

**May 29, 2007**

**Corey Goodman, Ph.D.: Report #2 to the Marin Co. Board of Supervisors  
Re: The impact of the oyster farm on the ecology of Drake's Estero**

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## **Introduction**

This report supplements my May 8, 2007 written testimony. The Point Reyes National Seashore (PRNS) web site ([www.nps.gov/pore](http://www.nps.gov/pore)), in the section "Coming Soon! A Restored Wilderness Estuary," in a report entitled *Drakes Estero, a Sheltered Wilderness Estuary* concludes:

*Specifically in Drakes Estero, ecological function has been degraded and altered over the past several decades due to activities associated with oyster farming and ranching. [Pg. 10]*

The PRNS does not have the data to support that claim. In fact, their data suggest just the opposite: namely, that the oyster farm and ranches have not harmed the ecology of Drake's Estero. In my analysis, I will refer to the PRNS report as the "PRNS 2007 report".

As described later in this analysis, the PRNS has posted multiple versions of the PRNS 2007 report on their web site. Throughout this analysis, unless otherwise stated, I will be referencing the most recent version of that report, dated May 11, 2007, three days after your hearing. Later in this analysis, the May 11 version will be compared to the May 8 version submitted to you, and an earlier April 1 version.

Please refer to my original testimony for my reasons for getting involved, relationship to West Marin, and analysis of the claims against the oyster farm. In my testimony, my scientific credentials were described as follows (CV available upon request):

*I have spent my entire life as a scientist. I spent 25 years as a professor, first on the faculty of Stanford University in the Department of Biological Sciences, and then at U.C. Berkeley in the Department of Molecular and Cell Biology. I've started two biotech companies and am currently CEO of one of those companies, Renovis. I've published over 200 peer-reviewed papers in major scientific journals. In 1983, I received the Alan T. Waterman Award from the National Science Board, an honor bestowed upon only one young scientist each year across the entire country. In 1995 I was elected a member of the National Academy of Sciences. I spent over a decade serving on the Board of Life Sciences of the National Research Council, the committee that sponsors most of the environmental studies for the federal government including the EPA. I chaired the BLS for 6 years until my term ended last summer. I also serve on the California Council of Science and Technology which advises our state government about science issues important to our environment, education, health, and economy.*

### ***Drakes Estero: A Sheltered Wilderness Estuary: The Claim that Oyster Feces are the Primary Source of Sediment in Drake's Estero***

On page 17 of the 22 page PRNS 2007 report, in their synopsis of the impact of the oyster farm on Drake's Estero entitled *Oyster farming impacts on the ecological communities of Drakes Estero*, they provide six major claims. Here I focus on claim #1. They write:

*A USGS researcher stated that a source for sediment fill in the estero was from oyster feces and from structures trapping sediment.*

This statement is a slightly modified version of what PRNS staff scientist Dr. Sarah Allen wrote in an article entitled *Coastal Wilderness: The Naturalist* in the April 26, 2007 issue of the *Pt. Reyes Light*. Allen wrote:

*Research has identified oyster feces as the primary source of sediment in the Estero, and this sediment smothers native species.*

This same claim appeared in the May 1, 2007 issue of the Coastal Post in an article entitled *Save Drakes Estero* by an undisclosed group of authors from the Sierra Club of West Marin, the Environmental Action Committee (EAC), the National Parks Conservation Association (NPCA), the Audubon Society, and Wilderness Watch. Their reference to USGS researchers most likely came from PRNS staff and not from the primary source – the USGS study by Anima (1991) -- since it is inaccurate and repeats the same misquotes made by PRNS staff. They wrote:

*Furthermore oyster feces add sediments to the eelgrass beds of the Estero. Researchers from the U.S. Geological Survey identified the feces of oysters - as much as a metric ton per 60 meter square oyster raft - as the primary source of sedimentation, which degrades eelgrass habitat and its ability to support abundant marine life.*

What data support this claim about oyster feces being the primary source of sediment in the Estero? What are the facts about the USGS study? What data exist on this issue?

Below is the complete section from the PRNS 2007 report supporting this claim about oyster feces and sediments. I have added the underlines and the numbers in brackets. Later in this report I will show that all 7 numbered subclaims in this section are either misleading, misquoted, or possibly fabricated. In the PRNS 2007 report, they wrote:

Sedimentation rates and types of material have changed because of a combination of factors over the past 150 years. The primary water arteries into the estuary were dammed by ranchers to create stock ponds for cattle. These impoundments reduce the flushing action of winter rains and the size of marshes at the stream mouths flowing into the esteros. The commercial oyster operation has also changed the type and rate of sedimentation where oyster equipment is located. [#1] The oyster operation included 1) stakes with plastic tubing that were embedded into intertidal mudflats, 2) bags that were placed on top of the intertidal mudflats, and 3) racks that were located on mudflats and open water channels. Oyster bags and racks have been documented in Drakes Estero and elsewhere to trap fine particulate sediment resulting in an alteration of hydrologic function and the type of substrate, and have integrated feces into the sediment below and around the structures (Anima 1990, Cranford et al. 2003, Porter et al. 2004). [#2] The reduced freshwater flushing from the watershed enables fine-grained sediments to build up within the estero around the oyster racks. USGS (Anima 1990) collected sediment cores from the estero and identified pseudo feces of oysters as the primary source for sediment fill, as has been seen in studies elsewhere. [#3] An estimate of 0.6 to 1.0 metric tons of fecal matter can be produced per year by a 60 meter square oyster raft. [#4] This sediment material is resistant to erosion because oyster racks are located in upper reaches of the estero where tidal action is lowest and the arrangement of the oyster racks acts as a "baffle to tidal currents where rack density is highest ...silt material accumulates on the leeward side of stacked oyster beds (Anima 1990)." [#5]

The ecology of the estero is altered by changes in hydrology and sedimentation, which in turn change habitats and their associated species. Eelgrass beds, for example, in Estero de Limantour where there is no oyster farming, had higher densities of standing stock, as measured by the number of turions and blades, compared to Drakes Estero (AMS 2002). [#6] Eel grass is very sensitive to light, nutrients, pollution and sedimentation, and is thus an excellent indicator of estuarine health. Oyster farming reduces the amount of light available to eelgrass beds because of shading by racks, increases the amount of sedimentation due to deposition of oyster pseudo-feces and trapping sediment, and contributes pollution from treated construction materials and from general operations (trash). Researchers from Oregon State University found through experimental tests that both stake and rack culture (as practiced in Drakes Estero) reduced submerged aquatic vegetation by 25% after one year. This was attributed to increased sedimentation and disturbance during placement and harvest of stakes, and increased shading and erosion under racks (Everett et al. 1995). They conclude that there is the potential for significant loss of submerged aquatic vegetation due to oyster culture. UC Davis researchers working in co-operation with the NPS have qualitatively noted that eelgrass growth is severely restricted under active oyster racks in Drake's Estero (Elliott-Fisk et al. 2005). [#7]

The "USGS researcher" in the references is Dr. Roberto Anima from the Menlo Park office of the U.S. Geological Survey (USGS), and the study cited is Anima (1991) (incorrectly cited as 1990 in the PRNS 2007 report), a study entitled: Pollution Studies of

Drakes Estero, and Abbotts Lagoon (open file 91-145). This study was commissioned and financed by the PRNS and the National Park Service (NPS). On Monday May 21, 2007, I spoke on the phone at length with Dr. Anima about his study on Drake's Estero to make sure that I was interpreting his study report correctly. He fully supported my analysis, agreed that the PRNS has misquoted his report, informed me that he told Allen on the previous week (May 14-18, after Allen called him and his supervisor) that PRNS references to his study were wrong, and thanked me for setting the record straight.

The other relevant study is Elliott-Fisk et al. (2005) (co-authored by PRNS staff scientist Sarah Allen) in a study entitled: Assessment of Oyster Farming in Drakes Estero, Point Reyes National Seashore. Final Completion Report. This study was also commissioned, financed, and designed in part by the PRNS and their staff, and conducted by U.C. Davis professor Elliott-Fisk and her three masters degree students. Anima (1991) and Elliott-Fisk et al. (2005) are the key studies providing data to support or refute the PRNS 2007 report claim that oyster feces are the primary source of sediment in Drake's Estero.

Most of the other references in the oyster feces and sediment section of the PRNS 2007 report have nothing to do with Drake's Estero. Cranford et al. 2003 report on data on mussel aquaculture from Tracadie Bay, Prince Edward Island, Canada. Porter et al. 2004 is a study on a different species of oyster from the waters of Virginia. Everett et al. 1995 is a study of oysters from the Pacific Northwest. The only exception is the reference cited as AMS 2002, a study for which there is no public access or peer-review:

*Applied Marine Sciences. 2002. Intertidal monitoring program at Point Reyes National Seashore. Report prepared for the National Park Service.*

AMS is a private Bay Area company. Their 2002 report appears to not be germane to the sediment claim (which is outside their expertise). They are referenced relative to eelgrass density, not oyster feces. Moreover, the AMS study was not referenced in the Elliott-Fisk et al. 2005 report, which has a section of data and discussion of oyster feces.

The results and conclusions from the Anima (1991) and Elliott-Fisk et al. (2005) papers will be reviewed first, followed by an analysis of the seven subclaims in the section of the PRNS 2007 report quoted above, to determine whether there are scientific data from Drake's Estero to support the PRNS claim that oyster feces are smothering the eelgrass and other native species. This analysis will show that these two PRNS-commissioned studies do not support the claims in the PRNS 2007 report, but rather the data support the opposite conclusion, that neither the oyster farm nor the surrounding ranches are harming the ecology of the Estero. Moreover, a careful reading reveals striking examples in which the PRNS has misrepresented and misquoted its own studies.

### **Anima, R. 1991. Department of the Interior, U.S.G.S. report 91-145: Pollution Studies of Drakes Estero, and Abbotts Lagoon**

This study by Dr. Roberto Anima from USGS is the study that PRNS refers to when they claim that a USGS researcher has shown that oyster feces are the primary source of sediments in Drake's Estero. This study was commissioned and funded by the NPS. The study was conducted during a period when 5.5 to 8 million oysters were grown annually in Drake's Estero, compared to 3.4 million grown in 2006. Below I number the quotes from Anima's paper, because they will be referenced later when we examine how the PRNS 2007 report misrepresented and misquoted Anima's study.

*This report results from a two year study requested by the National Park Service, Point Reyes National Seashore, to investigate pollution inputs into Drakes Estero and Abbotts Lagoon. The work was conducted by the U.S. Geological Survey with funding provided by the National Park Service under a two-phase program. [Pg 13, Anima quote #1]*

*The first year was directed at conducting a pollution study focused on herbicide inputs, later expanded to include pesticide inputs, and the compilation of an annotated bibliography. The second year examined nutrient inputs from surrounding grazing land and sedimentation rates in the lagoons. [Pg 14, Anima quote #2]*

The study focused on examining the impact of the ranches on Drake's Estero by measuring the amount of sediments, herbicides in the sediments, pesticides in the sediments, and nutrient (high nitrate) run-off in the creeks entering the Estero from the surrounding ranches. As described below, nothing negative was found. Anima wrote:

*The study investigated sedimentation patterns and sediment accumulation rates for the two areas, the amounts of herbicides and pesticides in the sediment of the systems, and the concentrations of plant nutrients in creeks entering the study sites during storm events. [Pg 9, Anima quote #3]*

*This study investigated the environmental and chemical inputs into Drakes Estero and Abbotts Lagoon to determine if the area has potential pollution problems that need to be addressed. [Pg 12, Anima quote #4]*

*The land around Drakes Estero, originally part of the Berry Spanish land grant, consists of farm lands used for grazing dairy and beef cattle. [Pg 12, Anima quote #5]*

The study was focused on the inputs from the ranches, and not the effects of the oyster farm, and contains no data whatsoever on the issue of oyster feces in the sediments. The 55 page "Results" section (pages 34 to 88) never mentions the words "feces", "pseudofeces", or "biodeposit", and uses the word "oyster" only once in a way that is not relevant to the issue of sediments.

If the report was not about oyster feces, then what did it study and what did it find? There are many findings about the sediments in the Estero. Anima found them to be quite similar to those of Abbotts Lagoon, which lacks oysters. Concerning herbicides in the sediments, Anima wrote:

*The analyses indicate that the amount of herbicide introduced is not appreciable and that any herbicide introduced into Drakes Estero is not preserved because the estero is shallow and is constantly being flushed by tides and because the estero does not attain the low O<sub>2</sub> levels nor the low temperatures that would be conducive to the preservation of herbicides. The low levels found in the estero could also be due to relatively small amounts of herbicides introduced into the system. [Pg. 53, Anima quote #6]*

Concerning pesticides in the sediments, Anima wrote:

*The results of the pesticide analysis show that the levels of traceable DDE in the sediment analyzed are below the limits set by the National Academy of Sciences and the U.S. Environmental Protection Agency for organisms. [Pg. 61, Anima quote #7]*

Concerning nutrients flowing into the Estero from the surrounding ranch lands, Anima first wrote about the purpose of his study as commissioned by the PRNS:

*The purpose of the nutrient study was to ascertain the influence of land use on the nutrient inputs to Drakes Estero and Abbotts Lagoon. [Pg. 86, Anima quote #8]*

He then described the hypothesis he tested:

*The original strategy of this study was to test two hypotheses: First, that the ratio of dissolved inorganic nitrogen or phosphorus to total dissolved inorganic concentration, aliased by the electrical conductivity, would be significantly higher in the creeks draining agriculturally utilized watersheds, and would be highest in the most intensely utilized watersheds. [Pg 86-88, Anima quote #9]*

Anima found no evidence to support this hypothesis that increased nutrients are entering the Estero from the ranch land. Rather, his highest measurement came from a "control" creek. He wrote:

*However, the highest nitrate plus nitrite (water year median 312 uM) and total dissolved nitrogen concentrations (340 uM) were seen in a "control" creek, one supposedly outside of the area of agricultural influence. [Pg 88, Anima quote #10]*

Concerning nutrients entering the Estero from surrounding ranches, Anima concluded:

*Although no firm conclusions can be reached as to the quantitative impact of agricultural land use, it seems unlikely that surface nutrient inputs to Drakes Estero are of concern. [Pg 88, Anima quote #11]*

Anima's study focused on sediment rates, looked for herbicides and pesticides in those sediments, and examined nutrients entering the Estero from the surrounding ranches. He did not study oyster feces. His "Conclusions" section of the study on Drake's Estero is 5 pages (Pgs. 89-93). For the first three of those pages, he systematically draws conclusions from his data in the results, as described below. But for the last two pages, he switches gears and discusses oyster feces, and their possible impact on the Estero, a topic for which he has no data. This part of the discussion is not based on his own data, but rather is based on his reading of studies by others from other parts of the world. When we spoke by phone on May 21, I asked Anima about his motivation in writing about a topic for which he had no data (i.e., oyster feces), and he answered that the literature indicated that this was a problem at some other locations, and thus he wanted to encourage the PRNS to commission a proper study to examine the issue in Drake's Estero (something they subsequently did and reported in Elliott-Fisk et al., 2005).

Concerning sediments, Anima concluded:

*The results of this study indicate that Drakes Estero is a slowly filling system that is being supplied with sediment from the open marine environment, streams, aeolian deposition, biological reworking, and erosion of the surrounding bedrock. Tidal action is playing the dominant role in sediment distribution, erosion of surrounding bedrock, and overall flushing of the system.[ Pg 89, Anima quote #12]*

Note the lack of any conclusion from his own data concerning oyster feces. He wrote:

*The increase in sedimentation could be attributed to increased land use as the population of the area increased, i.e., trail and road use, road building, increase in the paved areas that would increase the amount of surface runoff of rain water as opposed to ground absorption. But to relate the increase in sediment input to increased cattle grazing alone is very difficult to substantiate based on the change in population and overall land use of the area over the last 150 years. Based on geophysical record interpretations the lagoon has undergone 10-35 m of infilling in the past 8,000 years. Based on rates of sediment filling calculated using the three methods mentioned and comparing these rates of filling*

*to other areas along the west coast, Drakes Estero and Abbotts appear to be filling at a rate like other west coast lagoons. [ pg 90, Anima quote #13]*

In other words, he attributes the increase in sediment over the last 150 years to human impact largely from roads and trails. He never mentions any impact from the oyster farm, and suggests that it is difficult to determine what, if any, contribution comes from cattle grazing. He also says that Drake's Estero and Abbotts Lagoon (which does not have an oyster farm) are filling at the same rate and with similar sediments, and are equivalent to other west-coast lagoons. Thus there is nothing unusual about the Estero.

Concerning herbicides and pesticides, Anima concluded:

*The results of both herbicides and pesticides analyses indicate that input into the two study areas are near or below the detection limits of the analytical methods used. Comparing the results of this study to studies conducted in the San Joaquin River and San Francisco Bay show that the amounts detected in the this study are very low. [Pg 90, Anima quote #14]*

Concerning the impact of the ranches on nutrient levels, Anima concluded:

*The effects of range land use are not discernable from the nutrient monitoring program of the streams that flow into Drakes Estero and Abbotts Lagoon. [Pg 90, Anima quote #15]*

On page 92 Anima discussed what had been found by other scientists at other locations concerning the potential impact of oyster feces, a discussion which led to his recommendation that a study should be done to determine their potential impact in Drake's Estero. In his own results he never mentioned oyster feces, and he has no data relating to oyster feces. He wrote:

*Because they are filter feeders, the oysters being grown and harvested in the estero play an important role in the deposition of fine grained sediment. Haven and Morales- Alamo, (1966) in their study on the quantities of suspended matter removed by oysters (Crassostrea virginica) and deposited as feces and pseudofeces (material taken in by an organism but not digested, and expelled as pellets resembling feces), concluded that the amount of feces and pseudofeces (biodeposition) always greatly exceeded the deposition of solids by gravity or settling from suspension. Ito and Imai (1955) calculated that in Japanese waters a raft of oysters 60 m square would annually produce 0.6 to 1.0 metric tons (dry weight) of fecal material. In laboratory experiments (Haven, D. S., and Morales-Alamo, R., 1966), oysters were found to filter seston from the water and deposit it as feces or pseudofeces about seven times faster than it would settle by gravity. It was also determined that the amount of biodeposition differed between warm water and cold water conditions and that oyster ranked second in the amount of feces and pseudofeces produced only to the tunicate Mogula manhattensis, based on weight per unit of tissue weight. The Haven Morales-Alamo report points out that the biodeposition rate of other common species of invertebrates equals or exceeds that of the oyster. The combination of abundant native filter feeders and the introduced oyster raises questions of the impact the industry is having to the sedimentation rate of the lagoon.*

*Other work carried out by Haven and Morales-Alamo (1972) reported on the settling velocities of feces and pseudofeces, compared with velocities of naturally settling suspended sediment, support the idea that fine grained sediment in suspension tends to be deposited on the substrate surface more rapidly after having passed through the body of a filter feeder than by natural means. The quiet water environment of the upper middle part of the estero, where most of the oyster racks are found, could allow for the deposition*

*of silt-sized material in the form of feces and pseudofeces produced by the oysters. Once deposited, the material is resistant to erosion. Because the areas of greatest abundance of oysters are well into the lagoon, where tidal flushing is limited, the feces are not being transported out of the system with the tides. Areas adjacent to staked oyster beds have been observed to have higher accumulations of silt and clay sized material on the leeward and/or a down current direction from the beds. Studies mentioned on the production of silt-sized material by Atlantic oysters indicate that the amounts produced are significant. More research is needed to ascertain what amount of silt-sized material is being produced by oysters in the lagoon. [Pg. 92, Anima quote #16]*

This is a lengthy discussion of data from other scientists (neither from Anima nor from other USGS scientists) and from other locations. Haven and Morales-Alamo (1966 and 1972) studied a different species of oyster at the Virginia Institute of Marine Science in Gloucester Point, Virginia. Their data are from laboratory studies and not field studies. Ito and Imai (1955) studied an oyster bed in Japan. The numbers quoted in the PRNS 2007 report, or by the Sierra Club, EAC, and NPCA in their Coastal Post article of "1 metric ton per 60 meter square oyster raft", do not come from Drake's Estero, and are not from the USGS, but rather are from this 1955 study of oysters in Japan. None of this is USGS research, none of this was done by Roberto Anima, and none of it was done at Drake's Estero. The purpose of this discussion, as Anima told me on the phone on May 21, was to encourage the PRNS to commission a future study on oyster feces at Drake's Estero.

Thus, the statements by PRNS superintendent and staff in their PRNS 2007 report, or PRNS staff scientist Sarah Allen in her Pt. Reyes Light article, and by local environmental groups in their Coastal Post article, that a USGS researcher showed that oyster feces are the primary source of sediment in Drake's Estero, are false and completely without factual support. Anima made no such finding in his paper. Surely the PRNS staff scientists must know what is in the report that they commissioned and subsequently referenced in their PRNS 2007 report. The PRNS staff ultimately did get an answer to this question, and, as shown in their Elliott-Fisk et al. 2005 report, the decomposing eelgrass is the primary source.

How about the quotes attributed to Anima's paper on the observation of the oyster racks serving as a baffle to sediment? Anima makes no mention in his results section of the oyster racks serving as a baffle to trap sediments. In fact, his only observation of baffling was by eelgrass. In the results section, Anima wrote:

*Finer sediment is also found adjacent to areas of dense vegetation where the vegetation baffles the effects of currents and allows for the deposition of the suspended sediment. [Pg. 48, Anima quote #17]*

The possibility that the oyster racks might serve as a baffle to collect sediments is something for which Anima had no quantitative data, but was something that he thought should be investigated in the future. In his recommendations, Anima wrote:

*The methods used by the oyster industry in Drakes Estero appear to be serving as a baffle to tidal currents in those locations where rack density is highest i.e., mouth of Creamery Bay, Schooner Bay, and Home Bay. What the results of this current baffling might be needs further study. It has been observed that silt-sized material accumulates on the leeward and/or down-current side of the staked oyster beds. Further study is needed to ascertain what effects the methods and the large numbers of oysters, oyster racks, and staked oyster beds are having on the sedimentological makeup of the estero. The oyster*

*industry has left much debris in the estero over the years related to their operation. A cleanup effort to remove debris from the intertidal flats, subtidal channels, surrounding shoreline, and marsh areas would be beneficial to the esthetics of the estero. Also, consideration should be given to removing abandoned structures and devices not used by the operation. [Pg. 95, Anima quote #18]*

Anima's recommendations are very good ones. He was correctly concerned about the debris around the Estero from the oyster farm, and so he recommended that it be cleaned up. My understanding is that the new owner, Kevin Lunny, has done just that and begun cleaning up, at great expense, much of the debris left behind by the previous owner. Anima thoughtfully recommended that the PRNS study the potential impact of oyster feces, and the potential impact of oyster racks acting as baffles for sediments. But recommendations for future studies are not data. Nevertheless, it is in this section, which has no relationship to the study's design, or to its findings, from which the PRNS gets most of their quotes about the supposed impact of the oyster farm for their 2007 report. In "Recommended future work", Anima suggested:

*I. Conduct experimental studies on the production of fine-grained material from the various filter feeders that live in the lagoon to determine the effects the fine grained material on the deposition rate into the lagoon. Does this production of fines have an impact on the filling of the lagoon? [Pg. 96, Anima quote #19]*

This is sensible recommendation for future work. Since Anima did not collect data on oyster feces, he proposed that a future study should do so.

What can we conclude from Anima's study? First, he recommended that someone should study the impact of oyster feces on the sediments in Drake's Estero, since he had not. Second, the rate of sedimentation in Drake's Estero is similar to Abbott's and other west coast estuaries that lack oysters, and shows nothing out of the ordinary. Third, there is no increase in herbicides in Drake's Estero. Fourth, there is no increase in pesticides in the Estero. Fifth, there is no increase in nutrients flowing into the Estero from the surrounding ranch lands. Although the study set out to find negative impacts from the ranch lands, it found none. The ranches had no negative impact on the Estero.

There also was no USGS data on oyster feces as the primary source of sediments in Drake's Estero. Anyone concluding this from Anima (1991) has either never read his study, or if they have, they are making up this claim and hoping no one would check up on them. The Anima study was commissioned and funded by and delivered to the PRNS. PRNS staff are aware of the lack of data showing a negative impact of the ranches on Drake's Estero, and they are also aware of the lack of any data in Anima's study on the subject of oyster feces in the sediments. As a result, they made the issue of oyster feces in the sediments one of the goals of the NPS grant funding to Elliott-Fisk at U.C. Davis, her three graduate students (two former PRNS employees), and PRNS staff scientists, as analyzed below.

**Elliott-Fisk, D.L., S. Allen, A. Harbin, J. Wechsler, D. Press, D. Schirokauer, B. Becker. 2005. *Assessment of Oyster Farming in Drakes Estero, Point Reyes National Seashore. Final Completion Report***

[Elliott-Fisk is on the faculty at U.C. Davis; Allen, Schirokauer, and Becker are PRNS staff scientists; Harbin, Wechsler, and Press were U.C. Davis graduate students with Elliott-Fisk; Press and Wechsler were former PRNS employees, and Press was

employed at the GGNRA at the time the report was filed; this report was the final completion report for the NPS grant that supported this set of studies by U.C. Davis and PRNS. Allen takes credit for her role in the design of all of the studies.]

Harbin's studies with Elliott-Fisk focused in part on sediments, and looked for a direct or indirect impact of oyster pseudofeces (also known as biodeposits) on the Estero and the eelgrass in particular. In the section "Project Purpose and Objectives" in the final summary report, Elliott-Fisk et al. wrote:

*To detect whether direct and indirect impacts had occurred from the oyster culture, sampling of the biota, sediments, and water was done for this research project both immediately at and some distance away from the farming operation in Schooner Bay (and at a few other sites), as well as in the arm of the estero most remote from the oyster farm: Estero de Limantour in the designated Wilderness Area. [Pg 5, Elliott-Fisk quote #1]*

In the 2005 report summary, Elliott-Fisk et al. concluded:

*Although pseudofeces from the suspended oysters may contribute to the amount of organic matter below the racks, adding to the system, the amount of organic matter resulting from eelgrass decomposition is likely far greater considering how expansive and dense the beds are within the estuary, making any significant organic inputs from the oysters undetectable in this study (Harbin 2004). [Pg. 2, Elliott-Fisk quote #2]*

But lets take a deeper look at what Harbin and her fellow graduate students found. In the 2005 summary report, Elliott-Fisk et al. wrote:

*The hydrologic conditions of coastal embayments, such as Drakes Estero, including water circulation patterns, precipitation, and tidal flushing, play an important role in determining the fate of materials are deposited there (Hayakawa et al. 2001; Wechsler, 2005). The relatively small scale of the Johnson's oyster farming operation combined with the hydrologic conditions in Drakes Estero likely dissipate the accumulation of biodeposits (e.g., oyster feces) that other studies have been shown to effect benthic ecology and water quality. In Drakes Estero, the tidal prism is high and a large volume of water drains twice daily with the mixed, semi-diurnal tidal regime. Our analyses of a limited set of water and sediment samples suggest that no major deterioration in water quality exists adjacent to the oyster racks. [Pg. 25, Elliott-Fisk quote #3]*

Thus, whereas studies at other oyster farms around the world may have found an impact of biodeposits (i.e. oyster feces), Elliott-Fisk and her students did not find such an impact in Drake's Estero, possibly due (they suggest) to the hydrologic conditions.

How about the amount of organic matter in the sediments below the oyster racks? Elliott-Fisk et al. wrote:

*The amount of organic matter in sediment from adjacent areas was not found to be significantly different from that beneath racks. [Pg. 26, Elliott-Fisk quote #4]*

Finally, what is the role of eelgrass in the sediments? And is the oyster farm impacting the eelgrass? Elliott-Fisk et al. wrote:

*A significant difference in the percent organic matter in areas below and adjacent to the oyster racks was not detected and all sediments appeared oxygenated to at least a depth of 10 cm (Harbin 2004). Nugues et al. (1996) detected a decrease in the depth of the oxygenated layer and an increase in organic content of the sediment beneath oyster cultivation structures elsewhere. However, such patterns were not observed in Drakes Estero. The organic matter input into the estuary with the breakdown of the vegetative*

*material from the eelgrass in the fall and winter likely accounts for the relatively high percent organic matter found in all sediment cores. Although pseudofeces from the suspended oysters may contribute to the amount of organic matter below the racks, adding to the system, the amount of organic matter resulting from eelgrass decomposition is likely far greater considering how expansive and dense the beds are within the estuary, making any significant organic inputs from the oysters undetectable in this study (Harbin 2004). Tidal action, eelgrass root zone oxidation, and currents continuously mixing water through the estuary likely maintain oxygenated surface sediments. The expansive eel grass beds attest to this as Zostera prefers sediments in which the surface is oxidized (Wood et al. 1969). [Pg. 26, Elliott-Fisk quote #5]*

At the end of their report, in the section "Conclusions and Lessons Learned" (Pgs. 27-28), Elliott-Fisk et al. concluded:

*Although pseudofeces from the suspended oysters may contribute to the amount of organic matter below the racks, adding to the system, the amount of organic matter resulting from eelgrass decomposition is likely far greater considering how expansive and dense the beds are within the estuary, making any significant organic inputs from the oysters undetectable in this study (Harbin 2004). [Pg. 27, Elliott-Fisk quote #6]*

Interestingly, as described below, in the PRNS 2007 report on the PRNS web site which makes strong claims against the oyster farm, they never refer to any of these positive conclusions from the Elliott-Fisk summary report of the PRNS-funded studies on Drake's Estero. In the section of the PRNS 2007 report on sediments and eelgrass quoted above, they only refer to the Elliott-Fisk et al. report once when they wrote:

*UC Davis researchers working in co-operation with the NPS have qualitatively noted that eelgrass growth is severely restricted under active oyster racks in Drake's Estero (Elliott-Fisk et al. 2005).*

There is no such statement in the Elliott-Fisk et al. paper. Rather, in terms of the impact of the oyster racks on the eelgrass beds, Elliott-Fisk et al. concluded:

*We found the oyster racks to have no pronounced impacts on the eelgrass beds, which existed both under and away from the racks as an incredibly rich habitat type. [Pg. 28, Elliott-Fisk quote #7]*

In conclusion, the PRNS 2007 report misquoted the Elliott-Fisk et al. 2005 report to the PRNS. Moreover, the PRNS failed to refer to the major data and conclusions that the oyster feces were not a major source of sediment. The U.C. Davis studies summarized in the Elliott-Fisk et al. 2005 report (co-authored by PRNS staff scientist Allen) showed that in Drake's Estero, the primary source of sediment is from naturally decomposing eelgrass, that the contribution of oyster feces can not be detected, that they found no impact of the oyster racks on the eelgrass beds, and that the eelgrass is thriving. This is the opposite of the claims in the PRNS 2007 report from May 11 on the PRNS web site.

### ***Drakes Estero: A Sheltered Wilderness Estuary: Misrepresentations, Misquotes, and Misleading Statements Concerning Oyster Feces***

When we take what we have learned from the primary two sources for the claim concerning oyster feces in the sediments, and apply that knowledge to the 7 major subclaims on this topic in the PRNS 2007 report, we find that none of the subclaims are correct and that the PRNS has misrepresented, misquoted, and misled the public.

*Specifically in Drakes Estero, ecological function has been degraded and altered over the past several decades due to activities associated with oyster farming and ranching. Other than the oyster operation, there is no development along the shores of the estuary.*

There is no evidence for this conclusion. Anima (1991) reported that there has been no degradation from the ranches in terms of sediments, herbicides, pesticides, or nutrients. And Elliott-Fisk et al. (2005) reported that there has been no degradation of the eelgrass.

Below are the seven subclaims in the sediment section that I highlighted above on pages 3 and 4 of this report. In some cases, the truth has been twisted, misquoted, or possibly fabricated. In other cases, the reader has been misled to think that the data come from Drake's Estero when they do not. Finally, of course, is the omission of references to the positive data in both the Anima (1991) and Elliott-Fisk et al. (2005) reports to the PRNS, studies that were commissioned, funded, and designed by PRNS, and that showed just the opposite of what the PRNS claims.

*[#1] Sedimentation rates and types of material have changed because of a combination of factors over the past 150 years. The primary water arteries into the estuary were dammed by ranchers to create stock ponds for cattle. These impoundments reduce the flushing action of winter rains and the size of marshes at the stream mouths flowing into the esteros. The commercial oyster operation has also changed the type and rate of sedimentation where oyster equipment is located.*

This claim is not based on fact or scientific data. The quote from page 90 of Anima (Anima quote #13 above) discusses the factors that have contributed to the increase in sediments over the last 150 years. The damming of the creeks by the ranchers is not mentioned by Anima. The commercial oyster operation is not mentioned by Anima. This is a misquote of Anima's conclusions. He attributes the increase in sediment over the last 150 years to human impact from roads and trails. He never mentions the oyster farm. He says that Drake's Estero and Abbotts are filling at the same rate, equivalent to other west-coast lagoons.

*[#2] Oyster bags and racks have been documented in Drakes Estero and elsewhere to trap fine particulate sediment resulting in an alteration of hydrologic function and the type of substrate, and have integrated feces into the sediment below and around the structures (Anima 1990, Cranford et al. 2003, Porter et al. 2004).*

This claim is not true. The only paper of the three referenced above that pertains to Drake's Estero is Anima (1991), but he has no data on oyster feces. He has no data on the integration of oyster feces into the sediment below and around the oyster racks. Anima confirmed for me on the phone on May 21 that he had no data on oyster feces in the sediment. Rather, he proposed that someone should study this in the future. In fact, Elliott-Fisk et al. (2005) did just that, and reported that they could detect no contribution of oyster feces to the sediments in Drake's Estero. They suggest that this might be due to the hydrologic flushing of the Estero.

*[#3] The reduced freshwater flushing from the watershed enables fine-grained sediments to build up within the estero around the oyster racks. USGS (Anima 1990) collected sediment cores from the estero and identified pseudo feces of oysters as the primary source for sediment fill, as has been seen in studies elsewhere.*

This claim is not true. Anima (1991) did indeed collect sediment cores from Drake's Estero, but the data did not identify oyster feces in the sediments, and it certainly did not identify oyster feces as the primary source for sediment fill. There is absolutely no

data in the Anima (1991) study to support this claim. Anima confirmed for me on the phone on May 21 that he never looked for oyster feces in his sediment cores.

*[#4] An estimate of 0.6 to 1.0 metric tons of fecal matter can be produced per year by a 60 meter square oyster raft.*

This misleading representation has been picked up by others, including the Sierra Club, EAC, and NPCA in their article in the Coastal Post. It comes from page 92 at the end of the discussion in Anima (1991) as referenced above in Anima quote # 16. There is no data from Drake's Estero, and this is not USGS data. Rather, this is from the discussion and refers to studies from other scientists on oyster beds from other parts of the world. This quote is from a study by Ito and Imai in 1955 from an oyster farm in Japan. The reason the PRNS commissioned USGS marine geologist Anima to study the hydrology of Drake's Estero was because each environment is different, and one cannot make such comparisons from one hydrological environment to another.

*[#5] This sediment material is resistant to erosion because oyster racks are located in upper reaches of the estero where tidal action is lowest and the arrangement of the oyster racks acts as a "baffle to tidal currents where rack density is highest ...silt material accumulates on the leeward side of stacked oyster beds (Anima 1990)."*

This statement is highly misleading. Anima's study provided no evidence of the oyster racks acting as baffles and impacting sediments. The quote the PRNS authors use is taken from page 95 of Anima's report (Anima quote #18 above). It misleads the reader to think that the USGS study has found in their data that the oyster racks act as a baffle which leads to the accumulation of sediments on the leeward side of the oyster racks. But the USGS study had no such data. Moreover, this quote is shortened and taken out of context from its original intent, which was to suggest that a study on this topic is needed in the future. Anima simply wanted to see a future study on this topic. Anima wrote:

*The methods used by the oyster industry in Drakes Estero appear to be serving as a baffle to tidal currents in those locations where rack density is highest i.e., mouth of Creamery Bay, Schooner Bay, and Home Bay. What the results of this current baffling might be needs further study. It has been observed that silt-sized material accumulates on the leeward and/or down-current side of the staked oyster beds. Further study is needed to ascertain what effects the methods and the large numbers of oysters, oyster racks, and staked oyster beds are having on the sedimentological makeup of the estero. [Pg. 95, part of Anima quote #18]*

The PRNS 2007 report put together parts of sentences from the recommendation section of Anima's study, not the results section, and used them to mislead the public to believe that the USGS has evidence on the role of oyster racks in the formation of sediments.

*[#6] The ecology of the estero is altered by changes in hydrology and sedimentation, which in turn change habitats and their associated species. Eelgrass beds, for example, in Estero de Limantour where there is no oyster farming, had higher densities of standing stock, as measured by the number of turions and blades, compared to Drakes Estero (AMS 2002).*

I do not have a copy of the AMS report from 2002 because this report is not publicly available. But the Elliott-Fisk et al. report from 2005 studied the eelgrass beds, made no mention of this AMS 2002 report, and instead concluded from their own data that the oyster racks have had no pronounced impact on the eelgrass beds (page 28, Elliott-Fisk

quote #7 above).

[#7] UC Davis researchers working in co-operation with the NPS have qualitatively noted that eelgrass growth is severely restricted under active oyster racks in Drake's Estero (Elliott-Fisk et al. 2005).

There is no such statement in the Elliott-Fisk et al. paper. Rather, in terms of the impact of the oyster racks on the eelgrass beds, they concluded, as mentioned above, that they found that the oyster racks have had no pronounced impact on the eelgrass beds (page 28, Elliott-Fisk quote #7 above).

In summary, of the seven major subclaims in the section claiming to show that oyster feces are the primary source of sediments in Drake's Estero in the PRNS 2007 report, four of the claims are wrong or factually incorrect (#1, 2, 3, and 7), and the other three are misleading (#4, 5, and 6). Yet from these false claims, the official PRNS report entitled *Drakes Estero: A Sheltered Wilderness Estuary* concludes the following:

*Specifically in Drakes Estero, ecological function has been degraded and altered over the past several decades due to activities associated with oyster farming and ranching.*

The PRNS superintendent and staff scientists have no data to support this conclusion. In fact, their own studies show just the opposite. The Anima (1991) study shows no impact of the ranches on the sediments, herbicides, pesticides, or nutrients in Drake's Estero. The Elliott-Fisk et al. (2005) study shows no impact of the oyster farm on the sediments or the eelgrass in Drake's Estero. The truth is dramatically different from the claims made by the official PRNS 2007 report. The PRNS 2007 report on their web site is a troubling misuse of science for a political agenda.

### ***Drakes Estero: A Sheltered Wilderness Estuary: Changing Versions of the Supporting Statements and Claims Concerning Oyster Feces***

The PRNS continues to change the PRNS 2007 report that is posted on its web site. I have three different versions of the document *Drakes Estero: A Sheltered Wilderness Estuary*. My first version was downloaded by a colleague from the PRNS web site around April 1, 2007 (4/1/07 version, 18 pages). The second version (21 pages) was presented by the PRNS to the Marin County Board of Supervisors on May 8, 2007 (5/8/07 version). The third version (22 pages) was downloaded by me on May 17, and is dated May 11, 2007, three days after I testified in front of the Marin County Board of Supervisors and submitted my written analysis. I do not know how many other versions of this document have been posted, or how many revisions have been made.

These three different official versions provide some telling differences that reveal how the PRNS has inserted and deleted different supporting references and statements to back up their claims. Some of the changes to the document occurred three days after my testimony to you, and apparently in response to it. But rather than trying to make the document more accurate, they appear to be in some cases trying to shore up their claims with irrelevant references, and in other cases parsing the language to deflect my criticisms by sidestepping some of their most egregious claims, while still refusing to admit that they are wrong. Below are just a couple of examples focused on the oyster feces claim, although similar changes can be found in sections involving other claims.

**Oyster feces: April 1 version (two supporting statements and the major conclusion):**

*The bags and racks have trapped fine particulate sediment resulting in an alteration of hydrologic function and the type of substrate. [supporting text]*

*USGS (Anima 1990) collected sediment cores from the estero and identified pseudo feces of oysters as the primary source for sediment fill, as has been seen in studies elsewhere. [supporting text]*

*A USGS researcher stated that a primary source for sediment fill in the estero was from oyster feces and from structures trapping sediment. [summary claim #1 on page 14]*

**Oyster feces: May 8 version:**

*The bags and racks have trapped fine particulate sediment resulting in an alteration of hydrologic function and the type of substrate. [supporting text]*

*USGS (Anima 1990) collected sediment cores from the estero and identified pseudo feces of oysters as the primary source for sediment fill, as has been seen in studies elsewhere. [supporting text]*

*A USGS researcher stated that a source for sediment fill in the estero was from oyster feces and from structures trapping sediment. [summary claim #1 on page 17]*

**Oyster feces: May 11 version:**

*Oyster bags and racks have been documented in Drakes Estero and elsewhere to trap fine particulate sediment resulting in an alteration of hydrologic function and the type of substrate, and have integrated feces into the sediment below and around the structures (Anima 1990, Cranford et al. 2003, Porter et al. 2004). [supporting text]*

*USGS (Anima 1990) collected sediment cores from the estero and identified pseudo feces of oysters as the primary source for sediment fill, as has been seen in studies elsewhere. [supporting text]*

*A USGS researcher stated that a source for sediment fill in the estero was from oyster feces and from structures trapping sediment. [summary claim #1 on page 17]*

**Oyster feces: the data has not changed, but the report has:**

In the three days after my May 8 testimony in which I questioned their oyster feces claim, instead of removing this claim, they changed the wording in the 1<sup>st</sup> of the three quotes above to include "and elsewhere", they incorrectly attributed the Drake's Estero statement to Anima (incorrectly because Anima never studied oyster feces), and they added two references from Canada and Virginia (these are the "and elsewhere" references). These references are irrelevant, and appear to be an effort to cover up the fact that the only data they have from Drake's Estero on oyster feces in the sediments is in Elliott-Fisk et al. (2005), the summary report co-authored by PRNS staff that they failed to reference in this section. Elliott-Fisk et al. reported that the contribution of eelgrass decomposition to the sediments is so great that they cannot detect the contribution of oyster feces (see quote #6 above from Elliott-Fisk et al., 2005). Thus, oyster feces apparently are not a problem due to the hydrology of the Estero.

Perhaps the most interesting change in the section on oyster feces is the deletion of a single word in the summary claim #1 (on page 17 of the May 11 version). On April 1 they refer to oyster feces as the "primary source" whereas on May 8 and May 11 they simply call it a "source". They also used the words "primary source" in Allen's April 26 article in the Pt. Reyes Light. From the April 1 version to the May 8 version of their

official report, there is a one word change in this summary sentence, the deletion of the word "primary". Why did they delete this word? This softening of their statement does not make it any more true. What's more, they did not remove the word "primary" from the text of the report that supports claim #1. The 2<sup>nd</sup> of the three quotes above remained the same in all three versions and uses the words "primary source". They continue to falsely attribute this data to Anima, who never even studied oyster feces, let alone showed that oyster feces were the primary source of sediment in the Estero. In summary, over these three versions, the PRNS has continued to parse the language, but they have never simply reported the truth, which would require that they remove the claim about oyster feces in the sediments and instead quote Elliott-Fisk et al. (2005) as stating that oyster feces are apparently not an issue in the Estero due to its hydrology.

PRNS staff know that Anima (1991) never looked for oyster feces and had no data that it was a source, let alone the primary source, of sediment in Drake's Estero. In addition to simply reading the report, as mentioned above, Dr. Anima communicated by phone and email with Dr. Allen during the week of May 14-18, and told her that he never studied oyster feces and had not made the conclusions about oyster feces in the sediments of Drake's Estero that PRNS attributed to him. Even though they have made numerous changes to this document over the past few months, some in less than 3 days after your hearing, as of today (May 29, 2007), there is still no corrected version that stops falsely attributing data to Anima that the PRNS knows he never collected. Instead, the misrepresentations and misquotes of Anima's paper and many others persist in the PRNS 2007 report on their web site.

### ***Drakes Estero: A Sheltered Wilderness Estuary: The Misrepresentations Go Beyond Just the Oyster Feces Claim***

In selecting claim #1 concerning the oyster feces for detailed analysis here, I have not picked the only misrepresented claim, but rather just one example of many. My previous May 8 report to the Marin County Board of Supervisors analyzed all of their major claims in less detail, and showed that each major claim made by the PRNS is scientifically incorrect. But how about the official PRNS 2007 report? And in particular, how about the most recent May 11 version after they made revisions in response to my May 8 testimony? All of the incorrect claims remain, although dozens of changes have been made. Rather than go through each claim, below I briefly analyze one other claim – the impact on fish communities in the Estero – to show how broad and encompassing are the PRNS misrepresentations of their own data and reports. This is an additional claim that I did not highlight in my May 8 testimony. First, let's examine the available science on the fish in Drake's Estero.

The relevant study on the impact of the oyster farm on the fish communities in Drake's Estero comes from Jesse Wechsler's masters thesis in 2004 under the guidance of Professor Elliott-Fisk at U.C. Davis entitled:

*Assessing the Relationship between the Ichthyofauna and Oyster Mariculture in a Shallow Coastal Embayment, Drakes Estero, Point Reyes National Seashore.*

Wechsler's study was funded by the NPS, and conducted with the assistance of PRNS staff (where he previously worked). Wechsler compared Schooner Bay, an arm of Drake's Estero that has supported commercial oyster culture for over 70 years, to Estero de Limantour, a geographically isolated "wilderness" reference arm of the Estero

without oyster culture. He studied and compared three different locations: Limantour (the least impacted arm of the Estero without oysters), Schooner Adjacent (adjacent to the oyster racks, the most heavily farmed area), and Schooner Away (areas 75 meters away from the oyster racks in Schooner Bay, representing the majority of Drake's Estero that does not contain oyster racks).

As I described in my previous report on May 8, Wechsler's study began with the following hypothesis:

*Because studies have shown that bivalve mariculture can affect the biological, physical, and chemical characteristics of an aquatic ecosystem, I hypothesized that adjacent to the Drake's Estero oyster racks: (a) fish species diversity would be reduced, (b) fish abundance would be reduced, (c) fish species richness would be decreased, and (d) a few tolerant species would dominate the fish community.*

However, the data did not support this hypothesis, and Wechsler concluded:

*I found no statistically significant differences in fish abundance or species richness among the sampling locations, which indicated that the oyster farm had not exerted a noticeable effect on the ichthyofauna of Drake's Estero.*

Interestingly, species diversity and richness were greatest close to the oyster racks, which indicated that the physical structure of the oyster racks provided resources for a variety of fish species (e.g., feeding opportunities and/or refuge). He concluded:

*Because species richness and species diversity were greatest in the samples taken adjacent to the oyster racks, it is likely that the physical structure associated with the oyster mariculture facility has enhanced habitat complexity, thereby providing additional resources (e.g., cover and feeding opportunities) for fish.*

With Wechsler's masters thesis as background, let's examine how the May 11 version of the PRNS 2007 report described his data on fish communities. Wechsler is referenced 4 times: three times for statements about fish (see below) and once for a statement about the number of active oyster racks. Interestingly, none of the comments about the fish communities in Drake's Estero, and none of the references to Wechsler, ever mention Wechsler's major findings as described above that he found no impact of the oyster farm on the fish communities of Drake's Estero. Nevertheless, in the summary claims on page 17 at the end, the PRNS wrote:

*Schooner Bay, where there are many oyster racks, supported a different fish community than Estero de Limantour where no mariculture occurs. [pg. 17, point #3 of claim #3]*

Is that a true claim? Is that a misleading claim? What data do they present in the body of the report to support this claim? In the May 11 version, they presented only three references to Wechsler, none of which directly supports this claim about the fish in Drake's Estero. Concerning the relationship of certain species of fish to the eelgrass beds, they wrote:

*For example, within Drakes Estero many species such as Pacific herring, bay pipefish, gammarid and caprellid amphipods, the sea slug (*Phyllaplysia taylori*), and several shrimp species are directly dependent on eelgrass beds. [pg. 6]*

The first two references to Wechsler's report in the PRNS 2007 report were:

*Approximately 60 fish species have been documented in the area (Miller 1972, Wechsler 2004, D. Jacobs, unpubl. data). A recent study identified 35 species from 20 families. Five*

*species were dominant and represented 89% of the fish assemblage, including topsmelt, three-spined stickleback, staghorn sculpin, bay pipefish, and kelp surfperch (Elliott-Fisk et al. 2005, Wechsler 2004). [pg. 7]*

The third reference to Wechsler's report was:

*Wechsler (2004) detected few Pacific herring; even though this species was historically found in high numbers and spawns in eelgrass beds (Blunt 1984). [pg. 15]*

None of these references to Wechsler's report provide support for the claim that the oyster farm has changed the overall fish community in Schooner Bay or Drake's Estero in general. Interestingly, the April 1 version of the PRNS 2007 report contained two longer sections providing so-called support for this claim, but these two sections were deleted from the May 11 version, leaving the most recent version with no scientific support for this claim. What was wrong with the April 1 supporting statements? And if they were wrong, why wasn't the claim removed? In the April 1 version, in the passages deleted from the May 11 version referring to Wechsler's thesis, they wrote:

*The survey documented a difference in species composition between Drakes Estero and Estero de Limantour, with schooling fish that forage on plankton (topsmelt and herring) and benthic-oriented fish (staghorn sculpin) occurring primarily in Estero de Limantour and structure-feeding fish (several species of surfperch) occurring primarily in Drake Estero associated with oyster racks. Crevice-dwelling fish were also more common in Estero de Limantour (Elliott-Fisk et al., 2005).*

They went on to write in the April 1 version:

*The species richness of fish (the number of species) was the same between Estero de Limantour and Drakes Estero, but the species guilds were different. Schooner Bay where there are many oyster racks supported a completely different fish community than that in Estero de Limantour where no mariculture occurs. Wechsler (2004) concluded that the diversity of fish species was enhanced by the presence of the oyster rack structures (or any hard structure); however, his sample size was small and he was not able to sample eelgrass beds thoroughly because of logistical difficulties. Consequently, he may have missed species that are dependent on eelgrass.*

Both of these statements have been deleted from the May 11 version, leaving the PRNS with no support for their claim. Why were these statements deleted? My hunch is that they were removed because they are blatant misrepresentations of the data in Wechsler's masters thesis, and they knew that Wechsler's masters thesis was widely available. Whatever their reasoning, they eliminated the misquotes of his thesis, but did not eliminate the unsupported claim about the fish communities.

In the April 1 version, they misquote Wechsler as showing that pelagic fish (those that swim in the water and feed on creatures in the water such as plankton) and benthic fish (those that live on or near the bottom and feed at the bottom substrate) were more abundant in Estero de Linantour than in Drake's Estero. But this is not what he showed. Wechsler found that the topsmelt fish (the major pelagic species) were 39% of total fish in Limantour and 36% in Schooner Away, a statistically equivalent number. Total benthic-oriented fish were 20% in Limantour and 18% in Schooner Away, and total pelagic planktivore fish were 40% in Limantour and 38% in Schooner Away, both statistically equivalent comparisons. Thus, in contrast to these misquotes, there were no meaningful changes in these individual fish or fish guilds between Limantour and Drake's Estero.

What did Wechsler actually find and conclude? He placed fish into five ecological guilds: pelagic planktivores, benthic-oriented feeders, structure feeders, crevice dwelling fish, and eelgrass-dependent fish. When he compared Limantour to Schooner Away, he found no statistical difference in any measurement. In other words, in the areas of Schooner Bay that are 75 meters away from the highest density oyster racks, the fish communities are identical to Estero de Limantour. In conclusion, Schooner Bay was not different from Limantour. Rather, of the more than 2000 acres in the Estero, only the few acres directly adjacent to the oyster racks were different, and those differences were the increase in fish that use the hard structures for safety (i.e., structure feeders).

In the May 11 version, while removing the only two statements that supported their fish claim (probably because they so blatantly misquoted Wechsler's thesis), the PRNS did add a quote from a letter from a USGS scientist dated May 7, just a few days earlier. That is pretty fast for a letter to be received and make it into an official NPS report. The revisions of their reports must not get very carefully reviewed, let alone peer-reviewed.

This USGS scientist had not studied Drake's Estero, and had no data on Drake's Estero, but was rather proposing a hypothetical worry. Concerning possible impacts on fish, the PRNS wrote in their report on May 11:

*"The result of culturing bivalves in systems such as Drakes Estero is that there is a shift in the carbon from the pelagic food web to the benthic food web ..... we would also expect a shift in organic matter and nutrients to the bed. The pelagic to benthic shift can result in quite dramatic losses in the pelagic communities (zooplankton and fish) as have been seen with some exotic bivalve introductions (Zebra Mussel, Asian clam)" (Dr. Janet Thompson, a USGS benthic scientist, letter dated May 7, 2007). [pg. 14]*

Dr. Thompson is concerned that in certain other places, when a large number of bivalves (such as oysters) are cultured, it can lead to the filtering of so much plankton from the water that the pelagic (plankton feeding) fish no longer have enough food, and the community shifts to favor the benthic (bottom feeding) fish because that is where the nutrients now reside. This is an interesting hypothesis, but it is not supported by the data from Drake's Estero, data found in the PRNS-commissioned 2004 report by Wechsler. Oysters have been getting farmed in Schooner Bay for over 70 years. Surely, if the amount of plankton is rate limiting and the oysters are consuming all of it, then Dr. Thompson's proposed shift would have taken place decades ago, and Wechsler would have seen it. Did Wechsler find such a pelagic to benthic switch in the fish communities as Dr. Thompson's May 7 letter warns is possible? The answer is no.

Wechsler's thesis shows that the percent fish in the pelagic planktivore vs. the benthic oriented guilds are unchanged when he compared Limantour to Schooner Away (see numbers above). The fact that there is no change suggests that the hydrology of Drake's Estero provides sufficient amount of plankton and nutrients for the oysters and the fish to eat without disturbing the ecosystem. Although the PRNS quickly hurried Dr. Thompson's May 7 letter into their official May 11 report, thereby suggesting the potential for a switch in fish communities, they either did not do their homework, or if they did, they ignored it, because Wechsler's 2004 thesis refuted this hypothesis. Why did the PRNS include this potential dire warning without mentioning that their own data did not support it? And why did they rush this quote from this letter into an official report within just a few days?

Wechsler's thesis also showed that the eelgrass fish are thriving. The best indicator is the bay pipefish which represented 8% of fish in Limantour, 24% in Schooner Adjacent,

and 16% in Schooner Away. The Total eelgrass-dependent fish range from 8% in Limantour, 25% in Schooner Adjacent, and 16% in Schooner Away. This data hardly supports the claim that the oyster farm is leading to a decrease in eelgrass and a resulting decrease in fish dependent upon the eelgrass. Rather, it further supports the notion that the eelgrass is thriving, and so are the fish that depend upon it. In fact, the same number of eelgrass fish, but significantly more by percentage caught, were observed in Schooner Bay which contains oyster racks as compared to Estero de Limantour which does not. Wechsler (2004) wrote:

*Similar numbers of eelgrass dependent fish were observed in all sites.*

In summarizing her student's masters thesis, Elliott-Fisk (Elliott-Fisk et al., 2005) wrote:

*A similar number of eelgrass dependent fish was captured in all sites.*

The observation of a similar number of eelgrass fish in Schooner Bay as compared to Limantour is consistent with the observation that there is extensive eelgrass in Schooner Bay today. But that has not always been the case. The California Department of Fish and Game in collaboration with PRNS used aerial photographs to compare the extent of eelgrass coverage in the Estero, and have shown that eelgrass coverage has doubled from 368 acres in 1991 to 736 acres in 2007 (out of a total of 2200 acres), with eelgrass now growing closer to and in higher density surrounding the oyster racks. Most dramatic is the change in Schooner Bay which contains the highest density of oyster racks. In 1991, the aerial photos showed little eelgrass in Schooner Bay, whereas in 2007, this arm of the Estero is almost entirely covered by eelgrass. Clearly, both the eelgrass and eelgrass-dependent fish are thriving in Schooner Bay.

Finally, how about the herring? In the May 11 version, the herring are mentioned as something that Wechsler should have found, but did not, suggesting trouble with the eelgrass beds. Of course, the eelgrass-dependent fish are thriving, and are increased in the Estero which contains oyster racks. So how about the herring? Because most of his samples were outside the seasonal (December-January) period in which schools of herring enter the Estero to spawn, he missed the herring season all together. He trapped only one herring in Limantour and none in Drake's Estero. The reader will no doubt know that the difference between 1/1242 and 0/840 is not significant. Wechsler can make no comments on herring because he did not sample during the brief herring season. All of the regular eelgrass fish are thriving and their numbers are as good in Drake's Estero as they are at Estero de Limantour. Wechsler knew that he had nothing meaningful to say about herring because he never makes a point about the herring. It is only the PRNS that grasps this difference (1 herring in Limantour vs. 0 herring in Schooner Bay) and makes it into a conclusion worthy of their official report on a Department of the Interior web site.

In conclusion, let's return to the PRNS 2007 report summary claims on page 17, where the PRNS wrote:

*Schooner Bay, where there are many oyster racks, supported a different fish community than Estero de Limantour where no mariculture occurs. [pg. 17, point #3 of claim #3]*

Wechsler's data supports just the opposite claim. The fish communities in the majority of Schooner Bay away from the oyster racks are identical to the fish communities in Estero de Limantour. And adjacent to the oyster racks, the diversity and richness of fish are greater due to the physical structure associated with the oyster racks.

In his thesis, Wechsler wrote:

*This preliminary investigation into the relationship between oyster mariculture and the Drake's Estero ichthyofauna suggested that the fish community had not been adversely affected by the presence of the Johnson's Oyster Company. Analysis of variance tests showed no significant difference in species abundance or species richness at Schooner Adjacent, Schooner Away, or Estero de Limantour. Because species richness and species diversity were greatest in the samples taken adjacent to the oyster racks, it is likely that the physical structure associated with the oyster mariculture facility has enhanced habitat complexity, thereby providing additional resources (e.g., cover and feeding opportunities) for fish. These results support the ecological theory of spatial heterogeneity, which postulates that a direct correlation exists between increased habitat complexity and species diversity (Heck and Wetstone 1977).*

In conclusion, the fish and eelgrass are thriving in Drake's Estero. The PRNS 2007 report misrepresents and misquotes this data, and as a result, misleads the public.

## **Concluding Comments**

Most of the data that has been collected and published to date concerning Drake's Estero have been commissioned, reviewed, and in some cases co-authored by the PRNS, and apparently all of it without appropriate outside peer-review. Nevertheless, an analysis of these data and reports reveal that there is no compelling scientific reason to remove the oyster farm from Drake's Estero. There is also no scientific reason to eliminate the ranches surrounding the Estero. My initial report to you on May 8 supported that conclusion. This second report that I submit to you today further strengthens that conclusion: the available data show that the oyster farm and surrounding ranches are not negatively impacting the ecology of Drake's Estero.

The PRNS does not have the scientific data to support their conclusions. In fact, their own studies show just the opposite. The Anima (1991) study shows no impact of the ranches on the sediments, herbicides, pesticides, or nutrients in Drake's Estero. The Wechsler masters thesis shows no major impact of the oyster farm on the fish communities. The Elliott-Fisk et al. (2005) study shows no impact of the oyster farm on the sediments or the eelgrass in Drake's Estero. As mentioned in my first report on May 8, the PRNS Harbor Seal Monitoring reports of 2001 and 2006 show no impact of oyster workers on the harbor seals and pups in the Estero. The truth is dramatically different from the claims made in the PRNS report. This episode represents a troubling misuse of science for a political agenda. And it may be in violation of NPS policy.

In its published Director's Order #11B, entitled *Ensuring Quality of Information Disseminated by the National Park Service*, the NPS states that:

*The National Park Service will ensure that information it releases will be developed from reliable data sources and will otherwise ensure information quality at each stage of information development. The NPS's methods for producing quality information will be made transparent, to the maximum extent practicable, through accurate documentation, use of appropriate internal and external review procedures, consultation with experts and users, and verification of the quality of the information disseminated to the public. The NPS will also keep users informed about corrections and revisions.*

In its published 2006 Management Policies, the National Park Service states that:

*Decision-makers and planners will use the best available scientific and technical information and scholarly analysis to identify appropriate management actions for protection and use of park resources. [section 2.1.2]*

Later in the Management Policies, the NPS states:

*Research conducted by NPS personnel, contractors, and cooperative researchers will be subjected to peer review both inside and outside the Service to ensure that it meets professional standards, reflects current scholarship, and adheres to the principles of conduct for the appropriate discipline.*

The analysis presented here leads me to conclude that the PRNS has not followed NPS policies and orders to ensure quality information. PRNS has not used the best available scientific information, scholarly analysis, and external peer review. The process has not been transparent, and the public has not been informed of revisions. Rather, science has been misused by the PRNS to influence a policy decision. Most of the science, including the PRNS-commissioned studies and PRNS 2007 report, has not been peer-reviewed. Most of the science to which they refer is being selectively misrepresented. The raw data collected by the PRNS scientists, on which they are basing policy claims, are not being made publicly available for others outside the Service to analyze and review.

As a scientist, professor, and member of the National Academy of Sciences, I have attempted to review their data and conclusions. But my analysis has been hampered by a lack of full disclosure. In short, I do not have access to the full set of data on which the PRNS has made public claims. Immediately after the hearing on May 8, I contacted PRNS staff and requested scientific data relating to issues about which they testified before your Board. When it was not forthcoming, two Freedom of Information Act requests, one on May 12 and the other on May 13, were submitted to the Superintendent, requesting the customary reply within 10 days. Today, 17 and 16 days respectively after these FOIA requests were submitted, they remain unanswered by PRNS staff. If the data clearly support the PRNS claims, then I would have expected them to quickly and openly provide the requested data for analysis.

This misuse of science by the PRNS casts a dark shadow over the credibility of the NPS when it claims to use scientific studies to help set policy for the lands under its supervision. I believe that actions need to be taken to restore integrity to the NPS and its use of scientific data, eliminate the conflict-of-interest in the current PRNS reports and statements, and bring impartial peer-reviewed science to the debate on whether the oyster farm should stay or leave Drake's Estero.

I appreciate the opportunity to present this scientific analysis. I request that my letter and report be circulated to the other members of the Board.

Sincerely yours,

Corey S. Goodman, Ph.D.

goodman@renovis.com

cc: Superintendent Don Neubacher, Pt. Reyes National Seashore  
Kevin Lunny, owner, Drake's Bay Oyster Company