ABALONE RECOVERY AND MANAGEMENT PLAN REVIEW

Summary of Review Comments
Abalone Recovery and Management Plan

The following review of the Abalone Recovery and Management Plan (ARMP) is submitted in response to Section 7062 (a) of the Fish and Game Code, which requires "external peer review of the scientific basis of marine living resources management documents." These comments were written by a panel of four scientists with diverse backgrounds and expertise in fisheries matters (see attached CVs).

The peer review panelists acknowledge that developing a recovery and management plan for abalone is a complex and challenging task, and commend the staff of the Department of Fish and Game (DFG) for the work it has done. Nevertheless, the ARMP contains deficiencies that are identified and discussed in the following paragraphs.

Report Organization

The report as presently organized contains a great deal of redundancy and is lacking a logical progression in the presentation of information. Terms should be more specifically defined. The ARMP contains many assertions that should be supported by citations of the scientific literature. Technical editing is needed.

- A fishery management plan is a framework document that guides decisions. As such, it should contain a systematic assessment of what is known and not known about the fishery, its history, management objectives, and options for actions. The general structure of a fishery management plan is to begin with an assessment of the current situation (legal environment, status of stocks, management, and socio-economics) followed by an evaluative history of the fishery, specification of objectives, identification of management alternatives to meet those objectives, evaluation of management alternatives for achieving those objectives, specification of a plan to monitor and evaluate progress toward meeting objectives, and identification of research and data needs.
- The white abalone status report (Hobday, A.J. and M. J. Tegner. 2000. Status review of white abalone (*Haliotis sorenseni*) NOAA Technical Memorandum NAA-TM-NMFS-SWR-035. May 2000.) is a good example of the technical level of writing that should be in the plan.
- Chapter 4 (legal framework) lays out the institutional context for abalone management. This should be brought to the front of the document.
- A positive aspect of the plan highlighted by the review team is its inclusion of criteria to guide changes in TACs and to evaluate different stages of resource recovery. The criteria could be made more specific in terms of their operational definitions, but the fact that quantitative criteria to evaluate decisions are included is praiseworthy. It indicates intent to take a systematic, adaptive approach to recovery and management. However, the decision programs specified will work only if they are rigorously enforced (i.e., standards are not lowered when abundance declines).

Costs/Funding

The management of the abalone fishery was previously conducted with insufficient fishery-independent data or technical expertise, which contributed, in part, to the present need for closures, quota reductions, and restoration.

- The average annual allocations for recovery assessments total $66,000 and management assessments total $68,000. This represents only 9% of the costs identified

to implement the management plan and is inadequate to meet the stated need for improved stock assessment. The reviewers recommend that funding for stock assessment should be increased.

- The funding from sport fishers reporting cards creates a dependent relationship between continuation of the fishery and implementation of this plan, which compromises the precautionary approach and the objective to re-build stocks.
- The reviewers recommend that funding for community involvement and public education should be increased.
- Lacking funding from other sources, increases in cost recovery from user groups could be explored for funding of research, fishery catch monitoring and other critical rebuilding elements.

Expected Elements

The ARMP is not in the form of a typical fishery management plan or recovery plan. It needs to be a technical, scientifically supported framework that policy makers can use to make management decisions.

- The summary of existing scientific knowledge of California abalone should be complete (i.e., include all relevant scientific information) and well-documented (i.e., supported by references).
- Both technical terms (e.g., "keystone species") and critical commonly used terms (e.g., "sustainable") should be defined.
- In addition to definitions, the report needs an operational basis for computing the value of defined terms to enable judging whether a definition or goal is met (i.e. The northern California fishery is referred to as "sustainable"; does that simply mean that it has not collapsed yet?)
- Both recovery and fishery management require a clear assessment of alternative ways of meeting well-defined, measurable objectives.
- Fisheries management should follow a precautionary approach, including a Control Law (a statement of actions to be taken for all possible states of the fishery) based on both Target Reference Points and Limit Reference Points. Table 7-2 is a step in the right direction.

See:
Shelton, P.A. and J.R. Rice. 2002. Limits to overfishing: reference points in the context of the Canadian perspective on the precautionary approach. Canadian Science Advisory Secretariat Research Document 2002/084.
It can be read here: http://www.ncr.dfo.ca/csas/

- Recovery planning should be based on a measure of risk such as Probability of Extinction, and should include Delisting Criteria (i.e., measurable means of determining that a population is secure).
- Both fisheries management and recovery require a plan for monitoring, evaluation and adaptive management.
- The ARMP should also include an analytical summary of the driving economic and ecological forces in the fishery, identifying essential, specific knowledge, critical uncertainties and needed research.

History of Abalone Fishery Management

The report contains historical information scattered throughout different sections. What is missing is an integrated assessment of the evolution of the present abalone management problem.

- An ecological-economic-management history of abalone stocks, their management, the fishery and fishing communities, would integrate these pieces of information in a way that would demonstrate how the different pieces of this complicated picture have fit together. To set the stage for recovery and sustainable management, the report should provide a

clear understanding of how the different components of the fishery have interacted to produce the present situation.

- A summary of the history of management actions could be produced from information contained in Appendix A and included here.
- The integrated history should go beyond a description of *what* happened to evaluate *why* things happened. For example, the history should not only include past management decisions, but why those decisions were made, why stocks were overfished, why management has been ineffective, and why the commercial and recreational fisheries developed as they did.
- The point of the fishery history section is to evaluate the biological, ecological, economic and management history of the fishery in a way that allows lessons to be learned from what has been done in the past and sets the stage for assessing management alternatives for recovery.

Quantitative Analysis

The ARMP does not contain the quantitative analysis necessary for stock assessment and population viability analysis. This aspect seems to be inadequately funded. Additional expertise in this discipline is needed.

- No size distribution or growth data are presented. These data exist and can be used to estimate population parameters necessary to assess the effects of size limits, fishing effort, etc. on catch, sustainability and population persistence.
- A more complete discussion of the effectiveness, efficiency, and statistical adequacy of timed and transect surveys is needed, including discussion of habitat destruction in invasive surveys, and time lags of information on recruitment.
- The level of poaching and its effects on populations need to be estimated (e.g., included in mortality rates).
- There is inadequate scientific basis for the TAC estimation, and other population goals given. A program for refining the estimate should be identified. The uncertainty in the TAC should be quantified and the consequences should be assessed.
- An operational quantitative expression for relative population jeopardy or risk is needed for each species. It should include population abundance, size structure and spatial structure.
- Criterion 1 is not related to population dynamics, and depends as much on sample size as on existing population size structure.
- Constituent involvement in surveys is a good idea, but plans for training and data verification should be included.
- Consider closer monitoring of removals (catch).

Human Dimensions

The human component of the abalone fishery needs much greater emphasis in the document. The present Chapter 3 (History and Socio-economics of the Fishery) is inadequate. The ARMP neglects to present a thorough review of the literature, omits important economic aspects of abalone, and contains technical errors in the presentation of economics.

- An economist or other social scientist, with expertise in fishing systems, should write Chapter 3.
- The unique economic and ecological characteristics of abalone make the human component a large part of the recovery and management problem. The chapter should contain information on human demographics (e.g. population changes in California coastal communities over time), abalone markets (domestic and international), ports of landing, and user groups.
- An evaluation of the interaction of management and markets over time and their influence on compliance should be included.

Management

Chapter 7 describes present management measures and provides some management alternatives for the future. What is missing from the discussion is analysis of the effectiveness of alternative management tools for abalone populations.

- This section should contain a literature review of other abalone management programs with an emphasis on the effectiveness of various management instruments in abalone populations elsewhere.
- The ARMP needs a clearer assessment of how various management alternatives meet the goals. The section should outline a wider array of management alternatives and assess their relative merits for the California abalone recovery and management regions. Management alternatives to assess would include closing the northern fishery, access limitation, size limits, spatial management (e.g. TURFs), temporal management (e.g. open/closed areas that change over time), community based property rights (e.g. co-management by area) or individual property rights (e.g. tradable quota share). These management alternatives should be assessed for their potential to contribute to recovery, enforcement, social and economic net benefits.
- The management section should also identify critical uncertainties (gaps in data and knowledge) and discuss alternative means to reduce them. These uncertainties should be accommodated not only in management decisions (through precautionary adjustments) but also in a monitoring and evaluation plan designed to generate information. There needs to be a clear plan for monitoring and evaluating the fishery and the abalone populations as part of adaptive management.
- Collapse of the southern California fisheries lead naturally to the question of whether the northern California red abalone fishery is on the same path to collapse. The ARMP does not demonstrate that the northern California fishery is sustainable, but it does outline a management plan in Table 7-2.
- The Department should demonstrate that the northern California red abalone fishery is sustainable. Additional data, such as size distributions should be presented and analyzed. Further analysis of the apparent lack of recent recruitment and the evidence for local serial depletion should be presented. Analysis of the expected effects of recent reductions in take limits should be presented.
- If the fishery is not closed now, and it is not sustainable, the management plan embodied in Table 7-2 may close it in the near future. However, it can be depended on to do so only if rigorously enforced, and the population will be at an even lower level and take longer to recover. If the fishery is not closed now, that enforcement should be ensured. The Department should compare the costs of closing the fishery now with the cost of closing the fishery later, when it has declined even further.

Inter-jurisdictional issues

The relationship between state management of invertebrate resources (including recreational abalone and commercial urchin fisheries), federal management of ESA-listed species, and management of marine invertebrate resources in other nations should be discussed in greater detail.

- The white abalone is listed as an endangered species under ESA and black abalone may be a candidate species. The ranges of six abalone species found in California (including white abalone) extend into Mexico. It is not clear what cooperative structures exist with Mexico to address ESA protections and the relationship between Mexico abalone fisheries and illegal harvest of abalone in California.
- Inter-state and international enforcement issues should be discussed.
- The impact of sea otter reintroduction under the MMPA and ESA on abalone stocks needs additional development and discussion.
- International scientific exchange is not evident in the plan and should be encouraged to improve management.

- Use of university resources should also be employed to improve management and supplement limited management resources.

Enforcement/Poaching

The ARMP acknowledges that illegal harvest (poaching) has a major impact on abalone stocks, both in closed areas and areas open for (recreational) harvest. Consistent and successful enforcement effort is crucial to abalone recovery.

- Measurable criteria for enforcement success need to be developed, and included in the plan, with a schedule for evaluation.
- It is important to understand who is involved in poaching (sport or commercial divers) and what markets (personal, local or international) consume poached product, in order to find ways to curtail poaching.
- Use of forensics and other scientific procedures should be implemented to enhance enforcement and prosecution of poachers. For example, genetic analysis could be used to definitively identify species that are not open for harvest.
- Enforcement alone will not resolve the problem, however, and further development of a multidisciplinary approach to compliance is needed.
- If fishery managers are not presently including estimates of illegal harvest as part of the total fishery-related mortalities, then this should be done by subtracting it from the TAC (Total Allowable Catch).
- Opening other fisheries, such as the commercial urchin fishery, should take into account areas where remnant populations of abalone exist, either to exclude those areas and reduce the potential for poaching, or closely monitor the fishery and assess the abalone populations pre- and post-fishing.
- To raise public awareness, and encourage compliance, outreach strategies should be more fully developed. As examples the public could be engaged through a "coast watch" to monitor local fishing activities, education curricula could be developed, and internet games and activities could be utilized. Mechanisms should also be identified which encourage communication and linkage between enforcement, managers, and the public. Educating the public to the impacts of poaching could exert "peer" pressure to reduce poaching and encourage reporting of poaching activities.

Ecological interactions

Understanding the ecology of abalone is essential to the purpose of the plan.

- The relationship between abalone and sea urchins is described in the plan, due to similarities in the ecological niche and coordinated management of fisheries. Review and research into this important relationship needs to be more fully developed. For example, the beneficial role of sea urchins to the protection of juvenile abalone may be more important on smooth substrate versus highly rugose substrates.
- The complex interaction between sea otter re-introduction and removal of competitive/beneficial sea urchins through the commercial sea urchin fishery highlights the pressing need for additional research into suitable/preferred habitat, grazing preferences, and other predator/prey relationships such as sea stars.
- Information about critical/preferred habitat should be mapped and used in management decisions for identifying MPAs, enhancement sites, and fishery openings/closures.

Genetics/diseases

The panel recommends that the ARMP:

- Review hazards of introducing sabellid polychaetes, withering syndrome and other diseases and novel genes into new areas with abalone translocations.
- Discuss the existing DFG shellfish health program as it relates to abalone.
- Discuss the effectiveness of this program (e.g., for freedom of diseases) in screening and certification of transplanted brood stock and or progeny to and from hatcheries and into the wild.

Brood stock management

The panel recommends that the ARMP:

- Develop protocol to assess and minimize impact of wild brood stock removal on the extant wild population (i.e., numbers and sizes), for culture programs.
- Develop less damaging methods for brood stock collection (e.g., use of sea stars) to reduce mortality during handling and transport.
- Consider genetic issues for brood stock maintenance, control of inbreeding (maximize genetic diversity, reduce potential for genetic bottlenecks), and impacts of out planting offspring.
- Attempt to develop and use withering syndrome disease resistant strains in different abalone species.
- Develop hatchery methods for optimum survival and production of high quality gametes.

Recovery experiments

The ARMP should:

- Develop a program for disease control and genetics management prior to translocation.
- Review literature with pros and cons of each rebuilding method already tried in California and elsewhere.
- Provide rationale for specific methods to be tested with estimated cost benefits.
- Describe possible experimental design (treatment replicates & controls), trying different spatial scales may be important.

Marine Protected Area (MPA) Issues

The ARMP should:

- Discuss how development of restoration methods and use of pilot studies in no-take MPAs (i.e., Channel Islands), where no interference from poaching can be assured, is a supported and a recommended approach.
- Define the goals and objectives of MPAs for abalone in terms of suitable habitat, area size and location frequency requirements, and how this approach is appropriate as a rebuilding tool (e.g., brood stock protection and potential larval transport to other areas).
- Discuss the pros and cons of establishing MPAs throughout California coast, in terms of ecological and biological benefits to abalone populations, and how poaching in these no take areas can be avoided.
- Discuss implications of oceanic currents to larval dispersal & transport to local and distant areas (sources and sinks) in relation to MPAs
- Acknowledge that size structure information from long-term protected areas is essential for stock assessment.

- Provide scientific evidence and references for the assertion that the breath-hold snorkeling fishery provides a “de facto” MPA and therefore formal MPAs are not needed in these areas.
- Manage the abalone fishery and MPAs consistently with each other.
- Implement a monitoring plan to accompany implementation of MPAs.

Louis W. Botsford
Professor
Department of Wildlife, Fish, and Conservation Biology
University of California
Davis, CA 95616
916-752-6169
FAX 916-752-6169
lwbotsford@ucdavis.edu

Education

June 1967 University of California, Berkeley B.S. Electrical Engineering
March 1975 University of California, Davis M.S. Electrical Engineering
September 1978 University of California, Davis Ph. D. Electrical Engineering
Ph. D. Thesis: Modeling, Stability and Optimization of Aquatic Productive Systems

Positions

1980-present Professor
Department of Wildlife, Fish and Conservation Biology
University of California, Davis

1976-1980 Postgraduate Reseacher
Bodega Marine Laboratory
Economic analysis of fisheries and aquaculture

1975-1976 Teaching Assistant
University of California, Davis

1968-71 Research Engineer
Lockheed Research Laboratories
Palo Alto, CA

Selected Publications

1997 Botsford, L.W, J. C. Castilla, and C. H. Peterson. The management of fisheries and marine ecosystems. Science 277:509-515.

1997 Botsford, L.W. Human activities, climate changes affect marine populations. California Agriculture 51:36-44.

1997 Cisneros-Mata, M. A., L.W. Botsford, and J. F. Quinn. Projecting viability of *Totoaba macdonaldi*, a population with unknown age-dependent variability. Ecological Applications 7:968-980.

1997 Botsford, L.W, and J. G. Brittnacher. Viability of Sacramento River Winter-Run Chinook Salmon. Conservation Biology 12(1):65-79.

1998 Smith, B. D., L.W. Botsford, and S. R. Wing. Estimation of growth and mortality parameters from size frequency distributions lacking age patterns: the red sea urchin (Strongylocentrotus franciscanus) as an example. Canadian Journal of Fisheries and Aquatic Sciences. Vol. 55, No. 5, pp. 1236-1247.

1998 Smith, B. D. and L.W. Botsford. Interpretation of growth, mortality, and

recruitment patterns in size-at-age, growth, increment, and size frequency data. *In* Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. *Edited by* G. S. Jamieson and A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 125:125-139.

1998 Wing, S. R., L.W. Botsford, and J. F. Quinn. The impact of coastal circulation on the spatial distribution of invertebrate recruitment, with implications for management. *In* Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. *Edited by* G. S. Jamieson and A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 125:285-294.

1999 Hastings, A. and L.W. Botsford. Equivalence in yield from marine reserves and traditional fisheries management. Science 284: 1537-1538.

1999 Botsford, L.W., L.E. Morgan, D.R. Lockwood, and J.E. Wilen. Marine reserves and management of the northern California red sea urchin fishery. CalCOFI Rep. 40: 87-93.

1999 Murray, S.N., R.F. Ambrose, J.A. Bohnsack, L.W. Botsford, M.H. Carr, G.E. Davis, P.K. Dayton, D. Gotshall, D.R. Gunderson, M.A. Hixon, J. Lubchenco, M. Mangel, A. MacCall, D. A. Mc Ardle, J.C. Ogden, J. Roughgarden, R.M. Starr, M.J. Tegner, and M.M. Yoklavich. No-take reserve networks: sustaining fishery populations and marine ecosystems.Fisheries 24: 11-25.

1999 Morgan, L.E., L.W. Botsford, C.J. Lundquist and J.F. Quinn. 1999. The potential of no-take reserves to sustain the red sea urchin (Strongylocentrotus franciscanus) fishery in northern California. Bull Tohoku Natl. Fish. Res. Inst. 62: 83-94.

2000 Morgan, L.E., S.R.Wing, L.W. Botsford, C.J. Lundquist and J.M. Diehl. Spatial variability in red sea urchin (Strongylocentrotus franciscanus) recruitment in northern California. Fisheries Oceanography 9: 83-98.

. 2000 Morgan, L.E., L.W. Botsford, S.R. Wing and B.D. Smith. Spatial variability in growth and mortality of the red sea urchin, Strongylocentrotus franciscanus in northern California. Can. J. Fish Aquat. Sci. 57: 980-992.

2000 Lundquist, C.J., L.W. Botsford, L.E. Morgan, J.M. Diehl, T. Lee, D.R. Lockwood and E.L. Pearson. Effects of El Niño and La Niña on local invertebrate settlement in northern California. Cal COFI Rep. 41: 167-176.

IN PRESS

2002 Botsford, L.W. and A.M. Parma. Uncertainty in marine management. Ch. 25 in E. Norse and L.Crowder, eds. Marine Conservation Biology. Island Press.

2002 Hastings, A. and L.W. Botsford. Are marine reserves for fisheries and biodiversity compatible? Ecological Applications

. 2002 Botsford, L.W., F. Micheli and A. Hastings. Principles for the design of marine reserves. Ecological Applications.

CURRICULUM VITAE

ALAN CAMPBELL

Mailing Address: Fisheries and Oceans Canada, Pacific Biological Station,
Nanaimo, British Columbia, Canada V9R 5K6
Telephone (office) (250) 756-7124
(fax) (250) 756-7138
email: campbella@pac.dfo-mpo.gc.ca

Education

B. Sc. 1967 McGill University
M. Sc. 1969 University of Manitoba
Ph. D. 1973 Simon Fraser University

General Field of Specialization

Population ecology. Current research is focused on population dynamics and fishery stock assessment of marine invertebrates (i.e., Abalone, Sea Urchins, Geoduck, and Horse Clams) in British Columbia.

Employment

1973-75. Postdoctoral Fellow, Agriculture Canada Research Station, Winnipeg, Manitoba. Stored Product Insect Ecology.

1975-78. Research Project Director, Dept. of Biology, Acadia University, Wolfville, Nova Scotia. American Dog Tick Ecology.

1978-88. Research Scientist, and Section Head, D. F. O., Biological Station, St. Andrews, New Brunswick. Population Ecology and Assessment of Lobsters.

1988-Present Senior Research Scientist, and Head of Abalone and Red Sea Urchin Stock Assessment Program, Shellfish Section, Stock Assessment Division, Science Branch, Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, B.C. Population Ecology and Assessment of Marine Invertebrates.

Publications

60 Peer-reviewed Primary Publications, 3 Book Chapters and 53 Technical Reports. One Primary, 1 Book chapter, and 13 Technical reports on Northern Abalone (publication references available on request).

Conference Proceedings

1.Chairman of Organizing Committee of International Workshop on Lobster Recruitment held in St. Andrews, N.B., July, 1985. Proceedings published during 1986 in Can. J. Fish. Aquat. Sci. 43 issue No. 11.

2.Coorganizer and Coeditor (for Proceedings) of North Pacific Symposium on Invertebrate Stock Assessment and Management held in Nanaimo, B.C., March, 1995. Proceedings published during 1998 in Can. Spec. Publ. Fish. Aquat. Sci. 125. 462p.

3. Chairman of Organizing Committee and Editor (of Proceedings) of an international Workshop on Rebuilding Abalone Stocks in British Columbia, February, 1999. Proceedings published during 2000 in Can. Spec. Publ. Fish. Aquat. Sci. 130. 158p.

SUMMARY CURRICULUM VITA

SUSAN S. HANNA
Professor, Department of Agricultural and Resource Economics,
Oregon State University Corvallis, OR 97331-3601
541/ 737-1437; susan.hanna@orst.edu

Education: Bachelor of Arts, With Distinction, University of Maine, Orono, Maine, 1966
Major in Sociology, Minor in Psychology

Master of Science, University of Maine, Orono, Maine, 1977
Major in Agricultural and Resource Economics

Doctor of Philosophy, Oregon State University, Corvallis, Oregon, 1981
Major in Agricultural and Resource Economics
Specialization in Natural Resource Economics and in Fisheries Economics

Selected Professional Activities and Associations:

- Science Advisory Panel, U.S. Commission on Ocean Policy
- Science Advisory Board, National Oceanic and Atmospheric Administration (Executive Committee)
- Social Science Review Panel, Science Advisory Board, National Oceanic and Atmospheric Administration (Chair)
- Independent Scientific Review Panel, Northwest Power Planning Council (Executive Committee)
- Independent Science Advisory Board, National Marine Fisheries Service and Northwest Power Planning Council
- Scientific and Statistical Committee, Pacific Fishery Management Council (Chair, Economics Subcommittee)
- Ocean Studies Board, National Research Council, National Academy of Sciences (Executive Committee)
- Marine Fisheries Advisory Committee, National Oceanic and Atmospheric Administration, U.S. Department of Commerce (Executive Committee)
- Board of Trustees, Fishery Management Institute, North Sea Centre, Hirtshals, Denmark
- International Association for the Study of Common Property (President)
- International Institute of Fisheries Economics and Trade (Executive Committee)
- American Fisheries Society
- Committee to Review Individual Quotas in Fisheries, National Research Council, National Academy of Sciences
- Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Research Council, National Academy of Sciences
- Committee on Science and Policy for the Coastal Ocean, Ocean Studies Board, National Research Council, National Academy of Sciences
- Editorial Board, *Ecosystems*
- Editorial Board, *Ecological Economics*
- Associate Editor, *North American Journal of Fishery Management*
- Research Program Director (Managing U.S. Marine Fisheries), The H. John Heinz Center for Science, Economics and the Environment

Selected Publications Since 2000:

Hanna, S. 2003. Economics of Co-management. Chapter 3 in D. Wilson, J.R. Nielsen and P. Degnbol, eds. *The Fisheries Co-Management Experience: Accomplishments, Challenges and Prospects* Dordrecht, the Netherlands: Kluwer Academic Publishers, in press.

Hanna, S. 2002. More Than Meets The Eye: The Transactions Costs Of Litigation in Federal Marine Fisheries. *Ocean and Coastal Law Journal*, in press.

Hanna, S. 2002. The economics of fishery management: behavioral incentives and management costs. In Pew Oceans Commission. 2002. Managing Marine Fisheries in the United States: Proceedings of the Pew Oceans Commission Workshop on Marine Fishery Management, Seattle, Washington, 18-19, July 2001. Pew Oceans Commission, Arlington, Virginia.

Hanna, S. 2002. Transition in the American Fishing Commons: Management Problems and Institutional Design Challenges. Pp. 151-173 in N. Dolšak And E. Ostrom. eds. *The Commons at the Millennium*. Cambridge: MIT Press.

Hanna, S. 2001. Managing the Human-Ecological Interface: Marine Resources as Example and Laboratory. *Ecosystems*, 4(8):736-741.

Hanna, S. 2000. Property rights and biodiversity. In S. Levin, Ed. *Encyclopedia of Biodiversity Volume 4*, San Diego: Academic Press.

Hanna, S. and M. Hall-Arber, eds. 2000. *Change and Resilience in Fishing.* Oregon Sea Grant, Oregon State University.

Hanna, S. 2000. Change and Resilience in New England and Pacific Groundfish Fisheries. Chapter 1 in S. Hanna and M. Hall-Arber, eds. *Resilience and Change in Fisheries: Experiences from New England and the Pacific*, Oregon Sea Grant, Oregon State University.

Heinz Center for Science, Economics and the Environment. 2000. (authors: S. Hanna, H. Blough, R. Allen, S. Iudicello, G. Matlock, B. McCay). Fishing Grounds: Defining a New Era for American Fishery Management. Washington, D.C., Island Press.

Hanna, S. 2000. Institutional Redesign for Pacific Northwest Salmon Ecosystems. In *Salmon Policy Under Uncertainty and Limited Knowledge*, under review at Island Press.

Hanna, S. 2000. Property Rights and Marine Ecosystems. In *Proceedings of the UN Conference on the Ecosystem Approach for Sustainable Use of Biological Diversity*, Trondheim Norway, 6-10 September, 1999

Hanna, S. and H. Blough. 2000. Implementing and Reauthorizing the Magnuson-Stevens Fishery Conservation and Management Act: A National Synthesis. Washington, D.C.: The H. John Heinz III Center for Science, Economics and the Environment.

July 2002

ROBERT E. SIZEMORE

Geoduck Program Lead Scientist, Fisheries Biologist
Washington Department of Fish and Wildlife
360-902-2827
sizemres@dfw.wa.gov

Education

B.S. Biology, Western Washington University, 1983
M.A. Science Education, Western Washington University, 1991

Positions Held

Lead Scientist, WDFW Geoduck Program, 1995-present
Fisheries Biologist, Washington Department of Fish and Wildlife, 1991-present
Fisheries Biologist, Washington State Parks and Recreation Commission, 1990
Fisheries Biologist, Alaska Department of Fish and Game, 1984
Fisheries Biologist/Foreign Fisheries Observer, National Marine Fisheries Service, 1983

Professional Memberships

National Shellfisheries Association

Awards

2000 Certificate of Merit, Washington Department of Fish and Wildlife
1998 Certificate of Merit, Washington Department of Fish and Wildlife
1997 Certificate of Merit, Washington Department of Fish and Wildlife

Selected Publications

2002. Rothaus, D.P., Sizemore, B.E., Ulrich, M.J., and Friedman, C.S. Trends in abalone (*Haliotis kamtschatkana*) abundance at ten sites in the San Juan Islands and the outlook for long term management of the species in Washington state. (In press)

2002. Sizemore, B. and Ulrich, M. 2002 Geoduck Atlas, Atlas of major geoduck tracts of Puget Sound. WDFW Annual Report (FPA02-05): 112 pp.

2001. Goodwin, L., Bradbury, A., and Sizemore, B. Final Supplemental Environmental Impact Statement, State of Washington Commercial Geoduck Fishery. WDFW and DNR: 135 pp.

2000. Sizemore, B. Management of geoduck clams (*Panopea abrupta*) in Washington State. J. Shellfish. Res. 19(1): 625.

2000. Bradbury, A., Sizemore, B., Rothaus, D., and Ulrich, M. Stock assessment of subtidal geoduck clams (*Panopea abrupta*) in Washington. WDFW Tech. Report (FPT00-01): 62 pp.

2000. Bradbury, A., Rothaus, D.P., Sizemore, R., Ulrich, M. A tag method for estimating the natural mortality rate of geoducks (*Panopea abrupta*). J. Shellfish. Res. 19(1): 690.

1995 - 2001. Sizemore, B. et al. Geoduck Atlas, Atlas of major geoduck tracts of Puget Sound. WDFW Annual Reports.

1993. Sizemore, R.E and Palensky, L. Fisheries management implications of new growth and longetivity data for pink (*Chlamys rubida*) and spiny scallops (*C. hastata*) from Puget Sound, Washington. J. Shellfish Res. Vol. 12, No. 1:145-146.