Critical Review:
A Historical Perspective on the National Research Council's Report "Shellfish Mariculture in Drakes Estero"

Timothy Babalis, Historian
National Park Service, Pacific West Region
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Executive Summary

The following review is given in response to the recently-released report by the National Research Council (NRC), *Shellfish Mariculture in Drakes Estero*, as a critical analysis of the history used to support several of that report's conclusions.[1] This review does not claim to be an exhaustive history of oyster mariculture, but is meant only to address the specific assertions made by the NRC report and to evaluate their legitimacy in the context of west coast maricultural history. It also offers an assessment of the historical methodology used by the NRC and suggests that a more rigorous interpretation of the historical evidence might yield conclusions different from those currently made by the report. Hopefully, this critique will contribute toward the improvement of the NRC report by establishing its findings on a firmer and more responsible historical basis.

The NRC report was contracted by the National Park Service (NPS) in April 2008 for the purpose of obtaining a non-biased evaluation of the science relating to oyster mariculture and its impact on the natural environment of Drakes Estero within the Point Reyes National Seashore, California. The NRC's professional third-party perspective was sought in order to help resolve key questions in what had become an increasingly bitter conflict between interested parties with substantially disparate loyalties. After more than a year in preparation, the NRC report was released in early May of this year (2009). Its authors identified two points where their findings differed significantly from those of the National Park Service, the government agency principally responsible for managing Drakes Estero. One of these—the point under consideration here–is the assumption that native Olympia oysters (*Ostrea lurida*) once represented a keystone component of Drakes Estero before allegedly being extirpated by over-harvesting in the late nineteenth century.[2] (The other point concerns disturbance of harbor seal populations by maricultural activities but is not the subject of the present review). As the NRC report noted, the Park Service does not accept the claim that oysters (of any species) ever constituted a significant component of the prehistoric natural environment of Drakes Estero, but the authors of the report assert that oysters once did. The authors also conclude—based on the previous assertion—that the present maricultural industry (Drakes Bay Oyster Company) contributes towards the restoration of natural processes, because the industry has

[1] Charles H. Peterson, et al., *Shellfish Mariculture in Drakes Estero, Point Reyes National Seashore, California* (Washington, DC: The National Academies Press, 2009).
[2] The report refers to "... the changing ecological baseline of Drakes Estero, in which native Olympia oysters probably played an important role in structuring the estuary's ecosystem for millennia until human exploitation eliminated them in the period from the mid 1800s to the early 1900s." [Ibid., p. 2].

reintroduced oysters to a natural system where, according to the NRC, they were once abundant. The present review, however, finds this conclusion to be improbable and indefensible, because there is little factual evidence to support the assumptions on which it is based. Close examination of the sources cited in the NRC report reveals that the authors failed to research adequately the historical (and archeological) basis of their claims. Instead of consulting primary records, the report's authors relied on secondary sources which were misleading or otherwise unreliable, though they may have supported the authors' own presuppositions. A more thorough-going and critical review of the historic record reveals nearly the opposite of what the NRC claims and suggests that oyster mariculture represents an entirely novel and artificial introduction of oysters to Drakes Estero, originating in the early 1930s at the start of the present maricultural operation. This failure to employ professionally-acceptable standards of historical research calls into question the NRC report's effectiveness for guiding policy and seriously undermines its authoritative value in arbitrating the present conflict.

In making its assertion that the present oyster mariculture contributes towards restoration of natural process, the NRC report assumes, first, that a native species of oyster (*O. lurida*) was abundant in Drakes Estero prior to the mass immigration of American settlers in 1849; and, second, that overharvesting by these settlers virtually extirpated local populations of the native oyster in the ensuing decades. But there is little reason to believe that significant numbers of *O. lurida* (or any species of oyster) were present in Drakes Estero prior to the European arrival in northern California. Physically, Drakes Estero provides little natural habitat for oysters, since it has few hard surfaces for oyster larvae to adhere to. Sediment studies which reconstruct the morphological evolution of Drakes Estero show that its present soft bottom has characterized the estero almost since the time it was first formed by rising sea levels more than 10,000 years ago. Although shell deposition from existing oyster populations can create habitat even in geologically soft-bottomed environments, these populations would have to become established in the first place, and their existence—past or present—would be evidenced by the presence of oyster shells in sedimentary strata. However, core samples taken from the bottom of Drakes Estero have failed to reveal any trace of oyster shells, which corroborates the implications of the absence of natural habitat. The archeological record, represented by midden deposits in the vicinity of Drakes Estero, is dominated by clam shells—primarily butter clams (*Saxidomus nuttalli*) and Pacific gapers (*Tresus nuttalli*)—but few, if any, oyster shells.[3] These clam species are consistent with the physical environment found at Drakes Estero—unlike oysters, clams prefer muddy or sandy bottoms—but also reflect the preferential diet of the Native Americans who exploited them. Oysters, however, were also a desirable food item, and their near-absence from the middens strongly suggests that they were also absent or rare in the immediate environment. Finally, the historical record also provides no evidence that oysters were ever harvested or cultivated in

[3] Trace quantities of oyster shells have been confirmed in only one midden in the vicinity of Drakes Estero (Ca-Mrn-242), but the reliability of this archeological record was compromised by early historic-era disturbance. For more details on this subject, see Mark Rudo, "Little Archaeological Evidence of the Olympia Oyster (*Ostrea lurida*) at Drakes Estero, Point Reyes National Seashore, California," June 1, 2009, National Park Service, Pacific West Regional Office, Oakland CA.

Drakes Estero following European contact and prior to 1932, when the Pacific oyster (*Crassostrea gigas*) was introduced for the present industry.

If oysters were absent or rare in Drakes Estero prior to the historic period, then the NRC's other assumption—that overharvesting has extirpated native oyster populations—cannot be true. This assumption was based on the inappropriate application of a model designed to describe circumstances on the east coast, but not the west. The historical record shows no evidence of any organized mariculture at Drakes Estero prior to 1932. History is not silent on this matter simply because records failed to be kept or have been overlooked. The history of the Point Reyes peninsula is well-documented from at least the early 1850s, with the development of the region's prestigious dairy industry receiving considerable attention from contemporary observers and the local press. Two of the principal centers of this industry lay on the shores of Drakes Estero (Home Ranch and "F" Ranch), and the estero itself served as an important embarkation point for schooners bringing supplies to and from San Francisco (hence, "Schooner Bay"), but no mention is ever made of harvesting or cultivating oysters here. Also documented are the activities of San Francisco oystermen like John Stillwell Morgan, who systematically explored the Pacific coast for sources of marketable oysters and locations to cultivate them, but Drakes Estero is never mentioned in these records either, even though Drakes Estero lies scarcely fifty miles north of the principal nineteenth century oyster markets in San Francisco. The most reasonable interpretation which can be drawn from this lack of evidence is that no formal harvesting or cultivation of oysters occurred at Drakes Estero between 1849 and 1932, contrary to the assertions made in the NRC report.

Though the ecological effects of oyster mariculture in Drakes Estero remain a matter of debate, the industry cannot be said to contribute towards the restoration of natural processes, because oysters were not a significant element of the natural environment prior to the historic period. The cultivation of exotic oysters by the Drakes Bay Oyster Company represents an artificial modification of Drakes Estero with no known natural or historical precedent prior to the beginning of the present industry in 1932. This casts into doubt one of the central conclusions of the NRC report supporting the present oyster operations, and suggests that they cannot be justified on the basis of any presumed continuity with the past, natural or historic.

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Introduction

The following review is given in response to the recently-released report by the National Research Council (NRC), *Shellfish Mariculture in Drakes Estero*, as a critical analysis of the history used to support several of that report's conclusions.[4] This review does not claim to be an exhaustive history of oyster mariculture, but is meant only to address the specific assertions made by the NRC report and to evaluate their legitimacy in the context of west coast maricultural history. It also offers an assessment of the historical methodology used by the NRC and suggests that a more rigorous interpretation of the historical evidence might yield conclusions different from those currently made by the report. Hopefully, this critique will contribute toward the improvement of the NRC report by establishing its findings on a firmer and more responsible historical basis.

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In April 2008, the National Research Council (NRC) was contracted by the National Park Service (NPS) to investigate the scientific basis of conflicting allegations about the ecological impact of the Drakes Bay Oyster Company, a private mariculture industry operating under a forty-year Reservation of Use and Occupancy (RUO) and Special Use Permit (SUP) within a legislatively-designated Potential Wilderness Area of the Point Reyes National Seashore in Marin County, California. This lease is scheduled to expire in 2012. The current proprietor, Kevin Lunny, purchased the business and associated rights to operate it from Tom Johnson in 2005. (Tom Johnson is the son of Charles Johnson, who founded the family business on Drakes Estero in 1957). Since acquiring the business, Lunny has made substantial improvements in the quality but also the extent and intensity of operations, which eventually raised concern among Park Service resource managers about the potentially negative impact to a variety of natural resources associated with the estero, ranging from marine mammals which haul out on the estero's sandy shoals, to eelgrass beds on the estero floor. Because opinions varied widely as to the effect of the oyster industry on these and other natural resources, the NRC was asked to provide a non-biased, professional evaluation of the science relating to these questions. After more than a year in preparation, the NRC's report was released in early May of this year (2009).

[4] Charles H. Peterson, et al., *Shellfish Mariculture in Drakes Estero, Point Reyes National Seashore, California* (Washington, DC: The National Academies Press, 2009).

Among its findings, the NRC report concluded that the present activities of the Drakes Bay Oyster Company contribute towards a restoration of natural processes:

> The oyster re-introduction and enhancement through mariculture (albeit not the native oyster) represents a form of restoration of historic functionality of the estero ... Effects of nonnative oyster presence and its biogeochemical processing can be viewed as contributions towards restoring an historic baseline ecosystem in Drakes Estero.[5]

Unfortunately, this conclusion is based on unsubstantiated assumptions about historic baseline conditions. The report's authors assert that "... native Olympia oysters [*Ostrea lurida*] probably played an important role in structuring the estuary's ecosystem for millennia until human exploitation eliminated them in the period from the mid 1800s to the early 1900s."[6] But there is no evidence that oysters—native or otherwise—ever comprised a significant presence here prior to the advent of American civilization in the latter nineteenth century. The first documented record of any oyster associated with Drakes Estero dates from the early 1930s, when the exotic Pacific oyster (*Crassostrea gigas*) was introduced for commercial purposes. At the time, no other oyster was believed to be present.[7] This is an important point, because the authors of the NRC report place so much weight on the value of restoration to justify the ecological contributions of the present oyster industry, but if oysters were never a part of the estero's historic baseline functions, then the present cultivation of oysters cannot be interpreted as a restoration or justified upon that basis.

The quality of historical methodology is central to this discussion, because the NRC's argument depends upon an accurate establishment of baseline historic conditions. (Given this prioritization of history, one wonders why the NRC did not include on its investigative panel a professional historian or archeologist). The willingness to make such bold and unequivocal assertions without a strong foundation of evidence is inconsistent with the professional standards of history. This is especially regrettable in the present circumstances, because the NRC report may strongly influence decisions affecting the future management of Drakes Estero, with potentially profound consequences both for the natural resources and the livelihoods of many individuals. The poor use of historical evidence calls into question the NRC report's usefulness for guiding policy and seriously undermines its authoritative value in arbitrating the present conflict. The following provides a more comprehensive investigation of the historical record relating to oysters and oyster mariculture in Drakes Estero in the interests of correcting these weaknesses in the NRC report and establishing a more complete and reliable assessment of the present mariculture industry.

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[5] Ibid., p. 18.
[6] Ibid., p. 2.
[7] The only record of native oysters occurring in Drakes Estero comes from a personal recollection by Charles Johnson, who reported in 1995 to interiewer Patrick Baker that native Olympia oysters (*Ostrea lurida*) were "common but not abundant" there. [Patrick Baker, "Review of Ecology and Fishery of the Olympia Oyster, Ostrea lurida with Annotated Bibliography," *Journal of Shellfish Research* 14.2 (1995): 502]. But this observation comes more than sixty years after the introduction of oyster mariculture in Drakes Estero, and it is not corroborated by any other source.

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The NRC report makes two principal assumptions relating to the history of oysters in Drakes Estero and the greater San Francisco Bay area. First, the report assumes that the native oyster (*Ostrea lurida*) was overharvested and largely extirpated during the first few years of the Gold Rush at the beginning of the American Period, both from San Francisco Bay and from Drakes Estero.[8] The second assumption—implied in the first—is that these native oysters were abundant throughout the local area when American immigrants first began arriving in large numbers at the end of 1848.[9] These assumptions, and their corollaries, need to be addressed separately, although they are closely related.

Discussion

§ 1. Was the native oyster (*Ostrea lurida*) overharvested by American immigrants in the first few years of the Gold Rush?

In support of this assertion, the NRC report cites a study from 2004 by Michael Kirby, published in the *Proceedings of the National Academy of Sciences*. Kirby proposed a model for describing the geographical expansion of native oyster exploitation relative to market demand and centers of trade. Using historic fisheries data, he maps the moving frontier of the oyster industry in three locations: the Atlantic and Pacific coasts of the United States, and the Pacific coast of Australia. Kirby argues that this movement tended outward from market centers and followed the progressive degradation of native oyster habitat through overexploitation. The earliest oyster harvests, according to this model, would have occurred in native populations closest to market centers (Boston on the east coast, San Francisco on the west, and Sydney in Australia). As these sources of supply were exhausted, the industry would move to the next closest native source, and the process would repeat itself until each successive source was also exhausted. Eventually, the industry would utilize sources at the most extreme distance from the principal market, simply because nearer sources no longer existed. The pattern described by this model is simple; its value lies in its detailed correlation of time and event—Kirby arduously collected statistical data from oyster fisheries' landings, correlated this to geographical place, and illustrated how the location of harvests grows

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[8] The Olympia oyster is variously referred to as *Ostrea lurida*, *O. conchaphila*, and occasionally *Ostreola conchaphila*. This confusion dates to 1985, when Harry proposed the synonomy of *O. conchaphila* Carpenter 1857 and *O. lurida* Carpenter 1864 [H. Harry, "Synopsis of the Supraspecific Classification of Living Oysters (Bivalvia: Gryphaeidae and Ostreidae)," *Veliger* 28 (1985): 121-158]. The former species was typically associated with southerly waters from the Gulf of California south to Panama, while the latter was associated with waters extending north from Baja California to Vancouver Island, B.C. (and possibly even to Sitka, Alaska). More recently, molecular analysis conducted by Polson et al. suggest that the original taxa are, in fact, distinct species [Maria P. Polson, et al., "You Say *Conchaphila*, I Say *Lurida*: Molecular Evidence for Restricting the Olympia Oyster (*Ostrea lurida* Carpenter 1864) to Temperate Western North America," *Journal of Shellfish Research* 28.1 (2009): 11-21]. On the basis of this recent evidence, the present paper uses the taxon *Ostrea lurida* to refer to the Olympia oyster found from Baja California to Southern Alaska (*O. conchaphila* does not enter the present discussion). This usage is consistent with common historic practice.

[9] See "Historical Baselines and Human Modifications," in Peterson, *Shellfish Mariculture*, pp. 16-19.

increasingly distant from the location of market centers over time. Developed primarily from data collected on the Atlantic seaboard, where records are extensive, this model seems to accurately reflect events that occurred in that region.

Problems arise, however, when Kirby applies his model to vastly different places and circumstances. In the case of California, for example, he assumes from the fact that San Francisco oystermen were exploiting native oyster beds in Washington by 1851 that the local sources of native oysters had already been exhausted. Since the San Francisco market had only existed from the beginning of the Gold Rush migration in 1849, Kirby assumes—based upon his model—that an oyster industry was established, grew to maturity, and exhausted its resources within the space of only two years.[10] But little, if any, evidence exists to support this assumption. Although a market clearly existed among the Gold Rush immigrants, many of whom came from the east coast and already had a taste for oysters, this alone cannot justify his assumption that they exhausted a local supply of native oysters by 1851. In fact, there is no evidence that any local supply ever existed, at least not in marketable abundance. According to historical sources, including the statements of local oystermen, the reason oysters were imported from Washington in 1851 is because this was the closest source available to supply market demand. Oystermen explored nearly every estuary along the west coast looking for supply and eventually imported oysters from as far away as Mexico (the Gulf of California) and British Columbia.

As evidence to support his claim that an exploitative oyster industry existed at San Francisco from 1849 to 1851, Kirby cites a conference proceeding by Harold Beattie from 1982, but Beattie was not describing San Francisco Bay when he claimed that native *O. lurida* was overharvested. He was describing Willapa Bay, Washington during the period 1851 to 1920, when native Washington oysters (also *O. lurida*) were being harvested for import to San Francisco.[11] In addition to Kirby, the NRC report also cites Conte and Dupuy (from the same proceedings in which Beattie's paper was presented). In their brief historical overview of the California oyster industry, Conte and Dupuy state that the increase in population resulting from the Gold Rush "adversely affected" many of the state's resources, and "the influx of East Coast oyster consumers soon increased market demand beyond the natural capacity of the fishery."[12] This vague statement says nothing about the extent of the fishery or the original abundance of native oyster populations, though it implies that the latter was not great. Nor is it anything more than a reasonable conjecture made by Conte and Dupuy, who do not provide any evidence for their assertion or cite other sources. Conte and Dupuy also note that the native California oyster was unappealing to local taste, which was yet another inducement to search for alternative sources. Though not cited in this section, the NRC

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[10] "With the beginning of the California Gold Rush in 1849, oyster reefs in the bay were rapidly overfished." [Michael X. Kirby, "Fishing Down the Coast: Historical Expansion and Collapse of Oyster Fisheries Along Continental Margins," *PNAS* 101.35 (2004): 13097-13098].

[11] J. Harold Beattie, Dave McMillan, and Lee Wiegardt, "The Washington State Oyster Industry: A Brief Overview," in *Proceedings of the North American Oyster Workshop,* edited by Kenneth K. Chew (Baton Rouge, LA: Louisiana State University, 1982), pp. 28-30.

[12] Fred S. Conte and John L. Dupuy, "The California Oyster Industry," in *Proceedings of the North American Oyster Workshop,* edited by Kenneth K. Chew (Baton Rouge, LA: Louisiana State University, 1982), p. 44.

report also references Shaw, who writes that "in the 1840's California had a small fishery for the native Olympia oysters which served San Francisco."[13] But Shaw's source for his assertion was also Conte and Dupuy and so provides no additional evidence.[14]

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With the Gold Rush of 1849, San Francisco grew dramatically from a remote outpost of a few dozen individuals to the region's largest and most important city, functioning as the principal point of supply and embarkation for the gold miners, and the financial, social and cultural center of California's new mineral-based economy.[15] It was also the principal market for fresh oysters, whether they were consumed here in local restaurants or transported to the goldfields further east. One of the original gold miners from 1849 was an oysterman from New York state named John Stillwell Morgan, who would eventually become the largest oyster producer in the San Francisco Bay area. Morgan's reflections on the history of the Bay Area oyster business, recorded in an interview made by one of Hubert Howe Bancroft's staff in the 1890s, remains one of the few sources documenting the earliest period of this industry.[16] Morgan gave up mining within a year of his arrival in California, but decided to remain on the west coast and take up his family business here. By 1850, he had returned to San Francisco and was searching the local waters for a source of marketable oysters, but all he found was something he called a "bastard oyster," which was very small and generally considered unpalatable. Though he admitted that some people collected and ate the little mollusk, Morgan did not believe there was a market for it.

At about the same time, Morgan learned of an attempt by a man named Captain Felstead to import a more desirable variety of native oyster from Shoalwater Bay (now Willapa Bay) in Washington, about 750 miles further up the coast. Captain Felstead intended to bed these oysters in the tidelands adjacent to San Francisco, where they would be readily available for local sale. Although the experiment failed, it brought the existence of these northern oysters to the attention of Morgan and other potential San Francisco oystermen. In 1851, Anthony Ludlum brought the first successful shipment of Shoalwater Bay oysters to San Francisco, and later that year Morgan did the same. Thus was born the Shoalwater Bay trade. It would dominate the San Francisco market until the early 1870s, when the west coast oysters were largely replaced

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[13] William N. Shaw, "The Shellfish Industry of California—Past, Present, and Future," in *The History, Present Condition, and Future of the Molluscan Fisheries of North and Central America and Europe*, edited by C.L. MacKenzie, V.G. Burrell, A. Rosenfield, and W.L. Hobart, NOAA Technical Report NMFS 128, p. 59.

[14] Beattie, et al., "The Washington State Oyster Industry," pp. 28–38.

[15] By 1853, at the height of the Gold Rush immigration, San Francisco's population was estimated to number about 50,000 [David Lavender, *California: Land of New Beginnings* (Lincoln: University of Nebraska Press, 1972), p. 236].

[16] David R. Sessions, "John Stillwell Morgan Dictation and Biographical Sketch," typescript, 1888, Bancroft Library, Berkeley, CA.

by eastern oysters (*Crassostrea virginica*) imported from the Atlantic seaboard on the newly-completed transcontinental railroad.[17]

Morgan and his employees later explored the entire coast from Puget Sound to the Gulf of California in search of alternative supplies of oysters, but Shoalwater Bay remained their best source. While small beds of native oysters were discovered—and exploited—at Yaquina and Netarts Bay in Oregon, and around Olympia on Puget Sound in Washington, Willapa Bay remained the principal source for the duration of the Shoalwater Bay trade, accounting for an average of 90% of the oysters on the San Francisco market. Morgan did find a much more desirable variety growing in the warmer waters of the Gulf of California (*Ostrea conchaphila*), but repeated attempts to ship this oyster north always met with failure.[18] Morgan never mentions finding oysters in either Drakes Estero or Tomales Bay, though he must have examined these locations with some interest, given their relative proximity to the San Francisco market (Drakes Estero lies about fifty miles north of San Francisco).

The oysters which were brought to San Francisco with the Shoalwater Bay trade were the species now commonly known as the Olympia (*Ostrea lurida*), though at that time they were often called California oysters on account of their popularity in San Francisco. Oddly, these appear to be the same species as the so-called "bastard oysters" which Morgan observed in San Francisco Bay during his initial explorations, but the Washington variety was much larger than the one found in California.[19] Morgan was never able to explain this anomaly and may have believed that the two were unrelated, as suggested by his assertion that there was no such thing as a California oyster, only the oysters which businessmen like himself had imported from outside the state.[20] But judging from Morgan's description, the "bastard oysters" of San Francisco Bay may simply have been young *O. lurida*, since the species does not appear to grow very large in San Francisco Bay waters.

With the completion of the transcontinental railroad in 1869, Morgan (and other oystermen who had entered the business by now) began importing eastern oysters (*C. virginica*) from the Atlantic seaboard. The San Francisco oystermen were motivated by two reasons. First, the eastern oyster was larger and more appealing to the taste of their customers, many of whom had also come from the east. But another reason is that the Olympia oysters which were being imported from Willapa Bay were declining in quality, at least the oystermen believed they were. Morgan claimed that, "... the native oysters are degenerating—they are not more than half the size they used to be. We had a great storm there [in Willapa Bay] 15 or 18 years ago

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[17] Hubert Howe Bancroft, *History of California*,Vol. VII (San Francisco, CA: The History Co., 1890), p. 83. Bancroft cites the *San Francisco Bulletin*, March 13, 1868; Aug. 14, 1871; and Jan. 27, 1875; and the *San Francisco Call*, Aug. 1, 1874; and March 4, 1875. See also Titus F. Cronise, *The Natural Wealth of California* (San Francisco, CA: H.H. Bancroft & Co., 1868), pp. 499-500.

[18] Ernest Ingersoll, *The History and Present Condition of the Fisheries Industries: The Oyster-Industry* (Washington, DC: Government Printing Office, 1881).

[19] Charles H. Townsend, "Report of Observations Respecting the Oyster Resources and Oyster Fishery of the Pacific Coast of the United States," in *Report of the United States Fisheries Commission, 1889 to 1891* (Washington, DC: Government Printing Office, 1893), p. 356.

[20] "There is no such thing as a California oyster here—only what is transplanted from the east. Those little oysters we have here that are called California oysters, are really oysters from Shoal Water Bay." [Sessions, "John Stillwell Morgan"].

and it tore up the beds and created a great growth of grass and killed the oysters all out and finally they grew up again, but very much smaller and we cannot make them come up to the size they were."[21] The storm he refers to must have happened around 1870, about the same time he began importing *C. virginica* from the east. Whether the failure of the Willapa Bay oysters to mature was due to a gradual degradation of their environment or was simply an expression of the oystermen's impatience—since the native *O. lurida* require at least two more years to come to size than their exotic competitors—is impossible to know with any certainty, but the fact that eastern oysters could now be marketed in San Francisco is a compelling reason to suspect the latter. Nonetheless, the completion of the transcontinental railroad was a key factor in this evolution of the California oyster industry. A large and well-developed industry based on the distribution by rail of *C. virginica* had existed in the east since the 1850s. In fact, it was a Chicago corporation—A. Booth & Co.—which dominated the national shipping market at this time and would supply Morgan. This business dwarfed the entire west coast oyster industry, capitalized at a level far beyond what San Francisco's producers could ever hope to match. Some historians believe that Morgan, already familiar with the east coast industry from his roots in New York state, may have anticipated this transformation and was simply biding his time until the railroad arrived and made the more desirable eastern stock available to the western market.[22]

At first only mature oysters were brought from the east, shipped by the carload and bedded down on San Francisco Bay tidal flats until they could be sold. Although the eastern oysters were immediately popular, shipping them whole proved expensive, since most of the mass was waste as far as the businessman was concerned, comprised of thick shell and only a small amount of meat. A solution was found when seed, the larval form of the oyster, was successfully frozen in barrels of water and stacked tightly in railroad cars. Far more larval oysters could be contained in a single shipment than mature oysters in the shell, so the oystermen realized a significant savings, even though a quarter of the seed usually died enroute. After arriving on the west coast, the seed was broadcast from boats in San Francisco Bay and allowed to set on prepared beds of old oyster shells, known as cultch. Here it was allowed to grow to maturity—about three to four years—and then harvested for market.

The eastern oysters flourished in California waters, once the oystermen learned to move their growing beds to the warmer and more protected tidal flats of the south bay near San Mateo, Milbrae, and Belmont. But San Francisco Bay's waters were still too cold to allow the eastern oyster to spawn, or at least that is what local growers believed.[23] This assumption encouraged the oystermen to continue importing eastern seed in order to maintain their fisheries. (They would later face the same challenge with the Pacific oyster [*C. gigas*], though the cost of transporting seed from Japan was less, one of several advantages to the introduction of this species). This disadvantage was more than compensated by the fact

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[21] Ibid.

[22] Matthew Morse Booker, personal communication, June 1, 2009; Mark Kurlansky, *The Big Oyster: New York on the Half Shell* (New York: Ballantine Books, 2006).

[23] Charles Townsend later found evidence that, in fact, some *C. virginica* was naturalizing in San Francisco Bay waters in selected locations [Townsend, "Oyster Fishery on the Pacific Coast"].

that eastern oysters grew to maturity almost twelve months sooner in San Francisco than in their native Atlantic. This was due to California's more temperate winters, which were only a few degrees cooler, on average, than its summers, allowing the eastern oysters to continue metabolizing food all year long, whereas on the east coast they typically became dormant during the cold winter months. By 1875, after all of the San Francisco Bay oyster industry had successfully relocated to the south bay, the imported eastern oyster (*C. virginica*) had largely replaced the native Olympia oyster (*O. lurida*) in California's mariculture economy. While importation of *O. lurida* from Willapa Bay continued, this species no longer dominated the market, even though absolute quantities of *O. lurida* imports actually increased up until 1890. Thereafter, the market for *O. lurida* evaporated as the availability of this species declined precipitously. Between 1890 and 1930, the California market was almost exclusively dominated by eastern *C. virginica*, and from 1930 to the present by *C. gigas* imported from Japan (though now raised in west coast hatcheries).[24]

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It was not until 1875 that any businessman tried to develop West Marin's natural advantages for the oyster market. This date coincided with the opening of the Northwestern Pacific Railroad. The principal purpose of this narrow-gauge line was to connect the logging industry on the Russian River with the San Francisco lumber market, but the railroad also brought commodities like West Marin's dairy products closer to urban consumers, since the train passed through many of the Point Reyes area communities along Tomales Bay. Weinard and Terry, who already had experience in the San Francisco Bay oyster industry, thought the railroad might present an opportunity to develop Tomales Bay and compete with the already-established San Francisco Bay growers.[25] They planted a small bed of eastern oysters (*Crassostrea virginica*) on an experimental basis in the vicinity of Millerton's Point but abandoned the venture within two or three years. Although there was no problem with growing the exotic oysters, the distance from market, despite the railroad, was still too great to compete with the local San Francisco producers.

This abortive venture offers a useful comparison for assessing the possibility of any oyster industry on Drakes Estero at that time. Since Tomales Bay lay directly on the Northwestern Pacific's rail line, access to this modern transportation was immediate. Drakes Estero, on the other hand, lay six miles to the west on the further side of Inverness Ridge, which at that time was crossed by only primitive dirt roads. Although schooners also traveled between Drakes Estero and San Francisco, strong currents and

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[24] Elinore M. Barrett, *The California Oyster Industry*, Fish Bulletin 123 (Sacramento, CA: The Resources Agency of California, 1963); Mitchell Postel, "A Lost Resource: Shellfish in San Francisco Bay," *California History* 67 (1988): 26-41; and Matthew Morse Booker, "Oyster Growers and Oyster Pirates in San Francisco Bay," *Pacific Historical Review* 75.1 (2006): 63-88.

[25] Townsend, "Oyster Fishery of the Pacific Coast," p. 364; Christine Avery, *Tomales Bay Environmental History and Historic Resource Study—Draft* (Seattle, WA: National Park Service, Pacific West Regional Office, 2006), pp. 73-77.

unpredictable weather made this means of transportation far less reliable than the railroad and often much longer in duration. If oyster mariculture could not survive on Tomales Bay, it is even less likely that any industry could have been successfully established at that time on Drakes Estero, where the practical challenges were far greater. Certainly, no evidence of an organized industry exists, although the history of Point Reyes peninsula and the economic activities associated with it are well-documented.[26] It was first settled by dairy farmers in the late 1850s, and from 1869 managed by three prominent San Francisco lawyers—Charles Howard and brothers James and Oscar Shafter—whose dairies supplied high-quality products for the San Francisco market and frequently gained the attention of the local press. If any oysters were harvested from Drakes Estero during this period, it was not done for market, or the press would have noted it. On the other hand, if the local dairymen informally harvested native oysters from Drakes Estero for their own consumption—assuming that *O. lurida* were even present—it is unlikely their impact could have been very great, since the ranch population for the entire peninsula at this time did not number more than a few hundred (and far less for the ranches immediately adjacent to Drakes Estero). This is less than the estimated population for the native Miwok who inhabited the region prior to European contact. It is unlikely these dairymen could have extirpated an abundant native oyster population between the late 1850s and the early twentieth century when the first documented surveys for oysters were made.

By 1905, degradation of water quality in San Francisco Bay was beginning to affect even the eastern oysters being raised here. This situation degenerated quickly over the next several years, and by 1910 it had become impossible to raise oysters in the bay. Mature oysters were still imported from the east and bedded on San Francisco Bay tidelands, but seed was no longer grown. Even the practice of bedding mature oysters in San Francisco Bay was abandoned by 1939. Most of the oyster companies began looking elsewhere for suitable locations to continue their business, and it was in this context that Tomales Bay finally became competitive. In 1913, the Tomales Bay Oyster Company was established on tidal flats near Millerton Point toward the south end of the bay, while Henry Jensen established a small local operation toward the north end of the bay at Hamlet. The former of these businesses is still in operation. The Morgan Oyster Company, now reorganized, moved to Humboldt Bay in 1910, but attempts to expand the area of the native oyster beds proved unsuccessful and the venture was abandoned after a few years.[27]

With the abandonment of seed-growing cultivation in San Francisco Bay after 1910, the California oyster industry declined to a shadow of its former scale and importance over the next two decades. Only mature oysters were imported from the East Coast or the Pacific Northwest to be sold fresh for market. Some were temporarily bedded in San Francisco Bay or in Tomales Bay until they could be sold. During the 1920s the state became interested in expanding the industry. Little could be done at first, but in 1931 a

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[26] D.S. Livingston, *Ranching on the Point Reyes Peninsula: A History of the Dairy and Beef Ranches Within Point Reyes National Seashore, 1834-1992* (Point Reyes Station, CA: National Park Service, 1994). One of the earliest maps of Drakes Estero from the American period shows no evidence of oyster culture, though details of early homesteading and ranching activities are indicated [R.C. Matthewson, "Plat of the Rancho Punta de los Reyes ... Confirmed to Andrew Randall," U.S. Surveyor General's Office, San Francisco, CA, 1858 (Archival Collections, Point Reyes National Seashore, Point Reyes Station, CA)].
[27] Barrett, *California Oyster Industry*, pp. 26-28, 36-37.

cooperative agreement was signed between the California Department of Fish and Game and the U.S. Bureau of Fisheries (the predecessor of the National Marine Fisheries Service). Surveys were made of the California coast for suitable mariculture sites. The state's largest estuarine systems at San Diego and San Francisco were quickly ruled out because of water pollution associated with urban development. The most promising habitats identified by the government surveyors were at Elkhorn Slough on Monterey Bay, Humboldt Bay on the north coast, and Drakes Estero. This was the earliest recorded survey of Drakes Estero made specifically to assess its potential for growing oysters. (John Morgan must also have surveyed Drakes Estero during his reconnaissance of the Pacific coast in the 1850s, but he does not mention it in his memoirs). While Drakes Estero was thought to provide good habitat for the introduction of oyster mariculture, no native oysters were discovered. At this time, Tomales Bay already had ongoing experiments by Jensens and the Tomales Bay Oyster Company, but further expansion of the industry here was seen to be unlikely, owing to limited tideland habitat and the presence of the Atlantic oyster drill (*Urosalpinx cinerea*), a predator which had inadvertently been introduced with eastern oysters sometime after 1869.[28]

The U.S. Bureau of Fisheries and the California Department of Fish and Game (CDFG) encouraged private businessmen to develop oyster mariculture in all of these potential sites and promoted the introduction of Pacific oysters (*Crassostrea gigas*) from Japan. The potential of this large and very resilient species had been recognized as early as 1874 by Professor George Davidson of the University of California, but successful introduction of the species to west coast mariculture did not occur until 1916, when a Japanese firm planted them in Samish Bay on northern Puget Sound.[29] The earliest commercial introduction in California was made in 1928 on an experimental basis by the Tomales Bay Oyster Company off Millerton Point at the southeast end of Tomales Bay.[30] The following year, a similar experiment was made in Elkhorn Slough (in Monterey Bay) by another private business. In all of these instances, the Pacific oyster did well and promised to be economically profitable. Encouraged by these results, the CDFG assisted in making small plantings in 1932 at Drakes Estero, Bodega Bay, Morro Bay, Mugu Lagoon, Anaheim Creek, and Newport Bay. No introductions were made in Humboldt Bay, even though government surveyors had identified this as one of the prime oyster growing habitats in California, because the CDFG had chosen to experiment here with establishing a native oyster (*O. lurida*) industry. All exotic introductions were forbidden, and attempts were made to increase the extent of native *O. lurida* beds—these had always been relatively small in area—in order to develop sufficient quantities of the oyster for market. The experiment did not succeed and was finally abandoned in the early 1950s.

Historian Elinore Barrett attributes this failure of the Humboldt Bay experiment primarily to the unpalatability of the native oyster and to its small size, much as John Morgan had nearly a century earlier.

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[28] Barrett, *California Oyster Industry*, pp. 42-43.
[29] Ibid., pp. 48-49
[30] After these initial experiments proved successful, full-scale plantings were made a few years later. The first major harvest of *C. gigas* in Tomales Bay occurred in 1935. Henry Jensen started planting *C. gigas* at Hamlet in 1939. [Barrett, *California Oyster Industry*, p. 61].

These qualities made it difficult to market the species and virtually impossible to compete with the more desirable eastern oyster (*C. virginica*) and the recently-introduced Pacific oyster (*C. gigas*). However, Barrett also observes that the Humboldt Bay experiment failed to substantially increase the extent of *O. lurida* bedding habitat. This point is worth noting in relation to the present study, as it illustrates the comparatively narrow limitations of *O. lurida* environmental tolerance (in marked contrast to the more resilient *C. gigas*). This helps to explain why both historic and prehistoric records show that *O. lurida* was found in only sporadic locations along the California coast prior to European contact and the period of historic settlement. While the species was present in San Francisco Bay as early as 1835—indicating that its occurrence here was natural and not the product of anthropogenic manipulation—there are no records suggesting that it was also present in any signficiant abundance in Drakes Estero, even though this embayment lies only fifty miles north of San Francisco. But Drakes Estero is characterized by a very different environment than San Francisco Bay, having little hard substrate for oyster larvae to adhere to. Although Drakes Estero was subsequently used for the cultivation of exotic Pacific oysters, these were grown on artificial cultch.[31]

The earliest record of mariculture in Drakes Estero dates from 1932, when several experimental plantings of *C. gigas* were made. The source of this information, Paul Bonnot, a biologist with the CDFG, does not say who made the plantings, but it is clear that his agency provided technical assistance.[32] Following the success of these experiments, The Drakes Bay Oyster Company was organized by Coast Oyster Company of Washington in 1935.[33] In 1957, the business was purchased by Charles Johnson, an employee of Coast Oyster Company, and became the Johnson Oyster Company. Johnson introduced the present method of growing seed oysters from hanging cultch, strings of oyster shells suspended from permanent wooden racks constructed within the estero. In 1972, ten years after the establishment of Point Reyes National Seashore, the National Park Service bought the property from Charles Johnson's son Tom, who had by now inherited the family business. At that time, the Park Service agreed to a forty-year Reservation of Use and Occupancy lease, which allowed the Johnsons to continue to operate their business. In 2005, Tom Johnson sold the Johnson Oyster Company to Kevin Lunny, the current proprietor of Drakes Bay Oyster Company.[34]

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Contrary to Kirby's assumptions, and the assertions of the NRC report, no organized oyster industry existed prior to 1851 within San Francisco Bay or neighboring estuaries and embayments like Drakes Estero. At most, informal harvesting of the unpopular local variety of *O. lurida* occurred in San

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[31] See below, p. 18.
[32] Paul Bonnot, "Report of the California Oyster Industry for 1937," *California Fish and Game* 24.2 (1938): 191-195.
[33] Barrett, *California Oyster Industry*, p. 63.
[34] *Point Reyes Light*, January 20, 2005.

Francisco Bay alone. Recent scholarship has shown, however, that *O. lurida* seems to prefer deeper tidal habitat than either the eastern oyster (*C. virginica*) or the Pacific oyster (*C. gigas*), suggesting the possibility that much of the native *O. lurida* population may have lain beyond the reach (and knowledge) of early San Francisco Bay foragers.[35] If that is the case, then it is possible that only the upper margins of native *O. lurida* beds were harvested during the first few years of the Gold Rush immigration. This would make it appear that the entire population had been exhausted by 1851, when in fact only the readily-accessible beds had been exploited. This observation, however, only confirms the absence of any organized industry in San Francisco Bay during this brief period of time, as a formal industry would undoubtedly have learned to exploit even the less-accessible portions of the native population, if it was economically desirable to do so. The fact that it was not is probably owing to the inherent unpalatability of the San Francisco Bay variety of *O. lurida* as much as it was to the inaccessibility of local populations.

The native oyster beds of Willapa Bay, Washington suggest an interesting comparison, since there are sufficient records to document the existence of a formal industry based on the exploitation of native *O. lurida* here.[36] The Olympia oyster was harvested at Willapa Bay by oystermen like John Morgan for the San Francisco market beginning in 1851. The considerable distance of this source from San Fransisco—more than 700 miles—is evidence of the much greater desirability of the Washington variety of *O. lurida* than what could be found locally. Despite the intensity of demand, however, the Willapa Bay population of *O. lurida* did not begin to show a decline until 1890, when the rate of exploitation reached its peak, and was not finally exhausted until 1920. The reason San Francisco Bay oystermen began exploiting native Willapa Bay oysters in 1851 is not because they had exhausted their local supply, but because no satisfactory local supply ever existed. It remains uncertain, however, whether the local supply was inadequate because of its scarce abundance or because of its inherent quality (diminutive size, unappealing flavor, etc.), or some combination of both.

The absence of any reference to Drakes Estero during this same early period in the development of the California oyster industry strongly suggests that Drakes Estero also lacked any exploitable populations of native oysters. It may never be possible to prove this point definitively, because no reliable source can be found documenting the status of this species in Drakes Estero. Nevertheless, it is still possible to assert that no organized industry for the harvesting or cultivation of oysters existed here at any time during the latter half of the nineteenth century. The earliest formal industry organized for the San Francisco market was centered more than 700 miles north of San Francisco on Willapa Bay. Although San Francisco's pioneering oystermen searched the Pacific coast for a source closer to their markets, they found none. It

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[35] Patrick Baker, "Review of Ecology and Fishery of the Olympia Oyster, Ostrea lurida with Annotated Bibliography," *Journal of Shellfish Research* 14.2 (1995): 503. Baker cites studies done by the U.S. Bureau of Fisheries in the 1930s, which found that *O. lurida* prefers shallow subtidal areas. But Baker's own data also revealed that the species can be found as high as two meters above mean low tide in the intertidal zone. Early foragers may have exploited these intertidal populations but not the less-accessible subtidal populations.

[36] Conte and Dupuy, "The California Oyster Industry," 1982.

seems unlikely that they would have overlooked Drakes Estero, which lies only fifty miles north of San Francisco Bay.

§ 2. How abundant was the native oyster (*O. lurida*) in the greater San Francisco Bay Area—including Drakes Estero—at the beginning of the American period in California, and what was the nature of its distribution?

From a historical perspective, this question must begin with San Francisco Bay itself, because this was the only significant oyster habitat on the central California coast for which extensive documentation exists prior to the twentieth century. Conditions at a relatively remote location like Drakes Estero must be inferred from the history of oystering in San Francisco Bay, at least until more direct evidence becomes available in the 1920s. However, non-historical evidence—including archeological studies of pre-historic middens, core-sampling of estero-bottom sedimentation, and paleoarcheology based on isotopic analysis of diatoms, pollen, and shellfish deposition—allow for a more direct consideration of Drakes Estero itself and compliment the historical record to yield a more complete and reliable basis for determining baseline conditions and assessing historic change within the immediate area under consideration.

There seems little doubt that native oysters were present in San Francisco Bay at the beginning of the California Gold Rush. During the entire period of the San Francisco Bay's dominance in the West Coast oyster industry, a native oyster (apparently *O. lurida)* is mentioned in numerous documents, where it is described as everything from a potential economic resource to a chronic pest.[37] Although these records provide a convincing testimony of the existence of *O. lurida* within San Francisco Bay, they rarely provide any information about its abundance and distribution, because most observers had little interest in this diminutive and unpalatable oyster and were far more concerned with more marketable varieties. None of these early historic records provide any direct information about the presence or distribution of native oysters in nearby estuaries like Tomales Bay or Drakes Estero, but some conclusions may be inferred from circumstantial evidence. As already discussed, probably the most significant indication of the early historic population of *O. lurida* in these locations just north of San Francisco Bay comes from the failure of San Francisco oystermen to even mention them. John Morgan claimed to have searched for mature, marketable oysters in the immediate vicinity of San Francisco in 1851 but found none. Over the remaining decade, he surveyed much of the Pacific Coast of North America and found substantial beds of potentially marketable oysters in the Gulf of California and in several embayments from northern Oregon to Puget Sound. But he never mentioned Drakes Estero, or other nearby estuarine systems and embayments—like Bolinas Lagoon, Tomales Bay, or Bodega Bay—where one might expect to find mollusks. It seems unlikely that Morgan failed to notice these places, all of which lie within a 70 mile radius of San Francisco and were already known to mariners sailing up the northern California coast. Instead, the likely inference is that Morgan did

[37] Beginning, of course, with John Morgan, but see also sources listed in Bancroft, *History of California*, Vol. VII, p. 83.

inspect these locations but failed to find what he was looking for. It remains possible that very small populations of *O. lurida* existed at this time in some or all of these locations, but Morgan would not have taken notice of them, because they did not represent sufficient quantities to justify exploiting for the San Francisco market.

Some of the earliest positive evidence of *O. lurida* occurring in the San Francisco Bay area comes from archeological studies of Native American shellmounds (or middens) along the shore of the bay and other nearby estuaries. (This subject will be treated at greater length in a separate report).[38] Systematic study of San Francisco Bay shellmounds dates from the beginning of the twentieth century, mostly under the direction of Professor John C. Merriam of the University of California at Berkeley.[39] These initial investigations were followed by several more-refined studies over the next few decades, though rapid urban development with the post-war economic boom seriously compromised many of the archeological sites after the 1950s, with some major sites almost completely destroyed and most suffering at least partial destruction. As a result, the large-scale field studies of the early twentieth century had mostly ended by the time of the Second World War and were replaced by smaller, more focused investigations done for compliance with national and state laws in response to specific development impacts.[40]

Writing in 1951, at the end of this initial period of large-scale archeological work, Robert Greengo analyzed the results of existing investigations of the bayside shellmounds (including his own fieldwork), making several observations which are relevant to the present study. In brief, he found that shells of the native oyster (*O. lurida*) were present in many—though not all—of these shellmounds, but were usually much more common at the base of each mound than in the upper layers. This suggested that the native oysters had been more abundant in the distant past but had declined substantially in more recent centuries. As an example, one of the mounds which showed the greatest overall abundance of *O. lurida* shells was Ca-Ala-307 in West Berkeley along the east shore of San Francisco Bay. Here, native oyster shells comprised nearly half (44.1%) of the total quantity by weight of shells found in the lowest strata but decline to only ten percent in the upper-most strata. The latter represents the period of time just before the mound was abandoned, which probably occurred between 1780 and 1790, when the indigenous Ohlone, who had created the mound, were removed to nearby Spanish missions.[41] Mussel shells (*Mytilus* spp.) often, though not always, showed a similar reduction in percent quantity from lower to upper strata. Similar

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[38] Mark Rudo, "Briefing Statement: Little Archaeological Evidence of the Olympia Oyster (*Ostrea lurida*) at Drakes Estero, Point Reyes National Seashore," May 31, 2009, National Park Service, Pacific West Regional Office, Oakland, CA.

[39] Max Uhle, "The Emeryville Shellmound," *University of California Publications in American Archaeology and Ethnology* 7.1 (1907): 1-106; N.C. Nelson, "Shellmounds of the San Francisco Bay Region," *University of California Publications in American Archaeology and Ethnology* 7.4 (1909): 309-356; and N.C. Nelson, "The Ellis Landing Shellmound," *University of California Publications in American Archaeology and Ethnology* 7.5 (1910): 357-426.

[40] Mark Rudo, personal communication, May 27, 2009.

[41] Some scholars believe the shellmounds were abandoned much earlier [Matthew Morse Booker, personal communication, June 1, 2009], but see Rudo, "Little Archaeological Evidence," for more details.

patterns of relative abundance were found in other shellmounds which Greengo studied in the greater San Francisco Bay area.[42]

Early investigators had noticed this pattern, and a variety of explanations had been proposed, including overexploitation of these food sources by the Native Ohloneans. But Greengo also noticed that the reduction of native oyster and mussel shells nearly always correlated with an increase in clam shells (for example, *Macoma nasuta*, but others as well). Since clams prefer soft tidal bottoms (sand or mud), while oysters and mussels must attach themselves to hard surfaces, Greengo speculated that this inverse correlation might be explained by changing environmental conditions within the bay. In effect, the tidal bottoms of San Francisco Bay had become dominated by unconsolidated sediments (sand and mud) long prior to the historic period. This suggests that the native oyster (*O. lurida*) may have suffered a substantial decline in population many centuries before Europeans even arrived in San Francisco Bay.[43] The fact that Europeans did subsequently observe *O. lurida* in San Francisco Bay indicates that the species never entirely disappeared, but its relative abundance and distribution at that time remain open questions. Judging from the archeological evidence, *O. lurida* probably was not plentiful during the period of initial European settlement at the end of the eighteenth century. Greengo also analyzed data from several archeological sites north of San Francisco Bay, including Drakes Estero (Ca-Mrn-307) and Tomales Bay (Ca-Mrn-266). The Drakes Estero site was dominated by species of clams, the most abundant being the California butter clam (*Saxidomus nuttalli*) and Pacific gaper (*Tresus nuttalli*). Significantly, mussels constituted less than four percent of the total shell mass by weight, while oysters (*O. lurida*) were not found at all. Greengo also found less than one percent *O. lurida* shells in middens at Bodega Bay, which lies only a few miles north of Drakes Estero. Other middens in the vicinity of Drakes Estero were investigated in later studies, but only one (Ca-Mrn-242) showed quantifiable, though comparatively minor, quantities of *O. lurida* shell. However, this site had been disturbed during the early historic era, and the archeological record was unreliable.[44]

These patterns observed in the archeological record were later corroborated by Jack Meyer, who summarized recent isotopic analyses of bay sediments.[45] His results show significant fluctuations in abundance of oyster shells correlated with changing concentrations of salinity and water temperature. Conditions appeared highly favorable to native oysters greater than approximately 2,000 years ago but

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[42] Robert E. Greengo, "Molluscan Species in California Shell Middens," Reports of the University of California Archaeological Survey, No. 13, Dec. 10, 1951, Berkeley, CA.

[43] Greengo thought this might be due to rising ocean levels, which had elevated the tidal zone into regions where deep soils had formed and left little rocky substrates exposed. He admitted, however, that this was purely speculation, and other explanations might be possible.

[44] A small cabin had been constructed on top of the midden, indicating the possibility of a non-Indian source of the oyster shells. [Rudo, "Little Archaeological Evidence," p. 2].

[45] Jack Meyer, "An Overview of Geoarcheological Research Issues," in *Archaeological Research Issues for the Point Reyes National Seashore—Golden Gate National Recreation Area*, edited by Suzanne Stewart and Adrian Praetzellis (Rohnert Park, CA: Sonoma State University, 2003), Pt. I, p. 6.

became increasingly unfavorable beginning about 1,500 years ago. Meyer suggests that these dates may correspond to the patterns in the shellmounds described by Greengo.[46]

Core samples have also been made in Drakes Estero for a number of studies unrelated to this question, but none of these have shown evidence of *O. lurida* shells. Most recently, graduate theses by Angie Harbin-Ireland in 2004, and David Press in 2005 analyzed core samples taken at depths of 15 cm at various locations from the bottom of Drakes Estero and adjacent Estero de Limantour.[47] The relatively shallow depth of these corings was probably sufficient to represent only recent sedimentation, assuming an average rate of deposition during the historic period (the last 150 years) of approximately 16 cm per hundred years.[48] This suggests that deposits from the bottom of these core samples originated somewhere near the early part of the historic period, though not prior to it. While clam shells were found—the most common were bent nose clam (*Macoma nasuta*) and *Nutricola* spp.—evidence of the native oyster (*O. lurida*) were entirely absent. These findings were cited by the NRC report to imply that little or no recovery of the oyster occurred in recent decades, continuing the NRC's assumptions that *O. lurida* had been present in Drakes Estero prior to the historic period and that it had been overharvested to the point of extirpation.[49] But the results of these core samples may just as likely indicate that *O. lurida* had never been abundant at Drakes Estero in the first place. The latter interpretation is strongly supported by a study done by Roberto Anima in the late 1980s, also involving core samples taken from the floor of Drakes Estero. Anima's corings were made to a depth of up to two meters and show a much greater range of depositional history. Again, no evidence of the native oyster (*O. lurida*) was found, though clam shells were common.[50] Combining this evidence with a variety of other sources, Anima was able to describe a history of sedimentation which characterized the morphological evolution of Drakes Estero for the last 8,000 years. While this study was unable to show that oysters were never present during this long extent of time, it did demonstrate that at least one important component of oyster habitat—a hard substrate—was uncommon or entirely absent.[51] (Hard substrate is found only in a few locations along the edges and intertidal zone at Bull Point and near the mouth of the estero, but these substrates consist mostly of soft sandstone and occur where the waters are generally too cold to support oysters).[52]

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[46] Ibid.
[47] Angie Harbin-Ireland, "Effects of Oyster Mariculture on the Benthic Invertebrate Community in Drakes Estero, Point Reyes Peninsula, California," Master thesis, University of California, Davis, 2004; David Press, "Ecological Impacts of Green Macroalgal Mats on Estuarine Tidal Flats," Masters thesis, University of California, Davis, 2005; and D.L. Elliott-Fisk, S. Allen, A. Harbin, J. Wechsler, D. Schirokauer, and B. Becker, "Assessment of Oyster Farming in Drakes Estero, Point Reyes National Seashore," Final Completion Report, National Park Service, Point Reyes National Seashore, 2005.
[48] Roberto J. Anima, *Pollution Studies of Drakes Estero and Abbotts Lagoon, Point Reyes National Seashore, California, USA* (Point Reyes Station, CA: National Park Service, 1990), p. 11. Anima defines the range for this period as 12 cm to 30 cm per hundred years.
[49] Peterson, "Shellfish Mariculture," p. 17.
[50] Anima, *Pollution Studies*, 1990.
[51] Roberto Anima, personal communication, May 29, 2009.
[52] David Press, personal communication, June 3, 2009.

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Permanent European settlement began in California with a Spanish colony initiated in 1769 and consisting of a series of religious missions supported by military presidios which eventually extended from San Diego in the south to present-day Marin County on the north shore of San Francisco Bay. The first Spanish settlement on San Francisco Bay itself dates from 1776, when a presidio and mission were established within the boundaries of the present city of San Francisco. Following Mexican independence from Spain in 1821, California's twenty-one Spanish missions were dissolved and their lands divided into numerous large cattle ranches, which then became the mainstay of the local economy.[53] During the entire Hispanic period, which lasted for scarcely eighty years, little or no systematic exploitation of California's marine resources occurred, except the hunting of marine mammals for the Asian fur trade.[54] There is no evidence to suggest that the Hispanic *Californios* ever developed a market for shellfish (or any other fish, for that matter), and if they did harvest wild shellfish for local consumption, it is doubtful whether this activity could have had any substantial impact on the resource, since the Hispanic population never exceeded more than about 7,000 individuals, most of whom were concentrated in Southern California and not on San Francisco Bay. During the same period, the Native American population was reduced by half, from an estimated 300,000 to about 150,000 by 1848, mostly as a result of diseases introduced by the Europeans.[55] The most heavily-affected were the native tribes living along the coast who traditionally relied on shellfish and other marine resources collected from the intertidal zone. As a result of this population dynamic and the changing emphasis in resource utilization, the net human consumptive impact on native shellfish populations during the brief period of Hispanic dominance in California may have actually been less than it was prior to European contact. We can assume, therefore, that the populations and distribution of native oysters were much the same, if not greater, at the beginning of the American period as they were at the beginning of the Hispanic period.

Though the Hispanic *Californios* left no descriptions of native shellfish—oysters or otherwise—some observations were made during this early historic period by visiting scientists from other nations. One of the earliest inventories of local shellfish species was made by English botanist and zoologist Thomas Nuttall, who passed through California and the Pacific Northwest between 1834 and 1835. Nuttall collected a number of native shells, one of which he identified as *Ostrea conchaphila*, noting that it could be found in both San Diego and Oregon.[56] This is probably the first documented collection of a native

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[53] One of the earliest and most comprehensive histories of the Hispanic period in California history remains Hubert Howe Bancroft, *History of California*, Vols. 1-7 (San Francisco, CA: The History Co., 1890).
[54] This was carried out primarily by Russians and Americans, though the Spanish also played a small role. The industry had a devastating effect on marine mammals, driving some species close to extinction [Adele Ogden, *The California Sea Otter Trade, 1784-1848* (Berkeley: University of California Press, 1941)].
[55] Sherburne F. Cook, *The Population of the California Indians, 1769-1970* (Berkeley: University of California Press, 1976).
[56] Philip P. Carpenter, "Monograph of the Shells Collected by T. Nuttall, Esq., on the Californian Coast, in the Years 1834-5," *Proceedings of the Zoological Society of London*, Part XXIV (1856): 209-229. The

California oyster. At least one of these specimens may have been *O. lurida*, but Nuttall did not distinguish between the separate species. Unfortunately, he also made no record of the distribution or abundance of the oysters he found. The native *O. lurida* was first identified as a distinct species by conchologist Philip P. Carpenter in 1864.[57] Like Nuttall, Carpenter also says nothing about the abundance of this oyster, only that it was found. (His omission was characteristic of the naturalists of that day, who were generally more interested in collecting specimens than describing population dynamics or ecological relationships).

More revealing were the observations made several years later by French scientist Duflot de Mofras when he visited San Francisco Bay in 1840. He drew a chart which represented a large reef of oysters ("Banc du Coquilles") along the east shore of the bay near present-day Alameda.[58] Mofras, however, does not say how many living oysters, if any, were present in this reef. Interestingly, the reef was located not far from the Native American shellmounds mentioned above, suggesting that this side of the bay may have been associated with native oyster populations from as much as several thousand years in the past. Barrett opined that the existence of these oyster shell deposits were evidence of times when environmental conditions were more favorable for the growth of the native mollusk; in effect, that such deposits represented the accumulated detritus from a period of abundance long pre-dating the arrival of Europeans, echoing the conclusions of Greengo, whom Barrett references.[59] Charles Townsend, a naturalist with the U.S. Bureau of Fisheries, noted in 1893 that this and other reefs of *O. lurida* shells made a poor foundation for living oysters, even though they represented an expanse of hard surface that was comparatively rare for San Francisco Bay, because the shells were so thin that they constantly moved around with the winds and tides. His comments suggest that these deposits at best represented only incidental habitat for living oysters. They were the marine equivalent of windrows, accumulations of dead material—in this case shells—deposited in the natural eddies of bay currents. James G. Cooper, a non-professional contemporary of Townsend, also described these reefs in an article written for a popular magazine in 1894.[60] He believed the reefs were formed when living oysters were broken from their preferred habitat on hard surfaces below mean low tide by storms or other disturbances and washed onto these beds. The living oysters might survive here for a couple of years longer, but they were usually suffocated by the shifting mass of debris. Cooper also suggested that these natural accumulations were the model for the artificial beds cultivated by oystermen. These various observations were corroborated some years later by Townsend's successor in the Bureau of Fisheries—E.L. Packard—who in 1912-1913 studied samples dredged from random locations on the floor of San Francisco Bay. He noted that shells of *O. lurida* were frequently encountered, occurring even within the Golden Gate channel at a depth of nineteen

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brief entry reads simply "Ostrea conchaphila, B.M. Cat. Maz. Moll. p. 161, no. 214. *Hab*. Oregon, San Diego." Quite possibly this represents two species: *O. lurida* in Oregon, and *O. conchaphila* in San Diego.

[57] Philip P. Carpenter, "Report on the Present State of Our Knowledge with Regards to the Mollusca of the West Coast of North America," in *Report of the Twenty-Sixth Meeting of the British Association for the Advancement of Science* (London: John Murray, 1857).

[58] Eugene Duflot de Mofras, *Duflot de Mofras' Travels on the Pacific Coast*, trans. by M.E. Wilber (Santa Ana, CA: Fine Arts Press, 1937); Matthew M. Booker, personal communication, May 20, 2009.

[59] Barrett, *California Oyster Industry*, p. 42.

[60] James G. Cooper, "Pacific Coast Oysters," *Overland Monthly* 23.138 (June, 1894): 648-660.

fathoms. But Packard concluded that the ubiquity of these shells was owing to their great mobility under the influence of strong bay currents, not to the extent of their viable habitat:

> The shells being light are quite easily shifted by the currents from the shallow waters to regions of deeper water, thereby accounting in part for great numbers of dead specimens dredged at certain localities.

Packard recognized that *O. lurida* was limited by the availability of hard surfaces, which were relatively scarce in San Francisco Bay.[61] Thus, the large accumulations of shells described by Mofras and others were not necessarily evidence of the present abundance of *O. lurida*, since they may only have represented the concentration of shells from a widely and unevenly distributed population over a long period of time. It is possible, too, that these large accumulations were simply very ancient oyster reefs.[62]

Scarcely ten years after Duflot de Mofras visited San Francisco Bay in 1840, John Morgan began his survey for marketable live oysters. He claims that he found none, though he admits to the presence of many "bastard oysters," which he describes as small and unpalatable. These must be *O. lurida*, as no other oyster is known to have been present in the Bay at that time which might have answered to Morgan's description. Although Morgan is not specific about the extent or distribution of these "bastards," he does imply that they were plentiful.[63] These bastard oysters raise a number of puzzling questions. If they are the same species as the Olympia oysters which Morgan and other San Francisco oystermen go through so much trouble to import from Washington, why do they appear so different? Judging from his description, Morgan's bastard oysters may simply be small *O. lurida*. If that is the case, the Washington oysters were more desirable because they were larger, at least at first (though they may also have been more palatable). The question then becomes why San Francisco Bay at that time seemed to lack any sizeable native oysters, but apparently did have plenty of these "bastards."

One possibility is that the environment of San Francisco Bay did not support the robust growth of this species. More than one observer, including Morgan, observed that *O. lurida* typically grew much larger in Washington than in California.[64] If this is true, then many of the bastard oysters which Morgan described may have been mature but diminutive adults rather than juvenile spat or larvae. This possibility argues against the likelihood that local populations were overharvested during the first few years of the Gold Rush, since it implies that the native San Francisco oyster was even less desirable than might be imagined if the population were similar to the Washington variety. The early date of Morgan's observations suggests that, if environmental factors were the crucial determinant, they were natural in

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[61] E.L. Packard, "Molluscan Fauna from San Francisco Bay," *University of California Publications in Zoology* 14.2 (Sept. 12, 1918): 251-252.

[62] Coring data from a Caltrans study done in 1972 show alternating layers of mud and shell dating back through sediments which represent several thousand years, adding weight to the latter interpretation [Matthew Morse Booker, personal communication, June 1, 2009].

[63] Morgan recalled that, "Early in '40 and '50 we found a little oyster here that we called the bastard oyster—they did formerly pick up some of these and bring them and sell them, but none now. They grow here and choke our other oysters. They will grow as big as your thumb in a few days and are like parasites to the other oysters." [Sessions, "John Stillwell Morgan."]

[64] For example, Charles Townsend, who wrote in 1893 that *O. lurida* "grows twice as large at Willapa Bay, Washington, as it does at San Francisco." [Townsend, "Oyster Fishery of the Pacific Coast," p. 356].

origin, since relevant anthropogenic impacts on the estuarine environment did not become ecologically significant until the late 1850s or later (the peak activity of hydraulic mining, for example, did not begin until about 1870).

Another possibility is that informal harvesting for local consumption during the years 1849 to 1851 had, in fact, extirpated many of the mature San Francisco Bay *O. lurida* population, leaving relatively few mature individuals but numerous juveniles. Even if demand for the mature native oysters was not great (as Morgan insinuates), and no formal industry was established to exploit them, they still may have been heavily impacted in proportion to their natural abundance if they were never very abundant in the first place, as the archeological evidence strongly suggests. The elimination of relatively few mature individuals would have had lasting affects on the local population consistent with Morgan's later observations, since *O. lurida* is relatively slow-growing and requires as many as five years to reach its mature size.[65]

Probably the most detailed contemporary account of the nineteenth century oyster industry in San Francisco Bay (and vicinity), after John Morgan, was made by Charles H. Townsend in the annual "Report of the Commissioner of Fish and Fisheries" from 1893. Townsend was the staff naturalist on board the U.S. Fish Commission steamer *Albatross*, which engaged in scientific research for the U.S. Government around the world. In this report, Townsend condensed the results of investigations made during three separate periods between 1890 and 1891 when the *Albatross* was on the Pacific coast. His studies included first-hand observations of San Francisco Bay, Tomales Bay and of the native oyster beds at Olympia and Willapa Bay, Washington. Townsend's observations corroborated those of John Morgan, confirming that a diminutive variety of *O. lurida* was widespread in San Francisco Bay and readily adhered to any available hard surface, making it a constant irritation for the oystermen growing exotic eastern oysters (*C. virginica*), because the native species would attach itself to the shells of the eastern oyster in such numbers that it threatened to suffocate them if the oystermen did not periodically remove the native species with special mallets.[66]

Townsend also observed native oysters growing in clusters upon the pilings of railroad trestles on sloughs at the south end of the bay (he also noticed naturalized *C. virginica* growing with them). Though Townsend himself seemed indifferent to the implications, this observation suggests some remarkable possibilities.[67] The urban development of San Francisco Bay, following the mass immigrations of the 1850s, may have inadvertently created new habitat for the native *O. lurida* by increasing the availability of hard surfaces on which its larvae could set. Railroad trestles, wharf pilings, and especially beds of mature eastern oysters, all provided hard substrate for the native larvae, and temporarily reversed one of the crucial

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[65] Barrett, *California Oyster Industry*, p. 13.
[66] Townsend, "Oyster Fishery of the Pacific Coast," p. 351.
[67] Later observers have also described *O. lurida* as a common fouling organism on rigid artificial surfaces. See, for example, the popular field guide by Eugene N. Kozloff, *Seashore Life of the Northern Pacific Coast* (Seattle: University of Washington Press, 1973).

limiting factors which has reduced the abundance of *O. lurida* over the last few thousand years at least.[68] If this interpretation is correct, the annoying proliferation of bastard oysters which Morgan described may have represented a brief flush of reproduction following the temporary improvement of native habitat. A similiar phenomenon was actually observed to occur at Los Penasquitos Lagoon in San Diego, California following dredging and construction of masonry rip-rap in the early 1970s. Although no marine shellfish existed in the lagoon prior to these channel improvements, within one year of their completion at least 20 species—including *O. lurida*—were observed.[69] In nineteenth century San Francisco, this apparent flush in the population may have seemed especially pronounced following the suppression of mature native oysters after a two-year period of overharvesting from the visible and easily-accessible intertidal zones. It would have been a relatively brief efflorescence, followed by a more substantial and lasting suppression of the population which resulted from increasing water pollution at the beginning of the twentieth century.[70]

Charles Townsend also visited Tomales Bay in the early 1890s, noting that "There are no signs of the propagation of eastern oysters there, although *Ostrea lurida* is not uncommon."[71] Greengo did not record any evidence of *O. lurida* shells in the one prehistoric midden he described here (Ca-Mrn-266) at McClure Beach on the northwest shore of the bay, so it is interesting, and puzzling, that Townsend finds the species in apparent abundance. Either *O. lurida* was introduced with early experiments importing the species from Washington in association with the Shoalwater Bay trade—perhaps by Morgan or one of his competitors—or it was naturally present but not abundant and consequently escaped utilization by local tribes. Paul Bonnot also observed the native species while he was making surveys for the U.S. Bureau of Fisheries in the early 1930s.[72] Townsend never visited Drakes Estero, and Bonnot, who did, never observed any native oysters occurring there, though he recommended Drakes Estero as an ideal location for oyster mariculture.

Summary and Conclusions

The opinion of the NRC that the Drakes Bay Oyster Company in Drakes Estero contributes towards restoring a historic baseline ecosystem cannot be supported by any strong positive evidence. In making its assertion, the NRC assumes, first, that a native species of oyster (*O. lurida*) was abundant in Drakes Estero prior to the mass immigration of American settlers in 1849; and, second, that overharvesting by these settlers virtually extirpated local populations of the native oyster in the ensuing decades. But there is little reason to believe that significant numbers of *O. lurida* (or any species of oyster) were present in Drakes Estero prior to the European arrival in northern California. Physically, Drakes Estero provides little

[68] Based on archeological evidence and core samples described above.
[69] P.J. Mudie, et al., cited in Baker (1995), p. 503.
[70] While this scenario is consistent with the historical and archeological evidence and seems a reasonable interpretation to this author, it should be reviewed by a natural scientist to assess whether it is reasonable from a biological point of view as well.
[71] Townsend, "Oyster Fishery of the Pacific Coast," p. 364.
[72] Paul Bonnot, "The California Oyster Industry," *California Fish and Game* 21.1 (1935): 68-75.

natural habitat for oysters, since it has few hard surfaces for oyster larvae to adhere to. Sediment studies which reconstruct the morphological evolution of Drakes Estero show that its present soft bottom has characterized the estero almost since the time it was first formed by rising sea levels more than 10,000 years ago. Although shell deposition from existing oyster populations can create habitat even in geologically soft-bottomed environments, these populations would have to become established in the first place, and their existence—past or present—would be evidenced by the presence of oyster shells in bottom deposits. However, core samples taken from the floor of Drakes Estero have failed to produce even trace quantities of oyster shells, which corroborates the implications of the absence of natural habitat. The archeological record, represented by midden deposits in the vicinity of Drakes Estero, is dominated by clam shells—primarily butter clams (*Saxidomus nuttalli*) and Pacific gapers (*Tresus nuttalli*)—but few, if any, oysters. These clam species are consistent with the physical environment found at Drakes Estero—unlike oysters, clams prefer soft bottoms—but also reflect the preferential diet of the Native Americans who exploited them. Oysters, however, were also a desirable food item for native people on the west coast of North America, and their near-absence from the middens suggests that they were also rare in the immediate environment. Finally, the historical record provides no evidence that oysters were ever harvested or cultivated in Drakes Estero following European contact and prior to 1932, when the Pacific oyster (*Crassostrea gigas*) was introduced for the present industry.

If oysters were rare or absent from Drakes Estero prior to the historic period, then the NRC's other assumption—that overharvesting has extirpated native oyster populations—cannot be true. This assumption was based on the inappropriate application of a model designed to describe circumstances on the east coast, but not the west. The historical record shows no evidence of any organized mariculture at Drakes Estero prior to 1932. History is not silent on this matter simply because records failed to be kept or have been overlooked. The history of the Point Reyes peninsula is well-documented from at least the early1850s, with the development of the region's prestigious dairy industry receiving considerable attention from contemporary observers and the local press. Two of the principal centers of this industry lay on the shores of Drakes Estero (Home Ranch and "F" Ranch), and the estero itself served as an important embarkation point for schooners bringing supplies to and from San Francisco (hence, "Schooner Bay"), but no mention is ever made of harvesting or cultivating oysters here. Also documented are the activities of San Francisco oystermen like John Morgan, who systematically explored the north coast for sources of marketable oysters and locations to cultivate them, but Drakes Estero is never mentioned in these records either, even though Drakes Estero lies scarcely fifty miles north of the principal nineteenth century oyster markets in San Francisco. The most reasonable interpretation which can be drawn from this lack of evidence is that no formal harvesting or cultivation of oysters occurred at Drakes Estero between 1849 and 1932, contrary to the assertions made in the NRC report.

The NRC report correctly observes that a major oyster mariculture industry did exist in this part of California during the latter half of the nineteenth century, supported by the appetites of hordes of Gold Rush immigrants. But the authors of the report—as well as many of their sources—fail to appreciate the

importance of distinguishing between geographical locations as different as Drakes Estero and San Francisco Bay, perhaps because these places appear to be relatively close in space. The nineteenth century oyster industry was centered in San Francisco Bay and succeeded largely because the bay was close enough to local markets for the industry to be economically feasible. It also possessed extensive areas of tideland habitat which were suitable for the introduction of commercial oyster cultivation. Drakes Estero did not possess the same advantages. Although the present activities of Drakes Bay Oyster Company show that artificial habitat can be constructed to support oyster mariculture here, during the nineteenth century Drakes Estero was too remote from markets to make such a capital investment practical. The initial failure to develop an economically competitive oyster industry in Tomales Bay in 1875, despite the opening of a direct link to San Francisco that year with the Northwestern Pacific Railroad, demonstrates how unique the opportunities and histories of two places within the same geographical region could be. The history of the greater San Francisco Bay area does not allow for broad generalizations which obscure such distinctions, and yet that is what the authors of the NRC report do when they assume "a pattern of regional overexploitation of the native oyster during the 1800s across every estuary of the western states..."[73] Because an extensive oyster industry existed in San Francisco Bay during the latter half of the nineteenth century does not mean that it also existed in Drakes Estero. All available evidence strongly suggests the contrary.

Whether or not overexploitation of native oyster populations occurred in San Francisco Bay, as the NRC report also claims, is a more complex issue. Even though this is a separate question, it has considerable relevance to the present discussion, because the market for oysters and the impetus for developing a regional oyster mariculture industry all centered in San Francisco and had repercussions for the entire Pacific coast. The NRC report assumes that an indigenous oyster population (*O. lurida*) was quickly exhausted between 1849 and 1851, because by 1851 San Francisco oystermen had begun importing native oysters (again, *O. lurida*) from Willapa Bay, 750 miles north of San Francisco in present Washington state. Also assumed is the exhaustion of presumed sources nearer to San Francisco, like Drakes Estero, within the same narrow time frame. This argument was not based on historical evidence, but instead was derived from a model which proposes that oystermen typically abandon local sources for distant ones only after they have exhausted the resources of the former. Since Willapa Bay lies at a considerable distance from San Francisco, where *O. lurida* is known to have been present (and still occurs), it was assumed that San Francisco Bay had been overexploited in the space of only two years, despite the fact that no formal industry yet existed. The alternative explanation, that San Francisco Bay (and other nearby estuaries and embayments) may not have had the resources to develop an industry sufficient to satisfy the demands of the local market, was not considered, although this seems to be more likely given

[73] Peterson, "Shellfish Mariculture," p. 16 (referencing Kirby). To be fair, the quote continues, "...for which historical fisheries landings data are available." There certainly were no data available for Drakes Estero, because no such fisheries existed here at that time, but the significance of this is precisely what the NRC report fails to appreciate, as indicated on the following page (p.17): "Although no fisheries data are available for Drakes Estero per se, the lack of effective management of the native fisheries ... suggests that a similar pattern of over-exploitation occurred in the nearby Drakes Estero."

that historical evidence does exist to support this interpretation. Pioneering oysterman John Morgan recalled that some people collected the diminutive San Francisco Bay oysters in the early years (1849 to 1851), but these oysters were not considered very desirable. It was this undesirability of the local resource rather than its exhaustion which drove Morgan to the Shoalwater Bay trade, importing mature *O. lurida* from a considerable distance and at great expense. If the local population of *O. lurida* was exhausted in the space of only two years and in the absence of an organized fishery, the original population must have been very small. For comparison, the native *O. lurida* which was harvested at Willapa Bay for the San Francisco market from 1851 on did not show signs of exhaustion until 1890, after nearly forty years of exploitation by a well-organized fishery for an every-increasing population.

Though the ecological effects of oyster mariculture in Drakes Estero remain a matter of debate, the industry cannot be said to contribute towards the restoration of natural processes, because oysters were not a significant element of the natural environment prior to the historic period. The cultivation of exotic oysters by the Drakes Bay Oyster Company represents an artificial modification of Drakes Estero with no known natural or historical precedent prior to the beginning of the present industry in 1932. This casts into doubt one of the central conclusions of the NRC report supporting the present oyster operations, and suggests that they cannot be justified on the basis of any presumed continuity with the past, natural or historic.

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