National Park Service
Clarification of Law, Policy, and Science on Drakes Estero

September 18, 2007

The information provided in this document is a response to comments presented to the Marin County Board of Supervisors by Dr. Corey S. Goodman, a molecular biologist, in two letters (May 8, 2007 and May 29, 2007). We will present background on the legislative authority and responsibility of Point Reyes National Seashore, and we will respond to comments regarding the science presented by the park concerning oyster farming in Drakes Estero. Dr. Goodman's statements to the Marin County Board of Supervisors contain what we believe are a number of mischaracterizations. This document seeks to examine those points of disagreement, relying on expert opinion from nationally recognized ecologists, peer-reviewed published literature, and National Park Service studies.

We acknowledge the following scientists and experts in the field of marine ecology who reviewed this document for accuracy and completeness:

- Dr. James Byers of the University of New Hampshire,
- Dr. James Carlton of Williams College and Director of the Maritime Studies Program of Williams College and Mystic Seaport,
- Dr. Gary Fellers of the USGS-Biological Resources Division,
- Dr. Frances Gulland of The Marine Mammal Center and on the Scientific Advisory Committee of the US Marine Mammal Commission,
- Dr. Edwin Grosholz of UC Davis and Bodega Marine Laboratory,
- Dr. John Kelly, scientist at Cypress Grove Research Center, Audubon Canyon Ranch,
- Dr. Steven Morgan of UC Davis and Bodega Marine Laboratory,
- Dr. Ben Becker, Director of the Pacific Coast Science and Learning Center, Point Reyes National Seashore,
- David Press, Ecologist, Inventory and Monitoring Program, National Park Service,
- Gary Davis, Chief Scientist of the Oceans Program of the National Park Service, and
- Dr. David Graber, Chief Scientist of the Pacific West Region of the National Park Service.

Background

Drakes Bay Oyster Company (DBOC) operates on land and within an estero owned by the United States of America and administered by the National Park Service as part of Point Reyes National Seashore, a unit of the National Park System. Much of DBOC's onshore operations occur on the approximately 1.5 acres delineated in a Reservation of Use and Occupancy (RUO) that expires in 2012; the remaining onshore operations and all of the operations in the waters of Drakes Estero occur on park property that is not part of the Reservation of Use and Occupancy. DBOC's operations are subject to the laws and policies governing units of the National Park System. These laws and policies provide the context for the scientific inquiry on the impacts of DBOC's operations. As summarized below, they set a high standard of protection for the natural environment--natural resources, processes, systems, and values--of Drakes Estero.

Park Law and Policy

Congress established Point Reyes National Seashore as a unit of the National Park System in 1962. In 1965, the State of California conveyed to the United States all right, title, and interest in the tidal and submerged lands within the park's boundaries, giving the National Park Service primary management authority over DBOC's oyster operations on these lands (California Department of Fish and Game letter, May 15, 2007). In 1976, Congress amended the park's enabling legislation to require that the park be administered "without impairment of its natural values, in a manner which provides for such recreational, educational, historic preservation, interpretation, and scientific research opportunities as are consistent with, based upon, and supportive of the maximum protection, restoration, and preservation of the natural environment within the area." Pub. L. No. 94-544 (Oct. 18, 1976), *codified at* 16 U.S.C. § 459c-6(a).

In 1976, Congress also designated certain areas of Point Reyes National Seashore as wilderness:

> …[I]n furtherance of the purposes of the Point Reyes National Seashore Act and of the Wilderness Act,…the following lands…are hereby designated as wilderness, and shall be administered by the Secretary of the Interior in accordance with the applicable provisions of the Wilderness Act: those lands comprising twenty-five thousand three hundred and seventy acres, and potential wilderness additions comprising eight thousand and three acres, depicted on a map…, to be known as the Point Reyes Wilderness.

Pub. L. No. 94-544 (Oct. 18, 1976) and Pub. L. No. 94-567 (Oct. 20, 1976), 16 U.S.C. § 1132 note. In 1985, Congress renamed the wilderness at Point Reyes National Seashore the "Phillip Burton Wilderness" in honor of the former Congressman. The wilderness designation encompasses much of the park's coastal land and water. In fact, Drakes Estero is part of the only federal marine estuarine wilderness along the Pacific coast from Washington to the Mexican border, and one of only 11 marine wilderness areas in the United States. The Congressional report accompanying the 1976 wilderness legislation states, "As is well established,…those lands and waters designated as potential

wilderness additions will be essentially managed as wilderness, to the extent possible, with efforts to steadily continue to remove all obstacles to the eventual conversion of these lands and waters to wilderness status. H. Rep. No. 94-1680, at 3; *see also, NPS Management Policies* ¶ 6.3.1 on "Wilderness Resource Management – General Policy." While most of Drakes Estero has now been designated or converted to wilderness status, the acreage containing DBOC's operations remains potential wilderness because of the nonconforming use associated with the Reservation of Use and Occupancy.

In addition to the Point Reyes National Seashore Act, 16 U.S.C. §§ 459c-459c-7, and the Wilderness Act, 16 U.S.C. §§ 1131-1136, the park is governed by the National Park Service Organic Act, as amended and supplemented, 16 U.S.C. §§ 1-4, which establishes as the "fundamental purpose" of units of the National Park System—

> …to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Congress reinforced this fundamental purpose in 1978 with the so-called "Redwoods Amendment" championed by Congressman Phillip Burton:

> The authorization of activities shall be construed and the protection, management, and administration…shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress.

16 U.S.C. § 1a-1.

In addition to specific regulations applicable to units of the National Park System (*see, e.g.,* 36 C.F.R. Chapter 1), the National Park Service *Management Policies* (updated in 2006) provides direction for park management. Several sections are particularly relevant to the evaluation of the impacts of DBOC's operations on the park resources and values of Drakes Estero. For example, *Management Policies* makes clear that the laws governing units of the National Park System prohibit the "impairment" or "derogation" of park resources and values (*Management Policies* ¶ 1.4 on "Park Management"). *Management Policies* therefore directs park managers to prevent "unacceptable impacts" and to allow only "appropriate uses" in parks to assure that park resources and values are not impaired (*Id.* ¶ 1.4 on "Park Management," ¶ 1.5 on "Appropriate Uses). With respect to the management of natural resources like those in Drakes Estero—

> Natural resources will be managed to preserve fundamental physical and biological processes, as well as individual species, features, and plant and animal communities. The Service will…try to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those

> ecosystems. Just as all components of a natural system will be recognized as important, natural change will also be recognized as an integral part of the functioning of natural systems….In managing parks to preserve naturally evolving ecosystems, and in accordance with the requirements of the National Parks Omnibus Management Act of 1998, the Service will use the findings of science and the analyses of scientifically trained resource specialists in decision-making.

Management Policies ¶ 4.1 ("General Management Concepts [for Natural Resource Management]").

Based on the laws and policies that govern park management, therefore, any changes from natural conditions are of concern and must be scrutinized carefully. This principle guides the National Park Service's scientific study and review of the impacts of DBOC's operations on Drakes Estero**.** "In cases of uncertainty as to the impacts of activities on park natural resources, the protection of natural resources will predominate." *Id.*

Of course, the National Park Service regulates activities to assure resource protection. For example, for the protection of the resources and values of Drakes Estero, the National Park Service does not allow power boats within Drakes Estero, except for the boats associated with the DBOC's Reservation of Use and Occupancy and rare NPS operations determined to be necessary under the "minimum requirement concept" for wilderness management (*see Management Policies* ¶ 6.3.5). All boats, except for the DBOC boats, are restricted within Drakes Estero during the harbor seal pupping season, March-June (Point Reyes National Seashore, Superintendent's Compendium).

Although the National Park Service is the primary agency responsible for the management of Drakes Estero, the NPS consults with appropriate state and federal agencies regarding park management issues. These consultations generally include the California Coastal Commission, the California Department of Fish and Game, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. As a unit of the National Park System, Point Reyes National Seashore is required to comply with the National Environmental Policy Act, the Clean Water Act, the Endangered Species Act, the Migratory Bird Treaty Act, the Marine Mammal Protection Act, the Coastal Zone Management Act, and other applicable law.

DBOC's Operations

As already described, DBOC is operating under a forty year Reservation of Use and Occupancy that expires in 2012. In 1972, Johnson Oyster Company sold its approximately 5 acres of onshore property to the United States and retained a right to use and occupy approximately 1.5 acres for 40 years. In 2005 Johnson Oyster Company assigned its right in the remaining years of the RUO to DBOC. According to its terms, the RUO is "for the purpose of processing and selling wholesale and retail oysters, seafood and complimentary food items, the interpretation of oyster cultivation to the visiting public, and residential purposes reasonably incidental thereto…" The RUO

contains 18 paragraphs of terms and conditions, including requirements that DBOC comply with all applicable Federal, State, and County health, sanitation and safety standards as well as NPS rules and regulations. In 2005, before DBOC purchased the RUO from Johnson Oyster Company, the National Park Service notified DBOC that the operations would have to cease upon the RUO's expiration in 2012.

DBOC holds a state water bottom lease from the California Department of Fish and Game (CDFG) encompassing approximately 1,000 acres of DBOC's oyster cultivation operations in Drakes Estero. CDFG recently confirmed that, by virtue of California's 1965 conveyance to the United States of the tidal and submerged lands within park boundaries, "the mariculture operation in question is properly within the primary management authority" of Point Reyes National Seashore (CDFG letter, May 15, 2007).

Oyster production and methods used within the estuary have varied over the past 50 years. The primary methods used, though, have been oyster racks (measuring around 10'x 100' each), stakes, and bags (measuring 1.5'x 3'). Most of the racks are distributed in the upper body of the estuary. Nearly 1000 oyster bags have been distributed along the margins of the estuary and on intertidal sandbars in the middle of the bay and in Home and Creamery Bays. CDFG reports that oyster production levels were high between 1981 and 1998 (annual production ranged 3-9 million oysters per year) and reduced between 1999 and 2005 (annual production < 2 million oysters per year). In 2006 DBOC planted 9.8 million oysters as cultch on racks, 4 million juvenile oysters in bags, and 1 million manila clam seed in bags (Tom Moore, CDFG, email April 26, 2007).

General Comments

In response to the question of whether the oyster farm is harming Drakes Estero, the answer depends not only on the scientific evidence but also on the standard of harm, or duty of care that applies. National Park areas like Drakes Estero acquire one of the nation's highest duties of care. As described above, under the laws and policies that govern units of the National Park System, any changes from natural conditions – including the natural abundance, diversity and genetic and ecological integrity of the plant and animal species native to those ecosystems—is of concern. Scientific studies to date are inconclusive as to the extent to which oyster farming is altering natural resources within the Estero, but the presence of a reported nine million oysters and one million clams (CDFG, pers. com.) within an area that would not have these resources naturally is itself enough to demonstrate an alteration of natural conditions. None of the Drakes Estero studies indicate that the operation "benefits" the estero, nor could they, as anthropogenic disturbance is contrary to NPS natural resource management principles and thus, by definition, degrades the natural values of the Estero. Additionally, we find in the broader scientific literature and from expert opinion that there are likely negative effects from the current level of operations in 2006 - 2007.

With regards to NPS studies within the estero, we wish to clarify points regarding the independence and quality of NPS data. Dr. Goodman questions the quality of the data collected by NPS biologists and others as not independent and not peer-reviewed through published scientific journals. It is true that much of the research within the NPS is

applied and often not published in scientific journals; nevertheless, research projects within the NPS are submitted to a rigorous peer-review process that includes scientists from the NPS, other agencies, and academia. An implementation plan is required before a project can begin which requires a detailed description and peer-review of the methods. The protocol development, although not as rigorous as the journal publication process, nevertheless does subject NPS applied research projects to a significant degree of review intended to insure the quality of the research and the integrity of the findings. The Point Reyes National Seashore Park News publication, "Drakes Estero – A Sheltered Wilderness Estuary," for example was reviewed by scientists from the U.S. Geological Survey and NPS.

Much of the research within Point Reyes National Seashore and other national parks across the nation is applied research that is designed to assist parks in specific management actions. For NPS and other Department of the Interior agencies, Congress specifically designates funds to conduct studies within parks to assist park managers in administering the parks so as to preserve and protect park resources and values for present and future generations. These studies rely on park biologists and on the expertise of both governmental and academic scientists to conduct the research. While the best available science is always sought, no land management agency has the luxury of supporting its management decisions strictly from published, peer-reviewed journals.

The claim that the NPS data collection lacked independence is simply mistaken. For example, Point Reyes National Seashore submitted a proposal to conduct a pilot study of the effects of oyster farming on Drakes Estero using a cooperative agreement with the University of California, Davis ("UC Davis"). The study methods were reviewed by UC Davis scientists, Drs. Deborah Elliott-Fisk and Peter Moyle. Dr. Elliott-Fisk is a wetland ecologist who was chair of the Department of Wildlife, Fish and Conservation Biology at UC Davis. Dr. Peter Moyle is a nationally recognized expert on fish. The proposal was subsequently funded by the NPS, but the research was conducted by the University of California faculty as an independent study.

With respect to individual biases in NPS research, we continue to believe that the studies conducted were not biased and there is no basis for such a claim. The NPS had no influence on the approach that Wechsler took in developing his Master's Thesis research, which was collaboration between him and his UC Davis thesis committee. Assertions that Wechsler's thesis hypothesis is biased are not true. Wechsler states "I hypothesized that adjacent to the Drakes 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". In the next sentence, Wechsler goes on to state "Alternatively, since the presence of bivalve filter feeders may bolster productivity and provide aquatic habitat abundance, richness, and diversity of fishes may have increased." Clearly providing for alternative hypotheses, Wechsler is displaying a disinterested scientific approach. Thus, there is no evidence that any of the study results were influenced by NPS staff to reach predetermined conclusions that there were negative impacts from mariculture.

Lastly, Dr. Goodman's claim that Dr. Allen, who co-authored an article in the weekly newspaper, The Point Reyes Light, did not mention her employment with the NPS is also not true (Goodman letter May 8, 2007). Dr. Allen's affiliation and that of the other co-authors were provided to the editor of the paper. That the paper chose not to publish the information is not the responsibility of NPS, nor does it support an allegation of NPS bias.

Fish Community

Dr. Goodman's review of Wechsler's thesis does point out several inconsistencies between Wechsler's results and the Point Reyes National Seashore Park News publication, "Drakes Estero – A Sheltered Wilderness Estuary." When we become aware of errors, oversights, or new information, we update park publications, as we did with this publication while it was on the park website.

There is no evidence, though, that the oyster facility has positively impacted the richness of a number of fish species (Goodman Letter May 8, 2007). Wechsler's thesis (2005) on the fish community of Drakes Estero clearly stated that his study "found no statistically significant differences in fish abundance or species richness among the sampling locations." Dr. Goodman's statement misinterprets the findings. The statement appears to be based on an insignificant increase of one species adjacent to the oyster racks and three species away from the racks compared to Estero de Limantour. Dr. Goodman incorrectly infers that increased richness, which is simply the total count of unique species, represents an improvement in this park ecosystem. Natural systems, however, have intrinsic levels of species richness and other measures of biodiversity, and divergences from those levels in either direction are generally considered a loss of naturalness.

Additionally, removing the oyster facility from Drake's Estero would not eliminate an important structural feature supporting the Estero's native fish biodiversity, and Wechsler does not report a statistical increase in biodiversity associated with the oyster racks. Although not statistically significant, Wechsler did indeed find that "species diversity and species richness were greatest at stations closest to the oyster racks." In addition, based on 4 out of 5 similarity indices "the fish assemblage adjacent to the racks was comprised of a group of species that diverged compositionally from the fish species captured in the reference site, which suggested that the racks favored structure-oriented and crevice dwelling fish." These are the elements of Wechsler's thesis that Dr. Goodman uses to support a claim of enhanced fish biodiversity.

Dr. Goodman mistakenly places importance on Wechsler's interesting but statistically insignificant results, and ignores Wechsler's data that suggest that oyster farming might harm the fish community. For example, counts of benthic oriented fish and schooling planktivorous fish were higher in Estero de Limantour than adjacent to the oyster racks and overall fish abundance was lowest adjacent to the oyster racks. The logic used to argue that oyster mariculture benefits the fish community could just as easily be used to suggest that oyster mariculture is detrimental to benthic oriented fish, schooling planktivorous fish, and overall fish abundance. All of these arguments would be an incorrect interpretation of statistically insignificant results.

To address the apparent disagreement on fish community effects, we recently conferred with Dr. Peter Moyle of UC Davis, a fish ecologist who served on the Wechsler thesis committee, and Dr. Edwin Grosholz of the UC Davis, an academic benthic ecologist. Dr. Moyle stated that "Jesse Wechsler's thesis did not demonstrate any negative impact of oyster racks on fish nor did it demonstrate any positive effects (Email to NPS, July 17, 2007)." Dr. Grosholz commented (Email to NPS, July 15, 2007) on Wechsler's thesis that "In summary, given that species diversity was never tested statistically and the tests of species number (richness) is strongly affected by sample size and incorrectly analyzed by date, there is little basis for concluding that the oyster racks had any affect on fish populations. By inspecting the data, it does appear that species identities do seem to shift, however no quantitative conclusions can be drawn from this analysis."

In summary then, Wechsler's thesis indicates that when he conducted his study prior to DBOC's operations, mariculture in Drakes Estero had no measurable effects on fish species abundance, diversity, or richness, but may have had an effect on fish composition. Similar results could have been found if other types of artificial reefs had been introduced to Drakes Estero. In Huntington Beach, California, for example, offshore oil rigs are popular scuba diving sites due to their large fish congregations and the interesting assemblage of marine invertebrates attached to the pilings. Oyster racks appeared to favor structure oriented fish; however, determining effects on fish composition within Drakes Estero by the current elevated level of oyster operations would require a more focused study.

Eelgrass

Dr. Goodman criticizes NPS for statements that eelgrass is impaired by the oyster operation, but he does not address evidence from the broader scientific literature on oyster operation effects on eelgrass or from preliminary studies in Drakes Estero showing reduced eelgrass growth below oyster racks and indirect effects from boat propeller damage.

Dr. Goodman correctly quotes Elliott-Fisk et al. (2005, page 28) "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." Elliott-Fisk, the primary author, apparently contradicted her research staff that published qualitative statements that eelgrass growth was very limited under the oyster racks (Harbin-Ireland 2004, Wechsler 2005). The NPS regrets that it did not discover the inconsistency between Elliott-Fisk's comment and the results reported by these two studies when reviewing the final draft of Elliott-Fisk et al. (2005). NPS acknowledges that eelgrass beds have expanded since the 1990s but, consistent with the results from these studies, NPS has also documented that eelgrass beds are locally affected by the oyster operation.

Dr. Goodman does not address the local direct damage of the oyster boats on the eelgrass (see aerial photographs R. Campbell, May 7, 2007 and Drakes Estero Site Visit Report 3/20/07). A site visit on March 20, 2007 documented that oyster structures (racks and floats) directly and adversely impacted 8.5 acres, or 1% of the 736 acres of eelgrass in the

estero. By simple measurement of high density boat tracks through eelgrass beds using GIS spatial analysis of aerial photographs, NPS conservatively documented a larger area of secondary impacts approaching 50 acres (NPS GIS map July, 2007). Numerous channels have been cut into the eelgrass beds by boat propellers. The long and short-term effects of these motorboat cuts in the eelgrass, if any, have yet to be determined; however, the main boat channel cutting through Schooner Bay is a clear example of boat traffic effect on eelgrass beds.

Dr. Grosholz provided expert opinion to the NPS on Dr. Goodman's statements regarding eelgrass (Email to NPS, July 15, 2007). Dr. Grosholz stated, "Dr. Goodman is correct to point out that we should base our decisions on the best science available, but curiously fails to cite any science at all on this point. He is correct that there is very little in the way of published literature, but what there is clearly indicates that oyster culture negatively affects eelgrasses. Everett et al. (1995) unambiguously demonstrates that oyster culture negatively effects eelgrass on a local scale. While this study takes place in Oregon, it involves the same species and same methods used in Drake's Estero. In the absence of a similar study in California, this is the best available science, period." Dr. Grosholz also states (Email to NPS, July 15, 2007)—

> Unfortunately, the evidence that Dr. Goodman provides has nothing to do with local impacts of oyster culture on eelgrass. The broad-scale increase of eelgrass beds in Drake's Estero is certainly good news. We all want to see increases in the coverage of this important and diverse community. It is equally possible that eelgrass would be even more abundant than the current level in Drake's Estero if oyster racks hadn't been present. In other words, we might have seen even greater recovery of eelgrass in the absence of oyster culture. The more relevant scale of analysis has to do with local impacts (scales of meters) of oyster racks on eelgrass. But the aerial photo data from CDFG has nothing to do with this. The aerial photos in this unpublished analysis are unlikely to have the necessary resolution, so the statement "eelgrass growing closer to and surrounding the oyster racks" has no quantitative support. Finally, the statement that eelgrass beds in California [have] "…otherwise been retreating and are in decline" is not supported by any published analysis I am aware of and no support for this statement is provided by Dr. Goodman. It's simply unsupported speculation and very misleading to imply that eelgrass is retreating everywhere in California except for Drake's Estero. Finally, the impacts of boat propellers on eelgrass due to the direct effects of physical damage and the indirect effects of increased turbidity remain an unquantified, but plausible mechanism and should be investigated.

The current level of impact to eelgrass beds by the oyster operation may or may not be significant to the overall persistence of eelgrass within Drakes Estero. The extent of indirect adverse impacts from boat operations or changes to water quality has not been measured and further research is clearly needed to determine the extent and persistence of these impacts. Nevertheless, the current level of impacts would not occur if the oyster

operations were reduced in or absent from Drakes Estero.

Sedimentation

NPS statements regarding sedimentation are challenged as not supported by published literature; however, there are several papers in the published literature regarding the negative effects of aquaculture operations on sedimentation from studies in other estuaries. Research in other estuaries has documented that the deposition from pseudofeces tends to be focused below and around mariculture structures (Cranford et al. 2003; Porter et al. 2004). Everett et al. (1995) who conducted a study in the Pacific Northwest noted that aquaculture techniques might have ecological impacts related to altered flow regimes and disturbance of the substrate.

Dr. Goodman correctly points out errors or oversights by NPS regarding interpretation of a report by a USGS researcher (Anima 1990). The researcher, Dr. Roberto Anima, conducted research in Drakes Estero in the late 1980s and provided both a report to the National Park Service (Anima 1990), and a U.S. Geological Survey report (Anima 1991). The NPS incorrectly interpreted the report by Dr. Roberto Anima (1990) that he had detected oyster pseudofeces in sediment core samples, that he estimated the amount of fecal matter produced by oyster rafts, and that he considered oyster farming as the primary source of sedimentation in the estero. NPS acknowledges the errors and clarifies here what Anima (1991) reported. Instead, Anima (1991; page 92) references another study - "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", and states “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….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.”

Although Dr. Anima did not quantify sedimentation related to the oyster farming, he provided expert opinion in the report that the sediment material was likely resistant to erosion because oyster racks were located in the upper reaches of the estero where tidal action was limited. He goes on to say, “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” (Anima 1991; page 93). It should be noted that DBOC does not use the staked method but instead puts oysters in bags using similar habitat.

The Elliott-Fisk et al. (2005) report notes oyster feces are not a problem in Drakes Estero. But, as noted above, the Elliott-Fisk et al. (2005) research took place in the late 1990s when only 38 racks (45%) were active (CDFG landing reports), before the current higher level of oyster production in Drakes Estero. In March 2007, there were 65 active racks and several hundred oyster bags in Drakes Estero in locations where bags were not previously located. In addition, Dr. Goodman fails to note that this research was only a preliminary study; that the sediment analysis suffered from low sample size collected on only one occasion; and that despite suggestions that decomposing eelgrass was a key source of sediment organic matter, no quantifiable evidence was presented to support this

claim. Determining past and current effects of oyster operations on sedimentation rates within Drakes Estero would require a more focused, site-specific study.

Dr. Thompson, who works for the U.S. Geological Survey, Water Resources Division in Menlo Park, provided expert opinion that addressed the potential effects that racks and bags might have on the hydrodynamics of the estero. Both bags and racks have the potential to increase sedimentation and erosion, depending upon the placement and number of bags. She states "If the mass is high, bacterial reduction of the organics can reduce the oxygen content of the sediment…The sediment will become enriched and the sediment grain size may be reduced as the fecal pellets become incorporated into the sediment" (May 7, 2007 letter to NPS). The bags may create an anoxic zone by sedimentation and sequestering of oyster feces into the sediment under the bags, severely stressing the native invertebrate community beneath. Dr. Thompson stated that once bags are removed the organisms will likely recolonize the sediment. In parts of Drakes Estero near where oysters are cultivated in bags on the tidal flats, native clams can be found in extremely high densities - up to 250 per square meter (Press 2005). No studies to date have investigated the impacts of the several hundred newly placed oyster bags on the underlying sediment and associated invertebrate community of Drakes Estero.

Finally, Dr. Grosholz provided expert opinion that addressed the potential effects of the oyster bags. "There is likely to be immediate impacts, mostly negative, on suspension feeders and surface deposit feeders immediately under the bags due to increased sedimentation, physical obstruction, decreased particle size and associated increased hypoxia. There may be positive effects for species requiring hard substrate for attachment. There may also be disturbance created by boats including increased turbidity as props resuspend particles in the water column. However, there are no well documented studies of this at present" (Letter to NPS May 6, 2007). He further states, "Once again, the work of Everett et al. (1995) is perhaps the only published study from the western U.S. that explicitly measures the effects of oyster culture on carbon content, grain size and other sediment parameters on relevant scales. They found very significant effects of oyster culture on sedimentation occurring in a matter of weeks, though it is important to point out that the effects varied with culture method" (Letter to NPS July 15, 2007).

Dr. Grosholz concludes that "In summary, the U.S.G.S. report and the subsequent interpretations should not be the basis for drawing conclusions about the effects of oyster culture on sedimentation. As discussed in point 1, the peer-reviewed scientific literature demonstrates that oyster culture can significantly influence sedimentation rates with negative local effects on eelgrass beds" (Letter to NPS July 15, 2007).

Invasive Tunicate

Dr. Goodman asserts that the NPS is overstating the potential risk of invasive species generally, and the potential damage of the colonial tunicate (*Didemnum* sp. A) to Drakes Estero. Expert opinion and direct evidence in Drakes Estero, however, support the NPS concern regarding this invasive species.

Drs. Carlton and Grosholz stated that the *Didemnum* sp. A is not endemic to the region and they consider the species to be highly invasive (see below and Bullard 2007a). The species also is on the National Aquatic Nuisance Species Watch List for Washington State. Furthermore, an infestation of *Didemnum* sp. A was found on natural sandstone and mudstone habitats at Bull Point within Drakes Estero in May 2007, showing that the species can invade and survive on native habitat and not just oyster equipment in Drakes Estero. There has been no field research to determine the minimum spacing needed to ensure that *Didemnum* will not spread from known habitat to population regions previously thought to be inhospitable.

Although Dr. Goodman correctly states that the oyster farm may not be the original source of the introduction of *Didemnum* within the estero, the pervasive presence of *Didemnum* on the racks increases the likelihood of invading native habitat. Dr. Grosholz stated (Letter to NPS July 15, 2007)—

> No one knows the history of the introduction of this species at this site. However, Dr. Goodman errs in his discussion of the establishment of this species when he states that the larvae of this species "are endemic in the plankton". Just because other tunicates are widely distributed along the west coast doesn't mean that this species of *Didemnum* is everywhere.…In fact, the recent study by Bullard et al. (2007) of which Dr. Goodman's colleague Mary Carman is also a coauthor clearly shows more than a half-dozen sites on the west coast where this species of *Didemnum* has not yet colonized. The issue is not whether Drake's Estero will become overrun with *Didemnum* sp. A. Dr. Goodman is correct that this tunicate is unlikely to overrun eelgrass beds or the other soft substrate habitats in the Estero. However, there is some limited hard substrate in the Estero that now has this tunicate and this may be of some concern in the future. However, an equally important issue is the likelihood of further spread of *Didemnum* sp. A to other sites.

Dr. Grosholz recently expressed his concerns in a letter to the California DF&G Commission (June 1, 2007):

> The expansion of shellfish production will provide more substrate for *Didemnum* and increase the degree to which Drake's Estero might act as a source for this species. The second concern is that current culture methods that involve scraping off the tunicate from culture apparatus will result in the release of large numbers of fragments into the estuary. Both of these issues represent significant concerns that should be formally addressed in a detailed environmental review of this proposal.

In a laboratory study, Bullard et al. (2007b) demonstrated that damaged and torn fragments of *Didemnum* could survive and reattach to other substrates.

NPS also has conferred with several national and regional experts on the topic of invasive non-native marine species, including Drs. Janet Thompson of USGS, Edwin Grosholz of UC Davis, James Byers of University of New Hampshire, and James Carlton of Williams

College and Director of the Maritime Studies Program of Williams College and Mystic Seaport. Each is familiar with or has conducted research in Drakes Estero.

Dr. Thompson stated that "there are no examples of extirpating aquatic exotic animals once they have spread in a system….The presence of hard structures such as racks supplies a habitat for epifauna that might be less likely to successfully invade this system." (Letter to NPS May 7, 2007). Consequently, the structures in the estero facilitate invasive species by providing an unnatural substrate.

Dr. Grosholz, in a recently published paper (Grosholz 2005), discovered that a non-invasive exotic species in Bodega Bay reached a tipping point, and became highly invasive based on the unintended effects of another newly invading species. This concept of "invasional meltdown" showed that additional invasive species can alter the system to the point where prior non-natives become highly invasive, thus having a far greater impact on the ecosystem. Specific to Drakes Estero, Dr. Grosholz stated as follows (Letter to NPS July 15, 2007):

> The extensive oyster racks permit the development of huge populations of many non-native species, not just *Didemnum* sp. A but other species with a much greater potential for larval dispersal. A recent study by Glasby et al. (2007) makes it clear how artificial structures disproportionately support non-native species at the expense of native species. Therefore, the extensive oyster racks in Drake's Estero potentially represent a large source of propagules that can increase the chance that *Didemnum* and other introduced species in Drake's Estero could be dispersed to other sites along the California coast by planktonic dispersal, attached to small boats or by the movement of shellfish products. However, it must be pointed out that there are no quantitative estimates of the magnitude of this risk.

Dr. Byers conducted his dissertation work on invasive aquatic species at Point Reyes in the 1990s. Dr. Byers stated (Email to NPS July 6, 2007; Byers 1999)—

> Nonindigenous oyster introduction has been an enormous vector of species introductions both globally and on the US West Coast. If there is no more oyster importation, one could argue that the damage in terms of hitchhiking nonindigenous species importation has already been done. However, even if new importation has abated, there still remains a large source pool of nonindigenous species that can invade nearby marine and estuarine habitats. For example, the Japanese mud snail (*Batillaria attramentaria*) was introduced to nearby Bolinas Lagoon not from an introduction directly from Japan, but from Japanese oysters from Drake's Estero that were outplanted to Bolinas Lagoon in 1955.

Dr. Carlton (Email to NPS July 16, 2007) states the following:

> The tunicate *Didemnum* now in Drakes Estero is not native to the Pacific coast of America, nor, indeed, to the Atlantic Ocean. It is not endemic to the world's

> oceans, and abundant historical, ecological, geographical, morphological, evolutionary, and genetic data now support that conclusion. The WHOI/USGS scientists at Woods Hole studying this species are keenly aware that it is not native to the Atlantic coast of America, which is one reason they are studying it and concerned about its aggressive and massive colonization of the Georges Bank fishing grounds. At this time, the trail appears to lead to Japan for the endemic region of this species.

Finally, invasive parasites that hitchhike on non-native species have recently been identified as another source of non-native species (http://sciencedaily.com/releases/2006/12/061219094419.htm. The Japanese mud snail was introduced into estuaries of North America via oyster farming (Carlton 1992). Recently researchers determined that the mud snail was also the host for an invasive trematode parasite that can infect native fish. The Japanese mud snail has been found in Drakes Estero (Byers 1999).

Leading experts in marine ecology consider nonnative invasive species, including *Didemnum* sp. A, as serious potential threats to the ecology of Drakes Estero.

Harbor seals

The overall population of harbor seals on the central California coast is healthy and has flourished over the past two decades (Sydeman and Allen 1999). However, Dr. Goodman incorrectly extrapolated from that regional trend that there are no local effects on seal numbers in Drakes Estero from the oyster farm because that regional study analyzes data from the Farallon Islands and Double Point, two completely different seal rookeries from Drakes Estero.

Dr. Grosholz also noted (Email to NPS July 6, 2007)

> Unlike the three previous claims where I would list myself an expert, I am not so with regard to marine mammals. However, reading the peer-reviewed paper by Sydeman and Allen, Dr. Goodman quotes "habitat saturation and/or prey limitation" is limiting harbor seal populations. But he fails to mention that later in the same paragraph, Sydeman and Allen state "We are unclear as to the limiting factors now affecting harbor seals in central California, but we suspect undisturbed habitat may be limiting breeding populations on the mainland." Why was this conclusion omitted from Dr. Goodman's analysis of this paper?

Finally, Dr. Goodman uses early reports that precede the current conditions within Drakes Estero to argue that the oyster operations are not disturbing the seals. His position relies solely on large, regional population patterns and ignores local occurrences of federally prohibited disturbance to harbor seals. Motorboats were rarely observed disturbing seals in Drakes Estero during the 1997 - 2006 breeding seasons (Manna et al. 2006). This is no longer true. During the 2007 harbor seal pupping season, the NPS documented 1) oyster boats disturbing mother seals with pups, and 2) oyster bags placed on sandbars where seals would normally give birth and nurse their pups (NPS Trip reports 4/13/2007 and 4/26/2007). Two oyster bag arrays (approximately 5 acres) were

within a regular harbor seal haul out site, and one other oyster bag site was within 50 meters of a regular harbor seal haul out site (NPS Trip Report April 13, 2007). Over the past 20 years, harbor seals have consistently used tidal sandbars in the central bay of Drakes Estero during the breeding season where females can raise pups without disturbance (Allen 1988). Also, it is incorrect to interpret from the NPS reports (Vanderhoof et al. 2005, Manna et al. 2006) that the number of seal pups increased in Drake's Estero from 2005 to 2006, in contrast to the general trend. The pup count in Drakes Estero was 332 in 2005 and 347 in 2006, indicating no statistically significant difference between the two years. More focused analyses are required to determine if oyster operations are affecting seal distribution and productivity within Drakes Estero.

The overall Drakes Estero and regional population declined in 2007, but not necessarily in response to the oyster farming operations. The analysis for 2007 has not yet been completed to determine whether this decline is statistically significant. Other confounding oceanographic factors likely are affecting seal productivity in the region. However, the oyster operation has contributed to site-specific disturbance and displacement within the estero, where historically many females with pups occur. Chronic disturbance at other seal haul out sites in the region have resulted in reduced usage and even abandonment (Grigg et al. 2004), and previous elevated disturbances in Drakes Estero from all types of boats prompted the National Park Service to close the estero to all boats, excluding the non-conforming use by the oyster operation, during the harbor seal pupping season (March 1 through June 30; Point Reyes National Seashore, Superintendent's Compendium 2007).

Conclusions

Based on the laws and policies that govern park management, any changes from natural conditions are of concern and must be scrutinized carefully. This principle guides the National Park Service's scientific study and review of the impacts of DBOC's operations on Drakes Estero**.** Both law and policy direct the National Park Service to use the findings of science and the analyses of scientifically trained resource specialists in decision-making. The National Park Service evaluates impacts on natural resources by applying scholarly, scientific, and technical information and uses National Park Service knowledge and expertise that comply appropriately with professional standards. Technical reports, expert opinions, and other sources of scientific data also provide decision-makers with reliable and verifiable information.

No data have been presented to support the claim of ecological benefits to Drakes Estero from the DBOC. No peer-reviewed journal publications have been referenced and little expert opinion has been provided. However, there is strong evidence from the broader scientific literature on negative effects of oyster farming, some of which was referenced in the NPS documents. Research by Kelly et al (1996) on shorebirds of Tomales Bay, for example, suggested a significant net decline in shorebird use of intertidal areas developed for oyster farming. A recent article by Ruesink et al. (2005) reports that "oysters are ecosystem engineers that influence many ecological processes, such as maintenance of biodiversity, population and food web dynamics and nutrient cycling."

NPS has relied on peer-reviewed published papers, government reports, and both local and national expert opinion. The peer-reviewed literature is not conclusive about the extent to which oyster farming has a negative effect on native ecosystems. Nevertheless, some effects have been identified and the preponderance of evidence demonstrates that there are serious potential and real negative effects within Drakes Estero. Many articles and experts in the field of marine ecology indicate that oyster farming in Drakes Estero likely would negatively affect the estero ecology and also point to the need for further research. Because of the controversy regarding the level of effects of oyster farming on the ecology of Drakes Estero, the National Park Service is seeking guidance from the National Academy of Sciences. The National Academy of Sciences is highly regarded for providing independent and objective advice based on the highest scientific standards. If the Academy chooses to accept the NPS request, results likely would be available in 2008.

Literature Cited

Allen, S.G. 1988. The movement and activity patterns of harbor seals in Drakes Estero, California. M.S. Thesis, University of California, Berkeley, 70 pp.

Anima, R. 1990. Pollution studies of Drakes Estero, and Abbotts Lagoon, Point Reyes National Seashore. Final National Park Service Report. 233 pp.

Anima, R. 1991. Pollution studies of Drakes Estero, and Abbotts Lagoon, Point Reyes National Seashore. U.S. Geological Survey. Report 91-145. 178 pp.

Bullard, S.G., Lambert, G., Carman, M.R., Byrnes, J., Whitlatch, R.B.,Ruiz, G.M., Miller, R.J., Harris, L.G., Valentine, P.C., Collie, J.S., Pederson, J., McNaught, D.C., Cohen, A.N., Asch, R.G., Dijkstra, J., Heinonen, K. 2007a. The invasive colonial ascidian Didemnum sp.: current distribution, basic biology, and potential threat to marine communities of the northeast and west coasts of the United States. Journal of Experimental Marine Biology and Ecology 342, 99–108.

Bullard, S.G., B. Sedlack, J.F. Reinhardt, C. Litty, K. Gareau, R.B. Whitlatch. 2007b. Fragmentation of colonial ascidians: differences in reattachment capability among species. Journal of Experimental Marine Biology and Ecology. 342: 166-168.

Byers, J.E. 1999. The distribution of an introduced mollusk and its role in the long-term demise of a native confamillial species. Biological Invasions 1:339-352.

Carlton, J. T. 1992. Introduced marine and estuarine mollusks of North America: an endof-the-20th-century perspective. Journal of Shellfish Research 11: 489-505.

Cranford, P., M. Dowd, J. Grant. B. Hargrave, and S. McGladdery. 2003. Ecosystem Level Effects of Marine Bivalve Aquaculture. In: Volume I: A Scientific Review of the Potential Environmental Effects of Aquaculture in Aquatic Ecosystems. Canadian Technical Report of Fisheries and Aquatic Sciences 2450. p. 51-84.

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. 105 pp.

Everett, R. A., G. M. Ruiz, and J. T. Carlton. 1995. Effect of oyster mariculture on submerged aquatic vegetation: an experimental test in a Pacific Northwest estuary. Marine Ecology Progress Series 125:205-217.

Glasby, T.M, S.D. Connell, M.G. Hollowy, and C.L. Hewitt. 2007. Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions? Mar. Biol. 151: 887-895.

Grigg E.K., S.G. Allen, D.E. Green, H. Markowitz. 2004. Harbor seal, *Phoca vitulina richardii*, population trends in the San Francisco Bay Estuary, 1970-2002. California Fish and Game 90(2):51-70.

Grosholz, E.D. 2005. Recent biological invasion may hasten invasional meltdown by accelerating historical introductions. Proceedings of the National Academy of Sciences. 102:1088-1091.

Harbin-Ireland, A. C. 2004. Effects of mariculture on the benthic invertebrate community in Drakes Estero, Pt. Reyes Peninsula, California. Master's thesis, University of California, Davis. 68 pp.

Kelly, J.P., J.G. Evens, R.W. Stallcup, and D. Wimpfheimer. 1996. Effects of aquaculture on habitat use by wintering shorebirds in Tomales Bay, California. California Fish and Game 82:160-174.

Manna, J., D. Roberts, D. Press, and S. Allen. 2006. Harbor seal monitoring, San Francisco Bay Area. Annual Report for the National Park Service. 21 pp.

Porter, E.T., Cornwell, J.C., and L. P. Sanford. 2004. Effect of oysters Crassostrea virginica and bottom shear velocity on benthic-pelagic coupling and estuarine water quality. Mar. Ecol. Prog. Ser. 271:61-75

Press, D. 2005. Ecological impacts of green macroalgal mats on estuarine tidal flats. Masters Thesis, University of California, Davis. 63 pp.

Ruesink, J.L., H.S. Lenihan, A.C. Trimble, K.W.Heiman, F.Micheli, J.E. Byers, and M.C. Kay. 2005. Introduction of non-native oysters: ecosystem effects and restoration implications. Ann. Rev. Ecol. Evol. 36:643-89.

Sydeman, Wm. And S. G. Allen. 1999. Pinnipeds in the Gulf of the Farallones; 25 years of monitoring. Marine Mammal Science. 15:446-461.

Vanderhoof, M. and S. Allen. 2005. Harbor seal monitoring at Point Reyes National Seashore and Golden Gate NRA. Annual Report to the National Park Service, Inventory and Monitoring Program. 19 pp.

Wechsler, J.F. 2004. Assessing the relationship between the ichthyfauna and oyster mariculture in a shallow coastal bay, Drakes Estero, Point Reyes National Seashore. Masters Thesis, University of California, Davis. 36 pp.