biology's expanding popularity (see below). Edwin Chapin Starks published a 'List of Fishes Collected at Port Ludlow, Wash.,' that later became incorporated in his important survey of West Coast fishes. Jordan himself contributed regularly to the journal, including his "Notes on Fishes, Little known or New to Science." The young Nettie M. Stevens, exhibiting a greater appreciation of laboratory techniques, contributed "Studies on Ciliate Infusoria" (a minute protozoa) from her summer spent at Hopkins as she completed her Masters degree.[28] Stevens moved from Stanford to Bryn Mawr in 1901 and entered the field of genetics with Thomas Hunt Morgan. Before her death in 1912 she played in important role in providing evidence that the "accessory chromosome" functioned as a sex-determinant.[29]

(primarily for unmarried women) or to laboratory assistants without formal leadership responsibilities. See the first four chapters of *Women Scientists, Vol 1*, 1-99.

[28] *Contributions to Biology from the Hopkins Seaside Laboratory of the Leland Stanford Jr. University.* Volumes I-XXX (1894-1903). Stevens' volume, number XXVI, was published in 1901.

[29] For biographical information and the social setting of Stevens' scientific career see Marilyn Bailey Ogilvie, "The 'New Look' Women and the Expansion of American Zoology: Nettie Maria Stevens and Alice Middleton Boring" in *The Expansion of American Biology*, edited by Keith Benson, et al., (Rutgers University Press, 1991), 52-79.

At the Puget Sound Biological Station (Friday Harbor), which published a journal of local research from 1915 through 1931, it is apparent that women constituted roughly 1/3 (and in some volumes over 1/2) of those doing publishable work. This is not surprising in light of the number of women present in pictures of the zoology department at the time. T. C. Frye brought the majority of Friday Harbor students from the University of Washington, with others coming from around the country to spend their summers at a site where the tides and geography conspired to allow relatively easy access to marine organisms.[30] Libby Hyman, notable among the early visitors and at the time working in the laboratory of Charles. M. Child at the University of Chicago after completing her doctorate in 1915, came with Child to Friday Harbor to study the rate of oxygen absorption in invertebrates, under the influence of potassium cyanide. Her reputation within marine biology did not follow from this kind of experimental research but rather from her later monumental guide to known invertebrate forms.[31] The primary point here, however, is to emphasize that within these university-associated marine stations, women commonly performed their own research and published their findings alongside their male colleagues. It is the tradition of openness to women (student)

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[30] *Puget Sound Biological Station Publications* (originally titled *Puget Sound Marine Station Publications*) published 1915-1931 through 7 volumes. In volume 1, 11 of 22 authors are women; 6 of 21 in vol 2; 7 of 22 in vol 3; 1 of 2 in vol 4; 3 of 12 in vol 5; 6 of 11 in vol 6; 8 of 27 in vol 7.

[31] G. Evelyn Hutchinson wrote with some awe of Hyman's six volume compilation *The Invertebrates,* "The only English precursor by a single author was Sedgewick's three-volume *Textbook of Zoology* (1898-1909), which now though sometimes useful is quite naturally out of date. As Pantin pointed out, the only works that can be compared with Hyman's six volumes, containing over 4,000 pages, are of composite authorship." *National Academy of Sciences Biographical Memoirs*, 1991, 60:103-114.

researchers, prevailing among this community of scientists, which helps to explain the scientific career path chosen by Dixy Lee Ray in the following decades.

While certain branches of biology may have been unique in their acceptance of women participants, geographic differences in how biologists practiced their science may be evident as well. A large body of literature has accumulated as historians have analyzed the generalization, especially within the American context, that claims "naturalists" dominated the nineteenth century and gave way to "experimentalists" in twentieth century life science. Yet, in looking closely at the differing practices across the disciplines that comprise the life sciences, historians have shown the persistence of an array of methodological and conceptual approaches. Moreover, what it meant to use experiments in research differed significantly from discipline to discipline, and from place to place.

One of the locations in which the use of experimental science has been analyzed is in the work of Victor Shelford at Friday Harbor. Shelford, an animal ecologist trained at the University of Chicago by Libby Hyman's mentor Charles M. Child, spent many of his summers from 1914 to 1930, working on "physiological animal geography" in the marine environment at Friday Harbor. Initially convinced he could transport his preferred methods of "naturalistic observation and controlled experiments" from the prairies of the Midwest to the intertidal and subtidal animal and plant communities, he eventually recognized the necessity of a modified approach. This new approach relied far more heavily on the naturalist tradition's practices of exhaustive description, and less on the practices of experiment. In order to make productive use of experiments in the future,

Shelford realized that first a more "thorough knowledge of the communities [would be] essential." This particular instance in which the "ideal of 'experiment'" had to be modified, and de-emphasized, in the study of marine intertidal ecology shows us, Benson argues, how geographic and disciplinary factors created significant diversity of "appropriate methods" within biology.[32]

Yet methodological variety within biology did not stem solely from the need to adapt techniques to particular situations. It is also clear that some scientists felt a certain constriction over what was to be considered good science as the successes of clearly experimental disciplines, such as genetics, garnered more and more attention. The ichthyologist David Starr Jordan, having recently stepped down from Stanford's presidency, gave an impassioned speech at Scripps in 1916 in which he called for greater acceptance of descriptive, organismal research. Sensitive to an emerging marginality of his kind of science, he said:

> ...By 'old-fashioned' Natural History I mean the recognition or study of animals and plants as completed organisms, each greater than the sum of all the parts. It involves a knowledge of names and of some degree of classification. It leads up to the problem of the origin of species, the affinities of forms, the complex relations we call habits, the problems of geological and geographical distribution, the details of

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[32] Keith Benson, "Experimental Ecology on the Pacific Coast: Victor Shelford and His Search for Appropriate Methods," *History and Philosophy of the Life Sciences*, 1992, 14(1):73-91. Quotations from pages 83, 84, 88. In a 1956 conference at Scripps, Woods Hole oceanographer Alfred Redfield argued (controversially, it must be noted) that in the U.S. "the progress of marine biology was retarded for fifty years by the introduction of experimental methods into biology. The leaders who came to Woods Hole [at the end of the 19th century]...became preoccupied ... with the mechanistic conception of life, the physiology of morphogenesis, and genetics – for which experimentation promised the answers." See "The Inadequacy of Experiment in Marine Biology," *Perspectives in Marine Biology* edited by A. A. Buzzati-Traverso (Berkeley, CA: University of California Press, 1958), 17.

> evolution and a balanced knowledge of things as they are, as actual though temporary stages in a universe of change. Study of this kind must end at large explanations, not narrow knowledge of 'chromosomes', unit characters, tropisms, synonomy, but of the whole great world of Life as it is, as it was,...

Jordan believed that too much emphasis was being placed on the current "popular" lines of research; rather there must be allowance for creative people to engage in all kinds of scientific inquiry with the end always in mind of "strengthening our conception of evolution" through which the multitudes of organisms could be better understood.[33]

William E. Ritter, director of Scripps, largely agreed. Having been trained at Harvard's Museum of Comparative Zoology and a frequent researcher at both the Naples Zoological Station and Woods Hole Marine Biology Laboratory, he and a colleague in the zoology department at the University of California at Berkeley founded the San Diego Marine Biological Institute (later Scripps) in 1903. At the same 1916 ceremony at which Jordan made his plea for natural history, a ceremony celebrating the new formal ties to the University of California system, Ritter explained the purpose of Scripps, explicitly minimizing the laboratory-based experimental research being adopted by many biologists of the time. In his view, naturalists' work of gathering, naming, and describing organisms needed to be continued and, at the same time, encouraged to expand in new directions. To do so, Ritter argued, biologists should not turn to "laboratory experimentation," for it necessarily removed the organism from the very environment

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[33] David Starr Jordan, "Plea for Old-Fashioned Natural History," *Bulletin of the Scripps Institution for Biological Research of the University of California*, 1916, 1:3-6. This was one of four dedicatory addresses delivered on 30 Dec, 1916, at a ceremony marking the opening of new laboratories at Scripps and a new organizational structure.

that must be increasingly taken into account. The study of organisms within the whole marine environment, he believed, must continue to be his institute's ultimate goal. Introducing a theme that animated marine biologists and oceanographers throughout the twentieth century, Ritter continued,

> But the modernization of [natural history] means the bringing of modern methods and instrumental equipment into scientific enterprises. It means intensified research, extended to large areas; and this means organized and institutionalized research. The perception that a high-power motor boat may be as essential to the solution of ultimate biological problems as a high-power microscope, introduces difficulties of operation that are surely considerable; but the perception is one of modern needs, and so must be met in the modern spirit and with modern resources.[34]

Ritter and Jordan were not alone in their goals for naturalists. Many believed much fruitful research, aimed at understanding fundamental biogeographic issues that would inform basic knowledge of evolution, still needed to be done through intensive study of plant and animal life in the field.[35] Yet, while the Scripps Institution participated fully in the network of marine research stations, its origin points out one important

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[34] Willliam E. Ritter, "What the Scripps Institution is Trying To Do," *Bulletin of the Scripps Institution for Biological Research of the University of California*, 1916, 1:19-24. Later publications of this bulletin (through the late 1920s) include papers on biological oceanography and how best to promote it, papers addressing field & lab issues, and eugenics. Interestingly, there are no women contributors to this series, except Miss Scripps who contributed a biographical portrait of Ritter in the 1920s.

[35] A 1913 essay by Richard Hesse, "The Ecological Foundations of Animal Distribution" was later enlarged into an influential monograph that for the first time gave equal emphasis to the growing knowledge of marine and fresh-water life with existing understanding of terrestrial zoogeography. This new information on aquatic life, he argued (and many agreed), held "significance for theoretical biology." See the English version, *Ecological Animal Geography*, by W. C. Allee and Karl P. Schmidt (1937) of Richard Hesse's, *Tiergeographie auf Oekologischer Grundlage* (1924).

difference from its West Coast neighbors: it was almost exclusively a research station for established scientists and graduate students. Therefore, unlike the Hopkins Marine Station, Friday Harbor, and Woods Hole, and the Naples Zoological Station, women rarely participated in the early scientific work at Scripps.[36]

Along with the establishment of academic institutions devoted to study of the biological sciences, a professional society came into being that drew together like-minded individuals working along the West Coast and served to link potentially competing research groups. The Western Society of Naturalists traces its origins to a small group of scientists who met in San Francisco in 1910. Charles Kofoid, Vernon Kellogg, and others felt the need to create a professional society to serve the needs of people working far from prominent scientific centers on the East Coast, and separate from national societies meeting "east of the Mississippi." This society, holding its first conference at

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[36] On the early history of Scripps, see Deborah Day, "Scripps Benefactions: The Role of the Scripps Family in the Founding of the Scripps Institution of Oceanography," and Fred Noel Spiess, "Charles Kofoid's Role in Establishing the Scripps Institution of Oceanography" in *Oceanographic History: The Pacific and Beyond*, edited by Keith Benson and Philip Rehbock (University of Washington Press, 2002). In this same publication, Benson argues "Ritter considered his station to be different from the other marine ventures" partly due to his quick abandonment of introductory courses but also because he had a vision for (in Ritter's words) "marine exploration along the broadest lines...with coordination and direction of individual effort toward the solution of the larger problems of the life of the sea." Keith Benson, "Marine Biology or Oceanography: Early American Developments in Marine Science on the West Coast" pages 300-301. It may be that the organizational structure envisioned by Ritter facilitated Scripps' rapid gravitation toward military-sponsored oceanographic work in the 1940s, which in turn reinforced the masculine culture of the institution. For an analysis of women and research at Scripps in a slightly later period see Naomi Oreskes, "Laissez-Tomber: Military Patronage and Women's Work in Mid-20th Century Oceanography" *Historical Studies of the Physical and Biological Sciences*, 2000, 30(2):373-393. Kathleen Crane's recent memoir, *Sea Legs: Tales of a Woman Oceanographer* (Westview Press, 2003), provides a glimpse into a female graduate student's experience at Scripps in the 1970s, describing numerous institutional and individual obstacles common at the time.

Berkeley in 1911, made membership available to "any person interested in scientific work of a research nature." Though seemingly open to any active scientist, the society soon came to be dominated by researchers associated with the various marine laboratories of the Coast and provided a welcoming forum for the kind of descriptive (later explicitly ecological) morphological studies proliferating from Puget Sound down to the gulf of California.[37] Interestingly, Toby Appel has written about a national organizing society, the American Society of Naturalists, and she argues that failures to create one national entity to represent the interests of biologists is simply a by-product of the very fractured status of the biological sciences since the late nineteenth century. The emergence of the Western Society of Naturalists, and its inability to join with the American Society of Naturalists (ASN), illustrates professional and simple geographic obstacles contributing to these divisions. By 1915 the Western Society of Naturalists proposed to the American Society of Naturalists that it become a West Coast branch of the ASN. After some deliberation, the ASN rebuffed the proposal on the grounds that higher standards of admittance would be required and "the East and West are geographically too far apart to make a workable union."[38] If in fact scientists at marine laboratories on the West Coast did research differently than colleagues in other locations, such as Shelford's work at Friday Harbor, or thought of their work as being at odds with a more popular laboratory-

[37] Michael S. Foster, Gayle I. Hansen, and Yost U. L. Amrein, *History of the Western Society of Naturalists* (Santa Barbara Museum of Natural History, 1999), 1-10.

[38] Ibid., 3. For the larger history of the ASN see Toby A. Appel, "Organizing Biology: The American Society of Naturalists and its 'Affiliated Societies'" in *The American Development of Biology* edited by Ronald Rainger, Keith R. Benson, and Jane Maienschein (University of Pennsylvania Press, 1988), 87-120.

based experimental science, then the creation of societies such as the WSN and its isolation from larger networks of colleagues may help to explain the popularity of descriptive ecological work at these stations through the twentieth century.

Dixy Lee Ray's Early Life: What Makes a Scientist?

Ray's paternal grandparents moved to Tacoma in the 1880s, around the time of completion of the Northern Pacific Railroad in 1883 which ensured the economic viability of Tacoma as a port city for the lumber and other raw materials of the region.[39] As mentioned above, it was a time of great population expansion up and down the West Coast, and particularly around the Puget Sound. In this booming economic climate, Dixy's grandfather opened a print shop, a business he knew well from working as a child in the family print shop back in Tennessee. Alvis Ray, Dixy's father, continued the tradition. First working under his father and eventually taking over the business himself, he provided a stable if somewhat meager income for the family until his death in 1947.

In Tennessee the Ray family had been leaders within the Southern Baptist Convention, and Dixy's grandparents continued to practice their faith after moving to the West Coast. Within her immediate family, devotion to the Baptist denomination

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[39] This section describes Ray's family background with the assumption that childhood and family setting have an important impact on a person's later career. In connection to the methodologies of oral history, David DeVorkin discusses how family background affects scientific careers in "Interviewing Physicists and Astronomers: Methods of Oral History," 44-65, *Physicists Look Back: Studies in the History of Physics*, edited by John Roche (Bristol, England: A. Hilger, 1990); see also Lewis Pyenson, "Who the Guys Were': Prosopography in the History of Science," *History of Science*, 1977, 15:155-188.

continued, characterized by regular church attendance throughout Dixy's childhood, but she apparently stopped practicing her religion sometime after leaving the family home. Guzzo recounts that during her years as governor Ray told a reporter that she remained a "devout Baptist." In another setting she contradicted this statement by saying "I consider myself a Christian...but not an adherent to any particular sect. And I don't like public manifestations of religion. I think it is a very private thing."[40]

Dixy Lee Ray's maternal grandfather was an actor who left his wife soon after the birth of Francis Adams (Dixy's mother). Other than expressing much love and admiration for her mother, little is known of the relationship between mother and daughter. Both parents, Alvis Ray and Francis Adams, were born in Tacoma. They eloped before completing high school, at the ages of 19 and 17, and had their first of five daughters within a year.[41] The second child, Margaret Ray, was born on 3 September, 1914. Possibly because of strong-willed and obstinate characteristics, someone in the family nick-named her "the little Dickens" which soon became "Dicks" or "Dick." For her own part, Dixy detested the name Margaret and at the age of 16 legally changed her

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[40] Lou Guzzo, *Is It True What They Say About Dixy? A Biography of Dixy Lee Ray* (Mercer Island, WA: The Writing Works, Inc., 1980), 19. This is the primary source for early biographical information on Dixy Lee Ray, yet Guzzo does not state how and from whom he obtained his information. There is no discussion of sources; he does thank family members and a handful of Ray's University of Washington colleagues for "assistance". Since he was Ray's political advisor at the time of writing, it can be assumed that he compiled information from informal and/or formal interviews with Ray, and the biography obtained Ray's blessing. Other sources include: Lynn and Gray Poole, *Scientists Who Work Outdoors* (Dodd, Mead & Co., 1963), 15-25; Janet Newlan Bower, "Dixy Lee Ray (1914-1994)" in *Women in the Biological Sciences: A Biobibliographic Sourcebook*, edited by Louise S. Grinstein, et al., 1997, 424-432.

[41] Guzzo, *Is It True,* 17-28.

name to Dixy Lee Ray. A biographer explains Ray's name change as a reaction to a deeply disliked grandmother. From her earliest memories, Ray recalls a powerful antipathy towards her paternal grandmother, Marguerite Ray, who came from a wealthy southern family and grew up accustomed to a life of luxury. According to Ray this grandmother did not gracefully accept the middle class income that came with her marriage to a printer. However this may be, Ray's dislike of Marguerite seems a plausible explanation of the motivation for her name change.[42] In addition, Ray's determination to change her name suggests an important early manifestation of her strong sense of independence and a desire to construct a unique identity. It is also not inconsequential that her chosen name conferred an ambiguous gender identity, an issue that will be explored further in chapter 5.

Guzzo recounts what he claims is Dixy's earliest memory, taking place at the time Dixy learned to walk. Apparently at one family gathering the young Dixy was encouraged to stand on her own. In trying to do this, wobbling about on unsteady legs, Dixy grabbed for the support of a chair and simultaneously, with her other hand, pinched her stomach and squealed. The sight of this performance elicited peals of laughter from the gathered adults and encouraged Dixy to continue her impromptu dance. For Guzzo, this memory served two purposes: to illustrate an innate capacity for and enjoyment of public performance. In his words this was her "introduction to show biz." It was, as well, an illustration of Ray's exceptional memory, stretching back (with unusual fidelity,

[42] Ibid., 15 & 22.

it is claimed) to her first couple years of life.[43] As for her attraction to public performance, by her early teens Dixy led her sisters and neighborhood friends in creating a marionette troupe, performing for local groups throughout Puget Sound in the early years of the Great Depression. In high school classmates commonly referred to her as "Dick," where she became a school champion in the debate club, participated in drama and excelled on the swim team (described as an all-around 'scrappy' athlete in her senior yearbook), and earned numerous scholastic honors through her four years at one of Tacoma's best public schools, Stadium High.[44]

With the recognition that internal family dynamics are complex, defy generalization, and should be treated with caution, several issues deserve attention for their possible implications on Dixy's later life and career. Her father, with whom she had a troubled relationship, could be violent and seemed incapable of showing approval toward Dixy. As the second of five daughters, Dixy's early years were lived within the sort of familial environment much studied by social scientists, including those interested in the development of scientists. As quoted in Guzzo's biography, Dixy explained her feeling that

> Dad was one of those men who wanted desperately to have a son, and I was the best he could come up with. For many years he treated me as if I were a son...because I really was a disappointment to him. Not in my whole life can I recall even the faintest stirring of affection for

[43] In reference to Dixy's memory, I assume that Guzzo's narrative is based on his own interpretation of conversations with Dixy but that she also wanted to convey this telling tidbit about her own powers of recollection.

[44] Stadium High year book, 1933. Viewed at Stadium High School administrative offices, March 2004.

> him. Again, I emphasize my memory goes back. My earliest recollections of him are of his speaking harshly... I was the one that usually needed correction, I guess, and I was afraid of him. At times I hated him. Mostly, I didn't respect him.[45]

The gendered roles assumed by siblings within a family are increasingly seen as developing in contrast to each other. In other words, siblings develop gendered roles intended to differentiate themselves from each other. Some argue that this is most pronounced within same sex sibling groups.[46] While there is a certain intuitive quality to this claim, it helps to explain the statement made by Guzzo that since Dixy's older sister "had been assigned the duties of 'assistant mother,' it was left to Dixy to do the 'muscular' or masculine chores of chopping and bringing in firewood... and doing generally what [her father] would have expected his son to do."[47]

Social scientists have studied the significance of early childhood environments in an effort to understand the particular social make-up of scientific communities. In a recent statistical analysis of the gender composition of scientists' social groups, and the identification of common factors among successful women scientists, Gerhard Sonnert (with Gerald Holton) summarized research on the gender composition of sibling groups. It has been observed that women scientists frequently come from all-female sibling groups. Sonnert theorizes that "the absence of sons may turn daughters into surrogate

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[45] Guzzo, *Is It True*, 24.

[46] Leslie Brody, *Gender, Emotion, and the Family* (Cambridge, MA: Harvard University Press, 1999), 156. Most explicitly in the chapter "Gender Identification and De-Identification in Families" Brody summarizes much recent research on sex/gender issues having to do with the development of gender roles as a function of family dynamics.

[47] Guzzo, *Is It True*, 24.

sons onto whom fathers project their ideas about a career suitable for a son...[and that] in all female groups...girls perform activities that are not considered typically female."[48] While this explanation resonates with the particular environment in which Dixy grew up, Sonnert's study of currently active women scientists found scant statistical basis for the significance of sex/gender composition of sibling groups. Rather, along the lines of Frank Sulloway's study of birth order, Sonnert and Holton found that first-born girls, like boys, were more likely to become leading (but not revolutionary) scientists. If Dixy's entry into a scientific career is viewed as a repudiation of gender norms, this would conform to Sulloway's main argument that later-born children are, in his words, "born to rebel."[49]

One of Dixy's early accomplishments, often cited in biographical sketches, involved her successful climb to the 14,410 foot peak of Mt. Rainier in 1927 at the age of 12.[50] This established Dixy as the youngest female to reach the summit of Mt. Rainier,

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[48] Gerhard Sonnert (with Gerald Holton), *Gender Differences in Science Careers: The Project Access Study* (Rutgers University Press, 1995), 70-71.

[49] Ibid., 69-72. Frank Sulloway, *Born to Rebel: Birth Order, Family Dynamics, and Creative Lives* (Pantheon Books, 1996), 158. The problem with sociological data of this kind for the historian, looking at specific people and events, is that it never correlates in all respects. Sulloway writes that along with being later-born, pioneering women scientists "also grew up in liberal families and espoused liberal social attitudes." This was not true of Dixy or her family. Furthermore, in many ways Dixy's scientific career matches more closely with what Sulloway describes as that of a stereotypical first-born. For another use of birth order analysis see Ronald Numbers, *Darwinism Comes To America* (Harvard University Press, 1998), 44-47.

[50] See for example the biographical entry for Ray in *Women in the Biological Sciences: A Biobibliographic Sourcebook,* edited by Louise S. Grinstein, et al., (Greenwood Press, 1997), 424-432; *The Biographical Dictionary of Women in Science: Pioneering Lives from Ancient*

besting the previous record set in 1891 by the 13 year old Susan Longmire (granddaughter of James Longmire, one of the first to climb Mt Rainier in 1870 and founder of the popular Longmire resort on the flanks of the mountain). Certainly this claim is believable as cited by Lou Guzzo in his biography.[51] Yet it isn't easily verified. However, inquiry into mountaineering in the Puget Sound in the decades around the turn of the century paints an interesting picture, one that makes Dixy's feat somewhat less remarkable. Fay Fuller, the first woman to climb successfully to the peak of Rainier did so in 1890, and it is clear from other evidence that women avidly participated in the rigorous and popular outdoor adventures taking place in the Cascades. By 1927, the year in which Dixy would have climbed Rainier, the local society of mountaineers listed 32 elite members as having summited the six major peaks of the state. Of this group, at least 12 are clearly women.[52] Thus the context surrounding Dixy's climbing adventure suggests at least two things: that climbing mountains, though undoubtedly requiring vigor and stamina, was an activity that accommodated both male and female participants at

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Times to the Mid-20th Century, edited by Marilyn Ogilvie and Joy Harvey (Routledge, 2000), 1079-80.

[51] Guzzo, *Is It True...*, 33. The context is worth repeating here: Guzzo writes that Ray was uncertain of the direction her life should take as she entered college, quoting her as saying, "When I entered college, I wasn't sure what I would be able to do to earn a living, because I had been work-oriented from the beginning. As a young college student, I was not unaware that Nature had endowed me in a variety of ways. I had a strong constitution and a reasonable amount of muscular strength and endurance." Guzzo then adds that "Dixy had been...the youngest girl – 12 – to climb the summit of Mount Rainier."

[52] Figures compiled from list of members cited in *The Mountaineer* (published by The Mountaineers, Seattle WA), 1927, 20(1):40-44.

least in this part of the world;[53] and, the enjoyment of outdoor activity took place in an atmosphere intended to edify and train the mind and body along the lines of the popular 'nature study' movement of the time, an approach to nature deemed fully appropriate for women and men.[54]

Connections between natural history, the nature study movement, and gendered aspects of science have been explored by a number of writers including, recently, Kim Tolley's study of the science education of American girls. Tolley argues that the images and rhetoric employed to introduce boys and girls to natural history suggested a concordance with acceptable middle-class femininity. Popular natural history texts "portrayed girls and women as turning to nature, not in order to advance scientific knowledge, but to develop orderly habits of observation, to seek beauty and spiritual solace."[55] And yet, women's acceptance within the fields of natural history did not only result in the burnishing of their domestic femininity. Tolley shows that as women increasingly dominated teaching at the elementary school level and incorporated nature

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[53] For a pertinent discussion of the gendered evolution of mountaineering in a different location – the Himalayas – see Sherry Ortner's chapter entitled "Borderland Politics and Erotics: Gender and Sexuality in Himalayan Mountaineering," *Making Gender: The Politics and Erotics of Culture* (Boston, MA: Beacon Press 1996), 181-211.

[54] On the nature study movement see Sally Gregory Kohlstedt, "Nature, Not Books: Scientists and the Origins of the Nature Study Movement in the 1890s," *Isis*, 2005, 96(3):324-352; Pamela M. Henson, "Through Books to Nature: Anna Botsford Comstock and the Nature Study Movement," *Natural Eloquence: Women Reinscribe Nature,* edited by Barbara Gates and Ann Shtier (University of Wisconsin Press, 1997), 116-143; E. W. Jenkins, "Science, Sentimentalism or Social Control? The Nature Study Movement in England and Wales, 1899-1914," *History of Education*, 1981, 10:33-43; B. Theunissen, "Nature Study and Happiness in Life: Hugo de Vries, Eli Heimans, and Jac P. Thijsse," *Gewina: Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek* 1993, 16: 287-307.

[55] Tolley, *The Science Education*, 123.

study practices in their science curriculum, the overall effect "served as an effective vehicle for interesting young girls in science generally and the life sciences in particular."[56]

Exemplifying the popularity of nature study and its convergence with outdoor activities, the annual journal of the Mountaineers in 1927 informed its members on various aspects of the natural world which they would do well to contemplate on their next adventure. For William S. Cooper, an ecologist introduced to the Northwest through his participation in the Phytogeographic Excursion of 1913 led by Henry Cowles and Frederic Clements (and including numerous other prominent naturalists), the pleasure of mountaineering should include more than simply an appreciation of beauty:

> Without question the greatest part of the average person's joy in mountain excursion is of a purely aesthetic nature: it is the sheer beauty of the hills that constitutes their irresistible attraction for us. And yet there are other features which, when understood and appreciated, add tremendously to our satisfaction. Scientific knowledge of the rocks, the glaciers and the plant life each contributes its quota to our enjoyment;.... Each of these lines, followed separately, gives pleasure in abundance, but the interest is multiplied when one considers their inter-relations.

Cooper then proceeded to outline aspects of high-altitude ecological relationships governing vegetation.[57] Writing in the 1927 edition of *The Mountaineer* (journal of the

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[56] Tolley, *The Science Education,* 148.

[57] William S. Cooper, "Vegetation and Glaciers" *The Mountaineer* (published by The Mountaineers, Seattle WA), 1927, 20(1):26-31. Cooper was a noted botanist, obtaining his PhD from the University of Chicago under Henry Cowles in 1911; after initially teaching ecology at Stanford (at the time of the Excursion) he spent the bulk of his career as professor of plant ecology at the University of Minnesota. While in Washington State in 1913, the Phytogeographic Excursion visited a host of sites, from the slopes of Mt. Rainier to the inter-tidal environment being explored by T. C. Frye, Victor Shelford, and others at Friday Harbor in the San Juan

most prominent Puget Sound outdoors society), Cooper explained that the purely physical pleasures of mountaineering were but one of the ennobling reasons for tramping into the hills. This particular edition of the journal included a number of other 'nature study' contributions, such as descriptions of geology to be found in parts of the Canadian Rockies, ornithological observations reserved for the mountaineer (Edmund Bidwell), and a guide to typical mushrooms of the region. In the Northwest, people ventured into the Cascades in order to appreciate the natural beauty of the region, and of equal importance, to cultivate and display the kind of practical knowledge encapsulated in nature study.

Finally mountaineering, considered as sport, has been analyzed by a number of scholars. One study of sporting activities among New Zealand women argues that certain activities were particularly open to women in these relatively young societies. In a highly agrarian setting which placed a premium on physical labor and where men and women often worked alongside each other, vigorous recreations of a practical nature such as horseback riding and mountaineering were acceptable, whereas the more formalized games popular back in England (cricket or tennis, for example) retained, in New Zealand,

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islands. As an example of nationalism and internationalism in science the phytogeographic excursions have been studied by Kaat Schulte-Fischedick & Terry Shinn, "The International Phytogeographical Excursions, 1911-1923: Intellectual Convergence in Vegetation Science" In E. Crawford, T. Shinn, and S. Sörlin (eds.), *Denationalizing Science: The Contexts of International Scientific Practice* (Dordrecht, The Netherlands: Kluwer Academic Publishers, 1993) 107-131. Tulley Long kindly provided me with her analysis of the Excursion in an unpublished paper, "The International Phytogeographical Excursions of 1911 and 1913: National and International Dynamics in Vegetation Science" (2004). For a short on-line overview of the Excursion, with access to numerous images, see Library of Congress, "Ecology and the American Environment," viewed 2 June 2004, http://memory.loc.gov/ammem/award97/icuhtml/aepsp6.html

their gendered associations to a far higher degree. While this kind of analysis seems instructive for our understanding of mountaineering in the Pacific Northwest near the turn of the century, it can be over-simplified as seen in one explanation of the prevalence of field scientists in the Western United States. The geographic and social isolation of the western United States

> began to change women psychologically and physically. Gradually it alienated them from European traditions and...customs of eastern America. ... frontier women became self-reliant, courageous, self-confident... their judgment sharpened. Their muscles toughened. Their manner became more straightforward and natural and their views more democratic.... In the far West, particularly, women could be nonconformists.[58]

While 'exceptionalism' and an over-determining quality ascribed to the rugged Western landscape may lead to simplistic generalizations, the formation and evolution of gendered practices must be understood as a complex development of local specificity and situated within the cultural norms of a specific time and place. In the United States, Susan Cahn has persuasively shown that, despite warnings of the masculinization of overly active woman, support for the "athletic girl" as an antidote to concerns over "female frailty" mounted through the nineteenth century. Not surprisingly the integral place sport came to play within collegiate culture, occurring at the same time that women

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[58] Anne LaBastille, *Women and Wilderness* (Sierre Club Books, 1980), 66. This book is primarily made up of short biographies of women field scientists, such as Eugenie Clark, the well-known ichthyologist and expert on shark behavior. She gained widespread recognition in her early 30's with the publication of her autobiography, *The Lady with a Spear* (1953), which portrayed her underwater research and adventures.

began entering higher education in large numbers, fuelled the popularity of (and concerns about) female athletics.[59]

The importance of Dixy's mountaineering experience is not only applicable to an understanding of the connections between outdoor culture and nature study, or for what it tells us about possible changes in the perceptions of acceptable female activities. On another level there are links between the practice of field sciences and the prizing of behaviors and characteristics – stamina, physical exertion, absence of fear in 'dangerous' situations, being nimble and sure-footed, etc. – often associated with the outdoorsman (and woman!).[60] In this regard, marine biologists often view their expeditions to remote beaches, collecting trips dictated at the whim of the ebb tides, and observations of new and exotic specimens to be foundational in their professional experience. Olga Hartman

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[59] For women and mountaineering in New Zealand see Scott A. G. M. Crawford, "Pioneering Women: Recreational and Sporting Opportunities in a Remote Colonial Setting," in *From Fair Sex to Feminism: Sport and the Socialization of Women in the Industrial and Post-Industrial Eras*, edited by J. A. Mangan and Roberta J. Park (Frank Cass & Co., 1987), 161-181. For discussion of the early appearance of female athletics in America see Susan K. Cahn, *Coming On Strong: Gender and Sexuality in Twentieth-Century Women's Sport* (The Free Press, 1994). Most pertinent is chapter 1, "The New Type of Athletic Girl."

[60] Bruce Hevly and Naomi Oreskes have each examined aspects of the field sciences within the framework of "heroism." For Hevly, scientists in 19th century Britain studied glacial motion within a culture that increasingly valued sport and, Hevly concludes "the rhetoric of adventure [was] an important element in the culture of field science...claiming reliable perception on the basis of authentic, rigorous, manly experience." Oreskes has analyzed the "ideology of scientific heroism" and claimed heroism, rather than a devotion to objectivity, explains the relative absence of women in the field sciences. For my study, the relatively large numbers of women engaged in mountaineering in the Pacific Northwest and their prevalence in zoology and botany, often in the marine setting, points up differences in local cultures (relative to Britain, in this case) and/or differences between disciplines. The lack of women's advancement within marine-oriented disciplines (especially as it became more closely allied with oceanography) would seem to support Oreskes' assertion. Bruce Hevly, "The Heroic Science of Glacier Motion," *Osiris*, 2nd Series, 1996, 11:66-86; and Naomi Oreskes, "Objectivity or Heroism? On the Invisibility of Women in Science," *Osiris*, 2nd Series, 1996, 11:87-113.

apparently exhibited this ruggedness as a student of Sol F. Light at Berkeley in the 1930s. Hartman later established herself as the premier authority on polychaetous annelids – a large and primarily marine group of segmented worms – and was a prominent West Coast marine biologist. In a remembrance written by her colleague John Mohr, he noted how during Light's famous beach-side summer courses everyone "worked the low tides beginning before sunrise and continued work in the laboratory...until midnight or later. Those were long sessions of taxonomy, punctuated only by mealtimes, the evening one often offering Nye's[61] delicious fresh abalone catch of the day." Following this narrative, which might equally describe a long day of mountaineering (except for the fresh abalone!), Mohr describes qualities separating Hartman from her colleagues: "Olga was the oldest of the students at Nye's [beach] that summer, but nevertheless the most agile. ... Olga cavorted over the slippery rocks like a gazelle, leaping across channels and up and down the face of boulders covered with glistening algae. ... Although many of the rest of us slipped, fell, and arose bruised, I never saw Olga exhibit even a slight contusion."[62] Similarly, Kenneth Boss, a young graduate student at Michigan State University (later to get his doctorate in biology at Harvard, studying mollusk systematics) attended a summer marine biology course at Friday Harbor in the 1950s and joined a weekend excursion to a remote beach on Vancouver Island, led by an indefatigable Dixy

[61] Charlie Nye operated a beach-side restaurant called *The Reefs* where this group of marine biologists regularly ate. Among the relatively small community of marine biologists on the West Coast, this was a well-known establishment.

[62] John L. Mohr, "Olga Hartman" in *Essays on Polychaetous Annelids: In Memory of Dr. Olga Hartman*, edited by Donald J. Reish and Kristian Fauchald (Allan Hancock Foundation, USC, 1977), 25-27.

Lee Ray. Boss recalled the hike out to the beach on the wild and remote western side of the island as one of the most dangerous, grueling adventures he had ever experienced, but with the incomparable reward of exploring magnificent tide-pools and dining on fresh salmon.[63] While pointing out the physically demanding nature of marine biology (or any number of other field sciences) may be stating the obvious, it may illustrate one of the ways in which Dixy's childhood experiences honed certain practices highly valued in the culture of marine biologists.[64]

This chapter has illustrated the early establishment of educational institutions on the West Coast, their place within a culture that keenly felt the need to civilize and ennoble its citizen's minds, and the central place of science in this endeavor. Around the turn of the century, marine-based laboratories became a popular and productive site for scientific education, firmly establishing the disciplinary existence of those specializing in the study of marine life . Moreover, interesting connections can be made between the expansion of women's education, the emergence of women in public activities, and the

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[63] Kenneth Boss, pers. com., 12 Dec 2003 at Museum of Comparative Zoology, Harvard University. In a humorous remark about Ray (which illustrates how she was perceived), Boss declared that "if Dixy had been directing the Normandy landing, WWII would have ended in a matter of days!"

[64] The intersection of scientific knowledge and 'bodily knowledge' has been explored in a set of essays edited by Steven Shapin & Christopher Lawrence, *Science Incarnate: Historical Embodiments of Natural Knowledge* (Chicago, IL: University of Chicago Press, 1998). Especially useful is Andrew Warwick's essay, "Exercising the Student Body: Mathematics and Athleticism in Victorian Cambridge," pp. 288-326, in which he explores, in part, the construction of (British) masculinity through the dual rigors of mathematics and sport in the 19th century. See also Larry Owens, "Pure and Sound Government: Laboratories, Gymnasia, and Playing Fields in Nineteenth Century America," *Isis*, 1985, 76:182-194.

inevitable changes taking place in the practice of science from the late nineteenth century through the early twentieth century. These developments, along with some of the purely biographical details of her early life, are foundational to a full understanding of the world of academic science entered by Dixy Lee Ray in the mid 1930s.

Chapter 2

Constructing a Marine Biologist: Mills College to Stanford University

> And yet the impulse which drives a man to poetry will send another man into the tide pools and force him to try to report what he finds there. Why is an expedition to Tibet undertaken, or a sea bottom dredged? Why do men, sitting at the microscope, examine the calcareous plates of a sea-cucumber, and, finding a new arrangement and number, feel an exaltation and give the new species a name, and write about it possessively? It would be good to know the impulse truly, not to be confused by the 'service to science' platitudes or the other little mazes into which we entice our minds so that they will not know what we are doing.[1]

This chapter concerns the construction of a full-fledged scientist, in this case a marine biologist. John Steinbeck and Edward Ricketts' statement might suggest that biologists are in some respect born with an "impulse" to investigate nature. The scientist, who as a young child had an inordinate fondness for bugs, birds, or some other feature of the natural world, is a standard trope in the history of science. And yet the impulse to study nature has, especially in the twentieth century, seldom been sufficient qualification for entry into the fraternity of science. A process of construction inevitably takes place in which the initiate learns not only the key ideas, the small facts, and the proper scientific techniques of the time, but also the acceptable forms of discourse and the role of science

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[1] John Steinbeck and Edward F. Ricketts, *The Sea of Cortez: A Leisurely Journal of Travel and Research (with a scientific appendix comprising materials for a source book on the marine animals of the Panamic Faunal Province)*, 1. Originally published in 1941 by The Viking Press and reissued, in facsimile edition, by Paul P. Appel, Mount Vernon NY, 1971.

in daily life. Or, as David Kaiser has reminded us, "scientists are not born, they are made."[2]

The social construction of a successful scientist through education, the young scientist's early researches, and the influence of mentors forms the underlying theme of this chapter. Through these shared practices, aspiring scientists are encouraged to adopt certain ideals concerning their discipline, particularly science's objectivity, its purely intellectual character, and its basis in the pursuit of 'natural' facts. In her study of mid-twentieth century American physicists, the anthropologist Sharon Traweek writes that the "rhetoric of disinterestedness is used explicitly to inspire young students to pursue a career in science." Traweek also concludes that the kinds of stories told in science perform a gendering function by linking exemplary science with "great men" in the history of science, by emphasizing individual struggle, and by connecting objectivity with masculinity. As the feminist critique of science has frequently asserted, objectivity, believed to be at the heart of science, has been directly tied to the ideals and performance of masculinity.[3] For a female scientist, then, the need to adopt the ideals, outlooks, and

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[2] David Kaiser, "Moving Pedagogy from the Periphery to the Center," *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives* (Cambridge, MA: MIT Press, 2005), 1. Kaiser's introduction, and his conclusion (with Andrew Warwick), provide a compelling argument for greater comparative analysis of the ways in which the educational process has been used for "transferring skills... and generating sensibilities" in scientists over time.

[3] Sharon Traweek, "Pilgrim's Progress: Male Tales Told during a Life in Physics," 525-542, *The Science Studies Reader,* edited by Mario Biagioli (New York, NY: Routledge, 1999), 529. This is abridged from *Beamtimes and Lifetimes: The World of High Energy Physicists* (Cambridge MA: Harvard University Press, 1988). For the extensive literature on objectivity, gender, and science, a good starting point is Evelyn Fox Keller's *Reflections on Gender and Science* (New Haven, CT: Yale University Press, 1985), especially Part Two, "The Inner World of Subjects and Objects." For an insightful history of objectivity itself, and the argument for its recent (19th

practices of the scientific community would have been of utmost importance. The ethos and culture of science adopted by Dixy Lee Ray during the 1930s and 1940s constitutes a significant aspect of the public person that she became later in life.

To Mills College: Developing Leadership & Discovering Science

Ray graduated in 1933 from Stadium High School in Tacoma, in the depths of the Great Depression, but as the nation looked forward to the fresh ideas and renewed economic prosperity promised by its new president, Franklin D. Roosevelt.[4] Over the following decade New Deal policies would have mixed results in combating America's economic trials. But Ray's fortunes took an immediate positive turn in 1933 as she received admission and scholarship to Mills College, the private all-girl liberal arts college in Oakland, California. This offer, coming from one of the elite schools of the West Coast, suited the young Ray since Mills encouraged active leadership among students and provided a broad education. In addition, for someone entering college without defined career goals, the single sex environment at Mills promised talented and ambitious young woman the most broadly stimulating and professionally progressive atmosphere.

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century) entry into the natural sciences, see Lorraine Daston, "Objectivity and the Escape from Perspective," *Social Studies of Science,* 1992, 22:597-618.

[4] For entry into the extensive literature on the New Deal era in American history, see Ronald Edsforth, *The New Deal: America's Response to the Great Depression* (Malden, MA: Blackwell Publishers, 2000); Alan Brinkley, *The End of Reform: New Deal Liberalism in Recession and War* (New York, NY: Alfred A. Knopf, 1995); and William E. Leuchtenburg, *Franklin D. Roosevelt and the New Deal* (New York, NY: Harper & Row, 1963).

Ray's decision to attend Mills deserves some analysis, since all-girl schools existed at the contested, and progressive, edge of American society and have had a significant impact on the make-up of American science. One way to better understand her decision is to explore some of the possible images associated with girls' schools in popular fiction, as two scholars have recently done. The dominant themes explored in this popular fiction revolved around binary concepts of heightened opportunity and social subversion associated with the higher education of women. On the one hand, this literature reflected positive, progressive views of women's higher education. The heroines at institutions such as Vassar (the most frequent model institution in this genre) lived in an environment that firmly cultivated the positive value of college education for women, defied the common notion that feminine sensibilities were damaged by intellectual endeavor and physical challenges, and strove to confirm that society benefited from the education of both sexes. On the other hand, a deeply conservative element of this college-girl literature espoused the notion that women's colleges offered a limited period of social release, four years at most in which the proper social norms could be flouted and women could explore the boundaries of femininity. At the conclusion of the college experience, the narrative heroines inevitably returned to lives of feminine propriety and gendered normality.[5] If in fact these popular notions of the all-girls college experience were known to Ray, as she made her post-high school decisions, Mills may

[5] Shirley Marchalonis, *College Girls: A Century in Fiction* (New Brunswick, NJ: Rutgers University Press, 1995). For the most pertinent sections, see pages 1-9, 29-70, 161-179. See also, Sherrie A. Inness, *Intimate Communities: Representation and Social Transformation in Women's College Fiction, 1895-1910* (Bowling Green, OH: Bowling Green State University Popular Press, 1995).

have been especially attractive to an outspoken and accomplished girl who nonetheless had a certain conservative disposition.

Ray's decision to matriculate at Mills was aided by the offer of a scholarship. For each of her four undergraduate years, Ray received a $400 scholarship to cover tuition.[6] Later in life Ray recalled the economic privations of the 1930s, which "permeated and controlled every facet of life," thereby making Mill's scholarship offer the deciding factor.[7] But the attraction of moving far from home also had a large influence on her decision. Always an independent child, Ray seized the opportunity to live on her own. As an adult she described her motivation as stemming from "the combination of a milieu from which I wanted to escape and a fist-clenching decision to show'em [sic] I could do something without their [parental] help." During the midst of the Great Depression, with the family's printing business struggling, Ray could not expect much financial help from her parents. Due to the strained relationship with her father, Ray received even less help than she might have expected. During her undergraduate years she usually remained in the San Francisco Bay area during the summers, working odd jobs such as house painting, waiting tables, and janitorial labor. This summer-time work barely repaid the living expenses accumulated over the previous academic year but she consistently entered the new year debt-free.[8]

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[6] John Simon Guggenheim Memorial Foundation fellowship application forms, submitted by Dixy Lee Ray in 1951. Documents provided by the Guggenheim Foundation, New York. All Information from Ray's application folder hereafter cited as "**Guggenheim**."

[7] Guzzo, *Is It True*, 29-30.

[8] Ibid., 29-31.

Ray's story of hardship overcome through hard work is an important and common element in the image of success portrayed by countless American professionals. Beyond simply being a by-product of the economic situation in pre-World War II America, the tribulations overcome by Ray at this time formed a crucial rite of passage for the aspiring scientist. Successfully handling increasingly challenging mental and physical obstacles served as a means to select the best scientists, and then for refining their natural abilities.[9] In Ray's own words, recollecting the meaning of her hard-won education, heavy intellectual and physical workloads "are tests to keep out the incompetent."[10] Within the physics community, Traweek argues that this storytelling, at the post-doctoral stage, takes the "literary form of low mimesis: the suffering hero strives for advancement, which is blocked by seemingly intractable obstacles; the obstacles are finally overcome by an opportunistic and vigorous response to unforeseen circumstances" which in the end creates the professional scientist "determined solely by scientific merit."[11]

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[9] The interplay between intellectual and physical challenge in constructing the scientist is explored by Andrew Warwick, "Exercising the Student Body: Mathematics and Athleticism in Victorian Cambridge," 288-326, Steven Shapin & Christopher Lawrence, eds., *Science Incarnate: Historical Embodiments of Natural Knowledge* (Chicago, IL: University of Chicago Press, 1998).

[10] Jay M. Steinberg, "Dr. Ray: Marine Biologist," *Progressive Woman: A Magazine of Awareness for Success-Minded Women*, March 1972. Box 1, Folder "Articles about Dixy Lee Ray, 1963-72," Dixy Lee Ray Collection, Accession No. 82106, Hoover Institution Archives, Stanford University. Hereafter cited as "**DLR**." Besides Guzzo's various references to Ray's hardships, and her triumph over them, see references to these themes in: "Dixy Rocks the Northwest," *Time,* 12 December, 1977, page 31 (where she is said to have made her way through college on janitorial work and then became an "instant success" as an instructor at the University of Washington); Poole, *Scientists Who*, 17-19.

[11] Traweek, "Male Tales," 534.

Whatever her expectations of college life, Ray quickly immersed herself in the various scholastic and social opportunities available. Her fondness for active leadership, apparent during high-school, blossomed at Mills College. Ray's active childhood and her robust physique well-prepared her for the sporting culture at Mills, an important facet of life at women's colleges.[12] As in high-school, she participated in basketball her freshman year, making the All-Star team in Mills' major winter sport.[13] From her sophomore through senior years, Ray held the presidency of the "Outing Club," a social organization for those interested in exploring the "seashore and the mountains" around Oakland. With the greater experience of a second-year student, Ray took up membership on the Athletic Board, helping to organize the overall sporting life at Mills. Her greatest extra-curricular achievement came in archery. From her second year on, Ray consistently topped intramural competitions, won numerous regional competitions, and ended her senior year as the school's sole all-star in that sport.[14] Ray's excellence in sports, dependent equally on development of a competitive sensibility as physical skills, informs our understanding of Ray's development as a field scientist and administrator.

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[12] Innes, *Intimate*, 69-95; she describes women's colleges as places where "sports fanaticism was...an important element." Moreover, she describes a shift from the dominance of individual sport (gymnastics) in the late century to team sport (basketball) by the 1930s. For women and sporting culture in America see Cahn, *Coming on Strong*, chapters 1 to 3.

[13] *The Crest* (Mills College yearbook), 1934, (not paginated) under the entry "Basketball" in the Athletics section.

[14] *The Crest*, 1935, 99, 109; 1936, 120; 1937, 116, 119; "A Tribute to Dixy Lee Ray" (ca. 1994; written and delivered by a family member at time of Ray's death). Copy in possession of author, provided by Deborah Steele Hazen, niece to Dixy Lee Ray.

While sport honed her physical and mental skills in one direction, Ray developed administrative skills in other ways. As a Junior, Ray was elected as an Associated Student Body leader and served on a board overseeing all college publications. In a hectic senior year, Ray served on an Executive Board, a Judicial Board (to consider serious infringements of campus regulations), and led a small committee intended to facilitate student-faculty communication and cooperation.[15] Ray's varied and busy extracurricular life while at Mills demonstrate one of the key justifications for women's colleges: the opportunity for, and encouragement of, active leadership. At co-educational colleges and universities in the nineteenth and early twentieth centuries, extracurricular activities were highly gendered and the kinds of leadership positions held by Ray at Mills would seldom, if ever, be open to a woman at places such as Stanford or the University of Washington. As in other careers, scientists' leadership ability is a vital component of their professional development, and it is often cultivated during the college years.[16] Not surprisingly then, young women denied or discouraged from leadership during college would find it difficult to develop these abilities in their post-college careers; Ray's later proficiency as an academic scientist and science administrator must be seen in light of these early experiences.

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[15] *The Crest*, 1937, 85, 87, 102.

[16] In her study of P. M. S. Blackett, Mary Jo Nye has similarly detailed some of the early activities important in creating and encouraging leadership, in this case a military school designed to cultivate military leadership but that no doubt contributed to Blackett's skill as a scientific leader. *Blackett: Physics, War, and Politics in the Twentieth Century* (Cambridge, MA: Harvard University Press, 2004), 11, 19-20.

Ray's extracurricular activities played an important part in developing characteristics for a successful scientific career, but her primary studies played a more immediate role. Ray eventually majored in zoology, but through her freshman and sophomore years she spent equal time in the drama department and ended up with a minor in that field. The years spent entertaining neighborhood children with puppet shows, and making money at it, led Ray to entertain the idea that she "could make a profession out of it." At least during her first year at Mills, she staged weekend performances in San Francisco that brought in a small amount of cash. As a more traditional thespian, Ray participated in the Mills Drama Association from her second year on, planning and performing in plays while honing her public performance skills.[17]

As a zoology major Ray excelled at the rote memory often required of entry-level coursework and proved adept, later on, in the laboratory. The Department of Biological Science, in which Ray pursued her degree, provided a broad perspective on the life sciences. The department's statement of purpose claimed that students would study organisms "as unified individuals adapted to maintaining themselves in their varying environments rather than as illustrations of the methods and principles of the different sub-sciences of biology."[18] Within the limited course offerings it is likely Ray's first experiences within her chosen degree came in Dr. A. Pringle Jameson's *Invertebrate Zoology* course, a standard introductory offering. Jameson was described as an expert on

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[17] Guzzo, *Is It True*, 27; *The Crest*, 1935, 1936, 1937.

[18] Mills College Course Catalogue, 1937, 86.

silkworms and parasitism, spoke with a "Scotch burr" and always wore "plaid ties."[19] He had been trained at the University of Aberdeen in Scotland, where he received his doctorate in 1920. After working in England, India, and for two years at the University of Washington, Pringle settled at Mills in 1927 where he chaired the Biological Science department. Nearing fifty when Ray arrived in 1933, Pringle seemed to epitomize the serious, sophisticated, and brilliant scientist-scholar. Ray found a supportive and challenging mentor in Pringle, and she would later credit him with her scientific success. Evincing her belief in the power of education to produce not only a more intelligent person but also a more civilized one, she claimed "He was a most remarkable man, not only a gentleman of the highest order but a truly inspired scholar. Dr. Jameson was trained in the classic tradition, as only the Scottish schools can do it. ... he was one of the most ingenious, capable scholars I have ever known. It was he who made a marine biologist out of me."[20]

Under the tutelage of Jameson, and others in the department, with her continued superior grades through college, and with noted communication skills, Ray ended her senior year at Mills in 1937 well-positioned to embark on what seemed the most practical and acceptable career for an unmarried, college-educated woman. Though teaching had always seemed a most undesirable job to Ray, the nearing conclusion of college, combined with the continued poor economic conditions of the mid 1930s and Ray's

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[19] *The Crest*, 1937, 107.

[20] Guzzo, *Is It True, 32.*

strained relations with her parents, all convinced her otherwise.[21] She could not bear to return to Tacoma and her father's print-shop, so Professor Jameson's advice to remain one more year at Mills, completing a Master of Arts in zoology with teaching credentials, held great appeal. As a science teacher she could at least retain the independence she had enjoyed the past four years. In the meantime the offer of a full-year Graduate Fellowship of $750 allowed Ray to stay at Mills where she committed herself to this new course.[22]

At the time of Ray's graduation, as she contemplated her future, it is unlikely that she seriously considered a science career much beyond teaching at the elementary or high school level. While undoubtedly progressive, women's colleges had by the 1930s become less concerned with expanding women's opportunities in professions, such as the sciences. The masses of unemployed (primarily men) through the decade made the career-minded woman even less welcome. The extent to which women's college education was now seen as preparation for an intellectually engaged yet firmly domestic life was suggested in a letter to graduating seniors in 1937 by Mills President Aurelia Reinhardt. For those young women who had studied the sciences while at Mills, Reinhardt noted that they had received "adequate" instruction and experience in the areas of science and technology, not for the possibility of pursing research careers themselves but because they would be "living in a science and technology era." Mills College graduates, along with the graduates of the other major women's colleges, had received

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[21] Guzzo, *Is It True*, 33-35.

[22] "Fellowship Application Form," 2. **Guggenheim.**

the best educations available to women at the time, Reinhardt concluded, and this prepared them for their future lives "of potential leadership...in a world of infinite difficulties."[23]

Reinhardt's pessimistic tone, however, cannot be faulted for being unrealistic. In 1937 *The New York Times* science editor wrote, "the day when a young woman could not study at a college or university is virtually over;" but he warned those women considering a career in science, with its multitude of obstacles, that "the day when sex is disregarded and scholarship and demonstrated ability in research are the sole criteria for appointment to a university professorship has not yet dawned."[24] Though Ray's decision to pursue a research career in science likely was made incrementally, as individual opportunities presented themselves, she nonetheless must have recognized the difficulties ahead as she edged in this direction.

Of Gribbles & 'Correct Working Methods'

Considering the organismal approach to the biological sciences found in Pringle's department, it is not surprising that Ray devised an ecological study as her masters' project. Having grown up on the shores of Puget Sound, followed by four years near the marine waters of the vast San Francisco bay, she quite naturally turned to the inter-tidal zone as the locus for an intense study of the habits and habitats of four different

[23] Mills College Year Book, 1937, "President's Message."

[24] Waldemar Kaempffert, *The New York Times*, "Women in Science: More research opportunity held needed in colleges" 11 April, 1937, Section 12, p.6. Rossiter concludes that "By 1940, women in all areas of science had reached an impasse. They could be educated to the doctoral level but would encounter great restrictions on their employment." *Struggles and Strategies*, 315.

burrowing forms of Eumalacostraca (an order of crustaceans, the most recognizable forms being shrimp and crabs). Hoping to complete her Master's in one year, Ray nonetheless designed an ambitious "three-sided" study, incorporating a traditional morphological component, an ecological component comprised of "observations of the living animal... and analysis of the environment," and finally the construction of laboratory experiments to extract otherwise obscured life-history information.[25] On this last point, as with the overall conception of her research, Ray followed the lead of America's foremost animal ecologist, Victor Shelford. In 1929 Shelford published his influential textbook, *Laboratory and Field Ecology: The Responses of Animals as Indicators of Correct Working Methods*, in which he argued that "The efforts of ecologists should be directed toward the explanation of community and habitat relations. To this end, experiments of various sorts may be performed in nature. This is a new field of experimentation which it is hoped this book may stimulate. In ecology it is even more true than in work from other viewpoints, that the precision of the laboratory is necessary."[26] Ray was well aware of Shelford's overall work as an ecologist, and her own research closely adhered to this methodological guideline.

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[25] Dixy Lee Ray, *A Comparative Study of the Life Habits of Some Species of Burrowing Eumalacostraca*, (MA Thesis, Mills College, 1938), 1-4.

[26] Victor Shelford, *Laboratory and Field Ecology: The Responses of Animals as Indicators of Correct Working Methods* (Baltimore, MD: Williams & Wilkins Company, 1929), 2.

Ray's choice of an ecological study of an inter-tidal animal community reflected more than just her local situation.[27] Within the life sciences the first half of the twentieth century witnessed the full establishment of professional ecology as a viable discipline. As a new and more professionally acceptable form of natural history, as a "borderland between the biological and social sciences," or as an alternative to the increasingly reductionist and lab-centered disciplines epitomized by genetics, ecology presented itself as a supremely useful, increasingly rigorous and formal scientific discipline that retained much of the aesthetic pleasures and edification of traditional natural history and of the nature study movement.[28] For Ray, formulating an ecological study would have been completely reasonable, well within an established tradition of scientific inquiry, and as I

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[27] It may be that marine scientists on the Pacific coast held a greater appreciation for ecological approaches in the first half of the twentieth century than in other parts of the country. Ronald Rainger has sketched out the emergence of an ecological perspective that he claims came to epitomize research at La Jolla beginning in the 1930s, "Adaptation and the Importance of Local Culture: Creating a Research School at the Scripps Institution of Oceanography," *Journal of the History of Biology*, 2003, 36(3):461-500; and Keith Benson has described the establishment of West Coast marine stations as well as the prominent work of ecologists at some of these stations, "Experimental Ecology on the Pacific Coast: Victor Shelford and His Search for Appropriate Methods," *History and Philosophy of the Life Sciences*, 1992, 14:73-91; and "Marine Biology or Oceanography: Early American Developments in Marine Science on the West Coast," 298-302, *Oceanographic History: The Pacific and Beyond*, edited by Keith Benson and Philip Rehbock (Seattle, WA: University of Washington Press, 2002).

[28] Quotation from Gregg Mitman, *The State of Nature: Ecology, Community, and American Social Thought, 1900-1950* (Chicago, IL: University of Chicago Press, 1992), 1. There is a rapidly growing literature in the history of ecology. Beyond Mitman (who explores the American social context of important ecological concepts), three valuable texts for the intellectual history of ecology are: Donald Worster, *Nature's Economy: A History of Ecological Ideas* (Cambridge, England: Cambridge University Press, 1994, 2nd Edition); Joel B. Hagen, *An Entangled Bank: The Origins of Ecosystem Ecology* (New Brunswick, NJ: Rutgers University Press, 1992); and Sharon Kingsland, *Modeling Nature: Episodes in the History of Population Ecology* (Chicago, IL: University of Chicago Press, 1985). For an interesting sociological/historical analysis, covering more than just "ecology", see Robert E. Kohler, *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology* (Chicago, IL: University of Chicago Press, 2002).

argued in the previous chapter, particularly suited to the marine biological community working along the West Coast at the time.

Within this productive ferment of early twentieth century science, from which ecology developed, a small group of West Coast biologists coalesced through their mutual interests in littoral marine life. More than solely the result of design, the study of sea-shore life came about from sheer practicality and availability. Though oceanographic expeditions had been taking place for decades, they were necessarily costly and therefore infrequent. The sea-shore, conversely, presented a wealth of unexamined organisms and ready problems for ecological investigations. In the opening sentence to Edward Ricketts' seminal work, *Between Pacific Tides*, he contrasted the East Coast with the rich West Coast marine environments: "The shore topography of the Pacific coast differs considerably from that of the Atlantic coast, and this fact, ... produces animal communities that seem strange to students from depauperate eastern shores."[29] If the East coast marine environment was indeed impoverished[30] (and therefore partially explained biologists' laboratory-oriented research at such places as Woods Hole), then bountiful environment of the Western coast, he went on to argue, resisted traditional biological

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[29] Edward F. Ricketts and Jack Calvin, *Between Pacific Tides* (Stanford, CA: Stanford University Press, 1939), 1. This text remains in print, having been revised by Ricketts and, following his death, by Joel Hedgpeth, and most recently by David W. Phillips in the 5th edition of 1985. Much of the colorful description of the original publication, including the quotation above, was removed from later versions.

[30] Ricketts' use of the word "depauperate" suggests that East coast marine life was stunted and arrested in its growth or development. Although this was likely written with humorous intent, it is interesting since it reflected a common way of thinking about the grand scale of the Western environment.

study of individual organisms, but perfectly suited the relatively new ecological approach. Taking advantage of this apparent luxury of organisms, offered up to anyone willing to wade in the littoral, Ricketts was already in the 1930s a person well known to most biologists working along the West Coast. And it was he, as much as anyone, who practiced and promoted marine ecology.

Ricketts, caricatured as the slightly eccentric, bohemian, but much admired 'Doc' in John Steinbeck's 1944 best-seller *Cannery Row*, in real life explored his interests in the arts and science, but never achieved wide acclaim in either during his life.[31] Having received some formal education with the ecologist Warder Clyde Allee at the University of Chicago, and picking up inspiration from Allee's pioneering studies of marine communities near Woods Hole, Ricketts abandoned formal university training before receiving an undergraduate degree. Ricketts ended up in the lively fishing community of Pacific Grove, California in 1923 after a period of vagabond travels around the United States, setting up shop as a supplier of biological organisms to teachers and researchers. The plentiful supply of marine animals at his doorstep convinced him of the viability of this business but, equally important, he recognized the opportunity to indulge his passion for 'holistic' thinking that this autonomous vocation allowed. As a collector of marine organisms, Ricketts could study the littoral up and down the West Coast, thereby

[31] *Between Pacific Tides* was a popular book during his life but was often seen by professional scientists as aimed at the amateur (and indeed written by an amateur). As something of a philosopher, his guiding intellectual concepts, written up in "The Philosophy of 'Breaking Through,'" was rejected by a number of publishers.

becoming intimately knowledgeable about the inter-connections of animal communities within an ecological framework.

Beginning in the late 1920s, Ricketts began compiling his most enduring publication – *Between Pacific Tides* – eventually published in 1939. In a draft introduction Ricketts laid out his belief that ecology, as a science and as a more complete approach to life, differed from other forms of knowledge about the natural world. As he saw it, taxonomic classification had long defined the work of naturalists, and at its core operated under the belief that "lines of demarcation are definite." On the other hand, ecology had to begin with the assumption that "any ecological classification will be inexact, suggestive rather than definitive." And whereas his approach may, in the eye of the professional zoologist, suffer from "inexactness and inconsistency" Ricketts argued that these were in fact the hallmarks of nature. In his words, the inexactness and inconsistency found in nature were in fact "the reality of natural things as contrasted with our intellectual need for realizing all phenomena in discrete states."[32]

Between Pacific Tides received a generally warm reception at its publication in 1939, just as Ricketts and Steinbeck began planning a voyage into the Sea of Cortez. Readers of the journal *American Midland Naturalist* heard from George E. MacGinitie, that *Between Pacific Tides* was one of those rare scientific books of value to both the

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[32] Edward F. Ricketts, "Zoological Introduction to *Between Pacific Tides*" published in *The Outer Shores, Part 1: Ed Ricketts and John Steinbeck Explore the Pacific Coast,"* edited by Joel W. Hedgpeth (Eureka, CA: Mad River Press, 1978). Quotations come from a *circa* 1936 introduction written by Ricketts as he tried to defend his methodology in the face of criticism from W. K. Fischer (director of the Hopkins Marine Station, and a very traditional invertebrate zoologist not impressed by ecological generalities) but not included in the published (1939) book.

"scientist and the layman." Yet the book's strength lay not only in its accessibility to a wide spectrum of readers: MacGinitie drew attention to the rather novel, and commendable, arrangement of the material such that animals were grouped according to the natural habitat in which they would likely be found. As another reviewer put it, animals were described using an "ecological rather than the usual phylogenetic organization," thereby making the book more useful while impressing on the reader the inter-relations of animals and habitats.[33]

Within this milieu of experimental and ecological marine research, Ray devised a study that incorporated both. The issue set out for study was, in her words, to better understand "the burrowing habit in Eumalacostraca." Four species composed the focus of her study: the "ghost shrimp" *Callianassa*, the "sand frog" *Emerita*, the "gribble" *Limnoria*, and the "rock borer" *Sphaeroma*.[34] First identifying the individual species, Ray proceeded with a comparative anatomical component, followed by three sections presenting the ecological field work undertaken, and concluded with experimental results.

As an experimentalist, Ray displayed natural aptitude, a characteristic that was repeatedly noted by instructors and colleagues. In this case Ray redesigned an experiment performed by the acknowledged *Callianassa* expert, George MacGinitie (director of the Kerckhoff Marine Laboratory at the California Institute of Technology),

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[33] G. E. MacGinitie, "Between Pacific Tides," *American Midland Naturalist*, 1939, 21(3):768; Ralph Buchsbaum, "A Handbook of the Common Invertebrates of the Pacific Coast" *Ecology*, 1940, 21(1):93-94.

[34] The full scientific names are: *Callianassa californiensis* Dana; *Emerita analoga* Stimpson; *Limnoria lignorum* Rathke; *Sphaeroma sp.*

to observe burrowing techniques. Where MacGinitie had created a viewing aquaria by placing a glass plate in front of a shallow wall of sand, thereby forcing the *Callianassa* to burrow in full view, Ray recognized that this did not adequately reproduce the natural burrowing environment. Her own experimental construction allowed the animals to burrow without the imposition of glass walls and led to the conclusion that "under conditions of artificial support *Callianassa* will dig vertically downward, while under more natural conditions the descent is of a much more gradual character."[35] No doubt this constituted a minor correction regarding the life habits of an obscure marine organism, but it illustrated the importance of technique in experimental ecology. Shelford's admonition that "the various factors of natural environments must be studied and duplicated so far as possible" had born fruit in Ray's research.[36] And what did Ray conclude from her study? Much as Shelford tempered his initial exuberance for experimentalism in ecology, Ray concluded that interpreting experimental observations or data was "more than difficult" and that the "extreme complexity of the many factors which may interact to cause an animal to burrow has not yet been clarified."[37]

Although Ray always gave credit to Professor Pringle for guiding her into science, it is curious that Eleanor Boone, an assistant professor in the Biology Department, actually oversaw the thesis. It is clear from early drafts of the thesis that Boone provided day-to-day guidance, and Boone's own research provided the model on

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[35] Dixy Lee Ray, *A Comparative Study*, 71-74.

[36] Shelford, *Laboratory and Field Ecology*, 3.

[37] Dixy Lee Ray, *A Comparative Study*, 97.

which Ray devised her thesis. Yet nowhere in Ray's later recollections of her early scientific work does she mention this mentor. Unlike Pringle, a man who could boast a doctorate from a prestigious European university, Boone had only completed a master's degree at Stanford. Of course, this was not uncommon for college teachers of the time, especially for women. Yet the inspirational role she played in Ray's career is clear. Boone completed her master's degree at the Hopkins Marine Station, with a study of polyclad species[38] collected at various locations along the California coast. Part of the methodology used in Ray's thesis, for which she collected specimens at numerous locations along the Pacific coast, would certainly have been encouraged by Boone.[39] After completing her thesis in 1927, it appears that Boone undertook work for the doctorate, furthering her study of polyclads. Boone never completed the dissertation, but it can be safely assumed that her connections forged at the Hopkins Marine Station (equally, if not more so than Jameson's) paved the way for her student to later pursue doctoral work there.[40]

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[38] A common yet inconspicuous flatworm inhabiting the littoral.

[39] Collecting with zoogeographical concerns in mind was, at the time, widely followed. Ricketts's own work bore directly on establishing improved zoogeographical understanding. It was in 1937 that W. C. Allee and Karl P. Schmidt translated into English (and re-worked) Richard Hesse's important textbook *Tiergeographie auf oekologischer Grundlage.*

[40] Like many women scientists of her time, it is difficult to track Boone's professional life. However she did publish three works as Eleanor (Sims) Boone: *Polyclads of the California Coast* (MA Thesis, Department of Zoology, Stanford, 1927); "Five new polyclads from the California Coast," *Annual Magazine of Natural History*, 1929, 10(3):33-46; *The Classification of the Polyclada: A Translation from the German of Studien über Polycladen by Dr. Sixten Bock and Die Polycladen by Dr. Arnold Lang, with Addenda by Eleanor S. Boone, A.M.* (Hopkins Marine Station, 1932). The first and last citations are in the collections of the Hopkins Marine Station library.

Before the finished product appeared, Ray's thesis underwent the usual criticism and comment from her advisors. Some aspects of this quotidian process bear significantly on the construction of Ray as a professional scientist. A key conceptual, methodological, and rhetorical component of modern science has been its belief in the attainability of objectivity. As Traweek has suggested, the emphasis on objectivity may be most important during a scientist's early formal training. Other scholars have demonstrated the gradual evolution of scientific rhetoric towards a style in which the "individual voice remains subservient to the presentation of a new knowledge claim."[41] Moreover, as Peter Dear has written, "language is not simply a transparent medium of communication, but a shaper (perhaps a realizer) of thought and an embodiment of social relations." Dear, Frederic Holmes, and Lisa Rosner have demonstrated ways in which the ideal of experiment has been variously represented and reconfigured in textual form.[42] A striking example of this is found in drafts of Ray's thesis, in which her advisor (Eleanor S. Boone) gently reformed Ray's language, effectively eliminating hints of subjectivity in the expression of her student's work and thought. One insightful passage

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[41] Alan G. Gross, Joseph E. Harmon, and Michael Reidy, *Communicating Science: The Scientific Article from the 17th Century to the Present* (Oxford, England: Oxford University Press, 2002), 165.

[42] Peter Dear, ed., *The Literary Structure of Scientific Argument: Historical Studies* (Philadelphia, PA: University of Pennsylvania Press, 1991), 4. For the essays explicitly addressing experiment and literary expression, see Dear, "Narratives, Anecdotes, and Experiments: Turning Experience into Science in the Seventeenth Century," 135-163; Frederic Holmes, "Argument and Narrative in Scientific Writing," 164-181; and Lisa Rosner, "Eighteenth-Century Medical Education and the Didactic Model of Experiment," 182-194.

is worth quoting in entirety. Here Ray introduced her field-work and made comments on its trustworthiness:

> In any attempt to make an evaluation of notes gathered from field observations, it must be kept in mind that such data is by its very nature, entirely subjective. As many able investigators have pointed out, interpretations of the type to be considered in this section may be unconsciously controlled or directed by the attitudes and mental states of the observer. Admitting this, not as an excuse or explanation, but as a caution against drawing unwarranted conclusions or in relying too much upon the veracity of observed reactions, the writer is keenly aware of the possibilities of error in judgment. Results of observations, therefore, are set forth as clearly and simply as possible, and the conclusions reached are considered in the light of previous work.[43]

By marking this paragraph with a question mark, and then crossing it out, Ray's advisor left little doubt as to the merits of this sort of writing for a scientist.

True professionals could be set apart from mere nature lovers by their ability to convey science as an objective body of knowledge. While Ray's instructors carefully led her to recognize and conform to the standards of the professional scientist, examples of the less-than-objective amateur abounded. About the time Ray completed her thesis, Edward Ricketts and the novelist John Steinbeck were sailing through the Sea of Cortez, collecting marine animals and writing about their experiences. This duo, the one a marginalized scientist and amateur philosopher, the other a first-rate novelist (who would go on to win the Nobel prize in literature), could freely think and write about the natural world in ways that were being walled off from Ray. Conveying near contempt for a

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[43] Draft of thesis, 103. Box 6, Folder "Graduate Work Research Notes," **DLR**. It is worth noting that Ray's seeming skepticism of field-work came at a time when much of the 'best' science was seen as being produced under the carefully controlled conditions of the laboratory.

seemingly trivial scientific objectivity, Steinbeck and Ricketts explained the purpose of their trip in the following terms:

> One of the reasons we gave ourselves for this trip...was to observe the distribution of invertebrates, to see and record their kinds and numbers, how they lived together, what they ate, and how they reproduced. ... We wanted to see everything our eyes would accommodate, to think what we could, and, out of our seeing and thinking, to build some kind of structure in modeled imitation of the observed reality. We knew that what we would see and record and construct would be warped, as all knowledge patterns are warped.... But knowing this, we might not fall into too many holes – we might maintain some balance between our warp and the separate thing, the external reality. [the dorsal spines of a fish] can easily be counted. But if the sierra strikes hard on the line so that our hands are burned, if the fish sounds and nearly escapes and finally comes in over the rail, his colors pulsing and his tail beating the air, a whole new relational externality has come into being.... The only way to count the spines of the sierra unaffected by this second relational reality is to sit in a laboratory , open an evil-smelling jar, remove a stiff colorless fish from formalin solution, count the spines, and write [down the number of dorsal spines]. ... [W]e were determined not to let a passion for unassailable little truths draw in the horizons and crowd the sky down on us. We knew that what seemed to us true could be only relatively true anyway. There is no other kind of observation.[44]

One other example is worth reciting, not only for the light it sheds on the desire for a detached, spare, even clinical language but also for the humorous anthropomorphizing of the original draft that Ray's advisers requested to be struck from the final version. In the description of burrowing by Callianassa, Ray provided a detailed and creative account of one particular animal's efforts: "a large and robust female forever quit her burrow, and without a single regretful backward glance half-ran, half-swam the entire length of the aquarium as if all the furies of domestic intrigue were in immediate

[44] Steinbeck & Ricketts, *Sea of Cortez*, 2-3.

pursuit. The other end of the tank seemed to be the objective, and this gained, the specimen began to dig.... Under the soothing influence of a job to be done, the previous undue haste disappeared and the work proceeded with deftness and deliberation."[45] Undoubtedly these kinds of expressions were frequently expunged from manuscripts, especially as students absorbed more acceptable rhetorical forms of their discipline. It is the very banality of this correction, the ease with which Ray and her advisors agreed on the suitable terms of description, that suggests the power of a discourse of dispassionate objectivity for an aspiring marine biologist. In the end, with the considerable and blunt advice of her advisors, with the "inadequate cerebration"[46] of her early drafts corrected, Ray produced a thesis that lived up to the scholarly expectations of professional scientists. In the process Professors Jameson and Boone taught a young scientist proper ways to think about and describe the natural world.

In June of 1938, as Ray completed the writing of her thesis, she sat the written exam as required. The series of questions posed by Pringle and Boone bring into focus the range of biological knowledge expected of Ray. The first question asked for a discussion of the common taxonomic features of crustaceans. A question on homology

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[45] Draft of thesis, 109-111. Box 6, Folder "Graduate Work Research Notes," **DLR**. The reflections upon Ray's own life (her physical attributes, her flight from home, her capacity for and enjoyment of work) in this description are inescapable.

[46] Handwritten notes, Box 7, Folder "Graduate Work Thesis," **DLR**. This phrase is used by Boone, but context makes clear that it was drawn from Pringle's unsparing description of an early draft of Ray's thesis.

preceded one on Hans Speman's "theory of the organizer,"[47] a popular and controversial idea in developmental mechanics at the time. The latter half of the exam questioned Ray's knowledge of ecological ideas and principles. One question called for evolutionary and ecological explanations of certain zoogeographical facts of marine life distribution, and another elicited discussion of differing definitions of an "animal community." Finally, in what certainly played to Ray's strengths for spontaneous, lucid, and imaginative expression, a request to describe a typical tide-pool, its inhabitants and their adaptation to the unique conditions, brought forth her longest answer. (It is worth noting that Ray's entry into educational television in the 1950s, discussed in a later chapter, uses essentially this question as its underlying theme. Life at the sea-shore seemed uniquely and marvelously adapted, and provided the ideal opportunity to teach about life in ecological and evolutionary terms.) For all her hard work Ray received the satisfaction of Dr. Pringle's terse mark of "100%."[48] With this exercise out of the way, Alexander Pringle, Eleanor Boone, and the rest of the Mills community bid Dixy Lee Ray farewell.

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[47] The organizer theory grew out of experiments that appeared to show one part of an embryo, possibly a chemical produced by cells in this region, held the ultimate power to control development. For fuller discussion see Garland Allen, *Life Science in the Twentieth Century* (Cambridge, England: Cambridge University Press, 1978), 114-126.

[48] Final Exam, Box 7, Folder "Graduate Work Thesis," **DLR**.

A PhD in Zoology & A Science of Living

With a Master's in zoology and teacher certification in hand, Ray immediately found employment in the Oakland, California school district. It was a job she had not envisioned for herself just a few years earlier. However, Americans had increasingly come to see people like Ray as ideal teachers at the elementary and high school level. Margaret Rossiter, Kim Tolley, and others have documented a transition in American education, from the mid nineteenth to the mid twentieth century, in which primary and secondary science education became predominantly women's domain.[49] The high-school science teaching job Ray obtained in the Oakland school district, from 1938 to 1942, fulfilled not only the financial needs of a well-educated single woman during the latter stages of the Great Depression, but also predominant social expectations. Two important factors can be seen creating the changed social expectations that made teaching seem to be fully acceptable as women's work. First, whereas formal education in the early decades of the nineteenth century had been relatively exclusive, by the early twentieth century compulsory elementary education had become the norm. This naturally required a dramatically enlarged workforce, and as more and more women matriculated through American colleges they held ample qualifications to enter the teaching ranks. As the teaching workforce grew, economic factors became increasingly important. Since it was widely accepted that women should earn less than men, schools could achieve significant

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[49] Rossiter, *Women Scientists, Vol 1*, and *Women Scientists in America, Volume 2: Before Affirmative Action, 1940-1972* (Baltimore, MD: The Johns Hopkins University Press, 1995); Tolley, *The Science Education of American Girls.*

savings by employing scores of well-prepared women. Thus, as teaching became a more common occupation, and as the need for a cheaper workforce increased, the demographic makeup and the gendered expectations of teachers in America changed.

As a teacher Ray developed an engaging, exuberant, and hands-on pedagogical style. Echoing Louis Agassiz's popular phrase to "study nature, not books", an educational philosophy exemplified in the nature study movement, Ray developed science courses that de-emphasized text-book learning. To Ray, having just completed field work intensive research, science course-work needed to accentuate the physical process, a process in which the student would be stimulated to learn by firsthand discovery. The belief in science as process had been instilled during her college years. She recounted years later that "at [Mills] I had been accustomed to collecting my own specimens, so [in high-school] we did everything. We got ourselves an aquarium, rat colonies, varieties of snakes, many kinds of worms, and all the types of marine animals we could find." The school at which she taught kept a small budget for supplies, possessed lab space and good microscopes, but Ray claims that until she arrived these were not used and, in fact, no one knew how to perform even the simplest experiments.[50]

Through the following four years, as the United States edged toward World War II, Ray obtained useful teaching skills. She also came to recognize that the repetition required in teaching high-school science courses could not be reconciled with her desire to engage in serious research. Calling upon Eleanor Boone's and Alexander Pringle's

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[50] Guzzo, *Is It True*, 38-39.

contacts with scientific colleagues, Ray explored the possibility of continuing graduate study. During the latter years of her stint in the Oakland school district, she spent many weekends and summers in Pacific Grove, getting acquainted with individuals at the Hopkins Marine Station. As America's college-age men entered military service, with the relative opening this created for women in traditionally male-dominated industries (including academia), Ray entered Stanford University in the autumn of 1942 with the goal of obtaining her doctorate in marine biology. This goal was made more readily obtainable by the offer of financial scholarships, which with renewals, paid for tuition expenses throughout her graduate years. And as she had done at Mills, Ray found service jobs to pay for other expenses.

Longstanding ties between Mills and Stanford made Ray's decision somewhat predictable. Moreover, Stanford had a well-respected reputation in the biological sciences going back to its first President, the eminent ichthyologist David Starr Jordan. By the early 1940s, the permanent staff in Pacific Grove included Cornelius B. van Niel, a well-known microbiologist and specialist on the photosynthetic processes of purple and green bacteria. Two traditional marine biologists included the Swedish born and educated Tage Skogsberg and Rolph Bolin, an ichthyologist who earned his degrees under Skogsberg at the Hopkins Marine Station in 1934.[51] Ray would became Bolin's first doctoral student. The larger community of biologists, based primarily at the main campus, included the biochemist Ed Tatum and geneticist George Beadle, both at

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[51] Rolph Ling Bolin, *Studies on California Cottidae: An Analysis of the Principles of Systematic Ichthyology*. 1934, Stanford University. dissertation.

Stanford from 1937 to 1945. The exciting and productive intellectual environment to be found at Hopkins centered around Van Niel and provided Ray opportunity to branch out into microbiology during her short time there. And as will be clear later, the friendship formed with Van Niel and contacts made through him proved of great value throughout her professional career.[52]

For unknown reasons, Ray worked under the supervision of Rolph Bolin, on a morphological examination of the nervous system of a common pelagic fish, *Lampanyctus leucopsarus*. *Lampanyctus* is more commonly termed a 'lantern fish,' so named for the light-emitting 'dots' spaced along their bodies. Guzzo provides a completely erroneous explanation for Ray's choice of advisors, claiming that her graduate work was interrupted and redirected by the unexpected death of Skogsberg, "her principal mentor...while on a special mission for the military during the Second World War."[53] There is no evidence that Skogsberg ever acted as Ray's primary advisor, and it

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[52] Beyond these individuals, permanent resident scientists at Hopkins (during the years 1942-45) included the director (through 1942) and invertebrate zoologist Walter K. Fisher, emeritus invertebrate zoologist Harold Heath, and the director (1943-1964) and plant physiologist Lawrence Blinks. Like other marine research stations, a dramatically increased summertime population existed. As for the general intellectual climate at Pacific Grove, one cannot forget that Ed Ricketts, John Steinbeck, the philosopher/mythologist Joseph Campbell, and other interesting characters made this their home. Undoubtedly this was an exciting place for a young student. A recent book details the relationship between Ricketts, Campbell, and Steinbeck: Eric Enno Tamm, *Beyond the Outer Shores: The Untold Odyssey of Ed Ricketts, the Pioneering Ecologist who Inspired John Steinbeck and Joseph Campbell* (New York, NY: Four Walls Eight Windows, 2004).

[53] Guzzo also claims that Skogsberg was the only invertebrate zoologist at Hopkins; this is also untrue. Skogsberg was not an invertebrate specialist, though his wide-ranging research did cover some invertebrates; moreover, others at Hopkins were indeed invertebrate specialists. Guzzo, *Is It True*, 51.

is clear he did not die until 1951, well after Ray finished her graduate work.[54] Another explanation makes much more sense. In a biographical sketch, the science writer Graham Chedd wrote that Ray had originally "wanted to work on a more ecologically oriented subject, involving marine biology. But her supervising professor convinced her that ecology would not be a good topic for her thesis. She would have to spend several seasons making observations to really understand any ecological phenomenon. And with the US embroiled in WWII, the West Coast was under curfew. Soldiers patrolled the beaches and sent people away at dusk, so she would not be able to make any observations after dusk. The professor also persuaded her that a thesis is a means to an end, in which learning the techniques of scholarship is far more important than the subject matter."[55] This plausible story would explain her abandonment of the apparently productive line of research originated at Mills; and her new topic certainly did allow for speedy completion under war-time conditions.

Margaret Rossiter and others have detailed the unusual opportunities for women in science that came into existence around the time of World War II. On the one hand, positions opened up within the many government-funded military projects, such as the massive efforts to develop radar, the proximity fuse, and the atomic bomb, which

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[54] The librarian at the Miller Library, Hopkins Marine Station kindly provided an obituary notice ("Memorial Resolution: Karl Jonas Tage Skogsberg") which along with other documents confirms Skogsberg's death on 16 August, 1951. This can be viewed online at http://www-marine.stanford.edu/HMSweb/Memorial%20Resolutions/index.htm

[55] Graham Chedd, "Dixy Lee Ray." Box 4, Folder "Biographical Data," **DLR**. I have been unable to determine if or where this biographical essay was published. Incidentally, Chedd became one of the founders of the *NOVA* series on PBS, among many other science journalism credits.

eventually allowed women with science backgrounds to participate. This work was consistently at entry levels, or in such areas deemed appropriately feminine, such as nutrition. On the other hand, the opportunities that emerged during the war were not sustained in the years to follow. In Rossiter's view, the retreat from wartime opportunities should be attributed to a renewed social conservatism in which women returned, for the most part willingly, to the domestic sphere.[56] To the extent this interpretation is an accurate depiction of the times, Ray's experiences (and those of other successful women scientists of the time) both support and challenge this model. Dixy Lee Ray's entry into Stanford as a graduate student must be seen, in part, as an individual capitalizing on an educational opportunity afforded through the extraordinary war-time conditions in the United States. If her research project was indeed conceived with the exigencies of war in mind, it paid dividends through timely completion and quick transition to an academic job just as American GIs returned home and re-entered higher education. World War II did open opportunities for women in science, and Ray became

[56] Rossiter, *Women Scientists, Vol 2*, 1-26. Wartime demand for oceanography was significant and allowed some women entrance to this field: witness Mary Sears's work in the Navy's hydrographic office. However, the situation was not the same for marine biologists, who at the time had little role in oceanography. Rossiter writes that "So great was the demand for nutritional advice for civilians (and so weak the demand for marine biologists) that even Rachel Carson, an associate aquatic biologist...was pressed into writing food-conservation bulletins on how to substitute local fish and other domestic seafoods in family menus." (Rossiter, p.3) Mary Sears's entry into oceanography during WWII has been explored by Kathleen Broom Williams in "From Civilian Planktonologist to Navy Oceanographer: Mary Sears in World War II" *The Machine In Neptune's Garden: Historical Perspectives on Technology and the Marine Environment*, edited by Helen M. Rozwadowski & David K. van Keuren (Sagamore Beach, MA: Science History Publications, 2004), 243-272.

one of the many who grasped the opportunity during the war and one of the few who rose to prominence in the decade to follow.[57]

Whatever Ray's reasons for re-entering university, it is clear she put in the requisite hard labor expected of graduate students. She completed a major study of the lantern fish neural system and all coursework in three years, while holding down janitorial jobs in the Pacific Grove area. Ray's dissertation, best described as solid, thorough, competent, but not path-breaking, entailed tracing each of the nerves that presumably controlled *Lampanyctus's* distinctive photophores, the light-emitting organs. The intent of this study was two-fold. First, delineating the nerve connection of each photophore could, Ray argued, help to settle an on-going question among ichthyologists and physiologists. In some organisms light emission resulted from hormonal action; the nervous system controlled photophore function in other organisms.[58] Ray's dissertation, the first systematic study showing the enervation of each photophore in one representative of the Myctophidae family, clearly supported the latter position.[59] The

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[57] A zoologist at the University of Washington, a woman of Ray's generation, explained her own professional life in similar terms, saying that her career "began and was established during the Second World War in a 'window' when women – or anybody – were welcome."

[58] Fifteen years later, in a survey of light emission in animals, J. A. C. Nicol could write with greater certainty that "In metazoans...[t]he excitatory mechanism, so far as known, is always nervous: a clear-cut instance of hormonal regulation has yet to be established. "The Regulation of Light Emission in Animals" *Biological Reviews of the Cambridge Philosophical Society*, 1960, 35(1):17.

[59] Dixy Lee Ray, "The Peripheral Nervous System of *Lampanyctus leucopsarus*: With Comparative Notes on Other *Iniomi*." PhD, Stanford University, 1945. In 1950 the dissertation was published, only slightly condensed, as D. L. Ray, "The Peripheral Nervous System of *Lampanyctus leucopsarus*," *Journal of Morphology*, 87:61-178.

second purpose was as an aid to classification, since photophore arrangement served as an important taxonomic character. In the end Ray's dissertation served its purpose. It proved her observational and technical skill, it established her ability to pose and tackle a scientific question, and it contributed to knowledge deemed important by colleagues.[60]

Ray's dissertation work took place at a time when genetics and molecular biology, particularly the methodologies employed in these disciplines, would likely have appeared to be at the vanguard among the various fields of biology. With ready examples provided by Beadle and Tatum, by Van Niel, and by Bolin, it is likely that Ray began recognizing some of the prevalent characterizations of the disciplines and, in turn, started forming her own notions as to what counted for good science. With this in mind, Ray's decision to pursue a morphologically-oriented dissertation, while developing experimental skills under Van Niel's tutelage, allows us to reflect on the historiographical debates over experimental methodologies in the life sciences. Some, most prominently Garland Allen, have argued for the marginalization of morphological studies, claiming that a "revolt" took place against an old style descriptive natural history. Others have countered that it was not morphology, per se, being disparaged. Rather, scientists gradually moved away from speculative and descriptive forms of science that did not attempt to incorporate the rigorous methodology of experiment. In this particular case it may be that Ray 'hedged her bets.' Her dissertation served to display a solid research capability in morphology, an area that continued to be of value in the life sciences. At

[60] On this last point, figures compiled from the *Science Citation Index*, and *Web of Science*, from 1945 through 2003, show that her study of *Lampanyctus* has been cited at least 25 times, a modest but not insignificant measure of the research's utility.

the same time, Ray developed knowledge and skills in microbiology that earned her a reputation in a cutting-edge discipline. These two areas of research, one considered more experimental and the other morphological, illustrate the historiographical claim that experimental work did not come to replace descriptive studies as the life science moved into the twentieth century. Rather, within the various disciplines of the life sciences experimentation came to be seen as a powerful and effective methodological tool, while a morphological orientation remained a touchstone especially of the zoological sciences. And, as Rainger, Benson, Maienschein (and others) have argued, careful historical examination reveals a good deal of complementarity between morphology and experimental biology from the late nineteenth century onwards.[61] In the end, Ray's choice to do a morphological dissertation while engaged in microbiological research with Van Niel, shows that Ray worked to broadly establish her credentials as a scientist entering a field – marine biology – that could not be easily defined.

For the advancement of her early career and the molding of her intellectual outlook, no other contact proved to be of more importance than Cornelius Bernardus van Niel. Often credited as the person responsible for bringing modern microbiology to the United States, Van Niel began teaching at the Hopkins Marine Station in 1930, soon after

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[61] For the origins of the debate over the nature of early 20th century life science, emphasizing the role and significance of morphology alongside experimentalism, see Jane Maienschein, Ronald Rainger, and Keith Benson, "Introduction: Were American Morphologists in Revolt?" *Journal of the History of Biology*, 1981, 14(1):83-87. The essays in this volume of the journal argue that changes in the life science in the early part of the 20th century should be seen as more gradual, that morphological traditions were not necessarily in retreat, and that the naturalist tradition flourished in certain disciplines. At the same time, these historians accept that experimentalism did leave an indelible mark across the life sciences.

completing his graduate education under the great Dutch microbiologists Martinus W. Beijerinck and (as primary advisor) Albert Jan Kluyver. Their researches, and the legacy they imparted to Van Niel, had been aimed at understanding physiological processes fundamental to microbiology. In this promising milieu, Van Niel began his studies of bacterial photosynthesis, an area in which he would eventually elucidate the basic chemical reactions involved. By the 1940s, the summer course he established at Hopkins attracted ambitious graduate students as well as eminent scientists eager to learn from Van Niel at what some called the "Mecca of American microbiology."[62]

Ray enrolled in Van Niel's microbiology course in 1942, and the notes she took in this class remained in her possession throughout life, attesting to the high value she placed on the experience. Although her primary work lay in the study of *Lampanyctus*, her doctoral research must not have provided much inspiration since she did not expand on any facet of ichthyology after leaving Stanford. Investigations performed under Van Niel's tutelage, on the other hand, constituted one of the two areas of research she would engage with in the years to come. After taking his course, Ray continued to work in Van Niel's lab, "familiarizing herself with the methods, organisms, and concepts" of microbiology. This was "time well spent," Van Niel believed, and helped to broaden Ray's capabilities as a scientist.[63] In the course of her microbiological study, Ray

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[62] Allan Campbell, Lawrence Blinks, and Arthur Giese, "Memorial Resolution: Cornelius Bernardus van Niel (1897-1985)." On file at the Miller Library, Hopkins Marine Station, and online at http://www-marine.stanford.edu/HMSweb/Memorial%20Resolutions/index.htm (viewed 20 Nov, 2004)

[63] C. B. van Niel's letter of support. **Guggenheim.**

isolated a previously unknown form of free-living soil ameba. The promise of this research led to the successful award of a Guggenheim fellowship in 1952. Yet, the introduction to Van Niel and the group of aspiring microbiologists surrounding him did more than just expand and sharpen her scientific tools. Ray also absorbed from Van Niel a view of life that aided her entry into the fraternity of academic scientists, later encouraged her leadership in the public understanding of science, and conditioned her reaction against much of the popular environmental movement emerging in the mid 1960s.

Professor Van Niel's philosophical outlook was, not surprisingly, grounded in his science and conveyed through his courses. As one former student put it, "His lectures often lasted for several hours and were presented with such clarity and histrionic skill as to capture the complete attention and stimulate the enthusiasm of his students. The lectures sounded as though he delivered universal truth...."[64] In his summer microbiology course, the teaching and laboratory aspects seemed to flow naturally together, with experiments raising questions that, through Van Niel's review of historical developments, would lead seamlessly into another set of experiments answering the first experiment while also raising new problems. His pedagogical style, imparting knowledge of fundamental ideas, crucial practices, a sense of historical progress, and the provisional nature of current knowledge, left his students with a firm belief in the powers

[64] Kim-Thom Chung, "Cornelius B. van Niel: Educator, Pioneer of General Microbiology" http://www.mhhe.com/biosci/cellmicro/nester/graphics/nester3ehp/common/vanniel.html (viewed 29 Nov, 2004)

of science. And as his colleagues noted, Van Niel's faith in science encompassed the whole of life.

Having discovered as a child the ability of experiments and direct, rational experience to test traditional ideas, Van Niel advocated "science as a way of life."[65] His views of science and its promise as a guiding philosophy of life were not uncommon, but he excelled in effectively conveying these sentiments to students.[66] For Van Niel, science consisted of observations and interpretations of those observations. Over time, with the build-up of trustworthy observations, earlier interpretations would get "refined" and "amplified." These methods, Van Niel continually stressed to his students, could be used throughout one's life. Science, he believed, could be "a way of living – not by force but by reason." It was true, he conceded, that scientists also argued with great emotion, but this was done "not as scientists, but as human beings with insufficient control over their emotions." Finally, if one seriously adopted his science-as-life philosophy, Van Niel urged that the "experimental attitude" provided the best means of settling human difference through a "willingness to abandon ideas if shown to be untenable."[67]

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[65] Allan Campbell, et al, "Memorial Resolution," 3. These colleagues went on to write that "As a teacher, Van Niel conveyed his strong philosophical commitment to the scientific method, applying it not just to his own discipline but to all aspects of human knowledge."

[66] Kim-Thom Chung also wrote, "Van Niel gave you the impression that you were participating in the most significant part of scientific progress. Every one of his students were so highly inspired and excited that they were willing to devote their whole career to the endeavor of microbiological research. This kind of inspiration and his personal charisma is beyond imagination." For citation see note 59.

[67] C. B. van Niel, lecture notes from 1947 (underlined words from original). C. B. van Niel Papers, Box 2, Folder 7, SC 325, Special Collections, Stanford University Libraries. Van Niel made one other point in these lectures that deserves attention for what it conveys about his belief

The power of this seemingly complete philosophical outlook must have struck Ray as convincing. Here was an internationally successful scientist, performing important and penetrating research, urging a supremely rational, unemotional, and continuously flexible outlook on the world. With so much success ascribed to science at the time, and with the world embroiled in wars against the irrational intolerance of fascism, ample justification existed to believe that science promised the best alternative for a livable future.

Dixy Lee Ray never claimed to have been born with a natural scientific bent. At one point she considered being a puppeteer, her early interests seemed to be in the literary arts, and her family history did not lead her toward the sciences. Above all, as a woman Ray had little reason to envision a future in the sciences. Beyond the Nobel Prize winning chemists Marie Curie and her daughter, few women scientists were known or could have acted as role models to a middle class girl growing up in 1920s Puget Sound. Rather, mentors such as Pringle and Boone, Bolin and Van Niel, and others provided the immediate models upon which Ray constructed her own scientific identity. Ray's

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in the moral qualities of science and what he believed to be a basic human need to do science: "Limitations of science: This leads to important question: good for what? Just material benefits? Some have reasoned that these have gone so far that one ought to stop and catch up morally. As ineffective as telling someone who wants to catch a train that he ought to stop running because there are other trains coming later. In other words: the scientist does sci[ence] because he wants to. And the answer is NOT to stop doing sci[ence]." Since these notes date from after WWII, he likely thought in terms of the connections between science and the atomic bomb, but the sentiment is also important for understanding Ray's firm belief in science, especially as the cultural revolutions of the late 1960s began to question sciences' purported neutrality and its social utility.

formation as a scientist came about through a gradual adoption of learned habits and practices as she was drawn into an existing discipline. The social theorist Andrew Abbott has described the professional disciplines in terms of a competitive "ecology,"[68] emphasizing how the important mental constructs, research methodologies, and cultural norms of a discipline vary over time and in relation to neighboring disciplines. And, as the discipline is continuously being refashioned, so too is the construction of the individual scientist: each is forever creating and refashioning the other. For this study of a marine biologist then, it is useful to think of the construction of Ray's scientific persona within a dynamic professional system. Her formation as a scientist came about as much through the study of gribbles and lantern fish as it did through the writing, rewriting, and socializing she did with mentors and colleagues.

This chapter has aimed to inform us about a person – Dixy Lee Ray – and the efforts that went into constructing a scientific persona appropriate to her field of marine biology and to her time.[69] Here I argue that to understand the twentieth century marine

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[68] Andrew Abbott, *The System of Professions: An Essay on the Division of Expert Labor* (Chicago, IL: University of Chicago Press, 1988), 33. This is one of Abbott's early works on the sociology of professionalization and disciplines, arguing that professions and disciplines are defined by the work individuals do and by the networks of people and institutions in which they exist. His conceptualization of professions attempts to reflect their continually changing nature, with the professions forever being (re)created by the changing ecology of the system.

[69] This draws on recent work that attempts to explore the varied constructions of the "scientific personae" through time, across disciplines, and in different national contexts. See Lorraine Daston's and H. Otto Sibum's overview, "Introduction: Scientific Personae and Their Histories," *Science In Context*, 2003, 16(1,2):1-8. Three essays in this journal volume were particularly instructive for my own thinking about the construction of the scientist: Paula Findlen, "Becoming a Scientist: Gender and Knowledge in Eighteenth Century Italy," 59-87; Anne Secord, "'Be What You Would Seem to Be:' Samuel Smiles, Thomas Edward, and the Making of a Working-Class Scientific Hero," 147-173; and Cathryn Carson, "Objectivity and the Scientist: Heisenberg Rethinks," 243-269.

biologist it is imperative to see how the enforcement of objectivity, the practice of research (and its interpretation), and the adoption of philosophical outlook were constructed through the scientist's formative years. In turn, Ray's gradual formation of an identity as a marine biologist led to a redefinition of the discipline, as we will see in the following chapter.

Chapter 3

Marine Biologist to Biological Oceanographer: Defining a Discipline

> Various organizations – foundations, government agencies, research institutes, universities – from time to time face the question: Should we or should we not undertake a new or much larger and more intensified program of activity 'X.' Now X may stand for ... a 'crash attack on cancer' or 'an adequate program in oceanography,' or 'the building of a larger radio telescope' or ....
>
> A common procedure is to set up a Special Committee of experts on X in order to find out whether X is a good idea. The committee... is formed of external experts of recognized standing (external as regards the agency in question but most emphatically internal as regards X), and always contains a comforting proportion of what might be called right names. These are men intensively interested in X, and sometimes with a recognizably fanatic concentration of interest on X. Quite clearly, they are just the lads to ask if you want to know whether X is a good idea.[1]

Warren Weaver wrote this satiric jab at the administration of American science at the very time oceanographers initiated a high-profile effort to define their discipline and to expand their share of the American science budget significantly. In terms of defining and promoting a scientific discipline, Weaver knew the rules of the game better than most. Over the preceding half century he spearheaded the 'molecularization' of biology, blending disciplinary and methodological approaches that helped to change the concept and practice of biological science in the twentieth century.[2] This chapter explores a

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[1] Warren Weaver, "Report of the Special Committee," *Science*, 20 Nov 1959, 130(3386):1390-1391.

[2] The Rockefeller Foundation's role, and Weaver's, in the creation of molecular biology is well documented. See, for example, Robert E. Kohler, *Partners in Science: Foundations and Natural*

similar development in the marine sciences, albeit with less dramatic results, as marine biology became increasingly tied to an interdisciplinary oceanography in the middle decades of the century through the kind of maneuvering Weaver pokes fun at in this passage.

In chapter one I sketched out social and institutional backgrounds important in framing the context of a young woman's entry into science. In chapter two I argued that in the construction of a professional zoologist, especially a female field-oriented marine biologist, formal training reinforced particular modes of thought and conduct – stressing rationality, detached objectivity, and 'science as a way of living.' In this chapter I primarily address disciplinary changes in marine biology and (biological) oceanography that took place in the 1950s and 1960s. I argue that two issues were at the heart of this change: a broadened redefinition of biological oceanography to include all biological study taking place in a marine environment and, associated with that, a revival of descriptive science. These changes occurred in dual contexts which prized the accumulation of factual knowledge: that of the increasingly popular and acceptable discipline of ecology (what Charles Elton had termed "scientific natural history"[3]), and that of space-age exploration.

Scientists, 1900-1945 (Chicago, IL: The University of Chicago Press, 1991); Lily E. Kay, *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology* (Oxford, England: Oxford University Press, 1993); Pnina Abir-Am, "The Discourse of Physical Power and Biological Knowledge in the 1930s: A Reappraisal of the Rockefeller Foundation's 'Policy' in Molecular Biology," *Social Studies of Science*, 1982, 12:341-382.

[3] Charles Elton, *Animal Ecology* (London: Sidgwick & Jackson Ltd, 1957, first published in 1927), 1.

These changes within marine biology and oceanography can be tracked through a small number of events that took place in the late 1950s and early 1960s in National Academy of Science panels, at the National Science Foundation, and through various gatherings of eminent marine-oriented scientists. This chapter will begin by addressing Dixy Lee Ray's academic career in the zoology department at the University of Washington, detailing the kind of research she pursued which gave her entry into a circle of increasingly prominent scientists. Her research did not lead to a major intellectual discovery, but displayed methodological and technical proficiency that provided professional legitimacy as she moved her career into areas of science administration. The latter half of the chapter – focusing on disciplinary changes – remains focused on Ray but also includes a larger network of individuals who worked strenuously to promote their visions of what the marine sciences should be at a time of rapid changes in the institutional framework and political power structure of science in America.

Historians' treatments of the marine sciences reflect a long-standing practical and conceptual division between oceanography and marine biology. In this bifurcation oceanography is understood to involve exploration of the deep sea and to be tightly enmeshed with economic and geo-political concerns. Marine biology, on the other hand, took place at seaside research stations, was more closely associated with academic natural history, and encompassed the didactic and recreational practices of the gentry. Since it is more often seen as a distinct discipline, oceanography has received greater explicit attention than marine biology and is shown to have emerged in the latter half of the nineteenth century, typically with the science-oriented *Challenger Expedition* of 1872

to 1876, an expedition funded by the British government.[4] More recent histories of oceanography have tried to contextualize the science within larger social, technological, and political developments, as in Helen Rozwadowski's intertwining of popular nineteenth century literature, the laying of inter-continental telegraph, and the gradual entry of middle-class scientists into maritime culture, into an illuminating picture of the emergence of oceanography in the Anglo-American world.[5]

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[4] For general histories of oceanography see Margaret Deacon, *Scientists and the Sea, 1650-1900: A Study of Marine Science* (London, England: Academic Press, 1989); Margaret Deacon, Tony Rice, and Colin Summerhayes, eds. *Understanding the Oceans: A Century of Ocean Exploration* (University College London: 2001); J. R. Dean, *Down to the Sea: A Century of Oceanography* (Glasgow: 1966); C. P. Idyll, ed. *Exploring the Ocean World: A history of Oceanography* (NY: 1972, revised); Susan Schlee, *The Edge of an Unfamiliar World: A History of Oceanography* (Dutton, NY: 1973); M. Sears and D. Merriman, eds. *Oceanography: The Past* (Springer-Verlag: 1980). Marine biology is generally treated in some larger disciplinary, social, or other context, such as in David Allen's study of natural history's social setting in Britain, *The Naturalist in Britain: A Social History* (London, England: Allen Lane, 1976), 122-140 & 207-214; Philip J. Pauly, *Biologists and the Promise of American Life: From Meriwether Lewis to Alfred Kinsey* (Princeton, NJ: Princeton University Press, 2000), 145-164 & 201-213; Toby Appel, *Shaping Biology* (Baltimore, MD: Johns Hopkins University Press, 2000), 185-195; Keith Benson, "History of American marine biology and marine biology institutions," *American Zoologist,* 1988, 28:1-34. And useful for placing the marine locale in cultural perspective, Alain Corbin (translated by Jocelyn Phelps), *The Lure of the Sea: The Discovery of the Seaside in the Western World, 1750-1840* (Berkeley, CA: University of California Press, 1994).

[5] Helen M. Rozwadowski, *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea* (Cambridge, MA: Harvard University Press, 2005). Similarly, Jacob Hamblin has written a history of mid-century oceanography in which he explores the somewhat schizophrenic political contexts of the discipline, in which the rhetoric of internationalism belied the deeply embedded national priorities of oceanographic work through the period of the Cold War. Jacob Darwin Hamblin, *Oceanography and the Cold War: Disciples of Marine Science* (Seattle, WA: University of Washington Press, 2005). For other recent studies of oceanography see also Jacob Darwin Hamblin, "The Navy's 'Sophisticated' Pursuit of Science: Undersea Warfare, the Limits of Internationalism, and the Utility of Basic Research, 1945-1956" *Isis*, 2002, 93:1-27; Gary Weir, *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment* (Texas A&M University Press, 2001); Helen M. Rozwadowski and David K. van Keuren, eds., *The Machine in Neptune's Garden: Historical Perspectives on Technology and the Marine Environment* (Sagamore Beach, MA: Science History Publications, 2004).

The overall separation of marine biology from oceanography can be justified up until the middle of the twentieth century. However, as Toby Appel has argued in her studies of the impact on biological disciplines due to National Science Foundation patronage, important changes began to occur throughout the biological sciences as this agency exerted its influence on the course of American science. In part, Appel traces the course of American marine biology and biological oceanography through a period she characterizes as that of "big biology." To the extent that this chapter and Appel's treatment of biological oceanography are correct, they suggest that marine biology and biological oceanography came to be roughly synonymous for purposes of attracting some of the generous funds being made available to oceanographers.[6] Eric Mills, the historian of oceanography, argues that biological oceanography became a distinct field of study in the late 19th and early 20th centuries "separate from marine biology and general ecology." This chapter shows that Dixy Lee Ray and others attempted a convergence of disciplines in order to define the field for optimum advantage.[7]

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[6] Toby Appel, *Shaping Biology*, 187-190; and with more detail (in relation to the marine sciences) in "Marine Biology/Biological Oceanography and the Federal Patron: The NSF Initiative in Biological Oceanography in the 1960s," *Oceanographic History: The Pacific and Beyond*, edited by Keith Benson & Philip Rehbock (Seattle, WA: University of Washington Press, 2002), 332-342.

[7] Eric Mills, *Biological Oceanography: An Early History, 1870-1960* (Ithaca NY: Cornell University Press), 3.

Research, Teaching, & Program Building

For Americans the spring of 1945 signaled the beginning of the end of World War Two. The surrender of Nazi Germany in May meant that the United States could concentrate its forces on the Pacific theatre, with the expectation that the Soviet Union would join the battle against Japan from the east. For a young marine biologist who had largely completed her graduate work, the end of the war presented the prospect of soldiers resuming their civilian lives, of undergraduates and graduates returning to universities, and improving teaching opportunities for a well-qualified scientist. Ray recalled that in the spring and summer of 1945 she spent "some time every day...in the living quarters" of Ed Ricketts's house, where she finished drafts of her thesis while being encouraged to sample drafts of warm beer. While Ray completed her thesis in time to enter the autumn job market, Ricketts was less than successful in educating her palate; she continued to prefer cold beer![8]

In Seattle, the end of the war ushered in significant transformations at the University of Washington. Not least of these changes came in the expansion of marine oriented research and training. Beginning in the 1930s and through World War II the University of Washington had been the lone American university offering a dedicated program in oceanography. In addition, the importance of fisheries in the region justified

[8] DLR to Joel Hedgpeth, 25 March, 1971. Box 48, Folder 1970-72 (correspondence), **DLR**. Lynn and Gray Poole's biographical sketch claims that Ray had difficulty submitting her final documents on the last day of the summer term because it turned out to be the day of Japan's surrender, ending World War Two on 14 August. See *Scientists Who Work Outdoors* (New York, NY: Dodd, Mead & Company, 1963), 19-20. Ricketts's fondness for beer, of all kinds, was made famous in the character of Doc, in *Cannery Row*, most memorably in Steinbeck's embellishment of a "beer-milkshake" invention.

a strong program in various aspects of aquaculture. In the early stages of World War II members of the fisheries program accepted Manhattan Project contracts to study the effects of radiation on fish. This research, necessitated by the establishment of plutonium production plants at Hanford, created a long-term program in radiation biology that oriented much of the fisheries and oceanographic work at the university. During the early Cold War period the growing concentration of expertise in oceanography, in studies of aquatic radiation biology, and in supporting disciplines, placed the University of Washington in a prime position to capitalize on expanding research opportunities in post-war America funded by such federal patrons as the Atomic Energy Commission, the Office of Naval Research, and the National Science Foundation.[9]

Though it couldn't be known at the time, it was an auspicious moment for a young scientist to be entering the work force. With the University of Washington's department of Animal Biology searching for an invertebrate zoologist, Ray jumped at the possibility of returning to the Puget Sound. Though not strictly an invertebrate zoologist, her broad education at Mills and Stanford qualified her to teach a host of general zoology

[9] For information on oceanography, fisheries, and radiation studies see Neal Hines, *Proving Ground: An Account of the Radiobiological Studies in the Pacific, 1946-1961* (Seattle, WA: University of Washington Press, 1962); Matthew W. Klingle, "Plying Atomic Waters: Lauren Donaldson and the 'Fern Lake Concept' of Fisheries Management" *Journal of the History of Biology*, Vol. 31, 1998, pp.1-32; D. Erik Ellis, *The Hanford Laboratories and the Growth of Environmental Research in the Pacific Northwest* (MA, Oregon State University, 2003), 51-72; and Vern O. Knudsen, et al, "Education and Training for Oceanographers" *Science*, 23 June, 1950, 111(2895):700-703.

courses.[10] Ray's extensive work in Cornelius B. van Niel's laboratory, his appreciation for her skill as a scientist, and his connections to persons on the hiring committee proved to be equally important. Art Martin, a young physiologist who had spent time working for Van Niel at the Hopkins Marine Station, recalled that "Van Niel wrote a very strong letter in her behalf, which led to her appointment."[11]

Ray entered the department as the first of a new generation. Professor Trevor Kincaid, and a handful of others, had built up a respectable but undistinguished zoology program prior to the war, primarily aimed at undergraduate training. Measured by graduate student success, the department had little to boast of outside Martin Johnson, who had become relatively well-known in oceanographic circles through co-authorship of the influential text, *The Oceans*, first published in 1942 with his Scripps colleagues Harald U. Sverdrup and Richard Fleming.[12] However, by the middle of the 1940s, a younger generation of biologists felt the need to reinvigorate and update teaching and research in the life sciences. Suggesting that they fought a progressive battle against the forces of scientific conservatism and stasis, this nucleus of energetic young biologists began referring to themselves as the "young turks." Led by the physiologist Art Martin,

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[10] The importance of an invertebrate zoology course for both teaching and research in the life sciences is stressed in W. D. Russell-Hunter's "An Evolutionary Century at Woods Hole: Instruction in Invertebrate Zoology" *Biological Bulletin*, 1985, 168(Supplement):88-98.

[11] Arthur W. Martin, *Autobiography of Arthur W. Martin, Jr.* (unpublished manuscript, 1995-1998), 79-85. Copy held in the Special Collections, University of Washington library.

[12] H. U. Sverdrup, Martin W. Johnson, & Richard H. Fleming, *The Oceans: Their Physics, Chemistry, and General Biology* (New York, NY: Prentice-Hall, 1942). This first general oceanographic text-book quickly became the defining text for oceanography, with Johnson taking primary responsibility for the biological aspects of the textbook.

the most senior of the group and chair of the department from the late 1940s through early 1960s, the botanist Daniel "Bud" Stuntz, and Dixy Lee Ray, this self-styled revolutionary band soon came to include Bob Fernald, an invertebrate zoologist from the UC Berkeley program,[13] the Princeton-trained developmental physiologist Arthur Whiteley[14], and W. T. Edmondson[15] a limnologist from G. Evelyn Hutchinson's program at Yale. Together this group of young biologists set about to reorganize the coursework and, more importantly, to bring in more research money and graduate students.[16]

Coming to the University of Washington in the fall of 1945 as an Instructor in Animal Biology, Ray taught the standard introductory biology course and, at least by 1947, invertebrate zoology and a course in comparative physiology.[17] She received a promotion to Assistant Professor, along with Fernald and Whitely, as the department

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[13] Under the direction of Sol F. Light and Charles A. Kofoid, the U.C. Berkeley Zoology program earned a reputation for producing some of the best invertebrate zoologists through the mid 20th century. Fernald graduated from Berkeley 1941, came to the University of Washington in 1947, and became the director of the Friday Harbor Laboratories in 1956.

[14] Whiteley began his career in Seattle in 1947, utilizing the abundant local fauna to establish a well respected research program in the physiology of marine invertebrate fertilization and development.

[15] Edmondson was less directly involved in research at Friday Harbor. Working in the fresh-water environments, notably that of Lake Washington, Edmondson became one of the leaders in understanding processes of eutrophication and was instrumental in spurring efforts to control pollution in urban lakes, notably the lakes around Seattle, through the 1960s.

[16] For "young turks" see Guzzo, *Is It True*, 51-55. Martin's autobiography makes similar claims about the revolutionary changes orchestrated by him and others in the years after WWII, *Autobiography*, 79-85.

[17] Course catalogues at the University of Washington did not list the courses taught by Ray until the 1947 catalogue.

reorganized in 1948, most likely as one of Martin's first actions as department chair.[18] At this time, and as a sign of the department's desire to rebuild the curriculum, the faculty began offering an additional course in the general biology sequence, specifically for advanced training of biology majors. Ray taught this, along with the comparative physiology course, which had also been expanded to include a segment specifically oriented to the comparative physiology of invertebrates.

In the early 1950s Ray began offering what became her signature course, entitled "Natural History of Marine Invertebrates." First appearing in the catalogue in 1950, this invertebrate course clearly built on Ray's love of field work, and billed itself as "a field and laboratory course emphasizing the habits, habitats, identification, and inter-relationships of marine animals." Taking cues from Ricketts's *Between Pacific Tides*, Ray introduced students to the kinds of organisms adapted to three broad categories of intertidal environment, such as the sheltered bays of Puget Sound, the rocky exposed beaches of the outer coast, and the broad and relatively sheltered bodies of water found at places like Willapa Bay. Over the years this course became well-known for the rigorous day and weekend field trips to such remote places as Lapush in the far northwest corner of the state. Those hardy enough to follow Ray on these trips were rewarded with exquisite field collecting experiences. The collecting, however, seldom took place simply for scientific identification. Since Ray was something of a gastronome, one former assistant also recalled learning "how valuable it is to eat well" while doing field-

[18] Guzzo, *Is It True*, 53.

work![19] Thus, at the end of a rigorous day of exploring the inter-tidal, Ray's students would commonly dine on fresh-caught salmon, crabs, or other readily available delicacies.

Ray's development of a course involving significant fieldwork is not surprising. For her Master's thesis research she had collected specimens throughout the Puget Sound and in several locations near Oakland. Though her doctoral research required only lab-work, the general course requirements regularly took Ray into the field while at the Hopkins Marine Station. In general, marine stations had been established in locations where collecting a wide variety of organisms could be easily done. Ray's attraction to the University of Washington, while being close to her childhood home, also hinged on the zoology program's connections to the Friday Harbor Laboratory. For a field-oriented marine biologist, this marine station provided a rare array of accessible aquatic environments. Building on the tradition of summertime research that had attracted the likes of Victor Shelford in the 1920s, Ray and her ambitious young colleagues began to recruit national and international colleagues to participate in stimulating teaching and research projects.

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[19] For the content of Ray's course, "Lecture and Laboratory Schedule," Box 41, Folder "UW Dept of Zool #2," **DLR**. In the mid 1960s Paul Dayton, a graduate student in the department, assisted in this course a number of times. His recollections were provided in a personal letter of 25 Nov, 2003. Ray's love of food was apparent throughout her life. For example, she launched her master's thesis with the following humorous touch, hinting at some deep connection between good food and good science: "The old adage that a man's intellectual efforts are conditioned by his culinary interests finds little exception in the history of natural science.... No doubt the crabs and lobsters abounding in the Aegean sea provided food for Aristotle's table as well as subject matter for his excellent and careful observations."

Paul Illg, working as a young invertebrate zoologist at the Smithsonian in the late 1940s, spent his first summer at Friday Harbor in 1950. In glowing letters back to his supervisors, he provided the kind of word-of-mouth reputation that would establish the station as one of the premier sites for marine research through the middle decades of the century. "I have been offered fine facilities," Illg gushed, and "average two boat excursions weekly and many auto trips to local shore collecting spots. One of these is the most spectacularly beautiful marine assemblages I've ever seen." Then in words that would have started an animated (but friendly) argument among his fellow marine biologists, he continued: "I hate to have to shove Carmel's Pescadero Point down to second place. I hope you won't let the word get out to other Californians."

At Friday Harbor Illg found the magnificent natural environment complemented by an energizing professional culture. "The group here is very congenial and of a fine size. There are no big names on the visiting list but the small fry present make up by their industry. Much midnight oil burns – but not ours. It takes a good eight or 9 hours sleep to keep going in this stimulating environment." Then, in a comment not unexpected from a museum-based zoologist, and the kind of remark frequently made by visitors to the best marine stations, Illg wrote that he had "been out at least twice weekly on dredging trips and have been subjected to some mighty high-powered scenery in the course of them. The hauls have been rich + very interesting. We've had wonderful shore collecting, too, so I really feel like I'm getting in touch with the Animal Kingdom instead

of mixed pickles for a change...."[20] Illg impressed the locals too.[21] By 1952 he joined the zoology department's now slightly older "young turks," sharing teaching duties in invertebrate zoology with Ray, as well as her natural history field course through the decade.

With all the work required to rebuild the department's courses, and with the organizational demands that came along with offering summer marine biology programs at Friday Harbor, Ray published none of her own work prior to 1950. According to Herschel Roman, a friend and colleague in the Botany department, from her arrival in 1945 Ray "set for herself the task of improving the teaching program of the department." This explained the "dearth of published material" and, writing in 1951, he believed that "only in the past year has she had sufficient time to give to research."[22] These were kind words from a friend, accurate enough but avoiding the fact that, up until then, Ray proved more adept at teaching and administrating than at developing a productive research program. Over the ensuing decade this preference would become ever more apparent.

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[20] Letters from Paul Illg to Fenner Chace, dated 11 & 20 July 1950. Box 24, Folder "Paul L. Illg, 1946-1950", Collection 307: Division of Crustacea, 1908-1979, Smithsonian Institution Archives. Records from the Smithsonian Institution Archives will hereafter be cited as "**Smithsonian**."

[21] Illg earned his doctorate at the George Washington University (while utilizing the Smithsonian's vast specimen collections) in 1949, where he specialized in crustacean systematics. However, his most important advisor was Sol F. Light at Berkeley, where he did his initial graduate training.

[22] Herschel Roman, letter of support in Ray's Guggenheim Fellowship application. **Guggenheim**

However, by 1952 Ray's research prospects definitely looked promising. The department's newsletter proudly proclaimed "the headline news" of Dr. Ray's appointment to a prestigious Guggenheim fellowship.[23] Ray, along with the Botany Department's professor of genetics, Herschel Roman, could take great pride in being the university's first Guggenheim fellows from their respective departments. Guggenheim Fellowships had been established in 1925 to provide a year of funding for exceptional scholars to focus complete attention on their research. And while a large number of women had been awarded fellowships in the twenty-seven years of the Guggenheim's existence, only about six other women working in biology (and ecology) had received this prestigious honor.[24]

For her application Ray had solicited letters of recommendation from an impressive list of colleagues. Her doctoral advisor, Rolph Bolin, recommended her without reservation, claiming that her dissertation was "without any doubt, the finest piece of work which was ever been done by any of my students." He went on to say that Ray had proved to be one of those increasingly rare scientists who cultivated breadth of interest in such diverse areas as morphology and physiology, systematics and biochemistry, while working with both vertebrates and invertebrates. Art Martin, Ray's

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[23] Department of Zoology Newsletter, No. 8 (9 June 1952). W. T. Edmondson papers, Box 20, Folder 34. University of Washington Manuscripts & Special Collections, University Archives. Hereafter cited as **Edmondson**.

[24] Figures compiled from *The John Simon Guggenheim Memorial Foundation, 1925-2000: A Seventy-Fifth Anniversary Record*, edited by G. Thomas Tanselle, Peter F. Kardon, & Eunice R. Schwager (New York, NY: John Simon Guggenheim Memorial Foundation, 2001). 124 awards were made in this category through the year 1952. If other categories within the Natural Sciences were counted (such as "Botany" or "Science Writing") more women recipients would no doubt be found.

department chair, noted that "Dr. Ray is a woman whose personality makes a considerable impact upon her associates." Having opened his letter with this quite ambiguous statement, Martin went on to assure adjudicators that Ray possessed "a genuine gift" in the area of research she had proposed. But of equal importance, the expertise of the proposed collaborators would enable Ray to tackle fully the range of issues attached to her project. Therefore, Martin wrote, a year spent working with these other scientists, having access to cutting-edge instruments and learning new techniques would be ideal for Ray's research project. Roger Stanier, a renowned microbiologist at the University of California Berkeley, added that while he had only a superficial knowledge of Ray's most recent work, the general topic represented an "important biological problem which deserves a close analysis." Dr. Albert Tyler, one of the biologists with whom Ray proposed to work at the California Institute of Technology, wrote a strong letter of support in which he assured reviewers that "she would be welcome in this laboratory" and he and his colleagues would provide whatever help they could.[25]

Where Stanier's letter conveyed a tone of modest endorsement, C. B. van Niel's letter exuded unconditional support. He wrote,

> she has, to a rare degree, that 'insatiable curiosity' which is the foundation of all scientific work. Coupled with this are an indefatigable energy, a keen power of observation and deduction, and a firm grasp of nearly all phases of biology. This includes not only a profound knowledge of the natural history of plants, animals, and

[25] Letters of support in Dixy Lee Ray's Guggenheim Fellowship application. **Guggenheim**.

> microbes, but also of the disciplines of morphology, cytology, physiology, and biochemistry.

Yet, recognizing that her academic career had so far lacked the normal signals of academic success, Van Niel turned Ray's limited publication record into a virtue.

> She has worked as hard as any one I know, often under very difficult conditions, and always for the sake of science rather than for her own advancement. Not interested in publishing anything that had not been fully worked out first, she has put her experience entirely at the disposal of others who could use it to advantage. ... [For example] since she carried a very heavy teaching load, and was also largely responsible for the construction of new quarters in the Biology building... as well as for many desirable changes in the arrangement of courses and an integrated curriculum in biology, she was not in a position to pursue the study of [a newly discovered algae] to the point of doing a 'monograph' on them. Hence, rather than publishing some preliminary reports, she immediately turned over all her material and experience with these bacteria" to a graduate student at the Hopkins Marine Station.

Then, after stating that Ray's intended research program impressed him as important and practicable, Van Niel concluded that he would "heartily endorse her application."[26] Coming from a scientist of stellar reputation, this unstinting support of Ray as a scientist and vigorous defense of her professional record clearly made a strong impression.

Up to this point, more than five years into her tenure-track position at the University of Washington, Ray had published only a minor revision of her dissertation.[27] While accepted by the very respectable *Journal of Morphology*, her careful morphological study of a fish nervous system did not represent a line of research she had

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[26] Ibid.

[27] D. L. Ray, "Peripheral Nervous System of *Lampanyctus leucopsarus*," *Journal of Morphology*, 1950, 87:61-178.

sustained since completing her graduate study. Rather, as her application for a Guggenheim fellowship illustrates, through the 1950s Ray became more interested in topics discovered initially in Van Niel's laboratory or on more refined investigations of organisms first studied while at Mills College. So, needing to develop a respectable research program in the early 1950s, Ray resumed research on a species of *Hartmanella* ameba,[28] a species she had discovered while in Van Niel's laboratory. For the Guggenheim fellowship, Ray proposed to study further the feeding processes and also the permeability of the nuclear membrane of these organisms. Ray had just submitted for publication her observations of an unusual feeding method in which motile bacteria became attached to the surface of the ameba and then, over time accumulated (agglutinized) in a clump, before being absorbed as a food vacuole.[29] With these intriguing and previously undocumented observations in hand, Ray proposed that a year's intensive study, first in Albert Tyler's laboratory (who had previously studied agglutination processes) and then in a laboratory with a high quality microscope, would allow her to determine mechanisms of agglutination and changes in the nucleus in various stages of the ameba's life cycle.[30]

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[28] This spelling, rather than the alternative spelling (amoeba), is taken from Ray's publications and will be used throughout.

[29] D. L. Ray, "Agglutination of Bacteria: A Feeding Method in the Soil Ameba Hartmanella sp." *Journal of Experimental Biology*, 1951, 118:443-466.

[30] In the Guggenheim Fellowship application, Ray expected to visit cytologists at Columbia University. However, for unexplained reasons she ended up spending the latter part of her research year with Dr. Kenneth Raper at the University of Wisconsin.

Leaving Seattle in the autumn of 1952, Ray traveled down the coast to Pasadena for the first stop of her fellowship year. The California Institute of Technology had established itself as one of the pre-eminent centers for molecular biology, with Linus Pauling among its stars, and stunning advances were being made in understanding the structures, biochemical properties, and physiological processes of many small and complex molecules. At the time Ray arrived at Cal Tech, Pauling and others were in the midst of their well documented quest for the structure of DNA. Ray's project couldn't compete with the study of DNA for prestige and attention, yet stepping into this dynamic environment, to examine the properties of her ameba, provided a first-hand glimpse into what many thought of as the premier field within biology. In a letter to her contact at the Guggenheim Foundation, Ray wrote of her "pleasant and scientifically worthwhile" stay, and that "the association with Dr. Tyler, Dr. Owen, and Dr. Pauling was particularly valuable."[31]

From Pasadena, Ray visited the laboratory of Kenneth Raper, a leading bacteriologist at the University of Wisconsin, where she continued her study of bacterial agglutination. Completing her fellowship year during the early summer of 1953, Ray traveled to France, Belgium, and England, consulting with experts, obtaining specimens of similar cultures of ameba, and defining the taxonomic identity of *H. astronyxis*. Within a year Ray compiled her *Hartmanella* research results and published a systematic

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[31] Letter from Ray to Henry Allen Moe, 25 Feb 1953. **Guggenheim**. Ray Owen, working primarily in genetics in the early 1950s, subsequently became interested in immunology through the 1960s and made his greatest impact in research on mechanisms of the immune response initiated by tissue transplantation.

report, once again in the *Journal of Morphology*. While not quite addressing the kind of "fundamental biological problems"[32] usually associated with biology in the 1950s, Ray turned out a solid, factual, and technically competent publication, the sort of work that had earned her praise as a graduate student. Demonstrating that she had discovered a new species of *Hartmanella* ameba, a species she named *astronyxis* for its typical star-shaped form in the cyst stage of its life-cycle, Ray reiterated the unusual feeding methods of this ameba and then gave detailed description of the various stages of the life-cycle.[33]

As many historians of biology have discussed, purely descriptive work in the life sciences was often disparaged in the twentieth century. Building a truly scientific biological science, it seemed, demanded greater reliance on experimentation, testable theory formulation, and model building. The stunning successes of genetics, and later of molecular biology, convinced many of the efficacy of the modern techniques and perspectives. This, in turn, seemed to justify the marginalization of "purely descriptive" approaches. Yet the very successes represented by molecular biology roused a backlash – conveniently encapsulated in the term "molecular wars" – by more traditional biologists concerned over declining knowledge of the organism, its behavior and environment.

Ecology, for example, had long been promoted as a field-based form of physiology in the belief that extensive measurements would produce solid knowledge of

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[32] This is the phrase used by Ray, and by some of her referees, to describe the proposed research project. See "Project Proposal." **Guggenheim.**

[33] D. L. Ray and Robert E. Hays, "Hartmannella astronyxis: a new species of free-living ameba" *Journal of Morphology*, 1954, 95:159-188. The co-author, Robert Hays, assisted Ray on this research while a graduate student in the zoology department.

the basic functions underlying the regular (and irregular) fluctuations of plant and animal communities.[34] As such, the basis of the discipline relied on massive accumulation of information, whether to construct or test hypotheses. By relating ecology to physiology, or through the theoretical mode of 'systems ecology,' ecologists from Victor Shelford to Eugene Odum recognized the importance of minimizing the assumption that ecology simply involved data gathering. Yet, the undeniable successes in molecular biology by scientists who often knew little or nothing about the organism whose molecular processes they studied, convinced many that the life sciences would be impoverished without an expanding understanding of the whole organism and its environment. In this sense, then, growth in such disciplines as ethology and ecology seemed to answer a need for balance in the life sciences and at the same time preserved disciplinary space for largely descriptive practices.[35] For those such as Ernst Mayr, Niko Tinbergen,[36] or Eugene

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[34] Victor Shelford argued that "Ecology is that branch of physiology which deals with the organism as a whole, with its general life processes as distinguished from the more special physiology of organs." *Animal Communities in Temperate America* (Chicago, IL: University of Chicago Press, 1913), 1. A similar motivation lay behind Elton's remark that ecology should be considered "scientific natural history."

[35] Marine biology, which became particularly ecological in its orientation through the 20th century, went through a period of scrutiny in the 1950s over the extent to which it should attempt to become more experimental. For example, at a conference designed to explore ways of bringing experiment to marine biology, A. C. Redfield, a biologist at Woods Hole, gave a paper in which he criticized Woods Hole colleagues who had since the turn of the century over-emphasized "experiment" in their research programs and thereby lost crucial knowledge of whole organisms, their life-cycles, and their environments. Joel Hedgpeth recorded that this statement was "greeted with applause" and generated a productive debate over the need for more balance (among marine biologists) between "observation and experiment." Howard Odum, on the other hand, claims that Redfield's statement "shocked some of his associates by setting up an antithesis between environmental science and experiment." In Odum's view, an argument then broke out in which "indoor and outdoor science" were pitted against each other and outdoor science amounted to nothing more than "description." A. C. Redfield, "The Inadequacy of Experiment in Marine Biology," *Perspectives in Marine Biology* (Berkeley, CA: University of California Press, 1958),

Odum, basic knowledge of the natural world needed to be an essential, and ongoing, component of biology, at least as long as this knowledge addressed important theoretical (or practical) problems in the natural world.[37]

Ray's study of *H. astronyxis* contributed to the factual store of knowledge about the natural world, yet it did not begin to address any larger, synthetic problem in biology. Considering the larger context of 1950s biology, it may be that Ray's careful descriptive study of a new form of ameba struck her colleagues as typical of an earlier and now anachronistic period in the life sciences. Lynn Nyhart's analysis of the German zoological professoriate in the last decades of nineteenth century argues that in most cases successful academics practiced "theoretical caution" and prized "technical proficiency." Those men who rose to the top of their profession "conducted research that was morphological,... and they made important technical and empirical contributions...

17-26; Joel Hedgpeth, "Personal Report on the Symposium..." pages 2-3, Box 24, Folder 3: "Post Symposium Notes, 1956-57," Scripps Institution of Oceanography, Subject Files, AC6, Scripps Institution of Oceanography Library Archives. Hereafter cited as "**SIO**." Howard Odum, "A Marine Biology Symposium" *Ecology*, 40(4):745-746.

[36] For an excellent history of ethology, focusing on Konrad Lorenz and Niko Tinbergen, and stressing ethology's orientation to evolutionary questions (especially on the part of Tinbergen), see Richard Burkhardt, *Patterns of Behavior: Konrad Lorenz, Niko Tinbergen and the Founding of Ethology* (Chicago, IL: University of Chicago Press, 2005).

[37] For the argument that 20th century biology was defined by experimentalism, see Garland Allen, *The Life Sciences in the Twentieth Century*. For counter-arguments see Jane Maienschein, Ronald Rainger, and Keith Benson, "Introduction: Were American Morphologists in Revolt?" *Journal of the History of Biology*, 1981, 14(1):83-87; Rainger, Benson, Maienschein, *American Development of Biology;* Keith Benson, "Biology's 'Phoenix': Historical Perspectives on the Importance of the Organism" *The American Zoologist*, 1989, 29:1067-1074. E. O. Wilson, "The Molecular Wars" in *The Naturalist* (Washington DC: Island Press, 1994), Chapter 12.

but their work was intellectually bland with regard to broader questions,"[38] Ray's research program on *Hartmanella* bears striking resemblance to that earlier morphological style of science which had become, by the 1950s, ambiguously valued by fellow biologists.

At the same time Ray worked on *Hartmanella*, she also developed another and quite unconnected area of research. While at Mills College, Ray included one of the more economically damaging marine organisms in her ecological study of inter-tidal burrowing crustaceans. *Limnoria lignorum*, a species commonly referred to as a gribble, abounds in the marine waters surrounding the United States, and though significant study had been done on this genus of borer,[39] Ray found in this organism an interesting and profitable problem to study. As she stated in her first publication on *Limnoria*, an earlier investigator had failed to detect cellulase in the gut of this exclusively wood-boring animal, and by 1950 a well-known British marine biologist wrote conclusively that *Limnoria* burrowed "primarily for protection."[40] Therefore, since *Limnoria* appeared

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[38] Lynn K. Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900* (Chicago, IL: University of Chicago Press, 1995), 322-325. The tension between compiling factual evidence and developing technical competence versus introducing theoretical novelty and conceptual reformulation, has been a constant feature of modern science. However, the progressive ideology of science, and likewise traditional history of science, have tended to obscure and minimize the former.

[39] Jean T. Henderson, "The Gribble: A Study of the Distribution Factors and the Life History of *Limnoria lignorum* at St. Andrews" *Canadian Biological Board Contribution*, 1924, 2:309-325; C. L. Hill & C. A. Kofoid, "Marine Borers and their Relation to Marine Construction on the Pacific Coast" *Report of San Francisco Marine Piling Commission,* 1927; C. M. Yonge, "The Absence of Cellulase in *Limnoria*" *Nature*, 1927, 119:855.

[40] C. M. Yonge, a friend and colleague of Ray's, wrote a number of scientific and popular works mentioning the burrowing habits of *Limnoria*. In *The Sea Shore* he stated that "there is no evidence that wood itself is digested.... They bore primarily for protection." Yonge provides as

incapable of breaking down the wood in which it burrowed, Ray concluded that "the nutrition of this destructive organism has remained a perplexing problem."[41] Throughout the middle of the decade Ray worked on this problem, first showing that the earlier report claiming an absence of cellulase had been in error and then gradually building up evidence that, as had been earlier assumed, "*Limnoria* burrows into submerged marine wooden structures primarily for food."[42]

Ray's research project on *Limnoria* and her efforts to promote the zoology program at the Friday Harbor Laboratories coincided in a conference she organized in September of 1957. This conference, on the biology of marine boring and fouling organisms, was the zoology department's first opportunity to host an international gathering at the Laboratories just as they were trying to prove that zoologists could make better use of the facilities than the University's oceanographers.[43] The direct economic

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evidence the fact that *Limnoria* could occasionally be discovered in the insulation of submarine cables. C. M. Yonge, *The Sea Shore* (London: Collins, 1949), 186. He amended this conclusion in later editions of his books to correspond with Ray's findings.

[41] D. L. Ray & Jean R. Julian, "Occurrence of Cellulase in *Limnoria*" *Nature*, 5 January, 1952, 169:32-33. Jean Julian was another of Ray's graduate students, having just completed an MS.

[42] D. L. Ray, "Digestion of Wood by *Limnoria Lignorum* (Rathke)" *Proceedings XIV International Congress of Zoology* [Copenhagen], 1953, page 279. 18th and 19th century naturalists had assumed, as simple observation would lead one to do, that *Limnoria* actually feeds on the wood in which it is found burrowing.

[43] Friday Harbor Laboratories had been administered by zoologists from 1904 until 1930, at which point Tommy Thompson, director of the new oceanography program, assumed control and remained in that position until 1950. Richard Fleming replaced Thompson as chair of oceanography and director of Friday Harbor in 1951. By 1956, with zoologists feeling that the Friday Harbor Laboratories were not being fully utilized under the oceanographers' direction, Fleming stepped aside and Robert Fernald became a full-time, on-sight director of the Laboratories.

importance of *Limnoria*, one among many boring and fouling marine organisms, made it relatively easy to obtain financial support from the Office of Naval Research and a host of corporations, such as the Shell Oil Company and the Port of Seattle. The conference aimed to bring together specialists from around the world for a general discussion of the biology of important wood boring organisms.

The various participants' firm belief in the complementary nature of pure and applied science structured the relationships between the biological knowledge being shared by academic scientists and the utilitarian desire to control nature by industrialists. Ray expressed the need for better communication between scientists and industrialists in a letter to Ruth Dixon Turner, malacologist at Harvard's Museum of Comparative Zoology and the world's expert on teredinien systematics.[44] This conference, Ray wrote, would allow scientists to deliver their knowledge directly to those who could put it to practical use, thereby providing a scientific basis upon which technical improvements could subsequently be made in marine construction. Many found the prospect of such a conference worthwhile, as did Turner who wrote that "it would be a most stimulating and profitable experience" for the various groups of scientists and industry representatives working on marine boring and fouling organisms to discuss their mutual interests.[45] In addition to organizing the conference, Ray's contribution to the proceedings entailed a

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[44] A bivalve mollusk, the shells of which are used to bore into wood. It is commonly referred to as "ship worm."

[45] Letter from Ray to Ruth Dixon Turner, 25 Feb, 1957. Correspondence Files of Ruth Dixon Turner papers, Museum of Comparative Zoology, Harvard University. Hereafter cited as **Turner**. Uncatalogued as of 2004.

compelling summary of her evidence that *Limnoria* used wood as its primary source of nourishment. Over thirty presentations covered other biological investigations of *Limnoria*, the similarly troublesome "ship worms" (*Teredinidae)*, and Barnacles.

To the 68 participants, the symposium appeared a great success. While not the most glamorous of topics, Ray recognized that this kind of research had become necessary for biologists to convince patrons of the importance of basic research. If *Limnoria* and ship worms proved to be interesting organisms for marine biological study, the mutually beneficial relationship being claimed between basic and applied science could be illustrated as well. As she stated in the Preface to the edited volume of papers, "only through a more thorough knowledge of the basic biology of boring and fouling organisms can we hope for ultimate understanding and control."[46] This message was delivered directly to a number of men from industry and from the military, and at least for one of the biologists it bore immediate fruit.

Ruth Dixon Turner, although a biologist at Harvard, had great difficulty securing research grants to support her work. In finding a patron at this meeting, Turner gushed: "The symposium, Dixie [sic], was a tremendous success and very stimulating. I do want to thank you for giving me an opportunity to participate in it. Certainly, I think a monograph of the Teredinidae will now become a reality directly as a result of those meetings. Without the financial help I was promised there I would never attempt doing

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[46] Dixy Lee Ray, "Preface" *Marine Boring and Fouling Organisms*, edited by Dixy Lee Ray (Seattle, WA: University of Washington Press, 1959), *v*.

much more than the catalogue."[47] Turner had met Sydney Galler, grants officer for the Office of Naval Research. He had been Ray's patron for a number of years and advocated the need to support basic biological research premised on the belief that practical benefits would naturally flow from science to industry, thereby strengthening both. While Turner may have established one of the most important contacts of her scientific career in Galler, she and Ray provided him with much of the best evidence that marine biology was important to the Navy.[48]

The conference provided more than just an opportunity to share scientific knowledge and cement ties with patrons. In a telling recollection of the conference, Art Martin, the department chair, provides not only a colorful account of this important episode but also a flavor of the social world in which Ray flourished, a point which is particularly important for appreciating her uncommonly successful career as a woman scientist. According to Martin, Ray did not have a good working relationship with Richard Fleming, departing director of the Friday Harbor Laboratories and chair of the Department of Oceanography. Not hesitant to make her views known, Ray informed administrators that "if [Fleming] were in attendance she would cancel the Symposium."

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[47] Letter from Ruth Dixon Turner to Ray, 4 Oct 1957. **Turner**.

[48] Galler used Turner and Ray's research prominently in his essay on the importance of marine biology to American national defense in *Ocean Sciences* (Annapolis, MD: United States Naval Institute, 1964) edited by E. John Long. See "Chapter 8: Marine Biology" 107-118, For an in-depth treatment of science patronage from the Navy, see Gary Weir, *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment* (College Station, TX: Texas A&M University Press, 2001).

Not willing to forgo the prestige of hosting this conference, administrators "told Dick [Fleming] to make himself scarce during this one week period."[49]

With Ray firmly in control of the conference, and with nearly $1000 for entertainment supplied by some of the invited businessmen, attendees enjoyed a boisterous good time. From the entertainment fund, Ray ordered the purchase of a considerable amount of liquor, beer, and cigarettes under the radar of University administrators. Martin's reminiscence of the conference, along the lines of James Watson's depiction of a life in science,[50] are worth repeating:

> Dixy was a noted salmon barbecue-ist, and managed that part of the preparation. At the barbecue I sat over a gasoline stove heating the fruit extracts and sugar, and then had the great satisfaction of holding a bottle of Jamaica rum in one hand, a Puerto Rican rum in the other and pouring pair after pair into the huge aluminum pot to heat. The crowd of over 100 men lined up and, not surprisingly, when they had consumed their paper cup fell into line again until the cases of rum were gone and it was time for salmon. It was quite a sight to see two distinguished U.S. Museum men with an arm around the other, singing bawdy songs on the beach. It was a famous party but, in addition, the papers were excellent and resulted in a book under Ray's editorship. The report to the dean was favorable and I expressed our regret that he [Fleming] could not have been there.[51]

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[49] Martin, *Autobiography*, 118.

[50] In *The Double Helix*, Watson dwelt significantly on extra-curricular activities that, while not directly contributing to the discovery of the structure of DNA, filled out the scientist's day and connected the scientist to the larger social world of the 1950s. And, rather than seeing a clear distinction between 'science,' and all other activities in a person's life, historians of science now believe that how science gets done and in what social contexts is of equal importance to the intellectual end-product.

[51] Martin, *Autobiography,* 118-119.

In the end, the conference represented a high-point in Ray's research career. It displayed her research program to a wider audience of like-minded colleagues; it proved her ability to attract considerable financial resources; and it was a time at which she discovered that she had considerable social power and prestige within her academic community. Foreshadowing an increasingly public life in the years to come, as the organizer of a scientific conference she existed comfortably at the center of attention and seemed to revel in the none too delicate social atmosphere common among the military, industrial, and academic persons that often commingled within the marine sciences.

Ray's Friday Harbor symposium helped provide a significant boost to her professional career. The edited volume that came out of the symposium, for which she had secured a contract with the University of Washington Press, added significantly to her publication record. Based on her growing record as a researcher, and on her notable strengths in the class-room, the zoology department voted to promote her to Associate Professor in 1957. Having been advanced to the position of assistant professor in 1948, Ray took nearly a decade to achieve this promotion. While the timing languished far behind that of the limnologist W. T. Edmondson, who went from assistant to full professor in roughly the same ten years, Ray's progress through the professorial ranks matched that of Robert Fernald and only lagged slightly behind Paul Illg. Both Ray and Fernald published relatively little during that decade, while Illg published regularly and

Edmondson pumped out a steady stream of important literature, including a highly regarded revision of a standard limnology textbook.[52]

Taken as a whole, Ray's research program exemplified a kind of matter-of-fact, observation driven, technically proficient yet conservative methodology. Whether conscious or not, she refrained from explicitly linking her research to theory-testing justification, or using her findings to promote a larger conceptual project. In comparison to John Bonner, who placed his examinations of the mechanisms of cell aggregation within a larger evolutionary framework, Ray constrained her inquiry to the description of specific morphological and physiological aspects of the *Hartmanella* ameba. As a result, Bonner's explicit attention to larger evolutionary questions met the perceived standards of the day more so than did Ray's work.[53] Yet, while Ray's research did not address theoretical questions (and did not cohere around one identifiable problem), she did engage in important aspects of the scientific project, as seen in the middle decades of the century. Namely, the description and study of *Hartmanella* contributed to the increasing store-house of factual knowledge seen to be at the base of the scientific enterprise,

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[52] Edmondson edited the revised version of *Fresh-Water Biology*, originally authored by Henry Baldwin Ward and George Chandler Whipple in 1918, with Edmondson's revised edition coming out in 1959. For zoology department publication record see UW Department of Zoology Newsletter, No. 9, May 1956, pages 60-63. Box 20, Folder 34, **Edmondson.**

[53] I use Bonner as an example because he spent a summer at Friday Harbor in the early 1950s and he and Ray discussed aggregation phenomena – yet their research careers differ significantly. He frequently cites Ray's *Hartmanella* papers, as in the following: J. T. Bonner, "Evidence for a Substance Responsible for the Spacing Pattern of Aggregation and Fruiting in the Cellular Slime Molds" *Journal of Embryology and Experimental Morphology*, 1963, 11(3):571-589. Here Bonner describes "the adaptive significance" of the observed spacing, which "produces optimum conditions for effective spore dispersal." Couching observations in this kind of theoretical framework does not occur in Ray's work.

especially in the life sciences; her work on *Limnoria* provided evidence that the scientific project was self correcting; and in both of these researches, Ray illustrated how experimental techniques, judiciously employed, deepened one's knowledge of the natural world.

Margaret Rossiter writes that, soon after being promoted to associate professor, Ray realized certain persons in her department would not support further promotion. In response she began to pursue opportunities outside the department, primarily in leading the Pacific Science Center beginning in 1963. Rossiter includes this as evidence for her argument that women who did obtain academic jobs often encountered strong resistance to advancement and therefore directed their professional energies in areas outside the normal academic track.[54] However, in this particular case, the specific details of Ray's academic record, and that of her immediate colleagues, does not unequivocally support the thesis. Rather, Ray's academic advancement proceeded roughly apace that of the colleagues whose publication records matched her own. In the end, Ray's research program lacked focus on a clearly defined biological problem, and her publishing record

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[54] Rossiter, *Women Scientists, Vol 2*, 253-254. Rossiter writes that Ray "discovered in the late 1950s that despite her Guggenheim Fellowship and other qualifications, her colleagues were not about to promote her any further. Thus, she deliberately pursued outside opportunities, including a three-year stint at the NSF.... Thus, the innovative Pacific Science Center was the right place at the right time: it enabled her to move beyond her blocked position at the university." This argument neglects to mention that from 1959 through 1963 she also served on panels at the NAS, and along with a number of prestigious male scientists she became involved with the United State's science pavilion at the Seattle World's Fair, before agreeing to serve as director of the Pacific Science Center. Thus, the conclusion that her work in these capacities resulted primarily from blocked opportunities within her department appears less convincing. Rather, Ray likely took advantage of interesting and high-status opportunities as she created them and/or as they were offered to her.

likely slowed her advancement. However, she established a respectable professional reputation and, rather than furthering her research program, she ventured into more public and popular arenas. The following section describes how she used her standing within the marine biology community to act as a decisive and effective communicator, administrator, and advocate for marine biology at a time of significant redefinition within oceanography.

What is Marine Biology?

World War II, often described as the physicist's war, marked an important point in the relationship between science and the federal government. Believing that investment in science would pay direct dividends for national defense and the general welfare of society, American political leaders encouraged all levels of federal government to utilize and promote science. With dramatic changes to the system of patronage emerging through the 1950s, particularly the establishment of the National Science Foundation and the Atomic Energy Commission, American scientists had a whole new set of political (and often very public) considerations to contend with. Within this new environment some areas of science, and the most eloquent or persistent scientists, justified their patronage more effectively than others. The marine sciences – generally termed "oceanography" – made a remarkable advance through the decade as the various science disciplines jockeyed for favored consideration under these new patronage conditions of post-war America. Typified by the indefatigable director of Scripps, Roger Revelle, a number of men (and at least one woman) relentlessly made the case to political leaders,

scientific colleagues, and the nation as a whole that the ocean sciences demanded greater support.[55] The remainder of this chapter presents a detailed picture of the way in which the disciplines of marine biology and biological oceanography came to be promoted, funded, and defined in the United States during the post-war era.

In this effort, Dixy Lee Ray played a pivotal role through her advocacy of marine biology at the National Academy of Science and in her work for the National Science Foundation in its attempt to become the primary patron for biological oceanography. Although Ray's scientific research did not make a significant impact on the direction of marine biology as an intellectual endeavor, the same can not be said of her many other activities. Of those persons who promoted oceanography through the 1950s and early 1960s, Ray led a small group of fellow marine biologists to focus particular attention on transforming biological oceanography and marine biology. She did so by creating a broad, inclusive, and singular definition of what often appeared to be distinct disciplines, and thereby ensured the inclusion of basic biological research within oceanography.[56]

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[55] For analysis of the development of the earth science following World War Two, see a special issue of *Social Studies of Science*, 2003, 33(5), that focuses on the influence of Cold War international and military concerns on these disciplines. See especially Ronald E. Doel, "Constituting the Postwar Earth Sciences: The Military's Influence on the Environmental Sciences in the USA after 1945," 635-666; and Naomi Oreskes, "A Context of Motivation: US Navy Oceanographic Research and the Discovery of Sea-Floor Hydrothermal Vents," 697-742. And for a useful analysis of Revelle's leadership, see Ronald Rainger, "Patronage and Science: Roger Revelle, the U.S. Navy, and Oceanography at the Scripps Institution," *Earth Sciences History*, 2000, 19:58-89.

[56] This argument follows that of Toby Appel, whose study of the National Science Foundation's support of biology led her to conclude that "a significant attempt to blur" the terms marine biology and biological oceanography successfully occurred in the late 1950s and early 1960s. "Marine Biology/Biological Oceanography and the Federal Patron: The NSF Initiative in Biological Oceanography in the 1960s," *Oceanographic History: The Pacific and Beyond*, 332.

Further, more than a simple melding of marine biology and biological oceanography, Ray promoted a broadly construed location-based definition of marine biology and biological oceanography that echoed the views expressed by ecologically oriented marine biologists. Because of Ray's adoption of the location-based definition, marine biology and biological oceanography evolved over the ensuing years, I argue, with relatively less emphasis on experimental methodologies prominently advocated at the time.

The years leading up to the main events presented in this chapter provide an important background and suggest that marine biologists felt keenly aware of their lack of professional identity. At two conferences, the first in Rome in 1955 and the second at La Jolla in 1956, prominent marine biologists struggled with the question of their disciplinary identity, and offered differing solutions. On one hand, it seemed that marine biology had come into existence as a by-product of the proliferation of sea-side research stations. In this case the term "marine" identified nothing more than the location at which "biologists" performed some important aspects of their research. Participants at the 1955 conference believed that an important need existed in reinvigorating the primary sites of marine biological research – laboratories such as the Hopkins Marine Station, the Naples Zoological Station, Woods Hole, and a host of others. The solution proposed by those at the Rome meeting entailed de-emphasizing any sense of uniqueness to marine

biology while stressing the importance, to all biologists, of research opportunities on marine organisms at the many marine laboratories around the world.[57]

Marine biology could, on the other hand, be seen as an emerging discipline in its own right, especially within the context of oceanography. Many of the participants at the much larger La Jolla conference in 1956 took this position. At the La Jolla meeting, where Ray was one of the invited speakers,[58] a main topic of discussion centered on the question "is there such a thing as marine biology?"[59] The conference was organized by A. A. Buzzati-Traverso, an Italian geneticist brought to the Scripps Institute of Oceanography to reorganize and stimulate the biological aspects of its program, and he had a well-formed answer to this question. In a paper composed in preparation for the "Perspectives in Marine Biology" conference, Buzzati-Traverso argued that marine biology had been dominated by a "descriptive" scientific methodology, but that if the discipline were to progress as a science, "the experimental approach should be stressed."

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[57] A summary of the 1955 conference resolutions, and main points of discussion, can be found in "Report on a Conference on Mediterranean Marine Biology" National Academy of Sciences – National Research Council publication (Washington DC, 1964), 1-3. Paul Weiss Collection, Box 88, Folder "Bellagio Conference on Marine Biology"; Record Group W436, Rockefeller Archive Center. Hereafter cited as "**Weiss.**" Also published in the International Union of Biological Sciences, *Bulletin*, 1955, 1:21-24.

[58] Dixy Lee Ray delivered a paper on potentially useful marine organisms for genetic study. Although she had not done research in this area, it is likely that Buzzati-Traverso, the conference organizer, asked Ray to speak on this topic based on her well-known use of laboratory techniques.

[59] "Symposium on 'Perspectives in Marine Biology' – 'Ideas,'" 26 March 1956. Box 24, Folder 2, "Symposium Perspectives in Marine Biology, March 23-April 2, 1956." Subject Files, **SIO**. The organizer of the conference builds on this question in his summary to the published papers: A. A. Buzzati-Traverso, "Perspectives in Marine Biology" *Perspectives in Marine Biology,* edited by A. A. Buzzati-Traverso (Berkeley, CA: University of California Press, 1960), 613.

In justifying this belief, he concluded that "the experimental method, from the time of Galileo, has offered the key to a far better understanding of nature." With widespread adoption of the experimental approach among marine biologists, "a new sort of biology [would be] born."[60]

While Buzzati-Traverso and a number of other participants believed that marine biology required an injection of experimental methodology, a different contingent felt a comprehensive view of aquatic life, from an ecological perspective, provided sufficient unity for marine biology. Joel Hedgpeth, writing a review of the conference for his colleagues at Scripps, believed the latter view dominated: "the sense of the meeting...was that marine biology, if it can be said to have one perspective rather than several, should be directed toward the study of life in the sea as an organically interrelated complex, as an ecological unit. It is this conscious realization of the need for synthesis that gives marine biology an essential unity."[61] At least for Hedgpeth, marine biology was a science concerned with a particular place and unified through the conceptual framework of ecology. Experimental methodologies mattered only secondarily, if at all. The concerns voiced at these conferences reflected important question of identity among marine biologists and colleagues throughout the marine sciences; in the years to come, clearly

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[60] "Why and What Sort of Marine Biology?" pages 3-4, 22. Box 11, Folder 48, "Marine Biology Program & Rockefeller Grant, 1954-1958." Subject Files, **SIO**.

[61] Joel Hedgpeth, "Personal Report on the Symposium..." page 5. Box 24, Folder 3, "Symposium Perspectives in Marine Biology, 1956 – Post Symposium Notes, 1956-57." Subject Files, **SIO**.

defining marine biology would be necessary to move beyond the rather muddled status quo.

As marine biologists struggled to articulate the main aims, methods, and scope of their discipline through the mid 1950s, another quite unrelated event took place that would open up new possibilities and create timely justifications for American science. The stunningly successful launch of Sputnik in 1957 alarmed many Americans who had assumed a second rate status for Soviet science and technology. In response the United States accelerated its space program and increased overall funding for science and technology to unprecedented levels. The fundamental challenge lay not only in getting Americans into space, but more generally for the United States to produce greater numbers of well trained scientists and engineers able to explore, claim, and control uncharted frontiers. In this climate oceanographers could effectively lay claim to a larger role in American science.[62]

The first International Oceanographic Congress and the formation of a National Academy of Sciences Committee on Oceanography played crucial roles in oceanography's rise to prominence in the late 1950s. This oceanographic congress, held at the United Nations building in New York City during the late summer of 1959,

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[62] In monetary terms the boost to science was dramatic. Daniel Kevles cites a rise in NSF funding from $30 million to $76 million from 1957 to 1961. And in a move especially important for a national defense oriented discipline such as oceanography, the Defense Department ordered an increase, rather than the planned decrease, in "basic research" funding immediately after the launch of Sputnik. Daniel Kevles, *The Physicists: The History of a Scientific Community in Modern America* (Cambridge, MA: Harvard University Press, 1995, 4th edition), 384-392. See also Toby Appel, *Shaping Biology*, 68, 78-79, 154-156, for Sputnik's effect on the National Science Foundation and funding for biological sciences; Hamblin, *Oceanographers and the Cold War*, 91-99, 139-141, for specifically oceanographic changes resulting from Sputnik.

attracted nearly 1000 scientists from around the world. Many of the usual suspects in marine biology organized a section entitled "Populations of the Sea," including Dixy Lee Ray, Joel Hedgpeth, and A. A. Buzzati-Traverso.[63] Yet, while biologists actively participated in this congress, the headlines for the congress came from the physical and chemical oceanographers. For the opening address, delivered in the impressive General Assembly Hall, a number of prominent oceanographers presented their mounting evidence for continental drift. *The New York Times* gave the story second page coverage, telling their readers that "Scientists from East and West were told here today that they seemed to be drifting apart – not politically, but geographically."[64] Having a 'revolutionary' theory at their disposal could do much more than organize oceanographic facts and spur productive research; oceanographers could now more effectively present their science as modern, sophisticated, and conceptually progressive.[65]

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[63] Congress organizers created five topical sections: "History of the Oceans," "Populations of the Sea," "The Deep Sea," "Boundaries of the Sea," and "Cycles of Organic and Inorganic Substances in the Sea." While organizers clearly tried to avoid dividing the congress into the traditional domains of oceanography – physical, chemical, and biological – the "Populations" session most clearly addressed biological issues. Mary Sears, ed., *International Oceanographic Congress, 31 August - 12 September, 1959: Preprints of Abstracts of Papers to be Presented at Afternoon Sessions* (Washington DC: American Association for the Advancement of Science, 1959).

[64] Walter Sullivan, "Continents Seen Drifting Apart: Scientists Hear Europe and America Move About One Yard Every 1000 Years" *The New York Times,* 1 September, 1959, page 3. Continental Drift, discussed on the first day of the congress, provided an eye-catching headline for a wider audience and was described as a "respectable" theory according to Roger Revelle. Organizers made a concerted effort to attract media attention, and it paid off in large part because of the prominent presentation of the topic continental drift. Dael Wolfle, "The 1959 Oceanographic Congress: An Informal History" *Oceanography: The Past*, edited by Mary Sears and Daniel Merriman (New York, NY: Springer-Verlag, 1980), 42-48.

[65] For a technical overview of the development of plate tectonics, see Naomi Oreskes, "From Continental Drift to Plate Tectonics," *Plate Tectonics: An Insider's History of the Modern Theory*

As a science, oceanography could present the theory of plate tectonics as evidence for its arrival as a mature science, according to methodological norms of the day. But in practice it owed much to the far less glamorous demands of supplying descriptive information about the ocean environment to government and industry. These competing faces of the science were not contradictory. As Ray's own research illustrates, scientists could profitably justify their work in terms of the binary definitions of pure and applied science. For oceanographers in general, they effectively promoted the science as one that, at once, served the desires of scientists to engage in intellectually satisfying work while delivering useful knowledge to those using the marine environment for practical ends.

(Re)Defining Marine Biology

Preceding the Congress by a few months, the National Academy of Sciences Committee on Oceanography issued the first chapter of a report intended to give direction to the field over the coming decade. The Committee's work, like the International Congress, played an integral part in oceanographer's ambitions to raise their national and international profile.[66] NASCO, as the committee became known, had been meeting since 1957 and

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of the Earth, Naomi Oreskes & Homer Le Grand, eds. (Boulder, CO: Westview Press, 2001), 3-27. Although not explicitly about oceanography, efforts to popularize the theory of plate tectonics helped bring attention to oceanography. See Daniel Jacobi, Andrée Bergeron, and Thierry Malvesy, "The Popularization of Plate Tectonics: Presenting the Concepts of Dynamics and Time," *Public Understanding of Science*, 1996, 5:75-100.

[66] Oceanographers had good reason to think of their science as particularly amenable to international cooperation, especially as they observed (or participated in) the successful researches of the International Geophysical Year in the late 1950s. Oceanographers' own big

timed the release of its various reports on oceanography to bring attention to the International Congress, and then in turn to build momentum from the combined attention. The National Academy's report and news release certainly got people's attention. The summary of the report boldly stated that "the United States must – within the next ten years – double its present rate of deep-sea research or face serious economic, political and military hazards." The report argued that new knowledge about the ocean basin's major geophysical features would blossom, based on recent scientific advances; that ocean resources, such as food, would need far more efficient exploitation in coming decades; that improved knowledge of climate patterns would allow for "prediction and possibly control" of earth's climate; and that the nation's military preparedness depended on superior oceanographic knowledge. These and other reasons made it imperative, the report concluded, that the nation invest an additional $650 million in all facets of oceanography. Recognizing that this would appear extravagant, the writers of the report reminded Americans that study of the oceans would be less expensive than space exploration and could, in many ways, serve as an essential adjunct. Drawing attention to

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international research project – the International Indian Ocean Expedition (IIOE) – of the early 1960s came as a direct result of the IGY. Planning for the IIOE, and other oceanographic projects of the time, took place at the 1959 Oceanographic Congress as well as within the various national oceanographic committees, which were all connected to the Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU). Torben Wolff, "The Creation and First Years of SCOR," *Ocean Sciences: Their History and Relation to Man – Proceedings of the 4th International Congress on the History of Oceanography, 1987* (Published as a special issue of *Deutsche Hydrographische Zeitschrift*, Series B, No. 22, 1990), 337-343.

what some had begun calling "inner space," they posited that "we know less about many regions of the oceans today than we know of the lunar surface.[67]

These points were all repeated prominently in American newspapers. Not surprisingly, most journalists zeroed in on those parts of the report suggesting the United States might be losing an oceanographic competition with the Soviet Union.[68] The chair of the Oceanographic Committee protested this interpretation of their report by the media, reiterating what he felt the report had communicated: namely that oceanography needed to be supported for its intellectual and practical benefits, not in order to "keep up with the Russians."[69]

While journalists may have misrepresented the Committee's report, others within the scientific community read the first installment of the report and found their own cause for alarm.[70] NASCO, reflecting the way high-level science panels operated, was

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[67] "News from National Academy of Sciences, National Research Council: for release 3 pm, EST, Sunday, February 15, 1959." Folder: Earth Sciences: Com on Oceanography: Reports Oceanography 1960-1970, (1959); Central Files series, Earth Sciences Division, National Academy of Sciences. National Academy of Sciences Archive. Hereafter cited as "**NASCO.**"

[68] John W. Finney, "Vast Ocean Study by U. S. is Urged: National Science Academy Panel Warns of Soviet's Gain in Sea Exploring" *The New York Times*, 15 Feb, 1959, page 1. Much as John F. Kennedy would use a purported "missile gap" to great effect against Richard Nixon during the following summer's election, the writer of this article stressed the possibility that the United States was falling behind the Soviet Union in size and quantity of oceanographic vessels.

[69] Letter from Harrison Brown to Alfred Friendly (Editor, Washington Post), 12 March, 1959. Folder: NASCO Report: Feb. 1959 (Publicity), (1958-59). Committee on Oceanography, unorganized records deposit; P85-032-1. **NASCO.**

[70] The report, entitled *Oceanography 1960 to 1970*, was to be composed of twelve chapters, and released over a three year period as chapters were completed by the various subcommittees. The first installment, which aroused so much concern on the part of biologists, was entitled "Introduction and Summary of Recommendations." The remaining eleven chapters were: "Basic Research in Oceanography During the Next Ten Years," "Ocean Resources," "Oceanographic

composed of eminent men who were thought to be most capable of representing oceanography's interests. Harrison Brown, chair of the committee and the only non-oceanographer in the group, was a geochemist at the California Institute of Technology. Physical oceanographers made up the bulk of the group, including Roger Revelle from Scripps, Maurice Ewing from Columbia University, Fritz Koczy from the University of Miami, and Athelstan Spilhaus from the University of Minnesota. Two members, the Yale plankton ecologist Gordon Riley and the fisheries biologist (director of the Inter-American Tropical Tuna Commission) Milner Schaefer initially represented biological oceanography. A small stir among marine biologists resulted in the appointment of Colin Pittendrigh, a biologist from Princeton who did pioneering work on the biological bases of circadian rhythms.

Yet, even with Pittendrigh on the committee, marine biologists smelled a rat. NASCO had been formed within the Academy's Division of Earth Sciences. Gordon Riley appeared too close to the other members of the committee, and it was feared that he would not stand up for the broader needs of biologists. And the tone of the report – stressing the needs of applied fisheries biology – had the fingerprints of an applied biologist rather than those of a "pure" marine biologist. To a number of biologists, this committee clearly skewed its report to favor the concerns of physical oceanography.

Research for Defense Applications," "Artificial Radioactivity in the Marine Environment," "New Research Ships," "Engineering Needs for Ocean Exploration," "Education and Manpower," "Ocean-Wide Surveys," "International Cooperation," "History of Oceanography," "Marine Sciences in the United States – 1958." National Academy of Science – National Research Council, *Oceanography 1960 to 1970: A Report by the Committee on Oceanography* (Washington, DC: NAS-NRC Printing and Publishing Office, 1959), volumes 1-12.

When it came to biology, this committee could think of little more than boosting fish production from the oceans.

Sensing an opportunity to productively re-define their science, marine biologists sprang into action. During the summer of 1959 members of NASCO heard from marine biologists, and particularly through the program director for Environmental Biology at the NSF, that the biological aspects of oceanography required far more attention than the committee had so far shown.[71] Specifically, a Marine Biology Panel needed to be composed with the advice of the American Society for Limnology & Oceanography and the American Institute of Biological Sciences. Rather than representing a perfunctory alteration to NASCO plans, this request set off "heated discussion" over the inclusion, or intrusion, depending on one's perspective, of marine biology into oceanography.[72]

Legislation being proposed by Washington State Senator Warren Magnuson added intensity to the whole issue of oceanography's future. Titled the *Marine Sciences and Research Act*, Magnuson's legislation had in its initial stages been drafted with close attention to the NASCO report. While at the International Oceanography Congress in New York, Ray had paid a visit to Magnuson's office in order to gather details of his legislation. Following that meeting she turned to her marine biologist colleagues, urging

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[71] This came at a time when the National Science Foundation was, in general, enlarging its oceanographic programs. For the NSF's oceanographic initiatives at this time, see David K. van Keuren, "Building a New Foundation for the Ocean Sciences: The National Science Foundation and Oceanography, 1951-1965," *Earth Sciences History*, 2000, 19:90-109.

[72] See Bi-Weekly meeting notes, specifically for 2 Jul 1959 and 25 Sept 1959. Committee on Oceanography, unorganized records deposit; P85-032-1; Folder: 3.5: Bi-Weekly Notes, 1959-1963; Div ES: com on Oceanography. **NASCO**

them to press their objectives in regard to both the NASCO report and Magnuson's legislation. "It's imperative that biology should be well represented by biologists," she wrote, "Too often scientists from other disciplines are presuming to speak for biology and I for one am 'fed up'!"[73] In late November of 1959 an ad hoc Committee on Aquatic Biology, sponsored jointly through the Academy's Division of Biology & Agriculture and AIBS, met to discuss strategy. This group of biologists, including Robert Hiatt (Dean of Research at the University of Hawaii) and Dixy Lee Ray, agreed that some mechanism should be created whereby biologists could voice their particular concerns with more effectiveness within political circles.

While all the ad hoc committee members agreed to this rather bland statement, some had expressed more concern for the future of biology than others. All of the members wrote summary memoranda, including Ray who argued vigorously that there was "urgent need for biologists to take the initiative in planning and speaking for the future development of our particular scientific discipline. There are plenty of warning signs now that if this is not done, the spokesmen for biology will increasingly come from outside the ranks...of professional biologists" (in this case physical oceanographers). Ray also mentioned that considerable discussion centered on the "distinction often made between the ill-defined, arbitrary, yet commonly used terms 'marine biology' and 'biological oceanography.'" Then, suggesting that the time for action might be short, the writer claimed that "it was generally agreed that for biologists to remain silent now and to

[73] Letters from Ray to Waldo Schmitt, 6 & 19 Oct 1959. Box 28, Folder "Ray, Dixie Lee, 1956-1960." Collection 7231: Manuscript Collections; Waldo Lasalle Schmitt papers, 1907-1977. **Smithsonian**.

abdicate our responsibility to advise on matters of biological research would be to relinquish for all time the right to be represented and consulted."[74] Ray, for one, was ready and willing for action.

By the end of 1959 marine biologists had made their point loud and clear to the most important people in Washington. Some positive opportunities seemed to be opening up. Detlev Bronk, president of the National Academy of Sciences, had been informed of the protest being waged by marine biologists, a protest being intensified by the prospect of a new appointment brought on by the resignation of Colin Pittendrigh, the most prominent biologist on the committee.[75] Richard Vetter, NASCO committee secretary, began to compile a list of potential replacements acceptable to the committee and asked for comment from H. Burr Steinbach, director of the National Academy's Division of Biology and Agriculture. According to Steinbach, the physiologist Per Scholander topped the list, but he told Vetter that "the names you suggest are all good" and concluded by asking "why not enlarge the contingent and add two names?" Others

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[74] "Memorandum on the Meeting of the NAS-NRC – AIBS ad hoc Committee on Aquatic Biology" (Memo stamped 23 Dec 1959). Folder: Biology & Agriculture: Com on Marine Biology: Ad hoc (1959-1960). **NAS**. In the same set of documents, illustrating the diversity of viewpoints, one of the other members of the committee addressed the issue of marine biology and biological oceanography in the following way: "...Your letter asks if it is correct to equate marine biology to the biological aspects of oceanography. This is clearly a question of definition and of attitude .... Certainly marine biology in its broadest definitions includes the biological aspects of oceanography, but unfortunately many who consider themselves marine biologists have a narrow definition of the field. On the other hand the mere use of a marine organism as a tool in a biological experiment does not automatically make a marine biologist out of the experimenter. ..." Letter from B. Ketchum to H. Burr Steinbach (23 Oct 1959).

[75] Memo, S. D. Cornell to Detlev Bronk, 28 Oct 1959. Earth Sciences: Com on Oceanography: General (1959). **NASCO**.

on Vetter's list were John Ryther, from the Woods Hole Oceanographic Institution, and Dixy Lee Ray, both directly involved in the row over marine biology and oceanography. Two zoologists, not considered marine biologists, also made the list: Daniel Mazia and Sidney Fox, from Berkeley and the University of Florida, respectively.[76] By February of the new year the committee had decided to ask Scholander and Ray to join.[77] Scholander, like Revelle an oceanographer from Scripps, brought to the committee "an intense desire to find ways and means of getting scientists onto the oceans" and felt that properly outfitted ships would allow biological oceanographers to adopt an experimental methodology.[78]

For her part, Ray joined the committee because of her outspoken views on the need for high-level representation of marine biology in just such places as NASCO. Also, it can be assumed that Ray's service on NASCO was calculated to aid in the ongoing discussions over marine sciences draft legislation sponsored by Warren Magnuson, the senator from Ray's home state.[79] In short, the two new appointments to

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[76] Letter from Vetter to Steinbach, 27 Oct 1959; and letter from Steinbach to Vetter 3 Nov, 1959. Biology & Agriculture: Com on Marine Biology: Ad hoc (1959-1960). **NAS**.

[77] Letter from Bronk to Scholander and Ray, 19 Feb 1960; Letter from Scholander to Bronk, 26 Feb 1960; Letter from Ray to Bronk, 14 March 1960. File: Earth Sciences: Com on Oceanography: General (1960). **NASCO.**

[78] The ship (none too subtly christened) *Alpha Helix*, a 133-foot "floating physiological laboratory" built especially for biological oceanography, entered use at Scripps in 1966. Appel, "Marine Biology" 336-339. For Scholander's interests see: notes for 11 Dec, 1959, "3.5: Bi-Weekly Notes, 1959-1963." Committee on Oceanography, unorganized records deposit, P85-032-1. Letter from Scholander to Bronk, File: Earth Sciences: Com on Oceanography: General (1960). **NASCO**.

[79] See letters between Ray and Steinbach concerning Magnuson legislation, 16 & 20 Oct, 1959. Biology & Agriculture: Com on Marine Biology: Ad hoc (1959-1960). **NAS**.

NASCO had that intensive interest, even "fanatic concentration of interest" in oceanography that would in no way threaten the committee's message of support for oceanography. They were, to continue with Weaver's language, "just the lads to ask if you want to know whether X is a good idea."

Yet, even with Ray and Scholander's appointment to the oceanographic committee, marine biologists were not assured of success. So they continued to press their grievances. Marine biologists felt perturbed and, at the same time, sensed an opportunity to exert some control over their discipline. Robert Hiatt, the dean of research at the University of Hawaii and chair of the AIBS Hydrobiology Committee, sent a letter to Burr Steinbach elaborating on the problem as seen by marine biologists. "Pushing aside the possibility that the NASCO reports fail to give sufficient emphasis to marine biology," he wrote,

> the important point being made by marine biologists is that the field should nowise by restricted to problems relating to fisheries conservation and development. The NASCO group and the Executive Committee have entirely overlooked the importance of studying aquatic organisms and their environmental relationships to solve fundamental problems relating to life and living processes generally.

Then, taking issue with what some marine biologists thought of as an overly restrictive definition of oceanography (namely, the study of deep marine waters), Hiatt offered a broader definition for the field which, he believed, should include "fresh water environments." Finally, Hiatt asked that the wider community of scientists respect the scientific judgments and disciplinary domain of marine biologists. "As marine biologists we would not venture to pass judgment upon the physical oceanographic

recommendations in the NASCO report" he stated, and therefore "the earth scientists should be as humble concerning marine biology."[80]

Requesting greater respect for marine biologists' judgments was one thing; actually having marine biologists pursuing oceanographic kinds of research entailed quite another – namely being granted the money, ship-time, and other resources required to do "biological oceanography." To that end the division of Biological & Medical sciences at the National Science Foundation appointed Ray as a consultant to the Division of Biological and Medical Sciences. Her job description entailed addressing the "problem of biological oceanography" in order to initiate an NSF program in that field to ensure that biologists could readily participate in the anticipated boom in oceanography. As a staunch supporter of marine biology, as well as a member of NASCO, Ray would be "just the lad" to help the NSF develop a strong funding program for biological oceanography. Discreetly acknowledging her recent appointment to NASCO, which required a supposedly objective and dispassionate scrutiny of oceanography, Ray's immediate boss wrote that he felt her NSF appointment "would in no way interfere with your Committee responsibilities."[81]

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[80] Letter from Robert Hiatt (Chair of AIBS Committee on Hydrobiology) to Burr Steinbach, 19 April, 1960. Folder "Earth Sciences: Com on Oceanography: Reports Oceanography 1960-1970, (1960)" **NASCO**. This letter was drafted by Rolf Bolin, Arthur Hasler, Joel Hedgpeth, Robert Hiatt, Dixy Lee Ray, and William E. Schevill

[81] Memo from John T. Wilson (Assistant Director, Division of Biological and Medical Sciences) to Dixy Lee Ray, 8 June 1960. Box 42, Folder "Division of Biological and Medical Sciences, 1960," National Science Foundation General Records, 1949-63, (Waterman's Subject Files), Record Group 307, National Science Foundation. NARA, College Park MD. Hereafter cited as "**NSF Gen**".

Through the remainder of 1960, and into the new year, Ray seemed to thrive in her new assignments, advocating for the biological aspects of oceanography for NASCO and coming up with a workable plan to fund biological oceanography for the NSF. According to one of her fellow marine biologists at the Smithsonian Institution, Ray was "doing her usual fine job at NSF. If she was a normal person, she would be looking forward to the comparative peace and quiet of Seattle when her stint here is over, but I have an idea that she thrives on those activities that threaten the very lives of most of us."[82] For NASCO, Ray appeared before congressional committees giving "excellent reviews" of the needs in biological oceanography, and in NASCO's ongoing oceanography reports she took special responsibility for representing biologists' concerns in the conduct of ocean surveys.[83]

Ray's primary task at the National Science Foundation entailed the organization of a committee which would report on the status and future funding needs of biological oceanography. For this task a small committee of individuals convened under Ray's leadership from 1960 through 1962.[84] Hinting at the broad perspective she would bring

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[82] Letter from Fenner Chace to Paul Illg, 22 Sept 1960. Box 24, Folder "Paul L. Illg, 1946-1950," Collection 307: Division of Crustacea, 1908-1979, **Smithsonian**.

[83] For congressional testimony see notes for 8 June 1960, File: "3.5: Bi-Weekly Notes, 1959-1963." Committee on Oceanography, unorganized records deposit, P85-032-1. For ocean-wide survey see correspondence between Ray, Gordon Riley, Milner Schaefer, and Richard Vetter: File "Earth Sciences: Com on Oceanography: Reports Oceanography 1960-1970, (1960). **NASCO**.

[84] Members of the committee were: Rolph Bolin, Hopkins Marine Station; Dr. Ralph Emerson, Dept of Botany, UC Berkeley; Dr. Erling Ordal, Dept Microbiology, Univ. of Washington; Dr. John Ryther, Woods Hole Oceanographic Institution; Dr. H. Burr Steinbach, University of Chicago and head of biological division at NAS; Dr. Karl Wilbur, Duke University. "A Report to

to this project, Ray initiated a study of marine stations and personally visited key marine biologists in a number of foreign countries, including France, Italy, Sweden, Israel, and England. She also convened a conference of 40 marine station directors from the United States, to survey their needs and opinions. To no one's surprise, most believed that marine biology could be expanded, that thinking of marine biology and biological oceanography as more or less unified might prove to be the best means of achieving expansion, but that however one thinks about the marine sciences, they required greater resources in order to fully realize their potential.[85]

The final report by Ray's ad hoc Committee on Biological Oceanography began by reminding readers of the larger political justifications that had, in recent years, placed oceanography in the limelight. The National Academy of Sciences had argued for a massively increased federal effort in oceanography, and in response President John F. Kennedy stated his administration's intention that "knowledge and understanding of the oceans promise to assume greater and greater importance ... [and that] A vigorous program will capture those opportunities." Pending legislation seemed ready to deliver substantial resources to this supremely practical realm of science. With this apparent windfall coming to anything oceanographic, the ad hoc committee set out to define what in fact constituted "biological oceanography."

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the Division of Biological and Medical Sciences of the National Science Foundation by the ad hoc Committee on Biological Oceanography." Box 31, Folder "National Science Foundation," **DLR**.

[85] See Paul Scherer, Memorandum to Members of the National Science Board, 13 June, 1963; "Biological Oceanography: Personnel Requirements – Present Complement and 10 Year Requirement." Box 31, Folder "National Science Foundation," **DLR**.

They began by stating that everyone tended to define "biological oceanography" in different ways, and that "similar trouble plagues the whole field of oceanography." Thus the committee members felt an urgent need to articulate and establish the disciplinary parameters. Rejecting various restrictions, such as the common belief that oceanography must involve deep-sea investigations, the writers began to formulate their own position. In order to "develop a true understanding of the oceans as part of the natural world," the committee premised, "the broadest possible approach by scientists of all complexions is required." Moreover, oceanography could not be considered a discipline in the "usually accepted sense," but rather must be thought of as spanning multiple disciplines.

The committee then took pains to refute a number of "restrictions" commonly used when defining oceanography. They concluded that "it is spurious to restrict oceanography by geography, by approach, or by substantive area." Rather, "all parts of the sea are interrelated and so are all studies that seek to understand its features and its phenomena." Thus, having defined oceanography as a necessarily interdisciplinary field, the committee then argued that greater efforts must be made to include members of all pertinent academic disciplines since "individuals, with rare exceptions, are not" interdisciplinary. With this supremely broad definition, a definition that opened

oceanography to marine biologists, the report proceeded to lay out what it considered appropriate biological studies in the marine environment.[86]

The committee, reflecting the traditional organismal perspectives of its members and eschewing overemphasis on experimental methodologies, stated that the primary thrust in research needed to be "careful, continuing, systematic study of marine life." If the research program sounded old-fashioned, this committee likely had no quarrel. The report stated boldly that "there is much more to be learned about the natural history of marine organisms – if we may use that fine old term in its once-respected sense – before we attain a very broad understanding of biological activities in the sea."[87] Beyond greater taxonomic knowledge, important as that was, understanding the biology of the marine environment required studies of "life cycles and habits of breeding, ... seasonal or cyclical appearance of particular species or of a sequence of forms. ... in short, all the facets and approaches that characterize modern systematics and ecology."[88] Borrowing language from ecologists and from those concerned with the increasingly apparent human impact on the world, the report argued that marine biologists must engage in more studies

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[86] All quotations from "A Report to the Division of Biological and Medical Sciences of the National Science Foundation by the ad hoc Committee on Biological Oceanography." Box 31, Folder "National Science Foundation," **DLR**.

[87] Ibid., p. 5. Though Ray emphasized the utilization of simple experimental techniques in her own research, she also valued the tradition of 'natural history' – as in the title of her signature course, *Natural History of Marine Invertebrates*, and as will be seen in the following chapter, in her presentation of sea-shore life on television. This suggests she viewed natural history as a good foundation upon which to build the life sciences, and not as a kind of unscientific anachronism of a previous age.

[88] Ibid., p. 6.

of communities of organisms to understand "the dynamics of stable ecological systems." In the face of a history in which human interference had taken place largely "without reflection beyond immediate needs," the connection with future survival seemed clear: greater understanding of how diverse biological communities maximized long-term stability would inform human activity "as man... interferes more and more with the balance of nature."[89]

With these general program goals in mind, Ray's committee then suggested ways in which the NSF could best achieve progress in biological oceanography. The suggestions were simple and logical, but clearly expensive. Unlike some of the most prominent laboratory-based biological disciplines of the time – which stressed reproducibility, abstraction, and control – marine biology had long been associated with studies of particular places and in many ways represented the antithesis of the laboratory. While laboratory practices had been emphasized at Woods Hole and Naples Zoological Station for decades, the rise of ecology through the 1950s had served to re-emphasize broadly ecological and location-specific research throughout the network of marine stations.[90] Within this context, the report stated that "no area of biology is to a greater

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[89] Ibid., pp. 7, 10.

[90] Explicitly ecological courses were revived at Woods Hole in the 1950s, first under the instruction of Eugene Odum. Similarly, the Naples Zoological Station began a program of ecological research on a nearby island by the early 1960s. Robert Kohler, in *Landscapes and Labscapes*, has argued that the field sciences, in the late 19th through mid 20th centuries, actively tried to employ laboratory practices as a means of legitimizing and bolstering their scientific standing. By the 1960s, I would argue, the field sciences did not need to take this approach to the extent they had in earlier decades, as exploration, discovery, and conservation became more acceptable scientific activities.

degree facility-dependent than is the field of marine studies. The environment must be examined where it is." Therefore, marine stations of many kinds and at many different locations required constant funding. Along with the shore-based facilities, many of which had long been established, marine biology and biological oceanography needed greater access to boats of different kinds in order to expand study of the marine environments across the oceans.[91]

Rather than asking "what is marine biology?" as had been done a few years earlier to little result, Ray's committee asked "What is biological oceanography?" Quite simply, they answered, "it is the study of life in the sea. Nothing less." It was the politically expedient question; yet while not producing an intellectually sophisticated answer, this definition opened the door for a decade, at least, of expanding opportunities for those studying life in the marine environment. The broadening of what constituted oceanography, and specifically biological oceanography, represented much more than just a semantic game played by a few irritated biologists and Washington bureaucrats. In the summer of 1963 Paul Scherer, then acting director of the National Science Foundation, in a memo to members of the National Science Board casually but explicitly equated biological oceanography with "marine biology as it is more accurately called." The conflation of what had been two separate fields of inquiry, what Ray's ad hoc committee had argued, appeared complete at least within the National Science Foundation.

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[91] "A Report to the Division of Biological..." 11-17 (quotation from page 11).

Marine stations may have profited the most: Woods Hole Oceanographic Institution, the Friday Harbor Laboratories, and the Duke University Marine Laboratory were just the beginning of a list of twenty-six stations that built, or renovated, laboratories and other sea-side structures using NSF funds in the years immediately following Ray's committee report. Similarly, funds for individual research projects increased markedly. From 1958 to 1965 the number of awards doubled and the amount of money dispersed grew from $776,000 to $3.6 million, with most of the grants coming out of the programs in Systematic Biology and Environmental Biology in accord with the priorities of Ray's committee report. Overall, the NSF's division of Biology & Medicine spent less than $1.35 million on what it considered to be biological oceanography or marine biology research projects and facilities in 1958. By 1965 this had mushroomed to nearly $10 million.[92]

Ray's work for the NSF did not result only in securing resources for American marine biologists. Her disciplinary work took place at a time when biologists around the world were questioning the future of biology as a whole. Ray's attempt to unify marine biology and biological oceanography took place in a context in which, at least for certain biologists, themes of unification loomed large. At a 1963 conference near Lake Como in Italy, designed to bring financial stability to marine stations in the Mediterranean, Paul

[92] Toby Appel, *Shaping Biology*, 188-190. In Appel's essay, "Marine Biology/Biological Oceanography" she argues that, at least within the NSF, the union of the two fields lasted only through the 1960s. Since the 1970s due to many factors, but primarily to reduced budgets for costly infrastructure and for basic science, she writes that "biological oceanography has become more oceanographic than biological." See pp. 338-340.

Weiss, a neurophysiologist from the Rockefeller University, and Dixy Lee Ray convinced the leaders of local marine stations to cooperate and pool resources. But more significantly, Weiss and Ray built their argument on the premise that marine biology represented a common field around which divergent interests could be successfully integrated and cooperatively attacked. In the words of their conference resolution, they argued that "marine biology as a science is unitary but not unified," and that the diversity of locations, aims, and methods in marine biology should be thought of as an asset for which marine stations should begin to act cooperatively. For some, marine biology represented the study of various forms of sea life, for others the utilization of marine organisms to analyze basic biological mechanisms, and yet others worked on practical problems of marine productivity. Yet, if this diversity was to be seen as a strength, or more accurately a potential strength, it hinged on life scientists' ability to focus on unifying themes.

Reflecting Ray's disciplinary activism of the previous few years, the resolution stated that "the realization of the intrinsic unity of the field of marine biology, hence the need for inner cohesion and integration, is of relatively recent date. The history of its origin in separate, incoherent fragments is still reflected in the fact that its agents – the marine biological stations – do not constitute a communal network of interrelated members, but are essentially a loose array of unrelated piecemeal products...."[93] In order

[93] "Report on a Conference on Mediterranean Marine Biology," National Academy of Sciences – National Research Council publication (Washington DC, 1964), 5. Box 88, Folder "Bellagio Conference on Marine Biology," **Weiss**.

for marine biology to overcome this fragmented history, in order for it to prosper in the future, biologists needed to recognize a common level of unity.

For many, including Weiss and Ray, the organism represented the natural unifying objective within the life sciences. While unification represented much of Ray's recent thinking in terms of marine biology, it also coincided with a larger unification movement within zoology of which Weiss was an important advocate. Two months after this small marine biology conference took place in 1963, leading zoologists gathered at the *XVI International Congress of Zoology* in Washington DC at which they consciously tried to counteract what they saw as expanding disciplinary fractures within the zoological sciences. An outline for the congress argued that "After a century in which the progress of zoology has been marked by the fragmentation ... into specialties and sub-specialties, it is becoming possible for zoologists to work once more toward the proper ultimate goal of all biological work, namely: an understanding of whole organisms." Because of this organizers confidently proclaimed, "We are witnessing a rebirth of animal biology."[94] For Paul Weiss and the other organizers, zoologists needed to retain an appreciation of the whole organism in order to maintain fruitful dialogue across disciplines, whether studying at the level of the molecule or the ecosystem. To represent an anticipated re-unification of their science, organizers selected the phoenix as conference emblem. Embodying biologist's aspirations for the future of their discipline,

[94] "Proposed Program," page 1. 13 Nov 1962. Box 26, Folder 189. Rockefeller Foundation, Record Group 1.2 Projects, Series 200 U.S., Sub-series AIBS. Rockefeller Archives Center.

the phoenix powerfully delivered what they believed was a timely message "for the revivified union of the whole organism from the ashes of disintegration."[95]

By the end of the decade a re-evaluation of oceanography, and virtually all the sciences, began to take place. The 1960s had been a decade that showered oceanography with resources to explore all corners of the marine environment, thanks in large part to the advocacy of people like Ray. Yet for many, science had been given too much freedom, and resources, in relation to other social needs. In short, perhaps more science was not always the solution.

Ray participated in one more high-level oceanographic committee in 1969 as a result of a presidential statement calling for yet more oceanographic research. With typical Presidential hyperbole, Nixon said, "the fringes of outer space have already been visited by man; the depths of inner space await our first, tentative, courageous investigations ... here is a source of benefits so vast, opportunities so diverse, and power so immense that it rivals our previous frontiers of the land and the heavens...." This time, however, Ray felt that perhaps "oceanography has already been oversold with respect to the probable benefits." In committee discussions, Ray stressed her belief that a White House statement on oceanography should clearly identify a single problem for national attention. A hodge-podge of equally pressing oceanographic issues would do nothing but confuse the public and produce ammunition for those accusing science of

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[95] Minutes of 6th meeting, Organizing Committee for the XVI International Congress of Zoology, 15 Oct 1961. Folder "Congress of Zoology, 1 of 3," Box 11, **Weiss**. According to other documents in this collection, Weiss took much of the credit for organizing the conference around the practical and conceptual unity of the organism.

waste, irrelevance, or fraud. Reflecting the growing concern that science address broad social problems, Ray wrote that the one problem in most need of national attention should be competing issues of "recreation, pollution, fishing, and seaports" affecting near shore environments. Scientists, she felt, could help adjudicate problems by supplying solid, factual knowledge about this delicate and important environment. But, whatever issues the committee eventually emphasized in the report, Ray begged that they not make the mistakes of the past, in which oceanographers had made it seem that "oceanography is almost as good as Motherhood. Please let's not let that happen!"[96]

In conclusion, while Ray may not have remained fully enamored with all things oceanographic, she could take pride in having helped bring financial prosperity to marine biology and in articulating a broad and vigorous definition of marine biology's place within the sciences. For her and for many of her colleagues, marine biology could confidently define itself in terms of ecology, systematics, basic discovery of the natural world, or as natural history – "to use that fine old term." Therefore, where some have seen marine biologists, and their many marine laboratories, as having "remained havens for purely descriptive, morphological or taxonomic work," it may be more accurate to see the middle decades of the twentieth century as a time of a resurgence in broadly

[96] Richard Nixon, "The Sea: Our Last Unexplored Frontier," delivered 30 October, 1968. Letter from Ray to James H. Wakelin, 5 Dec, 1969. Location of both documents: Box 145, Folder 2: "White House Task Force on Oceanography, WAN, Oct., '69." William Nierenberg Papers, **SIO**.

descriptive research that did not depend on sophisticated experimentation, rather than as an anachronism from the previous century.[97]

[97] Garland Allen, "The Changing Image of Biology in the Twentieth Century," *The Changing Image of the Sciences*, edited by Ida H. Stamhuis, Teun Koetsier, et al., (Dordrecht, the Netherlands: Kluwer Academic Publishers, 2002), 62.

Chapter 4

(Re)Presenting Science: Bringing Science to the People

> It is the scientist's mission not only to uncover nature but also to interpret his results to his fellow men. Scientific knowledge is itself neutral. It is the use that is made of it that is good or evil. Decisions concerning that use are not for scientists alone. The layman must therefore make his own effort at understanding. To assist him, the scientist must, in turn, be ready to leave his laboratory, to act as a guide.[1]

To Dixy Lee Ray this statement, by the Nobel Prize winning physicist Sir Edward V. Appleton, articulated the motivation behind the science popularization activities of her professional career. To Appleton, these words reflected his deeply held concern that there was a need in modern society for a fuller appreciation of the basic concepts, methods, and ethos of science. Encouraging a broad appreciation for science was not an uncommon concern through the twentieth century, as science came to be seen as a foundation of modern, progressive, and autonomous nations.

While at Stanford University, and certainly in the years immediately following World War II, Ray would have heard her good friend and mentor, Cornelius van Niel, promoting the idea that science should be seen as a way of life. At the root of this belief lay the necessity for scientists to communicate their way of life to the broader society in which they lived. These

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[1] Attributed to Sir Edward V. Appleton, British physicist and 1947 Nobel Prize recipient for physics of upper atmosphere. This quotation is found in Ray's personal papers, included among other documents that appear to be notes jotted down as she formulated her vision for the Pacific Science Center. Box 12, Folder "Notes, Science (PSC years)," **DLR**. Interestingly, Warren Weaver also made use of this quotation (also without full citation) in, "Science and the Citizen," *Science*, 13 Dec 1957, 126(3285):1225-1229.

were sentiments often repeated within Ray's community of intellectuals. The president of the American Council of Learned Societies, Charles E. Odegaard, in discussions to expand the public outreach of the American Association for the Advancement of Science, expressed his concern in 1951 that science in the public discourse was presented as technical knowledge more than as a general value system. He wrote, "I have been disappointed in critical junctures recently at the infrequency with which scientific leaders have cut through the heart of the matter to explain to the public that science is not only a subject matter but also a way of life embodied in the value systems of American Society."[2] While scientific knowledge itself may be neutral, many also held that greater knowledge about science would be crucial to the creation of societies that embodied values of objectivity, rationality, liberality, and civility.[3]

While some may have questioned the synonymy of science and an American way of life, notable American scientific and intellectual leaders, such as Vannevar Bush, James B. Conant, and Robert Merton, believed the two inseparable under optimum conditions.[4] And more generally, few leaders of American society seriously doubted the need for greater knowledge about science. To that end scientists brought the facts and values of science to the general

[2] Charles E. Odegaard, from 1951. Cited in Bruce Lewenstein, "Shifting Science from People to Programs: AAAS in the Postwar Years" *The Establishment of Science in America: 150 Years of the American Association for the Advancement of Science*, co-authored with Sally Kohlstedt and Michael Sokal (New Brunswick, NJ: Rutgers University Press, 1999), 112. Odegaard would, in 1958, become president of the University of Washington.

[3] David Hollinger explores this point in detail, "Science as a Weapon in Kulturkämpfe in the United States During and After World War II" *Science, Jews, and Secular Culture* (Princeton, NJ: Princeton University Press, 1996), 155-174.

[4] David Hollinger, "The Defense of Democracy and Robert K. Merton's Formulation of the Ethos of Science" and "Free Enterprise and Free Inquiry: The Emergence of Laissez-Faire Communitarianism in the Ideology of Science in the United States," *Science, Jews, and Secular Culture*, 80-120; Elizabeth Ann Melia, *Science, Values, and Education: The Search For Cultural Unity At Harvard Under Charles W. Eliot, A. Lawrence Lowell And James B. Conant* (PhD, The Johns Hopkins University, 1995).

public, with new tools at their disposal such as television and film, and through modernized museums or "science centers." This chapter explores aspects of the American post-war "public understanding of science" movement.[5] As in the previous chapter, the biographical thread binds together what could be considered divergent domains within the broad topic of science popularization.

Beginning in the 1950s with the origins of American non-commercial television, the first part of the chapter situates Ray's work in front of the camera within a broader effort to use this popular medium as an educational tool. In the second part of the chapter the focus shifts from the purely visual presentation of science (as in television and film), to the kind of presentation that had long taken place in museums. However, as Americans were increasingly enthralled by new forms of entertainment, such as the wonders of Disneyland or the "natural" excitements of Sea World, Ray and a group of Seattle-area community leaders envisioned and promoted the Pacific Science Center as an interactive space in which visitors would, it was hoped, experience the thrills of discovery.[6] These two inter-connected science popularization projects epitomized the impulse among science-oriented leaders to refashion society in a new and modern form. The

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[5] Lewenstein, "Shifting Science from People to Programs;" Bruce V. Lewenstein, "The Meaning of 'Public Understanding of Science' in the United States After World War II," *Public Understanding of Science*, 1992, 1:45-68; and Brian Wynne, "Public Understanding of Science," *Handbook of Science and Technology Studies*, edited by Sheila Jasanoff (Thousand Oaks, CA: Sage Publications, 1994), 361-392.

[6] Susan G. Davis, *Spectacular Nature: Corporate Culture and the Sea World Experience* (Berkeley, CA: University of California Press, 1997), especially pp. 117-151 where she focuses on the educational aspects of the theme park; Gregg Mitman, *Reel Nature: America's Romance with Wildlife on Film* (Cambridge, MA: Harvard University Press, 1999); John M. Findlay, *Magic Lands: Western Cityscapes and American Culture after 1940* (Berkeley, CA: University of California Press, 1992), 52-105. For 'Science Centers' see John G. Beetlestone, Colin H. Johnson, Melanie Quin, and Harry White, "The Science Center Movement: Contexts, Practice, Next Challenges," *Public Understanding of Science*, 1998, 7:5-26.

problems of the modern age seemed to be no longer theological, but rather ideological and technical. Only a scientifically literate society, it was assumed, could successfully navigate the technological obstacles faced by modern, resource consuming societies.[7] Recent scholarship has characterized mid-century public understanding of science efforts as the "deficit model," since the main thrust lay in expanding knowledge of scientific concepts as well as appreciation of the overall scientific enterprise among the general public. Reducing the public's deficit of scientific knowledge would invariably produce a more civil and productive public discourse.[8] It was in this idealistic, optimistic, atmosphere that Ray pursued the science popularization aspects of her professional career. And it was in this area, informed in certain instances by her traditional

[7] It was a commonly held notion that human progress had occurred from mythical, to religious, and finally to rational thought, such as in the work of Henri Frankfort, *Before Philosophy: The Intellectual Adventure of Ancient Man: an Essay on Speculative Thought in the Ancient Near East* (Baltimore, MD: Penguin Books, 1964), especially the conclusion, "The Emancipation of Thought from Myth." These ideas are also prevalent in Julian Huxley's writings on "evolutionary humanism," such as the chapters "The Humanist Frame" and "Education and Humanism" in *Essays of a Humanist* (New York, NY: Harper and Row, 1964), 72-146; Lancelot Hogben, *Science for the Citizen: A Self-Educator Based on the Social Background of Scientific Discovery* (New York, NY: A. A. Knopf, 1938), 1131. Here Hogben concludes his Marxist-influenced primer on science for the common man by stating that "Advancing scientific knowledge has swept away many beliefs which sustained popular aspirations in the formative stages of modern democracy. The providential dispensation which endorsed the same plan of governance for Church and State, the mythology of the Beautiful Savage and metaphysical libertarianism with its hypertrophied insistence on the diversity of personal preference, do not belong to the century in which we are living. In their place modern science offers us a NEW SOCIAL CONTRACT (sic). The social contract of scientific humanism is the recognition that the sufficient basis for rational co-operation between citizens is scientific investigation of the common needs of mankind."

[8] See special issue of *Public Understanding of Science*, "Science Meets the Public," 1993, 2:285-426. Of particular note is Gerald Holton's essay, "Can Science Be at the Center of Modern Culture?" where, as in other recent publications, he mounts a vigorous defense of what I describe here as the dominant mid-century conception of the scientific project. (It is interesting to note that Holton served with Dixy Lee Ray on the AAAS Committee for the Public Understanding of Science in the early 1970s.) Other sources include: Roger Cooter & Stephen Pumfrey, "Separate Spheres and Public Places: Reflections on the History of Science Popularization and Science in Popular Culture," *History of Science,* 1994, 32:237-267; R. C. Curtis, "Popularising Science: Polanyi or Popper?" *Minerva*, 1991, 29:116-130; Jane Gregory & Steve Miller, *Science in Public: Communication, Culture, and Credibility* (New York, NY: Plenum Trade, 1998); Alan Irwin & Brian Wynne, eds. *Misunderstanding Science? The Public Reconstruction of Science and Technology* (Cambridge, England: Cambridge University Press, 1996).

scientific work as a marine biologist, that Ray began to enter the public debates over appropriate uses of the environment and more generally man's place in the natural world.

Science on Screen

Beginning on 7 December, 1954 Seattle area elementary and high-school students began viewing new educational television programming in their classrooms. Over the next few years students would be able to view a host of science-oriented programming. With a minimum of effort, students visited exotic animals at the Boston zoo, took a field-trip with a local marine biologist to observe marine life crowding the shores of Puget Sound, learned from a Manhattan Project scientist about the parts of an atom and the forces that hold them together, and discovered an essential 'scientific method' from a distinguished chemist.[9] And all of this could be accomplished without leaving the classroom. While many aspects of popular science have received considerable attention by historians,[10] the role of television and the social context in which science and television co-evolved in the middle decades of the twentieth century has received little consideration. The one notable exception is Gregg Mitman's *Reel Nature*, where in part he analyzes representations of nature in the 1950s television show *Zoo Parade* and its

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[9] The following were just a few of the programs being shown on the early educational television stations, such as Seattle's KCTS: *Discovery*, hosted by Mary Lela Grimes; *Animals of the Seashore*, by Dixy Lee Ray; *What Holds an Atom Together?*, with Edward Teller; and *Scientific Methods,* by Joel Hildebrand.

[10] Aileen Fyfe, *Science and Salvation: Evangelical Popular Science Publishing in Victorian Britain* (Chicago, IL: University of Chicago Press, 2004); and in a similar vein, James Secord, *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation* (Chicago, IL: University of Chicago Press, 2000); Louise Henson, et al., eds., *Culture and Science in the Nineteenth-Century Media* (Burlington, VT: Ashgate, 2004); James T. Andrews, *Science for the Masses: The Bolshevik State and the Popular Imagination in Soviet Russia, 1917-1934* (College Station, TX: Texas A&M University Press, 2003).

later incarnation as *Wild Kingdom.* Mitman uses these popular television programs, as well as Disney wildlife films and other nature-oriented cinematic offerings of the era, to argue that these idealizations of nature came to define the social and geographical spaces of the wild and civilized world for mid-century Americans. "Poised at the intersection of art, science, and entertainment," he writes, "natural history film would transform American perceptions of and interactions with wildlife over the course of the twentieth century."[11]

Yet, while much scholarship has analyzed the ways in which television shaped and reflected mid-century American society, historians of science have largely ignored the various ways science was portrayed on television. Nor have they explored the larger social justifications for incorporating science into the programming options on American television channels as I aim to do here by examining the boundaries where the domains of art, science, and culture meet.[12] Caroline Jones and Peter Galison, for example, have recently explored some of the ways in which art and science form a kind of "binary economy" that co-produce "culture." In this sense, it is useful to look for science in new places and to see how it has been combined within larger

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[11] Gregg Mitman, *Reel Nature: America's Romance with Wildlife on Film* (Cambridge, MA: Harvard University Press, 1999), 6. For television, see the chapter entitled "Domesticating Nature on the Television Set," where Mitman claims that some 11 million viewers watched *Zoo Parade* at its peak in 1952. The show ran from 1950 to 1957, and then in 1963 the host, a zoo worker by the name of Marlin Perkins, started the even more successful show *Wild Kingdom.* Both shows were carried by NBC.

[12] See for example: Cecilia Tichi, *Electronic Hearth: Creating an American Television Culture* (New York, NY: Oxford University Press, 1991); Laurie Ouellette, "TV Viewing as Good Citizenship? Political Rationality, Enlightened Democracy and PBS," *Cultural Studies*, 1999, 13(1):62-90; Janet Thumin, *Inventing Television Culture: Men, Women, and the Box* (New York, NY: Oxford University Press, 2004); and the two following analyses of the historical role of television in American society in *The Television Studies Reader,* edited by Robert C. Allen and Annette Hill (New York NY: Routledge, 2004): Laurie Ouellette and Justin Lewis, "Moving Beyond the Vast Wasteland: Cultural Policy and Television in the United States," and David Hutchison, "Protecting the Citizen, Protecting Society."

social or cultural projects.[13] Indeed, leaders of the public understanding of science efforts in the 1950s and 1960s often spoke of science in similar terms, believing that science along with other forms of human knowledge was constitutive of a new humanism for the modern age.

While television per se has not been extensively analyzed by historians of science,[14] this is less true of film. Gregg Mitman examined representations of the natural world in popular films by Walt Disney, and argued that these images signficantly structured and romanticized an increasingly urban public's view of the natural world. Tania Munz is currently analyzing how film figured in the research of ethologists Karl von Frisch and Konrad Lorenz. She emphasizes, in part, that establishing "the epistemological status of film as a scientific tool" encountered significant obstacles in professional circles while, with the general public, film helped to establish ethology as a popular topic.[15] Munz's view is supported by a comment from a puzzled zoologist who noted in 1962 that films seemed to lie "in that gray zone between the strictly

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[13] Caroline A. Jones and Peter Galison, "Introduction," *Picturing Science, Producing Art*, edited by Caroline A. Jones, Peter Galison, with Amy Slatton (New York, NY: Routledge, 1998), 1-23, quotations from page 20. Other useful sources in this vein include N. Jardine, J. A. Secord, E. C. Spary, eds., *Cultures of Natural History* (Cambridge, England: Cambridge University Press, 1996); Lorraine Daston, ed., *Things that Talk: Object Lessons from Art and Science* (New York, NY: Zone Books, 2004); and Peder Anker, "The Bauhaus of Nature," *Modernism/Modernity*, 2005, 12:229-251.

[14] This is likely an artifact of the difficulty of locating television shows from the 1950s and 1960s which, especially for smaller television programs (such as were produced by non-commercial stations) were seldom archived, and were in fact often taped over. Analysis of current science television content, and how science is portrayed, is quite common, such as H. M. Collins, "Certainty and the Public Understanding of Science: Science on Television," *Social Studies of Science*, 1987, 17:689-713; and Marcel C. LaFollette, "Science on Television: Influences and Strategies," *Daedelus*, 1982, 111(4):183-198. Similarly, many social scientists have studied stereotypical portrayals of scientists on television, such as Marilee Long, et al., "Gender and Racial Counter-Stereotypes in Science Education Television: A Content Analysis," *Public Understanding of Science*, 2001, 10:255-269.

[15] Tania Munz, "Birds, Bees, Lights, Camera, Action: Karl von Frisch, Konrad Lorenz and the Behavior of Animals on Film," talk delivered at the 2004 History of Science Society meeting, Austin TX. View abstract online at: http://www.hssonline.org/meeting/program/archiveprogs/abstracts.pdf (viewed 25 Aug 2005)

scientific and the strictly arty." Yet, in the proliferation of zoological films over the preceding decade, not all of which seemed sufficiently scientific, this zoologist had to concede that he had seen "remarkable footage on the behavior of the stickleback" that lent credence to the work of ethologists.[16]

In general, this body of research by historians, philosophers, and sociologists is primarily concerned with understanding how film has been used within the research projects of scientists, or how film served as another means of communicating scientific knowledge to colleagues, patrons, and the wider public. Yet, much interesting work has been done on the intersection of science and film by scholars outside the history of science. Using analytic tools from cinema studies, for example, Alison Griffiths' examination of anthropological film deconstructs the "natural" representations made by the camera while also contextualizing the introduction of this new media into the accepted methodologies of a profession.[17] In addition, the portrayal of scientists in film has been the subject of critical study, exploring and critiquing the various but limited roles they play within the various genres of film.[18]

Some films on broadly scientific topics had gained notable recognition from the general public by the 1950s. Julian Huxley's film, *The Private Life of the Gannet* (1934), won numerous awards, including an Academy Award for Best Short Subject in 1938 after being picked up by

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[16] This comment came in response to a proposal for a "Zoological Theater" at the 1963 International Congress of Zoology. Letter from Gairdner Moment to John Moore, 1 Feb 1962. Box 5, Folder "ICZ Jan-March 1962," Alfred Romer papers, HUGFP 89.10, Harvard University Archives.

[17] Alison Griffiths, *Wondrous Difference: Cinema, Anthropology, and Turn-of-the-Century Visual Culture* (New York, NY: Columbia University Press, 2002).

[18] Roslynn D. Haynes, *From Faust to Strangelove: Representations of the Scientist in Western Literature* (Baltimore, MD: Johns Hopkins University Press, 1994); Scott D. Frank, *Lab Coats in the Dream Factory: Science and Scientists in Hollywood* (PhD, University of Southern California, 2002).

20th Century Fox's educational division and distributed to an American audience.[19] Rachel Carson's filmed version of *The Sea Around Us* garnered the Academy Award for Best Documentary in 1953, bringing even more recognition to Carson as one of America's best science writers.[20] Three years later another film about the oceans enthralled audiences the world over. Jacques-Yves Cousteau's first major underwater film, *The Silent World*, made with the assistance of the young Louis Malle (later in the decade to become an integral member of the French New Wave cinema movement), brought an adventuring oceanographic sensibility to the screen.[21] Cousteau's story of underwater exploration, with its stunning views of marine life, captivated viewers at Cannes where it won the *Palme d'Or,* and Hollywood judges as well who voted it the year's best documentary film in 1956.

One reviewer gushed that "this account of oceanographic exploration on and below the surface of the sea is surely the most beautiful and fascinating documentary of its sort ever filmed." In nature films that had tended to compromise authenticity in favor of story, especially those of Walt Disney, this science-oriented film gave the audience a vivid and yet unsentimental view of nature. In a riveting scene, Cousteau's crew bludgeoned to death an offending shark that

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[19] For broader discussion of Huxley's efforts at science popularization, see Daniel J. Kevles, "Huxley and the Popularization of Science," *Julian Huxley, Biologist and Statesman of Science,* edited by C. Kenneth Waters and Albert Van Helden (Houston, TX: Rice University Press, 1992).

[20] Carson's Pulitzer prize winning book, *The Sea Around Us*, appeared at the top of *The New York Times* bestseller list for thirty-one weeks after its publication in 1951 and won the National Book Award in 1952 among many other distinctions. Rachel Carson, *The Sea Around Us* (New York, NY: Oxford University Press, 1951). For biographical study of Carson and descriptions of the reception of *The Sea Around Us*, see Linda Lear, *Rachel Carson: Witness for Nature* (New York, NY: Henry Holt, 1997), 154-228.

[21] In 1958 Louis Malle produced *The Lover*, a significant film within French cinema's movement known as La Nouvelle Vague, a movement to reinvigorate the visual style of film and to make films that reflected a truer expression of a director's artistic vision. In this light it is not inconsequential that *The Silent World* was one of Malle's first films.

had begun to feed on an injured baby whale. This struck the reviewer as admirably authentic and led him to conclude that "Captain Cousteau and his leading associate, Louis Malle, have filmed with an integrity of events and in colors that are irreproachable. Like true scientists, they've eschewed trickery."[22] Cousteau would go on to produce numerous other films on sea life, as well as the popular television series, *The Undersea World of Jacques Cousteau*, which promoted marine conservation and made the Calypso a recognized feature of the environmental movement.

As television increasingly reached into American living-rooms and provided a smorgasbord of visual stimulation, civic and intellectual leaders worried that commercial stations lacked (and had little incentive to produce) culturally and intellectually invigorating material. Early commentators had optimistically seen "the beginning of a new era." In 1948 a *New York Times* editorial recommended that television should be utilized as the next great tool for improving the general public's knowledge of art and science. "If television is in its infancy, education in television must be described as hardly out of the delivery room. Nevertheless, the first, hesitant steps toward solid programming are already being taken." In the future, television could place every citizen "at the eye of the telescope, of the laboratory microscope, in the steel mill, in the halls of government, in the shipyards and the factories, vitalizing the world of which our children are trying to learn. ... Is it not too much to hope that sometime not too long distant that genius, the occasional very inspiring teacher who is remembered by students throughout their lives, will convey his inspiration through the television camera into many classrooms instead of one?" This possibility suggested a "great new challenge" for a better future. As

[22] Bosley Crowther, review of *The Silent World*, 25 Sept 1956, *The New York Times*.

television came "out of the barroom into the home," the writers cautioned that now was a time to "make no small plans."[23]

This kind of concern eventually led Congress to pressure the Federal Communications Council to set aside new channels specifically for educational television. Hearings at one congressional committee in the spring of 1951 began by stating that "many informed civic and educational groups have expressed deep concern that the tremendous potential promise of television for public service will not be realized unless present trends and policies are quickly altered."[24] A *New York Times* editorial, published the day of the hearings, urged Americans not to ignore this particular congressional action. Rather, since the educational uses of television required the nation's utmost attention and concern, senators and representatives needed to hear of Americans' desire for non-commercial television.[25]

Whether many Americans really did want more enlightening programs on their televisions is questionable. But civic leaders and major philanthropies, concerned with the overall quality of American life, firmly believed television could be used as a tool for social improvement. In a report entitled "A New Vision for Television," a Ford Foundation committee suggested that "The progress achieved [toward making education television a reality] is a tribute to the perception of Americans who have recognized the potential of television as a tool for adult

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[23] "Television and Education" editorial in *The New York Times*, 29 Dec 1948, 20.

[24] "Use of Television Frequencies for Educational Purposes," 1-2. Tuesday, 31 May 1951, Senate Committee on Interstate and Foreign Commerce.

[25] "Television and the Schools," *The New York Times*, 31 May 1951, 24.

and child education, plus entertainment, that is stimulating and leaves a residue of knowledge."[26] Turning television into a tool for education and social betterment seemed urgent. The possibility of television's continued pandering to low culture, and the subsequent disintegration of American society, loomed large in the imagination of American leaders. A former director of New York's Metropolitan Museum of Art believed that "television is to the American Renaissance what the invention of printing was to the Renaissance in Europe." However, "what kind of consciousness will be developed, nobody can predict" he added. A Ford Foundation grant administrator used this statement to stress that American society could just as easily slide "towards disintegration and revolution,... towards listless ignorance and a nationally jaded taste." Yet, with progressive intervention, television might propel society "towards higher standards of living and stability, towards the growth of knowledge and a more cultured civilization."[27]

Some of the motivation for Congress's inquiry into the educational uses of television came from developments of the previous few years. Educators, academics, and others concerned with the growing demands of the nation's educational systems had begun to extol the potential virtues of television for teaching in new and expanded ways. For those who enjoyed the modern comforts of their homes, one article suggested that the day was not far off when "it may be possible to earn a college degree without having to leave one's own living room." Well on the way to this utopia, the University of Michigan was just beginning a "video university" with the

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[26] National Citizens Committee for Educational Television, "A New Vision for Television," undated (probably 1953). Reel R-4171, Grant No. 530-0144, Ford Foundation Archives, New York.

[27] Ford Foundation, "Report on the TV-Radio Workshop of the Ford Foundation" 5-6. Report 010610, 1955, Ford Foundation Archives, New York.

potential to bring enlightenment to a "class of up to 1,000,000" at a time. Classes in this new offering would begin with traditional and foundational disciplines of history, the fine arts, music, and the natural sciences. Yet, the novelty of this new medium and the demands of "modern living" suggested the need for additional kinds of courses, such as "How to Buy a Home" and "How to be Happy in Later Years." With this basis in traditional and practical knowledge, television classes could introduce the common American to the more rarefied activities of the academy. Programming in this category would center on the basic research being undertaken by scientists: "classes will be taken into the research laboratories... which are usually open only to graduate students. By means of TV, the 'students' may [observe] the work that is being done by the university's various scientific expeditions which have explored such widely separated places as the frozen interior of Greenland and the jungles of Central America." This would all be accomplished, it was pointed out, without commercial sponsorship. In short, while the promise of television had so far been squandered by commercial interests, educators believed that a new opportunity may be emerging "for bringing enlightenment and understanding to a great new audience of our people."[28]

While some lamented the lack of educational television programming on commercial stations, commendable and popular examples did exist. Donald Herbert, trained in English and General Science as an undergraduate and hoping to make a career on Broadway prior to WWII, turned his career to radio and television in the early post-war years. After working on a number

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[28] Murray Illson, "Education in Review," *The New York Times*, 20 Aug 1950, 125. Two useful histories of non-commercial television in the United States, written by participants and primarily focusing on the PBS era, are: David C. Stewart, *The PBS Companion: A History of Public Television* (New York, NY: TV Books, 1999); and James Day, *The Vanishing Vision: The Inside Story of Public Television* (Berkeley, CA: University of California Press, 1995).

of children's programs, Herbert introduced one of the most popular science-oriented shows in 1951 called *Watch Mr. Wizard* on NBC. Performing primarily physics and chemistry experiments, with live assistance from children, Herbert's long-running show spawned some 5,000 Mr. Wizard Science Clubs around the nation and could boast of more than 100,000 members. Noting the show's success, the National Science Foundation and the American Chemical Society lauded Herbert for making science interesting and accessible to children.[29] At the same time, New York's Museum of Natural History produced an award winning natural history program, *Adventure*, hosted by Charles Collingwood and Mike Wallace that drew upon the extensive library of film being created by the museum. Museum leadership had, as Alison Griffiths points out, urged their scientists to make full use of film while doing field work around the world. In its Peabody Award citation of 1954, the show was described as a "lucid and intelligent blending of science and showmanship."[30]

Yet, even with these successful and clearly educational offerings, many felt that commercial television programmers simply did not possess sufficient motivation to deliver consistently enlightening fare. Roger Revelle, director of the Scripps Institution of Oceanography and a regular on any number of Washington DC panels, likened commercial

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[29] Joel Sternberg, "Watch Mr. Wizard," *The Encyclopedia of Television* (Published by The Museum of Broadcast Communications, online at http://www.museum.tv/archives/etv); Marc Weingarten, "When Science was Simple: Watching Mr. Wizard," *The New York Times,* 27 June 2004, Arts Section, 17.

[30] See Peabody Award information online at http://www.peabody.uga.edu/archives under "Adventure" (1954); Griffiths, *Wondrous Difference*, 255-275. Another program, *Omnibus*, funded by the Ford Foundation but aired on commercial television, incorporated science into what was portrayed as a "serious" program covering theatre, music, science, literature, and other areas of high-culture. *Omnibus* began airing weekly in 1952 with Alistair Cooke as host, his first U.S. television appearance. "Report on the TV-Radio Workshop of the Ford Foundation," 1955 Ford Foundation Archives, Report No. 010610, Ford Foundation Archives, New York.

television to original sin. "My justification for taking a somewhat pessimistic view of commercial television is basically a Christian one," he told a panel of Federal education experts. "Man is not only partly divine; he is also partly an animal," he continued, which led him to believe that in certain situations humans were, by nature, drawn to base, violent, and degrading features of life. "Commercial television in general," Revelle concluded, "brings out the very worst in people. There is some fundamental sinfulness about the medium." On the other hand, Revelle expressed himself as "wholeheartedly in favor of educational television as a revolutionary teaching aid."[31]

Acknowledging the demand for non-commercial television, the FCC opened new frequencies exclusively for educational, non-profit use in 1952. Encouraged by funding from the Ford Foundation's Fund for Adult Education, and from such sources as the Emerson Radio and Television corporation, new non-commercial stations began popping up around the country in the early 1950s such as KCTS in Seattle. With the start of the Puget Sound's new non-commercial television station, cooperatively sponsored by the Seattle Public School district, the University of Washington, and Seattle Pacific University, a need arose for programming.[32]

Sometime within the first few months of operation, station programmers asked Dixy Lee Ray if she would be willing to create a biology program. Naturally, as a person having already

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[31] "Testimony by Roger Revelle," *Educational Television - The Next Ten Years: A Report and Summary of Major Studies on the Problems and Potential of Educational Television, Conducted Under the Auspices of the United States Office of Education* (Palo Alto, CA: Stanford University Institute for Communication Research, 1962), 88-89.

[32] As one of the first 10 licensed non-commercial stations to begin broadcasting, KCTS received $10,000 from Emerson Radio & Television. They also received over $120,000 worth of equipment from a local commercial television station (KING), with matching funds from the Fund for Adult Education (Ford Foundation). See Homer Ernest Howard, *Present Practices in and Suggested Improvement of Elementary Educational TV in Seattle School District Number One* (MA Thesis, Seattle Pacific College, 1963), 3-15.

achieved some publicity as an expert on Puget Sound marine life, hers would be a program on the animals to be found at the sea shore.[33] Borrowing a title from a previously published guide to Northwest marine life, written by Muriel Guberlet (wife of the zoology department's long-time invertebrate zoologist), Ray's *Animals of the Seashore* began airing on KCTS in the autumn of 1955.[34] Initially composed of eight 20-minute episodes, on which "she spent a great deal of time," this program was broadcast repeatedly in its first year, and according to a zoology department newsletter, garnered "such a favorable reception that [Ray] is being urged to prepare a new script for their use at a more advanced level."[35]

With the recognition that excellent programming could be difficult to produce locally, especially by cash-strapped non-commercial stations, the Ford Foundation spearheaded a national clearing-house for programs. Called the National Education Television Center, and based initially in Ann Arbor, Michigan, the Ford Foundation provided funds for exceptional local programs to be made available to other stations through a national education television network. In all, the Ford Foundation poured over $45 million into television program

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[33] A short 1952 newspaper article introduced Dixy Lee Ray to Seattle area readers as a "University of Washington expert on marine life" and used her as a guide to the "vast natural aquarium" of Puget Sound, offering "countless opportunities for study" of marine creatures on Seattle beaches. Lucile McDonald, "Millions of Creatures Thrive on Pacific Northwest Beaches, says U. W. Expert on Puget Sound Marine Life," *The Seattle Times*, Sunday 6 July 1952, Magazine Section, 3.

[34] Muriel Guberlet, *Animals of the Seashore: the Common Seashore Animals of the Pacific Northwest.* Initially published by Metropolitan Press of Portland, Oregon, in 1936, it was revised and reprinted in 1949 and 1962 and was considered a local classic by members of the Friday Harbor Laboratory community.

[35] Department of Zoology Newsletter (No. 9), May 1956, 58. Box 20, Folder "34." **Edmondson**.

development from 1952 through the end of the decade.[36] As one of the many recipients of this largesse, Ray re-worked and expanded *Animals of the Seashore* into fifteen 30-minute programs.[37] Drawing on the major marine ecological zones presented in Rickett's *Between Pacific Tides*, and on which Ray developed her popular field course "Natural History of Marine Invertebrates," the television program introduced viewers to the various ways in which life adapted to the dominant physical environments of the inter-tidal zone.[38] Beginning with an overview of animals likely to be encountered at local beaches during low or high tides, Ray proceeded to describe how the different communities of organisms were adapted to living in protected rocky shore environments, on muddy or sandy beaches, and on beaches exposed to constant and violent wave action. In other programs she took viewers on an oceanographic expedition into deep Puget Sound waters, dredging up organisms from well below areas accessible to waders and divers. While no explicit discussions of scientific concepts took place, Ray continually emphasized the ways in which organisms had become adapted to particular ecological niches over countless generations.[39]

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[36] "Ford Foundation Activities in Noncommercial Broadcasting, 1951-1976," 23. Ford Foundation Publication, LC 76-24968, Ford Foundation Archives, New York.

[37] Department of Zoology Newsletter (No. 10), June 1957. Box 1. W. U. Zoology Department, Accession No. 89-83. University of Washington Archives, Seattle.

[38] The program's teacher's guide included a list of suggested readings to complement the show, including Rickett's *Between Pacific Tides*. For children, Ray suggested Guberlet's *Animals of the Seashore.* Teachers Guide to *Animals of the Seashore: A Series of Science Programs for Grades 4-5-6* (Produced by Seattle Public Schools). Original program date, Tuesdays, beginning 27 Sept 1955. Box 1, Folder "Teachers Guides, 1955-56," Accession W. U. KCTS-TV (#82-153), University of Washington Archives, Seattle.

[39] Ibid.

Exactly how and why Dixy Lee Ray became involved in creating a program for KCTS is unclear, but two factors certainly would have played major roles. First, Ray displayed a lively and engaging teaching style. Her ability to perform before a live audience had been honed as a young adult, first with puppet shows and later as regular participant in drama productions at Mills College. These kinds of performance skills were relatively rare among full-fledged scientists. In early science-oriented television programs the most successful personalities, such as Don Herbert of *Watch Mr. Wizard* and Marlin Perkins of *Zoo Parade*, were non-scientists. Indeed, *Zoo Parade* emphasized Perkins' "hillbilly" background. As Mitman argues, "The explicit rural, anti-intellectual connotations of 'hillbilly' foregrounded experiential knowledge over scientific training."[40] This approach appealed to average American viewers, whose impressions of scientists as cold and impersonal were often reinforced by lifeless presentations of science-oriented programming. For the Seattle educational station, the search for engaging television talent became a high-priority. There seemed to be a dearth of expert teachers, scientists or otherwise, who exhibited a flair for television performance. A survey of Puget Sound teachers showed that a high priority should be placed on locating "teachers with effervescent personalities and pleasing voices" and that it would perhaps be best to "hire actors and actresses to present the lessons."[41] A 1962 report on educational television in Seattle stated that "television teacher selection" needed to be a higher priority in order to obtain highly qualified instructors who would also display "television ability or potential." The report singled out Ray and her program as the best example of using talented local experts for science

[40] Mitman, *Reel Nature*, 139.

[41] Howard, *Present Practices,* 54.

programming.[42] In this context, Ray's experience as a professional scientist, her engaging presentation style, and her willingness to participate in public science endeavors allowed her to excel in this new project.

This program also helped to elevate Ray's recognition among a generation of Northwest residents, if not nationally. In a letter to a Smithsonian zoologist interested in showing the film to his colleagues, one National Education Television representative noted that Ray's program had been receiving national exposure. "You may be interested in knowing that this [*Animals of the Seashore*] has proved to be a very useful series for nearly all of our forty-six affiliated ETV stations across the country," the representative observed. Explaining that many stations had aired the program multiple times, he concluded that "It has proved to be interesting to a broad general audience of ETV viewers, and also as enrichment material for transmission into classrooms to supplement in-school instruction."[43]

However, the advent of non-commercial educational television by no means put an end to the national worry over the content of American television programming. By the end of the 1950s leaders continued to portray the situation as poor. Alan Waterman, director of the National Science Foundation, a person charged with promoting the sciences on all fronts, complained of an "overdose of soap operas, shoot-em-up Westerns and glib-tongued emcees of empty entertainment." What America desperately needed, he urged, was more programming that

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[42] "Citizen's Advisory Committee on Television in Education," *Report to Seattle Public Schools* (1962), 18, 19, 57. Catalogue Number: 055.026, Seattle School District Archives. Seattle WA.

[43] Letter from James Robertson (Director of Station Relations, National Educational Television and Radio Center) to Dr. Waldo Schmitt (Zoology Division, Smithsonian Institution) 25 April 1960. Box 28, folder "Ray, Dixie Lee, 1956-1960." Collection 7231: Manuscript Collections; Waldo Lasalle Schmitt papers, 1907-1977, **Smithsonian.**

"appealed to the mind as distinguished from those that appealed to the emotions."[44] Accordingly, the numerous stations comprising the National Education Television system began to provide a new venue for science-oriented programs, such as Ray's, which paved the way for some of the most influential programs of later decades. Jacques-Yves Cousteau's program devoted to the marine environment, Jacob Bronowski's *The Ascent of Man*, and Carl Sagan's *Cosmos* all became prominent public television programs in their own right, but they were preceded by a host of smaller, often less widely recognized, programs designed to elevate American's understanding and appreciation of science.

Ray took a hiatus from television work during her time in Washington DC and her first few years at the Science Center. However, beginning in 1967 Ray again appeared on KCTS in a weekly program on oceanography. Finding this to be a success, KCTS made the show a permanent part of its weekly schedule, beginning on Christmas Day, 1967, with the first installment of *Doorways to Science*. Unlike the original episodes, Ray's program would now focus on a variety of science-related topics. That first installment, timed with the holiday, discussed astronomical events that could account for the observations of the star of Bethlehem. This would be followed by programs covering such topics as ancient Greek mathematics, the

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[44] Associated Press, "Scientist Deplores 'Empty' TV Shows," *The New York Times*, 7 Nov 1959, 13. At the same time, the Presidential Science Advisory Committee in 1959 reviewed the nation's overall science education strategies and issued a report stating that much more could be done in promoting effective teaching of science and technology in American classrooms. Particularly, Americans needed to "learn to use effectively every possible teaching aid, including television [and] motion pictures." In accord with earlier hopes, it was believed that better use of television would bring "the great teacher ... before an even larger number of students" and thereby strengthen American science. "National Goals for Strengthening Science and Engineering Education," cited from "Text of Summary by Science Advisors," *The New York Times*, 24 May 1959, 74.

biological basis of circadian rhythms, and "space biology."[45] The popularity of this show helped Ray become a recognizable authority on science in the Puget Sound, called on to identify strange marine organisms, explain the effects of increased water temperature on marine life, and promote anti-littering campaigns around the state. For many Puget Sound residents, *Doorway's to Science* brought the return of a much beloved figure who delivered a "highly interesting and informative program" on her "frequent visits to our living room."[46] This set Ray apart from most of her scientific colleagues.[47]

In all, Ray succeeded on television in part for her convincing, authoritative, yet somehow endearing style of presentation. On a medium requiring a particular (and rather indefinable) blend of physical and expressive attributes, one viewer described her television presence in these terms:

> She is wonderfully articulate and persuasive. She doesn't have the air of malevolence that so many academics shed on TV. ... She has a friendly quality about her, an air of good humor, and a crisp intellectual approach. She doesn't talk down to the public and her syntax is untangled. She does make long answers but what she says is logically constructed and a pleasure to follow. Her smile is ingratiating in the nicest sense. Her voice is pleasant both on radio and

[45] Pacific Science Center Annual Report, 1967. Records held at Pacific Science Center.

[46] Quotations come from Lucille Palmer, 13 June 1969. All correspondence found in Box 48, in chronological folders, **DLR**. Naturally, much of the correspondence generated by her television appearances dealt with questions concerning marine life. And, reminding us once again of the gastronomic theme in Ray's life, her most memorable show (if volume of letters is a reliable gauge), came from an episode in which Ray made her famous bouillabaisse. In doing so she instructed viewers on how and when to collect the best seafood from Puget Sound beaches.

[47] For the argument that a small but growing number of scientists were finding success on the public stage as authoritative voices on science and policy, see Rae Goodell, *The Visible Scientists* (Boston, MA: Little, Brown & Co., 1977).

> TV and she speaks out or enunciates clearly without losing her voice at the end.[48]

Utilizing these qualities to relatively new ends, Ray explored ways in which scientists could advance their careers along the well-established path of science popularization but in a thoroughly modern context. As feminist scholars have pointed out, women scientists commonly devised innovative strategies for building their professional careers. In this sense, Ray's adventures in science television must also be acknowledged as another effective tactic employed by a female scientist who wanted to participate in the life of science.[49]

Television promised lives of increasing leisure, of comforts, of ready entertainment. It also seemed to offer an opportunity to bring high culture into the living rooms of every family. Non-commercial television, spearheaded by such socially concerned philanthropies as the Ford Foundation, began to deliver on the vision in ways that commercial television seemed less capable of doing. And in this, science played an important part based on the belief that modern civilized society required a deep knowledge of how the natural world worked. As Warren Weaver argued in his essay *Science and the Citizen*, "No longer is it an intellectual luxury to know a little about this great new tool of the mind called science. It has become a simple and plain necessity that people in general have some understanding of this, one of the greatest of the

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[48] Letter from Ray Owen to Ray, 31 Dec 1973. Box 9, Folder "Ray Owen." **DLR**.

[49] Of the many good sources on women scientist's innovative career strategies, see the essays in *Uneasy Careers and Intimate Lives: Women in Science, 1789-1979*, edited by Pnina G. Abir-Am and Dorinda Outram (New Brunswick, NJ: Rutgers University Press, 1987); Mary Frank Fox, "Women and Scientific Careers," *Handbook of Science and Technology Studies* (Thousand Oaks, CA: Sage Publications, 1994), 205-228; and for a case-study that focuses on marine biology, Marianne Gosztonyi Ainley, "Marriage and Scientific Work in 20th-Century Canada: The Berkeleys in Marine Biology and the Hoggs in Astronomy," 143-155, *Creative Couples in the Sciences*, edited by Helena M. Pycior, et al., (New Brunswick, NJ: Rutgers University Press, 1996).

forces that shape our modern lives." Yet this knowledge, in turn, disciplined the citizen and aided in producing enlightened society. Weaver continued, "without some of this [knowledge of science] we simply cannot be intelligent citizens of a modern free democracy, served and protected by science. Without this we will not know how to face the modern problems of our home, our school, our village, state, or nation."[50]

Living Science

With science providing the bedrock of modern civilization, as Weaver and others would have it, Cold War America entered a period in which the federal government supported science to an unprecedented degree and in which science was presented to the American people as a kind of utopian future. As Vannevar Bush termed it at the end of World War Two, science represented an "endless frontier" of the mind, a frontier superior in all ways to the western frontier that had imbued Americans with an adventurous spirit. In the coming age, this adventurous spirit, guided by the disciplines of science, could lead a free people to a promised land of plentiful "jobs, higher wages, shorter hours, more abundant crops, more leisure for recreation, for study, for learning to live without the deadening drudgery which has been the burden of the common man for ages past." In this utopian future, even the dread of disease would be relieved by science.[51]

Television provided one means to communicate this good news to the general public. It could bring science into the living rooms of Americans from Maine to California. But outside the home, and outside of the classroom, science could be presented in the public square to the

[50] Weaver, "Science and the Citizen," 1226.

[51] Vannevar Bush, *Science the Endless Frontier: A Report to the President* (Washington, DC: National Science Foundation, 1990. Originally published July, 1945), 5.

common citizen in other forms such as museums or, since the latter half of the nineteenth century, as part of World's Fair extravaganzas.[52] In the early 1960s, the Seattle World's Fair began with a distinct focus on science and ended by converting the science exhibits into a permanent museum. Or, as will be discussed below, regional leaders created a "Living Science Center." Museums, they believed, encouraged the passive viewing of objects such as stuffed birds and old, out-of-date scientific instruments, that seemed unacceptably passé in modern public science education. As a Seattle resident with a growing reputation as an effective science communicator, it is hardly surprising that Dixy Lee Ray became involved in advising the content creation for the United States Science Exhibit and in their conversion into a permanent Science Center.

The Fair's overall focus on science resulted from the convergence of two groups' visions for science and the future. Seattle area promoters thought a theme which illustrated the wonders and promise of science and technology for the twenty-first century would captivate a wide audience. At the same time "a small group of scientists" had become increasingly "disturbed at the lack of U.S. popular understanding of science, and [were] anxious to do something to

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[52] For museums, see David Livingstone, *Putting Science in its Place*, 20-40; Sally Gregory Kohlstedt, "Curiosities and Cabinets: Natural History Museums and Education on the Antebellum Campus," *Isis*, 1988, 79:405-426; Thomas K. Simpson, "Abode of the Modern Muse: The Science Museum," *Great Ideas Today*, 1998, 3-66. For World's Fairs, see *Fair Representations: World's Fairs and the Modern World*, Robert W. Rydell and Nancy Gwinn, eds. (Amsterdam: VU University Press, 1994), particularly the essay by Brigitte Schroeder-Gudehus and David Cloutier, "Popularizing Science and Technology during the Cold War: Brussels 1958;" Peter J. Kuznik, "Losing the World of Tomorrow: The Battle Over the Presentation of Science at the 1939 New York World's Fair," *American Quarterly*, 1994, 46:341-373. Also pertinent for discussions of the zoo as a quasi-scientific site for learning about aspects of the natural world, *New Worlds, New Animals: From Menagerie to Zoological Park in the 19th Century*, R. J. Hoage and William A. Deiss, eds. (Baltimore, MD: Johns Hopkins University Press, 1996).

strengthen public support of scientific research."[53] The successful launch of Sputnik in 1957 cemented the relationship and ensured that the federal government would generously fund a science exhibit for the 1962 spectacle in Seattle. Quickly, scientists from across the nation were recruited to advise and oversee the project. Under their complete control, and learning lessons from an apparently unsuccessful science-themed Brussels World's Fair of 1958 (in which "professors produced exhibits of interest only to other professors"[54]), American scientists decided that "the exhibits must deal with science not in terms of technology, but as an adventure of the mind, as man's effort to understand the universe." According to those designing the exhibits, a presentation focusing on the conceptual foundations of science, and implicitly placing material benefits in a secondary position, would "appeal to the general public."[55] No doubt this approach resonated with certain mainstream American socio-political views as well.

But not with everyone. Robert Heinlein, having emerged through the decade as one of America's most popular science fiction writers, took exception to the overall idealism of the exhibits. Heinlein's fiction, well grounded in the scientific developments of the time, explored the social ramifications of human space colonization and championed a libertarian ethos.[56] When asked to comment on the exhibits being planned for Seattle, he felt strongly that this

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[53] "Development of the Theme," *United States Science Exhibit, Seattle World's Fair, Final Report* (Washington, DC: U.S. Department of Commerce, 1962), 3.

[54] Donald Menzel to Fred Hoyle, 25 Nov, 1958. Papers of Donald Howard Menzel, 1931-1986, Harvard University Archives, HUG 4567.18 (correspondence relating to publications, one box), Folder 1, 1958. Hereafter cited as **Menzel**.

[55] "Development of the Theme," 4.

[56] Some of his many books include *Citizen of the Galaxy* (1958), *Have Space Suit – Will Travel* (1958), *Stranger in a Strange Land* (1961), and *The Moon is a Harsh Mistress* (1965), the latter two winning Hugo Awards and now considered science fiction classics.

portrayal of American science should fully illustrate the "impact of military requirements on the progress of technical arts and basic science." Recognizing that this was not being considered by the scientists as they devised exhibits centered on the intellectual adventure of science, Heinlein expressed his disdain for the naïve utopian exhibits that, in his opinion, would be presented in Seattle. In a letter to Donald Menzel, Heinlein explained his disappointment with the overall tenor of the United States science exhibition:

> Whether any pure scientist likes it or not, most support for all research these days comes directly or indirectly from the needs of national defense. It may be necessary for the purposes of this fair for you to pretend that the world is an ivory tower rather than the jungle we know it to be – but I don't have to like the pretense. Bad as this world is (and it is <u>much</u> worse than most laymen realize), I prefer to look the real world in the eye and admit its existence to closing my eyes and pretending that it is something else, closer to heart's desire. ... Wouldn't there be something rather sardonic about finding yourself at ground-zero with an exhibit which portrays nothing but sweetness & light? Is there not possibly some professional obligation to make scientific exhibition consonant with the world as we know it to be rather than with a world that is <u>not</u> and which cannot legitimately be extrapolated from the world we know? ... [This] strikes me as wishful thinking of the worst sort – more of that soothing syrup that the American public has been taught to crave.[57]

This spirited and insightful critique notwithstanding, the scientists in charge of the United States exhibits could be confident that few fair-goers would bring such a critical eye to their part of the Fair, or any other for that matter. With their idealistic and intellectual theme firmly intact, exhibit designers began to fill the spaces of a massive set of "Space Gothic" buildings designed by architect Minoru Yamasaki, who a few years later would design the World Trade Center

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[57] Letter from Robert A. Heinlein to Donald Menzel, 8 Feb 1959. Folder 2, 1959. **Menzel,**.

towers in New York City.[58] The scientific designers and advisors included the neurobiologist Paul Weiss of the Rockefeller University and member of the National Science Planning Board; physicist Frederick Seitz of the University of Illinois and soon to head the National Academy of Sciences; atmospheric scientist W. Orr Reynolds, chief scientist of the Department of Defense's Office of Science; Dael Wolfl, the executive secretary of the American Association for the Advancement of Science; Dixy Lee Ray;[59] the Harvard astronomer (and occasional science fiction writer) Donald Menzel; and Athelstan Spilhaus. Spilhaus, known as the inventor of the bathythermograph (a tool to measure ocean temperatures at varying depths), had become a well-known person among science administrators and, at the time of his appointment to head the United States Science Exhibit, was also beginning his tenure on the National Academy of Sciences Committee on Oceanography, along with Ray. Beyond the scientists, exhibit creators

[58] Yamasaki grew up in the Seattle area and earned a degree in architecture from the University of Washington in 1934 before moving to New York and establishing himself as one of the more important architects of the era. For discussions of the Fair's overall architecture and design see James Gilbert, *Redeeming Culture: American Religion in an Age of Science* (Chicago, IL: University of Chicago Press, 1997), especially chapter entitled "Space Gothic in Seattle," 297-319; John Findlay, *Magic Lands: Western Cityscapes and American Culture after 1940* (University of California Press, 1992), 215-230. Also, Robert W. Rydell, John E. Findling, and Kimberly D. Pelle, *Fair America: World's Fairs in the United States* (Smithsonian Institution Press, 2000), 100-104; Murry Morgan, *Century 21: The Story of the Seattle World's Fair, 1962* (Seattle, WA: Acme Press, 1963).

[59] Unfortunately, Dixy Lee Ray's papers do not record what her role was in designing, advising, or critiquing the exhibits. As with most of the others in this list of scientific advisors, it is only clear that they served on the "Science Advisory Committee for the Federal Science Exhibits." Ray did, however, record a short description (essentially an advertisement) of the United States Science Exhibit to be played on television. The film clip is held by the Museum of History and Industry, Seattle WA, as part of their Seattle World's Fair collection. Among archives visited, only Donald Menzel's papers contain correspondence providing a glimpse of the scientist's involvement and interest in particular facets of the science exhibits.

brought in the famous design team of Charles and Ray Eames[60] to provide their truly American style to the displays.

Viewers entered the United States Science Exhibit in the "House of Science," an oval room in which the grand narrative of science was presented as a collage of images. Using a multimedia format that would be increasingly associated with their design methods, Charles and Ray Eames constructed a system of seven projectors to splay images of science continuously on the curved wall, illustrating the long construction and refinement of knowledge in the form of an ever-expanding but orderly structure, at once organic and humanly contrived. The closing scenes included a summary narrative designed to set the tone for the viewers' continued tour of the sciences. "Science is essentially an artistic or philosophical enterprise carried on for its own sake," the narrator explained. "In this it is more akin to play than to work. But it is quite a sophisticated play in which the scientist uses nature as a system of interlocking puzzles." Then, suggestive of the ways in which science could help to mold a cohesive, productive, and civil world, the narration continued by affirming the rationality of science (and the scientist), his – always his[61] – consistent use of experimentation and cautious theory formation, and "his desire to

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[60] Charles and Ray Eames were probably best known for designing modern home and office furniture in the 1950s and 1960s, such as their mass-produced molded ply-wood or plastic chairs. For an in-depth description of the couple's various interests, including their interest in the development of science and technology, see the Library of Congress's online exhibition, "The Work of Charles and Ray Eames: A Legacy of Invention," http://www.loc.gov/exhibits/eames/eameshome.html (viewed 5 Oct 2005).

[61] Not surprisingly, the gendered ideal of 'the scientist' could be seen throughout the exhibit. Though the intent was, largely, to attract many more young people to science, the exhibits did so in ways that re-enforced the gendered roles thought to be appropriate. The narration throughout the exhibits seem to have used the masculine pronoun, and images of scientists were (as far as I can determine) all of men, yet the actual guides and demonstrators were all young women. These women were, however, never identified as "scientists," as in the following description of "The Modern Laboratory." "No science exhibit would be complete without showing what the interior of a laboratory might look like. A demonstration laboratory shows four girl technicians at work with various biological experiments ...

reach out with his mind and his imagination to something outside himself."[62] With this inspiring and ennobling message, fair-goers proceeded on to the remaining exhibit buildings.

The grand sweep of the history or development of science encapsulated the second building, portraying man's basic curiosity as the foundation of knowledge and then explaining how certain men, from Galileo, to Darwin, and up to the men of the present, had systematically refined and disciplined their practices of gathering knowledge. To scientists, this exhibit was important, although it had the possibility of being rather dry. It needed to be followed by something a bit more exciting. As a result of his experiences at the 1958 Brussels Fair, the British astronomer Fred Hoyle suggested that as a "sure-fire recipe for pleasing the public ... films of anything will 'go'! Astronomers at work, launching of rockets, and so on, [but] avoid charts and diagrams like the plague."[63] With this in mind, planners provided viewers with a filmed space adventure in a domed building called the Spacearium. This fantastical journey, that took twelve minutes, sent would-be astronauts from earth to the farthest reaches of the universe and back! The journey included glimpses of exploding stars and fly-bys of distant galaxies, all portrayed "with scientific accuracy." Scientists repeatedly reminded viewers that this was "a

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[such as] irradiating living material with a cobalt 60 source.... Closed-circuit television is used throughout, and a girl narrator speaks for the technicians." See Lloyd M. Beidler, "The United States Science Exhibit at the Seattle World's Fair" *AIBS Bulletin*, Aug 1962, 39-41.

[62] Description of the exhibits, including the quotation from the "House of Science," can be found in *United States Science Exhibit, Seattle World's Fair, Final Report,* 6-34.

[63] Letter from Fred Hoyle to Donald Menzel, 18 Nov 1958. Folder 1, 1958. **Menzel**.

voyage of the imagination;" the laws of physics forbid flight at the speed required to make this "Journey to the Stars."[64]

Visitors to the United States Science Exhibit could then move through the remaining three sections. There was a rest and reflection area for the older set and a hands-on "Junior Laboratory" for children. Building Four described the Methods of Science; and the final section, the Horizons of Science, conveyed how science would structure the future of human life on earth. Here, with a digital counter representing human population growth, visitors were sent away with dual messages. On a practical level, science provided a means for greater control. "Man is getting more and more able to control things," one of the displays stated. "We may farm the oceans and control the rain to make the deserts bloom. But before we control things we must know what is going to happen." This was one benefit of science. On the other hand, real science was a pleasure in itself that all could enjoy. "Everyone can appreciate the orderly scientific approach and the delight of knowing the common laws that govern things." The most important benefits came from the way in which science led the development of a civilized, orderly, and progressive culture. Yet words from a Robert Conquest poem suggested not simply a positive aspect to science, but also the dire consequences that would come to those who remained ignorant of it.

> Pure joy of knowledge rides as high as art,
> The whole heart cannot keep alive on either.
> Wills as of Drake and Shakespeare strike together.
> Cultures turn rotten when they part.[65]

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[64] See description of the film "Journey to the Stars," in *United States Science Exhibit, Seattle World's Fair, Final Report*, 18-19.

[65] Ibid., 34. Poem entitled, "For the 1956 Opposition of Mars."

The effect of the Science Exhibits, within the general mishmash of entertainment, education, and consumption that characterized all Fairs, probably came close to the lofty aims intended by the scientists and other organizers. In their own eyes and in the eyes of the public, this attempt at science popularization largely "avoid[ed] the Scylla of dullness as much as the Charybdis of pseudo-science."[66] A contemporary writer came away aglow with the sense that science was "a delightful intellectual pursuit, a never-ending hunt for harmony and beauty."[67] With this kind of positive reception, the scientists and the local organizers had an opportunity to make the Science Exhibit a permanent part of the Puget Sound civic landscape.

Even before the official start of the Fair, regional leaders, scientists active in creating the government's science exhibit, and others began thinking of ways to permanently utilize the Science Exhibit buildings. Dr. Athelstan Spilhaus, Commissioner of the U.S. Science Exhibit, received a letter from his science advisory committee in the spring of 1962 urging him to secure funding to cover operating costs for a year following the end of the Fair. During this time the facility would be converted into an as-yet undetermined center for science education. But, even without a firm plan, proponents felt that the educational opportunities should not be wasted. Among the initial ideas offered by the science advisory committee included making it a "Smithsonian of the Northwest," a regional center for the National Educational Television

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[66] Letter from Robert A. Heinlein to Donald Menzel, 16 Jan 1959. Folder 2, 1959. **Menzel**.

[67] Morgan, *Century 21*, 15. *United States Science Exhibit, Seattle World's Fair, Final Report* (US Dept of Commerce, 1962), 49.

system, or a "Northwest Science Center" that could be used for scientific meetings as well as science-oriented exhibits.[68]

By June of 1962 Joseph McCarthy, Dean of the University of Washington Graduate School, Dixy Lee Ray, and a select group of civic leaders had begun to articulate a vision for the continuation of the Science Exhibit. Believing that the "transmission" of scientific knowledge was "now an urgent task," and that persons knowledgeable in science "are thereby better equipped to live as individuals" as well as being "more responsible citizens," these leaders argued that the best use of the facilities lay in continuing its public science education mission. Latching onto a phrase that they would later define more explicitly, McCarthy and Ray described the proposed plan as a "permanent living Science Center." In a grant application to the National Science Foundation, it was proposed that Ray would direct a planning group assigned to work out the details.[69]

With the end of the Fair in October of 1962, the United States Science Exhibit closed and the need to secure the Center's future became increasingly urgent. The federal government, at the urging of Washington Senator Warren Magnuson, agreed to lease the complex of buildings for $1 per year. With a grant from the National Science Foundation of $100,000, the Pacific Science Center Foundation had much of the funding necessary to remain partially open to the public through the end of 1963. For the time being, though, officials closed the "Horizons of

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[68] Letter from Orr Reynolds and Science Advisory Committee to Athelstan Spilhaus, 27 March 1962. Box 218, Folder 5, Warren G. Magnuson Papers (Acc # 3181-4), University of Washington Archives. Hereafter cited as **Magnuson**. Members of the committee included the Orr Reynolds (chair), Richard Bolt, Allen Astin, George Irving, A. E. Parr, Dixy Lee Ray, and Dael Wolfe, executive secretary of the AAAS.

[69] Joseph L. McCarthy, "A Proposal for The Establishment and Operation of a Planning Group for a National Living Science Center," 15 June 1962. Box 218, Folder 11. **Magnuson**.

Science" building, the Eames theater "House of Science" and the Spacearium film "Journey to the Stars" were shown only on weekends, while the other three exhibit buildings remained open seven days per week.[70] Through the fall and winter, at a time when Ray worked primarily at the National Science Foundation in Washington DC and continued to serve on the NAS Committee on Oceanography, she also began to think more and more about the future of this new creation, the Pacific Science Center.

At a Board of Trustees meeting in early 1963, Ray explained in her typically forceful manner that "The Pacific Science Center should not be a hold-over attraction: a United States Science Exhibition continued in perpetuity." No matter how successful the World's Fair exhibits may have been, the future success of a "viable, living science center" required a new and dynamic vision for the educational mission, taking into consideration what the Center "can do in the Pacific Northwest with and for the resident population." Ray, now as "Education Coordinator," argued that leaders should not think in terms of a "museum in the classical sense of a repository where objects of permanent interest in the arts and sciences are preserved" since these tended to encourage a passive audience. Museums were important, she believed, but the region had a range of existing institutions fitting that bill. Rather, the vision of the Science Center should be to "amuse, beguile, stimulate, inspire, [and] inform" the residents of the region on the "essence as well as the aims and methods of science." The Pacific Science Center should embark on a "great experiment" designed to "make the people, all the people, of the Pacific

[70] For lease terms and associated correspondence, see Proposal to General Services Administration for Pacific Science Center Foundation, 12 Oct 1962. Box 218, Folder "Pacific Science Center Foundation, Gen Corresp, 1962" (Folder 5), **Magnuson**. For NSF grant and operation schedule see "A Request to the National Science Foundation from the Pacific Science Center Foundation Inc., for the Grant of One Hundred Thousand Dollars..." 18 Sept 1962. Box "Museum, 1962," Folder "Pacific Science Center Foundation." Archive, Museum of Science, Boston. Hereafter cited as **Museum of Science**.

Northwest scientifically the most literate" of any region in the nation. To this end, Ray proposed reducing and condensing the existing exhibits into one building while, in close collaboration with local schools, devoting most of the remaining exhibit space to "learning equipment" that could be used by students with the guidance of expert staff of the Center.[71]

Ray's ideas, as all could see, would require a significant workforce of well educated persons. Recognizing this herself, Ray made one of her rare comments on the status of women in modern America. Having worked with a number of female graduate students, Ray assumed that there must be a sizeable population of women in the region with quality undergraduate (and even graduate) degrees in science. "I submit that the greatest waste in the United States is the country's educated women," she asserted. "With relatively little effort... they could form a cadre of science assistants or demonstrators." Finally, not wanting to leave out opportunities for adult science education, Ray proposed having the Center sponsor public lectures "on controversial topics in science." These could include radioactive fallout, population increase and control, pollution in the environment, and many other topics. No doubt such a series would "arouse interest," but with careful planning and control of speakers and media coverage, Ray felt confident that they could succeed in "informing" rather than "merely inflaming" the public. Through these many efforts, Ray concluded, the region and the Science Center would quickly become "leaders in the field of public understanding of science."[72]

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[71] Dixy Lee Ray, "Educational Programs: Some Preliminary Thoughts and Some Propositions," 3-2 to 3-9. Box 9, Folder "Pac Sci Cen Foundation Board of Trustees, Annual Meeting, 1963." Joseph L. McCarthy Papers (Accession 3331-84-34). University of Washington Archives and Special Collections, Seattle WA. Hereafter cited as "**McCarthy**."

[72] Ibid., 3-9 to 3-12.

With her experience in popularization and her contacts at the NSF, Ray, along with a handful of other civic and scientific leaders, provided the vision and resources for the Pacific Science Center's immediate future. But a director would be needed for long-term stability. Presumably, the prospective leader would need to have a solid reputation within science, as well as experience with popular science education. And most importantly, the leader would have to raise considerable amounts of money, so contacts with business, philanthropic organizations, and the government would be important. Allan Waterman, retiring director of the National Science Foundation, seemed to some a perfect candidate in these regards. Even though he was an older man and might not "be as vigorous as the job may demand," his connections would more than make up for this possible lack of energy.[73] In the end, Waterman declined the offer, leaving the selection of Science Center director to Lee Hiltner, a Boeing engineer who had worked on technical matters related to the Spacearium film. Hiltner, roughly one year older than Ray, would act as the director while Ray, completing her work at the NSF in the Spring of 1963, would be hired as the "Education Coordinator."[74] Hiltner's appointment did not turn out particularly well. He resigned by the middle of July, barely four months into the job, and within a week the Pacific Science Center Foundation convinced Ray to become the director.

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[73] See letter from Edward Carlson, chair of the Pacific Science Center Foundation, to Warren Magnuson, 5 Jan 1963. Box 218, Folder "PSCF, Gen Corresp. 1963" (Folder 6). **Magnuson**.

[74] Ray apparently expected to resume work at the University of Washington, essentially full-time, upon her return from the NSF. However, Pacific Science Center leaders also expected to hire her in some capacity. Interestingly, one of her colleagues at the NSF mentioned to the president of Stanford University that Ray would be a good candidate for a job opening up at the Hopkins Marine Station. At this time it seems that Ray had a number of career options; her eventual acceptance of work at the PSC may be due in part to her decreasing influence within the zoology department, and likely due to personal antagonisms as well. However, archival evidence of poor departmental relationships does not appear until the early 1970s.

The announcement of Ray's appointment to head the Pacific Science Center, with the sudden and unexplained resignation of Hiltner, made Ray's transition from the NSF complete. Although she retained her faculty position at the University, with minimal teaching responsibility, Ray focused her primary attention on the Center. The news release of her appointment provided an opportunity to summarize her vision for the Science Center (as opposed to a museum), saying "Here, people may learn about science by participating in science."[75] Ray's willingness to step into the Center's leadership came at the right time for her, and at a crucial time for the institution. To some very experienced observers, the future of the Center had become frighteningly murky. Bradford Washburn, the long-time director of the Museum of Science in Boston, wrote to MIT president Julius Stratton that the Science Center had not "nailed down any sort of hard-boiled, realistic plan even to cover interim needs." While the Pacific Science Center presented "a magnificent challenge," Washburn knew it would "take some very rapid and tough decisions to get it solidly on the track." Having spent many long years scrambling to make ends meet at his museum, Washburn wondered why a realistic funding plan had not been formulated and exclaimed, "how on earth they are going to finance this operation is a mystery to me."[76]

In order to attract financial backing Ray felt the Science Center needed the prestige of an illustrious advisory committee. To do this, Ray could draw on a network of colleagues that Hiltner could not. She began with one of her bosses at the NSF who was at the time acting as

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[75] "News" Pacific Science Center Foundation, 19 July 1963. Box "Museum, 1963," Folder "Pacific Science Center Foundation." **Museum of Science**.

[76] Letter from Bradford Washburn to Julius Stratton, 15 July 1963. Both men were members of the Science Center's Board of Trustees, and were about to resign. Box "Museum, 1963," Folder "Pacific Science Center Foundation." **Museum of Science**.

interim director following the retirement of Allan Waterman. Although Paul Scherer had not pursued an advanced degree in science, he had become well networked within the institutions of science patronage. His father had been president of Throop College, the pre-cursor to the California Institute of Technology, and Scherer married the daughter of George Ellery Hale. Then, during World War Two, Scherer befriended and worked for Vannevar Bush in the Office of Research and Development, which led to his first post-war position as executive officer of the Carnegie Institution.[77]

With Scherer's agreement to serve as the chair of the Science Advisory Committee, Ray then called on a number of the men she had worked with during the Fair: Paul Weiss of the Rockefeller University, Dael Wolfle of the AAAS, W. Orr Reynolds the recently appointed director of the National Center for Atmospheric Research, Glenn Seaborg of the Atomic Energy Commission, Frederick Seitz of the National Academy of Sciences, and Bradford Washburn who was happy to reform his association with Center. Ray also could call on men whom she knew from other associations, including Edward Tatum, 1958 Nobel Prize winner who was eager to join the Advisory Panel, especially since it meant more time for West Coast skiing; Ray Owen who had shared his laboratory at the California Institute of Technology with Ray during her Guggenheim year; and Cornelius van Neil, her long-time friend and mentor from Stanford. With this group of eminent colleagues putting their names and presence behind the Center, Ray could begin to canvass confidently for support among businesses, philanthropies, and government agencies.

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[77] See biographical sketch by Lee Anna Embry, "Paul A. Scherer," *Science*, 1954, 119(3086):231-233.

With a distinguished board in place by late summer, Ray called the first meeting of the Advisory Committee for November of 1963. Ray wanted input on how to re-organize the Center as well as an opportunity to impress upon these men her need to raise money. Unfortunately the "tragedy of that weekend in late November" – the assassination of President Kennedy – prevented the meeting from taking place. Nevertheless, individual advisors visited through December, providing input and face-to-face discussions with Ray. While Ray had advocated massive changes prior to becoming director, she moderated her priorities for the "living science center" as the realities of operating the Center set in. She now proposed to re-work the exhibits into "more rational, orderly arrangements," and clarify confusing explanations. She could report that two classrooms were being constructed, that a Mycological Society had been formed, and that information was being gathered on creating a Science Academy to be based out of the Center. Finally, during the holiday season more special films and science demonstrations were being offered, while sometime early in the new year an Arctic Life exhibit would be unveiled.[78]

The new year began, however, with Ray preparing for a three month research trip to the Indian Ocean. In the terms of her appointment, Ray requested leave to participate in the International Indian Ocean Expedition (IIOE), as scientific leader of the Te Vega, a ship specifically outfitted for biological oceanography. This leg of the Te Vega's IIOE program would begin in Colombo Ceylon (Sri Lanka), then track southwest across the Indian Ocean to end in Port Louis, Mauritius. Much of Ray's work for the NAS Committee on Oceanography, and with the NSF, involved planning the biological aspects for American ships in the IIOE. The

[78] Memo from Dixy Lee Ray to Science Advisory Committee, 2 Jan 1964. Box 32, Folder "Pacific Science Center." **Weiss**.

Te Vega, a 172-foot two-masted schooner, had been given to Stanford University by a wealthy trustee and outfitted by the National Science Foundation for biological oceanography.[79] Ray, as senior scientist, would be in charge of eight graduate students, while four other scientists would perform their own research and, where applicable, advise the graduate student projects.

The expedition did not proceed as envisioned. In a letter to one of her science advisors, Ray explained the situation both at the Center and with her research trip: "there's MUCH to do before I can romp off to the Indian Ocean. Te Vega has a broken shaft and last news is that she's becalmed – isn't that a lovely thought?! Anyhow dry docking in Ceylon will be necessary and our cruise is put off until 15 February. I'll still return in early May though in plenty of time for the spring Advisory Committee meeting. We're bush here and everything goes well except money-raising. Thanks for suggestion of Kettering Foundation – will try."[80] Once in Ceylon, Ray discovered that not only was the ship in poor shape, but the crew did not measure up to her expectations, particularly the captain. Describing him as a "lush," Ray and advisors from Stanford quickly fired him and brought in a new captain. At the same time, Ray ordered everyone, including the graduate students, to pitch in and clean the boat, which she thought was

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[79] As an indication of how the NSF, undoubtedly with Ray's help, was getting into biological oceanography, the head of the biology department informed Stanford's president that "On its own initiative, the NSF has urged the Marine Station to apply for funds in rather massive amount to acquire and operate a large vessel for strictly biological (as opposed to oceanographic) exploration and investigation in the whole Pacific area." Rolph Bolin, Ray's dissertation advisor, became the primary scientist in charge of the Te Vega's research trips. After the Indian Ocean Expedition, Te Vega was used as a graduate training ship for biological oceanographers until 1968 when budget cut-backs made it difficult to operate such an expensive vessel. See letters concerning acquisition of Te Vega, Box, 1, Folder "HMS – Te Vega Program March 1957-March 1966," Biology Department Records, Hopkins Marine Station, SC 256, Stanford University Archives. For the end of Te Vega's operation see Toby Appel, "Marine Biology/Biological Oceanography," 339.

[80] Letter from Ray to Ray Owen, 3 Jan 1964. Box 54, Folder "Science Advisory Committee." **DLR**.

a disgraceful mess. With improved morale and a functioning boat, the Te Vega finally set sail in mid March and completed her journey by the middle of June.

While this research trip burnished Ray's scientific credentials as leader of the Science Center,[81] her colleagues at the University of Washington may have been wondering if Ray was ever going to be a full member of the department again. Paul Illg, Ray's fellow invertebrate zoologist wrote to a colleague at the Smithsonian that his question probably required Ray's expertise. But unfortunately, "Dixy is really out of contact just now. She is leading the current Te Vega cruise and should be half way across the Indian Ocean." In fact even though Ray had returned from her two-year leave of absence, Illg continued, "We haven't seen much of her the past year anyway. She has been taken up almost completely with her job as Director of the local Pacific Science Center.... It has been a very worthy project but has relatively little to do with our University operations. She has not severed with our department however, and expects to be on at least half-time status with us next year."[82] Ray continued to participate in the department's activities, but only minimally. She offered her course, "Natural History of Marine Invertebrates" at least twice after her return from the Indian Ocean and continued to participate in summer teaching at Friday Harbor. By the end of the decade, partly in response to her broadening

[81] Bradford Washburn, director of the Museum of Science, Boston, similarly built his reputation by making significant aerial photographs of Alaskan geography, particularly the region's mountains and glaciers. For Washburn's scientific work see Michael Sfraga. *Bradford Washburn: A Life of Exploration* (Corvallis, OR: Oregon State University Press, 2004).

[82] Letter from Illg to Waldo Schmidt, 24 April 1964. Box 28, Folder "Illg, Paul L., 1946-74." Collection 7231: Manuscript Collections, Waldo Lasalle Schmitt papers, 1907-1977. **Smithsonian.**

interests, Ray also developed a course on the social, ethical, and technological implications of science, particularly the biological sciences.[83]

Yet, Ray's primary obligation lay with the Science Center. Washburn had indicated his concern that the Center needed a financial plan, and that the former director had not made sufficient progress. Ray, on the other hand, got to work on this problem almost immediately. Prior to her oceanographic voyage on the Te Vega, she and the chair of the Pacific Science Center Foundation visited New York, "seeking $ support for the Science Center." To Paul Weiss, of the Rockefeller University, she expressed how dire the situation was. "The next two weeks will tell whether we have to close up or can continue to operate. We're getting plenty of school customers -- but no $. We haven't given up ... We'll keep you informed how it goes as we work for a miracle."[84] Following her return Ray again visited potential donors at the Carnegie Corporation and the Alfred P. Sloan Foundation, following leads provided by Ed Tatum.[85] Ray's indefatigable fund raising soon began to pay off. The Science Center did not close, and though Ray frequently mentioned the Center's precarious financial situation (a good strategy when running a 'non-profit' institution), by 1967 the treasurer proclaimed "the financial

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[83] University of Washington course catalogues show her "Natural History" course being offered in 1965 and 1966, and in 1969 a course entitled "Science and Human Society" was offered by Ray. She did, however, teach more than these courses. The marine biologist Jane Lubchenco recalls taking an advanced invertebrate zoology summer course at Friday Harbor in 1970, co-taught by Ray.

[84] Note from Ray to Paul Weiss penciled on Science Advisory Committee Memo, 2 Jan 1964. Box 32, Folder "Pacific Science Center." **Weiss**.

[85] Letter from Ray to C. B. van Niel, 3 Jan 1964 and DLR to Ed Tatum, 4 Dec 1964. Box 47, File "Personal." **DLR**. Tatum also provided Ray with an introduction to Emanuel Piore, vice president at IBM, who then received a request for a computer that would act both as a working exhibit ("a significant tool of science") and as a reference database.

position... is strong."[86] The Carnegie and Sloan foundations had provided grants of nearly $300,000, a host of creditors had been convinced to forgive over $300,000 worth of Pacific Science Center Foundation debt, and agreements with regional public school districts brought in over $100,000 annually.[87] With this and other forms of income, the Center had successfully developed into a permanent and financially healthy regional science education institution.

The creation of a new award, called the "Arches of Science" award, exemplified the Center's ability to secure the backing of the community. It also displayed Ray's effectiveness in tapping into the perceived need for more recognition of the "public understanding of science." Courting the Pacific Northwest Bell Telephone Company through 1964, members of the Pacific Science Center convinced them to fund an annual award that would recognize lifetime achievements toward improving the public understanding of science. With agreement from Bell executives, members of the Science Center award committee decided to search for those scientists who had most contributed to making "a citizen out of the scientist, and to a certain extent, a scientist out of the citizen." On 5 October, 1965, Warren Weaver became the first recipient of an "Arches of Science" medal, along with a prize of $25,000. Much to the Center's appreciation, an ABC News reference to the Award called it the "American Nobel Prize," which only aided in bringing extensive media coverage to the award.[88] In subsequent years the Center selected René Dubos, James Conant, Glenn Seaborg, Gerard Piel, and before being discontinued

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[86] Pacific Science Center Annual Report, 1967. Records held at the Pacific Science Center.

[87] See annual reports for years 1965, 1966, 1967 (records held at Pacific Science Center); and letter from Ray to Florence Anderson, Carnegie Corporation, 15 May 1970. Box 47, File "Personal." **DLR**.

[88] "Summary of the Record of the First meeting of the Arches of Science Award Committee," 6 Feb 1965 and attached documents describing the first award, including media coverage. Box 7, Folder "Pacific Science C. Arches of Science Award Comm, 1965." **McCarthy**.

in 1971, a final award to Margaret Mead. Dubos best summed up the connecting mood of these scientists, as well as the Science Center's motivation in giving the award: "ignorance of science should be no excuse in technical societies," he believed, "because all important decisions now have scientific determinants." To Dubos, the other winners, and to those in charge of the Science Center, this belief motivated their efforts to instruct the general public about science. In order for society – at least Western society – to honor individual independence and autonomy, all citizens must keep themselves knowledgeable about science. As Dubos concluded,

> citizens should acquire the kind of general understanding that facilitates recognition and evaluation of the social consequences of science and technology. For lack of this understanding, the citizen will have to submit to the tyranny of the expert, who will then become a decision-maker without being answerable to the community. In contrast, if the public can share in a more enlightened manner in the decision-making process involving scientific problems, democratic societies may regain the social coherence which is the condition of their survival.[89]

Ray took this sentiment to heart. She not only promoted the desirability of a scientifically informed citizenry, but played the part as well. Seattle in the 1960s, like many other cities around the country, had been considering fluoridation of the drinking water in an effort to combat tooth decay. Yet, as parodied in the character of Col. Jack D. Ripper in *Dr. Strangelove*, fluoridation represented for many Americans an insidious invasion of their bodies and their privacy. As in more than half the towns having put the issue to a vote, Seattle residents rejected just such a ballot measure in 1963. A second attempt to pass a fluoridation measure took place in 1968, with promoters stressing the safety and rationality of using fluoride to

[89] René Dubos, quoted in Pacific Science Center Annual Report, 1967. Records held at the Pacific Science Center.

improve public health. Ray, along with Bill Olwell, King county labor council, and local celebrity Jim Owens, University of Washington athletic director and coach of the football team, co-chaired the "Seattle For Fluoridation" campaign. Using newspaper ads, Ray's "Doorway's to Science" weekly television program, and the backing of Seattle's well-connected citizens (such as local NBC TV station owner Mrs. Scott Bullitt, the wife of Washington's governor, Mrs. Elizabeth Wright Evans, and University of Washington Medical School Dean, John Hogness), the measure passed with relative ease.[90]

In another venture into the realm of the scientist-citizen, Ray teamed up with a biologist from the University of Puget Sound and the vice president of a local engineering firm to report on the feasibility of creating a new shipping port south of Tacoma. Analyzing the prospect of a proposed "superport" at the Nisqually delta, this team weighed the compatibility of industrial development with the competing desire for a wildlife and game reserve in the same location, as expressed by a number of conservationists. In regard to whether these competing claims could be compatible, Ray and her co-authors wrote that "the answer is a simple emphatic no." Any industrial, or other kind of development, at the mouth of the Puget Sound's "least dammed and polluted" river system, would inevitably cause "simplification of the ecosystem" and thereby ruin the value being prized by conservationists.

However, Ray and her colleagues did not conclude that industrial development should never by undertaken. Recognizing that development or conservation presented roughly equal and competing claims to the Nisqually delta, the report urged the Washington State legislature

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[90] Notes and newspaper clippings in Box 27, Folder "Fluoridation." **DLR**. The ballot measure passed with 56% of the vote.

appoint a committee to perform detailed investigations into the relative value of each claim. This would take a considerable amount of time but, they believed, could "convert the present conflict into a constructive controversy in which informed reason will be served to the benefit of the citizens of the State of Washington."[91] While this report did not directly prevent the creation of a port at Nisqually, it did provide the justification for further study that eventually resulted in the creation of a wildlife refuge at that site. But whatever the outcome, Ray could not help but be affirmed in her beliefs about the appropriateness of rational, science-based problem solving.

At the time Ray worked on the Nisqually Delta report, she used her science television show to publicize some of the issues that revolved around industrialization within Puget Sound. As she wrote to a colleague, "For some time I have been trying to be as effective as possible in the cause of marine pollution and the sensible use of shore and shallow water resources and environment. In uncounted talks to civic and service club groups, in writings, and radio and television programs, I have been trying to promote a sensible approach to learning what the possible consequences might be before development or exploitation of the environment occurs." This concern for her beloved Puget Sound – the place where she grew up, did much of her research, and had recently purchased beach-front property – had been aroused by reports of prospecting for oil. This possibility severely tested her scientific outlook. She continued, "The very thought strikes such horror that it requires an effort of will on my part to remain objective and reasonable about it." Yet, believing that even this horrible potentiality could be best dealt with by acquiring knowledge, she asked her colleague to provide her with "visual and illustrative

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[91] Gordon Alcorn, Dixy Lee Ray, and Gary B. Lewis, "The Future of the Nisqually Delta Area: A Memorandum Report to the Washington State Legislative Council, Committee on Parks and Natural Resources," 9 Nov 1970. Box 31, Folder "Nisqually Report." **DLR**.

materials ... showing the effect of spilled oil or any other activity relating to problems of oil drilling along shores or in shallow water" that she could use to inform the public.[92] Clearly, to Ray and many others, the role of science in society increasingly required knowledge of the ways in which humans affected their environment. This and other kinds of broadly "environmental" issues dominated the latter part of her career. And while many began to take a less optimistic view of the scientific and technical role in understanding nature and dealing with environmental problems, Ray saw this as an "anti-intellectual" retreat.[93]

Back within the Science Center, exhibits had changed considerably by 1970, reflecting the currently popular activities in the scientific world as well as the changed sensibilities of the times. The American space program, specifically NASA's lunar mission, captivated the public. In response, and based on the availability of used spacecraft donated by NASA, the Science Center created a whole exhibit area devoted to the lunar program. "Luna '69" included a massive, realistically detailed mock-up of the moon; displayed Mercury, Gemini, and Apollo spacecraft; and displayed live information from Houston detailing the progress of the eagerly awaited journey of Apollo XI.[94] For residents of the Puget Sound region, the Science Center

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[92] Letter from Ray to Dr. John Harville, 7 May 1970. Box 44, Folder "Chronological file, 1970." **DLR**. Very similar letter sent to other California-based scientists, including colleagues at the Hopkins Marine Station.

[93] Letter from Ray to Nard Jones, 9 April 1971. Box 48, Folder "1970-72." **DLR**.

[94] Anonymous, "Luna '69 Features Apollo XI Hookup," *Queen City*, July 1969, pp. 60-61. See also Pacific Science Center Annual Report, 1970. Records held at Pacific Science Center.

became the first place to see, in person, a piece of the moon, with a fragment on display in the late spring of 1970.[95]

While attention focused on Neil Armstrong's "one small step," Ray and her staff were actively reworking another part of the Center to illustrate the giant steps taken over the history of human society. In tune with the growing concern for the environment, the Center began designing a new exhibit to be called "Man and Nature." Here the viewer would encounter, in the first part, a re-created Native American village from a time before Western migrants explored and settled the region. The main feature of the exhibit comprised a full-scale ceremonial house built with the help of local Kwakuitl tribal members. In the second part, viewers would find exhibits explaining how recent human societies had used, altered, and constructed their own civilization using the resources available in the Puget Sound region. The fundamental differences in modes of modern, post-industrial living would be shown to result from the "the resources of science and technology at his disposal." In ways strikingly similar to Jacob Bronowski's contemporaneous television show *The Ascent of Man*, this science-based explanation of human social, cultural, and technological evolution emphasized "the dependence of the culture and lifestyle upon the resources available and the existing knowledge of their use."[96]

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[95] Letter from Ray to Al Nagy, Office of Public Affairs, NASA, 31 Oct 1969. Box 45, Folder "Chronological File, 1969." **DLR**.

[96] Report of the Director to the Annual Meeting of the Board of Trustees of the Pacific Science Center Foundation, 5 Nov 1970. Records held at the Pacific Science Center. See also, "Man and the Environment: General Plan" and hand-written notes "Defining Man + the Environment," Box 12, Folder "PSC." **DLR**.

The Science Center's slowly developing "Man and Nature" exhibits mirrored a course Ray developed, and delivered, for the Zoology Department at the University of Washington. Based on Ray's growing concern over the content of popular discussions of environmental issues, the course explored issues concerning humans, the development of science, and human uses of the natural world. Like the Science Center's exhibit, Ray began with extensive coverage of Native American culture and modes of survival and concluded with discussions of modern environmental issues, from human population growth to energy production. Using, among others, Vannevar Bush's *Science is Not Enough*, Warren Weaver's *Science and Imagination*, and René Dubos recent Pulitzer winner, *So Human an Animal*, Ray attempted to convey "a rational outlook on the role of science in today's world."[97]

Ray considered the class to have been reasonably successful, yet it puzzled her "that the science majors were by no means immune from a wholly emotional treatment of questions concerning pollution, insecticides, over-population," and other issues.[98] This, to Ray, suggested an significant failure among aspiring scientists in adopting an fundamental component of the scientific outlook. It may be expected within the general public, and corrected through efforts such as the Science Center, but this apparently unscientific and "emotional" outlook among science students was deeply troubling. While this anti-scientific approach to the natural world among science students disturbed her most, she was also becoming somewhat more pessimistic about the general public's ability to make "social decisions... on a rational basis, rather than

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[97] Course outline. Box 41, Folder "UW Dept of Zoology, #2." **DLR**.

[98] Course outline and letter from Ray to Donald Farner (chair of zoology department), 4 Feb 1970. Box 41, Folder "UW Dept of Zoology, #2." **DLR**.

resorting to fear or succumbing to hysteria." While she continued to hold out hope for the aims of public understanding of science, "many recent events [e.g. the SST decision, emotional environmentalism, and protests against nearly every use of technology] do not seem encouraging."[99]

Through the 1960s, Ray's leadership of the Pacific Science Center reflected her capabilities as an administrator, her ability to express convincingly a vision of science's role in society, and the positive results that a well-networked professional could bring to an ambitious civic project. However, the success of the Science Center itself, and the particular program Ray brought to it, also mirror a larger social project advanced by science-minded leaders in America at that time. Well after Ray's career at the Science Center ended, she recalled her work there as being something of a rebellion against the professional scientific ethos of the day. She suggested that the practicalities of popularization had been scorned by "elitists in science," but countered that if "[Walt Disney's] techniques permit me to explain the sciences to anyone who passes by, bring on Mickey Mouse and Co.!"[100] Considering the variety of scientists attracted by the World's Fair project, and the subsequent scientific and civic interest in the success of the Pacific Science Center, it is more appropriate to view the whole public understanding of science

[99] Letter from Ray to Nard Jones, 9 April 1971. Box 48, Folder "1970-72." **DLR**.

[100] Quoted in Guzzo, *Is It True*, 69. This statement probably reflects Ray's thinking from the late 1970s more than the early 1960s. And as in other quotations used by Guzzo (Ray's political strategist as she ran for re-election in the 1980 gubernatorial elections), it is unclear to what extent he has manipulated the statement to cast his subject as a social and political iconoclast and an individual not beholden to outmoded traditions of privileged interest-groups. Nonetheless, this is an interesting statement for what it may say about the status of science popularization, the place of the rebel in scientific and political spheres, and not least for the possibility that Walt Disney (and Disneyland) appeared to provide a successful model for communication of socially important concepts and ideals.

enterprise as being a significant part of the scientific project within America at the time. Various colleagues with whom Ray interacted clearly expressed the justifications and explanations for a deeper appreciation of science.

In an essay Paul Weiss referred to as his "'credo' about Adult Education," he argued that Western society needed to be working towards a unified appreciation of knowledge. Taking C. P. Snow's "Two Cultures" argument as his point of departure, Weiss felt an urgent need to overcome the sense that scientific knowledge lay apart from more humanistic realms of knowledge. Education, which he envisioned to be a life-long project, had the difficult task of "salvaging the unity of culture." And, "rather than serving merely as a filler for leisure time, it must conceive its mission on that high plane and organize its practices accordingly. Its primary objective must be to demonstrate to a large part of an uninitiated population the superiority of knowledge over ignorance in a variety of disciplines so as to endow ever more people at a much faster rate than population increase, with a deep faith in rational behavior and with disciplined guidelines for its exercise."[101]

Striking a similar tone, but focusing on the ways in which science and citizenship depended upon each other in the modern world, Warren Weaver exhorted Americans to think of science as a realm of knowledge open to all but requiring particular disciplines of mind and attitude. "On the average, scientists tend to be pretty bright," Weaver offered, "but by and large, scientists are very much like other folk." What separated the scientist from "other folk" had to do with their education. While possibly possessing more "curiosity for the insides of things...

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[101] Paul Weiss, essay (probably unpublished) included with letter to Clara Mayer, 4 March 1963. Box 26, Folder "Mayer, Clara." **Weiss.**

and a rather special appetite for sharply focused and logical thinking," that which elevated the scientist was "an intellectual inheritance, transmitted to them in their education as scientists, from the centuries of tradition about the scientific method and the scientific attitude towards the world."[102] The scientist, specially constructed through their education, began life pretty much as everyone else. This suggested the possibility that all could, with some effort, develop the "scientific attitude."

What was this "scientific attitude?" Weaver believed it to be a "highly purified" form of reasoning that "*Homo sapiens* has used ever since he first began to become *sapiens*." Some of the hallmarks of this scientific thought, Weaver believed, included the suspension of prejudice as one searches for relevant facts, suspicion of "tradition and hearsay" while "accepting the story which is told by the facts," and valuing logical precision. To these qualities of the intellect he added other more general personality traits which, one is led to believe, are encouraged most forcefully through the vocation of science: "high standards of personal honesty, open-mindedness, ... love of truth... and curiosity," and capped by the belief that "nature is orderly and reasonable, not capricious and mad."[103] While acknowledging that even scientists had been known to lack some of these characteristics when venturing into business, social, or political affairs, Weaver confidently asserted that a public more versed in science would not need to revert to the "overly emotional, poorly informed, and indeed sometimes quite nonsensical behavior" that seemed to dominate social attitudes outside of the sciences.[104]

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[102] Weaver, "Science and the Citizen," 1227.

[103] Ibid., 1228.

[104] Ibid., 1228.

By the early 1970s, as Ray became slightly less optimistic about the effectiveness of the public understanding of science, President Nixon offered her a seat on the Atomic Energy Commission. This career move took Ray into an explicitly political realm and, for the most part, out of science popularization. Not inconsequently, her appointment by the Nixon administration likely had negative effects on her standing among immediate scientific colleagues in the life sciences. Art Martin, her friend and former Zoology Department chair, told Ray that at a departmental tenure meeting, the general feeling was that "you contributed no credit to the Department," and therefore the younger members of the department denied her promotion to full professor. Clearly, by this time Ray's positions on socially-charged topics such as nuclear energy, and now her work for the AEC counted against her as new ideals of scientific propriety came to the fore.[105]

Ray claims that she became motivated to engage in public understanding of science, in part, as a way to allow greater portions of the population "to challenge science or scientists." In her view, the 1950s had been marked by an unquestioned "'faith in science' syndrome" that required tempering with knowledge of what science could and could not (or should not) do.[106] This seemed a noble and important work, and Ray's efforts to instruct the public about science were matched by many of her colleagues. Public understanding of science efforts prospered through the 1960s but, for many like Ray the persistence and widespread acceptance of apparently anti-intellectual and "wholly emotional" voices within society caused considerable

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[105] Ray was nominated for the AEC in the summer of 1972. For departmental tenure, see letter from Art Martin to Ray, 21 Nov 1972. Box 9, Folder "UW Dept of Zoology." **DLR**. Ray had come out in the late 1960s in favor of nuclear power development (see "Nuclear Power: In Search of an Ombudsman," *Queen City*, July 1969, 16-19, 35.)

[106] Quoted in Guzzo, *Is It True*, 68.

worry. This was a failure of scientists, for as Ray believed: "the root of the hostility toward science will be found in the failure of science itself and those who teach it to make a strong effort toward getting information and understanding about the sciences to all those people out there who never have and never will become scientists."[107]

Efforts to bring the good news of science to the general public on television, in science museums, or in other ways, may have been popular with the public. Yet, those engaged in public understanding of science set for themselves the difficult task of not only adding to people's factual knowledge but also attempting to change their values and ways of thinking. Jacob Bronowski, like Ray a popularizer of science (but who differed in his explicit philosophical defenses of 'scientific humanism'), stated in the print version of *The Ascent of Man*, that his motivation for popularization came from a desire to encourage a broader cultural shift toward the values of science. "My ambition here," Bronowski wrote as way of introduction, "has been...to create a philosophy for the twentieth century which shall be all of one piece. [The Ascent of Man] presents a philosophy rather than a history, and a philosophy of nature rather than of science. ..."[108] This too, however, was seen as a "faith in science syndrome" by many of a younger generation.

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[107] Ibid., 68.

[108] Jacob Bronowski, *The Ascent of Man* (Boston, MA: Little, Brown & Co., 1973), 15. The BBC television program, from which this book was made, aired on the BBC beginning in 1972, and in the United States was carried by numerous PBS stations beginning in 1973. Moreover, his earlier writings, such as *Science and Human Values* (1956) had a strong following among science-minded intellectuals. C. B. van Niel, in 1965 and 1967, submitted Bronowski's name for the Arches of Science Award, suggesting that his focus on the "human values of science" was in fact the "prime purpose of the Center." Letter from C. B. van Niel to Ray, 18 April 1965. Box 54, Folder "Science Advisory Committee." **DLR.**

Dixy Lee Ray, as had been instilled in her early scientific training, saw the world in objective terms. True knowledge was, for her, never relative but provided a solid base upon which to build a civilized, modern, and progressive society. Convinced of society's need to know more about science, she acted on this belief through popular television programs, directing a new and successful science education center, and by becoming the model of a modern citizen, able to approach the world in an unemotional and scientific manner. In January of 1970, at the start of a decade in which she would become an active and successful politician, Ray delivered another in a growing number of speeches to a non-scientific audience. The Garden Club of Portland Oregon had invited Ray to speak on the gathering environmental crisis that seemed to be consuming the nation and the world. Drawing on more than a decade of science popularization, Ray exhorted her audience to believe that "there has never been a time when it was so necessary for the intelligent, for the interested, for the concerned citizen to understand more of what is going on in science, what is possible to accomplish by knowledge and understanding and what the limitations are."[109] To this small gathering of fellow citizens she argued that the future lay in confidently confronting the challenges posed by an ever-growing population. But, as her background had taught her, and in line with the ethos of science she had adopted throughout her career, the challenges of the future would be overcome only through society's continued reliance on rational thought, its sustained belief in science, and by eschewing "emotionalism" in the face of difficult decisions. This message struck a cord with many mainstream Americans, but it also was beginning to mark her as a product of the past. This

[109] Transcript of speech by Dixy Lee Ray, Portland Garden Club, January 1970. Box 56, Folder "Speeches and Writings." **DLR**.

confidence in science and rationality – hallmarks of the science popularization movement in which she participated – would earn her positions of political authority in the coming decades. And in turn, she would come to be seen as an increasingly polarizing figure as American society changed.

Edward Appleton, the British scientist who opened this chapter, eloquently articulated the qualities many scientists hoped would spread from the scientist throughout the rest of society. In a speech before the British Association for the Advancement of Science, on his election to the presidency of that body in 1953, he sketched out the "mental quality and awareness that science requires in its followers." "The scientific vocation," Appleton continued, "by its very nature, calls for personal qualities that deserve to be recognized and honoured... such as tolerance and open-mindedness to new ideas..., freedom from prejudice, muddle, [and] hypocrisy." Then, quoting from Adam Smith's *Theory of Moral Sentiments*, he further illustrated what he believed to be those admirable qualities found in the scientist. "Mathematicians and Natural Philosophers, from their independency upon the public opinion, have little temptation to form themselves into factions and cabals," Smith had written. Appleton seized upon these as ideal qualities scientists brought to the public sphere. Continuing to quote from Smith, Appleton suggested that the scientist promised to be the model citizen: "They are almost always men of the most amiable simplicity of manners, who live in good harmony with one another, ... enter into no intrigue in order to secure the public applause, but are pleased when their works are approved of, without being much vexed or very angry when they are neglected."[110] This vision of the scientist, as a civilized product of his noble vocation, struck a cord in certain segments of mid twentieth

[110] Sir Edward Appleton, "Science for Its Own Sake," *Science*, 22 Jan 1954, 119(3082):105.

century society. It powerfully suggested that, in the face of a world torn by ideological division and irrational passions for race, nation, or other ideals, science provided the personal qualities upon which modern society could enter a new age of relative peace, tolerance, and prosperity. This required dissemination of the scientist's knowledge and attitude to the masses, of moving from the cloistered laboratory into the public square. The 1950s through the early 1960s may have been the heyday for this movement, but what appeared as continued unruliness among the citizenry prevented a happy completion of this modernist vision.

Chapter 5

Performing Science, Performing Gender: Image and Identity in the Scientist's Life

I'm not concerned with, or about, my 'image.'[1]

A rejuvenated feminist movement spread through American society in the 1960s, intellectually inspired by a renewed sense of inequality expressed in such writings as Simone de Beauvoir's *The Second Sex* and Betty Friedan's *The Feminine Mystique*.[2] In November of 1970, Dixy Lee Ray received a questionnaire from a graduate student who was energized and emboldened by the cause. To this young woman, likely a Puget Sound resident, Ray must have appeared as a model of female (professional) accomplishment who could share valuable insights into the male dominated worlds of business, academia, and politics. The questionnaire was meant to elicit information illustrating the systematic discrimination of women in professional life, evidence of more subtle marginalization happening in the masculine work environment, and examples of the many ways in which aspiring women found their ambitions and their femininity circumscribed by the traditional expectations of the professional workplace. To the

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[1] Dixy Lee Ray's response to a survey question inquiring "How often do your emotions interfere with the image that you want to portray on the job?" Document entitled "Research Paper Questionnaire," dated 24 Nov 1970. Box 8, Folder "Miscellanea." **DLR**.

[2] Beauvoir's book was originally published in 1949 as *Le Deuxième Sexe*. It was translated into English and first published in the United States in 1953, and had gone through 9 printings by the mid 1970s. Freidan's book first appeared in 1963, and is often seen as the text most responsible for crystallizing the feminist movement of the 1960s and 1970s. For a general overview of 20th century feminism, see Marlene LeGates, *In Their Time: A History of Feminism in Western Society* (New York, NY: Routledge, 2001), 237-364.

question of how her "emotions interfered" with the "image" she tried to portray on the job, Ray responded tersely that she did not concern herself with her "image."

For the present generation of historians, gender, self-image, and sexual identity have proven to be fruitful concepts for stimulating new historical questions.[3] In many fields historians have been trying to understand better the various ways in which the histories of 'invisible' groups challenge, modify, or completely diverge from those of more dominant groups. Within the history of science, the feminist challenge has been one of the most productive avenues for this broader sort of historical approach. The challenge for studying women in science can be, as in other fields, going beyond simply documenting their existence. Analyzing women's lives in terms of gender image and professional identity is constructive for interpreting and understanding how women thought of themselves and how they were perceived. Sally Kohlstedt and Donald Opitz have recently written that "scientists construct private and public images of themselves that affect how they navigate through and beyond the social conventions of their time."[4]

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[3] For a general argument in favor of thinking historically in terms of gender, see Joan Scott, *Gender and the Politics of History* (New York, NY: Columbia University Press, 1988), especially the chapter entitled "Gender: A Useful Category of Historical Analysis." Within the history of science Evelyn Fox Keller has been at the forefront in arguing for greater analysis of the gendered construction of science and how an appreciation of this can shape historical scholarship. For a good theoretical overview, see Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven, CT: Yale University Press, 1985). And for an up-to-date example and evaluation of feminist scholarship, see Angela N. H. Creager, Elizabeth Lunbeck, and Londa Schiebinger's introduction to *Feminism in Twentieth-Century Science, Technology, and Medicine* (Chicago IL: The University of Chicago Press, 2001), 1-22.

[4] Sally Gregory Kohlstedt and Donald L. Opitz, "Re-Imag(in)ing Women in Science: Projecting Identity and Negotiating Gender in Science," *The Changing Image of the Sciences*, edited by Ida H. Stamhuis, Teun Koetsier, et al., (Dordrecht, the Netherlands: Kluwer Academic Publishers, 2002), 105.

Careful consideration of these public and private images, they go on to show, provides new and important information about the gendered nature of the scientific enterprise.

The problem is, however, that many twentieth century scientists (especially women) left scant evidence of how they might have thought about image, gender, or identity, if they dwelt on these issues at all. Moreover, historians themselves must be careful to avoid imposing current modes of thinking upon the past, which may be particularly difficult when it comes to gender as a performative aspect of life (for which there may be less prohibition against a sort of 'whiggishness').[5] Nevertheless, some analysis of Ray's life in terms of the image she presented to scientific colleagues or the wider public, and consideration of the gendered performance of science in general, is important particularly for understanding how this female scientist forged a remarkably successful scientific career in an age that has been characterized as particularly hostile to professional women.[6] Claiming not to be concerned with "image" seems to have excused Ray for not cultivating feminine characteristics of beauty, fashion, delicacy, or deference. As a consequence she was free to cultivate qualities prized in the scientific world, such as

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[5] For a criticism of unhistorical approaches to gender studies, see Judith Halberstam (chapter 2), "Perverse Presentism: The Androgyne, the Tribade, the Female Husband, and other Pre-Twentieth-Century Genders," *Female Masculinity* (Durham, NC: Duke University Press, 1998), 32-51. For the feminist literature on the performative nature of gender, which draws heavily upon (and critiques) Jean Baudrillard's cultural theories of identity, see Judith Butler, *Gender Trouble: Feminism and the Subversion of Identity* (New York, NY: Routledge, 1990); and *Bodies that Matter: On the Discursive Limits of 'Sex'* (New York, NY: Routledge, 1993). And for a useful analysis of Butler, Baudrillard, and performative gender, see Victoria Grace, *Baudrillard's Challenge: A Feminist Reading* (New York, NY: Routledge, 2000), 115-140.

[6] This is the main thesis of Rossiter's second volume, *Struggles and Strategies*. Similarly, the late recognition of Barbara McClintock's work relies on this interpretation. See Evelyn Fox Keller, *A Feeling for the Organism: The Life and Work of Barbara McClintock* (New York, NY: W. H. Freeman, 1993, tenth anniversary edition).

candor, ruggedness (especially valued in a field scientist), independence, and nonconformity, which may be seen as aiding Ray's inclusion within the scientific community.[7]

Ray's life in science may be contrasted to that of her contemporary, Barbara McClintock, for the ways in which their careers differed. In Evelyn Fox Keller's biography, *A Feeling for the Organism*, the male-dominated community of geneticists is described as not fully accepting of McClintock because her feminine approach to science placed her outside the domain of 'good' science (through the early part of her career) as defined by a masculine profession. A more recent biography, by Nathaniel Comfort, has critiqued this interpretation, but he similarly offers up McClintock as an outsider based on her original and unconventional research in genetics (but he denies that it had anything to do with being a woman).[8] While Keller argues that McClintock performed science in an essentially feminine way, and Comfort stresses how scientific originality contributed to her marginalization within genetics, both accounts of McClintock's life rely on the fact that the scientific community came to appreciate McClintock's contributions later in her

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[7] Where Nathaniel Comfort has argued that Barbara McClintock cast herself as an outsider, rather than simply being forced into marginalized positions, I argue that Ray could construct an identity as a scientific insider partly through emphasizing non-conformity to feminine norms. Nathaniel C. Comfort, *A Tangled Field: Barbara McClintock's Search for the Patterns of Genetic Control* (Cambridge, MA: Harvard University Press, 2001), 20-22, 30-31. Others have emphasized how women were portrayed as outsiders or nonconformists in order to marginalize women's scientific contributions within a world that saw femininity as incompatible with science. See for example, Marcel LeFollette, "Eyes on the Stars: Images of Women Scientists in Popular Magazines," *Science, Technology & Human Values*, 1988, 13:262-275; and Jessica Nash, "Freaks of Nature: Images of Barbara McClintock," *Studies in History and Philosophy of Biological and Biomedical Sciences,* 1999, 30(1):21-43.

[8] Keller, *A Feeling for the Organism*, 1-15, 197-207; and Comfort, *A Tangled Field*, 8-13, 266-269.

life. Her Nobel prize in 1983 signaled that, while a maverick (and possibly even an outcast) through much of her career, she was thereafter seen as a central figure in twentieth century science.

If McClintock was marginalized through her early career largely because of her unconventional work in genetics, this study of Dixy Lee Ray provides an interesting counterpoint. Like McClintock, Ray received excellent training, moved among many of the important persons in the scientific community, and cultivated a rebellious or at least 'prickly' persona. Yet in striking contrast, Ray's scientific work fell squarely within the bounds of traditional science: it was descriptive, she employed accepted methodologies, much of her research addressed practical concerns, and it did no more than add to or corrected established knowledge. Combined with her social skills and a facility for cultivating relationships with powerful persons in the scientific community, Ray's identity as a scientific insider led to positions of administrative authority and eventually into the political sphere. In this role – as a politician – Ray fell increasingly out of step with her closest scientific colleagues in the life sciences. In contrast to McClintock, Ray moved from being a central character within certain fields in the life sciences to being described as "unscientific" and a betrayer of science at the end of her life. Thus, in very different ways McClintock and Ray's lives can provide interesting insights into women's scientific lives and legacies in the twentieth century.

Gender, Mind, & Body

As the literature on sexuality and gender has evolved, greater emphasis has been placed on the ways in which gender functions not as a simple mirror of sexual bodies, but rather as a complex, continuously negotiated and reconstructed performance of gendered roles that individuals fashion out of a range of available models. Some refer to "situational" gender in an effort to emphasize how gendered identities are constantly being built in response to a host of signals. This "situational" gender attempts to refrain from essentializing "woman" by substituting broader conceptions of how female (and male) roles are constructed, and it offers a useful framework for thinking about Ray as a female scientist.[9] Situational gender avoids 'natural' categories of 'women' and 'men' and therefore recovers for the scholar the complexity of gendered behavior and how this behavior contributes to the structuring of public life.[10]

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[9] A recent example in the history of science literature using this approach is Arleen Marcia Tuchman, "Situating Gender: Marie E. Zakrzewska and the Place of Science in Women's Medical Education," *Isis*, 2004, 95:34-57. For sustained and more theoretical treatments of gender identity, see Judith Lorber, *Paradoxes of Gender* (New Haven, CT: Yale University Press, 1994); and *Revisioning Gender*, edited by Myra Marx Ferree, Judith Lorber, and Beth B. Hess (Thousand Oaks, CA: Sage Publications, 1999).

[10] Margaret Rossiter's important books on the history of American women scientists tend to essentialize. This is a result, one assumes, from their methodological approach rooted in social history, which has often been accused of creating overly rigid social categories. For Rossiter's post-WWII thesis, a successful scientist like Ray presents a significant problem. Rossiter solves the dilemma by claiming that Ray's academic career was thwarted, which then convinced her to enter science popularization as the next-best strategy for a successful career. This dissertation, however, aims to show that Ray built and maintained a successful career in science into the 1970s and that her work in the public understanding of science should not be seen as a diversion imposed upon her by an unwelcoming academic community or as a second-best alternative to a research career in academia.

In Ray's case, as a woman she forged a significant scientific and public career, yet it has always been noted that she dismissed or ignored many of the feminine social conventions of her time. It is my argument here that Ray constructed a nontraditional gendered identity over her lifetime which facilitated her acceptance within professional (and primarily scientific) social circles dominated by masculine discourse, behavior, and modes of thinking. At the same time, by denying she was constructing an image Ray avoided alienating herself from the realm of traditional femininity which thereby broadened her popular appeal as a science communicator and later as a politician. It seems plausible that her gender identity – neither traditionally feminine nor masculine – factored significantly in her successes (and failures) as a professional and public figure.[11]

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[11] I am deliberately avoiding characterizing Ray in terms of "lesbian" or some other label of sexual orientation. More people than I can recall have either told me she was a "lesbian" (without having any evidence), or have asked me whether Ray was a lesbian. My argument, however, is that Ray consciously or unconsciously *avoided* labeling herself in such a way, and by so doing retained full membership within the scientific community and acceptance within mainstream American culture. Whether Ray was sexually attracted to males or females is immaterial, but to be a lesbian in mid twentieth century America would have been to take on a marginalized identity that would not have allowed her to achieve the kind of recognition within science or politics that she did. Moreover, unlike the anthropologist Margaret Mead, whose professional work explicitly dealt with the construction of human sexual roles, Ray's scientific community (marine biology and/or oceanography) and her social background did not directly provide her with the conceptual tools to explore sexuality and gender. It is telling that whereas Mead's correspondence provides a detailed view into her sexual identity, there is virtually nothing in Ray's correspondence from which to gain insight into her personal relationships. As for social background, a recent dual biography of Mead and Ruth Benedict situates their early relationship (beginning in the 1920s) in the context of the sub-culture of "free-love" in Northeast progressive circles. At about this time San Francisco was becoming a center of homosexual life, yet Ray attended an all-girls school in nearby Oakland during the Great Depression and this was certainly a more traditional and conservative milieu in which she would have formed her early identity and social outlook. Further comparisons between Mead and Ray would be fruitful, but will not be explored here. For Mead and Benedict's lives together, see Lois W. Banner, *Intertwined Lives: Margaret Mead, Ruth Benedict, and Their Circle* (New York, NY: Alfred A. Knopf, 2003); and for a depiction of the San Francisco lesbian community in the 1930s, see Nan Alamilla Boyd, *Wide Open Town: A History of Queer San Francisco to 1965* (Berkeley, CA: University of California Press, 2003), 68-101.

Yet, the focus on a woman scientist's image and identity presents something of a challenge. Within the traditions of the history of science, it has proven difficult to combine intellectual history with social and cultural histories, or more precisely, to show how scientific knowledge is linked with the seemingly quotidian practices that constitute daily life. To use the words of Steven Shapin and Christopher Lawrence, "To bring body and knowledge into contact ... is occasionally taken as funny, sometimes as enraging, more often just as pointless." They argue that the disappearance from modern discourse of sophisticated language connecting knowledge, body, and the habits of life is of historical interest.[12] Especially in the twentieth century, the intellect and the body have been ever more sharply divided. However, Shapin and Lawrence continue, not too long ago people in Western society "very much acknowledged the pertinence of speaking about the special bodily constitution, temperament, complexion, and dietetics of the Truth-seeker, and the notion that the philosopher was *differently constituted* (sic) than the ordinary person was not necessarily treated as at all funny."[13]

While the explicit language for this bodily knowledge may have disappeared, knowledge has continued to be connected to the body in less obvious ways. I argued in the previous chapter that science, broadly construed, was not just seen as a domain of knowledge but that it could also be envisioned as fundamentally altering the body politic,

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[12] Steven Shapin & Christopher Lawrence, "Introduction: The Body of Knowledge," *Science Incarnate: Historical Embodiments of Natural Knowledge* (Chicago, IL: University of Chicago Press, 1998), 2. Londa Schiebinger has written extensively on the historical connections between the body and scientific knowledge, most directly in *Nature's Body: Gender and the Making of Modern Science* (Boston, MA: Beacon Press, 1993).

[13] Ibid., 14.

and thereby the thought, actions, and conduct of the individual citizen. And in this chapter, it is suggested that (as many feminist scholars have done), women and the feminine sensibility have been construed as inimical to the intellectual and physical rigors of science. This viewpoint, in its own way, makes important connections between the body and the mind in modern society. So, drawing on Shapin and Lawrence's simple assertion that attempts should be made to recover the links between body and knowledge, this chapter presents aspects of Ray's image and identity in an effort to connect the many complex and interrelated components of a life. Only through the totality of Ray's life (but not through her intellectual accomplishments alone) can we begin to recapture how she became an influential American scientist and public figure in the twentieth century.

Authority & Image

At some point during her Guggenheim-funded sabbatical, Ray visited with a group of Danish marine biologists who had expected a male colleague to show up at their laboratory. Soon after her arrival, no doubt after some moments of confusion, they all laughed at this misguided assumption. It is little wonder that Ray would be mistaken for a man on occasion since she chose to name herself "Dixy Lee" as a young adult, and then established herself as an academic scientist at a time when relatively few women achieved that distinction. With the expectation that "Dixy" was a man, these Danish biologists discovered a great rarity – a singularly successful woman scientist. One of these biologists bluntly recalled the event years later in a letter to Ray: "Dear Dixy, you certainly remember our small controversy back in 1953 as to whether you were a male or

a female." To which Ray responded, "How wonderful it was to hear from you and to be reminded of that delightful episode."[14] If her colleagues had expected a man to appear at their laboratory, and were surprised to find a woman, Ray had the ability to quickly re-establish confidence in her ability to fully act the part of a scientist. She could go along with the joke, downplay her femininity and make irrelevant the fact she was a woman. Ray's life presents numerous other moments in which she exhibited a similar ability to present a neutral gendered identity that allowed colleagues to accept her as a full member of the scientific community.

From her earliest years, Ray apparently felt little attraction to traditionally feminine toys and activities. Asked in the mid 1970s what she remembered playing with as a child, Ray responded with a short list of her favorite childhood objects and pursuits. A "kiddie car, wagon, baseball, bow & arrow, wrestling, and Girl Scouts" stuck in her memory as the few toys or activities available to her. But, she added with great emphasis, "I HATED DOLLS (till puppets!)." She reminded the writer, however, that the range of toys had been quite limited during her childhood compared to the more affluent situation in post-war America.[15] While Ray did not elaborate on this strong dislike for dolls, her simple statement reaffirmed her self-identity as a non-conformist, an individual who would and could challenge the stereotypical behaviors that constrained women, either as young girls or adults.

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[14] Letter from Torben Wolff to Ray, undated. Reply from Ray to Wolff, 24 May 1971. Box 48, Folder "Personal File, 1970-72." **DLR**.

[15] Letter from Gloria Hafemeister to Ray, 16 Feb 1976. Box 8, Folder "miscellanea." **DLR**.

Yet, Dixy Lee Ray avoided directly addressing her success as a woman in science. This was not an uncommon strategy employed by those women who worked in the sciences at a time when, from the 1940s through the early 1960s, little public sympathy existed for feminist causes. The malacologist Ruth Dixon Turner, Ray's friend and contemporary, was asked in an oral history interview what it was like working in marine biology "as a woman." After initially responding with an exasperated, "I don't know!" she added, "You just worked! You do your job."[16] Although Turner became the first American woman to participate in a deep-water submarine dive on the *Alvin*, and could recount the awkward reception she received in the exclusively male world of deep sea research, she was hesitant to speak of this as a triumph for women. Rather, Turner focused on the scientific accomplishment which proved that the wood-boring organisms she had spent a lifetime studying in relatively shallow waters also lived in the deepest parts of the ocean.

In a similar vein, Ray eschewed thinking that scientific accomplishments resulted from anything but hard work and intelligence. And, at least in most circumstances, Ray believed that the scientific community rewarded hard working females similarly to men, if not always equally. For Ray, many women would not do the necessary work, which she cited as the main reason few became scientists: "Any person, male or female, that is not willing to do those things necessary to performing a job – be it wearing a hard hat and jeans or diving into the sea – is not suitable for that kind of a job and shouldn't be in that

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[16] Oral history interview conducted by Judith Walzer, 9 & 15 July, 1981, session 3, part 1 (page 20 of transcript). Judith Walzer collection (93-m123), Box 2, Folder "Ruth Dixon Turner." Schlesinger Library, Harvard University.

field." Asked in an interview what strategies women should use to succeed in science she replied, "It makes it an awful lot easier if one forgets about whether or not you are going to be female all the time. You know, it really doesn't make any difference if you want to get a job done!" Ray recognized that barriers existed in all the professions, not least science, but she believed these were deliberately erected in the form of performance standards more so than conscious or unconscious discriminatory prejudice. In characteristically blunt language, Ray described these obstacles as "tests to keep out the incompetent."[17] For Ray, the kinds of explicit and objective barriers she recognized were important for creating dynamic and meritocratic institutions. Other kinds of discrimination often existed in a nether world of the subjective, even the subconscious, and Ray had little inclination or training to think in these terms.

Like many women scientists, including Barbara McClintock and Ruth Dixon Turner, Dixy Lee Ray did not marry.[18] There is no indication, from the archives or any other testimony, that she entered into intimate relationships at any time from high-school onward. Guzzo's biography of Ray, written in the late 1970s, suggests a possible early romance at the University of Washington, but if true she never made reference to it.[19]

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[17] Jay M. Steinberg, "Dr. Ray: Marine Biologist" *Progressive Woman: A Magazine of Awareness for Success-Minded Women,*" March 1972. Box 1, Folder "Articles about DLR, 1963-1972." **DLR**.

[18] Data from Rossiter suggests that more and more women scientists married during the course of the 20th century. In the late 1920s, some 35% of women with PhDs were married(or had been), compared to about 60% of women from 1950 to 1959. However, the comparable percentage of married male scientists remained significantly higher. Rossiter, *Struggles and Strategies,* 114.

[19] Guzzo hints at romantic relationships, going back to her days in high-school. He places this in the context of affirming her traditional femininity in the face of a somewhat unfeminine appearance. After describing her as "strong," "stocky," and with the tortured phrase "never

When pushed later in life to explain why she had remained unmarried, Ray half-joked that she was "too ugly," and suggested that in wanting to build a career she had little time for marriage.[20] Yet, Ray always had an active social life and especially through her early years at the University of Washington, she maintained a large circle of close friendships. Preparation of a weekly dinner rotated among some faculty members in the zoology department, including outside visitors and guests from other departments. These were lively and well-known affairs through the 1950s and, by all accounts, sustained a tightly knit nucleus of young scientists. In addition, Ray invested much energy into building up not only the physical structures at Friday Harbor but also creating a stimulating and dynamic community of zoologists. When asked to chair a fund-raising effort on behalf of the Laboratory, while serving on the Atomic Energy Commission in the early 1970s, Ray suggested her deep level of attachment to all that the Laboratory represented by stating that she "gave about 15 years of my life" to the institution.[21] The request to raise funds came about not for building new facilities but for continuing a tradition of inviting (and funding) outside researchers and graduate students, a tradition in which Ray had played a significant founding role.

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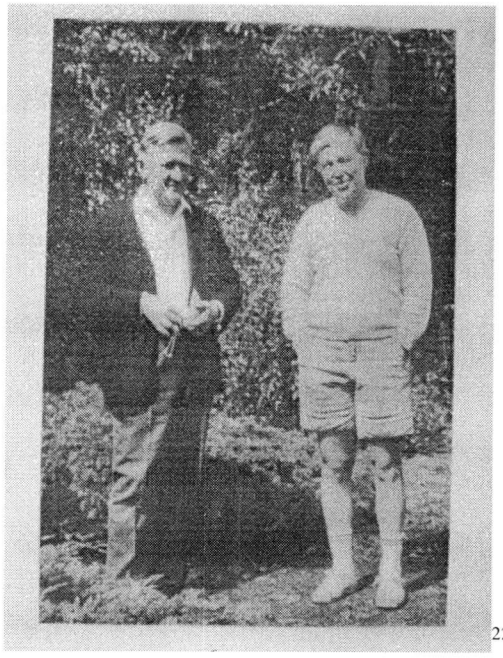
unprepossessing," Guzzo seemed compelled to assert that "Despite her physique, there is no question that Dixy Lee Ray is feminine. If she had chosen, I'm sure she would have made an exceptional wife and mother." Guzzo, *Is It True*, 33-34.

[20] Ibid., 34; and Virginia Keeting, "The Farmer of Fox Island," *The Port Angeles Daily News*, 29 Nov 1976.

[21] Ray's handwritten note attached to letter from Dennis Willows, Director of Friday Harbor Laboratories, 21 Feb 1974. Box 41, "UW Dept of Zool" #2. **DLR**.

 [22]

Ray's status as an unmarried woman scientist probably did not strike colleagues, or the general public, as unusual. More likely it reinforced a stereotype of the overly-dedicated, somewhat eccentric, or possibly frigid female scientist that people encountered on film and television.[23] Yet Ray likely stood out from her rather small cohort of women scientists in other ways. Those who knew Ray often remarked at her fondness for exotic and fast cars. While living in Washington DC, Ray purchased what is now one of the iconic British sports cars of the age – an Austin-Healy. Ironically, though sports-cars in general may be associated with a masculine image, just about the time that Ray was

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[22] Dixy Lee Ray (right) with Bertil Swedmark (director of the Kristineberg Marine Research Station, Sweden) at Friday Harbor, summer of 1960. Image Collection, Folder "H." **DLR.**

[23] A recent study of representation of women scientists in film found that most could be lumped into one of six categories: 1) the old maid, 2) the male woman, 3) the naïve expert, 4) the evil plotter, 5) daughter or assistant to a senior male scientist, and 6) the lonely heroine. Eva Flicker, "Between Brains and Breasts – Women Scientists in Fiction Film: On the Marginalization and Sexualization of Scientific Competence," *Public Understanding of Science*, 2003, 12:307-318.

zipping about the nation's capitol in her little two-door convertible, Barbie – the commercial model of modern femininity – received a coral green Austin Healy as her very first car. If Ray noticed this odd symmetry at all, it would surely have seemed a cruel blow to her sense of indomitable individuality (while intensifying her distaste for dolls!). Upon returning to Seattle in 1963, Ray moved on from the little convertible to a more formidable British sports car. For the duration of her tenure at the Pacific Science Center, Ray could be seen driving around the Puget Sound in the notoriously unreliable (and unmistakably phallic) Jaguar XKE, a car advertised in the early 1960s as the first consumer automobile designed to achieve speeds of 150mph. According to a niece, Ray regularly thrilled family and friends with high-speed adventures in this car.[24] When she ran for governor of Washington State, Ray owned a Toyota Land Cruiser "with a winch on the front used to clear her farm," but her greatest desire, she claimed, was to own the "raciest, flashiest and fastest sports car" available.[25]

As we have already seen, Ray did not think of herself as femininely attractive. She was of average height at 5'4", and of sturdy build. Throughout high school, college,

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[24] Paul Dayton, a graduate student in the University of Washington zoology department through the mid 1960s, recalled occasionally being driven about by Ray in her Jaguar. The seating position was uncommonly low in that car, he recalled, providing a direct view of tires on nearby cars or trucks. On one memorable occasion Dayton was surprised to learn that Ray possessed an extensive knowledge about tires, their manufacture, which brands were best for wear versus handling, etc. This anecdote provides not so much an insight into Ray's personality, but more so a key to the gendered perception of automobile knowledge and appreciation. This knowledge seemed remarkable because it came from a woman. A wonderful set of essays on the gendered nature of technological artifacts in American history can be found in the volume edited by Roger Horowitz, *Boys and Their Toys? Masculinity, Technology, and Class in America* (New York, NY: Routledge, 2001). For Ray's car ownership see Box 8, Folder "Miscellanea." **DLR**.

[25] Keeting, "The Farmer of Fox Island," *The Port Angeles Daily News*, 29 Oct 1976.

and later, Ray excelled in athletics, enjoyed outdoor pursuits, and was seen as having exceptional stamina as a field scientist. Ray sported a short gamine hairstyle, occasionally curled but usually straight and unstyled. Ray complemented her functional hairstyle with equally practical dress, preferring jeans and heavy work-shirts, or skirts and knee-socks, to the dominant feminine of the day. From the public point of view, Ray's physical presentation could be seen as a product of her scientific occupation. One journalist wrote that as "a woman of science, [Ray] finds no time for the nonessential, the devious, or the pretentious." Being a scientist somehow explained Ray's mental outlook and her sociability as much as her style of dress, where there was "no room for fuss or frills."[26]

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[26] Ibid.

[27] Left: Ray at Friday Harbor, undated (probably mid to late 1950s). Image Collection, Folder "H." **DLR**. Right: Formal portrait of Ray, included in *Marine Biology* (20th Biology Colloquium, Oregon State University) edited by Ivan Pratt and James E. McCauly (Corvallis OR: Oregon State University Press, 1959). Ray gave the keynote lecture at this colloquium held in 1959.

Yet if Ray's unfashionable and unadorned sense of style complemented her identity as a marine biologist, and more generally as a scientist, one other practice placed her well outside the bounds of standard femininity. According to one of her early graduate students, Ray enjoyed the pleasures of a good cigar and kept a well-stocked humidor in her cabin at Friday Harbor. This was an activity Ray enjoyed in privacy, or possibly with her closest associates. Women who smoked cigars were not completely unknown in American society, but the uncommonness of it carried a strong challenge to traditional masculinity and femininity. And while more and more women took up cigarette smoking in post-war America, epitomized by the late 1960s marketing campaign slogan for Virginia Slims ("You've come a long way Baby"), the pleasure of a cigar retained a profoundly masculine connotation. Within polite and professional society, as Margaret Rossiter has pointed out for the scientific community in the early decades of the century, the act of smoking and the social tradition of "the smoker" served to exclude women from important social functions through the early years of the twentieth century. Although women were being encouraged to smoke, and were being increasingly included within smoking culture from the 1920s onward, it is likely that for Ray this practice contributed to her social inclusion within the professional social circles.[28]

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[28] For the masculine social tradition known as "the smoker" as a barrier to female participation in science, see Rossiter, *Struggles and Strategies*, 92-94. And for the broader masculine culture of science, see Robert A. Nye, "Medicine and Science as Masculine 'Fields of Honor,'" *Osiris*, 1997, 2nd Series, 12:60-79.

While Ray enjoyed certain activities that may be seen as masculine, comported herself in nontraditional ways, and enjoyed success in the professional world of the marine sciences, she did not self-identify as an androgyne, let alone butch, individual. Her scientific career spanned a period which may have been dominated by a general return to traditional binary gender roles, yet a variety of subcultures persisted and offered alternative identities (at the price of marginalization) which Ray did not join.[29]

By leaving her gendered identity undefined, Ray participated in a well-respected tradition of Western frontier non-conformity that prized strong individuality. Emmet Watson, a long-time Seattle journalist who often wrote about the region's peculiar characters as emblematic of the true westerner, predicted that Ray's move from Seattle to the Atomic Energy Commission in Washington, DC would breathe vigor into the nation's overly staid capitol. To Watson, Ray's idiosyncratic dress, her forthright manner, and her rugged energy represented nothing but "real Northwest character."[30] If Watson described Ray as a product of a unique social and geographical setting, a journalist counterpart in Baltimore portrayed Ray simply as a great American individual. Joseph Alsop of the *Baltimore Sun*, welcomed Ray's arrival to Washington DC as "an original" – the best product of meritocratic American society. To Alsop, Ray was a true original because she

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[29] For entry into the historical literature on 20th century American sexual/gender identity, and an essay that attempts to avoid an essentialist perspective of gender formation, see Elizabeth Lapovsky Kennedy and Madeline D. Davis, "The Reproduction of Butch-Fem Roles: A Social Constructionist Approach," 177-190, *The Other Americans: Sexual Variance in the National Past*, edited by Charles O. Jackson (Westport, CT: Preager, 1996).

[30] Emmet Watson, *Seattle Post-Intelligencer*, 11 Aug 1972.

possessed "a style and character defiantly personal and uncommon" who, as a woman, had not compromised that style in rising to the pinnacles of power.[31]

In her own mind Ray likely thought of herself in similar terms – as a unique individual, someone who would not conform to the dictates of fickle but powerful social fashions. And as a non-conformist, Ray could argue that she and others like her contributed an important element of diversity to an ever more uniform and bland society. An episode from her years at the AEC provides a telling insight, even though Ray's words came in response to an uproar over the propriety of bringing her two dogs to work. In drafting a standard response to the many letter-writers complaining about her well-documented practice of bringing her two dogs to the workplace, Ray wrote that "the insistence upon uniformity ('...nobody must have dogs or cats or...') offends me. We do not want automatons in or out of government service, and I do not intend becoming one because a few people hate animals – or people." She then concluded with a line that could well have reflected her thinking in other aspects of life: "Why should everybody adhere to a nonexistent code of behavior which, if accepted, would doom the world to dullness deservedly?"[32]

Language, like other performative aspects of masculine and feminine behavior, has been deeply analyzed by scholars of gender. In a classic essay Robin Lakoff has argued that the different lexicon and syntax used by men and women reinforces

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[31] Joseph Alsop, "Dixy Ray is a Rarity – an Original Lady with Power," *Baltimore Sun*, 2 April 1974. Box 1, Folder "Articles about DLR, 1972-1975." **DLR**.

[32] Memo from Ray to Ambassador Robert J. McCloskey, "Subject: Congressional Inquiries Concerning Dogs." Box 4, Folder "Dogs, Correspondence." **DLR.**

established power dynamics in public and private life. Specifically, while men use a language of power and tend to make declarative statements, women rely more on open ended phrases, more commonly inflect their sentences in the form of questions, and tend to avoid direct confrontation.[33] To the extent this generalization has been valid through the twentieth century, Ray developed a form of discourse that would have to be seen as distinctly unfeminine. She was notoriously blunt and direct in conversation, and some of this came through in personal correspondence with colleagues. Significantly, she explicitly ascribed her manner of argumentation to her training in science. While working through drafts of a chapter in NASCO's 10-Year Report with a male colleague, Ray exchanged comments, and differences of opinion on what should be emphasized in biological surveys. She expressed her differences in forthright language, charging that some of his (and other contributors) ideas concerning what to observe and measure on a survey "had little meaning biologically." Ray concluded that the proposed plan "fell far short" of the goal of good research. At the end of this volley of strong statements, Ray suggested that she viewed this exercise as something of a violent sporting match. Employing a metaphor from boxing, Ray concluded by stating, "Guess that rings the bell for this round – your turn!"[34]

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[33] Robin Lakoff, "Extract from Language and Women's Place" *The Feminist Critique of Language*, edited by Deborah Cameron (New York, NY: Routledge, 1990), 242-252. This essay was originally published in 1973. For a more recent and complementary perspective on masculine language, see *Language and Masculinity*, edited by Sally Johnson and Ulrike Meinhof (Cambridge, MA: Blackwell Publishers, 1997), especially the overview of gender and language studies since Lakoff, provided by Sally Johnson, "Theorizing Language and Masculinity: A Feminist Perspective," 8-26.

[34] Letter from Ray to Milner Schaefer, 11 March 1960. Earth Sciences: Com on Oceanography: Reports Oceanography 1960-1970, (1960). **NASCO**.

A few years later in discussions at the National Science Foundation over the long-term aims of oceanography, Ray justified her directness and candor in terms of her scientific training. "Not to speak out on an issue that I believe to be important," Ray informed her male colleagues, "is contrary to my training as a scientist and to my conscience."[35] By justifying her style of argumentation in the context of scientific training, Ray could at once affirm her deep commitment to science and the need for openness in scientific discourse, while stifling any thought that she might be acting in emotional and feminine ways.

To the public Ray cultivated an authoritative yet approachable manner in which science constituted a serious and civil topic for all. As seen in the previous chapter, a television viewer found her to convey "a friendly quality..., an air of good humor, and a crisp intellectual approach." This viewer sensed that she did not "talk down to the public" and commended her use of a clear and simple language.[36] In another instance, a Puget Sound resident asked Ray to help her identify a strange seashore animal which the lady described only as "flesh-colored and rather obscene-looking." To this Ray responded that, while the lady may have been observing a large sea anemone, the description was insufficient for a better identification. But more importantly, Ray made sure to point out that the natural world was a place for wonder and curiosity but not for prudishness. "I know what flesh-colored means," she replied, "but I don't know what obscene looking

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[35] Ray, memo of 2 Feb 1962. Box 25, Folder "Special Oceanography 10-Year Projection." National Science Foundation, Historian's Files (RG 307). National Archives and Records Administration, College Park, MD.

[36] Letter from Ray Owen to Ray, 31 Dec 1973. Box 9, Folder "Owen, Ray." **DLR**.

might mean. To me, no animal on the shore is obscene or obscene looking."[37] David Allen relates that a nineteenth century British writer advocated the collecting of sea shells as "a study particularly suited to ladies; there is no cruelty in the pursuit, the subjects are so brightly clean, so ornamental to a boudoir."[38] By the mid twentieth century, with American society opening up to the possibility of greater equality between the sexes, all of science could be open to women and, in turn, Ray believed that women should no longer act and think in an outdated Victorian manner

Reaction to Feminism

From the mid 1960s onward it became virtually impossible to ignore the growing feminist movement. The contentious Civil Rights Act of 1964 offered legal protections for minorities and women in their efforts to gain equal treatment in the workplace and in American civic life. This momentous piece of legislation grew out of a deep yet divisive cultural revolution taking place in America in which traditional women's (as well as ethnic minorities) roles and professional opportunities were being challenged. In the case of the Civil Rights Act, and the later (but never enacted) Equal Rights Amendment, these movements aimed to ensure the expansion of women's presence in American public life. Yet, in subtle and overt ways Ray distanced herself from the feminist movement and the explicit ways in which it focused on the sex of the worker. In 1968 and 1969 Ray chaired a committee which evaluated Smithsonian research and provided outside advice on the

[37] Letters from Mrs. Elisabeth Lagergren to Ray, 1 Aug 1969, and Ray's response. Box 48, Folder "Personal File, 1968-71." **DLR**.

[38] David Allen, *The Naturalist in Britain*, 127.

quality of various science projects. In correspondence with her longtime friend Sydney Galler, formerly of the Office of Naval Research but by this time the Smithsonian's Assistant Secretary for Science, Ray referred to herself as the "chairman" as had been customary throughout her career. Galler, on the other hand, used the term "chairwoman." This might have seemed an insignificant matter, but it undoubtedly suggested that Ray preferred not to break with tradition and, more importantly, tried not to draw attention to her sex, a category she had always downplayed in her professional life.[39]

When providing advice to young women interested in following Ray's lead as a marine biologist, Ray refrained from encouraging them to challenge the status quo. To one inquiring high-school student interested in becoming a marine biologist, Ray advised the girl to set her sights on teaching at the high-school level, since "the plain, blunt truth is there aren't very many [research] job possibilities available." This was undoubtedly true, but Ray concluded with words that would have made the situation seem unalterable: "I think I need only to suggest that you look at the faculty of your own college and see for yourself how many women are employed there, or look at the faculties of other universities and ask yourself the same question, and you will see that the employment opportunities for women in science at the college and university level are severely limited." In a way that was increasingly out of step with the more idealistic goals of the feminist movement, Ray preferred to provide advice based on what she felt was the reality of the situation. Providing sound advice that came out of her own experience,

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[39] Letters between Ray and Sydney Galler (Assistant Secretary for Science, Smithsonian), 5 Sept 1968 and undated (spring of 1969), Box 136, Folder "Research Awards Advisory Committee – FY 1970." Collection 254: Assistant Secretary for Science, 1963-1978. **Smithsonian**.

although not the most inspiring advice by the end of the 1960s, Ray concluded that "For a woman, teaching is by all odds the best bet for employment."[40]

Yet, even as Ray dispensed advice that accorded with her own career development rather than a more activist perspective, she recognized that women in general had not advanced in professional careers since World War Two. "If you check actual records," she told one interviewer in the early 1970s, "you will find the proportion of women on university faculties was greater in the 1920s and 1930s than it is now. Women, instead of gaining in professional positions, have lost ground until very recently." Yet, Ray seemed to suggest that the blame for this retreat should fall on the women of her generation who did not follow up on earlier advances. As a result of the "suffrage" movement, Ray continued, "a great many [women] took steps to become professionally trained in various occupations that really had been quite closed to them before." As Ray portrayed it, the successes of these women came from their willingness to join the professions as they existed. The problem with the current age, Ray seemed to suggest, stemmed from women's desires to change the established order and to set up special privileges that could only divert scientists (in her case) from their investigations of the natural world. Addressing the feminist cause, as she saw it in the early 1970s, Ray stated that "Sex is a wonderful thing, and has its place, but to try to intrude it into every working hour and profession is ridiculous." Laying responsibility at the feet of women

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[40] Letter from Ray to Marlita Monahan of Massachusetts, 1 Aug 1969. Box 44, Folder "Chronological File, 1969." **DLR**.

for their lack of continued advances in professional life, she concluded by stating that a woman should not expect to succeed in many careers "if she is going to worry about being a woman all the time."[41] Working within an established social system had served Ray well, and though out of touch with many of the women who looked up to her, she undoubtedly saw it as the realistic way to advance a more equitable and yet meritocratic society.

Ray emphasized individual hard work, intelligence, and the role of personal initiative in explaining her scientific career. At the same time she recognized, as she moved from the Pacific Science Center to the Atomic Energy Commission (AEC), that feminism played an increasingly important role in this career development. Senator Warren Magnuson, Ray's friend since their mutual work for the discipline of oceanography over a decade earlier, formally introduced Ray to the Joint Committee on Atomic Energy upon her arrival in Washington, DC. As a skilled politician he touched all the timely factors that made Ray an ideal nominee for this post: biologist, environmentalist, and woman.[42] "At a time when scrutiny of the A.E.C. is building rapidly," Magnuson told his colleagues, "I think the addition of a non-nuclear scientist,

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[41] Jay M. Steinberg, "Dr. Ray: Marine Biologist" *Progressive Woman: A Magazine of Awareness for Success-Minded Women,*" March 1972. Box 1, Folder "Articles about DLR, 1963-1972." **DLR**

[42] The AEC had long been concerned with promoting its relevancy to biomedical and ecological research. In addition, it has been argued that the life sciences offered more socially beneficial areas of research for many of the scientists coming out of World War II. Nicolas Rasmussen, "The Mid-Century Biophysics Bubble: Hiroshima and the Biological Revolution in America, Revisited," *History of Science*, 1997, 35(3):245-293; and Angela N. H. Creager, "Tracing the Politics of Changing Postwar Research Practices: The Export of 'American' Radioisotopes to European Biologists," *Studies in History and Philosophy of the Biological and Biomedical Sciences*, 2002, 33(C):367-388.

with emphasis on environment, especially a woman scientist with the credentials of Dr. Ray – is imperative."[43] A few months later Ray herself had to acknowledge that she had been singled out, in part, because of the growing pressures being exerted by the feminist movement. Asked about the role of the "woman's liberation movement" in promoting her nomination to the Atomic Energy Commission, Ray conceded, "I think it got me my job." But, true to her scientific training and the strategy around which she had built her career, she added "I don't see the link between sex and jobs."[44]

Ray displayed a deep suspicion of the efforts to place issues of women and gender at the forefront. Answers to questions posed in the questionnaire cited at the beginning of this chapter show that Ray resisted characterizing professional success as resulting from anything but individual merit. For a woman who had found success by keeping body and mind well separated, Ray easily parried the questions posed to her, since they rested on assumptions and essential identities that Ray did not accept. The writer of the questionnaire, believing that the professional workplace compromised femininity, asked how often Ray acted in "an unfeminine manner in the execution of [her] responsibilities?" To this Ray responded with the typically cryptic response, "What is 'unfeminine'?" While at once suggesting an absence of fixity to such concepts as femininity and masculinity, Ray's reply also implied that for her, these constructs had played little or no part in her rise to leadership of the Pacific Science Center. A following question posed the possibility that women had to act as "one of the boys" in order to be

[43] Warren Magnuson's speech before the Joint Committee on Atomic Energy, endorsing Ray's nomination to the AEC, 1 Aug 1972. Box 1, Folder "Articles about DLR, 1972-1975." **DLR**.

[44] Joseph Alsop, "Dixy Ray is a Rarity," *Baltimore Sun*, 2 April 1974.

accepted as a professional equal. Since in Ray's mind "femininity" played no part in her success, so too, she had never felt compelled to act unnaturally masculine.[45]

According to the questionnaire, the masculine professional world tended to offend delicate sensibilities. Within a male workforce, a woman could expect to encounter "profanity and 'off-color' jokes" that might cause a woman to feel out of place. The questionnaire wanted to know how often Ray had been made to feel this way. Ray responded that vulgar company had never made her feel uncomfortable. Ray dismissed a question regarding how often emotions detracted from effective leadership by asserting that "There is no such thing as being without emotion for either sex." Ray clearly meant this statement to refer to the performance of professional work. In other instances Ray drew critical parallels between emotion and irrationality, and lumped the two together as being emblematic of unscientific thought. Yet, in the more rough-and-tumble world of leadership Ray unequivocally stated that emotion, per se, should not be considered antithetical to leadership.[46]

In reference to her leadership of the Pacific Science Center, the questionnaire inquired whether Ray felt she had experienced any "natural trait" advantages or disadvantages as a woman when compared with a man in the same position. To this question Ray responded that being a female director had offered no benefit, but likewise it had not hindered her in any way. Similarly, she thought that there was no greater need to prove herself competent in dealing with male counterparts or business associates. A

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[45] Document entitled "Research Paper Questionnaire," dated 24 Nov 1970. Box 8, Folder "Miscellanea." **DLR**.

[46] Ibid.

final section of the questionnaire juxtaposed "home or female role" with "job or professional role." To this Ray quickly pointed out that setting up the category of "Female" in opposition to "Professional" made no sense at all. In her life, the professional concerned him or herself with issues of knowledge, of fact, of appropriate methods for better understanding the natural world, and with persuading colleagues or fellow citizens through rational argument. These important categories for the professional scientist became confused only when one tried to impose unrelated categories of femininity and masculinity, male or female. In the end, Ray wholeheartedly agreed with the statement that "as long as [women] are technically competent and possess the attributes necessary for their position, there is no discrimination at all." "You can always find discrimination if you really look for it," she added.[47] Ray had been taught early on in her scientific training that an objective world existed that could be examined, analyzed, tested, and discussed in rational and productive ways. Outside that natural world lay a far less ordered reality, a realm of personal opinion and subjective views, where emotion and irrationality seemed to have equal standing to the most rigorous and objective knowledge produced by scientifically trained minds. Ray resisted accepting those aspects of the feminist movement which she saw as advocating social revolution at the expense of the established systems of knowledge production. Having excelled in the established American scientific community, she would not take up the cause for its reformation.

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[47] Ibid. At the very end, Ray re-iterated that as a professional scientist she did not act in reference to other people's opinions. When asked how her colleagues would rate her on a spectrum of professional or domestic interests, she stated that "I neither know nor care to know."

In conclusion, Ray's life suggests some of the ways in which women scientists forged successful careers. In a "world without women" – to borrow from David Noble – the construction of a neutral (or at least not traditionally feminine) gendered identity by successful and prominent women scientists may be considered somewhat predictable. Noble traces the roots of Western science back into the structures, practices, and world view of early and medieval Christianity. The development of Christianity progressively excluded women from positions of authority and privilege, based in large part on a deep suspicion of sexuality (thus the eventual celibacy of priests), and particularly female sexuality. The basis of modern science in the learned cultures of Western Christendom, Noble concludes, provides a compelling explanation for the persistent marginalization of women in science.[48] Considering this thesis, it is not surprising that we find women constructing nontraditional identities as they entered the "priesthood" of science. Ray's success as a scientist, through the middle decades of the century, must be considered in light of her neutral gendered identity which at once unbound her from traditional femininity while allowing her to cultivate traits that supported her entry into the masculine community of science.

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[48] David F. Noble, *A World Without Women: The Christian Clerical Culture of Western Science* (New York, NY: Alfred A. Knopf, 1992); see also, Londa Schiebinger, *The Mind has no Sex? Women in the Origins of Modern Science* (Cambridge, MA: Harvard University Press, 1989).

Epilogue

Historical Legacies and Cultural Revolutions

As described at the beginning of this dissertation, a conservation biologist writing in 1994 portrayed Dixy Lee Ray as "unscientific." This statement reflected a wider criticism of Ray in the latter years of her life, in which she was seen to be, if not unscientific, then certainly out of touch with the ideals, concerns, and dominant conceptions of her colleagues in the life sciences. Yet, cursory knowledge of her life has indicated that her rise to positions of leadership was based on a successful career as a marine biologist, a career in which Ray embodied the ambitions of her generation in the scientific community.

The incongruity of the judgment made in 1994 with her earlier achievements formed the basic motivation for this dissertation, which has been to better understand the historical context in which Ray developed her scientific career. If we dig beyond the facile assertions that Ray did not progress with the times, that she failed to comprehend the true practices of modern science, or that she betrayed reason and science, we can formulate a more interesting historical question: how was it that Ray could be trusted as a solid member of the scientific community and spokesperson for its values in the 1950s and 1960s, and then two decades later come to be seen as unscientific? To what extent did the culture shift, both the scientific culture in which she formed her professional identity and the broader American culture? Conversely, did Ray undergo a transformation over this period that explains the incongruity between her early and late

life? This dissertation only gestures at the social and cultural changes beginning to take place in the late 1960s, but by arguing that Ray adopted and promoted a set of scientific practices and values that resonated with certain elite segments of American society in the early post-war years I suggest that a deep cultural shift underlay the radically different perceptions of Ray over her career.

Entering a world in which women were increasingly allowed, even encouraged, to pursue professional careers and establish identities outside the domestic sphere, Ray took advantage of these opportunities and fashioned a significant and active scientific career. Although she was uncommon and possibly idiosyncratic as a visible professional women entrusted with leadership positions, I argue that to understand her successes one must examine how Ray's research, training, and other professional activities reflected the broader values of the scientific community.

Through her earliest training in science, Ray imbibed an instrumental appreciation of the natural world, and to be a scientist meant to express ideas from a dispassionate and rational perspective. While the natural world contained wonders and returned abundant delights to those who studied it, real scientists learned to separate their sentimental attachments to plant or animal life from rational knowledge about processes and fundamental laws of nature.[1] In her research, Ray employed experimental techniques that allowed simple and effective manipulations of organisms in order to gain superior insight

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[1] Peter Dear has addressed this point, arguing that a longstanding tension and ambiguity within science has arisen due to modern science's combining of practical knowledge and contemplative knowledge into an "unstable ideology of natural knowledge." Peter Dear, "What is the History of Science the History of? Early Modern Roots of the Ideology of Modern Science," *Isis*, 2005, 96(3):390.

into their behaviors and habits. Being a keen and diligent observer allowed her to establish factual knowledge about various forms of life, buttressed by pertinent experimental evidence. She avoided directly addressing issues of scientific theory in her investigations, preferring to add empirical data to the storehouse of natural knowledge. Contributing to a strong tradition in science that valued the correction and refinement of existing knowledge, Ray's major research program on the nutritional physiology of *Limnoria* displayed her skilled, careful, and conservative scientific ideals and methodologies. Yet, not only did this research establish a valid scientific identity for Ray, but its practical orientation to concerns within maritime industry seemed to prove the link between unfettered basic science and the expected application to broader concerns of industry, government, and society. Although science's practical application had long been prized, in post-war America it had become a necessary component to the expanding scientific enterprise as articulated by leaders such as Vannevar Bush. The nation's investment in basic science, these leaders promised, would pay dividends in the form of a safer and more livable world.

The vision of an expanding scientific enterprise, directed not by politicians but by scientists, required active participation in advocating the appropriate goals and domains for the various disciplines. As a trusted member of the scientific community, Ray played a crucial role justifying and implementing much of the growth in marine biology and biological oceanography that took place in the mid twentieth century. Yet again, the expansion of these scientific fields stemmed from the binary values in which increased knowledge of marine life constituted an intellectual good in itself and would lead to a

greater social good. Undergirding this generation's faith in science, from investments in atomic energy to exploration of the oceans, lay the belief that science allowed for a greater ability to control nature while living more comfortably off its bounty.

Outside the narrow interests of disciplinary expansion, which rested more often than not on implicit assumptions about science's greater social good, Ray participated in the explicit promotion of science to the public. The values, the modes of thinking, and the mental disciplines of science, embodied in so many ways through Ray's scientific career, could be disseminated to the general public with the intention of ensuring the continued progress of American society. Science excelled at delivering factual knowledge which, if citizens better understood the methods and content of science, would foster civil and more productive public debate on many of the central issues of modern life. Similarly, it was believed that science, being progressive, would continuously reinvigorate a natural American curiosity and confidence in the future. These and other values, assumed to be at the heart of science, animated the public understanding of science movement and made Dixy Lee Ray one of its leading practitioners.

Yet, as the decade of the 1960s came to a close this modernist vision for a scientifically oriented, rational, and progressive society seemed to be faltering. A younger generation of Americans, coming of age at a time dominated by a dubious war abroad and social upheavals at home, saw the uses of science and the modernist project quite differently.[2] Ray fretted over what she saw as young scientists who were "by no

[2] For perceptions of science in the public sphere, see Amitai Etzioni and Clyde Nunn, "The Public Appreciation of Science in Contemporary America," *Science and Its Public: The Changing Relationship* (Boston Studies in the Philosophy of Science, vol. 33), edited by Gerald Holton and William A. Blanpied (Dordrecht, NL: Reidel,1976), 229-243. This essay, as well as other essays

means immune from a wholly emotional treatment of questions concerning pollution, insecticides, over-population," and other issues. She similarly despaired over the general public's inability to make "social decisions... on a rational basis," even after the success of places like the Pacific Science Center. In Ray's opinion, Americans were increasingly "resorting to fear and succumbing to hysteria."[3] This sentiment marked much of her later life, as she became a political force in Washington DC and Washington state, and later in her commentaries on the status of American society and the role that science was, or was not, having in the betterment of the human condition. But Ray's views were bound up with a vision of science, and its role in society, that became increasingly alien to a younger generation suspicious of the ties science had made with the military, industry, and the social order of Ray's generation.

Scientists live and participate in their own disciplinary communities and adopt views, ideals, and practices constructed by those communities. At the same time scientists constitute and shape the larger culture of their time and place. While historians of science often examine those figures who seem to transcend their time and whose ideas changed the world in fundamental ways, it is also important to examine how scientists (and science) are produced by the particular social and cultural milieu in which they lived. This biographical study of Dixy Lee Ray's scientific career aims to do just that,

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in this volume echo the concerns Ray exhibited at this time over the role of science in American society.

[3] Letter from Ray to Donald Farner (chair of zoology department), 4 Feb 1970. Box 41, Folder "UW Dept of Zoology, #2." **DLR**.

and thereby add to our understanding of the interplay between American society and American science through the first two decades of the Cold War. In the end, a contextualized understanding of Ray's scientific career begins to explain the radically different perceptions of an important American scientist over her lifetime.

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