Testimony of Edward L. Miles to the Subcommittee on Oceans, Atmosphere, Fisheries, and the Coast Guard of the U.S. Senate Committee on Commerce, Science, and Transportation, Seattle Aquarium, Seattle, WA., May 27, 2008

My name is Edward L. Miles and I am the Virginia and Prentice Bloedel Professor of Marine Studies and Public Affairs in the School of Marine Affairs at the University of Washington. In addition, I hold a joint appointment in the Evans School of Public Affairs and an Adjunct Appointment in the School of Aquatic and Fisheries Sciences. I also serve as Co-Director of the Center for Science in the Earth System (CSES) of the Joint Institute for the Study of Oceans and Atmosphere (JISAO), where I am the team leader of the Climate Impacts Group (CIG), the first of NOAA's Regional Integrated Sciences Assessment (RISA) teams. The CIG was created on July 1, 1995.

The Committee has asked me to address the following issues:

1. Summarize the work of the Climate Impacts Group and explain how this work enables an understanding of climate change and its effects on Washington's marine and coastal ecosystems.
2. Discuss the integrated approach that interest groups in Washington have taken to understand and adapt to climate change.
3. 3. Describe specifically how the University of Washington, the Pacific Marine Environmental Lab, the state of Washington, and local communities are working together to address climate change issues.
4. Discuss the implications of climate change for coastal and ocean resource managers and the needs of managers to effectively respond to the resulting impacts.

Since it will not be possible to respond to all these questions orally in the time allotted to me, I shall respond in my written statement provided in the record and, for my oral presentation, I shall present the challenges which climate change poses to the region's oceans and coasts and focus on the new and very serious problem we now face in the world ocean as a whole. This is the problem of ocean acidification combined with a changing ocean thermal structure.

The Work of the CIG

The CSES consists of the Climate Dynamics Group (CDG) and the CIG as a completely integrated "one-stop-shop". The CDG studies the physical climate system relevant to the Pacific Northwest and the CIG examines the impacts of climate variability and change on the Pacific Northwest, and produces climate information products and derived predictions (e.g. streamflow forecasts) for a large set of local stakeholders.

Formed as a spin-off of Miles' experience in the Second Assessment of the Intergovernmental Panel on Climate Change (IPCC) in 1994-1995, the CIG focuses on developing climate impacts science as the study of how climate, natural resources, and human socio-economic systems affect each other. This requires the integration of

physical and social science research, as well as the integration of stakeholders' perspectives (federal, state, tribal, local, private sector, and NGOs).

With core support from NOAA, we focus on four sectors: the regional hydrology/water resources management, forest ecosystems, aquatic ecosystems (primarily salmonids and the ecosystem structures and fisheries of Puget Sound and the Northern California Current System, including the coastal zones of Washington and Oregon). We study the dynamics of climate variability as a basis for making projections of likely scenarios of climate change.

The Emerging Integration of Interest Groups in Washington in Understanding and Adapting to Climate Change

How we got to where we are now can be described as a series of steps. It is an evolutionary unfolding rather than the result of a deliberate strategic plan.

1. We began with an initial focus on understanding climate variability in the PNW and impacts across the four sectors. We shared the results of our investigations with stakeholders from 1995-1997 in general annual meetings of declining utility.
2. 1997-1998 was a year of transition defined by two major experiences. These were the First National Assessment of climate change impacts on the U.S., conceived and implemented in the Clinton Administration by then Vice-President Al Gore, and the most intense El Niño of 20th century. The latter event generated intense interest in climate which was sustained by widespread media coverage. With combined additional investment from NOAA and UW to expand the outreach capacity of the CIG, we hired Dr. Philip Mote to be our 2nd climate dynamicist, focused on the general circulation models (GCMs) of IPCC and CIG specialist in charge of outreach. In addition, we shifted to custom-made workshops for interest groups across the four sectors. CIG emphasis was then equal between climate variability & climate change; currently we place a heavier emphasis on issues related to climate change. Between 2000 and 2005 we expanded our contacts with stakeholders and deepened our connections to those who had joined us early.
3. A new threshold was crossed as a result of increasingly observed effects of climate change combined with exercise of leadership by NE states, California, the Chief Executive of King CO., the Mayor of Seattle, and the Tri-State Governor's Initiative involving California, Oregon, & Washington by 2004. In 2005 we participated in a highly successful collaboration between King CO and the CIG in the form of a workshop for >700 people in Quest Field covering eight sectors of the PNW. Collaboration with King Co continued in the design and preparation of an adaptation Guidebook for Local Governments and on joint research projects. Research results began to support policy development at this stage.
4. In 2007-2008 collaboration occurred between the CIG, the Washington Legislature, and the Governor's Initiative on Climate Change. Agreement converged on an eight-sector assessment of likely climate change impacts (HB 1303 & 2860). This initiative is overseen jointly by the Division of Community, Trade, and Economic Development (CTED) of the Office of the Governor and Washington Dept. of Ecology. An increasingly close and very effective collaboration between CIG & Ecology has emerged across all areas.

Collaboration between UW, NOAA/PMEL, NMFS Northwest Fisheries Science Center, NMFS Alaska Fisheries Science Center, and Local Communities to Address Climate Change Issues

The University of Washington has very great strengths in the earth sciences and particularly so on matters related to climate dynamics, climate impacts, and climate change. This expertise is distributed across the following units:
1. The Program on Climate Change (PCC) combines as core units the School of Oceanography, Dept. of Atmospheric Sciences, and Dept. of Earth and Space Sciences. The principal foci are research, education, and outreach. PCC also involves the Quaternary Research Center, the Applied Physics Laboratory (APL), JISAO, the CIG, and NOAA's Pacific Marine Environmental Laboratory (PMEL).
http://www.uwpcc.washington.edu/
2. JISAO is a "center of excellence" fostering collaboration between NOAA and UW on research themes which are allied with NOAA's strategic plan. These include climate, environmental chemistry, marine ecosystems, and coastal oceanography.
http://jisao.washington.edu The CSES/CIG is also based in JISAO.
http://cses.washington.edu

Examples of the ways in which these organizations combine and recombine to deal with problems of climate impacts would include collaboration between CSES and the NMFS Northwest Fisheries Science Center on the investigation of harmful algal blooms in Puget Sound; on improving rebuilding plans for overfished West Coast rockfish stocks through inclusion of climate information; on modeling studies to support conservation planning for Pacific Salmon; on developing quantitative tools for evaluating the effects of climate change on the population dynamics of Pacific salmon; and on predicting the responses of wild Pacific salmon to climate change.

Another area of activity which was launched in April 2007 concerns the comprehensive investigation of the impacts of changing ocean thermal structure and increasing acidification in the Northeast Pacific Ocean. This effort integrates the efforts of CSES, UW School of Oceanography, School of Aquatic and Fishery Sciences (SAFS), School of Marine Affairs (SMA), and Friday Harbor Laboratories (FHL) with NOAA/PMEL, the Northwest Fisheries Science Center, the Alaska Fisheries Science Center, and the Marine Conservation Biology Institute. The workshop established a priority for building a mesocosm at FHL as a national facility for the purpose of conducting experiments on the impacts of ocean acidification and agreed on a Steering Committee to move the programming forward. Since then the Steering Committee has secured a grant from the Educational Foundation of America combined with a contribution from Dean Arthur Nowell to hold a workshop to produce a detailed design for the mesocosm. The Steering Committee is currently engaged in developing a fundraising effort for constructing a mesocosm as well as for beginning a substantive research program, the first steps of which have been outlined. These investigations will be conducted in an "end-to-end" mode involving fundamental and applied science connected to identification and evaluation of alternative approaches to mitigation of and adaptation to the combined problem drivers of acidification and changing ocean thermal structure.

Linked to, but going substantially beyond the acidification problem is an activity that combines the strengths of NOAA/PMEL with APL at UW and King County to determine a regional carbon budget for the Seattle area. A comprehensive plan is now being developed in the form of a White Paper. However, even before the plan is finished, NOAA/PMEL has collected carbon samples from a winter cruise conducted by the PRISM Program at UW. More samples will be collected this summer to get a first look at the carbon budget of Puget Sound. As a first step in the implementation of a continuous monitoring system, PMEL has emplaced a CO_2 mooring off Aberdeen, WA. for the purpose of measuring surface water and atmospheric CO_2. This mooring has been operating for the last two years. These tentative steps are very important for a number of reasons. As local governments seek to reduce their emissions of CO_2 they will need to develop the capability to verify that policies enacted are reducing emissions as intended. This capability requires an in-depth understanding of sources and sinks of the gases which are targeted for reduction. That understand would be substantially enlarged by a monitoring system such as the one being designed in the collaboration between NOAA/PMEL, UW/APL, and King CO.

Of the eight sectors identified in the HB 1303 investigation, two involve ocean problems. These are Coasts, Estuaries, Harbors, Salmon and Marine Ecosystems. In the former category, the legislation requires CIG and its partners to estimate to what extent rising sea levels and ocean temperatures will impact the coasts, estuaries, and harbors of the State of Washington through inundation, increased flooding, and/or erosion. In the latter case, the legislation requires assessment of the extent to which climate change will alter the state's streams for salmonids, and where and under what conditions is salmonid habitat most vulnerable to direct (rising water temperatures) and indirect (habitat) effects of climate change.

The Implications of Climate Change for Ocean and Coastal Resource Managers and the Needs of Managers to Respond Effectively to the Resulting Impacts.

Challenges Posed by Climate Change in the Pacific Northwest:
1. Changing ocean thermal structure (increasing surface & sub-surface heat) inducing large-scale biogeographic shifts of ecosystems, including commercial fisheries.
2. Increasing ocean acidification in both the North Pacific Ocean and particularly in the coastal ocean off the West Coast of North America with negative results for all species requiring calcium carbonate for building their skeletons and unknown effects for fisheries.
3. Increasing stratification of the water column as a result of changing ocean thermal structure, accentuated by increased input of freshwater from melting glaciers.
4. Expanding areal extent of oligotrophic gyres (i.e., waters rich in dissolved oxygen, but lacking nutrients & plant life).
5. Salmon, and salmon restoration programs affected by multiple stresses connecting both terrestrial and marine dimensions of the life cycle from watersheds to the open ocean.
6. Harmful algal blooms.

7. Coastal hypoxia.
8. Changes in the frequency and predictability of fisheries recruitment events as a result of cascading changes in the marine environment.
9. Very complex, but largely unknown, changes in nearshore structural algae (eelgrass, kelp) as habitat for a wide range of coastal fish species.
10. Changes in the magnitude and type of coastal hazards generated by varying levels of sea level rise and the ways these changes will impact coastal development and public infrastructure.

Managerial Needs
1. Increased information derived from expansions in monitoring capacity in the open & coastal ocean and Puget Sound.
2. Research & assessment tied to policy development.
3. Systematic evaluation of potential alternative suites of policy options to respond effectively to severe problems of multiple stresses in a changing environment.

In summary, over the past 13 years the CSES has engaged in a wide range of issue-driven scientific research and outreach related to the coasts and marine waters of the Pacific Northwest region. The region's needs for improved information and decision-support tools for managing marine resources is great, and threats posed by future climate change and ocean acidification will likely amplify existing decision-support needs in the very near future.