Marine Sanctuaries Conservation Series MSD-01-04

Olympic Coast National Marine Sanctuary: Proceedings of the 1998 Research Workshop, Seattle, Washington

November 2001

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Ocean and Coastal Resource Management
Marine Sanctuaries Division

About the Marine Sanctuaries Conservation Series

The National Oceanic and Atmospheric Administration's Marine Sanctuary Division (MSD) administers the National Marine Sanctuary Program. Its mission is to identify, designate, protect and manage the ecological, recreational, research, educational, historical, and aesthetic resources and qualities of nationally significant coastal and marine areas. The existing marine sanctuaries differ widely in their natural and historical resources and include nearshore and open ocean areas ranging in size from less than one to over 5,000 square miles. Protected habitats include rocky coasts, kelp forests, coral reefs, sea grass beds, estuarine habitats, hard and soft bottom habitats, segments of whale migration routes, and shipwrecks.

Because of considerable differences in settings, resources, and threats, each marine sanctuary has a tailored management plan. Conservation, education, research, monitoring and enforcement programs vary accordingly. The integration of these programs is fundamental to marine protected area management. The Marine Sanctuaries Conservation Series reflects and supports this integration by providing a forum for publication and discussion of the complex issues currently facing the National Marine Sanctuary Program. Topics of published reports vary substantially and may include descriptions of educational programs, discussions on resource management issues, and results of scientific research and monitoring projects. The series will facilitate integration of natural sciences, socioeconomic and cultural sciences, education, and policy development to accomplish the diverse needs of NOAA's resource protection mandate.

Olympic Coast National Marine Sanctuary: Proceedings of the 1998 Research Workshop, Seattle, Washington

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Silver Spring, Maryland
November 2001

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SUGGESTED CITATION

Bowlby, C. Edward, Barbara A. Blackie, and Julia K. Parrish (editors). 2001. Olympic Coast National Marine Sanctuary: Proceedings of the 1998 Research Workshop, Seattle, Washington. Marine Sanctuaries Conservation Series MSD-01-04. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Marine Sanctuaries Division, Silver Spring, MD. 84 pp.

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EXECUTIVE SUMMARY

The Olympic Coast National Marine Sanctuary (OCNMS or Sanctuary) planned and organized the 1998 Research Workshop as part of its mission to protect and improve understanding of its marine resources through research and education programs. The Sanctuary is also mandated to coordinate and facilitate information exchanges and sponsors periodic research workshops to that end.

The goals of the 1998 Research Workshop were as follows:

A. Highlight and prioritize research needs for the Sanctuary relative to the development of a framework for a five-year research plan;
B. Build on results from the Olympic Coast Marine Research Workshop of 1996;
C. Present recent/ongoing research;
D. Share multi-disciplinary information;
E. Select priority sites for multi-disciplinary studies; and
F. Promote student participation and research.

Pre-workshop information packets were sent to a targeted audience of marine scientists, resource managers, interested individuals, and students. This packet contained the major recommendations from the 1996 Research Workshop. It also contained a list of potential topics that would be open for discussion during the two-day workshop. The topics included:

- Funding partnerships for long-term mooring(s) for temperature, salinity, dissolved oxygen, current velocity, chlorophyll *a*, turbidity;
- Ways to promote student participation and research;
- Ways OCNMS could support and/or leverage existing programs as well as new projects;
- El Niño Southern Oscillation effects;
- Harmful Algal Blooms effects;
- *Tenyo Maru* restoration plans;
- Marine biodiversity; and
- Introduced species.

To promote a multi-disciplinary information exchange and to highlight general disciplinary areas, the Sanctuary invited a series of speakers to provide overviews on: 1) the Sanctuary program; 2) the bigger NOAA (National Oceanic and Atmospheric Administration) picture; 3) Coastal oceanography; 4) Harmful algal blooms; 5) Trawl surveys and habitat types; 6) Geological surveys; 7) Intertidal ecology; 8) Sea otter and subtidal surveys; 9) Pinniped population trends; 10) Seabird colonies; and 11) At-sea distribution of seabirds.

The Sanctuary also solicited researchers to share information on their on-going investigations off the Washington coast. Twenty-two abstracts were submitted and are included with the proceedings, as part of the Sanctuary's mission for information exchange.

After plenary presentations, the 68 participants broke into concurrent focus group sessions that addressed the following disciplinary topics: 1) Nearshore Communities; 2) Fish and Shellfish Biology; 3) Seabirds and Marine Mammals; 4) Physical and Biological Oceanography; and 5) Cultural and Historical Resources. To assist in formulating recommendations and priorities for the Sanctuary's research program, facilitators led the groups through a discussion list. Representatives from each group reported back to the re-assembled plenary session on their major findings and recommended priorities.

Recommendations from the Workshop included several basic needs and identified several outstanding data gaps. The need to inventory living and cultural/historical resources, as well as following-up with long-term monitoring, was identified throughout. Participants also recommended that monitoring include distinctions between natural versus anthropogenic influences. High-resolution seafloor mapping, for both living and cultural/historical resources, was noted as a primary data gap.

Assessing linkages between offshore, nearshore, and watershed processes was highlighted, as well as the need for year-round information on currents and other physical parameters.

The need for centralized databases to be shared across disciplines was another common theme. Requests were also made for resource inventories to be placed in GIS for both researchers use and for public awareness.

Several groups expressed interest and concern with harmful algal blooms, from both an ecosystem level as well as a harvest-related concern.

Participants cautioned that more information was needed before the selection of which long-term monitoring sites or indicator species could be determined. The use of endangered/threatened species as criteria versus using trophic-based or habitat-based communities was discussed.

The Workshop concluded with a note of thanks to all the participants for their very constructive recommendations and comments.

Keywords: Olympic Coast National Marine Sanctuary, research workshop proceedings, research plan, NOAA, marine resources, physical oceanography, biological oceanography, harmful algal blooms, marine fish, shellfish, marine mammals, seabirds, intertidal, subtidal, kelp, macroinvertebrates, macroalgae, introduced species, biodiversity, El Niño, long-term monitoring, cultural and historical resources.

INTRODUCTION

Invitations and announcements for this workshop were mailed to attendees of the first Olympic Coast National Marine Sanctuary (OCNMS or Sanctuary) research workshop that was held in 1996 (Strickland 1996), as well as other interested individuals. The targeted audience included: 1) marine scientists and resource managers, and 2) interested individuals and students. Prior to the workshop, attendees received the following information:

Workshop Goals:

- Highlight and prioritize research needs for the Sanctuary relative to the development of a framework for a five-year research plan (participants were referred to the research section of the Final Environmental Impact Statement/Management Plan for OCNMS [NOAA 1993])
- Build on results from the Olympic Coast Marine Research Workshop '96 (Strickland 1996)
- Present recent/ongoing research
- Share multi-disciplinary information
- Select priority sites for multi-disciplinary studies
- Promote student participation and research

These information packets also contained background topics that the Sanctuary was proposing for potential discussion items at the workshop.

Potential Discussion Topics:

- Funding partnerships for long-term mooring(s) for temperature, salinity, dissolved oxygen, current velocity, chlorophyll *a*, turbidity
- Ways to promote student participation and research
- Identify ways OCNMS could support and/or leverage existing programs as well as new projects
- El Niño Southern Oscillation effects
- Harmful algal blooms effects
- *Tenyo Maru* restoration plans
- Marine biodiversity
- Introduced species

Participants were informed in the pre-workshop packets that the workshop would build on major recommendations from the first Sanctuary research workshop (Strickland 1996). These recommendations were sent to participants and are listed in Table 1.

The workshop agenda is shown in Table 2. The plenary sessions were audiotaped and are summarized below under plenary speaker names. Representative reports from each focus group were also audiotaped and are outlined under their respective disciplines.

Numerous abstracts and posters were submitted for the workshop and are recorded in Table 3. A table of acronyms used during the workshop is listed in Table 4.

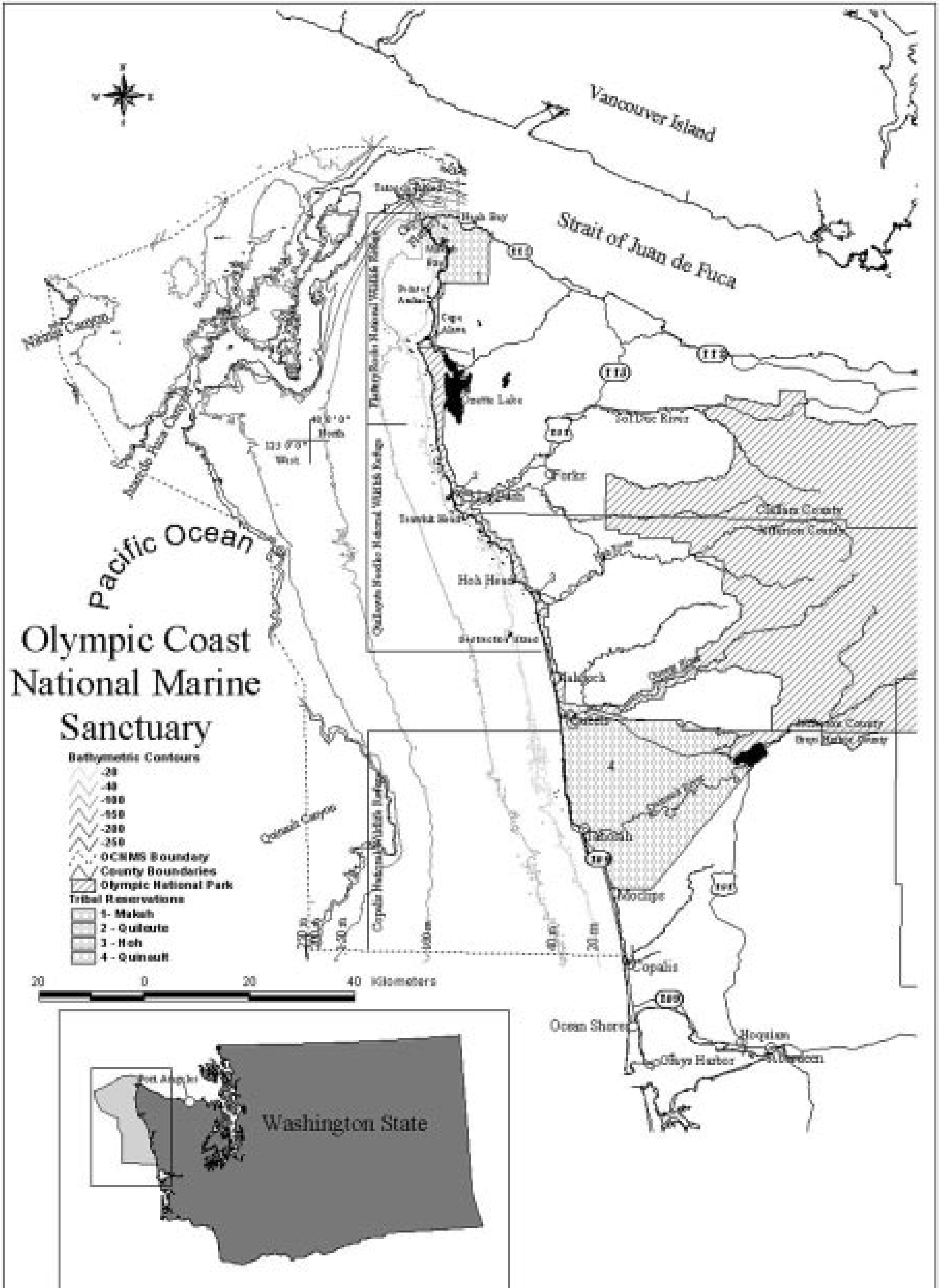

Figure 1. Chart of Olympic Coast National Marine Sanctuary

PRESENTATIONS

Workshop Overview - Ed Bowlby, Research Coordinator, NOAA/OCNMS

The workshop was convened on the morning of February 12, 1998, at the National Oceanic and Atmospheric Administration (NOAA) facilities in Seattle, Washington. Approximately 68 participants (Table 5) from various agencies, universities, and disciplines attended. Ed Bowlby, Research Coordinator for the OCNMS and co-convener of the workshop, outlined the workshop goals and provided an overview of the logistics for the two-day workshop. He directed the participants' attention to the information packets provided prior to the workshop, stating that this was the roadmap for the next two days. The plenary session continued through early afternoon, and consisted of invited speakers highlighting marine resource issues and general disciplinary topics.

Concurrent sessions followed the plenary presentations. These breakout, focus groups discussed pre-selected discipline topics (Table 6) which were summarized onto worksheets. Individuals were also asked to rank their professional or organizational priorities within worksheets, which were tallied after the workshop. Poster viewing and a no-host social hour concluded the first day's activities.

Participants convened the following morning as a plenary session. Focus group representatives reported preliminary findings and initial round-table discussions were held. The workshop concluded in the afternoon with an attempt to develop consensus on the discussion list and to provide recommendations for research priorities and direction.

Workshop Goals - Julia Parrish, Assistant Professor, University of Washington

Julia Parrish, co-convener of the workshop, research representative on the Sanctuary Advisory Council, and an Assistant Professor at the University of Washington's Zoology Department, focused attention on the purpose of the workshop. She encouraged participants to think about what research endeavors were really needed on the outer coast. Participants were to make some suppositions about what research needed to be done, and what research initiatives could be done within the confines of funding and personnel availability. To this end, she encouraged participants to explore options for cooperation and integration of existing programs, including state, federal agencies, tribal, academic programs, and various funding sources including private foundations.

Several examples of existing integrated efforts to leverage funding and research/monitoring were given. The *Tenyo Maru* Trustees had funds for restoration efforts as a result of an oil spill in 1991, and they were well on the way to figuring out what the restoration efforts were going to be. The Sanctuary had been affected by the oil spill, so the Sanctuary stood to benefit both in terms of restoration and in terms of monitoring. Parrish mentioned the Pacific Northwest Coastal Ecosystem Research Study (PNCERS), which incorporated the Sanctuary as well as the southern parts of Washington and on down into Oregon. PNCERS involves many players from several states, academic institutions, and agencies. The new Cape Flattery Trail combined funding efforts from the Makah Tribe and Washington Department of Natural Resources (WDNR). People with differing interests had been able to work together within the bounds of the Sanctuary. She asked the participants to identify what research they were doing and, specifically, what was working well. This type of information would assist the Sanctuary in building a comprehensive research plan.

Sanctuary Program - Todd Jacobs, Sanctuary Manager, NOAA/OCNMS

Todd Jacobs, then the Olympic Coast Sanctuary Manager, thanked the assembled participants on behalf of NOAA and OCNMS, for spending the two days to help the Sanctuary put together a research plan. He outlined how the Sanctuary supported various resource programs and how these programs fit into the Sanctuary's research plan.

Jacobs highlighted some of the Sanctuary's history. The Olympic Sanctuary was designated in 1994, making it a recent addition to the National Marine Sanctuary System. The boundaries extended for a little more than half of Washington's outer coast. The offshore boundary approximated the continental shelf break and the coastal boundary extended from approximately Cape Flattery down to the Copalis River for about 135 linear miles of coast (Figure 1). This very pristine area encompasses the coastal strip of Olympic National Park, the offshore National Wildlife Refuge islands and the Usual and Accustomed fishing areas for four treaty tribes (the Makah, Quileute, Hoh and Quinault). It included many management partners, including the tribal entities, the state agencies, and the academic community. Todd reiterated that as of 1998, there were only 12 National Marine Sanctuaries in the entire country, so these areas represent special recognition and a significant commitment from NOAA and the federal government.

Todd outlined how sanctuaries worked and described the three main tenets of the National Marine Sanctuary System:

- To provide comprehensive resource protection
- To help coordinate research and education activities within a Sanctuary
- To ensure compatibility of these multiple-use areas (some commercial activities are allowed such as commercial fishing and shipping) with the above mandates.

Marine Sanctuaries provide a framework that facilitates coordination of the various activities that occur within their waters. They provide a catalyst for making activities happen and they promote national visibility, which could be used as leverage for facilitating partnerships. Sanctuaries function with an emphasis on partnerships. Jacobs stated that this workshop emphasized partnerships as well.

OCNMS provided support to marine research primarily through its in-kind contributions. The Sanctuary's major in-kind support included: 1) the operation of OCNMS's research vessel, the R/V *Tatoosh*; 2) ship time aboard the NOAA Ship *McArthur* (or other ships if available), which conduct surveys within the Sanctuary each summer; 3) research coordination; and 4) limited financial support.

Sanctuary Facilities

The NOAA Ship *McArthur*, a 175 foot research vessel, supports multi-disciplinary projects, including: 1) oceanographic collections (conductivity-temperature-depth (CTD) and acoustic doppler current profiler (ADCP) data) in conjunction with the University of Washington (UW) and NMFS; 2) harmful algal bloom investigations, with the UW and NMFS; 3) marine mammal and seabird surveys with Washington Department of Fish and Wildlife (WDFW) and Cascadia Research Collective (CRC); 4) investigations of floating algal mats for juvenile rockfish with the WDFW; and 5) geological work with United States Geological Survey (USGS). These investigations had been competitively ranked and combined together in a 24-hour operations plan that maximized use of ship time.

Jacobs provided a description of the Sanctuary's 36-foot workboat, the R/V *Tatoosh* as well as the OCNMS small field station, which was made available to scientific parties, generally in conjunction with *Tatoosh* projects. The field station is located at the United States Coast Guard (USCG) Station in Neah Bay and accommodates up to six people. OCNMS also has a 22-foot, rigid-hulled inflatable boat (RHIB) with GPS, radar, and twin outboards, capable of being launched by trailer from various locations.

The R/V *Tatoosh* conducts operations four to five months of the year while based at Neah Bay. It is equipped for many kinds of nearshore operations and has excellent navigation systems (DGPS), hydraulics, compressor, and salt-water connections on the deck. In earlier years it has supported seabird surveys with the WDFW, sea otter work with the Biological Resources Division (BRD) of USGS, benthic habitat work with California State University at Monterey Bay (CSUMB) and University of California at Santa Cruz (UCSC), and some archeological survey work for historical shipwrecks in the Sanctuary.

Financial Support

The Sanctuary occasionally provided modest financial support to selected research projects. During 1995-1998 Olympic Coast National Marine Sanctuary funding was approximately $600,000 dollars a year. Total staffing amounted to 12 or 13 individuals, which included a permanent staff of 5, with addition contracted summer staff. The staff included interpreters, skippers, and other personnel. Financial support for individual projects ranged from $500 to $9,000. Although these funding levels were relatively low, OCNMS was still able to provide leverage for additional funding by facilitating partnerships and coordinating research activities.

Research Workshop Results

Results of workshops such as the 1998 Research Workshop would be used to formulate the OCNMS five-year Research Plan. OCNMS envisioned interdisciplinary and interagency collaborations and partnerships as the backbone of the research plan. Partnerships would maximize the value and relevance of the research being carried out on the outer coast. Jacobs views the research plan, not as the Sanctuary's alone, but as a collaborative effort. He stated that not all the goals would necessarily be possible or obtainable due to the lack of available funds. But he suggested that over the two days of the workshop, the participants might make some commitments to the eventual implementation of some of research goals that are identified. Jacobs mentioned that many excellent programs currently operated off the coast, and he challenged the participants to help coordinate these programs and raise the level of research opportunities.

Jacobs then introduced Don Scavia, the former head of NOAA's Coastal Oceans Program and Chief Scientist at and National Ocean Service (NOS), who discussed how NOAA and NOS reorganizations offer opportunities to help OCNMS and other agencies gain more leverage and commitment to research and resource issues. Scavia discussed the big picture of NOAA and NOS and how the development of the new science office would provide opportunities and partnerships.

Bigger NOAA Picture - Don Scavia, National Oceans Service Chief Scientist

Don Scavia, the Chief Scientist at NOS, detailed the "*big picture*" of NOAA by referring to recent remarks made by President Clinton. Several times in the past month, the President had talked about the past few decades as being "*the era of physics*" and the next several decades as "*the era of biology.*" Scavia concluded that when the President mentioned biology, he was also talking about the areas of biology that marine researchers are interested in.

In a second context, then Vice President Gore had asked for the development of a report card for the health of the nation's ecosystems. In response, the White House Science Office created a team of federal and state governmental scientists, academicians, and representatives from private industry, to design such a report card. Coastal/Marine Systems was one of the three sectors included in the first pilot of the national report card. This developed into an opportunity to highlight coastal and marine areas and to start identifying opportunities and needs.

Although a heightened awareness of coastal issues from the federal government is positive, actual funding for NOS programs is a much better measure of progress in attracting attention for NOS policies. With regard to attracting funds, Scavia speculated that the future would be interesting and exciting. Within the White House Science Office and its Committee on the Environment and Natural Resources (CENR), there was growing support for a major interagency initiative on ecosystems. Scavia explained that, although budget initiatives sometimes did not advance in Washington, this organization had generated the Natural Disaster Reduction Initiative in the previous year, which amounted to hundreds of millions of dollars. Therefore, if the initiative went forward, a multiagency and multi-disciplinary effort led by the White House Science Office could be manifested in significant increases in budgets.

National Ocean Partnership Program

The National Ocean Partnership Program (NOPP) is a relatively new program consisting of 12 agencies focusing on funding ocean research and development. For example, the Program helped the U.S. Navy allocate its research budget, which approached $20 million in 1998. Funding allocation from NOPP was a competitive, peer-review process with annual calls-for-proposals. NOAA had requested that funds for the partnership program be moved into mutual areas of interests for both NOAA and the Navy. NOPP was a potential funding opportunity for Sanctuary research in future years.

In the past, the emphasis of the National Ocean Partnership Program has been on coastal ocean observations and predictions, baseline information, data access, and marine education. Physical oceanographic studies have dominated the programs sponsored by NOPP, but Scavia anticipated the program would be placing more attention on coastal activities, on land-sea interfaces, and on ecosystems in the future.

NOAA Developments

In 1998, NOAA went through a protracted analysis and then Administrator Jim Baker decided that NOS would be strengthened in two ways. First, it would refocus on coastal ocean issues by transferring global water oceanography programs out of the National Ocean Service. There were also developments on transferring the aeronautical charting part of NOS to the Department of Transportation. Most of those transfers had been accomplished.

The second part of the strengthening endeavor was to build a strong, responsive, and protective coastal science compliment within the National Ocean Service. That meant re-establishing a strong senior scientist for NOS and consolidating some of the stronger programs and laboratories into a new science office in NOS.

To meet that end, NOS would establish a senior scientist position. The role of that position would be to work with others in developing and overseeing a science policy for NOS, which had not been done before. The senior scientist would ensure that NOS science programs, were healthy, and appropriately connected to talented researchers external to NOS. The science programs would retain their high quality stature over time, and the senior scientist would provide national leadership for coastal ecosystem science.

National Centers for Coastal Ocean Science

In addition to reestablishing the senior scientist position, a science office was being created. It would support and conduct coastal ocean and Great Lakes monitoring, research, and assessment, as well as provide technical assistance. NOS would accomplish this by bringing together significant critical mass of internal and external programs. The new program, named the National Centers for Coastal Ocean Science (NCCOS), would be modeled after the National Centers for Environmental Predictions, an organization of the National Weather Service. NCCOS would consist of five centers.

The first would be the Center for Sponsored Research, which would include the Coastal Ocean Programs and the National Partnership Programs, both proposal driven and peer reviewed. The second center would be the Center for Coastal Monitoring and Assessment. This center would combine existing NOS monitoring programs, such as National Status and Trends' Mussel Watch, and a portion of the former Strategic Environmental Assessment Division in NOS, with the primary initial focus on habitat. The third center, the Center for Coastal Fisheries Habitat Research, was designed to be the premiere habitat research laboratories in the country with a new facility constructed in Lafayette, Louisiana. The fourth center, the Center for Environmental Health and Bimolecular Research in Charleston, was known previously as the National Fisheries Service Laboratory and it already had strong programs in toxicology, marine forensics, and other chemistry-based activities. Connected and working with that lab was a cooperative fish pathology lab in Oxford, Maryland. Finally, the fifth center would be the Center in the Great

Lakes Environmental Research Laboratory. In addition to the laboratory in Ann Arbor, which focused on environmental and ecological research and physical oceanography on the Great Lakes, additional facilities for this lab were in the development phase.

Scavia explained that NOS was working hard to develop a partnership with the Environmental Conservation Division (ECD) of the Northwest Fisheries Science Center (NWFSC) in Seattle, so that in the long term, the ECD would include a NOS presence on the West Coast.

At present, this was only a vision of what the offices would look like, and very little of that vision was actually in effect. Various pieces of the program required approval at different levels. In the meantime, Scavia asked the participants to engage in a little bit of 'let's pretend,' assuming that the new organization already existed and was starting to function. Specific relationships between the centers and the academic community would be forming and some connections would be developed through a competitive ranking approach while others would be through cooperative avenues. Rules of engagement would be developed between the centers and the management and operational parts of NOS, NOAA, and other state and federal partners.

The creation of these centers would not be easy. The expectations would be very high for this new organization, in fact the demands would be incredible at this point because only 10% of the organization would actually exist inside NOS, with the remainder scattered around the country. The toughest challenge in developing this activity would be to strike a balance between keeping the efforts scientifically strong and forward-reaching while at the same time being responsive to current needs.

Potential Partnerships for OCNMS

Scavia concluded by describing what he saw as potential opportunities between the Olympic Coast National Marine Sanctuary and the new Science Office. Most people were probably aware of the Coastal Ocean Program's PNCERS, which Julia Parrish had previously mentioned. Also in the Pacific Northwest, or what oceanographers would call the Northeast Pacific, was the Global Ocean Ecosystem Dynamics (GLOBEC) Program. GLOBEC was going to grow and evolve over time, and would be a program to follow closely. It had an outer coast and ocean focus that should be of interest to most participants. As mentioned previously, the National Ocean Partnership Program initiative had funding announcements every year and would likely focus closer to shore and more into ecosystems than it had in the past. This also would be administered through the Science Office. Coastal Ocean Program's Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) got a boost in 1998 because of the '*Pfeisteria* hysteria' on the east coast. This should be considered a great opportunity and it would not be exclusively focused on *Pfeisteria*. Scavia recommended that interested groups watch for the annual ECOHAB announcements.

In closing, Scavia promised that, over the next few years, more routine and more dependable ways to interact with the Science Office would develop allowing scientists to interact with other scientists.

Coastal Oceanography - Jerry Galt, Physical Oceanographer, NOAA

Before reviewing the oceanography and physical processes of the Sanctuary, Jerry Galt of NOAA's HAZMAT (Hazardous Materials) branch, explained that during his oceanography career he had opportunities to visit most of the nation's coastal areas and he ranked the Olympic coast as one of the most beautiful and scenic parts of the world.

Oceanographic and Physical Processes Within the Sanctuary

Galt described how the outer edge of the Sanctuary was under the influence of the California Current, a large scale, clockwise gyre that circles the North Pacific and is relatively quiet and stable offshore. Inshore, including most of the Sanctuary, seasonal winds are controlling. The Washington coast has two kinds of seasons, the summer season and the winter season. In the winter season, the flow is basically up-coast or south to north, and during the summer season, it reverses.

During the early 1960s scientists made a significant effort to locate the effluent from the Columbia River. Data showed that during the winter rains, sediment plumes flowed north, across the shelf. During the summer, the Columbia plume flowed south off the Oregon coast. Barbara Hickey at the University of Washington was the lead on analyzing the regional data.

Although most of the processes are understood, there were some areas of uncertainty. During the summer season when the general flow is south, the boundary between the California Current and the in-shore current mostly disappears. As that happens, the wind that is forcing the currents south also moves the water slightly offshore. Satellite thermal imagery reveals curls of cool water that materialize periodically. This moves flotsam offshore as well as signatures from the Columbia River plume.

During the winter, low-pressure systems cause the dominant winds to blow from the southwest, thus reversing the system, and the Columbia River plume moves north. The transition between these two seasonal patterns occurs in the fall. It can also lead to increased detection of bird mortality events along the beaches. But this can be an artifact of the transition, since organisms that have been dying in the ocean have been held offshore during the summer, and with the reversal in flow, can then be deposited on shore as if the result of a short-term event. Thus what might appear to be a short-term event might in reality be long-term events.

Winter and summer seasonal patterns are not always consistent off the outer coast. Winter flow, though usually northward with reversals in the summer flow, demonstrated within-season variability. That variability was important in ocean mixing and probably had some effect on habitat.

Another factor contributing to oceanographic variability, especially during the summer months, was stratification. For example, the lower, deeper currents tended to move north, such as the Davidson Current flowing north along over the shelf. During an upwelling event, that current could actually be entrained, suddenly appearing at the surface for a day or two. Galt was interested in this phenomenon because of the need to develop trajectories for oil spills. His group had experimented with deploying current moorings, but he also suggested using real time events, such as a spill itself, to actually map trajectories. He used the example of the Nestucca oil spill that occurred off the Washington coast in the 1980s, where the trajectory model actually predicted where it would flow, based on prevailing winds and known currents.

Galt discussed other smaller scale, oceanographic factors that dominated, or were significant for the Sanctuary. One such factor was the fresh water plume from the Columbia River. The water moved offshore and, with sufficient winds and direction, might pile up along the shoreline. This process made a small wedge that created a pressure force, that in turn drove a coastal, fresh-water current (10-15 km wide) close to shore. Although a number of rivers were located along the Washington coast, they were all relatively short and drained very quickly after storms. The Columbia, and the Fraser River in Canada, behaved differently. A relatively small current of low salinity could actually be detected in this area.

Bathymetric Influences in the Sanctuary

Bathymetric features controlled and tended to steer currents. The major feature was the Juan de Fuca Canyon that ran from the southwest to northeast, with a distinct hook into the Straits of Juan de Fuca. This caused a loop in the current, whether the current was moving north or south. This hook, combined with the Fraser River out-flow, could form an eddy-like pattern. This eddy could have closed circulation at times.

After providing the thumbnail sketch of what generally happened with the currents, Galt mentioned some specific effects, such as storm events. Off Washington storm events could have wind speeds of 80-90 knots. This created another phenomenon that was not completely understood, even though it was not uncommon. As the current moved north, the storm winds could force water to pile up in the canyon, precipitating a water surge into the Straits. This current tended to move on the south side of the Straits because of the Fraser River effect. Galt thought it was fairly common for it to travel a few kilometers east to the Pysht River, and on occasion as far as Port Angeles.

Questions from Participants

Oil fingerprinting. Galt was aware that this technique (identifying oil in the environment as originating from a specific oil spill event or a specific location of oil extraction), had been used during the *Nestucca* oil spill, but was not aware of its use by Canadian scientists for the *Tenyo Maru* oil spill. Although he complimented of the fine work of the Canadian scientists, he cautioned against putting too much faith in the technique of oil fingerprinting itself, saying that it was "*not an exact science.*" He mentioned that there had been trouble using the technique successfully in places as far-flung as Alaska and the Caribbean.

Drift cards. Galt discussed the use of this technique to discern current movements. His biggest criticism was that the return on them was very small, a tenth of one percent, so that it was difficult to say anything statistically conclusive about the results. He also mentioned that they had a slight sail and so were susceptible to windage. Nonetheless, he felt that their use could be provocative, interesting, and useful.

Shelf deepening. In discussions surrounding the United States Geological Service (USGS) and the Washington Department of Ecology (WDOE) study on beach erosion, some of the dialog included concerns that the shelf (from Tillamook Head to Point Grenville) was deepening due to loss of sediment and sand recruitment from the mouth of the Columbia. Galt discussed the dramatic changes in the sediment regime from the Columbia over the last 30 years in terms of outflow. Historically, (at least 30 years ago), the Columbia had two major floods, one in May when the big melt occurred and worked its way down the Columbia. The other flood occurred in October/November when the fall rains started and freeze-up had not started holding snow pack. The spring peak outflow was occasionally up to 1/2 million cubic feet of water per second. As the river got more and more developed, the actual characteristic of the outflow changed. For instance, the maximum values decreased to about 200 thousand cubic feet of water per second; 40% of the historic peak. In addition, the river no longer had a biannual cycle. Because of water storage, there is currently a fairly sharp peak high volume in May but the fall flow is relatively uniform. The fall peak, if there is a peak, is quite low, and subsequently there is a lot less sediment. This means that information gathered in the early 1960s on sediment transport from the Columbia might not be relevant.

As far as potential shelf deepening occurring north of Point Grenville through the rest of the coast, Galt was not aware of any shelf deepening in that region.

Harmful Algal Blooms - Jim Postel, Biological Oceanographer, University of Washington

Jim Postel, a biological oceanographer from the University of Washington, discussed the basics of harmful algal blooms (HAB), identifying what organisms were found off the Washington coast and where and when they occurred. He also addressed an important question - why they occur.

Postel gave some background information on his past work. He originally studied the Columbia River flow off the Oregon coast, and later on, he worked off the Washington coast at Copalis Beach. Early on in his career, Postel took note of the question his graduate advisor often posed, "*What kind of phytoplankton are off the coast?*" This question led him into his current career. Postel discussed the beauty as well as the taxonomy of the phytoplankton, giving a nod to Dr. Rita Horner, University of Washington, for her experience and expertise in phytoplankton taxonomy, both locally and around the world. He mentioned that Horner had a major influence on studies of HABs in local waters.

From 1990 through the present, Horner and Postel had been looking at the distribution of phytoplankton in Puget Sound and off the Washington Coast. They collected samples off piers and along the beaches using simple collection methods such as dipping buckets and nets into the water. The sites were all easily accessible by roads and short walks. Postel described some of the kinds of phytoplankton they commonly found.

Diatoms

Diatoms are a common group of phytoplankton they found on the outer coast. On typical stretches of ocean shoreline in the southern part of the Sanctuary, beaches are generally sandy and often the water has patches of brownish foam and scum at the surface. Usually this scum is comprised of concentrated populations of surface foam diatoms. These diatoms are prime food sources for razor clams. Diatom populations are highest during the fall and the winter.

The two researchers found that their samples rarely contained cells classified as harmful algal species. To be a harmful algal species, the phytoplankton has to either: 1) produce toxins that got into human food; 2) cause a fish kill; or 3) cause some sort of economic damage. In Washington, most problems involve organisms that produced toxins in shellfish, which in turn eliminate recreational claming, close commercial shellfisheries, and occasionally kill people. The diatom, *Pseudo-nitzschia* spp., produces toxins that affect birds and possibly marine mammals. There are many different types of *Pseudo-nitzschia*. For the most part the diatom appeared whitish with lentil shaped cells attaching at the head to form long chains. Some diatoms produced toxins and others do not. Identification was very difficult, and the detail of the shell patterns was needed to determine the species. Since 1991, Postel and Horner had been looking at one species in particular, trying to discern its distribution and the timing of its presence off the coast. It was one of the organisms that produce domoic acid.

Dinoflagellates

Postel discussed some of the dinoflagellates that showed up along the coast and were involved in paralytic shellfish poisoning (PSP). Paralytic shellfish toxin production affected people by accumulating in the shellfish and then into humans, if ingested. One species of *Alexandrium* showed up along the outer coast. Another dinoflagellate that showed up occasionally was *Heterosigma*. It appeared to be lethal to farmed fish and probably wild fish. They found this organism in Puget Sound, as well as occasionally off the coast, but its prevalence was unknown.

Cochlodinium

One species that researchers watched for, although not harmful per se, was *Cochlodinium.* On several transects surveyed during the 1997 *McArthur* cruise, *Cochlodinium* was observed in concentrations of more than 107 cells per liter. When it occurred in such high concentrations, it turned the water a spectacular chalky greenish-white color.

Pseudo-nitzschia Research in the Sanctuary

Postel and Horner had been seeing, very occasionally, small concentrations of some *Pseudo-nitzschia cultanium*, a domoic acid producing diatom, in their beach collections. However they appeared in low numbers even when shellfish themselves showed high enough levels of domoic acid to cause harvest closures. A small toxin data set, taken from Kalaloch Beach from 1992 through 1995 and analyzed by the National Fisheries Science Center in Conway, showed that toxin levels increased dramatically and then diminished over time. For years Postel and Rita had been trying to find the source of these peaks. They questioned what mechanism brought the phytoplankton to the shellfish beds where they were consumed by the clams. They also wondered how the shellfish were accumulating domoic acid since the *Pseudo-nitzschia* in their sample collections were not in high enough concentrations to cause the high toxin accumulation in the shellfish. They were extremely interested in getting samples from offshore. Their hypothesis was that the concentrated populations of *Pseudo-nitzschia* were offshore and were somehow swept onto the beach during specific oceanographic events. Then the clams, as part of their normal feeding activity, would ingest the *Pseudo-nitzschia*, as well as their normal surface foam diatoms, and they would accumulate domoic acid. But the researchers needed a way to get offshore to address that question.

Postel's research group got their first opportunity to collect offshore samples in 1995 through the Sanctuary program. They sent phytoplankton collection jars along with the Teachers-at-Sea Program aboard the NOAA Ship *McArthur*. Some of those samples revealed *Pseudo-nitzschia*. In 1996 the researchers themselves were invited participants on the *McArthur* cruise, and a more comprehensive collection of samples was taken. They returned in 1997 with a more specific sampling regime, trying to focus on areas where either high domoic acid in clams or high concentrations of *Pseudo-nitzschia* had been confirmed. They collected water samples and used the CTD rosette system to sample temperature/salinity profiles. Dr. Vera Trainer, from the NMFS Science Center, took measurements of domoic acid levels in the water. These were the first measurements they had been able to collect in coastal rather than shallow waters, and the first taken on the continental shelf in Sanctuary waters. In 1996 some of the individual samples had very high concentrations of domoic acid (greater than 1500/nanograms per liter in the peak measurements). In 1997, high concentrations of domoic acid were also found, but further offshore than in 1996.

In 1996, large numbers of *Pseudo-nitzschia* were present but were a species that had not previous been found to produce domoic acid. This was a new discovery for the area and would be historically valuable. Since that time, other researchers had shown that *Pseudo-nitzschia pungens* could produce domoic acid.

In 1997, yet another species of *Pseudo-nitzschia* appeared to be the most prevalent in the water, one that had not yet been identified completely. It was a very deeply silicified type.

In the individual transects sampled, different hydrographic conditions occurred in the north as opposed to the south. In 1996, the highest concentrations of domoic acid and *Pseudo-nitzschia* were all in the north, but neither was noted in the southern collections. In 1997, however, the distribution patterns were different. *Pseudo-nitzschia* was found in high concentrations in the south off Copalis Beach and in high concentrations (10^5 or 10^6 cells per liter) further offshore. A pocket of high concentration also, existed (about $10^{5.5}$), close to Cape Alava in 1996.

Their data set included information on the distributions of temperature, chlorophyll, and *Pseudo-nitzschia.* Postel showed examples of their data from an offshore transect by Portage Head, showing the water column from 0 to 45 meters. The figure showed a very thin layer of warm water at the surface, 14 degrees C and higher. The chlorophyll, for the most part, showed the highest concentration (greater than 10 micrograms per liter) in the upper 5 to 10 meters of water, demonstrating that the phytoplankton were normally at the surface because of the sunlight. The *Pseudo-nitzschia* concentrations roughly agreed with the chlorophyll maps, showing high concentrations in pockets of warm water. However, even though there were lots of *Pseudo-nitzschia* cells, they occurred with several other species, e.g., *Cochlodinium.* Although the concentrations of *Pseudo-nitzschia* could be high, they may only represent 25% of the total phytoplankton population in that area.

In the south, near Copalis Beach, the story was somewhat reversed. The warmest waters were close to the shore, the highest chlorophyll concentrations were close to shore, and the highest concentrations of *Pseudo-nitzschia* were also close to shore.

Summary

Postel reiterated that the question remained, "*Can we predict where we are going to see these things or whether we are going to see these things?*" What was needed, Postel offered, was a better understanding of the physics of how water moves, how the plankton grows, plankton trophic dynamics and genetic variability. Postel emphasized that Sanctuary cruises offered his research group a valuable opportunity to look beyond the beach in terms of sources and movements of harmful algal species.

Questions from Participants

<u>Correlations with ocean chemistry and physics</u>

Postel stated that their research was, as yet, unable to show a correlation between salinity or upwelling events and concentrations of *Pseudo-nitzschia* because of a lack of species data taken concurrently with such events. However, his research group had a proposal to look specifically at that question.

One researcher commented that, in recent plankton samples taken in the fall offshore of the Quinault reservation, higher concentrations of *Pseudo-nitzschia* had been seen than in the past, and that the samples did not seem to include many other species. However, Postel commented that the University of Washington's sampling had shown a high degree of variability with regard to concentrations of *Pseudo-nitzschia.*

Trawl Surveys and Habitat Types - Mark Zimmermann and Mark Wilkins, Fisheries Biologists, National Marine Fisheries Service

The goals of Mark Wilkins' presentation was to introduce the Alaska Fisheries Science Center and to inform the audience on what data they had and how the data and the Center could be useful to other researchers. He also would describe some of the historical data sets that had been collected over the years.

National Marine Fisheries Service

The National Marine Fisheries Service (NMFS) had five regional Science Centers on the Pacific coast. These include the Alaska Fisheries Science Center (AKFSC), the Northwest Fisheries Science Center (NWFSC), and the Southwest Fisheries Science Center (SEFSC). Ten years ago, the AKFSC and the NWFSC were one entity. When the original center was split into two separate centers, all the ground fish work went to the AKFSC, with offices in Alaska. Most of the salmonid work and coastal zone and estuarine studies work remained with the NWFSC, based in Seattle, Washington. The NWFSC was currently in the process of developing a strong ground fish presence in the Washington-Oregon-California region. But the AKFSC still did the majority of the trawl surveys and had done them since the late 1970s. Both Mark Wilkins and Mark Zimmermann worked with the Groundfish Assessment Task Force.

Triennial Groundfish Surveys, West Coast Region

The AKFSC conducts fishery-independent surveys, which consist primarily of two types of surveys: 1) bottom trawl surveys, and 2) hydro-acoustic, echo-integration, mid-water trawl surveys. They use some fixed gear methods to do some surveys (long-lines and pots and traps). The AKFSC's jurisdiction is broken into three or four different areas: 1) the Eastern Bering Sea and Aleutian Islands (considered one area), 2) the Gulf of Alaska, and 3) Washington-Oregon-California (the West Coast region). Among those three, there is a triennial rotation of major survey efforts, so every third year the West Coast receives a substantial amount of time to look at groundfish and pelagic resources off the coast. The survey year for the West Coast occurred in 1998.

The main focus of the surveys is to estimate the distribution and abundance of groundfish. The AKFSC use the data to describe the biological characteristics of groundfish resources in the area. They currently conduct two ongoing bottom trawl survey programs. One looks at the continental slope from 100 fathoms out to 700 fathoms. This began in earnest about 1988 and at that time, researchers only had about 4 weeks of survey time each year to collect data and it required a very intensive effort to fish at depths that deep. It took quite a bit of time to cover any one section of coast; for example, it took about 4 years to cover the entire coast north of San Francisco (from 1990 through 1993). This protracted survey time was a very contentious point when trying to look at stock assessments. In 1995 they implemented a program to extend their survey period and this allowed the entire west coast region to be surveyed in two years, (in 1995 they covered the top half, and in 1996 covered the bottom half). AKFSC still did not feel that this was good enough to get a synoptic view of the resource, so in 1997, they scaled back the density and enlarged the survey area and did the whole coast in 6 weeks. These triennial shelf surveys look at the groundfish resources between about 50 meters and 366 meters or 200 fathoms and, since 1995, extend out to 500 meters. The survey covers resources from Point Conception in California to half way up Vancouver Island. Concurrently there are hydro-acoustic, echo-integration surveys that cover from southern California to half way up the British Columbia coast.

Wilkins showed that most of the 1998 shelf survey was conducted within the Sanctuary boundaries. They collected temperature profiles and sometimes salinity profiles, however little oceanographic data was collected. The bulk of the data collected was biological data aimed at the groundfish resources; catch data, species compositions, size and age composition of the important ground fish, age at maturity and other biological parameters.

Most of the data went directly into the stock assessments that are prepared for purposes of managing groundfisheries. Abundance, distribution, and size and age composition were critical for stock assessments. Data was also collected for special projects that would improve knowledge about groundfish resources. Occasionally the researchers had extra time at the end of the surveys and used the time to do special studies, primarily aimed at improving the ability to conduct trawl surveys and obtain the best information. Some of those involved catchabiltiy of the survey trawl; others involved the habitat structure and community structures.

Mark Wilkins introduced Mark Zimmermann, his colleague at NMFS, Groundfish Assessment Task Force, who discussed the details of three of his groundfish research projects that include the OCNMS area.

Identifying Data Gaps in Groundfish Surveys

Zimmermann was interested in trying to determine where the data gaps were in triennial groundfish survey data and what it meant to the integrity of the data. The groundfish surveys involve dragging fishing nets along the seafloor. For the last few years Zimmermann had been trying to determine the areas along the coast where the researchers were actually prohibited from dragging a net along the bottom. Some areas encountered during the surveys were so rough and rocky that gear was not even put out because it most likely would have been lost. In other places, researchers tried to fish and deployed gear, but the gear ended up being torn, sometimes quite substantially.

As an example, Zimmermann discussed the Vancouver Area, from central Washington to southern British Columbia (BC), one of their northern most strata that overlapped with the OCNMS area. Zimmermann examined all the original data sheets for all the trawls that they had conducted along the coast. Over 4000 bottom trawls were taken from 1977 to 1995. He looked at all the anecdotal information that people had written on the sheets indicating if there had been any trouble with fishing with bottom gear, and, if there had been trouble, what the damage was. He wanted to focus on a small area that was ringed by the 100-fathom contour or 183-meter contour and the United States/Canada border. He categorized all the trawl attempts as either: 1) trawlable, 2) unsuccessfully trawled (e.g., nets hung up or lines shortened to avoid rocks), or 3) trawling avoided completely due to habitat. He used that information to map out untrawlable areas using ArcView, the GIS program NMFS used. His maps revealed a large untrawlable area in the southern part of the Sanctuary and several smaller ones scattered throughout. Within the Sanctuary, untrawlable areas existed in both shallow (55 to 183 meters) and deep (from 366 to 500 meters) strata.

Zimmermann then compared fish catches between trawlable and untrawlable areas. Preliminary results indicated that, for at least one species of rockfish, the untrawlable areas were very significant in terms of rockfish populations. More fish were found in the untrawlable areas (which represented about 20% of the strata) when compared to the number of fish in the trawlable areas (which represented 80% of the strata). Consequently, by being restricted to surveying primarily in the trawlable areas, researchers were probably under estimating rockfish populations.

Sediment Mapping

Zimmermann wanted to better understand the habitat of the trawlable areas, and toward that goal, he had been building a sediment map using published information. He had collected 2000 data points from various Masters', PhD's, and university project literature and had created a map for Oregon, Washington and southern BC. He hoped to use the map to describe trawl habitats and relate them to the catch data from the surveys.

Species Assemblage Analysis

Once those two projects were completed, Zimmermann planned to perform a species assemblage analysis of the catch data and relate the catch data to the sediments and the untrawlable areas. Originally he attempted to do this using some high-powered statistical techniques, such as factor analysis and cluster dendrograms, but results were unsuccessful due to the nature of the analyses. At this time he was studying the assemblage data using a relatively new technique called 'the cumulative percentage of plots' technique. Zimmermann briefly explained the technique using the following example. The data was first sorted by a specific variable of interest, such as water temperature, depth or latitude. The survey effort (approximately 500 trawl hauls per year), was sorted according to the variable, in this case, latitude. The data points were scaled to a percentage, 0 to 1 or 0 to 100, and the values were added up, for example, starting at 0 % and working up to 100 % of the last survey data point. Then the catch data was plotted using the habitat line as a reference. If you caught the exact same weight of a species of fish in each haul, the catch line would fall right on top of the variable line. If more of the catch was taken in the south, then the line would rise very quickly to 100 %, and would cross the reference line. In his data, rockfish were caught mostly in the north end of the survey area. In terms of latitude, no rockfish were caught until northern California and southern Oregon. Forty percent of the rockfish were caught by the time they got to the Columbia River and the rest, 60%, were caught from the Columbia River north.

Zimmermann then separated each species into size groups by weight: small, medium and large fish. Looking at the variable latitude, little difference in size distribution could be discerned. But in examining the variable depth, he found substantial differences in the distribution of the different size classes of rockfish at different depths. The large fish were in a substantially different depth range than the small fish. Without grouping the fish by size class, the composite of all the fish fell at an in-between depth. This depth did not describe any real group of rockfish and if that value was used in an assemblage analysis, the results could be quite misleading.

Questions from Participants

Black cod – Was more specific habitat work being done for black cod? Could Mark Zimmermann's work be analyzed to find out the more specific preferences for this species? Would such data affect quotas?

Zimmermann believed his data might be analyzed for this species, but with much difficulty. He did not know if that kind of information would influence how quotas were established. He mentioned that some work was being done on black cod at the NWFSC.

Sport fishing pressure – It was mentioned that sport fishing could put pressure on rocky refugia where large trawlers would not be fishing. Apparently sportfishing pressure was high on rockfish in central California, which negated the benefits of potential refugia.

Zimmermann could not attest to the amount of sportfishing pressure on rockfish that occurred off the Washington coast because most of his work was done further offshore where sport fishers did not usually go.

Geological Surveys - Pat McCrory, Geologist, U.S. Geological Survey (USGS)

Geologist Pat McCrory described the USGS's sea floor mapping project and a sediment processes study. She suggested that these two areas of expertise might be useful to the natural resource managers on the Olympic Coast.

The sea floor mapping project began in the summer of 1997 during the *McArthur* cruise. Predominantly, the USGS researchers conducted side-scan sonar mapping, which provided an image of the sea floor. They also took 100-meter deep core samples from the sea floor. The core samples provided an estimate of the thickness of the sediments making it possible to map distributions of bedrock, gravel, sand or mud deposits. This baseline dataset would provide a way to monitor any sort of change in sediment distribution in the future. These data could be used for many different purposes, including sea floor habitat mapping, which the Sanctuary is very interested in. The USGS would use the information in their Coastal Erosion Study and their Earthquake Hazard Study.

The second project McCrory discussed was a process-oriented study on coastal erosion, which looked at how sediment input from coastal streams was distributed in nearshore areas. In order to track these dynamic processes (which usually occurred during flood events), data was collected using instrument moorings stationed on the sea floor over an extended period of time. Geoprobes were left on the sea floor for several months. The probes took photographs documenting how sediments rippled across the sea floor. At the same time, they measured bottom currents, temperature, and other physical data.

During the *McArthur* cruises, McCrory and fellow researchers also collected bathymetry data. They used a bathymetric system on the port side of the ship, a seismic reflection sound source off the starboard side, and towed a side-scanning fishfinder off the aft A-frame. This provided real time images of what the floor looked like. McCrory provided some examples of their more interesting findings:

Grays Harbor Area Fault Zones

One surprising discovery was the presence of fault zones off the Grays Harbor area. Their images revealed an area of high bedrock with rocky outcrops where faults could be seen offsetting some of those beds. Side-scan images revealed a second fault zone nearer to shore. This fault zone contains a dike where mud had poured through at one time, probably created by methane gases rising up and erupting on the sea floor. Methane leakage can create high carbon concentrations, and unique bivalve and tubeworm communities can be associated with these types of areas. McCrory suggested that further exploration by biologists might be warranted.

McCrory next referred to the formation in the Grays Harbor area as a "fault boundary". She felt it was very important, in terms of earthquake hazards, to understand the activity of this fault.

Sediment Composition and Movement

McCrory and her research crew conducted sediment sampling and found rounded gravels in the shallower parts of the transect; in the deeper waters (about 70 meters), silty sand was present. Using these data, McCrory mapped out some of the sediment pathways from coastal streams.

Eighteen thousand years ago, during the glacial period, sea level was 120 meters lower than it is today. What exists now is a drowned shelf where much of the sediment was a relic from glacial times. Till and outwash from glaciation occurred from two glacial events, one occurring about 115,000 and the other occurring about 20,000 years ago. McCrory suspected that those glacial outwash sediments were the rounded gravels found in the samples taken off of Cape Elizabeth.

Another interesting piece of coastal geologic history was uncovered in 1967. Sediment samples taken on a UW cruise were analyzed for mineral content. The heavy concentration of minerals off of Grays Harbor could be traced to the Cascade volcanics of the Puget Sound area. One interpretation was that these sediments originated during glacial times, through the Chehalis River out of Grays Harbor onto the shelf, and those sediments were still there today. There were smaller sediment plumes off the major coastal rivers showing an Olympic Peninsula signature of minerals that were tied to the Olympic Mountains. Historically, sediment input from the Columbia River this far north of Grays Harbor was minimal, although to the south, there was quite a bit of input. During glacial times, the sea level was lower and it was thought that most of the sediment coming out of the Columbia River went directly into the Astoria Canyon, with very little escapement to the north (except during catastrophic floods as glaciation waned and things warmed up). Also, Lake Columbia had several catastrophic floods that eroded most of Eastern Washington and carried a tremendous amount of sediment out to the shelf.

Summary

The information gathered on the cruise was far-reaching geologically, as well as biologically. The bedrock high that was discovered seemed to be related to the tectonic boundary and appeared to still be active. The nearshore fault area was also an interesting discovery. The mix of sediments off the coast was not just coastal stream input, but contained sediments that came through the Chehalis River during glacial times. A strong component of the sediment was now coming from the south, from the Columbia River. The Astoria Canyon had, more or less, been shut off, and sediment could now travel north with the currents, where, historically, it could not.

Future research efforts would include collecting data further north in places such as Portage Head and Cape Flattery. McCrory indicated that she wanted to take a closer look at the Grays Harbor fault in order to discern how active it was.

Questions from Participants

<u>Methane seeps</u> – McCrory was asked to repeat the information regarding methane seeps being present at 17 meters. She said that the presence of methane seeps needed to be verified with sampling. Potential sampling of the identified areas were going to be conducted by Coastal Oceans Programs in the summer of 1998. Some dives, down to 6000 ft., had been conducted by

McCrory's research crew down-slope of the area in question during 1998. The divers found concretion slabs and some unusual marine invertebrates.

Petroleum hydrocarbons – McCrory explained that much offshore drilling occurred on the coast in the 1950s through the 60s. She was uncertain how someone would look for places where petroleum would be escaping. She mentioned that methane was associated with the compression and heating of sediments at the subduction zone.

Intertidal Ecology - Bob Paine, Professor, University of Washington

Bob Paine discussed biological variation in the Sanctuary area in light of the work he and his colleagues had conducted on Tatoosh Island (near Cape Flattery) for more than 30 years. He admitted a major conundrum in his study: Although the scientific community generally perceived that, in order to understand biological variation, it was necessary to look at it over extensive spatial scales, his work had been an intense, long-term study at only one site, Tatoosh Island. The variations that he observed were collected from one site, but over a long period of time. He found Tatoosh Island to be a biologically rich and variable area. He described the value of this type of long-term data set in helping understand biological variation regardless of the fact that it covers only a narrow spatial scale.

Project Background

His program began in 1962, as a long-term study funded by the Biological Oceanography Division of the National Science Foundation. It had been focused, not so much on monitoring or the excesses of sampling, but on establishing the background nature of a large number of the system's biological species. The program coupled this with experimental manipulation of all the elements. Over the years, the researchers had developed many techniques, and had looked at a wide variety of species, both plant and animal. The research intent had been to couple the patterns they observed from their sampling with the processes that developed those patterns.

Paine claimed that one could not assess variability if variability was driven externally to the system. One could make guesses as to what the causes might be, but those often tended to be guesses that were often compounded by the complexities of the environment. External forces that might drive variability in nearshore rocky intertidal communities included El Niño events, oil spills, and major winter storms. All impacted the nearshore community, and they produced local variation.

Internal forces also affected variability. Major variations in the life of an organism or a species occurred from year to year and from site to site. The study showed that some species had been diminishing in abundance for reasons that were often uncertain. And changes in abundance of one species had direct implications for the abundance patterns of others.

Paine briefly described the specifics of his work on Tatoosh, and its contributions beyond the scope of the scientific community. He and his researchers had been working there since 1968 with the approval and assistance of the Makah Tribal Council, and they worked exclusively on Makah tribal land. The site was visited as much as 80 days a year. They accessed the island by boat in the spring, summer and autumn months, and by helicopter in the winter. His research group usually consisted of about eight people, two individuals from the University of Chicago, himself, and graduate students and post-docs. Many of their findings had been published in the primary ecological literature. The resulting data was a very long term, high quality database, involving a large number of intertidal species, which had advantages for the Makah Tribe and the Sanctuary. One advantage was due to it being such a focused long-term study. It had received a certain amount of press in the literature and had attracted a lot of media attention. Julia Parrish's work on murres on Tatoosh was featured on National Public Radio. In a segment of David Attenborough's *Planet Earth*, almost all the intertidal images were filmed on Tatoosh Island. The work had been featured in *Audubon* magazine, on *Bill Nye the Science Guy* (Seattle TV science program), and in the national and international press. This sort of publicity had brought a lot of attention to the pristine nature and the biological importance of the Olympic Sanctuary. And this helped the press and the public identify why this was a precious piece of real estate that should be valued and protected.

A major problem in assessing biological richness was determining whether and how it changed. Paine demonstrated that the biological systems he studied were not in any clear, local equilibrium. They changed over time; species increased or decreased in abundance, and there was much natural variation. Individuals charged with identifying changes in species variation had to be able to distinguish between anthropogenic driven change and natural variation. Once you accepted the later, one had to be very sensitive to the former. It was very difficult to distinguish between the two unless a traumatic event, such as an oil spill, occurred. However many of these changes, could in fact, be quite subtle. For example, a die-off of starfish or sea urchins could be caused by a lack of recruitment, slightly increased water temperatures, or some departure from the normal pattern of offshore currents during larval recruitment.

Examples of Natural Variation on Tatoosh

Paine described Tatoosh Island as "A spectacular piece of marine real estate." The benthic community was very rich in species in those areas because heavy wave action produced a lot of disturbance and brought new resources to the benthic community. It was this disturbance regime that produced many of the distribution patterns on the shore.

One of the species that characterized the rocky shore intertidal was the outer coast mussel, *Mytilus californianus*, which is very susceptible to winter storms. During the winter of 1996-1997 about 50% of the intertidal mussel beds were removed. Storms were producing the patterning of mussels. Mussels were moved by the wave action, and this created bare patches for new mussels to invade. Mussels were immune to the forces of the storms when they were young and small, but by the time they were 6 to 7 years old, they were large enough and growing in layers so that they were susceptible to being swept away. These bouts of disturbance produced a mosaic of different-appearing patches. This pattern of diversity was natural and was an important aspect of the enrichment of the shore.

Paine discussed his thirty-year dataset on disturbance to mussel beds by winter storms. His data showed large inter-annual differences - some years showed very little disturbance and others showed mussel removal of greater than 50%. These peak disturbances seemed to be on a 6 to 7 year cycle or minimal rotation period. The peaks occurred under a variety of ocean conditions, including both cold and warm water events, so he found very little common cause for the disturbances. Whatever the causes, the data suggested that cycles of disturbance characterized the mussel populations.

Another factor determining mussel distribution on the Washington coast was predation by the sea star *Pisaster ochraceus*. This starfish set the lower limit of the distribution of mussels. Any change in *Pisaster* would have major effects on the nature of the shore. If *Pisaster* was removed or if its populations decreased, the lower limit of the mussel beds would move downshore and, in the process, effectively eliminate a large number of other characteristic species.

Iridaea cornucopiae, a red algae, was a common zone-forming species on the outer coast of Washington. Occasionally it bleached in the summer and turned into a characteristic white band of algae. This was common during summer months. This characteristic algal species had an epilithic system, where parts of the plant's thallus lived in the rock surface, which helped the plant retain its exact position on the shore the following year. Paine recorded the yearly algal position of *Iridaea* using permanent markers. From 1978 until about 1992, there were remarkable consistencies in the algae's position. Something happened in 1991, when suddenly what had appeared to be a very stable, upper limit of this zone-forming alga, became much less predictable. These sorts of long-term databases may not always provide clues to what was going on, but they at least provided a measure of the natural variation.

The last species that Paine addressed was sea urchins. The outer coast, at one time, had many sea urchins, both *Strongylocentrotus purpuratus* and *S. franciscanus*. Areas with abundant urchins were barren-grounds due to urchin grazing on benthic algae. Experimental devises, which excluded urchins, showed that brown algae would recolonize without the urchin grazing pressure. The implications of these results were that sea urchins controlled the distribution and abundance of algae. This small-scale experiment showed what happens when grazing pressure was decreased and this was precisely what the presence of sea otters will do. Sea otters are invading the area and that will transform the lower shore from one that is less productive, to one that is potentially an order of magnitude more productive. Paine believed that this was the sort of biologically driven change that the Sanctuary should be sensitive to.

Paine reiterated that long-term datasets were an essential aspect of monitoring. One cannot monitor everything because it was much too expensive and so one had to pick and choose. Rather than picking one species to monitor over a large area, benefits to monitoring many species in a few areas existed, as was shown in the Tatoosh research.

Questions from Participants

<u>Disruption of the algae minimum level</u>: Paine's hypothesis for what might cause the change in where algae can grow was that some environmental catastrophic factor had pushed the algae beyond what it could manage in terms of a recovery. One environmental change that Paine mentioned as a potential influence was that the shorelines are emerging at the rate of about 1 or 2 mm per year. In 30 years one would see a 3 to 4 cm change in the shoreline and that could be enough of a slope to produce the sorts of changes that he measured.

Measurements of productivity of algal communities: In urchin dominated shores, primary productivity was primarily maintained by export of primary production from elsewhere. The crustose algae that survive the grazing pressure of urchins could be measured for various rates of photoactivity and carbon fixation rates could then be compared to the kelp communities that dominated when grazing pressure of urchins was reduced by sea otters. Kelp communities were capable of producing approximately 50 kilograms of wet kelp mass per m^2, which were orders of magnitude greater primary production than was found in the crustose algal communities.

Sea Otter and Subtidal Surveys - Pat Iampietro, Marine Biologist, California State University at Monterey Bay

Pat Iampietro of California State University at Monterey Bay (CSUMB) described the research that he, Rikk Kvitek, and Ed Bowlby conducted in 1995 in the Olympic Coast Sanctuary. The research provided baseline data on benthic species distribution and abundance, particularly sea otter (*Enhydra lutris*) prey species. He also reviewed the sea otter work conducted in 1987.

Project Background

The sea otter and the giant kelp *Macrocystis pyrifera* are one of the most often cited examples of the keystone predator concept or hypothesis. The paradigm is described as thus: predation by otters controls the population levels of herbivores, mostly sea urchins, which in turn allow kelp and other understory algae to grow much more profusely than in the absence of otters. When there are more otters, there are more algae and habitat for living resources, like fish. When otters are absent, urchin populations increase dramatically and produce urchin barrens.

The otters on the Olympic Coast had increased dramatically since their reintroduction in 1969 and 1970, from approximately 59 individuals initially, to approximately 100 individuals by the time of the 1987 study. In 1998 more than 300 individuals lived in the Sanctuary area.

The 1987 investigation was a typical space-for-time-exchange study. When pre-otter data for benthic prey was unavailable, a spatial displacement, defined by three types of areas, was substituted. Three area types were defined: 1) primary - an area where more than three otters were recorded per aerial survey; 2) secondary - a range between one and three otters sighted per survey; and 3) areas with no otters sighted. The sanctuary had northern and southern secondary ranges as well as a range with no otters in the north.

The results of the 1987 study were very predictable. Areas with more otters had less prey abundance and biomass than areas with no otters, where there was a much higher prey biomass. The algal cover data also suggested the same pattern although the researchers did not look specifically at brown algae such as kelps. They recorded understory foliose red algae and coralline algal crusts. In areas without otters, coralline crusts were more dominant due to the fact that the foliose red algal turf had been grazed away by the urchins. And in areas with otters, foliose, red, understory algae was abundant and less coralline algae were present.

Video Sampling Methods

The study took three weeks with about six divers and logistically was a large undertaking. To survey all the sites required the establishment of field camps and a lot of very intense diving. The methods used involved *in situ* 1-m2 quadrats where divers counted and measured all benthic prey species and recorded percent coverage of the understory algae. This was very, very dive-intensive.

The 1995 study was limited to three divers and one week's time. Fortunately, the study had the support of the R/V *Tatoosh*, a superb and fast vessel. The *Tatoosh* allowed the researchers to travel to all the original sites, plus additional sites in the Neah Bay area. Because of limited time and having fewer divers available, the researchers opted to use video sampling methods. They had first used these techniques in research investigations in the Canadian arctic. There, the rugged and dangerous diving conditions necessitated finding a way to take more underwater samples more quickly. To do this, they used benthic video quadrat methods. This involved using a high-8 video camera, mounted on the back of a underwater scooter. PVC rods were projected onto the front of the scooter and were adjustable. When the diver placed the rods against the substrate, the field of view in the camera was a known area, either 0.25 or 0.1 m^2. The system required lights and two underwater lasers for a constant scale reference.

In regular deployment, a diver filmed 0.25 m^2 quadrats. For the 0.1 m^2 quadrats, about half or one third of the pod's legs were folded back, to obtain a smaller area. In the absence of the laser dots, the scale of replication was done using a 20-cm ruler of PVC placed on the substrate in the field of view at the beginning and the end of each of the series of quadrats. This verified the exact size of the area being filmed.

Transect video was also used. Instead of looking straight down at the bottom, the diver traveled along a preset or random path at a constant distance off the bottom and at a constant speed using the scooter. This gave both qualitative and, under the best of circumstances, quantitative data regarding living resources that were not only on the bottom but also in the water column.

Iampietro discussed the pros and cons of using video for sampling. In its favor, it was quick and optimized bottom-time, because all the analysis, all the measuring and counting of animals, was done in the lab. Video sampling provided a permanent record of all the quadrats sampled, which was very useful after the fact. Often patterns emerged during analyses that were not apparent during the sampling. Video sampling allowed researchers to return and measure a species that was not in the original sampling plan but appeared to be important later. With a permanent record, the researcher could always go back and reanalyze the tape as long as the organism of interest was visible. Also, the imagery that was gathered was useful for incorporating into different products, from outreach (e.g., making a videotape to show the general public), to the creation of world-wide-web sites, to Geographic Information System (GIS) products.

There were drawbacks to video sampling. Visibility and resolution were limited and, because of that, the sampling unit scale was quite limited. In order to obtain a larger quadrat size, for example, a 1 m^2 quadrat size, the camera would have to be very far off the bottom. This affected the ability to resolve things on the seafloor. Video sampling was also a problem if the organisms of interest were underneath the algae or some other obstruction that was between the camera and the bottom. Moving obstructing objects out of the field of view could substantially slow sampling down. Having organisms hidden from view required adjusting the analysis. But if its limits were understood, and if it was used when appropriate, and the results were ground-truthed, using a video camera could be an effective sampling method.

Iampietro and his colleagues' research goals in 1995 were twofold. First they wanted to re-survey all the 1987 sites. This would allow a comparison of the sites with the increased number of otters present in 1995. Second, they wanted to establish an archive of Sanctuary sampling footage that anyone could return to later and analyze as they wished. They also wanted to ground-truth the video sampling methods by duplicating the methods used in 1987. This allowed comparisons of the 1995 data to the 1987 data.

The sampling sites started in Neah Bay, wrapped around Cape Flattery, and continued south to Destruction Island. In 1995, the underwater visibility at Destruction Island was so limiting that the footage could not be used. Primary and secondary sea otter regions were similar to the 1987 regions, with the southern secondary, the northern secondary, and the primary areas staying the same. However, some areas that had no otters in 1987 did have otters in 1995. Two northern sites were added in 1995, one at Cape Flattery and one at Tatoosh Island. These sites had some interesting results but they could not be compared to any data from 1987.

Sampling was conducted from the R/V *Tatoosh* in July of 1995. Twenty-one 0.25 m^2 quadrats were recorded along continuous transects. At the 1987 sites, divers duplicated as closely as possible the methods used in 1987. One m^2 hand-deployed quadrats were done for ground-truthing purposes. All the benthic organisms were counted and measured and algal abundance was estimated. Transect surveys were also conducted. Videotapes were viewed in the lab. All prey species were counted and measured and sizes converted to scale.

The results of the ground-truthing showed that the data collected from the *in situ* and the video methods were not significantly different. Data was statistically analyzed using ANOVA. The power of the tests was slightly low but was substantial enough for testing purposes.

Results

The data shows high prey abundance outside the otter range and lower abundance where otters were present. In 1995, significant prey abundance was not seen anywhere, except at Tatoosh and Cape Flattery and those numbers were comparable to the highest prey densities that were seen in 1987. This was probably due to the fact that high currents and rough seas in these areas limited otter foraging. The otters, although they were moving into these areas now, historically had not hit them as hard so the urchins were still there in number. Biomass showed a similar pattern. In terms of algal cover, coralline algae were significantly lower, at least at Neah Bay, in 1995. Foliose red algae were higher at two sites in 1995 than 1987, probably due to the presence of otters reducing macroinvertebrate grazing.

In conclusion, the otter populations have expanded to the north. Higher otter numbers may have depleted sites previously rich in invertebrate prey. A change in algal cover was found, possibly due to the removal of grazing invertebrates. High prey numbers still remained at Cape Flattery and Tatoosh Island.

Iampietro thanked Ken Keist, Todd Jacobs, and George Galasso, for helping in the field, Jim Estes and Greg Green for reviewing their manuscript, and the various agencies that had provided assistance.

Questions from Participants

Other otter prey species – Iampietro observed little actual predation in 1995 but mentioned that they found *Chione* (a cockle) in some of the more offshore sampling sites that were sampled only in 1995. *Chione* was not observed in any of the sites that were sampled in both 1987 and 1995. *Haliotis* (abalone) was not observed on any of the sampling sites.

Pinniped Population Trends - Harriet Huber, Marine Mammalogist, National Marine Fisheries Service

Harriet Huber, of NMFS's National Marine Mammal Laboratory, provided an overview of the population trends of the common pinnipeds found in the Sanctuary, Steller sea lions, California sea lions and harbor seals. The data was derived from NMFS survey data.

Steller Sea Lions

Steller sea lions (*Eumetopias jubatus*) can be found within the Sanctuary any month of the year. The estimate of the numbers of resident animals in 1998 was about 4 to 600 individuals. The number was not constant, however, and during the spring (March and April), and in late summer (August), the numbers increased to about 1,000 animals. Branding programs in Oregon and in southeast Alaska at Forester Island marked sea lions with an identifying shoulder brand, and within the Sanctuary, several sightings of branded animals from both branding areas occurred. The re-sighting data of Stellers showed that the Sanctuary was somewhat of a mixing zone for animals from the northern and southern rookeries where they converged on the Sanctuary waters during the non-breeding season. This was potentially due to an abundance of hake in the Sanctuary at that time.

California Sea Lions

California sea lions (*Zalophus californianus*) do not breed in the Sanctuary and only the males move into the area. Therefore, as expected, during the 1998 breeding season, virtually no California sea lions were present. After the breeding season, numbers started to increase, and in November, December and January about 4 to 600 animals moved through the Sanctuary waters. In February, numbers dipped as they continued their migration north into British Columbia. Numbers of California sea lions did not increase in the Sanctuary again until March, and by April there were 1,000 to 1,100 animals, as they moved south again toward the breeding rookeries. California sea lions in the Pacific Northwest had been increasing by about 8% a year during the last 10 years.

Harbor Seals

Harbor seals (*Phoca vitulina*) are the only pinnipeds that breed in the Sanctuary, as well as the most ubiquitous pinniped. At low tide, on almost every rocky reef, at least one or two harbor seals can be seen. Two stocks of harbor seals reside in Washington State, the coastal stock and the inland waters stock, which was comprised of animals in the Strait of Juan de Fuca and Puget Sound. NMFS data elucidated one of the interesting differences between the two stocks; the timing of pupping. Chronology of pupping in Washington State showed a sharp division between the two stocks. In the coastal stock, the pups were born in May and June, and in the inland water stock they were born in August and September. The peak of pupping at Cape Alava was the middle of June, and the 1998 annual aerial surveys during that time recorded the highest abundance in the Sanctuary. Harbor seal annual abundance had increased from the 1970's. In 1977 approximately 1,800 harbor seals were estimated to be in the Sanctuary. By 1995 and 1996, there were between 4,000 and 5,000. This was an increase of approximately 6% a year. This upward trend was continuing but showed signs of leveling off.

Pinniped Management Concerns

To summarize pinniped population trends in the Sanctuary, two species were stable, the northern fur seal (*Callorhinus ursinus*) and Steller sea lion; three species were increasing, the harbor seal, California sea lion and the northern elephant seal (*Mirounga angustirostris*). This could be considered good news, with all pinniped populations in the Sanctuary being either stable or increasing. But these increasing pinniped populations were also increasing the demands on the ecosystem; the more seals and sea lions present in the Sanctuary, the more fish they ate. So the significant question was, "How great was the impact of these increasing populations on such things as endangered salmonids?" The NMFS would continue its work on pinniped populations in the Sanctuary and continue their work on pinniped food habits. They were trying to estimate the impact of pinniped populations had on fish stocks and fish resources, and, conversely, what impact fisheries had on these increasing pinniped populations.

Questions from Participants

<u>The effect that El Niño might have on food abundance for the pinnipeds</u>: All the pinnipeds were generalist feeders so if something happened to their food source as far north as the Sanctuary, the animals would simply shift their diet to another prey species. However, if something happened near their breeding grounds, as happened with California sea lions and fur seals in southern California during their breeding season in 1997, populations could be heavily affected. Because elephant seals did not breed until December/January, they were not affected at that time, although they may have been affected later.

It was unknown how El Niño would affect pinnipeds in the Sanctuary. What was known so far was that there were large numbers of Steller and California sea lions in the Sanctuary in December 1997. It was possible that they were pushed up into these waters from southern California waters where fish may have been less abundant because of the El Niño, but this was only speculation.

<u>Range expansions and unusual breeding sites</u>: California sea lions occasionally had moved as far north as central California, but no consistent breeding occurred there and they still remained primarily in southern California. Steller sea lions did not appear to be moving into

new areas. But elephant seals, since they were heavily exploited in the 1800s, had progressively been moving northward in their pupping areas. In January 1998, the first northern elephant seal pup was born in Washington State. About 8 pups had been born in Oregon over the last year.

Seabird Colonies - Julia Parrish, Assistant Professor, University of Washington

Julia Parrish presented a brief overview of seabirds along the Sanctuary coast, concentrating on the more common species that bred within the Sanctuary. The key species she discussed were the common murre, the tufted puffin, the pigeon guillemot, three species of cormorants, Leach's and fork-tailed storm-petrels, and gulls in general.

Breeding Seabird Overview

The common murre (*Uria aalge*), an alcid, breeds on Tatoosh Island. They also attend many of the southern islands, where recent evidence suggested some breeding might occur. In 1998, WDFW researchers had actually observed some chicks and fledglings from some of the southern colonies.

The tufted puffin (*Lunda cirrhata*) is also an alcid species. Parrish emphasized that this species warranted a greater concentration of research effort because its numbers appeared to be decreasing. Rigorous censusing of this species in the Sanctuary was lacking, although some colony work had been done on Destruction Island in earlier times. On Tatoosh Island, where Parrish and her research group study murres, researchers anecdotally saw noticeably fewer tufted puffins than had been seen in the past.

Pigeon guillemots (*Cepphus columba*), another alcid, are a particularly good species to observe in food habit studies because they had a tendency to catch fish and then swim around with them in their bills for hours. They also tend to aggregate in the rocky intertidal areas so they are very easy to count.

Three types of cormorants breed within the Sanctuary area, pelagic cormorants (*Phalacrocorax pelagicus*), Brandt's cormorants (*Phalacrocorax pelagicus*), and double-crested cormorants (*Phalacrocorax auritis*). The numbers of all three species were going up according to data from the National Wildlife Refuge (NWR). Refuge personnel performed aerial survey counts and had a long-term dataset. On Tatoosh Island, which was not included in the NWR data, double-crested cormorants moved into the system and had started to breed within the last two years. The population of double-crested cormorants on Tatoosh had gone from 0 to about 35 pairs in a 2-year period.

One of the longest time series databases on seabirds in this area was from mist-netting data on storm-petrels, collected by Bob Paine, UW, and his crew. The data series ran from 1978 to the present and included both Leach's (*Oceanodroma leucorhoa*) and fork-tailed (*O. furcata*) storm-petrels. Mist-netting storm-petrels required netting them during night, when they returned to their burrows. These data were quite valuable.

Several gull species were found within the Sanctuary. Glaucous-winged gulls (*Larus glaucescens*) nested within the Sanctuary, as did glaucous-winged-western hybrids (*Larus glaucescens-occidentalis*), and the two species frequent the Sanctuary in broadly mixed groups.

Future Research Priorities

The population data most often used for seabirds on the outer coast had been gathered mostly from aerial or boat-based surveys and was somewhat dated. Parrish identified acquiring better and more current population data directly from the colonies, as was done on Tatoosh Island, as a research priority for the outer coast seabird colonies. This kind of data could be very important. A good picture of what was going on at the seabird colony could become part of an integrated assessment of what was going on in the marine environment. Seabirds could be used as indicators and the data could be used in predictive models. As an example, if the variable was first defined, a perturbation such as an El Niño or La Niña could be factored into a model and predictions could be made of changes that followed. This type of modeling could be done with a variety of factors. These were kinds of things that the scientific community might be able to assess just by monitoring colonies.

Murre Populations on Tatoosh Island

For the duration of her presentation, Parrish concentrated on the results of her work with murres at Tatoosh Island, noting that many of the topics covered could be applied to almost any species that bred within the Sanctuary.

Populations of murres in California, Oregon, Washington, and British Columbia had decreased by one order of magnitude. Almost one million birds could be found south of Washington (Oregon/California), very few birds in Washington and British Columbia, and high numbers (in the millions) were present in the Gulf of Alaska. This was a rather odd distribution.

Several things adversely affected murres, not only in Washington, but everywhere. One factor was oil spills. On the Washington coast two recent oil spills, the *Nestucca* and the *Tenyo Maru* had occurred. From the total casualties resulting from these spills, murres comprised 75% of all the birds recovered from beaches. Murres also frequently die in gill nets. The results from two observer programs in California and Washington (the observer program of the gill net fishery in Puget Sound) showed that murres comprised the majority of the birds recovered in the nets.

Historically murres had bred all along, the coast within the boundaries of the Sanctuary. Currently great deal about murres on Tatoosh Island was known, but not much about murres on other colonies in the Sanctuary. Long-term datasets from the National Wildlife Refuge, and the counts from south of Tatoosh Island, showed a rather precipitous decline from around 1982 to the early 1990s. Since then, numbers had stayed fairly depressed. What precipitated this incredible decline and would there be a recovery, are two outstanding questions for scientists.

Looking specifically at the murre data from Tatoosh Island, a slightly different pattern emerged. The Tatoosh counts were taken from several vantage points on the island itself. This allowed researchers to closely examine many different murre nesting areas. Count data was taken in order to get estimates of population size or, more commonly, nest site attendance. Some of the nest areas with fewer birds were easier to count. These habitats were often shared with other species, mainly glaucous-winged gulls. The attendance pattern on Tatoosh since 1991 (note that the big drop in populations occurred prior to 1991) showed that they went into a slight decline during the 1990s, but actually from the early 1980s, there was a precipitous increase of murres on Tatoosh. So Tatoosh appeared to have a slightly different pattern than the rest of Washington. The murres had shifted their habitat, however, from big cliff tops to the ledges, so a change in habitat had accompanied the population trend.

Comparing the crevice nesting to the cliff top nesting in terms of attendance, crevices seemed to be relatively safe sites, exhibiting stable nest attendance, but cliff tops appeared to be more precarious. For example, one cliff top nest area went from about 1,500 birds to 0, in fact that nesting area went extinct in 1996. What were the potential causes? Bald eagles (*Haliaeetus leucocephalus*) were one. Oil spills and gill nets had also been implicated. However, eagles were one of the main avian predators of seabirds, not only on Tatoosh but everywhere else. Data taken from 1991 to 1997 showed that bald eagles arrived on the island before and during egg-laying by murres, but after July 20th eagles left.

Reproductive effort was another useful variable to observe. Sometimes it was difficult to see a signal in attendance, especially in crevice colonies, however a signal in reproductive effort was more likely to show a signal. Using unique blinds with one-way mirrors in six locations on the island, researchers could actually count the number of chicks.

Although there were year-to-year variations, reproductive success was higher in crevices than on cliff tops. Two messages emerged from this: 1) cliff tops are not safe places for chick rearing, and 2) even in a safe place, reproductive success is very variable. Parrish's research interests included examining the questions, why was reproductive success different between cliff tops and crevices and what specifically caused these differences?

One difference between the crevices and the cliff top was a function of eagle predator pressure. Parrish and her colleagues looked at and estimated the pressure that eagles had, both directly, by eating the adults, and indirectly, by suppressing reproductive success. Eagle predation pressure was a function of how many murres were nesting on the cliff tops (the bad places), versus those good places, the crevices. Looking at population growth rates and the formula, when population growth rate went below one, the population would go down. And the data showed several breeding seasons where this occurred, possibly from the increasing predator pressure from eagles.

Other factors, such as the huge El Niño that occurred in 1997, could also create dynamic variability. Both the El Niño Southern Oscillation (ENSO) and La Nina created a tropical sea surface anomaly which could have an effect on predator pressure but also could cause dynamic changes in sea surface temperature that affected upwelling, which in turn affected food supply. Within the data from 1991 to 1997, Parrish examined reproductive success for correlation with the effect of predator pressure (a top-down effect) and El Niño signals (a bottom-up effect). As examples, 1993 appeared to be a bad year for both the physical signal (bottom-up), and the predator signal (top-down). The year 1996, on the other hand, had no El Niño signal but had a predator signal.

In conclusion, Parrish used a postcard from 1903 that showed murres avoiding an eagle by eliciting the "*A Niagara of murres*" response and flushing off their site as a way of illustrating that these kinds of effects (predator effects and El Niño effects) had been happening for a long time.

Questions from Participants

Would the same kinds of patterns seen on Tatoosh Island (predation signals and physical signals) be detected at Destruction Island? Destruction Island was very different. Its habitat was more suited for burrow nesters such as rhinoceros auklets (*Cerorhinca monocerata*) and tufted puffins, and it had very few murres. Its habitat was also being affected by introduced rabbits, which were eating the vegetation and causing increased erosion, therefore, some of the dynamics on that island were not comparable to Tatoosh.

However eagles were in the area and a pair of eagles may have used Destruction Island in the past, so predation could be a factor, although the predation patterns on Tatoosh may be unique to that island. Broad spectrum effects, like El Niño, that affect food availability throughout the region, however, would be expected to produce the same pattern on Tatoosh and Destruction Island and anywhere else.

Records of exotic bird species associated with El Niño - David Duffy from the Heritage Program had a listing of El Niño birds and posted to that regularly. Bob Paine had a long-term birdwatching record from Tatoosh Island which could detect presence/absence. More systematic at-sea surveys needed to be done in order to detect exotic birds that rarely occurred here.

At-sea Distribution of Seabirds - Chris Thompson, Ornithologist, Washington Department of Fish and Wildlife

Chris Thompson, of the Washington Department of Fish and Wildlife, described the coastal seabird monitoring program that the state initiated in 1995. Prior to 1995, seabirds, along with ducks in Puget Sound, had been monitored under the Puget Sound Ambient Monitoring Program (PSAMP) but there was no counterpart for long-term monitoring of seabirds on the outer coast. There had been some historical studies, conducted without such research tools as GPS and GIS, but a solid database was lacking. It was determined that such a database was needed to gather distribution and abundance information in order to monitor population trends. He emphasized that it was important to have baseline data with which to evaluate the impacts of anthropogenic events, such as oil spills and gill net fishing. In the WDFW program, seabirds were being monitored using at-sea surveys conducted in the area from Port Angeles west to Neah Bay and south from Neah Bay to the Columbia River.

Thompson emphasized that one of the main goals of their project was to document patterns of abundance and distribution. This was the first step in understanding the underlying processes that determined those patterns. Understanding the processes themselves was the most useful for resource managers, but first the patterns had to be identified.

Scale was also an important concept in this study. Research was needed on varying scales and Thompson compared his work to the work that Bob Paine and Julia Parrish described on Tatoosh Island. Their studies were in-depth looks at one specific area. His study was on a much broader scale. He emphasized the need for a variety of investigations to occur at different spatial scales over a long period of time.

For the rest of the presentation, Thompson gave a brief overview of the relative distribution and abundance of several seabird species, then he gave a more detailed overview of marbled murrelets (*Brachyramphus marmoratum*) and common murres as examples of species that they looked at more closely. He also addressed the past and present role of the Sanctuary in their work, the directions WDFW wanted to go in the future, and how the Sanctuary might be able to help them get there.

Survey Results

In his overview, Thompson presented data collected from 1995 to 1997. In order of abundance, in the summer time, common murres and rhinoceros auklets dominate the species composition, followed by shearwaters (predominantly sooty shearwaters (*Puffinus griseus*)), scoters, (mainly white-winged (*Melanitta fusca*) and surf scoters (*M. perspicillata*)), cormorants, pigeon guillemots, marbled murrelets, tufted puffins, phalaropes, loons, and Cassin's auklets (*Ptychoramphus aleutica*). He cautioned that Cassin's auklet numbers were likely to be much higher in the entire Sanctuary than their data suggested. This was due to the fact that the WDFW survey effort was concentrated close to shore, within a kilometer or two, so more pelagic species, such as Cassin's auklets, were under represented. Their results were admittedly biased toward the nearshore environment.

Thompson agreed with earlier presenters, Julia Parrish and Bob Paine, that tufted puffin numbers were probably declining and that the species warranted more research attention than it was getting. This trend might be substantiated in Ulrich Wilson's research with the USFWS, which was not yet published. A similar trend might also be true for harlequin ducks (*Histrionicus histrionicus*) as had been suggested in anecdotal information from Bob Paine on Tatoosh Island. However, without clear documentation of a decline, it was very difficult to acquire funds to research these species, and this was a very real dilemma for resource managers.

Big differences could be seen between winter and summer in terms of relative abundance. For example, scoter numbers rose significantly in the winter time, harlequin ducks rose slightly, but murres, rhinoceros auklets and Cassin's auklets, disappeared entirely. Marbled murrelet numbers decreased in the wintertime as well. This was partially due to the birds actually migrating. Cassin's auklets migrated south then disappeared. Rhinoceros auklets, to a lesser extent, also migrated south to California. On the other hand, it was unknown exactly where murres went, whether they dispersed further out to sea or did something else, but it was clear that their numbers dramatically decreased in the winter.

One surprising finding of the study was that abundance and distribution of murrelets across seasons was correlated. Contrary to the general thought that seabird distributions were remarkably unpredictable in time and space, murrelets, for some reason, appeared to be quite predictably distributed. Although the absolute densities were higher in 1996 than in 1995, the hot spots were roughly in the same areas. This high predictability in distribution was useful information. For example, if a catastrophic event occurred, managers could assess the damage with greater confidence.

Marbled Murrelet Distribution Patterns

Marbled murrelets, an endangered species, and murres, a species of concern to managers, required unique and specific survey methodology. Thompson's group, along with other agency researchers, was developing protocols specifically for at-sea surveys of murrelets. They were trying to develop an at-sea counterpart to what the National Park Service biologists had developed to census murrelets in their forest habitat. They had looked at factors such as time of day and distance from shore, in order to discern exactly when was the best time and where to look for murrelets. They had determined that higher densities of murrelets occurred closer to shore and that morning counts produced higher densities than afternoon counts. Their data showed that murrelet abundance decreased with distance from shore, both in the summer and the winter. Not surprisingly, abundance was also correlated with water depth. The peak numbers of murrelets were found 30 to 40 meters from shore and numbers gradually dropped off as distance increased, so the Sanctuary shallow waters were where the most murrelets were.

What were the properties that caused this pattern? This was still unknown, but Thompson and others had begun to look at the data for correlations of murrelet abundance and kelp, asking the question, 'Do murrelets use kelp as a resource?' Future analyses would include a multiple variable analysis. Presently they had used GIS overlays to measure where the murrelet observations were in relationship to their distance from canopy kelp (both *Macrocytis* and *Nereocystis*). They looked at the expected number of murrelets and compared that to the observed number of murrelets seen at varying distances from kelp. A greater number of observations of murrelets were seen close to kelp. The farther away from kelp, fewer murrelets were found (relative to the expected number). Plotting the observed over expected ratio, the resulting line had a negative slope as distance from kelp increased. In this superficial analysis, it appeared that kelp might be an important resource to murrelets, but many of the confounding variables would need to be examined before this correlation could be confirmed.

Common Murre Foraging and Fall Migration

In another study, Thompson, in collaboration with Julia Parrish, examined the foraging range of murres breeding on Tatoosh Island. Their results showed high densities of murres feeding on the water close to the island; after a few kilometers, the numbers of murres dropped very rapidly until they disappeared after about 5 kilometers. These data suggested that murres were not going very far to forage. There had been speculation on whether marine birds from Tatoosh were getting caught in gill nets in Puget Sound and their data showed that was unlikely.

In determining why murres migrate up from Oregon after breeding and the timing of murre fledging, Thompson's research group monitored father and chick pairs along the southern coast of Washington, from the Columbia River to Tatoosh Island. Their fathers accompanied murre fledglings for a month or two, so by monitoring these dad-chick pairs, fledging could be observed. Their results showed that dad-chick pairs first showed up in high numbers along the southern coast, Columbia to Grays Harbor, in mid-July. They began to show up on the north coast, Grays Harbor to Tatoosh, at a similar time but their numbers did not increase as rapidly as they did in the south. In the Straits of Juan de Fuca, dad and chick pairs did not show up until some time in early August. These surveys were a useful tool for monitoring the movement of murres into Washington from Oregon.

Thompson took the time to acknowledge the Sanctuary, thanking the organization for providing space in their trailer at the Neah Bay Coast Guard Station and for use of the R/V *Tatoosh*. The Sanctuary's help had saved his project quite a bit of money. In order to establish population trends in seabird populations it was critical that surveys were conducted every year and over a long period of time. In light of this, it was hoped that the Sanctuary would continue its support of the at-sea surveys well into the future.

Questions from Participants

Records of exotic bird species associated with El Niño –

Thompson said that on their at-sea surveys, they documented all bird species with the exception of gull species, so if there were exotic species (other than gulls) they would be recorded in their database. They were not seeing many exotics from the seabird community standpoint. They had not noted any trend in unusual species showing up in their surveys that could be related to El Niño events. Thompson did note that one brown booby (*Sula leucogaster*) was seen in Puget Sound, but it was the only exotic seabird that he was aware of. Brown pelican (*Pelecanus occidentalis)* populations were increasing and there seemed to be a northward range expansion happening over the last few years, but it was not known if this was related to El Niño effects or other factors.

Julia Parrish added that the 1998 breeding season, not the 1997 season, would be the season where one would expect to see exotics showing up as a result of the influences of the 1997 El Niño.

FOCUS GROUP REPORTS

At the conclusion of the plenary presentations on Day One, participants broke into the following focus groups: 1) nearshore communities; 2) fish and shellfish biology; 3) marine mammals and seabirds; 4) physical and biological oceanography; and 5) cultural and historical resources. A Group Discussion List (Table 6) was provided to each group along with a facilitator to aid and guide discussions. Each group's mission was to discuss relevant issues, vote on the most critical research questions, and report back with a list of recommendations. Flip chart notes and individual Group Discussion List worksheets were collected to aid in creating a final synthesis outline (Table 7). A representative from each group summarized the findings to the plenary session in Day Two as outlined below. Time was allotted for general discussion from the re-assembled participants, to provide opportunities for multi-disciplinary exchanges.

Group Report on Nearshore Communities

1. Conduct inventories of marine resources, including distribution and abundance studies, and life-history information. Create central database. Temporal and spatial data gaps identified as:

- Nearshore fish populations, particularly juveniles
- Intertidal and subtidal communities
- Determine use of subtidal areas by juvenile offshore species
- Floating kelp mat communities
- Infaunal and epifaunal benthic communities

2. Identify processes that influence communities and examine interaction of biological oceanography with benthic and intertidal communities:

- Monitor influences from physical condition, water chemistry, and geomorphology
- Plankton investigations
- Modeling studies

3. Map and identify critical habitats and create central database (inventories in #1 would eventually lead to #3 and long-term monitoring), particularly:

- Seabird habitats
- Kelp habitats
- Nearshore fish habitats

The Nearshore Group discussed how the Sanctuary could support or facilitate some of those activities. The group agreed that public education/awareness was a good starting point. They also discussed becoming more familiar with NOS and its funding mechanism. The group talked about the funding prospects for identifying Essential Fish Habitat (EFH) through the National Marine Fisheries Service (NMFS), and listed other potential partners as: Washington Department of Natural Resources (WDNR), Washington Department of Fish and Wildlife (WDFW), Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) and watershed programs, tribes, United States Fish and Wildlife Service

(USFWS), U.S. Geologic Survey (USGS), United States Navy (USN), University of Washington (UW), Western Washington University (WWU), Sea Grant, Puget Sound Ambient Monitoring Program (PSAMP), Natural Resource Damage Assessment (NRDA), Department of Ecology (DOE), NOAA's Hazardous Materials Branch (HAZMAT), Pacific Northwest Coastal Ecosystem Research Study (PNCERS). They also discussed pursuing funding from the oil industry (it would be mutually advantageous to have resource inventories prior to a spill).

Other topics of discussion included:

- Consensus that not enough information is available to select indicator species; need basic resource inventories first, followed by long-term monitoring
- Use of subtidal by juvenile offshore species
- Identify processes that influence communities and affect population distribution and abundance (e.g., physical, water chemistry, and geology)
- Publicize why the area is so unique, since this could lead to more funding; but counterpoint noted that if area is considered pristine, there may be less funding available, since contaminants and other public concerns draw funding
- Increase number of Mussel-Watch sites and frequency of sampling
- More spatial and temporal monitoring needs to be layered onto the inventory aspect in order to detect trends
- Potential use of volunteer monitoring groups, such as Adopt-a-Beach and beached bird programs, and diver fish surveys (e.g., REEF)
- Identify critical limiting factors of various species in nearshore habitat and their various life stages
- Need for year-round vessel time

Group Report on Fish and Shellfish Biology

1. Determine spatial and temporal distribution and abundance of harmful algal blooms (HAB) and effects on marine food webs.

A. Specific research needed:

- Determining what vectors bring offshore blooms into the food web, particularly nearshore shellfish
- Connecting/coordinating the offshore, ocean research with nearshore research
- Considering weekly sampling periods for HAB work
- Determining how domoic acid vectors into Dungeness crabs and razor clams
- Increasing information (via sampling) on subtidal benthic communities

B. The Sanctuary could provide support for harmful algal bloom (HAB) information in the following ways:

- Letters of support from the Sanctuary could boost local entities (e.g., the Quinault Tribe) chances for securing funds from federal and state sources
- Assistance in developing a centralized database that would help researchers collaborate and connect offshore with nearshore data

- Development of a web page that would facilitate an exchange of data (the web page would act as a clearinghouse for new information, ongoing research, where data is available, etc. which would be especially suitable for monitoring biotoxins)
- Provide use of Sanctuary vessels for HAB work (e.g., R/V *Tatoosh* and RHIB)
- Contact more research agencies who work with biotoxins, commercial fisheries (e.g., crab and ground fishers); and sport fishing associations for support

C. Identify potential partnerships with regard to HAB
- Partner with WDFW for use of its R/V *Corliss* to use as a platform to sample the subtidal community with dredges (e.g., tribe could pay for gas and crew to join *Corliss* on its patrol, and conduct research off the vessel at the same time)
- Contact Washington Department of Health, (they used to sample razor clams and mussels until funding was limited), to explore if they are interested in being involved in a monitoring program

2. Select representative long-lived plant and animal species for long-term monitoring.

A. Suggested shellfish:
- Razor clams - some biotoxin work exists, but no long-term monitoring; condition indexing may be used as a tool for indication of population health; plankton populations (clam food supply) may be indirect measure of ecosystem health
- Mussels - some population monitoring already being done to determine harvestable amounts
- Mobile species (e.g., crabs) – however no good monitoring method exists; more information on their food habits might be a possible avenue of study
- Other species should be considered – examples in intertidal habitats

B. Suggested fish:
- Rockfish that live 60 to 70 years.

C. Sanctuary Help: Letters of support from the Sanctuary could be helpful in backing official requests.

D. Partnerships: Department of Health used to sample razor clams and mussels but their funding was limited; they might be interested in involvement in a monitoring program.

E. Discussion:

Long-lived species, such as rockfish, may not be the best choice for long-term monitoring. For example, if an organism is very long-lived, their reproductive cycle may be longer than the time a researcher can study them. It can make it difficult to see responses to perturbations in parameters such as reproductive success. Also, if monitoring of populations involves killing individuals, monitoring a long-lived species will mean culling very old individuals, which could be detrimental to the population.

One suggestion was to not specifically try to identify long-lived species for monitoring, but rather identify ecologically relevant species, or trophically relevant species. Long-lived species may not necessarily be good indicator species.

Monitoring specific communities may be an option. Mussel communities, for example, are long-lived, large, patchy, and ecologically relevant because of the way they accumulate biotoxins.

3. Address management concerns for harvest-related stresses:
   A. Anthropogenic contamination
   B. Habitat alteration (e.g., impact of trawl gear on seafloor habitats and communities)
   C. Effects of exotic species
      - Green crab example; how to monitor as its range expands up the coast; determine what factors control its expansion (do high energy environments like the Olympic coast deter it?)
      - Other exotics: Japanese seastar, some amphipods, ballast water discharge

   D. Sanctuary help - Provide education and outreach programs for the public (e.g., green crab and ballast water as a vector for exotic species)
   E. Partnerships – none mentioned

4. Conduct inventories of marine resources and map and create central databases/identify and map critical habitats and areas of special interest:
   - Create a list of species of special concern and note work being conducted on them
   - Create maps that identify where research was currently being, and had historically been conducted in the Sanctuary (e.g., ArcView and photograph library)
   - Create a repository of information to help connect the different pieces of data that various agencies and researchers possess (e.g., a list of what is being done and who is doing it)
   - Sanctuary efforts:
      - Act as repository for research
      - Act as a store house of information
      - Develop a web page that would link researchers and data
      - Provide access to maps
   - Partnerships – none mentioned

Discussion

Under the concept of identifying and mapping critical habitats, participants suggested that complex fisheries habitats, the places that are untrawlable, be mapped and protected because they harbor unique species such as long-lived anemones, sponges, and corals. Some of the species have not even been identified yet.

It was also suggested that non-complex, flat, sandy bottomed, highly trawlable areas be considered areas of special concern as well because they are continuously subjected to the adverse affects of trawling.

Group Report on Seabirds and Marine Mammals

1. Monitor long-lived species.

   A. Marine Mammals:

      Nearshore indicators:
      - Harbor Seals
      - Sea Otters

      Pelagic indicators:
      - Humpback Whales – advantage of being able to individually identify
      - Gray Whales – advantage of being able to individually identify
      - Harbor Porpoise

   B. Seabirds:
      - Advantages to monitoring seabirds at colonies (in addition to at-sea)
        - Multiple species can be surveyed at one spot
        - Different species are indicators of different niches and environments so get info from multiple areas from one colony location (e.g., Cassin's auklets are pelagic and eat plankton, pigeon guillemots are nearshore inhabitants, murres are generally distributed and are fish eaters)
      - Colony data provides information on parameters beyond population (e.g., nest initiation, nesting success, fledging success, mortality) and provides other ways to monitor change in the ecosystem.
      - Species to monitor:
        - Black oystercatcher – intertidal indicator
        - Pigeon guillemot – nearshore indicator
        - Common murre – generalist distribution/ fish indicator
        - Cassin's auklet – pelagic indicator/zooplankton indicator
        - Tufted puffin – sensitive/threatened species
        - Harlequin duck – sensitive/threatened species
        - Marbled murrelet – sensitive/threatened species

2. Monitor background mortality trends for seabirds

   A. Previous/ongoing work:
      - Oregon Dept. Fish and Wildlife had some collection data on Southern Washington coast for several years
      - WDFW had some data collected in 1980-1985; Chris Thompson crew collected data for last couple of years
      - Julia Parrish, UW, had collected data on Tatoosh Island

B. Current needs:
- Systematic mortality baseline data collection
- An accurate assessment of variability - what is real mortality vs. what is ocean condition-related
- An index versus actual total numbers (which requires more frequent surveys and an understanding of rate of persistence of carcasses on beaches)
- Professional versus volunteer observers

C. Future: Sanctuary is developing a part-time position that will include beached bird monitoring as well as a marine mammal stranding coordinator

3. Monitor status and trends in marine mammal populations

A. Previous/ongoing work:
- Sanctuary had supported Ron Jameson, BRD, with limited funds for sea otter population and distribution studies (in conjunction with the Makahs)
- University of California at Santa Cruz (UCSC), Biological Resources Division (BRD), Moss Landing Marine Lab (MLML) and Sanctuary subtidal habitat surveys in the Cape Flattery area looking at impacts of sea otter expansion
- University of Washington (UW) and U.S. Fish and Wildlife Service (USFWS)/Biological Resources Division (BRD) sub-tidal assessment east of Neah Bay
- Cascadia Research (partially funded by Sanctuary) doing humpback whale photo identification work offshore of Cape Flattery

B. Current Needs: More stability in monitoring in terms of long-term funding is needed.

4. Monitor status and trends in seabird populations

A. Previous/ongoing work:
- USFWS had one full time staff position to monitor seabirds at least annually; had conducted counts since 1976 or 77
- PSAMP started in 1990, but limited to Puget Sound; funding only assured for next 5 years; marine mammals and seabirds only a small component of the project
- Thompson's WDFW surveys on outer coast, but funding year to year and based on soft money

B. Current Needs:
- More stability in monitoring in terms of long-term funding
- Improve counts at seabird colonies; more than once per season; more systematic and standardize protocols
- More information needed on forage fish (large data gap) to include:
  - Spatial and temporal spawning information

- Distribution and abundance surveys
- Direct data from trawl surveys
- Indirect data from seabird diet studies at colonies and stomach contents from birds killed in gill nets (provided indices only)

5. Identifying and mapping critical habitats

   A. Map kelp communities as critical habitat
      - Previous/ongoing work:
         - DNR does annual kelp surveys since 1989
         - USGS sediment mapping which may relate to kelp recruitment

   B. Current needs:
      - Use GIS (e.g., kelp beds)
      - Obtain data on kelp communities and ecosystems
      - Map trawlable and untrawlable areas
      - Map pinniped and cetacean concentration areas
      - Identify/map species and habitats most susceptible to oil spills

6. What the Sanctuary should do:

   A. Assist in determining which species should have highest priority

   B. Inform funding agencies of importance of long-term funding

   C. Assist in creating partnerships between groups that have funding for individual species in order to maintain existing funding and/or acquire new funding

Discussion

<u>Sea Otters and Kelp</u>

Participants discussed historical accounts of kelp beds and sea otters further south than their present distribution. The original sea otter population historically ranged south to the Columbia River and there were historical reports of kelp beds northwest of Grays Harbor. Present kelp distribution, as defined by annual surveys conducted by DNR since 1989, was to Destruction Island, and was the same for sea otters. It was suggested that historic kelp areas may have been silted over, and that sub-bottom profile maps could identify where hard bottom exists that are overlain with recent sediment.

Ron Jameson, BRD, added that the kelp that was most likely to spread to the south was *Nereocystis*, not *Macrocystis*, which preferred more protected environments, such as the Straits. He also mentioned that when looking at kelp and otter distributions, it was important to remember that kelp did not support sea otters per se, other than providing them with refuges for resting. Several locations in Alaska contained sea otter populations but no kelp. Kelp was not an absolute requisite for sea otters.

Historical records for sea otters may be biased because they usually came from hunter's accounts who preferentially used the southern beaches as their hunting platforms. However, it was obvious from the use of otter parts in cultural artifacts from the Makah, that otters extended north into the Cape Flattery area, and historical accounts reveal that they came into the Straits as far as east as Discovery Bay.

The Washington coastline to the south was perhaps limiting the sea otters, with its long stretches of exposed sand beaches with no refugia for animals during winter storm events.

Chris Thompson, WDFW, noted that the USGS erosion study had been mapping the ocean floor and had noted that much of the seafloor in southern Washington was uniformly flat and sandy, not be the best habitat for kelp or otters.

Jameson reported that Chris Morganroth, from the Quileute tribe, had observed that kelp beds in the vicinity of La Push were much larger several decades ago than they were currently. He suspected that increased sediments coming out of the river were factoring in their decline.

Additional discussion followed regarding the value of monitoring kelp as an example of long-lived species. This would also involve examining the understory kelp (for example, *Alaria* spp.) as well as the canopy kelp. It was agreed that monitoring kelp as a long-lived species was a valuable idea, in the context of its relationship to seabirds and marine mammals. The group also felt it should remain under the category of Critical Habitat, and, as such, be monitored using aerial surveys, although aircraft only recorded canopy kelp.

Thompson noted that, although it was preferable to choose species for long-term monitoring based on their value as indicators of ecosystems, sometimes funding and policy dictated that sensitive species (e.g., threatened or endangered status) be used instead.

Although the plenary sessions outlined pinniped and sea otter issues, cetaceans were not covered. However, there are two cetacean abstracts in Table 3 that highlight some current issues with whales and porpoises.

Group Report on Physical and Biological Oceanography

1. Research Priorities
    - A. Conduct a complete survey of the changes in currents and water properties of the Sanctuary; quantitative data needed; very expensive
    - B. Look at the linkages between terrestrial and marine ecosystems and potential watershed effects
    - C. Look at the linkages between terrestrial and marine ecosystems and potential watershed effects

D. Identify localized effects
E. Understand if/how rivers/watersheds interact with ocean currents
F. Understand if/how rivers/watersheds affect biology, habitats, shellfish harvests
G. Predict how future development (in watershed) might affect coastline and beaches within Sanctuary
H. Determine the spatial and temporal distribution and abundance of harmful algal blooms and effects on marine food webs
I. Identify vectors / mechanisms of toxins from phytoplankton to shellfish
J. Understand how higher trophic levels of marine organisms might be affected by HABs (e.g., can HABs cause deaths and strandings in marine mammals?)
K. Conduct inventories of marine resources and map and create central databases
L. Establish new moorings to determine both physical and biological parameters (baseline information on water quality trends)
M. Use existing moorings or buoys such as navigational buoys or Coast Guard buoys
N. Conduct high-resolution seafloor mapping of representative habitats since mapping was key to the Sanctuary's role of understanding habitats and ecosystems

2. What the Sanctuary can do
   A. Lobby for oceanographic research funds from agencies (e.g., National Science Foundation and Foundation for Oceanographic Research)
   B. Linkages/Watershed effects:
      - Use information from watershed analyses that tribes and other organizations have conducted to analyze linkages
      - Put sensors at the mouths of rivers for monitoring sediment transport and O_2
   C. Harmful Algal Blooms:
      - Continue to provide time and space on the research cruises for HAB researchers from UW
      - Assist in acquiring funding for HAB research from ECOHAB Program
      - Determine effects on shellfish, marine mammals, and seabirds
      - Use data on phytoplankton distributions from SeaWIFS Program
   D. Moorings:
      - Identify sites that are important for long-term information needs (proposed Copalis Beach); make known to other research efforts
      - Establish baseline water-quality parameters and monitor trends
      - Put sensors on old navigational and weather buoys
      - Use existing structures such as the Navy Test Range Cable to attach moorings
   E. Inventory and Mapping: Sanctuary should be a clearinghouse for Sanctuary area maps (GIS and databses) and have ability to distribute information; need high-resolution seafloor maps
   F. General: Establish links so that people could obtain Sanctuary information

Discussion

<u>Watershed analyses</u>

Much of the discussion centered on the value of trying to correlate ocean conditions with information from watershed analyses as were currently conducted. There were several shortcomings associated with watershed analyses that made them difficult to correlate with ocean responses: 1) they usually preceded timber harvest and the harvest itself could potentially change the current water regime as analyzed; 2) they were often conducted far from the mouth of the river; 3) they usually only looked at a small part of the watershed; and 4) usually no monitoring of change-over-time occurred since they were a snapshot look at conditions.

Counter to that, it was mentioned that there was a growing awareness of the importance of understanding interactions between the ocean and the land, and in the future, there might be more attention given to this area of research.

Watershed analyses could give good information about sediment carrying capacity flow rates, which feeds into sediment transport along the coast. This was an important piece of information, especially for a place like the Sanctuary's coastline where most of the beach sediments came from local rivers.

Simpler ways of obtaining information might be to use environmental sensors in the rivers and at the mouths to gather information on sediment load and O_2 over time.

Some existing programs were mentioned that might provide some information or direction: 1) EMAP from EPA might provide some methodology suggestions; and 2) the Estuary Program from EPA might have case studies similar to ones in this region that might provide insight.

It was suggested that calls-for-proposals that involved land-sea linkages, such as ones issued from the National Science Foundation (NSF), were good opportunities to pool resources into cooperative proposals.

<u>Sand Shrimp</u>

The abundance of sand shrimp and anecdotal information that they might be spreading from estuaries to open shores was discussed. It was suggested that anthropogenic sources might be the source – perhaps the addition of organic material from bark and woodchips that accumulated on beaches might be providing the right conditions for the shrimp to proliferate. No substantial data was available on this, only conjectures, but it lead to a discussion regarding the Sanctuary's ability to examine affects to the resources when the source of the affect originated outside of the Sanctuary's boundary. The Sanctuary could look at such questions, however, it was the responsibility of the Sanctuary to prove that an outside source was the cause of damage. This was difficult to do, especially without baseline data for comparison.

<u>Expense of Oceanographic Research</u>

Because oceanography research was so expensive, two things were recommended to deal with the expense. First the Sanctuary could find inexpensive ways to obtain sensors for monitoring (suggestions incorporated in the above outline). Second, the academic community could create a comprehensive plan to answer key oceanographic questions addressing the data gaps off the Washington coast. This would allow researchers to then apply to a big funding source like GLOBEC. The Sanctuary could back such an effort with a letter of support.

Specific locations for sensors

Locations of moorings would be determined by the scope of questions that researchers formulated. For general monitoring, and if cost were no object, it was suggested that since local conditions could change approximately every 10 miles, there would be a need for multiple moorings to capture the complexity of the area. Moorings would be needed in the canyons and near the Strait of Juan de Fuca. Further south, where the beaches were uniform and gently sloping, a single, key mooring placed south of Kalaloch or Moclips, could generalize information all the way to Grays Harbor.

Group Report on Cultural and Historical Resources

1. Establish and maintain a database for historical research (though this might be beyond the scope of the Sanctuary); link to Bob Schwemmer's database
2. Promote education programs (which might also lead to funding partnerships)
    - Make presentations at schools (universities, colleges, primary schools)
    - Arrange information exchanges with historical organizations, museums, or societies
    - Establish volunteers
    - Develop a field school for training in underwater archeology
        - College level and/or primary level
        - Training in mapping, reconnaissance, excavation, and archiving techniques
    - Develop publications (e.g., interpretive pamphlets and academic publications)

3. Monitor archeological sites (for the purpose of protection)
    - Monitor and identify natural vs. human-generated impacts
    - Identify management/ protection needs

4. Promote partnerships and leveraging options with:
    A. DNR, since they were responsible for most artifacts found in State waters
    B. Museums and historical societies
        - West End Shipwrecked Project (through the Clallam County Museum)
        - Smithsonian
        - Puget Sound Maritime Museum
        - Columbia River Maritime Museum
        - Makah Museum
    C. National Park Service (e.g., Olympic National Park)
    D. Washington State University
    E. U.S. Navy (responsible for some shipwreck resources)
    F. Volunteers (e.g., Coastal Maritime Archeology Associates)
    G. Foundation grants
    H. Corporate sponsors

5. What the Sanctuary could do:
    A. Obtain records on traditional knowledge of marine resources
        - Native American use of marine (with historical and legal importance)
        - Local communities.
    B. More inventory and more detailed position mapping of artifacts

Discussion

Elevated coastline and underwater resources

The coastline that existed 6,000 years ago was now covered with water. The possibility that coastal village sites that existed 6,000 years ago might now be discovered underwater was discussed. One researcher felt that sites were highly unlikely because wood is poorly preserved over time, and also because the violent storms in the area reduced the likelihood of artifacts withstanding the elements over time. Also, the technology did not yet exist (in an affordable form) for exploration for artifacts in deep water. However, some underwater middens had been discovered in the Queen Charlotte Islands, so it was within the realm of possibility to look for artifacts underwater.

FINAL SYNTHESIS

Ed Bowlby and Julia Parrish concluded the two-day workshop with a summary of the work accomplished. Parrish summarized the research priorities of all the groups. The main categories she identified were as follows:

Inventory: She linked inventory to database creation. Once a list is available, it can be entered into computer and it becomes a database.

Monitoring:

- Monitoring all physical factors that were affecting water properties in the Sanctuary
- Monitoring cultural and historical sites relative to natural and anthropogenic impacts and protection of those sites
- Long-term monitoring of ecologically relevant species, either habitat-based or trophic-based
- Long-term monitoring of sensitive or threatened species relevant to ecological components

She reviewed the discussion regarding monitoring species that agencies are required to monitor and not worrying about priorities, versus selecting indicator species. Parrish also discussed monitoring background mortality trends in animals.

Parrish highlighted the interesting dichotomy between what the marine mammal and seabird group listed to monitor and what the fish and shellfish group listed. The fish and shellfish group thought more along the lines of 'why monitor.' They focused on monitoring relative to public health, to natural resource harvest issues, and to ecological constraints.

She noticed that harmful algal blooms were listed twice for monitoring, once by the fish and shellfish group and secondly by the physical and biological oceanographic group. The fish and shellfish people wanted to relate offshore surveys to endpoint impacts (e.g., health or harvest issues) while the physical and biological oceanography group was more interested in ecosystem effects.

Current Data

In summary, the recommendations from all the groups would either be to create an inventory, or if an inventory already existed, researchers would then need to decide which species or sets of species to monitor. All the information would be lodged in a database and linked to a GIS layering system. This would then provide a map of what was known about species or biological community locations.

One key suggestion for the Sanctuary office was to designate one person to be a webmaster. That person would cultivate ties with all researchers and would keep up to date with new developments. It would require at least a quarter to half of their time.

Parrish generated a list of what she called 'Limitations and Opportunities.' The list included: 1) public awareness (which was linked to education broadly defined); 2) access to vessels and platforms; 3) centralization of all of the monitoring and mapping and/or a metadatabase creation, so at least there would be a centralized place where everyone knew where to go for links; 4) interagency agreements and co-management opportunities, especially state/tribal interests relative to public health and natural resource extraction; 5) use of volunteers (e.g., for fish projects, beach monitoring, marine mammal stranding, archeology).

Bowlby reviewed the stated goals of the Research Workshop:

- To highlight and prioritize research needs for the Sanctuary relative to the development of framework for a five-year research plan
- To build on the results from the Research Workshop of 1996
- To make presentations on ongoing research
- To provide a platform for multidisciplinary information sharing
- To select priority sites for multidisciplinary studies
- To promote student participation in research

He believed that most of the goals had been met through constructive recommendations and the multi-disciplinary information exchanges. He commented that there hadn't been as much student participation as hoped. That meant that more work needed to be done next time to get more students involved, whether they be undergraduate/graduate students or even secondary level.

He mentioned that there had been scheduling conflicts that precluded some key people from attending the Research Workshop, pointing to the Ocean Sciences Conference taking place in San Diego. However, he admitted that it was probably impossible to schedule anything where there would not be a conflict. The Sanctuary would try to contact some of those people who had wanted to attend in order to obtain their input.

A hard copy of the Workshop Proceedings would be sent to all participants. And a list of participants' contact information would be sent to everyone before the Proceedings were distributed to facilitate immediate exchanges. The Proceedings would also include several abstracts that were not presented during the workshop.

Bowlby asked for feedback from the participants. One person wanted to know about the possibility of working with a non-profit organization that might do fund-raising for the Sanctuary. Bowlby and George Galasso, the Assistant Manager at OCNMS, explained that legally, the Sanctuary was able to form a partnership with a non-profit agency, but it could not solicit or lobby such an organization. A legal and bureaucratic process would have to be followed. A partnership between OCNMS and a local non-profit was an excellent idea, but none existed to date.

Sanctuary Web Site

Bowlby mentioned that the Sanctuary was in the process of developing an interactive web site. The Sanctuary would be hiring a contractor to speed-up the process and to train staff internally, in order to keep the web site up-to-date. The 1996 and 1998 Research Proceedings would be posted electronically at this site.

GIS Clearinghouse

Also, the Sanctuary was working in collaboration with the UW and Olympic Natural Resources Center (ONRC) to be a GIS clearinghouse for the Peninsula. The Sanctuary would primarily be responsible for the marine aspect of the clearinghouse.

There was also a GIS metadata clearinghouse project planned that would be tied into the web site. However, that was expected to be a long process. The technical expertise was lacking at the Sanctuary to manage all the data, so the revised plan would be to serve as a network for connecting interested parties with the right resources, but it would not necessarily have all the information in-house. The Sanctuary could provide links to the various sites where researchers would post their own data. This would also facilitate keeping the data current.

Based on the focus group reports and information exchanges during plenary discussions, a final synthesis of recommendations (Table 7) was created to highlight information needs and directions the Sanctuary should pursue.

The workshop concluded after Bowlby and Parrish thanked all participants for sharing their information and recommendations and for taking time out of their busy schedules to attend.

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ACKNOWLEDGEMENTS

We would like to acknowledge the following people who were very helpful with planning and running the workshop: Nancy Beres, Mary Sue Brancato, Lilli Ferguson, George Galasso, Michele Malarney-Hoshlyk, Mike Murray, and Bob Steelquist. Todd Jacobs, the Sanctuary Manager in 1998, was instrumental in the formative stages of this important endeavor. We would like to recognize Jacobs overall guidance he provided during the two-day workshop

We would like to thank our invited speakers Don Scavia, Jerry Galt, Jim Postel, Mark Zimmermann, Mark Wilkins Pat McCrory, Bob Paine, Pat Iampietro, Harriet Huber, Julia Parrish, and Chris Thompson, for their excellent presentations.

We greatly appreciated the assistance of facilitators George Galasso, Mike Murray, and Bob Steelquist. Their guidance in the break-out groups helped in discussions. Group representatives who provided their respective group overviews are also appreciated. Also many thanks to the researchers who prepared and shared their research abstracts.

But most of all, we would like to thank all the participants for taking two days out of their busy schedules to provide their constructive comments and recommendations to the Sanctuary's research program. Thank you all.

APPENDIX

Tables

Table 1. Major Recommendations from the First Olympic Coast Marine Research Workshop (Strickland 1996)

- Select representative long-lived plant and animal species for long-term monitoring
- Monitor background mortality rates of seabirds
- Assess sea otter/sea urchin interactions at Cape Flattery
- Monitor status and trends in marine mammal populations
- Conduct annual surveys of Washington coastal currents and water properties
- Conduct work on the biological effects of the Columbia River plume
- Increase understanding of ocean dynamics of Strait of Juan de Fuca, submarine canyons, coastal promontories, and plumes from coastal estuaries
- Examine interaction of biological oceanography with benthic and intertidal communities
- Update productivity information and determine plankton distribution and abundance
- Determine spatial and temporary distribution and abundance of harmful algal blooms and effects on marine food webs
- Monitor coastal waters to determine baseline data on water quality trends
- Establish moorings to determine both physical and biological parameters
- Distinguish natural from anthropogenic changes in water quality that my indicate environmental changes or emerging problems
- Address management concerns for harvest-related stresses; anthropogenic contamination; habitat alteration; affects of exotic species
- Conduct inventories of marine resources and map and create central databases
- Conduct high-resolution sea floor mapping of representative habitats
- Monitor sediment dynamics and links to community habitats
- Explore links between terrestrial and marine ecosystems, including potential watershed effects
- Develop better baseline data for seabird populations and life histories; kelp habitat; forage fish; and harvested shellfish
- Develop tissue archives for contaminants in marine organisms
- Develop models to integrate nearshore, oceanographic, and ecosystem scales
- Establish and maintain database on historical and archeological information; complete inventory of archeological sites and cultural resources
- Obtain additional background on traditional knowledge as related to marine resources
- Identify and map critical habitats and areas of special interest
- Consider long-term monitoring at following sites: Tatoosh Island, Cape Alava, La Push, Destruction Island, Kalaloch, Cape Elizabeth, and Copalis

Table 2. Agenda for the Olympic Coast National Marine Sanctuary's Research Workshop 1998

Day One - Thursday, February 12

9 a.m.	Plenary Session	Opening remarks and housekeeping items	Ed Bowlby, Research Coordinator for OCNMS, and Julia Parrish, Research Representative for Sanctuary Advisory Council
9:15		General comments on Sanctuary operations	Todd Jacobs, OCNMS Manager, 1998
9:30		Comments on the bigger NOAA picture, funding, etc.	Don Scavia, Director of NOAA's Coastal Ocean Program
10:00		Coastal oceanography	Jerry Galt, NOAA HAZMAT
10:20		Harmful algal blooms	Jim Postel, UW
10:40		Coffee break	
11:00	Plenary Session	Trawl surveys and habitat types	Mark Zimmermann & Mark Wilkins, NMFS
11:20		Geological surveys	Pat McCrory, USGS
11:40		Intertidal ecology	Bob Paine, UW
12:00		Subtidal surveys	Pat Iampietro, CSUM
12:20 p.m.		Lunch break	No-host lunch catered at NOAA cafeteria (see map)
1:00	Plenary Session	Pinniped population trends	Harriet Huber, NMFS
1:20		Seabird colonies	Julia Parrish, UW
1:40		At-sea seabird distribution	Chris Thompson, WDFW
2:00		Coffee break	
2:15	focus groups	Break-out into focus groups	Rooms to be assigned
4:30	Bldg. 9 foyer	Poster Session	Review of posters
5:30		Day 1 concludes	
6:00	Azteca	No-host social hour for drinks, food	Azteca Restaurant, Univ. Village

Table 2 (cont.). Agenda for the Olympic Coast National Marine Sanctuary's Research Workshop 1998

Day Two - Friday, February 13

9 a.m.	Plenary	Reports from focus groups	
9:30	Work Groups	Break-out into different work groups	Refer to Potential Discussion Topics
10:40		Coffee break	
11:00		Group discussions continued	
12:30 p.m.		Lunch break	No-host lunch catered at NOAA cafeteria (see map)
1:00	Work Groups	Continue work group sessions	Discussions
2:30		Coffee break	
2:45 - 4:00	Plenary Session	Wrap-up session	Develop consensus on discussion list and recommendations for research priorities

Table 3. Abstracts from the Olympic Coast National Marine Sanctuary's Research Workshop 1998

(1 -oral presentation; 2 -poster presentation; 3 -abstract only)

RAZOR CLAM (*Siliqua patula*) STOCK ASSESSMENT ON KALALOCH BEACH, OLYMPIC NATIONAL PARK, WASHINGTON USING THE PUMPED AREA METHOD (3). Dan L. Ayres and Donald D. Simons, Washington Department of Fish and Wildlife, 48 Devonshire Road, Montesano, WA 98563.

During the summers of 1995, 1996 and 1997 the Washington Department of Fish and Wildlife undertook the task of estimating the number of razor clams on some Olympic Peninsula, Washington beaches. The survey area included the sandy intertidal beaches located within the Kalaloch Ranger District of the Olympic National Park (ONP). In 1995 we surveyed the 3.0 mile section of beach between ONP Beach Trail Two and ONP Beach Trail Three. In 1996 and 1997 we extended our survey to include a total of 4.2 miles of beach between ONP South Beach Campground and ONP Beach Trail Three. In all three survey years we choose to use a new razor clam stock assessment technique, the pumped area method. Using this method, clams are removed from the sample plot by liquefying the sand with a high pressure jet of water, which causes the clams to float to the surface so they can be gathered and counted. We assumed that every square meter of the survey area was equally likely to be sampled. To meet this assumption, we used a systematic random sample to select transect and sample locations within tidal elevations of the beach. Starting at the highest elevation of the clam population we surveyed sample plots down to the lowest elevation available for the given sample day.

In 1995 we estimated a total of 1,130,000 razor clams living within our survey area and their average size was 101.1 mm. In 1996 we estimated a total of 1,300,000 razor clams, with an average size of 63.6 mm. Finally, in 1997 we found a total of 4,350,000 razor clams with an average size of 33.2 mm. We plan to continue this work during the summer of 1998.

THE RESEARCH VESSEL *TATOOSH* (2). Harry W. Branch, Captain, Independent Contractor; 239 N. Cushing, Olympia, WA 98502.

The Sanctuary's research vessel, the *Tatoosh*, can under ideal conditions, run at thirty knots. Speed improves productivity and in some cases accuracy. The *Tatoosh* is rugged, shallow draft, highly maneuverable and well suited to working among the rocks. DGPS navigation provides exact positioning and the ability to readily move from waypoint to waypoint.

Although the *Tatoosh* is not a heavy weather boat, the skipper can use the twin outdrives to power through waves or to brake like sea anchors. With both engines running the *Tatoosh* is quite formidable. However, if an engine fails she is difficult to control. It cannot be overemphasized that the Sanctuary is located in one of the most treacherous stretches of ocean in the world.

When planning itinerary, work aboard the *Tatoosh* should be conducted as close to Neah Bay as possible. Under ideal conditions the *Tatoosh* can make the run to Kalaloch at the southern terminus of the sanctuary in two hours. If the seas pick up out of the north, the trip back to Neah Bay can take considerably longer.

THE POTENTIAL BENEFITS OF MARINE RESERVES (2). Harry W. Branch, Captain, Independent Contractor; 239 N. Cushing, Olympia, WA 98502.

The rocky environment of the Olympic Coast National Marine Sanctuary is occupied by rock fish and other species with sedentary post settlement life histories. Spots in such environments that are left unfished tend to be occupied by large, older individuals. These large fish are highly fecund, producing as much as thirty times the number of offspring as younger, smaller fish. Large, older fish don't, over generations, produce earlier maturing, smaller offspring as do fish managed under the size limit model.

Marine reserves have great appeal to recreational divers and value to scientists because they are areas where fish can be observed and studied under natural conditions. It has been difficult to evaluate the productivity of no-take zones; the urge to catch fish always seems to precede the quest for knowledge. In a few reserves that have survived long enough, the presence of large fish is readily apparent, as are increased catches of the same species in waters surrounding the sanctuary.

The concept of marine reserves is gaining in popularity as their effectiveness becomes recognized. San Juan County has instituted three no-fish zones and the Washington State Department of Fish and Wildlife will probably follow suit with no take zones at Des Moines Beaches, Orchard Rocks and Octopus Hole in Hood Canal and an expansion of the Edmonds Underwater Park. The Florida Keys National Marine Sanctuary has created Wildlife Management Areas, Ecological Reserves and Sanctuary Preservation Areas, all variations of the no-take concept.

Marine reserves are most attractive to a collapsed fishery because there is less pressure to fish when there are no fish to catch. San Juan County posted a map with a box of thumb tacks and a sign asking people to put tacks at sites where they used to catch large fish and don't any more.

THE POTENTIAL OF EXISTING DIGITAL TECHNOLOGY IN DOCUMENTING AND ESTIMATING NUMBERS OF PLANTS AND ANIMALS (3). Harry W. Branch, Captain, Independent Contractor; 239 N. Cushing, Olympia, WA 98502.

New technology allows the capture of moving images with inexpensive digital cameras and the transfer of this information directly to computers. Image resolution is superior to analog video technology and data comprising the images can be manipulated and analyzed. It is theoretically possible through pattern, color and movement recognition to teach a computer to count birds, fish or other animals. As yet, a computer program is not available to coordinate digital analysis in this way and if such a system existed it would allow only six to twenty three minutes of real time per gigabit of memory. However, digital versatility is improving and may in the near future provide a valuable tool. Digital Video sampling and analysis could save costly drudgery. Video sampling doesn't entail harvesting plants or animals and minimally disrupts areas being sampled, factors that are particularly significant in reserves. Using video technology allows verification and the accomplishment of multiple projects per survey.

JUVENILE ROCKFISHES (*Sebastes*) USE OF SURFACE DRIFT ALGAL/SEAGRASS MATS AS RECRUITMENT HABITAT IN COASTAL WATERS (2). Raymond Buckley and Larry LeClair, Washington Department of Fish and Wildlife, 600 Capitol Way N. Olympia, WA 98501-1091.

Biological and ecological investigations of drift algae/seagrass habitat in surface marine waters of the Olympic Coast National Marine Sanctuary (OCNMS) have been conducted during the summer cruises of the NOAA Ship *McArthur* since 1995. This unusual ecosystem is produced by detachment of nearshore algae and seagrasses from substrates by oceanographic, environmental, and biological processes. The ecological functions of surface drift habitat are complex; the availability, composition, distribution, and duration of the habitat are dynamic at short temporal scales, as are the availability, density, and species composition of biota associated with the habitat. The use of surface drift habitat by juvenile marine fishes demonstrates an important direct link between nearshore and offshore ecosystems in the OCNMS.

Pelagic juveniles of several species of rockfishes (*Sebastes*) recruit to the surface drift habitats which function as pelagic nursery and refuge areas for unknown periods. Rockfishes are a major group of fishes, which have considerable ecological and harvest importance in OCNMS waters. The life history and the recruitment habitat pathways for juvenile rockfishes are virtually unknown in Washington coastal waters. Identification of juvenile rockfish to species is vital to determining the ecological importance of drift habitats, but is problematic due to similarities among many species in meristics and gross morphology, and to the delayed development of many morphological characteristics until sub-adult stages.

The 1995 investigations identified two species of juvenile rockfish (tiger rockfish, *S. nigrocinctus*, and splitnose rockfish, *S. diploproa*), and possibly a third species of juvenile rockfish, using the drift habitats. Gross morphological characteristics of the juvenile rockfishes collected in 1996 and 1997 found two, or possibly four, additional species associated with the drift habitats (in order of most likely identification: widow rockfish, *S. entomelas*, yellowtail rockfish, *S. flavidus*, bocaccio, *S. paucispinus*, and black rockfish, *S. melanops*). Pilot study identification of the juvenile rockfishes collected in 1997 using 30 allozyme loci as revealed with horizontal starch gel electrophoresis on muscle tissue, eliminated widow rockfish and bocaccio from the possible species. Further examinations of liver tissue indicated that the juveniles are most likely black rockfish, although examination of all of the juveniles using electrophoresis is needed to confirm the identifications. This is the first documentation of pelagic juvenile black rockfish recruiting to surface drift habitat in the substrate associated phase of recruitment pathways. Juvenile black rockfish were known to recruit to eelgrass (*Zostera marina*) habitat in coastal waters.

PHOTOGRAPHIC IDENTIFICATION OF HUMPBACK, GRAY, AND KILLER WHALES OFF WASHINGTON AND SOUTHERN BRITISH COLUMBIA (3). John Calambokidis and Dave Ellifrit. Cascadia Research, 2181/2 W Fourth Ave., Olympia, WA 98501.

Cascadia Research conducted studies on humpback whales and other large cetaceans (gray and killer whales) off northern Washington and southern British Columbia with the support of the Olympic Coast National Marine Sanctuary from 1995 to 1997. Primary objectives of the research included to: 1) obtain sighting and individual identification photographs of humpback whales to determine abundance and movements, 2) obtain sighting and identification photographs of gray whales for use in evaluating the residence status of these animals, and 3) obtain identification photographs of killer whales to determine which pods and communities utilize these waters. Surveys off the Washington coast were conducted primarily using Cascadia's 5.3 m rigid-hull inflatable and in association with the Olympic Coast National Marine Sanctuary's cruises using the NOAA Ship *McArthur*.

About 70 unique humpback whales have been identified during the research and these have been compared to other regions of the North Pacific including the more than 900 individuals identified off Oregon and Washington. These have revealed that this area is used primarily by a small population of animals that utilizes a fairly small feeding area. More than half the animals identified in 1997 had been seen in a previous year. Only limited interchange has been found with feeding areas off California and northern British Columbia and Alaska. Approximately 150 gray whales have been identified off the northern Washington coast and Strait of Juan de Fuca. A summer-regular population of gray whales returns annually to this area to feed and ranges along the coast of Washington and British Columbia. Identification of killer whales has revealed that these waters are used by all three recognized forms of killer whales (resident, transient, and offshore types).

SEAFLOOR MAPPING IN MARINE SANCTUARIES: THE MONTEREY BAY NMS EXAMPLE (2). Stephen L. Eittreim and Michael A. Fisher, US Geological Survey, MS-999, 345 Middlefield Rd., Bldg 2 rm. 2239 Menlo Park, CA 94025.

The US Geological Survey has investigated the seafloor geology and active geologic processes within the Monterey Bay National Marine Sanctuary (MBNMS). Two principal goals of the MBNMS project are to map in detail the continental shelf at better than 1-m pixel resolution, and to determine the modes of sediment transport in the Sanctuary. Side-scan-sonar data have been collected at an initial resolution of 12.5 cm and final mosaic map resolution of 40 cm. A total of over 1000 square kilometers of the continental shelf in the Monterey Bay area have been mapped to date. A primary use of the seafloor maps is to identify, categorize, and understand the many and diverse biologic habitats of the Sanctuary. We believe that accurate information about the seafloor environments, home to the varied benthic communities of the Sanctuary, is vital for understanding ecosystem functioning and health. Newly developed state-of-the-art seafloor imaging systems are ideal for this task.

The inner shelf of northern Monterey Bay, out to about 40-m water depth, contains a modern wave-cut platform of outcropping bedrock composed of similar strata as exposed in the adjacent coastal cliffs. The offshore outcrops contain joints and offset by faults that are clearly delineated in the side-scan imagery. In addition, high-backscatter coarse-grain sand patches that exhibit 1-m wavelength ripples, overprint the outcropping strata of the inner shelf.

We have acquired a total of over 400 box-cores on the shelf, using the EPA-formulated EMAP random sample pattern. The gross patterns of sediment type show a mid-shelf mudbelt, bordered inshore by a belt of active sands and outboard by outer-shelf relict sands near the shelf break. Initial Pb-210 profiles from these box-cores have given consistent vertical gradients that indicate modern sedimentation rates on the order of 2 mm/year.

The seafloor maps and other results from this project will be available on our web sites as well as distributed via CD-ROM in 1999.

TRENDS IN PINNIPED POPULATIONS IN THE OLYMPIC COAST NATIONAL MARINE SANCTUARY (1). Patrick J. Gearin, National Marine Mammal Laboratory, NMFS/NOAA, 7600 Sand Point Way, NE, Seattle, WA 98115, Steven J. Jeffries, Marine Mammal Investigations, WDFW, 7801 Phillips Road, SW, Tacoma, WA 98498, and Harriet R. Huber[1], National Marine Mammal Laboratory, NMFS/NOAA, 7600 Sand Point Way, NE, Seattle, WA 98115.

Five species of pinnipeds use the waters of the Olympic Coast National Marine Sanctuary: harbor seals, Steller sea lions, California sea lions, northern fur seals, and northern elephant seals. Only harbor seals pup and breed in Sanctuary waters, the other species use the Sanctuary seasonally. Harbor seals are present year round on the Washington coast; up to 800 pups are born along the coast north of Grays Harbor between late May and late June. Numbers have been increasing about 5 % annually since harbor seals were protected in 1972, but in recent years, the population may be leveling off (4,000 to 5,000 seals are present during peak counts). Steller sea lions are present year round, with lowest numbers present May, June and July when they move to breeding areas in Oregon and British Columbia. Numbers of Stellers are stable in Washington and Oregon, although listed as threatened south of the Gulf of Alaska. Peak counts of up to 1,000 Stellers have been counted within the Sanctuary during migration just before and just after the breeding season. California sea lions are present along the Washington coast during their migration between the southern breeding rookeries in California and Baja and winter feeding areas in British Columbia. Nearly all California sea lions in Washington state are adult and subadult males. Females and juveniles remain near the breeding grounds in California and Mexico. Over 1,000 California sea lions were seen at Bodelteh Island alone in December 1997, normally peak counts within the sanctuary are 500 to 600 sea lions. A few elephant seals regularly haul out on the eastern end of Destruction Island and occasionally may also be seen on mainland beaches along the Olympic Peninsula. Adult female and juvenile elephant seals from California feed March to June and August to October along the continental shelf. Northern fur seals from Alaska and California also feed along the continental shelf from February to April with peak numbers of around 86,000 off the coast of Washington in April.

UNDERWATER ARCHAEOLOGICAL FIELDWORK IN THE OLYMPIC COAST NATIONAL MARINE SANCTUARY (2). Carl C. Harrington III, Coastal Maritime Archaeology Resources, 24019 104th Place West, Edmonds, WA 98020.

Since before the age of European exploration, the Straight of Juan de Fuca served as a natural route to the interior northwest. Vessels have traversed these waters in exploration, governmental activity, natural resource exploitation, and commerce. Factors such as complex geography, quickly changing weather, as well as heavy vessel traffic, have lead to hundreds of vessels being lost in these waters. Some were driven ashore in gales, others burned to the waterline. Some sank after collision, and still others were lost without a trace far off shore.

Coastal Maritime Archaeology Resources (CMAR), a group of volunteers with extensive experience working in the Channel Islands National Park, has assisted the Olympic Coast National Marine Sanctuary (OCNMS) in fulfilling its mission to inventory, evaluate, and manage the underwater cultural resources within the sanctuary. Guided by NOAA Archaeologist Bruce Terrell, CMAR members have conducted archival research, assisted in a remote sensing program, and have participated in week-long field reconnaissance surveys in 1996 and 1997.

The diving programs included checking the 1995 remote sensing survey targets, reconnaissance, mapping, and evaluation of the ship *General Meigs*, and exploration and mapping of artifact material reported by local divers. Reports prepared by CMAR assist NOAA in managing the resources and planning future research. CMAR has been very successful at locating the remote sensing targets detected in the 1995 survey. Although none of the targets proved to be historical resources, the dives confirmed the utility of remote sensing and diver reconnaissance. Guided by archival research, further side-scan sonar and magnetometer surveys should provide promising targets for divers to investigate in the future. Already known resources such as the *General Meigs* require continued survey and monitoring. Regular visits provide the opportunity to survey the changing condition of a vessel and to examine any new material revealed by changing ground or water conditions. Recently lost vessels are monitored to assist in under standing artifact deposition processes.

From this established relationship with the OCNMS, CMAR looks forward to cooperating further with the OCNMS in providing expertise with underwater cultural resources. The data obtained from CMAR's research will contribute to understanding the maritime history of the region. As part of the inventory and data collection aspects, future work in the OCNMS could include an archaeological field school, which CMAR would assist organizing. Additionally, future partnerships with local schools and colleges would increase community participation.

AN OVERVIEW OF THE BIOLOGICAL RESOURCES DIVISION (USGS) SEA OTTER PROJECT IN WASHINGTON (2). Ronald J. Jameson and Mark Stafford, USGS Biological Resources Div., 200 SW 35th St., Corvallis, OR 97333; Bernie Krausse (Biological Resources Division, USGS)*, and Steve Jeffries , Washington Dept. Fish & Wildl., Marine Mammal

Investigations, 7801 Phillips Dr. SW, Tacoma, WA 98498 (*Currently with Washington Department of Fish and Wildlife).

Population Trends Sea otters (*Enhydra lutris kenyoni*) were extirpated by the fur trade in Washington by the early 20th century. However, in 1969 and 1970, 59 sea otters were translocated from Alaska to the Olympic coast of Washington, 29 near Pt. Grenville in 1969, and 30 near La Push in 1970. In 1969, 16 (55%) of the translocated sea otters were found dead within 2 weeks of release. The first intensive survey of the population was completed in 1977 when biologists surveyed the coast from Destruction Island (DI) to Cape Flattery. Nineteen otters were observed during the survey, and the range extended from DI to Cape Alava. Surveys were conducted biannually until 1989, but since then they have been conducted annually in cooperation with the Washington Department of Fish and Wildlife. In 1997, the inshore area from Pt. Grenville to Bullman Creek east of Neah Bay was surveyed and yielded 502 sea otters. The rate of increase since 1977 has been about $18\%^{-1}$, and the range has expanded from about 60 km in 1977 to over 160 km in 1997. The monitoring portion of this project is expected to be ongoing.

Population Biology In 1994 the Washington sea otter project expanded to include population biology and behavior. Objectives were to obtain information on movements, reproduction, and foraging behavior of radio-instrumented sea otters. Since 1994, 69 sea otters have been captured; 54 have been implanted with radio transmitters. Over 2300 relocation records have been obtained and preliminary analysis indicates individual sea otters have centers of activity connected by travel corridors through which they move fairly rapidly. Adult males tend to use larger segments of coastline than adult females, but long distance movements have been noted for both sex/age classes. Reproductive data have yet to be analyzed. Data on foraging and food habits have been separated into two segments: south of Cape Flattery and east of the "Cape". Nearly 12000 foraging records have been obtained, and preliminary analysis suggests the prey base south of Cape Flattery is similar to that found in areas where sea otters have been established for a long period of time. In contrast, the area near and east of Cape Flattery is an area recently reoccupied by sea otters. East of Cape Flattery red sea urchins (*Strongylocentrotus franciscanus*) and clams account for, respectively, 60% and 17% of the prey taken by number. South of Cape Flattery, where sea otters have been established for several decades, red sea urchins account for <1% of the prey taken. This portion of the project is scheduled to continue to the year 2000.

BENTHIC SEA OTTER HABITAT SURVEYS BETWEEN CAPE FLATTERY AND THE SEKIU RIVER (3). Michael Kenner, Univ. of California, Santa Cruz Field Stn., A316 Earth & Marine Sci. Bldg., Santa Cruz, CA 95064; Ronald J. Jameson , USGS Biological Resources Div., 200 SW 35th St., Corvallis, OR 97333; and Ed Bowlby, Olympic Coast National Marine Sanctuary, 138 W. 1st St., Port Angeles, WA 98362.

In order to document changes to the rocky-bottom subtidal due to sea otter (*Enhydra lutris kenyoni*) foraging, the Biological Resources Division, USGS, in cooperation with the Olympic Coast National Marine Sanctuary, sampled 40 subtidal sites between Waatch Point and the Sekiu River in 1996 and 1997. Sites were located randomly from a chart and were sampled at depths ranging from 6.5-10 m. At each site, kelps were counted, percent cover of fleshy red algae, erect coralline algae, and encrusting invertebrates was estimated, and the biomass of grazing echinoid and gastropod invertebrates was measured in 20 (0.25m^2) quadrats. In 1996, 14 sites were sampled between Tatoosh Island and Neah Bay and 12 sites were sampled between Neah Bay and the Sekiu River. In 1997 eight of the sites west of Neah Bay and four of the sites east of Neah Bay were resampled. Sites, which had the highest urchin densities in each area, were selected. In addition, eight new sites between Tatoosh Island and Neah Bay and six new sites on the outer coast between Waatch Point and Tatoosh Island were added.

In general, most sites were dominated by kelps and other fleshy algae. The most common grazers sampled were assorted limpets and small snails (*Calliostoma* and *Homolapoma* ssp.) but these did not have an obvious impact on the fleshy algae. Only five sites were found to have urchin densities greater than one per quadrat (all species combined) and three of these were at Tatoosh Island. These Tatoosh sites were the only ones to have patches where kelps had been obviously overgrazed. Of the twelve sites resampled, eight had lower urchin counts in 1997 than the previous year. The two Tatoosh sites, which were sampled both years, showed declines but were still among the three sites with the highest urchin densities and biomass. Data on sea otter distribution and habitat use suggests the *en masse* movement of a large group to east of Cape Flattery initially by-passed Tatoosh Island. However, recent observations indicates sea otter use of the water surrounding the island is increasing. We plan to re-sample these sites again in 1998 and 1999.

QUANTITATIVE VIDEO-BASED ASSESSMENT OF SEA OTTER BENTHIC PREY COMMUNITIES ALONG THE WASHINGTON STATE OLYMPIC COAST: 1995 RESURVEY OF 1985 SAMPLING STATIONS AND ESTABLISHMENT OF A QUANTITATIVE VIDEO BENTHIC ARCHIVE FOR ADDITIONAL OLYMPIC COAST STATIONS (1). Rikk G. Kvitek and Pat J. Iampietro[1], California State University Monterey Bay, Earth System Science & Policy, 100 Campus Center, Seaside, CA 93955-8001.

It has been conclusively shown for Alaskan habitats, that where sea otters (*Enhydra lutris*), occur, herbivores are rare and plants are abundant, whereas when sea otters are absent herbivores are relatively common and kelp plants are rare. Here, we take advantage of the rapid range expansion of the sea otters introduced into Washington State during 1969-70 to test this paradigm for a more southerly sea otter population. Rather than kelps, however, we focus on changes in understory foliose red and coralline algae, species with different levels of palatability to echinoids preyed upon by sea otters. Epifaunal benthic communities were sampled at eight sites inside and outside the sea otter range along the Olympic Peninsula Coast in August 1987. Using quantitative video sampling techniques, these same locations were resampled in June 1995 following the dramatic increase in sea otter numbers at sites within their 1987 range, and the colonization by otters of all previously sampled sites outside their 1987 range.

Significant decreases in prey abundance and biomass (primarily sea urchins and sea cucumbers) were found at all resampled sites. High numbers of large sea urchins were only found in the highly exposed, current swept sites at Cape Flattery and Tatoosh Island. These two sites are within the 1995 sea otter range, and were sampled only in 1995. Palatable algal abundance (foliose red algae) increased significantly where measured at sites recently occupied by sea otters, but less palatable coralline algae decreased in abundance at the site experiencing the most dramatic decline in sea urchin prey. The results from this natural experiment outside of Alaska support the general paradigm that sea otter occupancy favors enhanced abundance of palatable plants as a consequence of reduced herbivorous sea otter prey abundance. Our results also suggest that high water current areas may serve as refugia from sea otter predation for some time following sea otter range expansion. The use of video sampling techniques allowed rapid acquisition of a large number of samples, while also establishing an imagery archive for use in further scientific and outreach endeavors.

TRIBAL JOURNEYS (2). Cathy Lear and Mary Williams. Hoh Indian Tribe, 2464 Lower Hoh Road, Forks, WA 98331.

During the summer of 1997, tribes from the Olympic coast, Puget Sound, and Canada paddled from Campbel River, B.C., across the Strait of Juan de Fuca, to Neah Bay and through the Olympic Coast National Marine Sanctuary. Members of the Hoh Tribe carved a six person canoe and paddled it from Campbell River to their village at the mouth of the Hoh River.

Through photos, models, maps and videos, this poster presentation chronicles the Tribe's journey. A cedar log becomes a canoe; the canoe is paddled from Vancouver Island, across the Strait, through the Sanctuary, and home to Hoh River.

SIDESCAN SONAR AND SEISMIC REFLECTION SURVEYS ALONG THE OLYMPIC COAST, WASHINGTON (2). P. A. McCrory, D. C. Twichell, Jr, S. C. Wolf, T. F. O'Brien, D. S. Foster, S. E. Harrison*, V. A. Cross, and K. F. Parolski, U.S. Geological Survey, MS 977, 345 Middlefield Road, Menlo Park, CA 94025 (*currently at Seafloor Surveys international, Seattle, WA).

Geophysical surveys conducted by the US Geological Survey onboard the NOAA Ship *McArthur* and the WDFW Vessel *Corliss* in 1997 add a new component to the Olympic Coast National Marine Sanctuary's ongoing efforts to characterize biological productivity and physical habitats within the recently formed marine sanctuary off the coast of Washington. The main objective of the sonar and seismic surveys was to obtain reconnaissance data on the distribution of bedrock outcrop and sediment on the seafloor. These results will complement existing data—primarily surface-sample data—and together will be used to create a map of seafloor texture and morphology. These data also provide baseline information critical to the long-term monitoring of benthic habitats. In addition, the US Geological Survey is using these data to study coastal erosion within the Columbia River littoral cell and to characterize seismic hazards associated with nearshore faults.

We collected geophysical data along 400 km of trackline in water depths ranging from 100 to 20 m with the *R/V McArthur*. With the *R/V Corliss*, we collected data along 100 km of trackline within the Sanctuary in water depths ranging from 40 to 10 m. In addition to shipboard navigation systems, USGS DGPS (differential global positioning system) navigation was used on both cruises to locate tracklines with an accuracy of 5-10 m. A 3.5-kHz acoustic source recorded seismic reflection data with a resolution of 1-2 m in the upper few meters of strata below the sea floor. A lower frequency seismic reflection (boomer) system recorded data with a resolution of 3-6 m in the upper 100-150 m of strata below the sea floor. A 100-kHz sidescan sonar system collected backscatter data with a resolution of 0.5-1 m using a 400-m swath width on the *R/V McArthur* and a 200-m swath width on the *R/V Corliss*. The USGS also collected seafloor sediment samples in 70 to 30 m water depth during an east-west CTD transect offshore of Cape Elizabeth using a Shipek grab sampler. Samples from 50- and 70-m water depth recovered silty sand consistent with the facies recorded on the sidescan images. The shallower grab samples recovered rounded gravels with oxide coatings. These gravels are presumably relict stream gravels deposited during the last sea-level low stand.

These data document the offshore location of a fault zone which trends southwest across the shelf and comes onshore north of Grays Harbor. Twenty km offshore of Grays Harbor the fault vertically displaces the seafloor 12 m over a 1.7-km-wide zone. Here, the fault and an associated broad anticline form the southern end of a 20-km-wide structural high which extends northward on the inner shelf from Grays Harbor to the Raft River (as far north as data were collected). This high encompasses a region of intensely folded and faulted strata that display spectacular curved bedding traces on the sidescan images where rock crops out in relief. Some of these outcrops had reflective "clouds" in the water column above them that may represent concentrations of kelp or fish and other animal life. Seaward from about 50-m water depth, the bedrock high was commonly covered with rippled sediment. Nearshore, it was either barren of sediment or crossed by small channels filled with both rippled and apparently smooth sediment. The bedrock high disrupts the Holocene sediment distribution and modern sediment transport in this area. Columbia River sediment, which has been transported NW along the shelf during the Holocene, reaches 20 m in thickness on the middle shelf seaward of the structural high, is absent on top of it, and forms a thin discontinuous cover on its shoreward side. Sediment discharged from coastal streams such as the Copalis River is deposited on the inner shelf, shoreward of the high. Thus, the bedrock high serves as a barrier separating the inner shelf and middle shelf sediment provinces and contributes to starved beach conditions north of the Copalis River.

MONITOR WHAT? (1) R. T. Paine. Department of Zoology, Univ. of Washington, Seattle, WA 98195.

Large numbers of plant and animal species coexist on rocky shores along Washington’s coast. Their distribution and abundance patterns vary due to both extrinsic (El Niño, winter storms, oil spills) and intrinsic (changes in predators, variation in recruitment patterns) factors. For Tatoosh Island, I document the long-term variability in mussel populations (28 years), barnacle recruitment (20 years), and the upper limit of an algal population (19 years). In addition, I describe variation in sea urchin populations and its consequence for local algal productivity, in light of sea otter recovery. The manager’s dilemma is that most populations vary in space and time, variation is best established by long-term monitoring, not all species can be monitored, so hard choices must be made. In this context snapshot surveys are useless and can be misleading when it is important to understand the variation’s cause.

ABUNDANCE AND DISTRIBUTION OF PORPOISES AND OTHER MARINE MAMMALS IN THE INLAND WATERS OF WASHINGTON AND BRITISH COLUMBIA (3). Steve Osmek and John Calambokidis, Cascadia Research, 218 1/2 West 4th Ave., Olympia, Washington 98501; and Jeff L. Laake, NOAA's National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Washington 98115.

Harbor porpoise, harbor seals, and Dall's porpoise of Washington State and British Columbia inside waters are incidentally entangled in gillnets set for salmon. To determine the possible effect of these takes on populations and to mitigate mortality, information on their abundance and distribution is needed. Line-transect surveys were flown in a twin-engine high-wing aircraft during summer 1996. These surveys covered 6,263 km of the Strait of Juan de Fuca, the San Juan and Gulf Islands, and the Strait of Georgia. A total of 1,505 sightings of nine marine mammal species were seen with harbor seals, harbor porpoise, California sea lions, and Dall's porpoise being most frequent. Total abundance of harbor porpoise, the primary study species was divided as follows: 3,132 in the Strait of Juan de Fuca, 2,361 in the San Juan/Gulf Islands, and 911 in the Strait of Georgia. These estimates were generally higher than those obtained in some of these areas in surveys conducted in 1991. During 1996, the encounter rates of seals and Dall's were greatest in the shallow and deep water depths, respectively. Harbor porpoise sighting rates by depth was unclear, except for the San Juan/Gulf Islands where they generally preferred deeper waters. Analyzing sighting rates by 352 km^2 geographic cells showed sighting rates for all three species were highest around the boundary waters of the San Juan/Gulf Islands regions. Closing specific areas to gillnet fisheries may not be an effective method of reducing take levels because these species range widely and are present at all depths and distances from shore during summer.

ECOLOGICAL CONSEQUENCES OF VARIABILITY IN RECRUITMENT AND GROWTH IN MARINE POPULATIONS (3). Cathy Pfister, University of Chicago, Dept. of Ecology and Evolution, 1101 E. 57th St., Chicago, IL 60637.

Understanding how populations will respond to changes in the environment requires information about the how environmental variability affects ecologically important traits. My research on the performance of individuals among a variety of species allows me to explore the range of variation in the recruitment and growth of marine organisms, including some of the correlates of that variation. With the permission of the Makah Tribal Nation, nearly a decade of research on Tatoosh Island and nearby mainland sites has revealed the range of performance in several marine species. My work with marine intertidal fishes (sculpins: Cottidae) shows that nearshore recruitment events can be correlated with temperature and upwelling data from offshore buoys. Although annual variation in the timing of the recruitment event can greatly alter when fishes reach reproductive size, population changes are also very sensitive to alterations in the survivorship of adult fishes, underscoring the importance of integrating the effects of environmental change over the entire life cycle. Long-term demographic data collection for intertidal kelps (*Alaria nana, Hedophyllum sessile, Pleurophycus gardneri*) also reveal interannual variability in recruitment, especially for the shorter-lived *Alaria*.

Additionally, differences among individuals in size and growth are persistent and lead to variability in the estimates of productivity and detrital production for intertidal areas. Since we can also expect that variability in algal productivity and species composition will be altered by the reinvasion of sea otters and the commercial exploitation of sea urchins, I quantify both the changes in drift algae and how drift algae contribute to productivity in coastal areas. As a complement to these field studies, I am exploring how marine organisms should be best described quantitatively when there is such significant variability among individuals and among key events (e.g. recruitment) in a population. By comparing simple population models with more complex simulation models, I am asking when we will need more complicated population models to characterize variable marine populations in the OCNMS.

HARMFUL ALGAL BLOOMS IN THE OLYMPIC COAST NATIONAL MARINE SANCTUARY (1). James R. Postel[1], Rita A. Horner, and Barbara M. Hickey, University of Washington, School of Oceanography, Box 357940, Seattle, WA 98195-7940.

The Pacific Northwest coastal region is embedded in a large scale (~1000 km wide) Eastern Boundary System known as the California Current System (CCS). The Olympic Coast National Marine Sanctuary (OCNMS) extends from shore to beyond the shelf break from north of Grays Harbor to the Strait of Juan de Fuca; its waters are heavily influenced by the CCS. Both the prevailing winds and currents in nearshore regions of the Pacific Northwest undergo a strong seasonal variation, such that within any season, winds or currents or both can reverse from the seasonal mean direction for periods of several days or more.

Because of the strong wind forcing and narrow shelves, upwelling and downwelling advective processes play a dominant role in characterizing biological production in nearshore regions of the OCNMS, which is a highly productive and biologically diverse area especially from spring through late fall. Blooms of harmful algal species (HABs) occur all along the Washington coast including within the OCNMS at various times of year. At least 20 potential HAB species have been identified in the area, usually as a fraction of the total phytoplankton community, but their occurrences present significant problems to the region. These species include dinoflagellates in the genera *Alexandrium*, *Dinophysis*, *Ceratium*, and *Prorocentrum*; diatoms in the genera *Pseudo-nitzschia* and *Chaetoceros*; and the raphidophyte flagellate *Heterosigma akashiwo*. The most pressing public health and economic problems are related to *Pseudo-nitzschia* spp. that cause domoic acid poisoning, and *Alexandrium* spp. that are the source of paralytic shellfish poisoning.

In 1996 and 1997 we participated in sanctuary-sponsored cruises aboard the R/V *McArthur*. Data were collected to examine the hydrographic features, current flow and distribution of HABs over the geographic extent of the sanctuary. High concentrations of *Pseudo-nitzschia* were present each year, but not the same species, nor at the same locations in the two years. In 1996 maximum *Pseudo-nitzschia* numbers occurred in a narrow band about 5-10 km from shore in the northern part of OCNMS from Portage Head to La Push, with very few cells from Kalaloch south to Copalis Beach. In 1997 high concentrations occurred nearshore at Cape Alava, but they were more abundant farther offshore near the northwest boundary of the sanctuary; appreciable concentrations occurred in the area south of Kalaloch as well.

Alexandrium spp. were seen in very low concentrations (usually < 10,000 cells/liter) both years, but were observed in more locations in 1997 than in 1996.

Before these sanctuary cruises no consistent species data from off the coast existed, and we were limited to collecting samples from the beaches. With the advent of the OCNMS/*McArthur* cruises we have begun collecting long term data on HABs off the Washington coast as well as the necessary hydrographic and meteorological observations to help us understand their dynamics.

COUPLING THE ECOLOGY OF NEARSHORE HABITATS WITH COASTAL OCEAN PROCESSES (3). G. Carl Schoch, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331, and Megan N. Dethier, Friday Harbor Labs and Dept. of Zoology, University of Washington, Friday Harbor, WA 98250.

Processes linking oceanographic events (physical) and nearshore ecological patterns (biological) are poorly understood because of the difficult logistics of gathering oceanographic data in shallow waters of exposed coastlines. A potential key linkage is that between oceanic nutrient fluxes, coastal and nearshore plankton productivity, and the survival and growth of organisms on the shorelines. Upwelling (the flow of cold water from the depths to replace surface water advected away from the coast by winds) and the drainage of numerous rivers into the sea replenish the nutrients that drive inshore primary production. Data from a long-term intertidal monitoring program within the Sanctuary demonstrate that there is unexpected spatial variation in the abundance and biomass of sandy shore animals among physically similar areas, and that these spatial patterns are consistent from year to year. Preliminary oceanographic data on water temperatures, chlorophyll content, and nutrient levels along the coastline suggest that much of this variation in sand-beach secondary productivity correlates closely with levels of oceanic chlorophyll. The chlorophyll and nutrients appear to be controlled by a combination of upwelling events (affected by seasonal wind patterns and local bathymetry, e.g. canyons) and localized retention of nutrients in some areas with broad, flat sand beaches and subtidal zones (e.g., from the Kalaloch area southwards). We are currently seeking an El Niño 'signal' in the biota of these sand beach communities; because the worms and crustaceans in high-energy sand beaches have short life spans and are probably food-limited, alteration of inshore conditions caused by the current El Niño may be visible in their numbers. Understanding of such oceanic-nearshore linkages is critical if we are to scale up our understanding of local nearshore processes to larger areas. Many current issues, e.g. the effects of climate change or oil spills, are concerned with processes operating on scales of the landscape or region, but most of our knowledge base is comparatively fine-scale (the normal scale of ecological investigations). A goal of current and future research is to link physical shoreline and oceanographic databases with the extensive biotic databases for this coastline (rocky as well as sandy shores). An integrated coastal GIS database would help analyze the functional linkages between not only shoreline organisms and oceanographic productivity, but also other 'data layers' such as locations of seabird colonies and fishing grounds. Such a multi-disciplinary effort would result in an unusually unified picture of an important coastline.

SEASONAL PATTERNS OF DISTRIBUTION AND ABUNDANCE OF SEABIRDS WITHIN THE OLYMPIC COAST NATIONAL MARINE SANCTUARY, AND CORRELATES WITH HABITAT PARAMETERS (1). Christopher W. Thompson[1], Washington Department of Fish and Wildlife, 16018 Mill Creek Blvd., Mill Creek, WA 98019; Julia K. Parrish, Department of Zoology, Box 351800, University of Washington, Seattle, WA 98195; Kirsten Brennan and Monique Wilson, Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501.

Washington Department of Fish and Wildlife (WDFW), in collaboration with other organizations, has conducted at-sea surveys along the Strait of Juan de Fuca and outer coast of Washington, including the Olympic Coast National Marine Sanctuary (OCNMS) since the summer of 1995 in order to document the winter and summer distribution and abundance of seabirds in this area. We do not yet have sufficient data to indicate significant population changes in species for which we have collected data, though with continued seasonal monitoring, we hope to be able to track population trends in the future; also, estimates of population sizes and densities of seabird species from previous studies are not readily comparable to ours because these studies collected data by methods that are significantly different from our own. As a result, in cooperation with other seabird researchers and government agencies in California and Oregon, one of our main goals is to collaboratively develop standard methodologies for monitoring various seabirds to facilitate comparisons of data among studies in different geographic areas and for many years in the future. Within OCNMS waters, the relative and absolute abundances of various species changes dramatically between seasons; most notably, most locally breeding alcids decrease dramatically or disappear altogether. Although WDFW collects data on all seabird species, including waterfowl (but excluding gulls), our data analyses have focused mainly on issues regarding Marbled Murrelets, *Brachyramphus marmoratus* (hereafter murrelets), and Common Murres, *Uria aalge* (hereafter murres), because of recent declines in these species due to deforestation, oil spills, gill net bycatch, and El Niño - Southern Oscillation (ENSO) events. In addition to survey methodology issues, we have focused mainly on issues regarding habitat preferences and daily/seasonal patterns of movement of these species. Our data indicate that murrelets are found almost exclusively within one kilometer of shore; their density is highest close to shore (200-400 meters), at water depths usually less than 15 meters, in areas with kelp, and at mouths of harbors, bays and rivers; surprisingly, they are distributed very similarly throughout Washington waters in both summer and winter, but their overall densities are much lower in winter than summer. In addition, they are more abundant within sanctuary waters and along the Strait of Juan de Fuca than along the central and southern Washington coast. In contrast, murres show a distinct preference for waters 500 - 1500 meters from shore independent of water depth. During the breeding season, the density of murres around Tatoosh Island, the largest murre breeding colony in Washington, decreases exponentially with radial distance to background levels at about 5 km. Beginning in mid-July, reproductively mature murres from Oregon begin to disperse northward into Washington, reaching OCNMS waters by early August. Historical data indicate that this migration may be earlier in some years.

SPECIES INTERACTIONS AND THE EFFECTS OF EXTINCTION ON NATURAL ECOSYSTEMS (3). Tim Wootton, Department of Ecology & Evolution, University of Chicago, 1101 East 57th St., Chicago, IL 60637.

Despite tremendous public concern, the consequences of species extinction and other environmental impacts on complex natural ecosystems are poorly understood. Since 1984, I have been exploring experimentally the effects of species extinction in the intertidal communities of Tatoosh Island, Washington. Both experimental manipulations of shorebirds and marine invertebrates, and observations of bird communities following re-establishment of birds of prey, have repeatedly revealed complex consequences of extinctions, termed "indirect effects", which radiate through the ecosystem. Obtaining these results has also resulted in the development of new approaches, such as structural equation modeling, for detecting indirect effects. I am now exploring approaches to predict the complex consequences of extinction and other environmental impacts. A central focus is the analysis of ecological dynamics through the use of time-series data in combination with Markov/Cellular Automaton models and Structural Equation Modeling on dynamical data. If I can empirically apply and experimentally validate these approaches, they will be valuable tools for managers to predict the consequences of environmental impacts and will also identify new monitoring schemes to detect changes in ecosystem function. To develop the appropriate long-term data base for applying and evaluating these techniques, in 1993 I initiated censuses and experimental manipulations on permanent plots at thirty intertidal sites and eleven transects on Tatoosh. Aside from their direct ties to the modeling approaches, these data, in conjunction with several long-term bird monitoring programs that I began in the early 1980's, will serve as valuable baseline information for detecting environmental impacts on the Olympic Coast National Marine Sanctuary (OCNMS). Other ongoing projects include 1) basic population biology of, and likely harvesting impacts on, the goose barnacle *Pollicipes polymerus*, 2) experimental investigations of the importance of genetic and demographic factors on extinction risk in the sea palm (*Postelsia palmaeformis*), an exploited species of algae, 3) life history, feeding ecology, and population dynamics of glaucous-winged gulls, American black oystercatchers, and peregrine falcons, 4) size-dependent interactions among mussels and other intertidal invertebrates, 5) role of bird predation and indirect effects on the evolution of intertidal invertebrates, 6) consequences of nutrient variation in intertidal ecosystems, and 7) organization and energy base of food webs in rivers flowing into OCNMS and adjacent waters.

UNTRAWLABLE AREAS, SEDIMENTS, AND SPECIES ASSEMBLAGES IN THE NMFS TRIENNIAL WEST COAST BOTTOM TRAWL SURVEY OF CONTINENTAL SHELF GROUNDFISH RESOURCES (1). Mark Zimmermann, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA 98115.

The NMFS conducts a bottom trawl groundfish assessment survey along the US west coast every three years. This survey provides fishery independent data for the assessment and management of several commercially important groundfish species harvested in coastal waters. Using a stratified- random survey design, we distribute 600 sampling sites along 1700 km of coast between the depths of 55 and 500 m. Our surveys are conducted in the summer, starting in southern California and ending in southern British Columbia.

There are several places too rocky or steep to allow bottom trawling- these are places where we have torn up our nets trying to obtain a sample or do not attempt to fish. I've been using a GIS to determine the extent of these untrawlable places and to estimate the fish populations we might be missing inside them. I'm also interested in the variety of habitats where we can fish with our nets and have been constructing a sediment map as a means of describing it.

When these first two projects are complete, I'll conduct a size-related species assemblage analysis, and describe each assemblage in terms of its preferred depth, temperature, latitude, and habitat type. After determining where these assemblages occur, I will re-examine the utility of our current stratification system.

Table 4. List of acronyms used in the Olympic Coast National Marine Sanctuary's Research Workshop 1998.

AEC	Atomic Energy Commission
ACE	U.S. Army Corps of Engineers
ADCP	Acoustic Doppler Current Profiler
AOP	Annual Operating Plan
ASP	Amnesic Shellfish Poisoning
AVHRR	Advanced Very High Resolution Radiometer
BC	British Columbia, Canada
BRD	Biological Resources Division, USGS
CENR	Committee on the Environment and Natural Resources
CSUMB	California State University at Monterey Bay
CTD	Conductivity, Temperature, Depth
DEIS	Draft Environmental Impact Statement
DGPS	Differential Global Positioning System
DOE	U.S. Department of Energy
DSP	Diarrhetic Shellfish Poisoning
ECOHAB	Ecology and Oceanography of Harmful Algal Blooms
EFH	Essential Fish Habitat
EMAP	Environmental Monitoring and Assessment Program
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
GIS	Geographic Information System
GLOBEC	Global Ocean Ecosystem Dynamics
GPS	Global Positioning System
HAB	Harmful Algal Bloom
HAZMAT	NOAA’s Hazardous Materials branch
IOC	International Oceanographic Commission
IOS	Institute of Ocean Sciences, Sydney, British Columbia
MMPA	Marine Mammal Protection Act
NCCOS	National Centers for Coastal Ocean Science
NDBC	National Data Buoy Center, NOAA
NMFS	National Marine Fisheries Service, NOAA
NMML	National Marine Mammal Laboratory, NOAA
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Commission, NOAA
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
NSF	National Science Foundation
NWFSC	Northwest Fisheries Science Center, NMFS
NWIFC	Northwest Indian Fisheries Commission

OCNMS	Olympic Coast National Marine Sanctuary, NOAA
ONP	Olympic National Park
ONRC	Olympic Natural Resources Center, UW
OSU	Oregon State University
PMEL	Pacific Marine Environmental Lab, NOAA
PNCERS	Pacific Northwest Coastal Ecosystem Research Study
PSAMP	Puget Sound Ambient Monitoring Program
PSG	Pacific Seabird Group
PSP	Paralytic Shellfish Poisoning
RDA	Resource Damage Assessment
RFP	Request for Proposals
RHIB	Rigid hull inflatable boat
SAC	Sanctuary Advisory Council
SRD	Sanctuaries and Reserves Division, NOAA
SRP	Sanctuary Research Plan
US	United States
USCG	U.S. Coast Guard
USN	U.S. Navy
UBC	University of British Columbia
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
USN	U.S. Navy
UVIC	University of Victoria, British Columbia
UW	University of Washington
WDE	Washington Department of Ecology
WDFW	Washington Department of Fish & Wildlife
WDH	Washington Department of Health
WDNR	Washington Department of Natural Resources
WWU	Western Washington University

Table 5. Participant list from the Olympic Coast National Marine Sanctuary's Research Workshop 1998.

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Table 6. Group discussion list provided to participants of the Olympic Coast National Marine Sanctuary's Research Workshop 1998.

Name ________________________________ Focus Group ______

Affiliation _____________________________

GROUP DISCUSSION LIST

Resource Issue	Rank 1-5 (1 = highest, 5 = lowest priority)		Identify Partnerships, Ongoing Work, and How Collaboration Could Leverage Funding
	OCNMS	Your Organization	
select representative long-lived plant and animal species for long-term monitoring			
monitor background mortality rates of seabirds			
assess sea otter - sea urchin interactions at Cape Flattery			
monitor status and trends in marine mammal populations			
conduct a complete annual survey of Washington coastal currents and water properties since none have been done at any location off the Washington coast			
conduct work on the biological effects of the Columbia River plume			
increase understanding of effects of Strait of Juan de Fuca, submarine canyons, coastal promontories, and plumes from coastal estuaries			
examine interaction of biological oceanography with benthic and intertidal communities			
update productivity information and determine plankton distribution and abundance			
determine spatial and temporary distribution and abundance of harmful algal blooms and effects on marine food webs			
monitor coastal waters to determine baseline data on water quality trends; establish moorings to determine both physical and biological parameters			
distinguish natural from anthropogenic changes in water quality that my indicate environmental changes or emerging problems			

management concerns for harvest-related stresses; anthropogenic contamination; habitat alteration; affects of exotic species			
conduct inventories of marine resources and map and create central databases			
conduct high-resolution sea floor mapping of representative habitats			
monitor sediment dynamics and links to community habitats			
explore links between terrestrial and marine ecosystems, including potential for watershed effects			
develop better baseline data for seabird populations and life histories; kelp habitat; forage fish; and harvested shellfish			
develop tissue archives for contaminants in marine organisms			
develop models to integrate nearshore, oceanographic, and ecosystem scales			
establish and maintain database on historical and archeological information; complete inventory of archeological sites and cultural resources			
obtain additional background on traditional knowledge as related to marine resources			
identify and map critical habitats and areas of special interest			
some suggested long-term monitoring sites: Tatoosh Island, Cape Alava, La Push, Destruction Island, Kalaloch, Cape Elizabeth, and Copalis			
Other:			

Table 7. Final synthesis of recommendations from the Olympic Coast National Marine Sanctuary's Research Workshop 1998.

Nearshore Communities

- Conduct Inventories
  - Distribution/Abundance
  - All Life History Stages
  - Determine Data Gaps
  - Create Central Databases
- Identify Processes That Influences Community Changes
  - Physical Conditions/Oceanography
  - Water Chemistry
  - Biological/Ecological Interactions
  - Plankton Investigations
  - Conceptual Models
- Identify/Map Critical Habitat
  - Geomorphology
  - Sensitive Life History Stages
  - Links to Limiting Habitat
  - Nearshore Fish and Kelp Habitats

Fish and Shellfish Biology

- Harmful Algal Blooms
  - Link Offshore Surveys to Nearshore Sampling
  - Determine Spatial/temporal Distribution & Abundance
  - Determine Vector Process to Shellfish
- Long-term Monitoring
  - Public Health
  - Resource Harvest
  - Ecologically Relevant and/or Long-lived Species
- Mapping/Database Creation
  - Inventory Resources
  - Create Centralized Databases
  - Identify/map Critical Habitats
  - Note Physical Properties
  - Increase Research Effort
- Management Concerns
  - Harvest-related Stresses
  - Habitat Alteration
  - Contaminants
  - Exotic Species.

Physical and Biological Oceanography

- Surveys/Monitoring
  - Collect Year-round Currents & Water Properties
  - Collect Baseline Water Quality

- - Establish Moorings and Remote Sensing
- Watershed-Marine Linkages
    - Upland Inputs
    - Nearshore Responses
    - Interactions with Local Currents
- Harmful Algal Blooms
    - Map
    - Use Remote Sensing
    - Determine Ecosystem Effects
    - Determine Spatial/Temporal Distributions
- Inventory/Map/Database Creation
    - Resources and Habitats in GIS
    - Conduct High-resolution Seafloor Mapping.

Seabirds and Marine Mammals

- Long-term Monitoring
    - Status and Trends of Populations
    - Consider Long-lived Species
    - Consider Ecologically Relevant Species
        - Habitat-based
        - Trophically-based
    - Consider Sensitive/Threatened Species
    - Consider Indicator Species
    - Relevant Ecological Components
        - Habitat
        - Food
    - Background Mortality Trends in Beached Bird Surveys & Mammal Strandings
- Map Critical Habitat
    - Inventories in GIS
    - Relative Anthropogenic Effects
    - Biological Hot Spots.

Cultural and Historical Resources

- Inventory/Database Creation
    - Map/inventory Sites
    - Maintain Databases
    - Archive Material
- Long-term Monitoring
    - Determine Natural vs. Anthropogenic Impacts
    - Identify Protection and Management Needs
    - Promote Partnerships
- Survey Traditional Knowledge
- Promote Education and Training Programs.