Final Report on Peer Review of the Science Used in the National Park Service's Draft Environmental Impact Statement Drakes Bay Oyster Company Special Use Permit

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1.0 INTRODUCTION

In 2011 the National Park Service (NPS) prepared a Draft Environmental Impact Statement (DEIS) for the Drakes Bay Oyster Company (DBOC) Special Use Permit (SUP). The commercial shellfish company operates in Drakes Estero, within the Point Reyes National Seashore, and is the only nonconforming use that prevents conversion of the waters of Drakes Estero from congressionally designated potential wilderness to congressionally designated wilderness. Section 124 of Public Law (PL) 111-88, as part of the Department of the Interior (DOI), Environment, and Related Agencies Appropriations Act of 2010, grants the Secretary of the Interior the discretionary authority to issue a new SUP to DBOC that would be valid for a period of ten years. Under existing agreements (i.e., Reservation of Use [RUO] and SUP) the NPS lacks the authority to allow DBOC to operate after November 30, 2012. As part of the National Environmental Policy Act (NEPA) process, the purpose of the DEIS is to engage the public and evaluate the effects of issuing a SUP for the commercial shellfish operation by comparing four alternative scenarios. The final EIS will be used to inform the decision of whether or not to issue a new SUP to DBOC.

1.1 Objectives of Peer Review

The DOI requested an independent peer review of the DEIS (Chapters 3 and 4) to examine the scientific and technical information and scholarly analysis presented in the document and assess whether: (1) appropriate scientific information was used; (2) reasonable conclusions were drawn from the information; (3) significant information was omitted from consideration; and (4) NPS interpretation of the information is reasonable. The peer review was focused on the scientific underpinning of the DEIS and not intended to address other aspects of the NPS planning and decision-making processes or information not directly related to the use of scientific information (e.g., consistency with the park's purpose, quality of visitor experiences, or interpretation and application of policy and law). Ultimately, the purpose of the review was to obtain suggestions from the reviewers on how the DEIS can be improved from a scientific perspective.

The peer review was limited to the scientific information used in the DEIS including: (1) published papers in peer-reviewed journals; (2) technical reports of scientific data or analysis; (3) monitoring or other scientific data used in the DEIS but not published in the literature or as a technical report. Peer reviewers were not tasked with reviewing non-scientific information in the DEIS (e.g., policy or legal information) or offering any legal or policy opinions as those are the province of the NPS. Peer reviewers were also not tasked with reviewing the "intensity definitions" or their conclusions. Finally, reviewers were not asked to make recommendations on whether a particular alternative should be implemented or whether they would have conducted the impact analysis in a similar manner.

The reviewers were asked to conduct their reviews of the DEIS as independent desk reviews and address the following questions in their comments:

1. Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

- 2. Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.
- **3.** Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.
- **4.** Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.
- **5.** Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

2.0 PEER REVIEW PROCESS

Atkins, North America, hereafter referred to as Atkins, was retained by the DOI to select peer review panel members and facilitate the peer review process. The terms of the contract are set in the contractual document. They include the following:

- Review the DEIS to determine the appropriate expertise required to provide a high quality, independent peer review;
- select and engage reviewers;
- distribute materials to reviewers and coordinate start of review;
- manage reviewers/answer reviewers' questions and complete reviews;
- provide draft report to Contracting Officer's Representative (COR);
- provide final report to COR that addresses DOI comments from internal review; and
- present results of report and respond to questions from agency staff, if necessary.

2.1 Selection of Reviewers

Atkins was directed to select at least four well-qualified, independent reviewers with expertise in the following areas: (1) Marine Estuarine Ecology and Coastal Zone Management; (2) Water Quality; (3) Soundscapes; and (4) Socioeconomics. The DOI required that members of the peer review panel be selected in accordance with the general principles of the National Academy of Sciences (NAS) Policy on Committee Composition and Balance and Conflict of Interest for Committees. The Atkins Team requires that all reviewers comply with NAS conflicts of interest procedures. Several potential reviewers were considered for the review. One of these self-identified as conflicted because of previous interests and statements on the DEIS. Two other reviewers were contacted and were unable to commit the time necessary to carry out the review.

During the interview process the Atkins Team determined that the five reviewers listed below were not conflicted over preparing an impartial review.

Given the length of the marine estuarine ecology and coastal zone management sections, the Atkins Team selected two reviewers with expertise in those fields and one reviewer for each of the other three subject areas. All candidates had advanced expertise (Ph.D. level) and a record of research and publication in their respective fields. The Atkins Team submitted the candidates to DOI representatives for approval. The reviewers are:

- <u>Marine Estuarine Ecology and Coastal Zone Management:</u> Dr. Ted Grosholz, University of California Davis, and Dr. Dianna Padilla, Stony Brook University
- <u>Water Quality:</u> Dr. Charlie Wisdom, Parametrix
- <u>Soundscapes:</u> Dr. Christopher Clark, Cornell University
- <u>Socioeconomics:</u> Dr. James Wilen, University of California Davis

The qualifications of each reviewer are included in this document as Appendix A.

2.2 Document Review and Report Development

Reviewers conducted their independent desk reviews of Chapters 3 and 4 of the DEIS (according to their respective areas of expertise) between January 27, 2012 and February 19, 2012. All comments were submitted to Atkins as individual memoranda and are included in this document as Appendix B.

The Atkins Team (Dr. Steven Courtney, Rebecca Burns) prepared a draft report that included: (1) the individual reviewers' comments including responses to the questions above; (2) a summary and analysis of the reviewers' responses; and (3) a recommendation as to whether the scientific information included in the DEIS is the product of appropriate scientific standards and approaches for using, interpreting and applying data and information to draw reasonable conclusions as it relates to the subject of the DEIS.

3.0 **RESULTS**

Summaries of the individual reviewers' comments on the five questions the reviewers were directed to address are presented below and organized by subject area.

3.1 Question 1: Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

Marine Estuarine Ecology and Coastal Zone Management

Both reviewers agreed that, in general, the interpretations presented in the DEIS are reasonable, given the very limited data available for many of the topics. One reviewer (Grosholz) observed that impacts of oyster aquaculture on birds are speculative and unsupported by peer-reviewed publications, but noted that the report's authors cannot be faulted as there are no published data on these impacts. The other reviewer (Padilla) cautioned that "when there are no data to support or refute the notion that there is an impact, one cannot conclude that there is no impact" and noted that the National Research Council (NRC) report (NAS 2009) cited throughout the DEIS echoes that concept (Appendix B).

Both reviewers cited specific examples of interpretations in the DEIS that are not reasonable based on scientific evidence. Some comments were generally more minor (e.g., the DEIS ignores the potential for upward plant migration in response to sea level rise), whereas others were more significant. For example, the DEIS does not discuss the uncertainty associated with the estimates of eelgrass cover and damage due to boat propellers and does not include a citation for conclusions made about the most recent set of images (2010). Both reviewers commented that interpretation of oyster impacts could be significantly improved. Specifically, the DEIS bases interpretations of environmental impacts of *Crassostrea gigas* on studies conducted on *Crassostrea virginica*; however, the two species have very different biology and ecology. Much research has been published on environmental impacts of *C. gigas* in northern Europe, New Zealand and Australia that should be cited. The reviewers also noted other issues that are not fully discussed such as the risk of *C. gigas* and other cultivated species invasions to nearby areas, as well as several inaccuracies in the characterization of species as native vs. nonnative.

Water Quality

The water quality reviewer (Wisdom) found the analyses and interpretations of environmental impacts of oyster mariculture on marine water quality to be reasonable and appropriate in most aspects. One area of uncertainty was in the potential effects of chemicals leached from pressure-treated wood used by DBOC for docks and oyster cultivation racks. The reviewer cited National Oceanic and Atmospheric Association (NOAA) Fisheries guidelines for determining effects of chromate copper arsenate (CCA) leachate on juvenile coho salmon, which are known to be particularly sensitive to low levels of copper. The reviewer stated that the analysis does not provide sufficient detail to determine potential effects on this species.

Soundscapes

The soundscape reviewer (Clark) found the scientific interpretations and analyses in the DEIS to be reasonable and adherent to standard techniques and metrics. The reviewer noted several aspects that may require further examination, such as whether human noise footprints from DBOC activities have increased since 1995 when one of the two cited data sets was collected, as well as a working assumption related to nighttime versus daytime background sound levels and propagation that does not include supporting information.

Socioeconomics

The socioeconomics reviewer (Wilen) found that the methods used to conduct the economic assessment do not follow accepted economic impact analysis practice and the data required to conduct such an analysis (e.g., measures of value of gross sales, cost of labor and other materials for DBOC) missing from the DEIS. Economic impacts are assessed using qualitative judgments instead of quantitative measurements, leading to "unsubstantiated inferences and interpretations of impacts that are difficult to judge reasonable" (Appendix B).

3.2 Question 2: Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.

Marine Estuarine Ecology and Coastal Zone Management

The reviewers noted several exceptions where conclusions were not reasonable and/or scientifically sound, or other conclusions may be drawn. Both reviewers disagreed with the conclusion "Recreational take of clams would not interfere with preservation of wilderness characteristics in Drakes Estero," stating that recreational clamming causes significant disturbance to benthic habitats and eelgrass through digging and/or raking sediment. The reviewers also point out several instances where statements are made or alluded to without sufficient supporting information. For example, Padilla noted that positive effects of oyster culture on eelgrass (Zostra marina) are alluded to; however, there are no data to support this idea. She also stated that the DEIS assumes that the expansion of aquaculture activity will increase loss of eelgrass in linear fashion, but there are no data supporting that assumption. Grosholz commented that the DEIS states that the source of several species invasions in Drakes Bay was aquaculture, but this is a likelihood argument as the source of the primary invasion is unknown. Finally, Padilla observed that the relative impact of the two oyster culture methods (off-bottom racks versus on-bottom bags) was not consistently applied when assessing the impacts of the alternatives, affecting the DEIS conclusions.

Water Quality

Wisdom stated that the scientific information used in the analysis is adequate and appropriate for the types of disturbances and impacts under evaluation. He noted that alternate conclusions (direct adverse effect versus no direct adverse effect) could have been drawn with regard to the potential impacts of leachates from CCA-treated lumber on juvenile coho salmon. The flushing rate of Drakes Estero is likely to be high enough to dilute concentrations below fish thresholds; however, the amount of wood to be replaced annually exceeds NOAA Fisheries loading rates for coho salmon.

Soundscapes

Clark found the conclusions presented in the DEIS to be reasonable and supported by available data and scientific concepts.

Socioeconomics

As described in Question 1, Wilen found that the DEIS derives qualitative impact assessments with minimal comparative data and undefined criteria, leading to conclusions that are "vague at best, and misleading at worst" (Appendix B). He further noted that the conclusions seem to insinuate that a "small" impact is equivalent to no impact; however, this is a slippery slope because multiple small impacts could be seen as having no collective impact because they were each evaluated in isolation.

3.3 Question 3: Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.

Marine Estuarine Ecology and Coastal Zone Management

Both reviewers commented that the DEIS relies too heavily on unpublished theses that have not produced any peer-reviewed publications and are not generally accessible. The reviewers understood that, in some cases, there are no other studies of the project area to cite, but cautioned that conclusions from these studies should be treated as very preliminary. Also, the DEIS cites general references (i.e., textbook chapters) on ecological roles instead of primary literature on the species of concern.

Water Quality

Aside from the NOAA Fisheries guidance discussed under Question 1, Wisdom found that the DEIS includes and applies the best available science on the impacts of shellfish mariculture on water quality.

Soundscapes

Clark noted that the DEIS provides sufficient scientific information on wildlife dependence on natural soundscapes and the effects of disturbance from anthropogenic noise; however, he mentioned that further studies have been conducted since the DEIS was completed, but he does not include these studies in his review.

Socioeconomics

Wilen stated that the DEIS does not embody the best available science on socioeconomic impacts. Specifically, none of the peer-reviewed literature relevant to economic impact analysis methodology is acknowledged or cited in the DEIS. The DEIS does cite a NPS report (NPS 2011) that uses standard impact analyses to evaluate the importance of tourism, but it does not recognize that these same techniques should be used for analyzing the impacts of the different DBOC SUP alternatives.

3.4 Question 4: Are there any significant peer-reviewed papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.

Marine Estuarine Ecology and Coastal Zone Management

Both reviewers provided several peer-reviewed publications that should be considered by the DEIS. These papers are mostly related to research conducted through the Biogeochemical Reactions in Estuaries (BRIE) project in Tomales Bay and marine bivalve ecology and aquaculture.

Water Quality

The only additional publication suggested for consideration by the DEIS is the NOAA Fisheries guidance described previously.

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Soundscapes

Clark does not suggest any additional peer-reviewed papers for consideration by the DEIS.

Socioeconomics

As noted in Question 3, Wilen observed that there are no peer-reviewed scientific publications referenced in the socioeconomic impact analysis section. He listed several professional journals that regularly publish discussions of economic impact methodology and example studies, and noted that specific economic impact analyses for aquaculture and mariculture operations (e.g., oysters in Chesapeake Bay) are available online for download.

3.5 Question 5: Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

Marine Estuarine Ecology and Coastal Zone Management

The reviewers offered several suggestions for strengthening the scientific foundations. Padilla suggested more attention should be given to the primary literature as described above in Question 3; however, Grosholz stated that given the available data, the DEIS does a reasonably good job discussing both the lessons and the limits of these studies. Grosholz also noted that the DEIS fails to draw conclusions from one cited report (Konzak and Praetzellis 2011) that concludes there is little evidence of the presence of Olympia oysters in early American shell middens. Additionally, Padilla noted the risk of introducing target aquaculture species and facilitating habitat for other unwanted invaders deserve greater attention in the DEIS.

Water Quality

Wisdom concluded that the basic scientific foundation of the DEIS regarding water quality was reasonable and offered three options for strengthening which include the potential for chemicals leaching from CCA-treated lumber to affect juvenile coho salmon, which are presented in Appendix B.

Soundscapes

Clark concluded that the scientific foundation of the DEIS regarding soundscapes is reasonable, but offers a recommendation for strengthening. He suggests that the NPS conduct a "sound source verification" study to document all DBOC noise sources and map their footprints, both individually and cumulatively. Such a study would document changes in the soundscape over time and space within the Point Reyes National Seashore.

Socioeconomics

Based on previous comments regarding the methods used to conduct an economic assessment of the alternatives, Wilen concluded that the scientific foundation of the DEIS does not follow standard practice and as a result it is difficult to determine whether it is reasonable. He presented recommendations to strengthen the economic analysis in Appendix B. He also noted that the relationship and interconnection between visitor days to Point Reyes National Seashore and the DBOC is not analyzed as an economic impact of any of the alternatives and he provides several hypotheses that could be evaluated. Finally, Wilen recommended that the market level impacts of the DBOC component be strengthened by discussing the market and demand elasticities derived from other literature to estimate the quantitative impacts.

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4.0 SUMMARY

In general the reviewers found the DEIS to be well-written with adequate analysis and use of available scientific information. However in the socioeconomic analysis, the reviewer regards the analysis as unreflective of best available scientific information and practice.

Throughout their reviews, the reviewers identify data gaps (that require caution when analyzing), and some additional literature that should be included, as well as some factual errors regarding invasive species. The Atkins Team believes that these comments are well-founded, and that the current best available information supports the reviewers' positions. However, these comments are in general minor, relatively easily rectified, and do not affect the overall quality of the review.

Two reviewers comment on the use of non-peer reviewed literature, such as theses. Such information must be used with appropriate caution; however, the legal standard for any government action is "best available science". Under such circumstances, unpublished materials (theses) may be used, but it is usually wise to approach their use with acknowledged caution, and to seek confirmation from other available sources.

Hence the reviewers found some significant issues that may be addressed in any final EIS. The socioeconomic analysis is the most seriously criticized piece of the DEIS, but also general opinion may differ on the appropriate metrics to use for this issue. To the extent that this is an issue of policy, it falls outside of the scope of this review; moreover, given differing scientific opinion, it is plausible that the NPS analyses in the DEIS may be covered by "agency deference" rulings. However, the reviewers' comments are pertinent and should be given careful consideration in any revisions.

Overall, the reviewers found the analyses to be appropriate, and that there is no fundamental flaw with the larger scientific underpinning of the DEIS. The identified scientific misinterpretations, or lack of citation of appropriate literature are for the most part minor, and can be rectified if the NPS so wishes. This may also include making some additional adjustments to interpretation, and explicit acknowledgement of the lack of information on some key issues.

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6.0 APPENDICES

Appendix A: Reviewer Curricula Vitae

Appendix B: Individual Reviewer Memoranda

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APPENDIX A: REVIEWER CURRICULA VITAE

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CURRICULUM VITAE

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EDUCATION:

1990	University of California, Berkeley, Ph.D. (Zoology)
1982	Brown University, A.B. (Biology)

RESEARCH AND TEACHING INTERESTS:

Interactions of fundamental ecological processes and human impacts on coastal ecosystems; consequences of invasive species and vector management on ecosystem function, human economies and biosecurity; effects of global climate change on coastal systems; restoration and management of estuarine habitats

EMPLOYMENT:

2008-	Professor, Department of Environmental Science and Policy, University of
	California, Davis
2007-	Alexander and Elizabeth Swantz Endowed Specialist in Cooperative
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2006-2007	Specialist in Cooperative Extension, Department of Environmental
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2002-2006	Associate Specialist in Cooperative Extension, Department of
	Environmental Science and Policy, University of California, Davis
1998-2001	Assistant Specialist in Cooperative Extension, Department of
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1996-1998	Assistant Professor, Department of Zoology, University of New
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1993-95	Postdoctoral Fellow, Center for Population Biology, University of
	California, Davis, CA.
1992	Postdoctoral Fellow, Smithsonian Environmental Research Center,
	Edgewater, MD.
1991	Postdoctoral Fellow, Friday Harbor Laboratories, University of
	Washington, Friday Harbor, WA.

PROFESSIONAL MEMBERSHIPS:

American Society of Limnology and Oceanography Ecological Society of America Coastal and Estuarine Research Foundation Western Society of Naturalists

PUBLICATIONS:

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- Grosholz, E. D., P. G. Olin, B. Williams, and R. Tinsman. 2001. Reducing predation on Manila clams by nonindigenous European green crabs. Journal of Shellfish Research 20: 913-919.
- Grosholz, E. D. 2001. Small spatial scale differentiation among populations of an introduced colonial invertebrate. Oecologia 129: 58-64.
- Grosholz, E. D., G. M. Ruiz, C. A. Dean, K. A. Shirley, J. L. Maron, and P. G. Connors. 2000. The impacts of a nonindigenous marine predator in a California bay. Ecology 81: 1206-1224.
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- Grosholz, E. D. and G. M. Ruiz. 1997. Evidence for regional adaptation of Black Band Disease at Carrie Bow Cay, Belize. Proceedings of the 8th International Coral Reef Symposium 1: 579-581.
- Grosholz, E. D., and G. M. Ruiz. 1996. Predicting the impact of introduced marine species: lessons from the multiple invasions of the European green crab. Biological Conservation 78: 59-66.
- Grosholz, E. D. 1996. Contrasting rates of spread for introduced species in terrestrial and marine systems. Ecology 77: 1680-1686.
- Grosholz, E. D. 1996. Diseases, attofoxes, examodels, and zeptodata. Book review: "Ecology of Infectious Diseases" by B.T. Grenfell and A. P. Dobson. Ecology 77: 2577-2578.

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- Grosholz, E. D., and G. M. Ruiz. 1995. The spread and potential impact of the recently introduced European green crab, *Carcinus maenas*, in central California. Marine Biology 122: 239-247.
- Grosholz, E. D., and G. M. Ruiz. 1995. Does spatial heterogeneity and genetic variation in populations of the xanthid crab *Rhithropanopeus harrisii* (Gould) influence the prevalence of an introduced parasitic castrator? Journal of Experimental Marine Biology and Ecology 187: 129-145.
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- Grosholz, E. D. 1993. The influence of habitat heterogeneity on host-pathogen population dynamics. Oecologia 96: 347-353.
- Grosholz, E. D. 1992. Interactions of intraspecific, interspecific, and apparent competition with host-pathogen population dynamics. Ecology 73: 507-514.
- Sousa, W. P. and E. D. Grosholz. 1990. The influence of habitat structure on the transmission of parasites. In: *Habitat Structure: The Physical Arrangement of Objects in Space*, S. S. Bell, E. D. McCoy, and H. R. Mushinsky, editors. Chapman and Hall, London, pp. 300-324.
- Grosholz, E. D. 1990. The population dynamics of terrestrial isopods and an iridescent virus. Ph.D. Thesis. University of California, Berkeley.
- Ching, H. L. and E. D. Grosholz. 1987. Occurrence of the metacercaria of *Parvatrema* obscurum (Gymnophallidae) in the digestive gland of limpets, *Lottia digitalis*. Proc. Helm. Soc. Wash. 53: 104-105.
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GRANTS AWARDED:

- 2010-2014 National Science Foundation. \$1,495,487 (CNH-1009957) Removal and Restoration: Social, Economic and Ecological Dynamics of Invasive *Spartina* in San Francisco Bay. Co-P.I.s A. Hastings, J. Sanchirico, M. Lubell, C. Feldman.
- 2011-2012 Maryland Sea Grant. \$25,060. Importation of Baitworms and their Live Algal Packing Materials to the Mid-Atlantic: Vector Characterization and Management. Co-PI A.W. Miller.
- 2011-2012 California Ocean Science Trust. \$201,178 Invaders for sale: a vector analysis of commercial aquaculture and the aquarium and aquascape Trades. Co-P.I.s E. Grosholz and S. Williams.
- 2009 California Department of Fish and Game. \$23,000. Examination of sublethal impacts of the 2007 Cosco Busan oil spill on the native oyster *Ostrea lurida* in San Francisco Bay. Nutrients and Benthic Invasion Dynamics. Co-P.I.s E. Grosholz and C. Zabin.
- 2008-2009 National Oceanic and Atmospheric Administration and Pacific States Marine Fishery Commission. \$27,313. Green crab control methods: Expanding

capacity to control European Green crab populations in the northeast Pacific. Co-P.I.s E. Grosholz, C. de Rivera (Portland State), G. Ruiz (Smithsonian), M. Sytsma (Portland State).

- 2008-2012 US Fish and Wildlife Service. \$9,775. Master Gardener's prevent aquatic plant invasions through community education and outreach California Sea Grant College Program. C0-P.I.s E. Grosholz and H. Crosson.
- 2008-2009 Association of Bay Area Governments. \$15,000. Subtidal native oyster restoration. Co-P.I.s E. Grosholz and C. Zabin.
- 2008 California Department of Fish and Game. \$7,500. Train the trainer: Master Gardeners prevent aquatic invasive plant introductions through community education and outreach. C-P.I.s E. Grosholz and H. Crosson.
- 2007-2010 CALFED and CA Sea Grant. \$107,696. Nutrients and benthic invasion dynamics. P.I. E. Grosholz.
- 2007-2010 California Sea Grant College Program. \$219,564. Investigating the limits of native oyster recovery and restoration. P.I. E. Grosholz.
- 2006-2008 University of California Exotic/Invasive Pests and Disease Research Program.
 \$102,525. Assessment and control of the impact of non-native oyster drills on the restoration of native oysters. P.I. E. Grosholz.
- 2006-2008 University of California Marine Council. \$225,000. Establishing connectivity of invasive populations: a precursor to prioritization and implementation of eradication efforts. Co-P.I. E. Grosholz, S. Williams, S. Morgan, L. Levin, A. Kuris.
- 2006-2007 National Oceanic and Atmospheric Administration and Pacific States Marine Fishery Commission. \$249,375. Green crab control methods: Evaluating factors important for eradication of *Carcinus maenas*. Co-P.I.s E. Grosholz, C. de Rivera (PSU), G. Ruiz (SERC), M. Sytsma (PSU).
- 2006-2007 California Ocean Protection Council. \$149,827. Documenting the status of Native Oysters in San Francisco Bay, CA. P. I. E. Grosholz
- 2005-2006 Pacific States Marine Fishery Commission. \$32,565. Monitoring the European Green Crab Invasion in California. P.I. E. Grosholz.
- 2004-2005 National Park Service California Cooperative Ecosystem Studies. \$57,150. *Restoration of native oysters in Tomales Bay, California.* P.I. E. Grosholz.
- 2003-2006 University of California Center for Invasive Species Research. \$88,387. Sabellid polychaete detection in native gastropod populations and control at abalone cluture facilities. P.I.'s E. Grosholz and J. Moore.
- 2002-2005 University of California Center for Invasive Species Research. \$115,656. Managing the impacts of the introduced European green crab (Carcinus maenas) in coastal estuaries. P.I., E. Grosholz.
- 2004-2005 California Sea Grant Program. \$9,986. Increasing Graduate Student Participation: Sea Grant Trainee Session at the Western Society of Naturalists (WSN). P.I. E. Grosholz.
- 2004-2005 California Sea Grant Program. \$6,300. International Invasive *Spartina* Conference: Research, Management and Outreach. P.I. E. Grosholz.
- 2003-2006 National Science Foundation IGERT Program. \$2,596,186. Biological invasions: from genes to ecosystems, from science to society. P.I. R.

Grosberg, Co-P.I.s: H. Doremus, K. Rice, S. Strauss, S. Usting, others Collaborators: E. Grosholz and others.

- 2002-2004 National Oceanic and Atmospheric Administration. \$59,998. Community Based Restoration of Native Oysters in Central California. E. Grosholz, P.I.
- 2002-2004 U.S. Fish and Wildlife Service. \$97,545. *Evaluating nonindigenous aquatic species in the Sacramento-San Joaquin river system*. P.I.'s E. Grosholz and P. Moyle.
- 2002-2004 California Department of Fish and Game. \$40,000. *California aquatic nuisances species management plan.* P.I. E. Grosholz.
- 2002-2004 Pacific States Marine Fisheries Commission. \$29,671. *California green crab monitoring program.* P.I., E. Grosholz.
- 2002-2004 CALFED Bay/Delta Program. \$179,783. Reducing the introduction and damage of aquatic nonindigenous species through outreach and education, Part II. P.I. E. Grosholz.
- 2002-2005 CALFED Bay/Delta Program. \$2,521,236. The influence of flood regimes, vegetative and geomorphic structures on the links between aquatic and terrestrial systems. P.I.s J. Quinn, G. Fogg, E. Grosholz, K. T. Paw, M. Schwartz, M. Power (UCB), W. Rainey (UCB), N. Nur (PRBO).
- 2000-2005 National Science Foundation (DEB-0083583). \$3,799,621. Dynamics of an invasive non-native species and its biological, physical, and human impacts: Spartina alterniflora on the Pacific coast. P.I.'s A. Hastings, E. Grosholz, D. Layton, D. Strong, S. Ustin, L. Levin (UCSD), A. Cohen (SFEI).
- 2000-2005 U.S. Environmental Protection Agency EaGLES Program. \$4,118,221.
 Environmental indicators in the estuarine environment research program.
 P.I. S. Anderson, S. Morgan, G. Cherr, R. Nisbet (UCSB), collaborator Edwin Grosholz with others. 3/01/01-2/28/05.
- 2002 California Department of Fish and Game. \$50,002. *Caulerpa taxifolia Outreach*. E. Grosholz, P.I.
- 2002 United States Fish and Wildlife Service. \$10,000. International Caulerpa taxifolia Conference. E. Grosholz, P.I.
- 2002 California Sea Grant College Program. \$9,998. International Caulerpa taxifolia Conference. E. Grosholz, P.I.
- 2000-2002 CALFED Bay /Delta Program. \$556,000. McCormack-Williamson Tract restoration planning, design, and monitoring program I. J. Mount, E. Grosholz, P. Moyle, G. Pasternack, J. Quinn, G. Schladow.
- 1999-2002 CALFED Bay/Delta Program. \$1,946,167. Linked hydrogeomorphicecosystem models to support adaptive management: Cosumnes-Mokelumne paired basin project. P.I.'s J. Mount, E. Grosholz, P. Moyle, J. Quinn, L. Kavvas, G. Fogg, G. Pasternak, G. Schladow, Randy Dahlgren.
- 1999-2001 CALFED Bay/Delta Program. \$105,463. Reducing the risk of importation and distribution of non-native invasive species through outreach and education. P.I. E. Grosholz.
- 1999-2001 California Sea Grant. \$133,642. Post-invasion genetic structure of European green crab populations on the US west coast and its implications for the control. P.I. J. Geller, Co-P.I. E. Grosholz, M. Bagley.
- 1998-2000 United States Department of Agriculture, Hatch Program. \$22,000. The impact of a recently introduced fouling species on commercial oysters. P.I. E. Grosholz.
- 1998-2000 Sea Grant (New Hampshire/Maine)-NOAA Partnership Program. \$28,350. Quantifying the range expansion and ecological impact of the nonindigenous European green crab in western North America. P.I. E. Grosholz.

- 1997-1999 Washington State Sea Grant. \$154,217. Potential impacts of a nonindigenous crab on selected west coast commercial invertebrates. P.I. D. Armstrong, Co-P.I. G. Jensen, E. Grosholz, G. Ruiz, and G. Jamieson.
- 1996-1997 Smithsonian Institution Biodiversity Programs. Caribbean Coral Reef Ecosystems (CCRE). \$1,500. *Climatic and biotic factors influencing the distribution of black band disease at Carrie Bow Cay.* P.I.'s E. Grosholz, G. Ruiz, and A. Hines.
- 1996-1998 United States Department of Agriculture, Hatch Program (NH00385). \$25,000. Predicting the rate of range expansion of introduced species in the Gulf of Maine. P.I. E. Grosholz.
- 1996 National Science Foundation, Research Experience for Undergraduates (REU), Supplement to DEB-9322797, \$5,000.
- 1995 National Science Foundation, Research Experience for Undergraduates (REU) Supplement to DEB-9322797, \$5,000.
- 1994-1996 National Science Foundation, Conservation and Restoration Biology (DEB-9322797). \$185,000. Ecological and evolutionary consequences of the recent introduction of green crabs to the Pacific coast of North America. P.I. E. Grosholz; Co-P.I.'s, D. Hedgecock and G. Ruiz.
- 1994-1995 Smithsonian Institution Biodiversity Programs. Caribbean Coral Reef Ecosystems (CCRE), \$1,500. Assessing the distribution of black band disease at Carrie Bow Cay. P.I.'s E. Grosholz and G. Ruiz.
- 1993-1994 National Science Foundation, Biological Oceanography, Rapid Response (OCE-9400706), \$19,792. Impact of the recently introduced green crab on invertebrate and shorebird populations in Bodega Harbor. P.I. E. Grosholz; Co-P.I. G. Ruiz.
- 1993-1994 California Sea Grant, Rapid Response, \$9,999. Invasion of California estuaries by the non-indigenous green crab Carcinus maenas: Assessment of its impact and geographic spread. P.I. A. Kuris; Co-P.I.'s K. Lafferty, E. Grosholz, and G. Ruiz.
- 1992-1994 National Science Foundation, Postdoctoral Fellowship in Environmental Biology (DEB-9203217), \$69,600. *The influence of dispersal, predation, and spatial complexity on the population dynamics of a plant-vector-pathogen system.* (Awarded, but declined). P.I. P. Kareiva; Co-P.I. E. Grosholz.
- 1988-1990 National Science Foundation, Dissertation Improvement Grant (BSR-8800962), \$6,000. The effects of habitat structure on mortality due to virus infection in field populations of the terrestrial isopod Porcellio scaber. P.I. W. Sousa; Co-P.I. E. Grosholz.

REPORTS AND LIMITED DISTRIBUTION PUBLICATIONS:

- Carlton, J. T., G. M Ruiz, J. E. Byers, F. C. Dobbs, E. D. Grosholz, B. Leung, H. MacIsaac, M. J. Wonham. 2011. Assessing the relationship between propagule pressure and invasion risk in ballast water. Committee on Assessing Numeric Limits for Living Organisms in Ballast Water. Water Science and Technology Board, Division on Earth and Life Studies. The National Academies Press, Washington, D.C., 123 pp.
- Konzak, M., A. Praetzellis, E. D. Grosholz and C. Zabin. 2011. Archaelogy of Ostrea lurida in Drakes Estero, Point Reyes National Seashore. Cooperative Agreement No. H8537070194, Task Agreement No. J8537102387, United States Department of the Interior, National Park Service, Point Reyes National Seashore, Point Reyes Station, CA, 61 pp.

- Zabin, C.J., V. Guerra, E.D. Grosholz, K. Lesyna and J. McGowan. 2011. The Asian kelp *Undaria pinnatifida* in San Francisco and Half Moon bays: extent of current population, and update on removal and outreach efforts to date. Final Report to the San Francisco Regional Water Quality Control Board, 32 pp.
- Grosholz, E. D. and B. Breen. 2010. Estuarine Habitat. In: J. Largier, B. Cheng and K. Higgason, eds. Climate change impacts Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils, 121 pp.
- Grosholz, E. D. 2010. Invasive Species. In: J. Largier, B. Cheng and K. Higgason, eds. Climate change impacts – Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils, 121 pp.
- Zabin, C.J., S. Attoe, E.D. Grosholz. 2010. Shellfish Restoration Goals for San Francisco Bay: Final Report for the Subtidal Goals Committee, 107 pp.
- Tezak, S., K. Reyna, M. Brown, B. Carmen, B. Brostoff, Bowser, B., G. Bennett, R. Camiccia, J. Collins, R. Ferris, E. Grosholz, G. Heistand, D, Kamieniecki, B. Ketcham, B. Mace, T. Moore, C. Morton, N. Nidzieko, G. Page. 2008. Bolinas Lagoon Restoration Ecosystem Project. Gulf of the Farallones National Marine Sanctuary.
- Zabin, C. J., S. Attoe, E. D. Grosholz and C. Coleman-Hulbert. 2009. Shellfish Restoration Goals: Final Report for the Subtidal Goals Committee, 107 pp.
- Kimbro, D. L., S. Phillips and E. D. Grosholz. 2007. Proceedings: Workshop on Alternative Ballast Water Exchange Areas: Physical and Biological Oceanographic Considerations. Pacific States Marine Fisheries Commission, 22 pp.
- Lovell, S., E. Besedin and E. D. Grosholz. 2007. Modeling economic impacts of European green crabs. Selected paper for presentation at the American Agricultural Economics Association Meetings, Portland, OR.
- Grosholz, E. D., H. Crosson and K. Torres. 2006. Chinese (Mandarin) language version of "Introduced Aquatic Plants and Animals Cost Californians Millions! Preventing nonballast water introduction of aquatic pests in the San Francisco Bay-Delta Region. Wall Poster (www.ridnis.ucdavis.edu).
- Grosholz, E. D., H. Crosson and K. Torres. 2006. Chinese language (Cantonese voice, Mandarin subtitles) version The Great Escape: Preventing Aquatic Species Invasions. Video produced by DANR Publications (on DVD) (www.ridnis.ucdavis.edu).
- Grosholz, E. D. and H. Crosson. 2005. Workshop recommendations: aquarium industry strategies for consumer awareness and education about introduced aquatic species (www.ridnis.ucdavis.edu).
- Crosson, H. and E. D. Grosholz. 2005. Workshop recommendations: aquatic horticulture industry strategies for consumer awareness and education about introduced aquatic species (www.ridnis.ucdavis.edu).
- Grosholz, E.D. and H. Crosson. 2005. Invasores de la Bahia. Spanish language printed pamphlet (www.ridnis.ucdavis.edu).
- Crosson, H. and E. D. Grosholz. 2005. English language version of "Introduced Aquatic Plants and Animals Cost Californians Millions!" Preventing non-ballast water introduction of aquatic pests in the San Francisco Bay-Delta Region. Wall Poster (www.ridnis.ucdavis.edu).
- Harris, L., G. Lambert, W. Fields, D. Cadien, J. Chapman, V. Coelho, E. D. Grosholz, B. Becker. 2005. Estuarine and Marine Invertebrates of Tomales Bay. National Park Service http://www.tomalesbaylife.org/checklists.asp.
- Light, T., E. D. Grosholz and P. B. Moyle. 2004. Delta ecological survey (Phase I): nonindigenous aquatic species in the Sacramento-San Joaquin Delta, a Literature Review. Draft final report for agreement # DCN 1113322J011. U.S. Fish and Wildlife Service, Stockton, CA.

- Light, T., E. D. Grosholz and P. B. Moyle. 2004. Introduced aquatic species database for the Sacramento-San Joaquin Delta (database on CD).
- Crosson, H. and Grosholz, E. D. 2003. California Invasive Species Management Plan. Submitted to California Department Fish and Game.
- Mount, J., Kavvas, L., Fogg, G., Florsheim, J. L., Pasternak, G., Dahlgren, R., Moyle, R., Grosholz, E. D. and Quinn, J. 2003. Cosumnes-Mokelumne Paired Basin Project: Linked Hydrogeomorphic-Ecosystem Models to Support Adaptive Management. Published by CALFED Bay-Delta Program (Project #99-N06). (copy included).
- Moyle, P. B. and Grosholz, E. D. 2003. Aquatic Resource Program Report. Published by CALFED Bay-Delta Program (Project #99-N06). (copy included).
- Grosholz, E. D. and E. Gallo. 2003. Aquatic Resource Survey of the Upper Cosumnes and Mokelumne Rivers: Invertebrates. Published by CALFED Bay-Delta Program (Project #99-N06). (copy included).
- Grosholz, E. D. and E. Gallo. 2003. Impact of Seasonal Flooding on Native and Non-Native Species, Cosumnes and Mokelumne Rivers. Published by CALFED Bay-Delta Program (Project #99-N06). (copy included).
- Grosholz, E. D. and E. Gallo. 2003. Floodplain Management to Enhance Primary Productivity and Native Invertebrates. Published by CALFED Bay-Delta Program (Project #99-N06).
- Grosholz, E. D. 2003. Floodplain Management Alternatives for Reduction in Invasive Aquatic Species. Published by CALFED Bay-Delta Program (Project #99-N06).
- Grosholz, E. D. 2003. Long-term Monitoring Recommendations for Aquatic Invertebrates in the Cosumnes and Mokelumne River Basins. Published by CALFED Bay-Delta Program (Project #99-N06).
- Grosholz, E. D. and E. Gallo. 2003. Aquatic Resource Survey of the Lower Mokelumne River and McCormack-Williamson Tract. Published by CALFED Bay-Delta Program.
- Williams, E. and Grosholz, E. D. 2002. *Caulerpa taxifolia* Watch. Watch card (both laminated waterproof and regular) produced by DANR Publications.
- Grosholz, E.D. and E. Williams. 2002. The Great Escape: Preventing Aquatic Species Invasions. Video produced by DANR Publications (on VHS tape).
- Grosholz, E.D. and P. Olin. 2001. Reducing Losses of Manila Clams to the European Green Crab. Funded by California Sea Grant.
- Grosholz, E.D. and E. Williams. 2001. International *Caulerpa taxifolia* Conference Proceedings. Published by California Sea Grant Program (on CD).
- Grosholz, E. D. and G. M. Ruiz. 2000. The impacts of the European green crab *Carcinus maenas* in central California. Dreissena: The Digest of the National Aquatic Nuisance Species Clearing House, Vol. 11(3) pp. 1-6.
- Grosholz, E. D. and G. M. Ruiz. 2000. European Green Crab Management Plan. Draft management plan submitted to the federal inter-agency Aquatic Nuisance Species Task Force, Green Crab Steering Committee.
- Grosholz, E. D. 1999. The Threat of Nonindigenous Aquatic Species to California Agriculture. Supplemental report to the UC Agricultural Issues Center, Exotic Pests and Diseases: Biology, Economics, Public Policy.
- Estelle, R. and E. D. Grosholz. 1999. The effects of introduced marine predators on shorebirds. Contribution to the 1999. National Shorebird Conservation Plan, Manomet Bird Observatory.

FELLOWSHIPS AND AWARDS:

- 2007 Alex and Elizabeth Swantz Endowed Chair in Cooperative Extension, University of California, Davis.
- 1993 Postdoctoral Fellowship, Center for Population Biology, University of California, Davis.
- 1991 Postdoctoral Fellowship, Smithsonian Environmental Research Center, Edgewater, MD.
- 1990 Postdoctoral Fellowship, Friday Harbor Laboratories, University of Washington.
- 1989 Outstanding Student Paper, Pacific Ecology Conference, Oregon Institute of Marine Biology, University of Oregon, Charleston, OR.
- 1989 Outstanding Student Paper, Ecology Section, American Society of Zoologists, Boston, MA.
- 1988 Regents Fellowship of the University of California.
- 1987 Theodore Roosevelt Fund of the American Museum of Natural History.

TEACHING EXPERIENCE:

- 2010 Introduction to Field and Lab Methods, UC Davis
- 2009 REACH IGERT Graduate training core course, UC Davis
- 2007 Marine Conservation Biology, UC Davis
- 2007 Seminar on Algal Biodiversity, UC Davis
- 2005 Marine Conservation Biology, UC Davis
- 2004 Seminar on Diseases in Marine Systems, UC Davis
- 2002 Seminar on Estuarine Ecology, UC Davis
- 2001 Current Issues in Marine Ecology, UC Davis
- 1998Marine Biology, University of New Hampshire
- 1997Marine Biology, University of New Hampshire
- 1997 Conservation Biology, University of New Hampshire
- 1996Marine Biology, University of New Hampshire
- 1996 Marine Ecology, University of New Hampshire
- 1990 Coastal and Marine Field Ecology, University of California, Davis

GRADUATE STUDENTS AND POSTDOCTORAL RESEARCHERS:

Postdoctoral Fellows: Sylvia Yang 2011-present, Chela Zabin 2006-2009 (currently Assistant Project Scientist, UC Davis), Christy Tyler 2002-2006 (currently Assistant Professor, Rochester Institute of Technology), Catherine DeRivera 2002-2005 (currently Associate Professor, Portland State University), Theo Light 2002-2004 (currently Associate Professor, Shippensburg University)

Ph. D. students: Elizabeth Brusati (2004), Anne Randall Hughes (2006), David Kimbro (2008), Andy Chang (2009), Heidi Weiskel (degree expected 2012), Christy Bowles (degree expected 2012), Betsy Wells (degree expected 2012), Brian Cheng (degree expected 2013), Megan Kelso (degree expected 2015)

M.S. students: David Kimbro (2004), Erika Gallo (2006), Anna Deck (2010), Holly Long (degree expected 2012)

INVITED SYMPOSIA AND SEMINARS:

- 2012 Workshop, NOAA Oyster Restoration Metrics, Silver Spring, MD
- 2011 NCEAS Working Group, Climate Change & Invasions, Santa Barbara, CA
- 2011 Symposium, Ecological Society of America, Austin, TX
- 2011 Biology Department, California State University, Long Beach, CA
- 2010 Panelist, Oil Spill Induced Trophic Cascades, Mote Marine, Sarasota, FL
- 2010 Symposium, California and World Oceans, San Francisco, CA
- 2010 Symposium, Western Society of Naturalists, San Diego, CA
- 2010 Biology Department, Humboldt State University, Arcata, CA
- 2009 Keynote Speaker, Maryland Sea Grant Workshop, Annapolis, MD
- 2009 Pacific AAAS Conference, San Francisco, CA
- 2008 Invasive Crab Risk Assessment Workshop, Fisheries & Oceans Canada, Montreal
- 2008 Invasive Green Crab Workshop, Pacific States Marine Fisheries Commission, Vancouver
- 2008 Department of Biology, University of Maryland, College Park, MD
- 2008 School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks
- 2008 School of Fisheries and Ocean Sciences, University of Alaska, Juneau
- 2008 Keynote Speaker, Northern Pacific Marine Science Organization (PICES), Dalian, China
- 2008 Romberg Tiburon Center, San Francisco State University
- 2007 Hadfield Marine Science Center, Oregon State University, Newport, OR
- 2007 Propagule Pressure Invited Session, Ecological Society of America, San Jose, CA
- 2007 COMPASS-Communication Partnership for Science and the Sea, Sacramento, CA
- 2006 Propagule Pressure Workshop, US EPA, Washington, D.C.
- 2006 Keynote Speaker, VI Jornadas Nacionales de Ciencias del Mar, Puerto Madryn, Argentina
- 2006 Panelist, Alternative Ballast Water Exchange Area Workshop, Seattle, WA
- 2005 Keynote Speaker, Associação Brasileira de Oceanografia, Vitoria, Brazil
- 2005 Department of Biology, University of California, Santa Cruz
- 2005 Humboldt Bay Symposium, Arcata, CA
- 2004 Ecological Society of America, Portland, OR
- 2004 3rd International Invasive Spartina Conference, San Francisco, CA
- 2004 American Society of Limnology and Oceanography, Honolulu, HI
- 2004 Pacific Northwest Economic Region Annual Summit, Victoria, BC
- 2003 National Marine Fisheries Service, Seattle, WA
- 2003 UC Davis Invasion Biology Colloquium, Davis, CA
- 2003 Estuarine Research Foundation, Seattle, WA
- 2003 NERR Invasive Monitoring Workshop, Monterey, CA
- 2003 The Nature Conservancy Forum on Invasive Species, San Francisco, CA
- 2003 Gulf of the Farallones Forum on Invasive Species, San Francisco, CA
- 2002 Scripps Institution of Oceanography, La Jolla, CA
- 2002 California and World Oceans Conference, Santa Barbara, CA
- 2002 Ecological Society of America, Tuscon, AZ
- 2001 State of the River Conference, Davis, CA
- 2001 NATO Advance Research Workshop on Invasions in the Mediterranean, Black and Caspian Seas, Baku, Azerbaijan (cancelled)
- 2001 North American Commission for Environmental Cooperation (CEC, US, Canada, Mexico), Montreal, Canada
- 2001 DANR Statewide Conference, UC Riverside, Riverside, CA
- 2000 Department of Biology, Colorado State University
- 2000 Department of Integrative Biology, University of California, Berkeley

- 2000 Symposium Co-Organizer (with John Maron): Ecological Consequences of Adaptive Evolution Among Invasive Species in Terrestrial and Marine Systems. Ecological Society of America, Snowbird, UT.
- 2000 Monterey Bay Aquarium Research Institute (MBARI), Monterey, CA.
- 2000 10th International Invasive Species Conference, Toronto, Canada
- 2000 State of Tomales Bay Conference, Inverness, CA
- 2000 CALFED Bay-Delta Science Conference, Sacramento, CA
- 1999 National Conference on Marine Bioinvasions, Sea Grant/NOAA, Massachusetts Institute of Technology Cambridge, MA
- 1998 Workshop: Controlling Established Populations of Alien Marine Species. Marine Conservation Biology Institute, Seattle, WA
- 1998 Symposium: The Multitrophic Level Impacts of the European Green Crab in Central California. Eighth International Zebra Mussel and Aquatic Nuisance Species Conference, Sacramento, CA
- 1998 Workshop: Exotics of the North Sea, Biologische Anstalt Helgoland, Wattenmeerstation Sylt, List/Sylt, Germany
- 1998 Symposium: The Range Expansion and Ecological Impacts of the European Green Crab in California. Workshop on the Potential Impacts of Green Crabs in the Pacific Northwest. Washington and Oregon Seagrant Programs, Portland, OR
- 1998 Department of Biology, Bowdoin College
- 1998 Department of Biologie, Universitie Laval, Montreal, Canada
- 1997 Symposium: The European Shore Crab (Carcinus maenas) in Australian waters. Workshop on Impacts and Management Options Commonwealth Scientific and Industrial Research Organization (CSIRO), Hobart, Tasmania
- 1997 Symposium Organizer: The Impact of Introduced Species in Aquatic, Terrestrial, and Marine Systems. Society for Conservation Biology, Victoria, Canada
- 1997 Symposium: Effects of Multiple Stressors on Freshwater and Marine Ecosystems. American Society of Limnology and Oceanography, Santa Fe, NM
- 1997 Symposium: Nonindigenous Species: Invasion Patterns, Ecosystem Impact, and Management. American Society of Limnology and Oceanography, Santa Fe, NM
- 1997 Symposium: Marine Biological Invasions: Patterns, Processes, and Prospects. American Association for the Advancement of Sciences, Seattle, WA
- 1996 Symposium: Marine and Coastal Aquatic Nuisance Species, Aquatic Nuisance Species Task Force, National Oceanic and Atmospheric Administration (NOAA) and U. S. Fish and Wildlife Service (FWS), Newark, CA
- 1996 Symposium: Non-indigenous Species Workshop. NOAA-California Sea Grant Program, Millbrae, CA
- 1996 Department of Zoology, University of Rhode Island
- 1996 Department of Ecology and Evolutionary Biology, Brown University
- 1996 Symposium: Research in Support of Sanctuaries and Reserves. American Association for the Advancement of Sciences, Pacific Division, Monterey, CA
- 1995 Department of Zoology, University of New Hampshire, Durham
- 1995 Department of Biology, Northeastern University, Boston
- 1995 Department of Biology, University of California, Los Angeles
- 1994 Department of Biology, California State University, Sonoma
- 1994 Symposium: American Association for the Advancement of Sciences, Pacific Division, San Francisco, CA
- 1994 USDA Invasion Biology Workshop, University of California, Davis, CA
- 1994 Department of Zoology, University of Texas, Austin
- 1993 Department of Ecology and Evolutionary Biology, Brown University, Providence, RI
- 1992 Department of Biological Sciences, University of Michigan, Ann Arbor
- 1990 Center for Population Biology, University of California, Davis

1990 Symposium Co-organizer (with Greg Dwyer): Experimental Approaches to Host-Parasite Population Dynamics. Ecological Society of America, Snowbird, UT

CONTRIBUTED PRESENTATIONS:

- 2011 7th International Marine Bioinvasions Conference, Barcelona, Spain
- 2011 Dreissenid Mussel Summit, Sacramento, CA
- 2010 International Conference on Aquatic Invasive Species, San Diego, CA
- 2009 Ecological Society of America, Albuquerque, NM
- 2009 6th International Marine Bioinvasions Conference, Portland, OR
- 2009 California Estuarine Research Society, Bodega Bay, CA
- 2008 American Geophysical Union, San Francisco, CA
- 2008 Ecological Society of America, Milwaukee, WI
- 2008 Western Society of Naturalists, Vancouver, Canada
- 2007 5th International Marine Bioinvasions Conference, Cambridge, MA
- 2007 California Estuarine Research Society, Bodega Bay, CA
- 2007 West Coast Native Oyster Restoration Workshop, Shelton, WA
- 2006 Western Society of Naturalists, Redmond, WA
- 2006 National Shellfisheries Association, Monterey, CA
- 2006 Ecological Society of America, Memphis, TN
- 2005 4th International Marine Bioinvasions Conference, Wellington, New Zealand
- 2005 Western Society of Naturalists, Monterey, CA
- 2005 Ecological Society of America, Montreal, Canada
- 2004 Western Society of Naturalists, Rohnert Park, CA
- 2004 CALFED Science Conference, Sacramento, CA
- 2003 3rd International Marine Bioinvasions Conference, La Jolla, CA
- 2003 Ecological Society of America, Savannah, GA
- 2003 Western Society of Naturalists, Long Beach, CA
- 2003 American Geophysical Union, San Francisco, CA
- 2003 CALFED Science Conference, Sacramento, CA
- 2002 Western Society of Naturalists, Monterey, CA
- 2002 Bodega Marine Laboratory, Bodega Bay, CA
- 2002 11th International Conference on Aquatic Invasive Species, Alexandria, VA
- 2001 Western Society of Naturalists, Ventura, CA
- 2001 2nd International Marine Bioinvasions Conference, New Orleans, LA
- 2000 CALFED Bay-Delta Science Conference, Sacramento, CA
- 1999 1st International Marine Bioinvasions Conference, MIT, Cambridge, MA
- 1999 Society for Integrative and Comparative Biology, Denver, MA
- 1997 Society for Integrative and Comparative Biology, Boston, MA0
- 1996 Ecological Society of America, Providence, RI.
- 1996 8th International Coral Reef Symposium, Smithsonian Tropical Research Institute, Panama City, Panama
- 1996 Benthic Ecology Society, Columbia, SC
- 1995 Society for Conservation Biology, Ft. Collins, CO
- 1994 Ecological Society of America, Knoxville, TN
- 1993 Ecological Society of America, Madison, WI
- 1993 Society for the Study of Evolution and American Society of Naturalists, Salt Lake City, UT

- 1992 Society for the Study of Evolution and American Society of Naturalists, Berkeley, CA
- 1992 Benthic Ecology Society, Newport, RI
- 1991 Western Society of Naturalists, University of California, Santa Barbara, CA
- 1991 Society for the Study of Evolution and the American Society of Naturalists, University of Hawaii, Hilo, HI
- 1991 Ecological Society of America, San Antonio, TX
- 1989 Ecological Society of America, Toronto, Ontario, Canada
- 1989 American Society of Zoologists, Boston, MA
- 1989 Pacific Ecology Conference, O.I.M.B., University of Oregon, Charleston, OR
- 1988 American Society of Zoologists, San Francisco, CA
- 1988 Ecological Society of America, UC Davis, Davis, CA
- 1987 Southwest Population Biology Conference, UC California James Reserve, Mt. San Jacinto, CA

EDITORIAL SERVICE:

Associate Editor: Frontiers in Ecology and the Environment (2005-present) Associate Editor: Ecology (2007-present)

Reviewer for: American Naturalist, Austral Ecology, Biological Conservation, Biological Invasions, Bioscience, Conservation Biology, Ecology, Ecology Letters, Ecological Applications, Frontiers in Ecology and the Environment, Invasion Biology, Journal of Experimental Marine Biology and Ecology, Estuaries, Journal of the Marine Biological Association of the U. K., Journal of Shellfish Research, Marine and Freshwater Research, Limnology and Oceanography, Marine Biology, Marine Ecology-Progress Series, National Science Foundation, National Environment Research Council (UK), Oecologia, Oikos, Proceedings of the National Academy of Sciences, Science, Trends in Ecology and Evolution, National Research Council (NAS), National Sciences and Engineering Research Council (Canada), various state Sea Grant programs

UNIVERSITY AND PROFESSIONAL SERVICE:

2011	San Francisco Bay Marine Life Protection Act Working Group
2010-2011	Member, Endemic/Invasive Pest & Disease SI Panel, UCD/SR
2009-2011	Member, San Francisco Bay Native Oyster Working Group
2009-2011	Chair of Admissions, Graduate Group in Ecology, UC Davis
2009-2011	Member, Graduate Group in Ecology Executive Committee, UCD
2009-2011	Member, SF Bay Subtidal Goals Working Group
2009-2011	Member, Merton Love Awards Committee, UC Davis
2009-2010	Committee Member, National Academy of Sciences, Committee
	On Assessing Numeric Limits for Living Organisms in Ballast
2009	Review Committee Member, NSERC Network on Aquatic Invasive
	Species
2008-2009	REACH IGERT Graduate Admissions Committee, UCD
2008-2009	Member, Bodega Marine Lab Nonindigenous Species Committee
2006-2012	Member, Pacific Rim Research Program Faculty Committee
2007-2010	Member, CAES Executive Committee, UC Davis

2007-2009	Co-Chair, San Francisco Bay Native Oyster Working Group
2007-2009	Member, NOAA San Francisco Bay Subtidal Goals Committees
2007-2008	Bolinas Lagoon Restoration Working Group
2007	Member, Search Committee, Global Change Informatics
2006-2007	Member, West Coast Native Oyster Restoration Conference Committee
2006	Member, Search Committee, Biogeochemical Modeler
2006-2007	Co-Chair. UC Office of the President Marine Invasive Species Council
2006-2008	Member, Grant Panel Review Committee, UC Pacific Rim Foundation
2004-2007	Member, Grant Review Committee, UC Center for Invasive Species
2003-2007	Member, Steering Committee, UC Davis IGERT Graduate Training Grant
2003	University of California External Review Committee for California Sea
	Grant Program
2003	Member, Search Committee for faculty position in Marine Ecology
2002-2006	Co-Chair, Coastal Committee of the Western Regional Panel of the
	Federal Aquatic Nuisance Species Task Force
2000-2007	Member, Green Crab Control Committee of the Federal Aquatic Nuisance
	Species Task Force (ANSTF)
2000-2005	Member, Southern California Caulerpa Action Team (SCCAT)
2000-2007	Co-Chair, Coastal and Marine Resources Workgroup, Division of
	Agriculture and Natural Resources, UC Davis
2002-2006	Advisor, Marine Ecology Area of Emphasis, Graduate Group in Ecology,
	UC Davis
2000-2001	Chair, Marine Ecology Area of Emphasis, Graduate Group in Ecology,
	UC Davis
2000-2001	Member, Joint NSF-NIH Grant Panel: Ecology of Infectious Diseases
2000-2001	Member, Non-native Invasive Species Strategic Planning and
	Implementation Committee, CALFED Bay-Delta Program
2000-2001	Member, Mitten Crab Project Work Team, San Francisco Bay Inter-
	Agency Ecological Program
2000	Committee Member, Search for Business Office Staff, Department of
	Environmental Science and Policy, UC Davis
1999-2000	Co-Chair, Public Affairs Committee, Division of Ecology and Evolution
	Division, Society for Integrative and Comparative Biology, (formerly
	ASZ)
1998-99	Co-Chair, Public Affairs Committee, Division of Ecology and Evolution
	Division, Society for Integrative and Comparative Biology, (formerly
	ASZ)
1997-98	Committee Member, Diving Control Board, University of New Hampshire
1997-99	Committee Member, Computer Advisory Committee, College of Life
	Sciences and Agriculture, University of New Hampshire
1997-98	Committee Member, Hubbard Marine Program Endowment Education
	Committee, University of New Hampshire
1997	Chair, Graduate Admissions Committee, Department of Zoology,
100 5	University of New Hampshire
1996	Volunteer Grant Consultant, Kreesge Foundation Project, Audubon
	Society of New Hampshire, Concord, NH

1996	Committee Member, Search for Associate Director of the Shoals Marine
	Laboratory, Cornell University and Department of Zoology, University of
	New Hampshire
1996	Committee Member, Zoology Department, Planning Committee for
	Hubbard Chair and Future Positions, University of New Hampshire
1996	Committee Member, Hubbard Marine Program Endowment Review
	Panel, University of New Hampshire
1995-97	Public Affairs Committee Representative, Division of Ecology and
	Evolution, Society for Integrative and Comparative Biology, (formerly
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CURRICULUM VITAE

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PRESENT POSITION

Professor, Department of Ecology and Evolution, State University of New York at Stony Brook, 2006 - Present, Associate Professor 1998 - 2006

Joint Professor, Marine Sciences Research Center, State University of New York at Stony Brook, 2006 - Present, Adjunct Associate Professor 1999 - 2006

PREVIOUS POSITIONS

Associate Professor, Department of Zoology University of Wisconsin-Madison, 1996-1998

- Assistant Professor, Department of Zoology, University of Wisconsin-Madison, September 1989-1996.
- Member Oceanography and Limnology Graduate Program, University of Wisconsin-Madison, 1989-1998.
- Program Director, Integrative Organismal Systems, Biology, National Science Foundation, 2006–2007.

EDUCATION

Postdoctoral 1987-89, Cornell University, Ithaca, NY

- PhD Zoology 1987, The University of Alberta, Edmonton
- MS Zoology 1982 Oregon State University, Corvallis
- BA Zoology 1978 University of Washington, Seattle
- BA Biological Oceanography 1978 University of Washington, Seattle

PUBLICATIONS

- Dianna K. Padilla. 1984. The importance of form: differences in competitive ability, resistance to consumers and environmental stress in an assemblage of coralline algae. J. Exp. Mar. Biol. Ecol. 79: 105-127.
- Dianna K. Padilla. 1985. Structural resistance of algae to herbivores. A biomechanical approach. Marine Biology 90: 103-109.
- John F. Addicott, J. M. Aho, Michael Antolin, Dianna K. Padilla, John S. Richardson, and Daniel A. Soluk. 1987. Ecological neighborhoods: scaling environmental patterns. Oikos 49: 340-346.
- Dianna K. Padilla. 1989. Algal structural defenses: form and calcification in resistance to tropical limpets. Ecology 70: 835-842.
- C. Drew Harvell and Dianna K. Padilla. 1990. Inducible morphology, heterochrony and size hierarchies in a colonial invertebrate monoculture. Proc. Natl. Acad. Sci. U.S.A. 87: 508-512.
- Charles W. Ramcharan, Dianna K. Padilla, and Stanley I. Dodson. 1992. A multivariate model for predicting population fluctuations of *Dreissena polymorpha* in North American lakes. Can. J. Fish. Aquat. Sci. 49(1): 150-158.

- Charles W. Ramcharan, Dianna K. Padilla, and Stanley I. Dodson. 1992. Models to predict potential occurrence and density of the zebra mussel, *Dreissena polymorpha*. Can. J. Fish. Aquat. Sci. 49(12): 2611-2620.
- Dianna K. Padilla. 1993. Rip stop in marine algae: minimizing the consequences of herbivore damage. Evolutionary Ecology 7: 634-644.
- Michael A. Koutnik and Dianna K. Padilla. 1994. Predicting the spatial distribution of *Dreissena polymorpha* (zebra mussel) among inland lakes of Wisconsin: modeling with a GIS. Can. J. Fish. Aquat. Sci. 51:1189-1196.
- Dianna K. Padilla, Stephen C. Adolph, Kathryn L. Cottingham, and Daniel W. Schneider. 1996. Predicting the consequences of dreissenid mussels on a pelagic food web. Ecological Modelling 85:129-144.
- Dianna K. Padilla and Stephen C. Adolph. 1996. Plastic inducible morphologies are not always adaptive: the importance of time delays in a stochastic environment. Evolutionary Ecology 10:105-117.
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- Dianna K. Padilla, Dawn E. Dittman, Jeffery Franz and Rebecca Sladek. 1996. Radular production rates in two species of *Lacuna* Turton (Gastropoda:Littorinidae). Journal of Molluscan Studies 62: 275-280.
- Ladd E. Johnson and Dianna K. Padilla. 1996. Geographic spread of exotic species: ecological lessons and opportunities from the invasion of the zebra mussel, *Dreissena polymorpha*. Biological Conservation 78:23-33.
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- Alexander Y. Karatayev, Lyubov E. Burlakova, and Dianna K. Padilla. 1997. The effects of *Dreissena polymorpha* (Pallas) invasion on aquatic communities in eastern Europe. Journal of Shellfish Research 16: 187-203.
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- Curt L. Elderkin, Daniel W. Schneider, James A. Stoeckel, and Dianna K. Padilla. 1998. A method for measuring in situ oxygen consumption rates of freshwater gastropods. Journal of the North American Benthological Society, 17: (3) 338-347.
- Lucy A. J. Buchan and Dianna K. Padilla. 1999 Estimating the probability of long-distance overland dispersal of invading aquatic species. Ecological Applications 9:254-265.
- Dianna K. Padilla and Bengt J. Allen. 2000. Paradigm lost: Reconsidering functional form and group hypotheses in marine ecology. Journal of Experimental Marine Biology and Ecology. 250:207-221.
- Lucy A. J. Buchan and Dianna K. Padilla. 2000. Predicting the likelihood of Eurasian
watermilfoil presence in lakes, macrophyte monitoring tool. Ecological Applications. 10: 1442-1455.

- Tara Reed-Anderson, Steven Carpenter, Dianna K. Padilla, and Richard Lathrop. 2000. Predicted impact of zebra mussel (*Dreissena polymorpha*) invasion on water clarity in Lake Mendota. Canadian Journal of Fisheries and Aquatic Science. 58:1617-1628.
- Lyubov E. Burlakova, Alexander Y. Karatayev, and Dianna K. Padilla. 2000. The impact of *Dreissena polymorpha* (Pallas) invasion on unionid bivalves. International Journal of Hydrobiology. 85:529-541.
- Dianna K. Padilla. 2001. Food and environmental cues trigger an inducible offense. Evolutionary Ecology Research. 3:15-25.
- Dawn E. Dittman, Susan E. Ford and Dianna K. Padilla. 2001 Effects of *Perkinsus marinus* on Reproduction and Condition of the Eastern Oyster, *Crassostrea virginica*, depend on timing. Journal of Shellfish Research 20 (3):1025-1034.
- Clifford E. Kraft, Patrick J. Sullivan, Alexander Y. Karatayev, Lyubov E. Burlakova, Jeffrey C. Nekola, Ladd E. Johnson, and Dianna K. Padilla. 2002. Landscape patterns of an aquatic invader: assessing dispersal extent from spatial distributions. Ecological Applications 12:749-759.
- Alexander Y. Karatayev, Lyubov E. Burlakova, Dianna K. Padilla. 2002. The impact of zebra mussels on aquatic communities and their role as ecosystem engineers. IN: Invasive aquatic species of Europe: distributions, impacts and management. Eds: Erkki Leppäkoski (Finland), Sergej Olenin (Lithuania) and Stephan Gollasch (Germany), Kluwer Scientific Publishers.
- Daniel W. Schneider, James A. Stoeckel, Chris R. Rehmann, K. Douglas Blodgett, Richard E. Sparks, Dianna K. Padilla. 2003. A developmental bottleneck in dispersing larvae: implications for spatial population dynamics Ecology Letters 6: 352-360.
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- Dianna K. Padilla and Susan L. Williams. 2004. Beyond ballast water: aquarium and ornamental trades as sources of invasive species in aquatic ecosystems. Frontiers in Ecology and the Environment. 2:131-138.
- Dianna K. Padilla 2004. Form and function of radular teeth of herbivorous molluscs: Focus on the future. American Malacological Bulletin 18: 163-168.
- Shirley M. Baker, Dianna K. Padilla. 2004. New Frontiers in the functional morphology of molluscs - A tribute to Drs. Vera Fretter and Ruth Turner. American Malacological Bulletin18: 121-127.
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- Jessica Gurevitch and Dianna K. Padilla. 2004 Response to Ricciardi. Assessing species invasions as a cause of extinction. Trends in Ecology and Evolution. 19:620.

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- Alexander Y. Karatayev, Demitri Botolvskoy, Dianna K. Padilla, and Lyubov E. Burlakova. 2007 The invasive bivalves *Dreissena polymorpha* and *Limnoperna fortunei*: parallels, contrasts, potential spread and invasion impacts. Journal of Shellfish Research. 26: 205-213.

- Michael H. Doall, Dianna K. Padilla, Carl P. Lobue, Christopher Clapp, Anna R. Webb and Jesse Hornstein. 2008. Evaluating northern quahog (hard clam, *Mercenaria mercenaria* L.) restoration: are transplanted clams spawning and reconditioning? Journal of Shellfish Research 27:1069-1080.
- Laurie L. Perino, Dianna K. Padilla and Michael H. Doall. 2008. Testing the accuracy of morphological identification of northern quahog larvae. Journal of Shellfish Research 27:1081-1085.
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- Lyubov E. Burlakova, Alexander Y. Karatayev, Dianna K. Padilla, Leah D. Cartwright and David N. Hollas. 2009. Wetland restoration and invasive species: apple snail (*Pomacea insularum*) feeding on native and invasive aquatic plants. Restoration Ecology 17: 433-440.
- Alexander Y. Karatayev, Lyubov E. Burlakova and Dianna K. Padilla. 2010. Dreissena polymorpha in Belarus: history of spread, population biology, and ecosystem impacts. In: The Zebra Mussels in Europe (G. van der Velde, S. Rajagopal and A. bij de Vaate, eds.). Margraf Publishers, Netherlands.
- Kurt Schwenk, Dianna K. Padilla, George S. Bakken and Robert J. Full (shared first authorship). 2009. Grand challenges in organismal biology. Integrative and Comparative Biology. 49:7-14.
- Alexander Y. Karatayev, Lyubov E. Burlakova, Dianna K. Padilla, Sergey E Mastitsky and Sergej Olenin. 2009. Invaders are not a random selection of species. Biological Invasions 11 SI: 2009-2019.
- Michael H. Doall, Dianna K. Padilla, and Carl P. Lobue. 2009. Factors impacting condition and spawning of the northern quahog (*Mercenaria mercenaria*): implications for restoration. Journal of Shellfish Research 28:693-693 (2nd most downloaded paper in 2009).
- Lyubov E. Burlakova, Dianna K. Padilla, Alexander Y. Karatayev, David N. Hollas, Leah D. Cartwright and Kevin D. Nichol. 2010. Differences in population dynamics and potential impacts of a freshwater invader driven by temporal habitat stability. Biological Invasions 12: 927-941.
- Dianna K. Padilla. 2010. Context-dependent impacts of a non-native ecosystem engineer, the Pacific oyster *Crassostrea gigas*. Integrative and Comparative Biology 50: 213-225.
- Gene Robinson*, Jody Banks*, Dianna K Padilla* (*shared first author), Warren W. Burggren,
 C. Sarah Cohen, Charles F Delwiche, Vicki Funk, Hopi E Hoekstra, Erich D Jarvis, Loretta
 Johnson, Mark Q Martindale, Carlos Martinez del Rio CM (del Rio, Monica, David E Salt,
 Saurabh Sinha, Chelsea Specht, Kevin Strange, Joan E Strassmann, Billie J Swalla, Lars
 Tomanek. 2010. Empowering 21st Century Biology. Bioscience 60: 923-930.
- Brian Tsukimura, Hanna V Carey, Dianna K Padilla. 2010. Workshop on the Implementation of the Grand Challenges. Integrative And Comparative Biology 50: 945-947.
- Jonathon H. Stillman, Mark Denny, Dianna K. Padilla, Marvalee H. Wake, Sheila Patek and Brian Tsukimura. 2011. Grand Opportunities: Strategies for addressing grand challenges in organismal animal biology. Integrative and Comparative Biology 51:7-13.
- Alexander Y. Karatayev, Sergey E.Mastitsky, Dianna K.Padilla, Lyubov E.Burlakova and

Marissa M. Hajduk. 2011. Differences in growth and survivorship of zebra and quagga mussels: size matters. Hydrobiologia 668:183-194.

- Alexander Y. Karatayev, Lyubov E.Burlakova, Sergey E.Mastitsky, Dianna K.Padilla and Edward L Mills 2011. Contrasting rates of spread of two congeners, *Dreissena polymorpha* and *Dreissena rostriformis bugensis*, at different spatial scales. Journal Of Shellfish Research 30:923-931.
- Dianna K Padilla, Michael J McCann, Sandra E Shumway. 2011. Marine invaders and bivalve aquaculture: sources, impacts and consequences. In: Shellfish Aquaculture and the Environment, SE Shumway, editor. Wiley Blackwell.
- Alexander Y. Karatayev, Lyubov E. Burlakova and Dianna K. Padilla. 2012. General overview of zebra and quagga mussels: what we know and do not know. In T. F. Nalepa and D. W. Schloesser [eds] Quagga and Zebra Mussels: Biology, Impacts, and Control. 2nd Edition. CRC Press, Boca Raton, FL. (accepted).
- Islay D. Marsden, Sandra E. Shumway and Dianna K. Padilla. 2012. Does size matter? The effects of body size and declining oxygen tension on oxygen uptake in gastropods. Journal of the Marine Biological Association of the United Kingdom doi:10.1017/S0025315411001512.

GRANTS

- University of Wisconsin Graduate School Research Award, July 1990 June 1991, (\$21,625) "Evolutionary consequences of radular variability in an herbivorous snail."
- NOAA Sea Grant Institute 1990 (\$10,918) "Monitoring and Disseminating Information on the Spread of Zebra Mussels in the Upper Great Lakes -- Northern Lake Michigan Sites". To A. Miller, D.K. Padilla and S.I. Dodson.
- NOAA Sea Grant Institute 1990-1991 (\$38,724) "Monitoring and Disseminating Information on the Spread of Zebra Mussels in the Upper Great Lakes -- Northern Lake Michigan Sites". To A. Miller, D.K. Padilla and S.I. Dodson.
- NSF September 1990- September 1992; BSR-9009070 (\$12,000) "RPG: Radular Variability in the Herbivorous Gastropod Lacuna".
- University of Wisconsin Graduate School Research Award, July 1991 June 1992, (\$18,888) "Ecological and evolutionary consequences of variable radular morphology in the herbivorous snail Lacuna".
- NSF 1991 (June 1991 September 1992; REU Supplement to BSR-9009070, \$10,000) "Ecological and evolutionary consequences of radular variability".
- NOAA 1991 94 (\$196,530; NA16RG0531-01) "Exotic species invasions: population dynamics and community consequences of the zebra mussel, Dreissena polymorpha".
- University of Wisconsin Graduate School Research Award, July 1992 June 1993 (\$17,865) "Radular variability and functional morphology in the herbivorous gastropod Lacuna: a phylogenetic approach."
- University of Wisconsin Graduate School Research Award, July 1993 June 1994 (\$18,000) "Radular variability and functional morphology in the herbivorous gastropod Lacuna: a phylogenetic approach."
- University of Wisconsin Graduate School Research Award, July 1994 June 1995 (\$17,000) "Exotic species invasions: Ecological consequences and spread of aquatic Invaders across a landscape."
- NSF 1994 1997 (\$210,000; IBN-9317293) "Functional and evolutionary analysis of an

inducible, phenotypically plastic feeding morphology."

- NOAA 1994 97 (\$169,210; NA46RG0481); "Population and energetic consequences of zebra mussel fouling on native gastropod fauna of Lake Michigan. To: Dianna K. Padilla, J. Ellen Marsden, Daniel Schneider.
- NSF 1995 (\$5,000; May 1995 December 1995; REU Supplement to IBN-9317293) "Functional and evolutionary analysis of an inducible, phenotypically plastic feeding morphology."
- University of Wisconsin Graduate School Research Award, July 1995 June 1996 (\$17,000) "Exotic species invasions: Ecological consequences and spread of aquatic Invaders across a landscape."
- NOAA 1995 97 (\$108,814; R/LR-65) "Facilitation of exotic species information exchange between North America and the former Soviet Union."
- NSERC 1995 1998 (\$330,000 Collaborative Project Grant); AEvolutionary Ecology of Exotic Species Introductions into the Great Lakes.@ To: E.G. Boulding, P.D.N. Hebert, P. Yodzis, G. Sprules, J. Havel, and D.K. Padilla).
- NSF 1999-02 (\$210,000; DBI-9977377), AMRI: Acquisition of Instrumentation for Research and Training in Functional Ecology.@, To: D. K. Padilla and M. Lerdau.
- NSF 1999-02 (\$270,000 + REU supplements \$13,100, IBN-994594), AFunctional and Evolutionary Ecology Of A Phenotypically Plastic Feeding Morphology@.
- NOAA/SeaGrant 1999-01 (\$250,000) AResearch and Outreach to Prevent and Control Aquatic Nuisance Species Invasions: The Role of Larval Growth, Mortality and Transport in Metapopulation Dynamics and Control of the Zebra Mussel in Freshwater and Estuarine Systems. To: D.K. Padilla, D.W. Schneider, R. Sparks, and C. Rehmann.
- NOAA/Illinois-Indiana Sea Grant College Program 2000-2002 (\$96,371)"Predicting zebra mussel transport in rivers and estuaries" To: C. R. Rehmann, D. K. Padilla, D.W. Schneider.
- NSF 2000 (\$11,000; IBN-9983235) "WORKSHOP: Increasing Minority Involvement In Integrative and Comparative Biology, to be held at the annual meeting of SICB, Atlanta, Georgia, January 4_8, 2000." To: D.K. Padilla, F. Thomas.
- NSF 2000 (\$4,500; IBN-9982794) ASICB Symposium: New Approaches to the Study of Marine Plant-Animal Interactions@. To: D.K. Padilla and K.L. VanAlstyne.
- NSF 2001 (\$5,950, IBN-0090902; Funding split between IBN and IAB) "World Congress of Malacology Symposium: New Frontiers in Functional Morphology of Molluscs." To: D.K. Padilla and S. Baker.
- NOAA/SeaGrant 2002-2004 (\$300,000) Aquatic Nuisance Species. Metapopulation Dynamics and Control of the Zebra Mussel in Freshwater and Estuarine Systems: The Effects of Hydrodynamics, Larval Supply, and Embayments. To: D.K. Padilla, D.W. Schneider, and C. Rehmann.
- NOAA/SeaGrant 2003-2006 (\$267,318) Aquatic Nuisance Species Research Program: Biological Invasion of Marine Reserves by Aquatic Nuisance Species. To: Terrie Klinger and Dianna Padilla.
- Nature Conservancy 2004-2005 (\$67,400) Gonad production, condition index and larval production in hard clam spawners sanctuaries. To: Dianna Padilla and Michael Doall.
- NY Sea Grant 2004-2005 (\$49,655) The effects of brown tide and plankton quality on hard clam larval growth and survivorship. To: Dianna Padilla and Christopher Gobler.

Army Corp of Engineers (\$15,000) Modeling aquatic invaders. To: Dianna K. Padilla.

Nature Conservancy 2005 (\$12,385). Larval production in hard clam spawners sanctuaries. To: Dianna K. Padilla.

- NSF 2009 2012 (\$573,096). IOS-0920032 9/11-9/14 Phenotypic Plasticity in Feeding: Ontogenetic Solutions to Scaling Limitations. To: Dianna K. Padilla, Sandra Shumway, J. Evan Ward.
- Nature Conservancy 2010 (\$2,651). Predation Rates on Hard Clams by Channeled and Knobbed Whelk. To: Dianna K. Padilla.

AWARDS AND FELLOWSHIPS

Elise B. Newell Distinguished Lecture, Florida Sea Grant, U. Florida, 1999

Aldo Leopold Leadership Fellow in Conservation, ESA 2000 - 2002

Elise B. Newell Distinguished Lecture, Florida Sea Grant, Florida State U. 2001

Elise B. Newell Distinguished Lecture, Florida Sea Grant, U. Central Florida. 2002

Bodega Marine Laboratory Distinguished Research Fellow, 2002

Center Fellowship, National Center for Ecological Analysis and Synthesis, 2005

2009 Hispanic Heritage Month Latino Faculty Recognition Award

NATIONAL SERVICE

Panel Member, NSF Minority Postdoc Awards, 1995, 1996, 1997

Panel Member, NSF Ecological and Evolutionary Physiology, 2001

Panel Member, NSF Integrative Organismal Systems, Organism Environment Interactions 2010

Panel Member, EPA Star Grants in Biopollution, 2000

Madison Ecology Group (group of all campus faculty in ecology), Executive Board 1996, 1997; Chair Activities Committee Chair 1995, 1996, 1997; Organized campus symposium on Ecology 1996

Sigma Xi Madison Chapter Board Member, 1994-1997; Treasurer 1995-96; President Elect 1996-97

Chair, Ecology and Evolution Division, Society for Comparative and Integrative Biology, Member Executive Committee, 1997 - 1999

- Chair, Division of Invertebrate Zoology, Society for Comparative and Integrative Biology, Member Executive Committee, 2009-2012
- Member at Large, Executive Committee Society for Integrative and Comparative Biology, 2001-2004
- Committee to Increase Diversity in Integrative and Comparative Biology, 2000 2004

Editorial Board, (American Zoologist) Integrative and Comparative Biology 2000 - 2012

Vice President, American Malacological Society 2002-2003

President Elect, American Malacological Society 2003-2004

President, American Malacological Society 2004-2005

Executive Council, American Malacological Society 2003 - 2007

Editorial Board American Malacological Bulletin 2004 - present

Friday Harbor Laboratories Academic Advisory Board 2002 - present

CURRICULUM VITAE

Charlie Wisdom, PhD, AICP Parametrix Sr. Consultant

Charlie Wisdom is a water quality specialist with 29 years of experience investigating the impacts of chemicals discharged from sewage treatment plants on aquatic life, wildlife, and humans as well as the environmental impacts of stormwater runoff on aquatic habitats and endangered species. During this time, he has provided both public and private client assistance in issues related to water quality, stormwater impacts, NPDES permit compliance, Endangered Species Act Biological Assessments, and NEPA Environmental Assessments and Environmental Impact Statements. His work has also addressed the terrestrial and aquatic toxicity and fate chemistry of metals released as point sources such as sewage treatment plants and from nonpoint sources of metals to urban stormwater. Charlie has both helped prepare NEPA documents for private proponents and state and federal agencies as well as acting as a reviewer and commenter on NEPA documents for potentially affected parties. He has assisted in the preparation of NEPA EAs and EISs, NEPA natural environment discipline reports (particularly water resources), and has acted as a third-party reviewer for technical documents prepared in support of EIS effect determinations

Selected Project Experience

Aquatic Resources HCP EIS - Washington DNR, USFWS, NMFS, Washington

Charlie worked with a team of Parametrix scientists responsible for the preparation of this NEPA EIS that will also satisfy the requirements of SEPA. The EIS will evaluate the environmental effects of implementing the Washington Department of Natural Resources (DNR) proposed Aquatic Lands HCP. DNR manages approximately 2.4 million acres of state-owned aquatic lands in Washington State. DNR is preparing an HCP for 23 species of fish and wildlife that occur on these lands and might be affected by activities that DNR conducts or authorizes. With the Aquatic Lands HCP, DNR plans to maintain, improve, or provide habitat for covered species of fish and wildlife, including several that are listed as threatened or endangered. Charlie is preparing the water quality evaluation of the aquatic land management activities currently proposed for coverage in the HCP include 1) aquaculture of fin fish and shellfish; 2) overwater structures (docks, boat ramps, boat launches, mooring buoys, nearshore buildings, floating homes, marinas, and shipyards and terminals); and 3) log booming and storage.

Years of Experience: 29

Education PhD, Chemical Ecology, 1982 BA, Biology, 1977

AA, Biology, 1975

Intertidal Geoduck Farming Assessment – People for Puget Sound, Seattle, Washington

Charlie helped prepare a technical review and analysis of available studies on geoduck intertidal farming to assess the environmental impacts of intertidal geoduck farming in the Puget Sound. The intent of this evaluation was to review and evaluate available scientific information on intertidal geoduck farming to provide the People for Puget Sound for their use in the development of positions on proposed state guidelines/regulations for farming operations and a shoreline owner proposed moratorium on farming until a comprehensive environmental impact assessment is prepared. This review found that there is no available evidence that intertidal geoduck farming has any different impacts from either intertidal oyster or manila clam farming operations and that it does not appear that the current level of intertidal geoduck farming poses a threat of extinction to either listed fish species or to the benthic communities found in Puget Sound's intertidal habitat.

Third Party Review of Risk Assessment for Cortez South Pipeline Environmental Impact Statement – Bureau of Land Management, Nevada

Charlie acted as a third party reviewer in the development of an aquatic life and wildlife risk assessment of a future pit lake associated with the Cortez South Pipeline project for a Bureau of Land Management EIS as a subconsultant to Environmental Management Associates. The EIS was in support of the expansion of the ongoing mining operation for the Pipeline project. Charlie reviewed the completed risk assessment, critiquing the scientific validity of the risk assessment and summarizing the risk assessment for the draft EIS, as well as participating in and responded to public review of the EIS.

Prepared Response to Comments on Goldstrike Mine EIS - Barrick Resources, Nevada

Charlie assisted Barrick Resources with developing responses to comments received on the Barrick Goldstrike EIS, through the preparation of a conceptual site model to describe the specific receptors of concern and their pathways of exposure to constituents that are predicted to be present in the future Pit Lake that will develop at the Goldstrike facility following mine closure. Charlie developed a narrative risk characterization of the conditions of the Goldstrike discharge to the Humboldt River and potential effects on the receiving environment. He also reviewed methods and calculation provided by a third party used to estimate risks from mercury and selenium bioaccumulation in the future pit lake.

SR 520 Bridge Replacement and HOV Project Draft EIS – King County, WA

Charlie prepared water resources and navigation discipline reports for the potential effects of replacing the floating bridge connecting Seattle to the cities on the eastern shoreline of Lake Washington. The major environmental concern in this evaluation was the transport of road and bridge contaminants in stormwater to local environments. Most stormwater generated by SR 520 today is not treated and flows are not controlled before being discharged. The proposed alternatives would increase the amount of land covered by pollutant generating impervious surfaces in the project area. However, by applying stormwater treatment and flow control in their designs, both alternatives would meet state and federal water quality regulations, and both alternatives would provide more treatment than is required for stormwater discharging from the Evergreen Point Bridge. Charlie determined that construction impacts and the permanent operation of the bridge would have negligible effects on aquatic life and humans using groundwater. It was also determined that this would increase pollutant generating impervious

surfaces in the project area; however, this increase would not cause a detectable change to surface water or groundwater quality. Lastly, Charlie evaluated the need for additional mitigation in addition to that included in the overall design of the replacement bridge and roadways.

Puget Sound Region Hatchery Resource Management Plan NEPA EIS, Northwest Indian Fish Commission – Puget Sound, WA

Charlie was the water quality/quantity task leader for a programmatic EIS on two resource management plans (RMPs) submitted by the hatchery co-owners (Washington Department of Fish and Wildlife and Puget Sound Treat Tribes) for approval pursuant to ESA 4(d) Rule Limit 6. The RMPs and associated hatchery genetic management plans (HGMPs) describe 113 hatchery programs and evaluate their effects on salmonid populations protected under the ESA. In this process, Dr. Wisdom assessed the potential programmatic water quality and hydrologic impacts of Puget Sound hatchery programs on ESA listed species in Puget Sound, primarily through compliance with the Clean Water Act criteria.

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CURRICULUM VITAE

Christopher Willes Clark

Cornell Lab of Ornithology 159 Sapsucker Woods Road Ithaca, NY 14850 Phone: (607) 254-2405 e-mail: cwc2@cornell.edu

(a) **PROFESSIONAL PREPARATION**

Stony Brook University	Biological Sciences	B.S. 1972
Stony Brook University	Engineering Sciences	B.E. 1972
Stony Brook University	Electrical Engineering	M.S.E.E. 1974
Stony Brook University	Neurobiology & Behavior	Ph.D. 1980
The Rockefeller University	Postdoctoral Scientist	1981-83

(b) APPOINTMENTS

1983 - 1987 Assistant Professor, The Rockefeller University, New York, NY

- 1987 present Director Bioacoustics Research Program, The Cornell Lab of Ornithology
- 1989 1994 Senior Research Associate, Department of Neurobiology & Behavior, Cornell University
- 1994 present Senior Scientist, Department of Neurobiology & Behavior, Cornell University
- 1985 present Member, U. S. delegation to the International Whaling Commission Scientific Committee, since 1985
- 2005 2007 Member, NRC Committee on Environmental Impacts of Wind Energy Projects

2006 - present Graduate member Field of Zoology

(c) SCIENTIFIC PUBLICATIONS

(i)

- Clark, C. W., Ellison, W. T., Southall, B. L., Hatch, L., Van Parijs, S., Frankel, A., and Ponirakis. 2009. Acoustic Masking in Marine Ecosystems: Intuitions, Analysis, and Implications. Mar. Ecol. Progr. Ser. 395:201-222.
- Clark, C. W., Brown, M. W. and Corkeron, P. 2010. Visual and acoustic surveys for North Atlantic right whales, *Eubalaena glacialis*, in Cape Cod Bay, Massachusetts, 2001-2005: Management implications. Marine Mammal Science 26:837-854.
- Ellison, W. T., Southall, B. L., Clark, C. W., and Frankel, A. In press. A new context-based paradigm to assess behavioral responses of marine mammals to sound. Con. Bio.
- Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Thompson, M., and Wiley, D. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environ. Management. 42:735-752.
- Staaterman E. R., Clark, C. W., Gallagher, A. J., deVries, M. S, Claverie, T. and Patek, S. N. 2011. Rumbling in the benthos: the acoustic ecology of the California mantis shrimp. Aquat. Biol. 13:97-105.

(ii)

- Clark, C.W., Gillespie, D., Nowacek, D.P., and Parks, S.E. 2007. Listening to Their World: Acoustics for Monitoring and Protecting Right Whales in an Urbanized Ocean. In: <u>The</u> <u>Urban Whale</u> (Eds. S. Kraus and R. Rolland). Harvard University Press, Cambridge, MA. pp. 333-357.
- George, J. C. "Craig", Zeh, J., Suydam, R., and Clark, C. 2004. Abundance and population trend (1978-2001) of the western Arctic bowhead whales surveyed near Barrow, Alaska. Marine Mammal Science 20: 755-773.
- Kraus, S., M. W. Brown, H. Caswell, C. W. Clark, M. Fujiwara, P. K. Hamilton, R. D. Kenney, A. R. Knowlton, S. Landry, C. A. Mayo, W. A. McLellan, M. J. Moore, D. P. Nowacek, D. A. Pabst, A. J. Read and R. M. Rolland. 2005. North Atlantic right whales in crisis. *Science* 309:561-562.
- Parks, S., Clark, C.W., and Tyack, P.L. 2007. Short and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. J. Acoust. Soc. Am., 122:3725-3731.
- Van Parijs, S. and C.W. Clark. 2006. Long term mating tactics in an aquatic mating pinniped the bearded seal, *Erignathus barbatus*. Animal Behavior, 72: 1269-1277.

(d) SELECTED SYNERGISTIC ACTIVITIES

- 1996 present: Acoustic monitoring of large whale distributions, behaviors, and movements relative to environmental factors and man-made activities in the North Atlantic using Navy IUSS assets.
- 2000 present: Elephant Listening Project. Working with Gabonese researchers and conservationists to understand acoustic behavior ecology of African forest elephants and the potential impacts of seismic exploration activities.
- 2002 present: Application of passive acoustic methods to quantify the potential influences of environmental factors and man-made activities on endangered whales off New England and in mid-Atlantic waters; NOAA, Northeast Consortium, MA Division of Marine Fisheries.
- 2007 2014: Design, installation and operation of near-real-time auto-detection system for large whale acoustic monitoring and mitigation of Northeast Gateway Deepwater Port. Excelerate Energy and Suez Energy North America.
- 2008 2011: An ocean observing system for large-scale monitoring and mapping of noise throughout the Stellwagen Bank National Marine Sanctuary; NOAA-SBNMS, NOAA-NESFC.
- 2011 2014: Portable and Persistent Autonomous Real-Time Marine Mammal Acoustic Monitoring. NSF: OCE Ocean Tech & Interdisc. Coordin.
- 2011 2014: DCL System Using Deep Learning Approaches for Land-based or Ship-based Real-time Recognition and Localization of Marine Mammals. ONR.

Cornell: Please feel free to treat all Cornell faculty and extension staff as collaborators.

Non-Cornell Collaborators: I. Boyd (SMRU, St. Andrews, Scotland), L. Hatch (SBNMS, NOAA), S. V. Parijs (NOAA-NEFSC), L. Garrison (NOAA-SEFSC), D. Moretti (NUWC), P. Tyack (WHOI), A. Turkalo (WCS, Gabon, CAR).

- Graduate and postdoctoral Advisors: Dr. Charles Walcott (SBU), Dr. Peter Marler (Rockefeller Univ.).
- Postdocs: Adam Frankel, Dave Mellinger, Sofie V. Parijs, Ildar Urazghildiiev.

- **Ph.D.** Thesis advisees (Cornell only) John Bower, Bernard Brennan, Renata deSousa Lima Mobley, Danielle Cholewiak, Mya Thompson.
- **Ph.D.** Minor advisees (Cornell only) Ingrid Biedron, Dan Pendleton, Lynn Fletcher, Yianna Samuel, Damian Elias, Andrew Farnsworth, Leila Hatch, Karen Fisher, Hamilton Farris, Matt Weeg, Paul Faure, David Haskell, Jessica McKibben, Andrea Lee, Beth Weisburn, Stacey Benton David Haskell, Adam Frankel.

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CURRICULUM VITAE

James E. Wilen 36925 Russell Blvd. Davis, CA 95616

Telephone: (530) 752-6093 (530) 753-2493

Date and Place of Birth: June 23, 1947, Petaluma, California

Education

Ph.D., 1973, University of California, Riverside. Specialty fields: Natural Resource Economics, Environmental Economics, Economic Theory.

B.A., 1970, California State University, Sonoma. Concentration in Urban Economics, Regional Economics, Economic Development, and Mathematics.

Honors and Awards

Distinguished Fellow, American Agricultural Economics Association, 2001

Fellow, Beijer Institute of Ecological Economics, 2007

Distinguished Graduate Mentoring Award, 2004: University of California, Davis Publication of Enduring Quality, 2010; Association of Environmental/Resource Economists Quality of Research Discovery Award, 2009: American Applied Economics Association Quality of Research Discovery Award, 2000: American Agricultural Economics Association Quality of Research Discovery Award, 2000: American Agricultural Economics Association Quality of Research Discovery Award, 1998: American Agricultural Economics Association Quality of Research Discovery Award, 1998: Mestern Agricultural Economics Association Outstanding Published Research Award, 1998: Western Agricultural Economics Association Distinguished Graduate Teaching Award, 1998: American Agricultural Economics Association Supervisor, Outstanding Ph.D. Dissertation, American Agricultural Economics Association Supervisor, Gordon King Dissertation Award, UC Davis, Ag & Res. Econ. Dept. (6 times) Supervisor, Institute for Transportation Studies Outstanding Ph.D. Dissertation, 2006, UCD Distinguished Conservation Scholar, Duke University Marine Lab, August 2005 Resources for the Future, Inc. Doctoral Dissertation Fellowship, UCR, 1972-73 National Science Foundation Fellowship, UCR, 1970-72 B.A. with Honors and with Distinction in Economics, CSUS, 1970

Research Interests

Bioeconomic modeling; dynamics of open access exploitation; micro foundations of entry-exit decisions; factor distortion in regulated common property industries; energy economics; recreation economics; transferable quotas; economics of search; economics of aquaculture; natural resource damage analysis; agricultural pollution; fisheries input/output markets; technical change and productivity in resource industries; economics of cooperation; economic development/natural resources; spatial-dynamic models of resource use

47

Teaching Experience

Natural Resource Economics - 37 years: Undergraduate and Graduate level Dynamic Analysis Environmental Economics Introductory and Intermediate Micro Theory Energy Economics Environmental Policy Analysis Fisheries Economics Applied Research Methodology

Work Experience

- Research Assistant, California State University, Sonoma, Economics Department, Summers of 1968 and 1969.
- Teaching Assistant, California State University, Sonoma, Economics Department, February 1970-June 1970.
- Consultant, Department of Interior, Climatic Impact Assessment Program--economic impact of SST flights in the upper atmosphere, September 1973-December 1974.
- Consultant, Mathematica, Inc.--analysis of costs and effectiveness of Clean Air Act of 1972 on air pollution in the United States, May 1974-August 1974.
- Consultant, National Commission on Water Quality--conceptual foundations of benefit measurement, August 1975.
- Assistant Professor of Economics, University of British Columbia, January 1974-June 1978.
- Assistant Professor of Economics and of Environmental Studies, University of Washington, July 1978-June 1979.
- Associate Professor of Agricultural Economics and of Environmental Studies, University of California, Davis, July 1979-June 1986.
- Professor of Agricultural Economics and of Environmental Studies, University of California, Davis, July 1986-June 1996.
- Professor of Agricultural and Resource Economics, University of California, Davis, July 1996 to present.
- Director, Center for Natural Resource Policy Analysis., University of California, Davis, July 2002 to present.

Selected Publications and Completed Research

- "A Model of Economic System-Ecosystem Interaction," <u>Environment and Planning</u>, Vol. 5, 1973, pp. 409-420.
- "Depletion and Diplomacy: The North Pacific Seal Hunt, 1880-1910," in Paul Uselding (ed.), <u>Research in Economic History</u>, 1977, (with D. G. Patterson).
- "The Impact of Canada's Pacific Fleet Salmon Control Program," <u>The Journal of the Fisheries</u> <u>Research Board of Canada</u>, Vol. 36, No. 7, 1979 (with P. H. Pearse).
- "Regulatory Implications of Alternative Models of Fishermen Behavior," <u>The Journal of the</u> <u>Fisheries Research Board of Canada</u>, Vol. 36, No. 7, 1979.

- <u>The Public Regulation of Commercial Fisheries</u>, Vol. I (with A. D. Scott, J. A. Crutchfield, P. H. Pearse, G. R. Munro, M. Tugwell), Economic Council of Canada, Queens Printer Ottawa, Canada, June 1981.
- "Regulation of the British Columbia Herring Industry," in: <u>The Public Regulation of</u> <u>Commercial Fisheries</u>, Vol. II (A. D. Scott <u>et al</u>.).
- "Cyclic Covariation in the California King Salmon, Silver Salmon, and Dungeness Crab Fisheries," <u>Fishery Bulletin</u>, Vol. 80, No. 4, 1982, (with Louis Botsford and Richard Methot)," <u>Natural Resources Journal</u>, Vol. 23, April 1983, (with R. Davis and R. Jergovic).
- "Towards a Theory of the Regulated Fishery," Journal of Marine Resource Economics, Vol. I, No. 4, 1985.
- "Biological Models with Applications in Natural Resource Economics," in A. V. Kneese and J. L. Sweeney (eds.), <u>Handbook of Natural Resource and Energy Economics</u>, North-Holland Publishing Co., 1985.
- "Commercial Fisheries vs. Aquaculture: Conflicts in the Northwest Salmon Fishery," in Richard Johnston (ed.), <u>Fisheries Economics and Trade: Proceedings of the Second Conference</u>, University of Oregon, July 1985, (with James L. Anderson).
- "Estimating the Population Dynamics of Coho Salmon Using Pooled Time-Series and Cross Section Data," in <u>Canadian Journal of Fisheries and Aquatic Science</u>, Vol. 42, No. 3, 1985, (with James L. Anderson).
- "Modeling Fishermen and Regulator Behavior in Schooling and Search Fisheries," in A. D. Scott et al. (eds.), <u>Progress in Natural Resource Economics</u>, Oxford University Press, 1986.
- "An Examination of Fishing Location Choice in the Pink Shrimp Fishery," Journal of Marine <u>Resource Economics</u>, Vol. 2, No. 4, 1986, (with James Eales).
- "Optimal Recovery Paths for Perturbations of Trophic Level Bioeconomic Systems," Journal of Environmental Economics and Management, Vol. 13, 1986, (with Gardner Brown).
- "Implications of Private Salmon Aquaculture Development on Prices, Production, and Management of Salmon Resources," <u>American Journal of Agricultural Economics</u>, Vol. 68, No. 4, 1986, (with James Anderson).
- "Angler Response to Success in the California Salmon Sportfishery: Evidence and Management Implications," <u>Journal of Marine Resource Economics</u>, Vol. 5, No. 2, 1988, (with E. J. Andrews).
- "Limited Entry Licensing: A Retrospective Assessment," Journal of Marine Resource Economics, Vol. 5, No. 4, 1988.
- "Rent Generation in Limited Entry Fisheries," in P.A. Neher, R. Arnason and N. Mollett (eds.), <u>Rights-Based Fishing</u>, Kluwer Academic Publishers, The Netherlands, 1989.
- "Fishermen and Labor Markets: Participation, Earnings, and Alternatives in Pacific Coast Fisheries," National Marine Fisheries Service, Southwest Fisheries Center Report, (with Tzy-Ning Chen and Frances Homans), August 1991.
- "License Values in Restricted Access Fisheries," (with S. Stefanou), <u>Bulletin of Mathematical</u> <u>Biology</u>. Vol. 54, No. 2/3, 1992.
- "Economic Analysis of Japanese Household Demand for Salmon" (with Cathy Wessells), Journal of the World Aquaculture Society, vol. 24, No. 3, Sept. 1993.
- "Inventory Dissipation in the Japanese Wholesale Salmon Market," (with Cathy Wessells), Journal of Marine Resource Economics, vol. 8, 1993, pp. 1-16.

- "Enhancing Economic Analysis in Fishery Management: Discussion," <u>American Journal of</u> <u>Agricultural Economics</u>, vol. 75, December 1993, pp. 1198-1199.
- "U.S. Fishery Regulation Policy: Lessons for Peru," in Eduardo Loayza,(ed.), <u>Managing Fishery</u> <u>Resources</u>, World Bank Discussion Paper No. 217, the World Bank, Washington, D.C., 1994.
- "Seasonal Patterns and Regional Preferences in Japanese Household Demand for Seafood," (with Cathy Wessells), <u>Canadian Journal of Agricultural Economics</u>, March 1994.
- "Marketing Losses in Regulated Open Access Fisheries," (with Frances Homans) in M. Antona, J. Catanzano, and J. Sutinen (eds.) <u>Fisheries Economics and Trade:</u> <u>Proceedings of the</u> <u>Sixth Conference</u>, IFREMER-SEM, pp. 795-801, 1994.
- "The Effects of Individual Transferable Harvest Quotas in the British Columbia Halibut Fishery," (with K. Casey, C. Dewees, B.Turris), <u>Marine Resource Economics</u>, vol. 10, no. 5, 1995.
- "Principles for the Conservation of Wild Living Resources" <u>Ecological Applications</u>, vol. 6, no. 2, May 1995 (with Marc Mangel, Lee Talbot, Gary Meffe et. al.).
- "Efficiency and Factor Productivity in Common Property Resource Use," <u>Proceedings, Global</u> <u>Science Policy for the Twenty-first Century</u>, Melbourne, Australia, August 1996.
- "A Model of Regulated Open Access Resource Use," <u>Journal of Environmental Economics and</u> <u>Management</u>, vol. 32, no. 1, 1997, (with Frances Homans). Reprinted in L. Anderson (ed.) <u>Fisheries Economics, Selected Essays</u>, Ashgate Press, 2002. AAEA Quality of Research Discovery Award, 1998. AERE Publication of Enduring Quality, 2010.
- "Ecosystem Management and the 1996 Reauthorization of the Magnuson Act," <u>Ecological Law</u> <u>Quarterly</u>, vol. 24, no. 4, 1997, (with Shi-Ling Hsu). exerpted in: J.C.Nagel and J.B.Ruhl (eds.) <u>The Law of Bidiversity and Ecosystem Management</u>, Foundation Press, New York, 1st Edition (2002) and 2d Edition (2006).
- "Unraveling Rent Losses in Modern Fisheries: Production, Market, or Regulatory Inefficiencies?"(with Frances Homans) in Daniel Huppert, Ellen Pitkitch, and Michael Sissenwine (eds), <u>Fisheries Management: Global Trends</u>, University of Washington Press, 1997.
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- "Optimal Spatial Control of Biological Invasions", forthcoming 2012, <u>Journal of Environmental</u> <u>Economics and Management</u>, (with Becky Epanchin-Niell).
- "Regulated Open Access and Regulated Restricted Access Fisheries" forthcoming 2012, J. Shogren (ed.) <u>Encyclopedia of Energy, Natural Resource and Environmental Economics</u>, Elsevier, Oxford (with Matt Reimer).
- "Economics of TURFs, or Territorial Use Rights Fisheries", forthcoming 2012, <u>Review of</u> <u>Environmental Economics and Policy</u>.
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APPENDIX B: INDIVIDUAL REVIEWER MEMORANDA

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Review of Draft Environmental Impact Statement Drakes Bay Oyster Company Special Use Permit

Edwin Grosholz, University of California, Davis

In the review below, I focus primarily on the following topics "Wetlands" and "Birds" with occasional references to "Eelgrass" and "Benthic Fauna" where appropriate. My review is structured to address questions 1-5 with a general summary for these topics as a result of my review of Chapters 3 and 4. For each question, I also refer to more specific discussion below. In addition, I provide very specific comments on a several issues in Chapters 2-4. Finally, I provide a discussion of "Water Quality" issues that relate specifically to the impacts of oyster filter feeding on water column properties.

1. Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

Yes, the broad conclusions regarding of the Draft Environmental Impact Statement (DEIS) are reasonable and generally well supported given the very limited data available for many of the topics. However, some topics and interpretations were either lacking support or fundamentally incorrect.

Wetlands. The discussion is reasonably comprehensive and involves substantial description of communities from intertidal 100 feet landward of the "high tide line". A systematic error is noted with the listing of the genus name *Salicornia*, which has been *Sarcoconia* for several years. The discussion of sea level rise (SLR) on wetlands seems to ignore the potential for plants to migrate upward in tidal elevation to avoid inundation associated with SLR. Distinctions should be made between unarmored areas where wetlands can migrate landward versus armored areas bordered by roads, levees, and railways.

Birds. The impacts of oyster aquaculture on birds include some aspects that may reflect general shorebird behavior, but are also speculative based on a few observations without support from peer-reviewed publications. The report's authors again cannot be faulted for this as there simply are no published data bearing on these impacts. The survey studies cited and the authors of those studies (e.g., Page, Stenzel, and Kelly) do represent the best studies to date for this poorly studied estuary and, thus, do capture the diversity of birds and the importance of this estuary for waterbirds and shorebirds. The report accurately reports the presence of oyster bags lying directly on the sediment in the outer bay as a de facto loss of foraging habitat for shorebirds, so this is likely to be among the most direct effect of aquaculture. The report reasonably describes disturbances due to noise and presence of small boats. The authors highlight the connection of Drakes Estero to the larger network of sites and its proximity to San Francisco Bay is also important. However, the numbers of wintering birds listed for San Francisco Bay is more like one million rather than 500 thousand (Pt. Reyes Bird Observatory, unpubl. data). Also see specific comments below (p. 266) about tunicate impacts on foraging Brandt.

Other topics. A related topic is the failure of the report to discuss the substantial uncertainty regarding estimates of eelgrass cover and damage due to boat propellers in Drakes Estero. These estimates are based on data from California Department of Fish and Game (CDFG) and are very rough and subject to significant mistakes in interpretation. Colleagues who have independently examined the CDFG images from 2007 have found that accurate estimates of either eelgrass cover or area damaged by propellers cannot be reasonably based on these images (S. Williams, UCD Bodega Marine Laboratory, pers. comm.). The authors repeatedly refer to these images, which have been criticized by the National Academy of Sciences (NAS). The authors refer to a more recent set of images from 2010 are made entirely without citation. Nothing is currently known about the quality of these images and whether they are any more reliable that the set from 2007. See specific commnents below (p. 261 and p. 262).

Among the interpretations that should have received more discussion is the assumption that cultivation of the European flat oyster would have no more impact than Pacific oysters. It is important to state clearly that unlike Pacific oysters, there are no "naturalized" or established populations of European flat oysters anywhere in California (Smithsonian Environmental Research Center, NEMESIS database). Although these are listed on the Drakes Bay Oyster Company (DBOC) permit, introducing *Ostrea edulis* for aquaculture in sites like Drakes Estero where it is currently not established would require a significant review process outside the scope of this DEIS. The potential for unwanted ecological impacts following the establishment and spread of European flat oysters could be considerable. The discussion of "remant populations" on the DBOC begs for immediate investigation of the status of European oysters.

2. Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.

One important exception to the overall conclusions regarding birds (as well as invertebrates, and fishes) is the allowance of "recreational take of clams" under the MLPA guidelines. It should be stated firmly that recreational clamming results in extensive and very long-term disturbance to benthic habitats, which will influence the abundance of benthic invertebrates and consequently shorebird foraging. Clamming results in the digging and turnover of many feet of sediment over significant areas dependent on the number of clam diggers. The fact that they will not be using boats does little to reduce their potential impacts. It is hard to understand how the authors of the report can conclude "Recreational take of clams would not interfere with preservation of wilderness characteristics in Drakes Estero."

Regarding additional indirect impacts of aquaculture on birds, in one passage (see specific comments below p. 266) the authors conclude that invasive invertebrates such as the tunicate *Didemnum* (presumably *D. vexillum*) would foul eelgrass blades rendering these unpalatable for migratory Brant. This is stated without support and I personally am unaware of any published studies supporting this point.

Furthermore, it is also stated rather unequivocally that the source of the *Didemnum* invasion in Drakes Bay was aquaculture. Aquaculture is also blamed for the introduction of the mud snail *Batillaria attramentaria* (see specific comments below). It is important to state that these are likelihood arguments and except for few introduced species do we really know the source of the primary invasion. While secondary invasions within and among bays are more likely facilitated by movement of aquaculture activities, hull fouling must also be considered as a likely vector for primary and secondary introduction and spread of invasive tunicates.

3. Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.

In general the report does a good job of identifying the appropriate literature and the best available science. Unfortunately, there are several cases where there are little if any defensible scientific data from peer-reviewed sources and conclusions are necessarily circumspect.

It should be noted that data from studies specific to Drakes Estero for birds and other taxa including invertebrates, fishes are cited from three unpublished theses by Harbin-Ireland, Press, and Wechsler. These theses have not produced a single peer-reviewed publication. Therefore, the conclusions from these studies should be viewed as very preliminary and with caution. The report relies too much on these studies, perhaps understandably, since there are really no other studies available.

4. Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.

In general, there were only a few areas where the report missed important peer-reviewed papers that would have improved the conclusions of the study.

In their discussion of the impacts of oysters on water column productivity, the authors apparently overlooked or were unaware of nearly a decade of work from the Biogeochemical Reactions in Estuaries (BRIE) project funded by the Land-Margin Ecosystem Research Program at the National Science Foundation (NSF). This produced extensive data and studies from Tomales Bay, which is a much more similar to Drakes Estero than the San Francisco Bay studies cited in the DEIS. This work would more accurately represent the biomass of phytoplankton and the relative importance of benthic primary production (eelgrass and macroalgae) versus water column primary production (phytoplankton) and hence the impacts of oyster filter feeding. Unfortunately, only one study from this work (Largier et al. 1997) is cited in the DEIS. See Water Quality discussion below and comments on p. 161. There are also better studies of phytoplankton dynamics in San Francisco Bay than what is cited (e.g. Wilkerson et al. 2006).

Fourqurean, J. W., K. L. Webb, J. T. Hollibaugh, and S. V. Smith. 1997. Contributions of the plankton community to ecosystem respiration, Tomales Bay, California. Estuarine Coastal and Shelf Science 44:493-505.

Hearn, C. J., and J. L. Largier. 1997. The summer buoyancy dynamics of a shallow

Mediterranean estuary and some effects of changing bathymetry: Tomales bay, California. Estuarine Coastal and Shelf Science 45:497-506.

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- Wilkerson, F. P., R. C. Dugdale, V. E. Hogue et al. 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay. Estuaries and Coasts 29: 401-416.

5. Is the scientific foundation of the DEIS reasonable; and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

Yes, if general, the scientific foundations are sound. I think the DEIS draws the reasonable conclusion that there are insufficient data on which to base estimates of impact. Given the data that are in hand, the DEIS does a reasonably good job of discussion both the lessons and limits presented by these data.

In addition to the areas of literature identified above under the previous questions, a newly available report would substantially strengthen one of the overall conclusions of the DESI report and would clarify conclusions in the National Academy of Sciences (NAS) report that were poorly supported. The conjecture that whatever impacts of oyster aquaculture might have on water column processes somehow mimics or is a replacement for similar impacts caused by historic populations of native Olympia oysters is premised on there being significant populations of these native oysters in Drakes Estero. The DEIS refers to the NAS report, which did not in fact address this topic comprehensively. The new report by Konzak and Praetzellis (2011) provides a fairly definitive evaluation of this topic and concludes that there is little evidence of the presence (and hence use) of Olympia oysters in early American middens. They conclude it is unlikely that Olympia oysters were ever abundant in Drakes Estero unlike nearby Tomales Bay and San Francisco Bay. The authors of the DEIS cite this study, but draw no conclusions from it and simply state the NAS report failed to address this. In fact, the archeologists conclude that

there was little presence historically of native oysters, and, thus, impacts of oyster mariculture have no historical analogue. See specific comments below p. 236.

Consequences of Bivalve Filter Feeding on "Water Quality"

To begin with, there are no studies of the impacts of Pacific oysters on water column properties in California. The extent of our knowledge is based on extrapolations from studies in Washington that address filter feeding consequences. The authors of the DEIS state that the filtering capacity of bivalves including oysters has been documented elsewhere and is likely to have some effect in Drakes Estero. They note that available studies (Dumbauld et al. 2009) suggest the effects will be limited. In fact there are really no data at all from this system and it remains an open question entirely whether oyster filter feeding has any effect positive or negative on eelgrass. The phytoplankton productivity and the residence time of water in Drakes Estero remain entirely unquantified. Certainly first principles would suggest that since oysters filter the water and consume phytoplankton that they could potentially influence phytoplankton biomass in the water column. But whether this impact is important or trivial is absolutely not known.

The overall understanding of the relative importance of water column primary production in comparison with eelgrass in Drake Estero also merits discussion. The impacts of oyster aquaculture on eelgrass and primary production generally including water column primary production (phytoplankton) is based on comparisons with San Francisco Bay (Chapter 3), which is probably less similar to Drakes Estero than any other bay in the region. The authors apparently overlook or are unaware of a nearly a decade of work from the BRIE project funded by the Land-Margin Ecosystem Research Program at NSF. This produced extensive data and studies from Tomales Bay, which is much more similar to Drakes Estero than San Francisco Bay. Only one study from this work is available (Largier et al. 1997). See specific comments below (p. 161). Studies from San Francisco Bay (e.g. Carr et al. 2010) provide little insight into similar processes in Drakes Estero. The Master's thesis by Press (2005) has produced no peer-reviewed publications and the results should be viewed as very preliminary.

Additional Specific Comments Chapter 3

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"Given that water quality in Drakes Estero is relatively high (NAS 2009), it is likely that phytoplankton productivity is also high relative to other embayments within the region. However, epiphytes are expected to represent a minor component of the overall primary productivity in this region, as Carr, Boyer, and Brooks (2010) have noted for San Francisco Bay. This reemphasizes the dominant role that eelgrass, and to a lesser extent, phytoplankton, play in the overall primary productivity within Drakes Estero."

San Francisco Bay is probably the least similar bay in the region to Drakes Estero and a poor choice for comparison. San Francisco Bay has enormous riverine inputs relative to most bays in the region and is extremely turbid with very limited light penetration and limited eelgrass production. The authors are probably correct to say that phytoplankton productivity is high in

Drakes Estero than in San Francisco Bay, but certainly not "relative to other embayments within the region". There are extensive data and studies from Tomales Bay that are a much better example and there was a decade of excellent studies funded by the NSF funded LMER program. The fact that none of this work is cited in the context of this DEIS is a remarkable oversight. Among notably relevant studies is Smith and Hollibaugh 1997, which completed a mass balance study of net ecosystem productivity. They conclude:

"Despite being hydrographically simple, the biotic composition of the system is typical of relatively undisturbed coastal embayments along central and northern California, Oregon, and Washington. Primary production is dominated by phytoplankton, although seagrass (Zostera marina) is visually conspicuous (Spratt 1989)."

Studies by Harbin-Ireland, Press and Wechsler are all unpublished theses at University of California, Davis that have not produced a single peer-reviewed publication. I was on the thesis committee for both Press and Harbin-Ireland, so I know these studies well. Although these studies are cited throughout the DEIS, their conclusions should be viewed as extremely preliminary and interpreted cautiously.

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No source is cited regarding the new higher resolution geographic information system (GIS) based imagery to look at impacts on eelgrass. The 2007 images were deemed by many including NAS inconclusive due to poor resolution.

"In an effort to provide a more detailed and current assessment of propeller damage to eelgrass, recent (2010) high-resolution aerial photography of Drakes Estero was evaluated using GIS technology."

No reference to these new images, so hard to say much about new findings regarding propeller damage.

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There is no such thing as "aquaculture reefs created for oyster fisheries." There are no Pacific oyster reefs, just bags and sticks on racks.

Also the following is suggested as a reason for failure of Olympia oysters: (3) preference to colonize Pacific oyster habitat, thereby being subjected to competition from the successful Pacific oyster. There is no Pacific oyster habitat. Pacific oysters are not naturalized in Drakes Estero. The study cited Trimble et al. 2009 applies only to Washington, not California. Other significant factors include introduced oysters drills (Kimbro et al. 2009).

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Special status species. I am wondering if tidewater gobies (federally endangered) have ever been collected from Drakes Estero. I do not think anyone has looked carefully. Drakes Estero seems at least as likely to be potential habitat for tidewater gobies as it does for leatherback turtles.

Chapter 4

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"It should also be noted that archeological and historical sources that pertain directly to the presence or absence of oysters in Drakes Estero prior to the establishment of an oyster operation in the 1930s were not considered in the NAS study."

However, there is a final report now from the Sonoma State University archaelogists concluding: "Sites in Drakes Estero that contain oysters include the site closest to Tomales Bay (CA-MRN-296) and the largest site in the vicinity of the Estero (CA-MRN-242). While small populations of Olympia oyster may have existed in the Estero and been utilized by the Coast Miwok, the relative abundance of oyster remains in Tomales Bay and their absence at all but two archaeological sites in Drakes Estero make it more likely that the oysters were brought in from Tomales Bay." (Konzak and Praeztellis p. 26.)

Page 240

"...indicating that increased monitoring and management of *Didemnum* and Manila clam may be necessary to protect native eelgrass habitat and benthic populations within Drakes Estero."

It is important to point out that European oysters would need to be monitored outside of cultured areas to determine if they are becoming naturalizing and spreading.

Page 244, Table 1

There is no current "monitoring/management of invasive species" in Drakes Estero. Monitoring has been very limited and there is certainly no management.

Page 261

"To assess the impact of propeller damage on eelgrass in Drakes Estero, recent highresolution aerial photography was reviewed, and propeller damage lines were digitized using GIS technology. The source for the aerial photographs used in this analysis was California Department of Fish and Game (CDFG) imagery taken in 2010."

Quotes about new analysis of aerial imagery with no reference to who or what this was. In an earlier study, CDFG conducted a substandard analysis of low resolution images and drew unwarranted conclusions. Need to be better support for this new analysis.

Page 262

"Eelgrass habitat within Drakes Estero has doubled from 1991 to 2007 a trend seen in some other west coast estuaries. (NAS 2009)"

NAS relied on faulty CDFG analysis of low resolution images. This trend is not reliable.

"Research elsewhere demonstrates that damaged eelgrass blades have rapid regeneration capacity and that eelgrass productivity can be locally enhanced by the cultured oysters through a reduction in turbidity and fertilization via nutrient regeneration."

Also NAS concludes that research done elsewhere indicates a positive effect of oyster culture on eelgrass. There are no studies (as they note) showing this to be the case with Pacific oysters and *Zostera marina*. While re-growth after damage is likely general, there is no reason to expect the positive effects of oysters on eelgrass, or if so, what scale that might occur. This very well could be the case, but it has yet to be demonstrated.

Page 263

"However, to the extent that localized beneficial effects from DBOC bivalves influence eelgrass productivity near DBOC beds and racks (see discussion under alternative B), the removal of DBOC cultured bivalves under alternative A would result in adverse impacts on eelgrass at these sites."

Given the lack of demonstration of positive effects, the inferred negative effects of the loss of oyster aquaculture on eelgrass is equally speculative.

Page 266

"Tunicates also render eelgrass blades inedible to foraging species such as the black brant."

I am not familiar with a study showing Brandt shy away from eelgrass with tunicates and none are cited.

Page 267

"...algae (termed "epiphytic" algae) can become established on the eelgrass blades and thereby reduce the photosynthetic surface of the eelgrass blades, which can lead to a reduction in primary productivity as noted above (Hauxwell et al. 2001; Dumbauld, Ruesink, and Rumrill 2009; NAS 2010)."

Although possibly true, this has also not been demonstrated for these species in this region.

"Clarity and productivity characteristics are also due in part to the relatively small watersheds that feed into coastal lagoon systems like Drakes Estero, because small watersheds do not tend to contribute large volumes of suspended sediments and organic detritus."

Water column clarity and productivity are in large part also due to the very seasonal nature of the watershed inputs in Mediterranean climates. There is a five month drought, but the "outflow" season is even shorter (typically January to April/May) so there is very little watershed input in most California estuaries regardless of the size of the watershed (no rain, no input).

Page 269

"The cumulative impact would be long-term moderate adverse, and alternative B would contribute an appreciable adverse increment to the overall cumulative impact."

The conclusion seems reasonably well supported.

Page 274

"Examples of other fouling organisms include barnacles, sponges, and goblet worms (Light, Grosholz, Moyle 2005)"

This reference is to a freshwater database for the Sacramento-San Joaquin Delta. There are no invasive goblet worms (*entoprocts*) in Drakes and these are not a problem taxa generally. Bad call, many better references.

Page 279

"Because shellfish mariculture is the most likely mode of introduction for invasive tunicates on the west coast (Herborg, O'Hara, and Therriault 2009)"

Evidence that shellfish mariculture may be an important secondary vector, but the primary invasion may be due to hull fouling.

"In addition, Byers (1999) studied the invasion of a nonnative mud snail (Batillaria attramentaria), making specific reference to its introduction by JOC, the previous oyster operator in Drakes Estero."

Again, no certainty that JOC is the source of the invasion. It was introduced into nearby Tomales Bay long before JOC was in operation.

Page 339

"Therefore, while ceasing mariculture operations would end the ability of the oysters to filter water within Drakes Estero, any appreciable differences in water quality may be restricted to areas immediately adjacent to structures (Dumbauld, Ruesink, and Rumrill 2009)."

Again, same issue. Not clear to what degree oysters have any significant impact on the water column.

Page 370

"NPS would continue to monitor and manage invasive species, including *Didemnum*, Manila clams, and *Spartina* marshgrass."

Under Alternatives B-D, they would need to manage European flat oysters as well.

Page 371

"Recreational take of clams would not interfere with preservation of wilderness characteristics in Drakes Estero."

Why is an extractive fishery consistent with wilderness characteristics and designation? Clamming is quite a disturbance and fairly destructive. This needs to be identified.

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Review of Draft Environmental Impact Statement Drakes Bay Oyster Company Special Use Permit

Dianna K.Padilla, State University of New York at Stony Brook February 17, 2012

Impacts of the aquaculture of Crassostrea gigas, the Pacific oyster and other bivalves.

1. Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

In many cases, the interpretation of information presented is reasonable. In general, however, throughout this report there are many questions regarding the impact of different activities on different aspects of the system. In many cases, there is no scientific information regarding factors of interest. However, when there are no data to support or refute the notion that there is an impact, one cannot conclude that there is no impact. Lack of evidence is not the same as evidence that there is no effect. In fact, the National Research Council (NRC) Report that is cited heavily in this document states, "Importantly from a management perspective, lack of evidence of major adverse effects is not the same as proof of no adverse effects nor is it a guarantee that such effects will not manifest in the future".

Overall, it is prudent to not assume that no evidence means no harm, and caution should be used when managing resources. Evidence from other systems can be used, but correct comparisons should be made. In most cases, the interpretations of the environmental impacts of farming Crassostrea gigas are based on studies of a different species with very different biology that grows in different physical environments, the eastern oyster, Crassostrea virginica. For example, C. virginica is a reef builder, and lives in freshwater influenced estuaries on the Atlantic and Gulf coasts of North America - very different environment than the Pacific coast of North America, which has bays and estuaries with extremely high flushing rates, very large tidal excursions, and high nutrients. When given other hare substrates for settlement, C. gigas will not generally settle on conspecifics, and prefers rocky habitat if available. There has been a great deal of research on environmental impacts of C. gigas in northern Europe (reviewed in Padilla 2010, Lejart and Hily 2011 and references therein) and New Zealand and Australia (Forrest et al. 2009). One general finding across the studies is that the impact of C. gigas differs among habitats - habitat specific impacts are the rule, rather than the exception (Padilla 2010), making predictions of impacts among habitats difficult. It should not be assumed that the environmental effects or impacts of C. gigas are the same as those of C. virginica.

Little data exist regarding the impacts of *C. gigas* culture in Drakes Estero. What data are cited are generally unpublished MS Theses (which are not generally available, and I could not access), and many personal communications and emails, none of which are available to evaluate. Therefore, it is challenging in many parts to determine how solid the basis is for conclusions made. In other cases, we can draw general conclusions from other situations. More information should be drawn from European experiences with *C. gigas* than what is known about *C. virginica*.

One important issue that is not discussed, but is of growing concern is the potential impacts of continuing to cultivate C. gigas in high densities and the likelihood that it will escape cultivation and invade nearby shores, and the risk of introduction of the target aquaculture species for each scenario. C. gigas is considered one of the 100 worst invaders in the world. At present, it has escaped cultivation and established feral populations and is impacting shores in over 30 countries (Padilla 2010, Padilla, McCann, Shumway 2011). Because this species is long-lived and has dispersal larvae, impacts are readily seen in environments where they do not breed, but rather are seeded by distant areas where they can reproduce (generally when there is warm water). This has been seen in Germany, France, The Netherlands, and in Northern Washington State (reviewed in Padilla 2010). In the San Juan Archipelago in Washington State the waters are too cold for local reproduction of oysters. However, C. gigas has invaded the shores by larval transport from elsewhere (likely Canada), and is more abundant in marine reserves than nonreserve areas (Klinger, Padilla, Britton-Simmons 2006). In these rocky shore communities, where it is dense, there is a large decrease in local biodiversity (Padilla and Gray in prep). With increased frequency of El Nino Southern Oscillation (ENSO) events and general warming, it is likely C. gigas will reproduce and have the potential to invade nearby rocky shores.

Similarly, there is no consideration of the risk of introduction associated with culture of *Venerupis (Ruditapes) philippinarum* (manila clam) or the flat oyster, (*Ostrea edulis*), both of which have escaped aquaculture where introduced (McKindsey et al. 2007, Padilla et al. 2011). One important finding, which is true for all species introductions, the lag time between first introduction and escape or spread cannot be predicted. For *C. gigas* invasions due to aquaculture thus far, that lag time has been as short as one year or as long as 100 years (Padilla 2010). The longer a species is grown in an area, the greater the probability that it will escape.

2. Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.

The effects of different culture methods differ. Off-bottom racks have a different impact than on-bottom bags. Although this is initially mentioned, the relative amount of impact of the two culture methods is not followed through when assessing impacts of different alternatives. Above sediment methods tend to have lower impacts on soft bottom epibenthic and infaunal species, but also create novel habitat for fishes, crabs and other demersal species, altering species distributions, behaviors and densities, and facilitate invasion by non-native species that inhibit hard substrata, especially nonnative ascidians - which include more than just the one species considered here, *Didemnum viexillum* (Anon 2005).

Although positive effects of oyster culture on eelgrass (*Zostra marina*) are alluded to, to date there are no direct studies that show a positive effect of *C. gigas* culture on eelgrass. Other work in Willipa Bay has correlations between aquacuture and changes in overall seagrass abundance, they do not separate the abundance of *Zostra marina* and the invasive *Zostra japonica*. Although *Zostra japonica* is in the same genus, it does not serve the same ecological role as *Zostra marina*, and should not be considered an ecological equivalent or substitute. Thus, there are no data to
support a notion that in this systems aquaculture improves water quality or habitat quality for eelgrass.

3. Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.

Most of the data on the ecological roles and effects of taxa is based on very general references (mostly chapters from the text book on Marine Community Ecology, edited by Bertness, Gaines and Hay [2000], rather than primary literature that has directly studied the questions and species under concern. As stated above, there are many studies on the impacts of *C. gigas* in Europe and New Zealand, as well as the risk that aquaculture species in general, and the species cultured and proposed to be cultured (under the different scenarios). When impacts have not been quantified locally in the Estero, impacts would be best predicted from studies of *C. gigas* (rather than *C. virginica*). In some cases, it would not change interpretations, while in others, it may. In general, peer-reviewed literature should be preferred sources of such information.

4. Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.

Full citations are given at the end of this report. Anon 2005 Baker 1995 Brandt et al. 2008 Dame 1996 **Diana** 2009 Diedrich et al. 2005 Diedrich 2006 Forrest et al 2009 Hégaret et al. 2008 Klinger, Padilla, Britton-Simmons 2006 Lejart and Hily 2011 and references therein McKindsey et al. 2007, 2009 Padilla et al. 2011 and references therein Padilla 2010 and references therein Smaal et al. 2005 Shatkin et al. 1997 Shumway (Editor) 2011 (many chapters in this book are relevant) Whitely and Bendell-Young 2007

5. Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

Greater attention should be paid to the primary literature, especially peer-reviewed publications. This report relies heavily on unpublished work, and private conversations and emails and a text book on Marine Community Ecology that was published in 2000, 12 years ago.

Attention should be paid to the risk of introduction of the target aquaculture species for each scenario. The problem of species introductions - one major issue not considered is that the introduced species themselves are important potential invaders. In addition, the potential for non-target species introductions remains, and is not necessarily remedied by current aquaculture practices. Because adult animals are no longer transported, many avenues of species introduction have been removed that were important in the past. There should be continued concern, even with transport of spat, and attention paid to the transport of disease causing agents, including protozoans, bacteria and viruses, as well as harmful algae, which can cause blooms causing wide-spread environmental harm (e.g., Hégaret et al. 2008)

Facilitating habitat for other unwanted invaders, increasing their abundance, and increasing the likelihood of long term effects should be addressed more. One tunicate, *Didemnum* is mentioned, however there are many species of introduced tunicates, all of which can be facilitated and whose densities can be greatly enhanced with oyster culture facilities.

Eelgrass

1. Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

In general, there is no evidence to support the notion that in this system aquaculture will enhance eelgrass, or in similar systems on the west coast where *C. gigas* in cultured (Everett et al 1995, Kelly and Volpe 2007). There is evidence of negative impacts of motor boat activity and aquaculture activities in this bay, which has been documented elsewhere (Balaguer et al. 2011). It is assumed that expansion of the aquaculture activity will increase loss of eelgrass in a linear fashion, but there are no data to support that.

Curiously, the nonnative mussel *Musculista senhousia* is listed with the native bivalves in the community. It is an important invader, and extensive work has been done on the ecological impacts of *Musculista senhousia* (e.g., Reusch and Williams 1998, Williams et al. 2005, Williams 2007) on eelgrass communities, but this is not addressed, nor is it indicated if this invader is associated with the bivalve farming areas. If it is not - it is still an important invader that needs to be controlled in the reserve, and some assessment should be made as to whether any future expansion of bivalve farming would be affected. If, however, there is an association between aquaculture and this invader, this would be a concern that would need to be addressed.

2. Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.

Of the experimental studies that have been done in similar environment, none have shown a positive impact of the culture of *C. gigas* on nearby eelgrass (Kelly and Volpe 2007). Also see comments in the above section about shellfish culture in general.

Another important consideration that is not addressed is the sports harvesting of clams (Cabaco et al. 2005, Van Alstyne et al. 2011). Part of the plan appears to be to allow sports harvesting, but the impacts of this activity has not been addressed. Sports harvesting (recreational or for food) does have impacts on eelgrass where it is raked or when clams are dug (see section on benthos below).

3. Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.

More reliance on experimental work done to examine the impacts of *Crassostrea gigas* per se would be important, as well as other factors in similar bays that affect eelgrass, including clamming.

4. Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.

Balaguer et al. 2011 Cabaco et al. 2005 Crooks 1998 Everett et al. 1995 Kelly and Volpe 2007 Reusch and Williams 1998 Van Alstyne et al. 2011 Williams 2007 Williams et al. 2005

5. Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

Greater reliance on published scientific studies would be helpful, especially studies that directly address the species involved or comparable systems.

Benthos

1. Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

Surprisingly little data are provided regarding the species in the benthos, functional diversity, overall species diversity or biomass of major taxa in the bay away from, in proximity to, and under aquaculture facilities. Such data may not exist, but if that is the case, it needs to be stated explicitly. It is well known that different aquaculture gear has different impacts, but the partitioning of different gears and growth methods and consideration of those differential impacts are not given full consideration here.

Cautiously, two non-native bivalves are listed as part of the native community - *Gemma gemma*, and *Musculista senhousia*. Although to date no one has examined any possible effects of the introduction of *Gemma gemma*, extensive work has been done on the ecological impacts of *Musculista senhousia* (see section on eelgrass and Crooks 1998). If this invader is associated with the aquaculture activity, it needs to be considered.

2. Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.

Again, as is mentioned above in the section on aquaculture, the impacts of *C. gigas* culture will differ from those seen by growth of *C. virginica* (the references used here), and has been shown to be different in different contexts and habitat types. They impact both the infauna and epifauna, and depending on the environment, may increase diversity or decrease the diversity of each. Studies have shown that the benthic community in eelgrass beds is affected by *C. gigas* culture in west coast bays (Kelly et al. 2008).

Surprisingly, no consideration is given to the impact of sports (recreational or for food) harvesting of bivalves. This activity is incredibly destructive in many environments McLaughlin et al. 2007). Rake harvesting in general has a lower impact than digging, but both are harmful through direct disruption of the benthic fauna, but also through changes in biogeochemical interactions and sediment characteristics, and are likely to have long term impacts.

3. Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.

More studies of the impacts of aquacutlure on the benthos, particularly of *C. gigas* culture, should be used.

Again, few data on impacts should not be interpreted as there being no impacts.

4. Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.

Balaguer et al. 2011 Cabaco et al. 2005 Crooks 1998 Everett et al. 1995 Kelly and Volpe 2007 Kelly et al. 2008 Reusch and Williams 1998 Van Alstyne et al. 2011 Williams 2007 Williams et al. 2005 Whiteley, J; Bendell-Young, L 2007

5. Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

Greater reliance on published scientific studies would be helpful, especially studies that directly address the species involved or comparable systems would strengthen this report.

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General Note:

More care should have been taken in proof reading this report. There are many repeated misspellings, etc. For example, desiccation is spelled with 2 c's, not 2 s's.

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Review of Draft Environmental Impact Statement Drakes Bay Oyster Company Special Use Permit

Charlie Wisdom, Parametrix

The following review addresses the completeness, the scientific soundness, and the reasonableness of the conclusions presented in the water quality sections of Chapters 3 and 4 of the Drake's Bay Oyster Company (DBOC) Special Use Permit (SUP) Draft Environmental Impact Statement (DEIS). An area of potential uncertainty concerning the evaluation of water quality effects on threatened juvenile coho salmon is identified, and options for strengthening the scientific foundations are presented.

1) Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

Overall, the water quality analysis presented in Chapter 3 of the DBOC SUP DEIS suitably describes:

- a. The types and sources of potential contaminants that could be generated by the actions associated with each alternative and could affect estuary water quality
- b. The site-specific condition of Drake's Estero for the transport of contaminants from sources to aquatic habitats. Of particular importance in determining water quality effects is the understanding of the well-flushed, strongly tidally influenced nature of this West Coast estuary that can significantly dilute the point and non-point source discharges from the surrounding landscape, onshore facilities, and offshore facilities to the estuary
- c. The aquatic resources habitat and species that could be affected by these discharges

The analyses and scientific interpretations presented in Chapter 4 are, in most aspects, reasonable and appropriate and in accord with the reviewed scientific findings for the general environmental impacts of oyster mariculture on marine water quality. This is particularly true due to the site-specific conditions of Drake's Estero: strong, twice-daily tidal flushing, which diminishes the sediment disturbances associated with oyster cultivation and dilutes and transports dissolved and particulate pollutants out of the estuary.

The one area of uncertainty in the scientific interpretations presented concerns the potential effect of chemicals leached from chromate copper arsenate (CCA) treated wood. The review presented and conclusions reached are reasonable and appropriate for typical marine waters of the United States. Several studies have established that, for areas of high tidal flushing, concentrations of metals leached from woods treated with preservatives such as CCA do not reach levels that detectably impact benthic communities or fish. However, National Oceanic and Atmospheric Agency (NOAA) Fisheries has found that juvenile coho salmon are particularly sensitive to very low levels of copper that can leach from CCA-treated wood used in docks and oyster cultivation racks (NOAA Fisheries – Southwest Region, 2009), and the agency has established

Atkins: Drakes Bay Oyster Company SUP Peer Review Draft Report (R100025958)

analytical procedures for determining effects on this threatened species. While a review of the NOAA Fisheries guidance document does suggest the possibility that the conditions in Drake's Estero could prevent concentrations from reaching effect thresholds, the analysis presented in Chapter 4 does not provide sufficient detail to determine whether CCA leachate would adversely affect juvenile coho salmon.

<u>Reference</u>: NOAA Fisheries – Southwest Region. 2009. The use of treated wood products in aquatic environments: Guidelines to West Coast NOAA Fisheries staff for Endangered Species Act and Essential Fish Habitat Consultations in the Alaska, Northwest, and Southwest Regions. Prepared on October 12, 2009. <u>http://swr.nmfs.noaa.gov/pdf/Treated%20Wood%20Guidelines-FINALClean_2010.pdf</u>. Accessed February 7, 2012.

2) Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.

The DEIS authors reach reasonable and scientifically sound conclusions for most of the analysis presented in Chapter 4 – Environmental Consequences. The scientific information used in the analysis is adequate and appropriate for evaluating the sediment disturbances associated with oyster cultivation (e.g., workers walking across intertidal sediments and propeller wash from boat traffic to and from cultivation racks) and the discharge of point and non-point sources from onshore facilities (e.g., oyster processing, shell storage, vehicle traffic, and on-site sewage treatment). The positive effect of bivalve filtration on water quality is appropriately described, and the high tidal flushing of Drake's Estero likely prevents the buildup of contaminants discharged from onshore and offshore facilities to thresholds that would adversely affect the benthic communities or most fish species.

The one instance where two different but equally reasonable sound scientific conclusions could be drawn concerns the potential impact of leachates from CCA-treated lumber on juvenile coho salmon. Based on the type and amount of information presented in the DEIS, it is possible to support either a conclusion of direct adverse effect or no direct adverse effect on this endangered species from exposure to CCA leachate. While the flushing rate necessary to dilute metals concentrations below the coho effects thresholds (NOAA Fisheries – Southwest Region, 2009) is likely exceeded in Drake's Estero, the amount of treated wood to be replaced annually also substantially exceeds the loading rates established by NOAA Fisheries to "not likely to adversely effect" coho salmon. Both NOAA Fisheries and the Western Wood Preservers Institute recommend site-specific evaluation when more than 100 pilings are proposed for a project. How this compares with "DBOC would repair or replace approximately 5 percent of rack structures annually, resulting in up to 1,285 feet of rack and 8,900 feet of new lumber installed per year" is unclear. Lastly, the NOAA Fisheries guidance document (2009) suggests that timing of treated wood replacement could offset any potential effects, but

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since this level of operational detail is not included in the DEIS, it is not possible to use this in making an effects determination.

3) Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.

As noted above, the DEIS has done a generally good job in identifying and applying best available science concerning the environmental impacts of oyster and clam mariculture on water quality. The one area of best available science to be expanded upon is the sensitivity of juvenile coho salmon to copper leached from CCA-treated lumber. Several scientific reports summarizing this effect, along with a spreadsheet developed by NOAA Fisheries for estimating the potential for effects based on current velocity and piling number and density are identified in NOAA Fisheries – Southwest Region (2009).

4) Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.

Several peer-reviewed scientific papers are cited in the guidance document published by NOAA Fisheries for Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultations that should be considered in evaluating the water quality effects of using CCA-treated lumber for dock and rack structure replacement on juvenile coho salmon (NOAA Fisheries – Southwest Region 2009).

5) Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

For the points made above, the basic scientific foundation of the DEIS treatment of water quality is reasonable, and it addresses the actions that could adversely affect water quality. Concerning the potential for CCA-treated lumber to adversely affect juvenile coho salmon, there are at least three options that could be considered to strengthen the scientific foundation:

- Option 1: Use the information and analytical procedures developed by NOAA Fisheries to determine the potential for adverse effects on juvenile coho salmon.
- Option 2: Review and propose the Best Management Procedures (BMPs) presented in NOAA Fisheries – Southwest Region (2009) to offset and mitigate any adverse effects identified in the analysis conducted in Option 1.
- Option 3: Review the scientific studies in NOAA Fisheries Southwest Region (2009) to develop the same level of analytical detail presented for other water quality impacts in the DEIS. Conduct the detailed analytical approach in the ESA and EFH consultation efforts that are reported as underway for the DEIS and will be required for the U.S. Army Corps of Engineers (USACE) permitting process as noted in the DEIS.

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Review of Draft Environmental Impact Statement Drakes Bay Oyster Company Special Use Permit

Christopher W. Clark, Cornell University February 23, 2012

I was asked to review Chapters 3 and 4 of the Draft Environmental Impact Statement (DEIS) (excluding visitor experience/recreation and National Park Service [NPS] operations), according to my area of expertise. My area of expertise is acoustics and bioacoustics, particularly as these pertain to the quantification and scientific interpretation of anthropogenic acoustic "footprints" on the natural acoustic habitats (i.e., wilderness) of free-ranging animals. Here, I do not comment on grammatical items or style that need correction (e.g., on page 213, 5th line up from the bottom, "When asked to identify *the* why a national park is important, the…"; or on page 365, 2nd paragraph, 3rd line, "30 November 2010 would allow…"). Rather, I concentrate on the DEIS sections of my expertise relative to the five following (5) questions.

- 1. Are the scientific interpretations and analyses presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.
- 2. Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.
- 3. Does the DEIS base its interpretations, analyses and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of each situation.
- 4. Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.
- 5. Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

Given the five tasks, I read and relied on:

- Chapter 3, Affected Environment, Impact topic: Wildlife and Wildlife Habitat, pp. 173 184.
- 2) Chapter 3, Affected Environment, Impact topic: Soundscapes, pp. 201 207.
- 3) Chapter 3, Affected Environment, Impact topic: Wilderness, pp. 207-212.
- 4) Chapter 3, Affected Environment, Impact topic: Visitor Experience and Recreation, p. 213
- 5) Chapter 4, Environmental Consequences, Impacts on Soundscapes, pp. 349-364. This evaluation is a function of the four alternatives (A, B, C, and D) and is enhanced by table 2-5 in Chapter 2.

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- a) Alternative A (No-action) expiration of the existing RUO and SUP.
- b) Alternative B another 10 years under 2010 conditions. Not clear if this is a one-time action, or might be open to extension for another 10-year period.
- c) Alternative C another 10 years under 2008 conditions, unpermitted facilities removed. Not clear if this is a one-time action, or might be open to extension for another 10-year period.
- d) Alternative D expansion of DBOC etc.
- 6) Chapter 4, Environmental Consequences, Impacts on Wilderness, pp. 364-378. The texts in parentheses are my abbreviated summations of that action.
 - a) Alternative A (No-action) expiration of the existing RUO and SUP.
 - b) Alternative B another 10 years under 2010 conditions. Not clear if this is a one-time action, or might be open to extension for another 10-year period.
 - c) Alternative C another 10 years under 2008 conditions, unpermitted facilities removed. Not clear if this is a one-time action, or might be open to extension for another 10-year period.
 - d) Alternative D expansion of DBOC etc.

Given these five tasks and the importance I placed on summarizing my evaluation of the DEIS document, I begin here with my summaries of the Chapter 3 Soundscape and Wilderness sections and the Chapter 4 Soundscape and Wilderness sections. Overall the document was very well organized, coherent and very readable.

Summary of Chapter 3 Soundscape and Wilderness Sections

Overall, I found that the Soundscape section provided compelling support for its conclusion that "low-frequency, high-amplitude, nearly omnipresent sound produced by roads, vehicles, airports, and mechanical equipment" can, degrade the acoustic habitat in a way that is similar to the physical degradation of the physical habitat caused by development or other human activities.

The data and synthesis presented in both sections support the conclusion that noise producing DBOC activities not only impact human experiences in the Drakes Estero but also have the potential to negatively effect wildlife in the Point Reyes National Seashore.

I conclude that there is ample acoustic scientific evidence by which the DEIS can determine that DBOC noise-generating activities have negative impacts on both the human visitor experience and the seashore's wildlife.

In addition, I can readily envision that further scientific study would substantiate the DEIS conclusions regarding the various acoustic impacts and influences of DBOC noise generating activities on the area's acoustic space and wildlife.

Summary of Chapter 4 Soundscape and Wilderness Sections

The data and synthesis presented in Chapter 3 and often reworked in Chapter 4, support the conclusion that present DBOC activities adversely impact human experiences in the Drakes Estero and have the potential to negatively effect wildlife in the Point Reyes National Seashore.

The scientific evidence presented leads me to conclude that this DEIS is robust, and that its recommendation for Alternative A is substantial and justifiable.

In addition, I can easily envision that a scientific study would actually document the relationship between removal of all DBOC structures and resulting changes in the natural wilderness acoustic soundscape and the experiences of visitors to the Point Reyes National Seashore.

My more specific comments for the sections in Chapter 3 are as follows:

 Chapter 3, Affected Environment, Impact topic: Wildlife and Wildlife Habitat, pp. 173 – 184.

Although this section does not specifically discuss acoustics, it underscores the value of Drakes Estero for wildlife, the impacts of human disturbance on habitat and wildlife, and in particular the critical importance of Drakes Estero for wildlife as maintained in its natural state. This is an important component in support of the document's following Soundscapes section.

2. Chapter 3, Affected Environment, Impact topic: Soundscapes, pp. 201 – 207. This section addresses one of the document's core issues referred to as Soundscapes, especially as it relates to the NPS *Management policies 2006* document and the *Director's Order 47: Soundscape Preservation and Noise Management* section regarding the maintenance and restoration of natural soundscapes in national parks.

This Chapter 3 Soundscape section:

- a. Provides a well-written presentation of basic acoustic metrics and concepts (e.g., decibels, L₅₀, soundscape, community noise).
- b. Provides some sound level data for Drakes Estero using standard techniques and metrics. Two sets of data are presented. Data (considered "best available and reasonable measurement") were collected in 2009 (Volpe 2011) from a site two miles from the onshore DBOC operations. They use A-weighted L₅₀ values, in dBA units, as the acoustic metric. As stated in the report: "These measured levels included noise from DBOC operations and other human activities, and they included natural sound energy from portions of the audio spectrum well above the noise energy generated by DBOC." Table 3-3 shows noise level values within close proximity to specific DBOC noise sources. According to this table these data were collected by Noise Unlimited, Inc. (1995) and represent two types of relatively small motorboat engines (20 horse power [HP] and 40 HP), a diesel forklift, pneumatic drills and an

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oyster tumbler. Noise level values in dBA are given relative to 50 feet from each of these sources. The document concludes that these measures are reasonable representations of the existing acoustic environment by which to make comparisons. It could be argued that the human noise footprints from DBOC activities could have increased since 1995, but this is never discussed.

- c. Articulates the notional concepts of a "value" that humans place on such things as "undeveloped character" and solitude. Visitors to national parks expect and place high value on wildlife experiences that are naturally authentic and unblemished by anthropogenic acoustic intrusions. The document's conclusions and synthesis on this topic are based on NPS survey results and apply especially to human acoustic experiences.
- d. Presents scientifically based evidence that wildlife species and populations depend on natural soundscapes for basic life functions (e.g., foraging, territory defense, sexual communication), and that there are costs to wildlife from the introduction of anthropogenic noise into the wilderness (i.e., acoustic disturbance.). References for disturbance are given to support the working assumption that the loss of the natural soundscape can have impacts across multiple taxonomic vertebrate groups (birds and mammals). I should mention that in the time since this document was completed further evidence has been accumulated to further support this conclusion of impact on wildlife from loss of acoustic habitat.
- e. Concludes that: "The noise from DBOC operations can detract from these values. The sounds serve as evidence of man's imprint on the natural landscape and can disrupt opportunities for solitude. Similarly, visitors wishing to enjoy a natural experience within the congressionally designated potential wilderness of Drakes Estero may not welcome these disturbances; noise may reduce visitor enjoyment of recreational use of the project area."
- 3. Chapter 3, Affected Environment, Impact topic: Wilderness, pp. 207-212. My concluding comments for the above "Soundscape" section readily apply to this "Wilderness" section. Thus, for example, the document's statement on page 211 that the combination of DBOC activities "results in an intrusion upon the solitude that is otherwise experienced by recreational visitors to Drakes Estero" is applicable here.
- 4. Chapter 3, Affected Environment, Impact topic: Visitor Experience and Recreation, p. 213.

This section of the DEIS states that the area of the Point Reyes National Seashore offers visitors "an outstanding opportunity for solitude while enjoying primitive and unconfined recreation. This is a hallmark quality of a designated wilderness area." Again, my concluding comments for the above "Soundscape" section readily apply to this "Visitor Experience and Recreation" section. The survey data presented in this section regarding local public attitudes are rather compelling regarding the conclusions as to peoples' values of the park as a unique recreational and experiential wilderness, where this experience includes quiet solitude and natural acoustic experience.

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My more specific comments for the sections in Chapter 4 are as follows:

- 5. Chapter 4, Environmental Consequences, Impacts on Soundscapes, pp. 349-364. The texts in parentheses are my abbreviated summations of that action.
 - a. Alternative A (No-action and expiration of the existing RUO and SUP.) This section summarizes the acoustic metrics caused by what are assumed to be typical daily DBOC activities. This section was well written. The conclusion that "Alternative A would contribute an appreciable beneficial increment to the cumulative impact," is totally reasonable and was supported by available data and scientific concepts. I could not find any support for the section's working assumption that "background sound levels and sound propagation conditions do not vary substantially between day and night." Furthermore, aside from human sounds, human caused noise by kayakers would also include noises produced by kayaking (e.g., a paddle hitting against the side of the kayak.). Although trivial acoustically, this was not mentioned.

Overall, this is a section for which it would have been beneficial for DEIS to present noise maps showing the spatial-temporal dynamics of DBOC noise on human communication space as well as wildlife acoustic space, especially given that NPS scientists are now pioneering the analytical mechanisms for and the interpretations of the results from such an acoustic mapping process. The document does provide some simple plots for noise footprints for Alternatives B.

- b. Alternative B (another 10 years under 2010 conditions.) This section is also well written and summarizes the acoustic impacts caused by what are assumed to be typical daily DBOC activities, including day and night considerations. The figures showing the spatial scales of noise impact are particularly useful for visualizing the extent of a typical DBOC acoustic activity. These definitely reinforce the DEIS conclusion that DBOC noise-making activities do and would continue to have major impacts on the human wilderness experience and likely wildlife, and that cessation of DBOC activities under Alternative A would be most beneficial to human experiences in the park and wildlife conservation.
- c. Alternative C (another 10 years under 2008 conditions, unpermitted facilities removed.). The document's conclusion is that impacts from this alternative would be similar to those from Alternative B, and I agree with this conclusion. Furthermore, with specific regard to soundscapes, Alternative C would certainly not further the goals of NPS soundscape management.
- d. Alternative D (expansion of DBOC etc.). The document concludes that impacts from this alternative would be greater than those as given under Alternative B or Alternative C. I agree with this conclusion that Alternative D would result in long-term, major adverse impacts on human experiences and wildlife in the Point Reyes National Seashore.

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- 6. Chapter 4, Environmental Consequences, Impacts on Wilderness, pp. 364-378. The texts in parentheses are my abbreviated summations of that action.
 - a. Alternative A (No-action and expiration of the existing RUO and SUP.). As in the section on Impacts on Soundscapes, this section considers and summarizes the wilderness impacts from typical daily DBOC activities and the benefits to the natural ecosystem that would result from the removal of those activities. This section refers to text and arguments laid out in Chapter 3. It is succinct and well written. The conclusion that "removal of DBOC facilities would result in a readily apparent, widespread enhancement of wilderness characteristics and would allow for the conversion of the approximately 1,363 acres of congressionally designated potential wilderness to congressionally designated wilderness," is reasonable and supported by available data and scientific concepts.

My comment above under Chapter 4, Environmental Consequences, Impacts on Soundscapes, pp. 349-364, Alternative A, 2^{nd} paragraph also pertain here. Furthermore, I agree with the conclusions in this section and find the arguments in support of Alternative A as the preferred action valid and substantial.

- b. Alternative B (another 10 years under 2010 conditions.). This section summarizes the adverse impacts on "wilderness character" that would persist under this action as a result of the continuation of typical daily DBOC activities. For example, continuation would allow the operation of motorboats in the Drake Estero six days per week, for approximately eight hours per day throughout the next ten years, resulting in the loss of such fundamental NPS values as solitude, primitive and unconfined recreation, and a natural acoustic habitat. Furthermore, the document states that acceptance of the Alternative B action would "prevent conversion of the 1,363 acres of congressionally designated potential wilderness within Drakes Estero to congressionally designated wilderness" and "would contribute an appreciable adverse increment to the cumulative impact." I agree with this conclusion and find the arguments in support of this conclusion valid and substantial.
- c. Alternative C (another 10 years under 2008 conditions, unpermitted facilities removed.). The document's conclusions are that impacts from this alternative would be similar to those from Alternative B. With specific regard to soundscapes, Alternative C would not further the goals of NPS soundscape management. I agree with these conclusions and find the supporting documentation in other portions of the DEIS scientifically robust, rational and compelling.
- d. Alternative D (expansion of DBOC etc.). The document concludes that impacts from this alternative would be even greater than those given under Alternative B or Alternative C. I agree with the DEIS conclusion that Alternative D would result in long-term, major adverse impacts on human experiences and wildlife in the Point Reyes National Seashore.

Review of Draft Environmental Impact Statement Peer Review Drakes Bay Oyster Company Special Use Permit

James E. Wilen, PhD., University of California, Davis

Socio-Economic Impacts

1. Are the scientific interpretations and analysis presented in the DEIS reasonable? If no, please identify those that are not and the specifics of each situation.

As I interpret my task, it is to assess the quality of the science used to assess socio-economic impacts of the various policy options assessed in the Draft Environmental Impact Statement (DEIS) for the Drakes Bay Oyster Company (DBOC). The policy options in question span a range from immediate closure of the DBOC (option A), to an extended lease of existing resources for ten years, at different scales relative to the current scale (options B,C and D).

For reasons outlined and elaborated below, it is my opinion that the methods used to conduct an economic assessment of policy options do not follow accepted economic impact analysis practice. The basic issue appears to be that the data required to conduct an economic impact analysis has not been gathered. That basic data would include, at minimum, measures of the value of gross sales and of the costs of labor and other materials for DBOC. As a result of data deficiencies, the analysis is not able to quantitatively scale the direct first round economic impacts. An adequately conducted economic impact study would contain, at minimum, a quantitative estimate of value-added associated with existing operations. In addition, there would be some attempt to measure the multiplier effects of direct impacts, by estimating the degree to which first round DBOC expenditures are spent and contained within the region and stimulate additional economic activity. A proper impact analysis would then estimate and report measures of quantitative impacts associated with changes from the status quo or baseline option (Option B).

Since this study does not quantitatively measure economic impacts, the authors are forced to summarize and assess impacts using qualitative judgments. These summary judgments are difficult to reconcile since there are no criteria set to judge whether an impact should be thought of as "minor" or "significant." As elaborated below, this leads to unsubstantiated inferences and interpretations of impacts that are difficult to judge reasonable.

2. Do the authors of the DEIS draw reasonable and scientifically sound conclusions from the scientific information presented in the DEIS? Are there instances in the DEIS where a different but equally reasonable scientifically sound scientific conclusions might be drawn that differs from the conclusion drawn by the NPS? If any instances are found where that is the case, please provide the specifics of that situation.

The terms of reference admonish me to avoid discussing "intensity definitions" or conclusions regarding intensity definitions since those are "derived from relative standards" that are therefore

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"within the sole province of the National Park Service (NPS)." It is thus not absolutely clear to me how to assess "conclusions from the scientific information presented in the DEIS" (italics added). That said, this report attempts to derive summary qualitative assessments of impacts without using much comparative data, or without defining terms associated with qualitative summary judgments. This leads to conclusions that are vague at best, and misleading at worst. Consider, for example, the summary conclusions about options A and B. Option B continues the status quo, and Option A removes the DBOC and all of its associated economic impacts. The report concludes that "alternative A would result in long-term, minor, adverse impacts on regional socio-economic resources" (italics added; page 393). In its assessment of Alternative B, the report concludes that B "would result in a long-term beneficial cumulative impact on regional socioeconomic resources." (italics added; page 397). But while A and B are symmetrical---B is the absence of A and vice versa-the choice of imprecise language makes option A appear more acceptable since the impact is deemed "minor." This is the difficulty with analysis that fails to quantify important critical impact variables. Without quantification, one is reduced to descriptors that are meaningless at best, and misleading at worst.

The conclusions in this report seem to adopt the notion that if an impact is "small" then it is equivalent to no impact. For example, the analysis on page 393 concludes that closing down DBOC (option A) would cause impacts that "would be detectable but would not affect the overall regional economy." This conclusion is derived by asserting that DBOC is not a big part of the overall regional economy and that its absence would therefore not be missed. This is a slippery slope. If various policies that incrementally have small impacts are examined in isolation, one might be led to conclude that they collectively have no impact. Imagine, for example, that we analyze a number of policies that each have small but negative impacts on the provision of park environmental services. Most would not be willing to conclude that, while each has a "detectable" impact, there is no affect on the overall park system.

If the analysis had followed standard impact analysis methodology, the report would have at least summarized the quantitative scale of impacts in a meaningful way. Quantification of impacts would be useful in informing the choice of sensible policy options since the options would be comparable. If this report had utilized standard methods, it would have an executive summary that would read something like the following (with hypothetical numbers).

"Option B, the status quo, continues current DBOC operations for another decade. This would result in a yearly direct impact to the nearby region of five million dollars in gross sales, and three million in value added, together with 31 full time jobs. In addition, each dollar of direct value added would result in a local multiplier effect of 1.6 for both second and subsequent round expenditures and employment due to the spending of owner profits, labor income, rents, etc. Thus the total yearly economic impact for Option B is 7.8 million dollars and 80.6 jobs per year. Over a ten-year period, the present value (at a discount rate of 3%) of the economic impact of Option B is 66.55 million dollars, and 806 person-year jobs.

Option A, which removes DBOC, would result in a loss of economic impact of 66.55 million present value dollars and 80.6 person-year jobs for each of ten years from the region."

Without meaningful numerical impacts, one is reduced to the questionable procedure of summarizing important consequences with vague and arbitrary adjectives ("detectable...but no impact," "beneficial" if DBOC is maintained, but "no impact" if it is eliminated") rather than meaningful and comparable numerical evidence that can be used in rational decision-making.

3. Does the DEIS base its interpretations, analysis, and conclusions upon the best available science? If any instances are found where the best available science was not used please provide the specifics of that situation.

My summary assessment is that the socio-economic impact assessment part of the DEIS does not embody the best available science. There is a well-developed methodology in the literature to conduct so-called economic impact analysis. That methodology draws from economic theory and utilizes data in ways that would be readily recognized by economists and other impact analysis practitioners. None of the relevant literature is acknowledged in this report; there is no scientific peer reviewed literature in the body of the report that describes the methodology used here, and there is no literature listed in the report on standard socio-economic impact analysis. Moreover, as outlined above, the standard procedures that are widely used in practice are not utilized here.

Economic impact analyses attempt to quantitatively assess how a region will be affected by a project or policy change. The guiding principle is the so-called "with and without" principle, namely that analysis should describe the use of all of a region's resources and the values they generate with and without the particular policy under examination. The analyst chooses a base or status quo setting, and assesses policy options vis-a-vis that base. For example, in this case, the baseline might be to assume that option B is in place, a continuation of the current DBOC operations at their recent scale. Then an impact analysis would ask: how would the adoption of any of the other options influence the contribution of the DBOC to the economy of the region relative to the baseline case? In this case, one would answer this question for all three other options including immediate elimination of DBOC (option A), as well as alternative increases in scale of activity (options C and D).

Economic impact analysis typically measures impacts by tracing the income flow throughout an economy, including sales from a facility, jobs, income levels and payroll from employment, expenditures for materials and other inputs, and other flows such as taxes. Analysis typically distinguishes between direct impacts that are "first-round" impacts in the sector in question, from indirect impacts, which are second round and/or induced impacts associated with the change in direct impacts. This implies that an impact analysis must begin with a reasonably accurate representation of the baseline or status quo role direct first-round impacts of the DBOC. One would want to begin the baseline analysis with, at minimum, a measure of the market value of sales or revenues from DBOC. Gross sales value would be a first focus since it is the basis for computing direct, first round impacts, sometimes also called value added. Value added would subtract from total revenues the expenditures for inputs purchased from outside the region in order to isolate income flows beneficial to the region in question. From gross sales value, an estimate of non-labor costs for materials and other input costs purchased outside the reference region is subtracted, and the net amount is the direct impact of DBOC. If option A were adopted, the direct or first round impact would be the loss of this net value added. If options C

or D were adopted, the direct impact would be any increases in the net value added associated with increased scale and operations diversifications.

Once direct impacts are computed, analysts then turn to indirect and induced impacts. Indirect impacts are the net values added by the flow of first round expenditures through the reference region in subsequent rounds of spending. For example, employees and owners of DBOC spend wages to purchase groceries, gasoline, etc., and owners of these businesses also contribute net value added by further spending. To compute the indirect impacts accurately, analysts often rely on models of regional economies, input/output analysis, and other impact assessment tools that trace income flows through an economy. Absent specific models calibrated to particular regions, analysts use multipliers to gauge the manner in which direct first round impact are multiplied by subsequent rounds of purchases and expenditures by industries that serve the focus of the study.

The existing economic impact analysis in this report does not even quantify the first round or direct monetary flow of value added from DBOC. Instead, the report focuses on physical quantities such as gallons of product, percent of total market, numbers of jobs, and housing. This is despite the fact that the report cites (pages 217-8) economic impact analyses of the park by the NPS in terms of value added and other common methods used in the economic impact literature. There appears to be little recognition that the NPS report uses standard impact analyses to evaluate the importance of tourism, and that these same techniques of analysis should be adopted for analyzing the impact of policy options associated with DBOC.

4. Are there any significant peer-reviewed scientific papers that the DEIS omits from consideration that would enhance the scientific quality of the document? Please identify such papers.

This question is relatively easy to answer because there are **no** peer-reviewed scientific papers referenced to support the socio-economic impact analysis. The report sections that describe the methods used contain no literature describing procedures used in this study or procedures commonly utilized to carry out socio-economic impact analysis. Furthermore, out of the 37 pages of references listed in the bibliography, there is not a single methodological reference on economics, economic analysis, or socio-economic impact assessment. To be certain, the report does reference the National Academy of Sciences (NAS) report and hence (implicitly) all of the references associated with the socio-economic analysis there. But the NAS report acknowledged at its publication that there had been no economic impact analysis done of DBOC options. Since this report does not contain new analysis, there is still no economic impact analysis of DBOC policy options.

There are a number of professional journals that regularly publish discussions of economic impact methodology as well as examples of specific studies. Some examples are the Journal of Regional Science, Journal of Travel Research, Annals of Tourism Research, Land Economics, Ecological Economics, Journal of Environmental Management, and Transportation Research Record. There are also numerous analyses of the economic impacts of fisheries, both recreational, commercial and aquaculture. Google searches reveal dozens if not hundreds of papers that report economic impacts of changes in policies that affect fisheries in professional journals, books, and gray literature and government reports. Finally, there are specific economic

impact analyses reported for aquaculture and mariculture operations such as oysters in the Chesapeake region. Many of these are readily available for downloading and they report methods and techniques used to project economic impacts and results of particular applications of impact methodology.

5. Is the scientific foundation of the DEIS reasonable and how can it be strengthened? Please identify any options to strengthen the scientific foundations.

In my opinion, the scientific foundation of the DEIS as it pertains to socioeconomic impacts does not follow standard practice and hence it is hard to conclude that it is "reasonable." At minimum, economic impacts need to be assessed in terms of regional economic aggregates that are typically used in impact analysis and that attempt to at least scale the direct first round effects in terms of dollars. This study does not report even the first-round impacts of DBOC, let alone estimates of indirect impacts. On the positive side, it does report jobs associated with the policy options, but jobs per se are not as meaningful as the payroll associated with those jobs. For reasons that are not clear to me, the report addresses housing used by current employees and housing conditions elsewhere in the region. Housing is not a part of accepted impact analysis as far as I am aware, and the attempts to say something about impacts of policies on housing are not coherent.

In addition to the foundations that are inadequate in this report, a key issue that is not satisfactorily addressed is the relationship and interconnection between visitor days to the seashore and the DBOC. There are various hypotheses that could be entertained, including: 1) having DBOC on site reduces park visitors; 2) having DBOC in operation has no impact of park visits; 3) having DBOC in operation draws more people to the park than would otherwise visit; 4) having DBOC does not affect the number of park visitors, but it changes the value of a visitor day (increases or decreases). Since many tourists chain together multiple destinations and experiences in a given trip, it is likely that there is some interaction among at least some fraction of park visitors. This has not been analyzed as an economic impact of any of the proposed policies except to conclude that it is not important relative to park visitor impacts. DBOC reports a significant number of tourist visits, on the order of 50,000 per year. If we take an extreme assumption that these visits are only associated with DBOC and not tied to park visits, then clearly there are additional impacts of the DBOC on the region. If 50,000 visitors spend \$100 per day, then there are additional dollars of annual economic impacts that have been ignored by this study together with associated multiplier effects. It may be, of course, that all of these visitors are traveling to the region to visit the park and that the visit to the DBOC is part of a trip. If this is the case, we would need to apportion expenditures across two destination targets, and this would reduce direct and indirect benefits.

Regardless of whether DBOC visits are independent from or associated with park visits, the expenditures associated with current DBOC tourist visits have been essentially ignored here. This is despite the likelihood that they measure at least as large or larger than the direct operational impacts of DBOC. Once again, the justification for ignoring them is to assert that, in relationship to the aggregate value of park visits, DBOC visits are relatively insignificant. This assertion of insignificance is supported by the assumption that park visits create values on the order of 100 million dollar per year, a figure borrowed from the NAS study. Unfortunately, the

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100 million dollar estimate is not a sound comparison for gauging the relative economic impact of DBOC. The number appears to be derived from work by Loomis, who summarizes research on the value of wilderness experiences. But the value referenced by Loomis is the net consumer surplus (averaging \$40 per day hence the estimate for 2.5 million seashore visitors of 100 million dollars). Unfortunately, net consumer surplus values are not used in economic impact analyses. Instead, economic impact analyses use net value added from expenditures by tourists on locally purchased items such as hotels, food, and recreational supplies. It is not clear what these expenditures are for seashore park visitors, or how they compare with the (incorrectly utilized) figure of \$40 per day of consumer surplus. In any case, a valid impact analysis would report the manner in which policy options are likely to quantitatively alter the values associated with visits to DBOC. Since this report has no basic data to compute these values, it simply asserts them to be small and hence for all intents and purposes zero. In this setting, the valued added associated with the actual expenditures for DBOC visits are likely to be significant, and of the order equivalent or more than the primary shellfish production value added. The correct procedure for conducting economic impact analysis would compute these impacts quantitatively, and add those to the primary impacts associated with DBOC production.

Another important component of the economic assessment that could be strengthened is the market level impacts of the DBOC. Because there has been only cursory assembly of economic data, the report resorts to vague and imprecise assessments of these market level impacts. In the end, the report concludes that adopting option A would have "long-term major adverse" impacts to California's shellfish markets because of the relatively large share contributed by DBOC. This is elaborated more by characterizing those impacts as "highly noticeable, "which would "substantially influence" California shellfish production, and would contribute a "substantial adverse ... impact." I am not certain what these terms mean, how to judge them, and how to compare them to (for example) the employment effects which, if DBOC were eliminated, would allegedly have "minor adverse" regional impacts. What is needed here is some simple discussion of the market, together with demand elasticities that might be derived from other literature, so that quantitative estimates of impacts could be estimated. Will the removal of DBOC have an impact on consumer prices? Will it cause changes in supplies to the California market, and if so, what kinds of impacts will these generate? These issues are often ignored in other impact analyses for which the industry in question is too small to have a market impact. In this case, the DBOC is large enough to impact the overall market and prices, and this impact should be included in an economic impact analysis.

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