

University of Washington

Washington Sea Grant

2012-2014

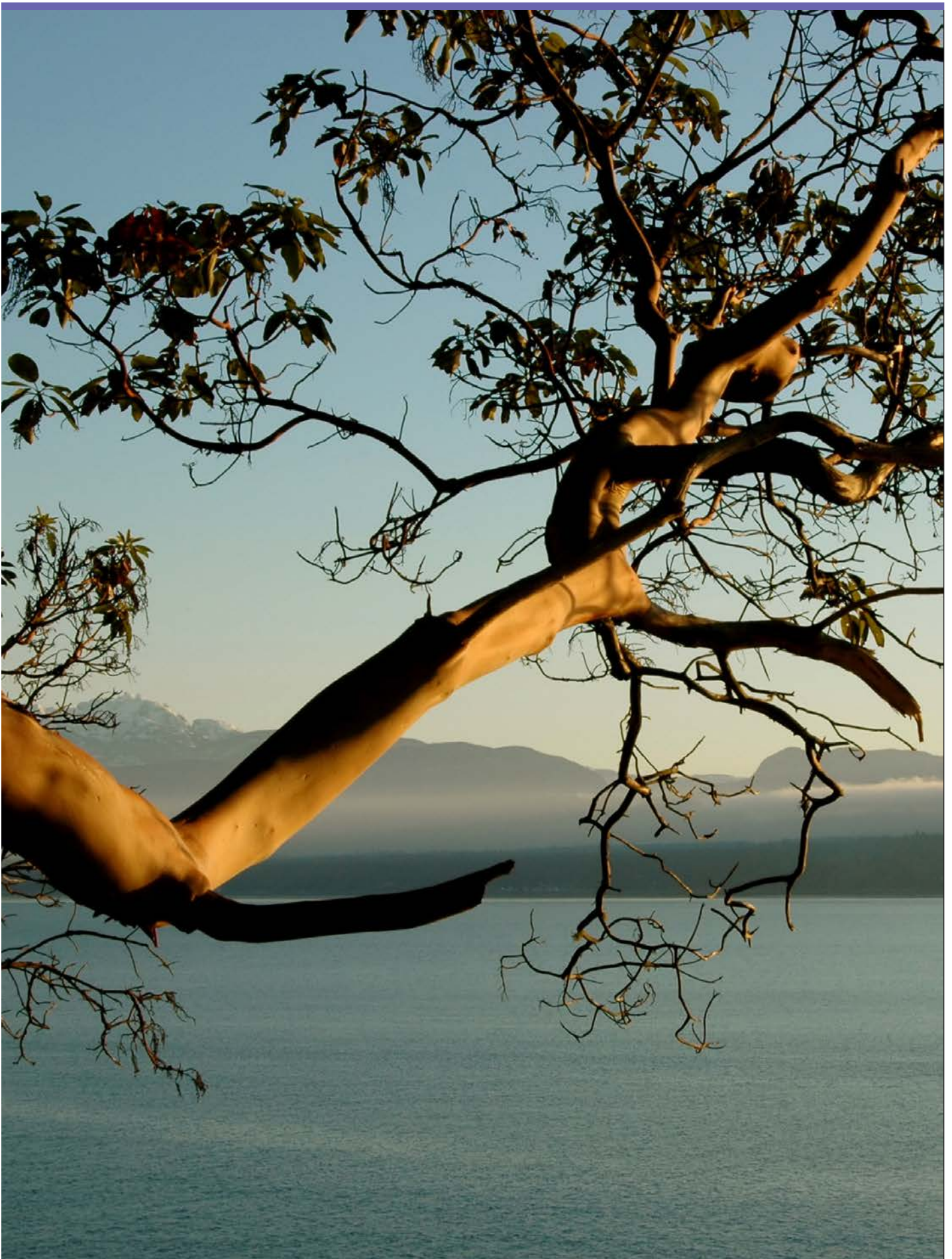
Program Directory

Research, Outreach, Education and Communications



INTRODUCTION	1
I. CONSERVATION AND USE OF LIVING MARINE RESOURCES	2
Marine Mammals and Seabirds	2
Pacific Salmon	3
Fisheries Management	4
Marine Aquaculture and Shellfish Harvests	5
Geoduck Aquaculture	7
II. SUSTAINABLE AND RESILIENT COASTAL COMMUNITIES	8
Marine Business Support	8
Coastal and Watershed Management	10
Hazard Resilience and Climate Change Adaptation	11
III. OCEAN AND COASTAL ENVIRONMENTAL HEALTH	12
Ocean Acidification	12
Invasive Species, Harmful Algal Blooms and Other Environmental Threats	13
Water Quality	15
Habitat Conservation and Restoration	16
IV. OCEAN EDUCATION AND PUBLIC AWARENESS	17
Citizen Engagement	17
Ocean Literacy	18
Future Ocean Professionals	18
CONTACT INFORMATION	20





INTRODUCTION

About this Directory

This publication contains brief descriptions of the current Washington Sea Grant (WSG) research, outreach, education and communications projects for 2012-2014. Project descriptions are organized within four interrelated topics that broadly align with critical program areas identified in WSG's strategic plan. More information is available through the WSG website (wsg.washington.edu) and from the project leaders and researchers, for whom contact information is listed at the end of this directory.

Introducing Washington Sea Grant

Washington's ocean and coastal environment is a fundamental part of the state's history, industry and culture. Today, the state's ocean economy generates about \$7 billion annually. Understanding, protecting and sustaining marine resources are vital to the Washington way of life, and that's what WSG is all about. WSG funds marine research, shares its expertise with coastal businesses and communities and engages the public in practices that contribute to the sustainable use of ocean and coastal resources.

WSG is part of a national network of 33 Sea Grant college programs, housed within the University of Washington (UW) College of the Environment. Primary funding comes from the National Oceanic and Atmospheric Administration (NOAA) and the University of Washington. WSG coordinates with many local, state, tribal and regional organizations, including the Puget Sound Partnership, the state agencies that manage ocean and coastal resources, NOAA's Western Region, the five other Pacific Sea Grant programs and the West Coast Governors' Alliance on Ocean Health.

Core Functions

WSG organizes its activities around four core functions: research, outreach, education and communications. Integration of these functions is key to effectively carrying out WSG's mission: improving translation of scientific and technical information into knowledge for use in the marine environment.

Research sponsored by WSG combines scientific excellence, rigorous review and a focus on problems and opportunities faced by ocean users and managers in Washington and the Pacific Northwest. Current projects are helping to develop new approaches to assess and restore threatened and endangered salmon and marine mammal populations, manage regional aquaculture and fisheries, build more resilient coastal communities and probe the effects of ocean acidification and other environmental changes on marine life and human communities.

WSG outreach experts provide technical assistance and connect marine and coastal constituents to the best scientific information available. Campus- and community-based specialists conduct research and share university resources and their own expertise with governments, tribes, businesses, residents and other stakeholders to address issues of local concern. They work in a broad range of topic areas, including aquaculture, fisheries, water quality, habitat restoration, citizen science, aquatic invasive species, community sustainability, coastal development and management, marine operational safety and technology, oil spill prevention and hazard resiliency.

WSG education activities engage learners of all ages to enhance understanding and stewardship of marine resources and pique their interest in the ocean. WSG offers informal education programs like summer camps to students in kindergarten through high school and provides professional development opportunities to encourage recruitment to ocean-related careers. Fellows and interns gain first-hand experience in marine science, policy and resource management. Some work with legislators and agency staff; others study population dynamics of fish and marine mammals or resource economics.

WSG communications keep the public informed about current research and technology and promote understanding of relevant issues among marine resource users. Unbiased brokers of information, WSG communicators produce and distribute informational print publications, create public exhibits, respond to media inquiries and maintain the WSG website. They share their expertise with diverse partners like the Puget Sound Nearshore Ecosystem Restoration Project, NOAA's Northwest Fisheries Science Center and the UW College of the Environment, helping them inform their constituents about important marine issues.



I. CONSERVATION AND USE OF LIVING MARINE RESOURCES

Marine Mammals and Seabirds

Partitioning multiple pressures impacting southern resident killer whales

Sam Wasser, UW Center for Conservation Biology

Beginning in the 1990s, the southern resident killer whale population has experienced an unexplained decline, triggering conservation action in both the United States and Canada. The U.S. recovery plan identifies three potential threats: decline in Chinook salmon, a major killer whale diet component; vessel traffic disturbance; and exposure to persistent organic pollutants. This project supports application of a novel, noninvasive approach to assess the relative importance of these identified threats. The approach relies on a detection dog to locate fresh killer whale scat that can be used to derive physiologic, genetic and toxicant measures for partitioning relative threat impacts. In addition to improved sampling, use of the detection dog increases public awareness of problems facing the Salish Sea and its resident killer whales.

Acoustic propagation measurement and modeling in Puget Sound to better mitigate noise environmental impacts

Peter Dahl, UW Applied Physics Laboratory

Underwater noise from marine construction can pose a threat to sensitive marine species like killer whales, and developers must establish monitoring plans to prevent exposure to harmful noise levels. Current monitoring plans are based on a simple model for underwater sound transmission that may not accurately estimate levels within tens of square kilometers, potentially adding significantly to a construction project's cost. This project will undertake a detailed study of sound propagation in Puget Sound waters and develop a new and more accurate model. The goal is a more cost-effective means to address underwater noise from marine construction that provides more reliable protection for sensitive marine animals.

Reducing seabird mortality in fisheries

Edward F. Melvin and Troy Guy, Washington Sea Grant



Seabird avoidance measures developed and tested by WSG have dramatically reduced seabird mortalities in Alaska longline fisheries. These measures have been incorporated into regulations in the North Pacific. On the West Coast, these approaches are studied with cooperation from tribal and nontribal longline fishermen.

On an international level, WSG is promoting a coordinated effort to curb the accidental capture of seabirds. Few countries require seabird avoidance measures and, in the extensive longline and trawl fleets throughout the world's oceans, this continues to threaten far-ranging albatrosses, petrels and other seabird species. Past and current WSG-initiated projects have addressed this issue globally.



Pacific Salmon

Linking genetic variation, selection and adaptation in Chinook salmon: next-generation genome sequencing



Kerry Naish and Jim Seeb, UW School of Aquatic and Fishery Sciences

One of the key challenges remaining in the conservation and management of fish populations is the ability to anticipate their adaptive response to human activities. Understanding their response allows researchers to track the impact of such activities, explore alternative management strategies and assess the success of remedial actions. This project is developing powerful tools, based on next-generation DNA sequencing, to identify source populations in mixed-stock harvest fisheries, determine reintroduction success in hatcheries, track the impacts of hybridization among populations and survey the genome for genetic variation that plays an important functional role in population fitness. Scientists are developing bioinformatic approaches for processing and analyzing large volumes of sequencing data and sharing the approaches with state, federal and tribal managers.

Governing complex environmental commons: stakeholder partnerships in West Coast salmon recovery

Nives Dolšak, UW School of Marine and Environmental Affairs; Sara Singleton, Western Washington University Department of Political Science

Northwest salmon populations face severe conservation challenges. Half of Washington's 32 salmon and steelhead populations are listed as threatened or endangered, including four Puget Sound runs. This project will evaluate the process and success of federal efforts to seek stakeholder collaboration and maximize local involvement in developing and implementing salmon recovery strategies. It will compare recovery in Puget Sound and the Lower Columbia/Willamette River to improve understanding of governance across complex coastal and marine issues (land-use, habitat protection, water pollution, water quantity) and different resource management and stakeholder groups.

Recovery of Elwha River salmon and trout after dam removal: recolonization and the awakening of dormant life-history diversity

Thomas Quinn, UW School of Aquatic and Fishery Sciences

Pacific salmon and trout are among the most important fishes in the region and are keystone species for stream and riparian ecosystems. Impassable dams have contributed to reductions in Pacific Northwest salmon populations. The removal of two dams on the Elwha River began in 2011, and the response of the local ecosystem is a matter of great scientific and public interest. This study will explore the expansion of salmon and trout populations, their spatial use of the basin and the diversity of their life history traits in the Elwha River system as the dams are removed.

Survival of salmon and steelhead in the Salish Sea marine environment

Michael Schmidt, Long Live the Kings

Evidence is increasing that changes in the Salish Sea marine environment may be significantly affecting the overall survival of salmon, notably coho, Chinook and steelhead. The interaction between salmon and the environment is complex, requiring a detailed and complete understanding of how the fish are affected by changes in Salish Sea physical, chemical and biological characteristics. This project is supporting U.S and Canadian conservation efforts to convene scientists, managers and stakeholders and develop, coordinate and implement a trans-boundary research program. The program will identify the most significant factors affecting salmon survival and productivity in the Salish Sea marine environment and make research findings available to improve salmon management.

Exploring mechanisms of mortality in the first ocean year of Chinook salmon

James Anderson, UW School of Aquatic and Fishery Sciences, in support of Jeffrey Rutter, Sea Grant/NOAA Fisheries Fellow in Population Dynamics

Recovery of wild salmon populations has largely focused on increasing the production and improving the condition of young fish, before they migrate to the sea. Similarly, salmon hatcheries have been releasing increasing numbers of large, healthy juveniles in order to maintain and expand salmon fisheries. Nevertheless, for several stocks, the number of returning adults seems largely independent of the number of outgoing smolts, calling into question the fundamental basis of wild stock recovery efforts. This project is identifying density-dependent processes in the marine environment to understand first-year Chinook marine mortality and improve management of salmon populations.



Fisheries Management

Accounting for spatial structure in stock assessments: the case of the Pacific sardine

Andre Punt, UW School of Aquatic and Fishery Sciences; Richard Methot, NOAA Northwest Fisheries Science Center; Kevin Hill, NOAA Southwest Fisheries Science Center

Northern Pacific sardines are one of the largest federally managed fisheries on the West Coast, but current stock assessment methods do not fully account for where the fish are located. Spatial structure and movement of the northern subpopulation of Pacific sardines could affect the outcome of the stock assessments that are key to stakeholder acceptance of management regulations. In 2008, the fishing industry challenged the Pacific sardine stock assessment because of uncertainty about the current model assumptions and outcomes. This project is developing computer models that test the impact of spatial structure on the Pacific sardine stock assessment.

Social and economic effects of individual fishing quotas on the West Coast groundfish fishery: solving the weak stock/bycatch problem

Christopher Costello (regional lead), Steven Gaines and Robert Deacon, University of California Santa Barbara; Trevor Branch (Washington lead) and Ray Hilborn, UW School of Aquatic and Fishery Sciences

Allocation of catch shares among fishermen is an increasingly common approach to fisheries management in the United States. Such quota allocations provide demonstrated economic and ecological benefits, but concern is widespread that they can result in changes that may be socially undesirable or fail to solve other management goals, such as reducing unintended bycatch of stocks that are prohibited or depleted. The West Coast groundfish fishery currently is moving to an individual fishing quota system and faces a number of bycatch problems. This project will document the socioeconomic effects of the new system and suggest management options for achieving a sustainable ecosystem and vibrant fishing communities.

Local adaptation in Puget Sound Pacific cod

Lorenz Hauser, UW School of Aquatic and Fishery Sciences; Michael Canino, NOAA Alaska Fisheries Science Center; Tien-Shuin Tsou, Washington Department of Fish and Wildlife

In Puget Sound, Pacific cod is at the southern edge of its range and appears to be affected by warming temperatures. The population has been declining for several decades, especially in comparison to abundant north Pacific stocks that support one of the most valuable fisheries in the world. Puget Sound Pacific cod recently was listed as a species of concern, in part based on its genetic isolation from ocean populations. This project will investigate the level of local adaptation of Pacific cod in the Sound by examining its genetic makeup in combination with captive selection experiments. It will improve understanding of the species' ability to adapt to warming climate conditions and assist state and tribal managers in planning for Pacific cod stock protection and recovery in Puget Sound.

An evaluation of stock assessment methods for eastern Bering Sea snow crab

Andre Punt, UW School of Aquatic and Fishery Sciences, in support of Cody Szuwalski, Sea Grant/NOAA Fisheries Fellow in Population Dynamics

The current method of snow crab population assessment assumes that the stock is a single biological unit. However, several observations raise questions about this assumption: a spatial gradient in size and maturity of snow crabs is apparent across the shelf of the eastern Bering Sea; evidence exists that spawning biomass from some locations on the shelf contribute more to recruitment; and the fishery does not span the entire distributional range of snow crab. This project will study the current stock assessment method and its assumptions about the spatial structure of the population, incorporating spatial heterogeneity in recruitment processes, distribution of spawning biomass and fishing pressure. The results will improve the ability of managers to achieve fishery conservation and management goals.

Marine Aquaculture and Shellfish Harvests

Supporting Northwest aquaculture

Teri King, Pete Granger and Steve Harbell, Washington Sea Grant

Shellfish are valuable, both nutritionally and economically; in 2008, Washington's farmed shellfish harvest was 7.6 million pounds, with an estimated value of \$107 million. At the same time, areas for shellfish culture are limited and may be threatened by pollution, algal toxins and pathogenic bacteria. Shellfish are also vulnerable to ecosystem changes. Growers must understand natural and human-caused trends in order to predict and manage culture and harvest opportunities and ensure a safe seafood supply. WSG works closely with NOAA, West Coast shellfish farmers, state agencies and tribes to support sustainable Northwest aquaculture efforts. It provides conferences and training opportunities to address shellfish aquaculture needs, and funds and reports on research to address emerging issues. WSG sponsors and participates in the Pacific Rim Shellfish Sanitation Conference and the California Current Acidification Network (C-CAN) and is playing a substantive role in the Washington State Shellfish Initiative. WSG also is conducting an extensive survey of seafood consumer perceptions in the Pacific Northwest. Results will shed light on the public's understanding of aquaculture sustainability and shellfish product quality.

Factors influencing recruitment variability in estuarine bivalves

Jennifer Ruesink and Alan Trimble, UW Department of Biology

Willapa Bay currently produces 10 percent of the oysters grown in the United States, and clam harvests have increased by an order of magnitude over two decades. However, existing literature provides no reliable guidance about the timing of recruitment for species like Manila clams, nor its contribution to commercial yields. What is known is that larvae preferentially settle on clean shell, and natural settlement of bivalve larvae represents a variable but important source of "seed" clams and oysters for shellfish aquaculture. To take advantage of this natural settlement, growers deploy shell at times and places where settlement of larvae will occur soon afterwards. Only a brief window of time may exist for placing shell to receive optimum settlement. This project is producing bulletins about larval abundance, growth and location to advise oyster growers on the best times to deploy shells.

West Coast shellfish aquaculture — economic impacts, barriers to entry, and opportunities for expanded production

Dan Cheney, Pacific Shellfish Institute; Katherine Wellman, Northern Economics; Ted Kuiper, Kuiper Mariculture Inc.; Peter Becker, Olympic Aquaculture Farms; Robert Emanuel, Oregon Sea Grant

NOAA Sea Grant Aquaculture Research Program

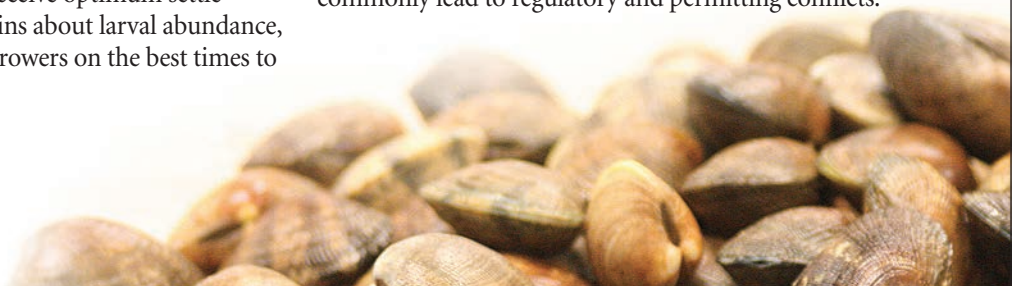
Shellfish support ecologically sustainable aquaculture that could make a significant contribution to meet growing demands for seafood in the United States and abroad. This project is using economic analyses and social science to support sustainable shellfish aquaculture along the West Coast. Specific project goals are to: (1) quantify the economic impacts of commercial shellfish production in the states of Washington, Oregon, and California; (2) investigate and summarize the barriers to entering the shellfish aquaculture industry in the three states; and (3) inform policy makers, industry and other stakeholders of the research outcomes and recommend action to enhance and expand sustainable shellfish production.

Planning for sustainable shellfish aquaculture in complex multiple-use environments: determining social and ecological carrying capacity for south Puget Sound

Dan Cheney, Pacific Shellfish Institute; João Ferreira, Longline Environment Ltd.; David Priekshot, Fisheries and Oceans Canada; Jonathan Davis, Baywater Inc.; Teri King, Washington Sea Grant; Mindy Roberts, Washington Department of Ecology; Danna Moore, Washington State University Social and Economic Research Center; Susan Bricker, NOAA National Ocean Service

NOAA Sea Grant Aquaculture Research Program

Shellfish aquaculture is poised to become a dominant player in the U.S. seafood industry. Production on the West Coast has increased steadily over the last 30 years, with expanding domestic and export markets. This project will provide tools and information for assessing the ecological and social capacity of South Puget Sound to support shellfish aquaculture. It will determine carrying capacity for shellfish aquaculture and develop methodologies and guidance documents that can be used to inform marine spatial planning activities. The project is using an ecosystem-based approach to support sustainable shellfish aquaculture and provide a framework for addressing issues that commonly lead to regulatory and permitting conflicts.



Planning for sustainable shellfish aquaculture: identifying current activities, public perceptions, conflicts and compatibilities

Kristin Rasmussen, Pacific Shellfish Institute; Teri King, Washington Sea Grant; David Landkamer, Oregon Sea Grant; Paul Olin, California Sea Grant

NOAA Sea Grant Aquaculture Research Program

This project is combining geospatial data on West Coast commercial aquaculture activities with research and outreach on the social impacts of shellfish aquaculture. Project goals aim to: (1) facilitate visualizations of the status and needs of shellfish aquaculture operations for marine and coastal planning efforts; (2) increase understanding of the range of public perspectives held about shellfish aquaculture; and (3) provide relevant shellfish aquaculture information that is responsive to a wide range of needs and interests. Results should help decision-makers understand interrelationships among social, economic and ecological values and multiple uses of ocean and coastal areas.

Fish aquaculture simulation model and GIS: validation and adaptation for government management use

Jack Rensel and Frank O'Brien, System Science Applications Inc.; Dale Kiefer, University of Southern California Department of Biology; James Morris, NOAA National Ocean Service

NOAA Sea Grant Aquaculture Research Program

U.S. waters are well suited for fish aquaculture, but to date, no commercial-scale operations have been permitted anywhere in the U.S. exclusive economic zone, which extends from three to 200 miles from the coast. Federal permitting and manage-

ment authorities are fragmented and unclear, and agencies lack necessary quantitative tools to develop clear requirements and safeguards for offshore aquaculture operations. This project will use AquaModel, a geospatial software system that simulates the siting, operational and environmental effects of individual or multiple net-pen fish farms in coastal and oceanic waters. It will examine relationships between operational and environmental conditions and fish farm effects and, with subsequent review, is intended to test and demonstrate the accuracy of the software program.

Alleviating regulatory impediments to native shellfish aquaculture

Steven Roberts, Brent Vadopalas and Carolyn Friedman, UW School of Aquatic and Fishery Sciences; Brady Blake, Washington Department of Fish and Wildlife; Jonathan Davis, Taylor Resources Inc.; Frederick Goetz, NOAA Fisheries Northwest Region

NOAA Sea Grant Aquaculture Research Program

Aquaculture of native shellfish can have both positive and adverse effects on the genetic makeup of nearby wild populations of the same species. Through interbreeding, aquaculture stock may jeopardize wild populations by decreasing their adaptive potential to local environmental conditions. On the other hand, the addition of diverse cultured organisms may enhance genetically depauperate wild populations. This project will examine local adaptation in native Olympia oysters to assist in predicting the impacts of culturing native shellfish species for restoration and commercial production. It will address the current lack of information that restricts distribution of hatchery-derived native shellfish and acts as a significant impediment to sustainable aquaculture.



Geoduck Aquaculture

Washington state geoduck aquaculture research program

Raechel Waters and Penny Dalton, Washington Sea Grant

Intertidal geoduck culture is a growing aquaculture sector. However there has been limited information available about its effects on the Salish Sea environment. In 2008, the Washington State Legislature established a six-year research program to address knowledge gaps and develop a scientific basis for managing geoduck culture. The program will conclude with a final report to the Legislature by the end of 2013 that incorporates peer-reviewed results of research projects addressing three separate environmental issues:

- **Cultured-wild interactions: disease prevalence in wild geoduck populations** *Carolyn Friedman and Brent Vadopalas, UW School of Aquatic and Fishery Sciences*
- **Resilience of soft-sediment communities after geoduck harvest in Samish Bay, Washington** *Jennifer Ruesink, UW Department of Biology*
- **Geochemical and ecological consequences of disturbances associated with geoduck aquaculture operations in Washington** *Glenn VanBlaricom, P. Sean McDonald, David Armstrong and Tim Essington, UW School of Aquatic and Fishery Sciences; Jeffrey Cornwell and Roger Newell, University of Maryland Horn Point Marine Laboratory*

Community and multi-trophic implications of structure additions associated with intertidal geoduck aquaculture

Glenn VanBlaricom, UW School of Aquatic and Fishery Sciences

NOAA Sea Grant Aquaculture Research Program

This project complements the state research program, focusing in greater detail on disturbance caused by geoduck planting and harvesting and its effects on intertidal ecological functions. These functions include distribution of fishes, benthic community dynamics and food web interactions. Project goals are to compare cultured geoduck areas to nearby reference beaches to: (1) characterize changes in benthic communities associated with geoduck planting and harvest; (2) explore differences in fish abundance and movement; (3) evaluate differences in fish diets in relation to prey abundance and availability; and (4) determine energetic consequences of diet shifts for growth and survival of fishes.



II. SUSTAINABLE AND RESILIENT COASTAL COMMUNITIES

Marine Business Support

Providing marine technology training for fishermen and boaters

Sarah Fiskén, Washington Sea Grant

Vessel operational systems and technology are changing constantly. Many boaters — both commercial and recreational — need continuing education to keep up with the changes. WSG offers classes and workshops that focus on vessel safety, maintenance and operations. Topics include marine refrigeration, corrosion, diesel engine troubleshooting, computers and navigation and other topics of interest to the owners and operators of vessels in Puget Sound and along the Washington coast. Many workshops are geared to commercial fishermen, but they also attract recreational boaters and others with close ties to the marine environment.

Training tribal and nontribal commercial fishermen in marine safety

Sarah Fiskén, Steve Harbell and Eric Olsson, Washington Sea Grant

West Coast and Alaska fisheries are the highest-risk fisheries in the country. Because of short seasons and competition for harvestable resources, fishermen face intense pressure to fish under adverse conditions. This pressure, combined with the severe ocean environment in the North Pacific, increases the threats to crews and their vessels. Port-based training for commercial fishermen improves their emergency preparedness and ability to use new safety equipment effectively. WSG has provided safety training for several years to tribal and nontribal commercial fishermen based in Puget Sound and on Washington's outer coast and the Columbia River.

Improving business opportunities and enhancing the value of seafood harvests for Washington tribes

Pete Granger and Sarah Fiskén, Washington Sea Grant

Western Washington tribal communities traditionally have relied on fish and shellfish catches as a central resource to their economies and culture. Today's challenges include stiff competition from high-quality seafood products and limited markets for tribal catch. Tribes benefit from improved catch handling and storage techniques, and from finding ways to market unique local products such as marbled king salmon. Working with Affiliated Tribes of Northwest Indians, WSG provides training to several western Washington tribes to improve seafood quality and marketing, increasing the profitability of their catch. WSG also is assisting the Lummi Nation to develop a retail seafood market serving Bellingham and Whatcom County with the goal of providing an outlet for Lummi fishery catches and value-added products that return increased prices.

Wild Seafood Exchange — helping fishermen sustain their businesses

Pete Granger, Washington Sea Grant; Peter Philips, Philips Publishing Group

Times have changed for commercial fishermen in Washington state. Because of lower ex-vessel prices, fewer fish buyers and downturns in the amount of fish available to catch, fishermen face shrinking profit margins and are looking for ways to increase the value of their catches. More fishermen are considering direct marketing to consumers, but this presents numerous challenges and requires that fishermen become proficient in quality control, processing, handling, storing and marketing. Over the past eight years, WSG has teamed with Philips Publishing Group to present the Wild Seafood Exchange. The Exchange provides opportunities for Pacific Northwest and Alaska fishermen to discuss ways to begin new or enhance existing direct marketing operations. It brings fishermen together with seafood buyers, restaurant operators and retail food dealers, and financial, business and marketing experts, providing an annual forum for networking and learning.

Training retailers in seafood handling

Pete Granger and Steve Harbell, Washington Sea Grant

Sustainable fisheries management and catch methods, seafood handling and safety, and health issues are of great concern to consumers, most of whom get their information from the workers behind seafood counters. Based on a survey of meatcutters and seafood department managers in several local grocery chains, WSG designed a 12-hour retail seafood-training program for apprentice meat cutters. The program is offered in conjunction with the Meatcutters Apprenticeship Programs of South Seattle and Tacoma community colleges and the United Food and Commercial Workers International Union. Evaluation of the program's impact on store customers is underway.



Preserving working waterfronts and waterways

Nicole Faghin, Washington Sea Grant

In the Pacific Northwest and across the nation, shoreline-dependent industries, governmental agencies, tribes and the public are struggling to resolve competing interests in and conflicts over access to shorelines, waterways and waterfronts. Working waterfronts contribute to local economies and are important parts of communities' cultural and social heritage. The past decade, however, has seen significant and accelerated losses of working waterfronts and waterways, with negative economic, cultural, social and environmental effects on coastal communities. WSG works with stakeholders and other Sea Grant programs and partners on access and other issues to facilitate best uses of working waterfronts. The network is organizing the third National Working Waterfronts and Waterways Symposium, scheduled for March 2013 in Tacoma.

Forging lane agreements between crabbers and towboat operators

Steve Harbell, Washington Sea Grant

Conflicts between ocean-going tugs and commercial crabbers in Washington, Oregon and California were a major problem in the late 1970s. Crab pots fouled tugs as they moved between coastal ports, and the loss of their gear was a severe economic loss for crab-boat owners. Sea Grant programs on the West Coast helped broker an agreement that provided navigable towboat and barge lanes through the crabbing grounds between Cape Flattery and San Francisco. WSG took a leadership role in the late 1990s that remains pivotal to annual lane negotiations, maintaining the cooperative relationship and saving these industries hundreds of thousands of dollars each year.

Clean marinas — good for business and the environment

Eric Olsson, Washington Sea Grant

Wherever large numbers of recreational boaters congregate — in marinas, for example — risks are greater for ecological impacts from paint, oil leaks, cleaning products, boat sewage and other potential sources of pollution. WSG plays an active role in Clean Marina Washington, a program that encourages marina operators to assess their operations and provides incentives to implement improvements to better protect the environment. Marinas that meet program standards can promote themselves to boaters as an official “Clean Marina” to attract tenants. It's a program that's good for business and good for the environment. WSG works with several organizations in the state to inspect and certify Clean Marinas.

Helping boat dealers track retail sales

Aaron Barnett and Robert Goodwin (retired), Washington Sea Grant

The boating industry — from boat building to boat sales — is an important part of Washington state's economy. WSG partners with the Washington Department of Licensing and the Northwest Marine Trade Association (NMTA) to provide access to monthly, quarterly and yearly data on boat sales in Washington. The information helps NMTA-member boat dealers keep a close eye on sales trends. They use the data to make more informed decisions about business operations, allowing them to redirect strategies and boost overall sales. State officials also can use boat sales information to more accurately site pumpout stations for boaters' waste, target prevention program strategies for small oil spills and validate demand for new in-water moorage or dry-stack storage throughout Washington.



Coastal and Watershed Management

Social science indicators for use in integrated ecosystem assessments

Penny Dalton, Washington Sea Grant; Phil Levin and Karma Norman, NOAA Northwest Fisheries Science Center; Nives Dolsak, UW School of Marine and Environmental Affairs

Over the past decade, scientists, ocean agencies, coastal communities, businesses and nongovernmental organizations have joined in a call for the adoption of ecosystem-based management as a guiding principle for ocean and coastal policy. One key to the success of such an effort is development and use of integrated ecosystem assessments (IEAs), the synthesis and quantitative analysis of information on relevant natural and socioeconomic factors related to specified ecosystem management goals. In collaboration with the Northwest Fisheries Science Center and the UW School of Marine and Environmental Affairs, WSG is developing a small number of workable social indicators with which to evaluate human wellbeing in terms of Washington state coastal ecosystems and resources. The development of these indicators will aid in the human dimensions of ecosystem research and IEAs for the Puget Sound and California Current ecosystems. The goal is a framework for measuring social and cultural attributes that are useful for ocean and coastal management and decision-making purposes.

Washington state marine spatial planning

Bridget Trosin, Penny Dalton and Jamie Mooney, Washington Sea Grant

In 2010, the Washington State Legislature enacted the Marine Waters Planning and Management Act, establishing the goal of sustainably managing increasing demands on marine resources while considering current uses and planning for future needs. State ocean agencies have identified priorities for furthering marine spatial planning in Washington, including development of data tools and stakeholder training and engagement. As part of this process, WSG will work with state and university partners to play a central role in three of the proposed activities: (1) facilitation of scientific and technical input from issue-based groups on development of data tools; (2) coordination of marine spatial planning short courses; and (3) coordination and facilitation of work sessions to draft marine spatial planning objectives.

Green Shores for Homes

Nicole Faghin, Washington Sea Grant

Washington has extensive regulations governing the use of shorelines, yet the state's natural shorelines continue to be affected by development and hard armoring. The Green Shores for Homes project uses voluntary incentives to promote sustainable use of coastal ecosystems through planning and design. Patterned after the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program, Green Shores will incentivize alternatives to traditional shoreline development and help minimize the environmental impacts of development in a cost-effective manner. WSG is partnering with the City of Seattle, San Juan County and the Green Shores technical team on a Green Shores pilot project.



Establishing and supporting a network of shoreline and coastal planners

Jamie Mooney, Washington Sea Grant

Communities, nongovernmental organizations and coastal businesses in western Washington need sources of information to anticipate and address future coastal issues. To meet this need, WSG incorporates training and outreach, network coordination and technical assistance to support shoreline and coastal planning. WSG developed and continues to support the Shoreline and Coastal Planners Group, which involves a listserv, a website, meeting coordination and professional development opportunities for shoreline planning professionals. The group facilitates new partnerships and provides a coordinated network for technical assistance.

Tidal energy development in Puget Sound

Nicole Faghin, Washington Sea Grant

Ocean energy offers opportunities for meeting the need to reduce carbon emissions and to supply the nation's power from clean, renewable sources. Puget Sound is one of a few regions in the United States with conditions amenable to tidal energy development. Tidal turbines placed in the water column can convert tidal currents into electricity, generating clean, reliable power. Sustainable tidal energy options, however, will need to be technically, economically, socially and environmentally viable. WSG is part of a multidisciplinary research project integrating energy engineering, ocean sciences, social sciences and outreach to evaluate large-scale tidal energy sustainability. Using Puget Sound as a case study, the effort will improve the understanding of tidal energy systems, quantify the trade-offs between technological, environmental and societal costs and develop tools to enable a sustainable pathway for tidal energy development.

Hazard Resilience and Climate Change Adaptation

Successful adaptation: identifying effective process and outcome characteristics and practice-relevant metrics

Pamela Matson (regional lead) and Susan Moser, Stanford University School of Earth Sciences and Woods Institute for the Environment; Amy Snover (Washington lead), UW Joint Institute for the Study of the Atmosphere and Ocean, Climate Impacts Group; Hannah Gosnell, Oregon State University Department of Geosciences

Climate change will have widespread environmental, economic and social impacts, forcing coastal communities to face difficult choices and trade-offs in the decades ahead. Managing the impacts of climate change and sea-level rise on coastal resources is a major concern in all three West Coast states and raises the question, “What would successful adaptation to climate change look like?” This project will engage scientists and coastal practitioners in answering that question. It will explore adaptation outcomes, processes and mechanisms as well as metrics with which to measure success in California, Oregon and Washington coastal communities.

Coastal resilience network

Jamie Mooney and Ian Miller, Washington Sea Grant

The Pacific Northwest is susceptible to a diverse range of natural hazards ranging from common threats like coastal erosion and flooding to rare but potentially catastrophic events like earthquakes and tsunamis. Hazard events create public safety concerns, damage property and reduce recreational and economic opportunities. Local, state, federal and tribal governments have invested in hazard-related research and management; however, planning to date has been limited, and enhanced coordination is needed. Partnering with Washington Department of Ecology, WSG is working to build a statewide coastal resilience network that will link research and planning activities and facilitate cooperation among scientists, researchers, managers, and end-users in the public and private sector. Such a network would transfer research findings to communities, encourage incorporation of lessons learned into community planning and facilitate more effective mitigation, response planning, and community awareness.

Building Pacific coastal community capacity to prepare for hazards and climate change

Ian Miller and Jamie Mooney, Washington Sea Grant

As Pacific coastal communities face climate change and more extreme or frequent natural hazards, the need for preparation to ensure a resilient future becomes more apparent. WSG is partnering with tribes, communities and state and federal agencies to monitor Olympic Peninsula and other shorelines and establish baselines against which to measure the impacts of coastal and climate change-related hazards such as sea level rise, changing coastal climate and tsunamis. WSG draws on academic, tribal and government expertise to assess community vulnerability, evaluate preparedness and provide technical assistance to meet local requests and needs.

Climate adaptation and hazard resilience training program

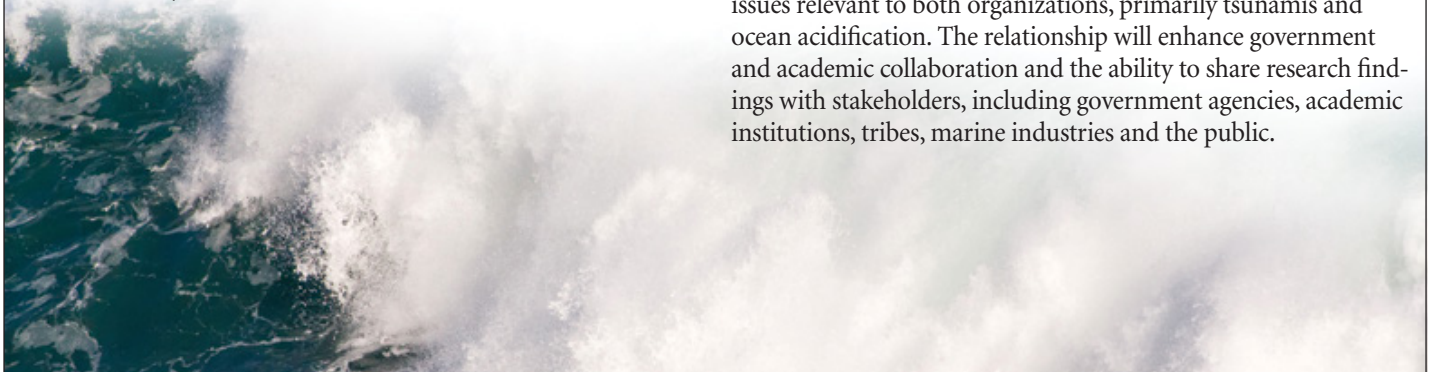
Jamie Mooney and Nicole Faghin, Washington Sea Grant

Adaptation requires consideration of a range of possible future conditions and changes, rather than relying on past practice and experience. Planning and infrastructure decisions that confer adaptive capacity in coastal communities are often made at the local level, and local managers need scientific information and tools to stimulate integration of adaptation practices into coastal planning. However, at present, little useful guidance is available to assist local jurisdictions in integrating climate change impacts into their planning processes. Working with several partners, WSG helped develop Planning for Climate Change, an adaptation-focused course for shoreline and coastal professionals. Other potential topics include sea level rise and tsunami preparations.

Pacific Marine Environmental Laboratory liaison

Meg Chadsey and Jamie Mooney, Washington Sea Grant

NOAA administers the National Sea Grant College Program and operates the Pacific Marine Environmental Laboratory (PMEL) that conducts world-class ocean and atmospheric research. Ongoing federal limitations on the availability of resources for scientific research highlight the need for NOAA to maximize the effectiveness of its research investments, both internally and with its academic partners. Through establishment of a liaison, WSG and PMEL will coordinate work on pressing marine issues relevant to both organizations, primarily tsunamis and ocean acidification. The relationship will enhance government and academic collaboration and the ability to share research findings with stakeholders, including government agencies, academic institutions, tribes, marine industries and the public.



III. OCEAN AND COASTAL ENVIRONMENTAL HEALTH

Ocean Acidification

Implementation of the Washington state report on ocean acidification

Meg Chadsey, Teri King, Penny Dalton and others, Washington Sea Grant

In 2012, the Washington governor appointed a blue ribbon panel to assess current scientific understanding of ocean acidification and its likely effects on marine resources and communities, and to recommend a state response. In addressing ocean acidification, the report emphasizes the need to: increase capacity for adaptation and remediation; monitor and investigate the causes and effects; and inform, educate and engage stakeholders, the public and decision makers in addressing the problem. Building on its ocean acidification-related research and outreach activities, WSG will be working to implement report recommendations.

Effects of ocean acidification on declining Puget Sound shellfish

Carolyn Friedman and Steven Roberts, UW School of Aquatic and Fishery Sciences; Simone Alin and Richard Feely, NOAA Pacific Marine Environmental Laboratory; Jonathan Davis, Taylor Resources Inc.; Ralph Elston, AquaTechnics

Over the next century, scientists predict that atmospheric carbon dioxide will significantly increase the acidity of global ocean surface water. Coastal upwelling and continued runoff into inland waters may exacerbate changes in the Pacific Northwest. Environmentally and economically important marine shell-builders like clams, oysters and other mollusks are vulnerable to this change in seawater chemistry. This project is conducting controlled laboratory studies examining early-life-stage responses of four marine mollusk species to multiple stressors, including increased dissolved carbon dioxide, varying temperature and exposure to *Vibrio tubiashii*. Molecular responses to these stressors are being studied as predictors of environmental stress.

Effects of early exposure of Pacific oysters to ocean acidification on subsequent performance

Carolyn Friedman, UW School of Aquatic and Fishery Sciences; Mark Camara, U.S. Department of Agriculture – Agriculture Research Service Shellfish Genetics Program; Jonathan Davis and Benoit Eudeline, Taylor Resources Inc.

An increasing number of studies document the negative effects of ocean acidification on larval performance of marine shellfish, and poor hatchery performance and low natural recruitment in Pacific oysters may be a direct result. However, experiments are needed that evaluate all life-history stages in order to forecast ocean acidification effects. This project will examine effects on later life stages of exposing broodstock and larvae to more corrosive waters. It will also estimate genetic parameters required to implement an effective breeding program for improved tolerance of acidic conditions.



Effects of ocean acidification on trophically important crustacean zooplankton of Washington state

Julie Keister, UW School of Oceanography; Paul McElhane, NOAA Northwest Fisheries Science Center

Ocean acidification and shifting ocean chemistry could have broad-ranging effects on the development, growth and survival of many marine organisms and on entire marine ecosystems. In experiments to date, most crustacean zooplankton have suffered negative impacts on early life survival, but some only at very high levels of acidity. This project will increase understanding of how coastal marine ecosystems are likely to respond by testing the effects of ocean acidification on these zooplankton under realistic current and future conditions. The research will provide managers with critically needed information about impacts on trophically important species and help improve forecasts of changes in trophic webs.

Invasive Species, Harmful Algal Blooms and Other Environmental Threats

Outreach and education on aquatic invasive species

Jeff Adams, Washington Sea Grant

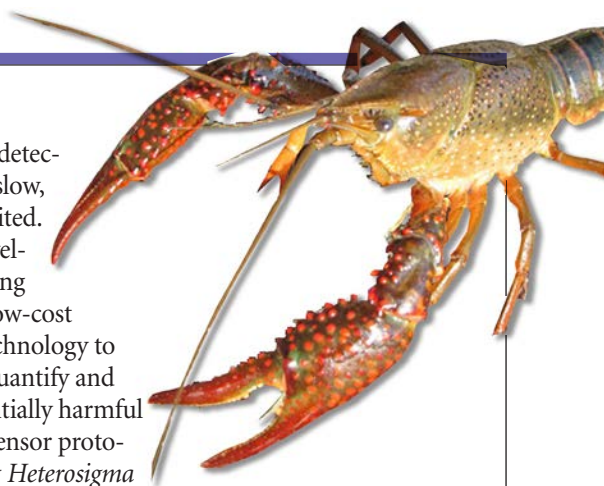
Non-native plants and animals are continuously being introduced into aquatic systems. A small number will thrive, threatening personal property, livelihoods, coastal habitats and native aquatic life. Understanding pathways for aquatic invasive species (AIS) allows marine resource managers and others to prevent their spread, develop rapid response plans for unwanted arrivals and minimize the impacts of established AIS. Pet stores, seafood suppliers, schools, marine businesses and the public also play important roles. WSG and UW colleagues collaborate with agencies at the state and regional levels to learn about introduction pathways and develop effective management strategies, promote and support volunteer monitoring of AIS by citizen scientists and work with schools to mitigate known introduction pathways.

Optical detection and characterization of the fish-killing alga *Heterosigma akashiwo*

Daniel Grünbaum, UW School of Oceanography

Heterosigma blooms create toxic conditions for marine ecosystems and aquaculture by forming dense surface aggregations. These aggregations are caused in part by cells' vigorous swimming behaviors that interact strongly with estuarine flows to concentrate the algae. Estuarine flow models can effectively predict future bloom trajectories, once they are detected.

However, current detection methods are slow, expensive and limited. This project is developing and deploying high-resolution, low-cost micro-imaging technology to remotely detect, quantify and characterize potentially harmful swimming cells. Sensor prototypes can quantify *Heterosigma* populations one or two orders of magnitude below aquaculturists' threshold for alarm.



Troubled sediments: *Heterosigma* cyst formation and longevity

Rose Ann Cattolico, UW Biology Department

The formation of toxic algal slicks by *Heterosigma akashiwo*, one of the world's most harmful algal species, can substantially impact Puget Sound salmon aquaculture operations; reduce the survival of oysters and sea urchin and compromise the health of coastal ecosystems. The effects of global climate change and other anthropogenic activities suggest an increasing occurrence of algal blooms. This project addresses the longstanding question of why algal blooms differ in intensity, longevity and toxicity. It will also provide new tools to commercial aquaculturists for monitoring *H. akashiwo* cells and cysts.

Understanding dormancy requirements and germination of *Alexandrium* cysts and evaluating cyst mapping as a tool for early warning of harmful algal blooms

Cheryl Greengrove and Julie Masura, UW Tacoma Environmental Science; Stephanie Moore and Brian Bill, NOAA Northwest Fisheries Science Center

Harmful algal blooms can contaminate shellfish and result in costly recalls of tainted product from the market, considerably reducing consumer confidence in seafood safety. To address this concern, health authorities in Washington dedicate significant resources to monitoring shellfish toxicity at more than 70 locations in the Sound at roughly two-week intervals. This project will enhance an early warning system for toxic blooms of one common culprit, *Alexandrium catenella*, in Puget Sound. Specifically, it will provide critical information on life-history characteristics of *A. catenella* that will inform a predictive model.

Projections of ocean properties along the Washington coast related to environmental health

Nicholas Bond and Albert Hermann, UW Atmospheric Sciences and Joint Institute for the Study of the Atmosphere and Oceans; Enrique Curchitser, Rutgers University Institute of Marine and Coastal Science



The climate of the future is likely to force changes in ocean conditions off the Washington coast. How might these changes affect incidences of harmful algal blooms, hypoxia, invasive species migration and other factors related to environmental health? An accurate, high-resolution modeling system could provide predictions of climate-associated changes that will affect ecosystem structure and function and evolving threats to coastal environmental health. This project is yielding state-of-the-art, high-resolution simulations of the ocean off Washington state for the first half of the 21st century. The simulations will be made available to the oceanographic and climate communities to begin anticipating how climate change is likely to impact the nearshore ecosystem in the Pacific Northwest.

How does hypoxia impact marine food webs and fisheries? Evaluating distributional shifts in Hood Canal

Tim Essington and David Armstrong, UW School of Aquatic and Fishery Sciences; Phil Levin, NOAA Northwest Fisheries Science Center; Leif Rasmuson, Skokomish Tribal Nation Department of Natural Resources

Low dissolved oxygen, or hypoxia, is a growing problem in the inshore marine waters of Puget Sound and particularly Hood Canal. Although fish kills are probably the most visible consequence of hypoxia, the sub-lethal ecological consequences of low-oxygen conditions may be far more complex, potentially affecting food-web structure, species relocation, vulnerability to fishing and species productivity. This project is assessing local and regional movements of Dungeness crab and English sole in Hood Canal during the summer months to gauge the spatial extent of the ecological “footprint” produced by hypoxia. Through a combination of acoustic tags, a network of receivers and video surveys, researchers are tracking individual animals to determine where they move to avoid low-oxygen water. The results will inform management decisions about fishing regulations in hypoxia-prone areas.

Hypoxia, climate change and water quality in Bellingham Bay

Sue Blake, Washington Sea Grant

In 2006, Lummi fisherman began reporting reduced catches of migratory fish and crab species in Bellingham Bay, attributing this to a newly developed “dead zone”. Research on its potential nature and extent was limited at the time, but hypoxia was of great concern due to the health, economic and cultural importance of these resources to the tribal and nontribal community. WSG partnered with the Northwest Indian College and Shannon Point Marine Center to begin collecting valuable information on the nature and extent of hypoxia in Bellingham Bay. The most recent efforts will engage tribal students in identifying nutrient sources, seasonal variability of inputs, changes in hypoxia, and potential influences of climate change on water quality in Bellingham Bay. The overarching goal of the project is to protect fisheries and shellfish resources, work to maintain local water quality, and help maintain economic and cultural resources.

Using microbiota for the evaluation and monitoring of Puget Sound ecosystems

Elizabeth Nesbitt, Burke Museum Invertebrate Paleontology Division and UW Earth and Space Sciences Department

The Puget Sound ecosystem is a complex stew of natural and human-produced ingredients. This study will assess the effects of the transfer of these ingredients into the system by monitoring foraminifera — tiny mineralizing organisms that are a vital link in the food web. Analyses of foraminiferal populations, including species richness, density, composition and diversity, correlated with sediment parameters, will yield a picture of the effects of inputs such as tides, currents, rivers, stormwater and sewage effluent. The project will develop a new, cost-effective tool for monitoring Puget Sound ecosystems and their response to environmental stresses.

Using zebrafish to assess the health effects of persistent pollutants in Pacific salmon

Evan Gallagher, UW Department of Environmental and Occupational Health Sciences

Levels of polybrominated diphenyl ether (PBDE) flame retardants have increased in fish, wildlife and human tissues during the past decade, and PBDE residues in resident Puget Sound Chinook salmon are high relative to many other species. At the same time, salmon consumption has demonstrated health benefits from nutrients such as omega-3 polyunsaturated fatty acids. This project uses zebrafish as a surrogate model to explore the human health risks associated with consumption of Puget Sound Chinook salmon containing PBDEs. It builds on an earlier study of the biochemical interactions among PBDEs and omega-3s at the cellular level to better understand the risks and trade-offs associated with eating salmon that contains both compounds.



Water Quality

Working with residents to improve water quality

Jeff Adams, Sue Blake and Teri King, Washington Sea Grant

In the Puget Sound region, about 500,000 acres are developed, and fully one-third of that area is impervious surface. Stormwater runoff carries toxic chemicals, nutrients, sediment and bacteria into the Sound. By educating individuals and communities about ways that they can reduce pollutant inputs and implement low-impact development measures, they can become part of the solution. WSG engages citizens in learning about their impacts on the marine environment and enlists them in activities and best practices that promote environmental stewardship. Activities include teaching property owners about low-impact residential practices, including sustainable landscaping, gardening and rain gardens; organizing volunteers to restore shellfish beds and clear tidelands of marine debris; teaching shoreline residents to raise shellfish; and working with local tribes and property owners to prevent livestock and pet waste from entering local waterways.

Bivalves for Clean Water

Teri King, Washington Sea Grant

Bivalves for Clean Water uses shellfish as the focal point in a multifaceted approach to educating marine shoreline owners about nonpoint source pollution. Through a combination of workshops, field trips, shellfish enhancement activities, citizen monitoring, beach walks and assessments, site visits, publications and one-on-one technical assistance, the program steers shoreline property owners through the range of water-quality challenges facing Puget Sound and Hood Canal. The program's diversity allows participants to select activities that fit their learning styles and interests. Volunteers are recruited and trained to identify and eliminate sources of pollution. Tribal, state and shellfish industry partners contribute shellfish for planting in restoration projects.

Preventing pollution from small oil-spills and boat sewage

Allegra Abramo, Aaron Barnett and Eric Olsson, Washington Sea Grant

Recreational boating activity can create pollution. The cumulative effects of small oil spills are particularly harmful to the marine environment. Often they occur in fertile nearshore marine habitats that are extremely vulnerable to pollution. Boat sewage discharged overboard, rather than pumped into on-shore treatment facilities, can also pollute shellfish beds and pose risks to human health. WSG's small oil-spill prevention education program emphasizes direct interaction with vessel and marina operators to provide safe and practical alternatives to spill-prone practices. WSG is also working with the Washington State Parks and Recreation Commission to raise boaters' awareness of state sewage pumpout facilities and to help marina operators secure grants to install them.

Effects of waterfront stormwater solution prototypes on water quality runoff in Penn Cove, Town of Coupeville

Nancy Rottle and Richard Horner, UW Landscape Architecture

Untreated runoff carries toxic chemicals that threaten aquatic natural resources and is one of the leading causes of degradation of Puget Sound. Stormwater outfall sites may provide the final opportunity to improve stormwater quality before it enters the Sound. This project will assess the effectiveness of green stormwater infrastructure in reducing the harmful effects of runoff on aquatic resources, including contamination, environmental degradation and habitat loss. The prototype will advance alternative stormwater solutions, providing coastal communities with new ways to approach local and regional planning decisions that enhance economic, aesthetic and ecological benefits.

Habitat Conservation and Restoration

Providing technical expertise to support restoration and preservation of marine riparian habitat

Jim Brennan, Washington Sea Grant

In the past century, Puget Sound has suffered the loss of about 80 percent of its tidal marshes and wetlands. In the face of continued regional growth and development, the state of Washington has undertaken a major initiative to restore and protect degraded Puget Sound habitats and help recover salmon populations. WSG contributes by providing technical expertise to local governments, state and federal resource management agencies, tribes, private businesses, nongovernmental organizations, conservation groups and private landowners to help them restore and protect shoreline habitats. Diverse support services have included development of a marine riparian guidance document for use by local jurisdictions as they update shoreline master plans and regulations. WSG also collaborated with the Bainbridge Island Land Trust to design the restoration plan for removal of about 1,500 feet of shoreline armoring and replanting of the adjacent riparian area.

Strait of Juan de Fuca shoreline response and recovery after Elwha Dam removal

Ian Miller, Washington Sea Grant

The coastline of the Strait of Juan de Fuca is moderately developed overall, with pockets of more intense development. The Elwha and Dungeness “drift cells” are of particular interest on this coastline, since both are heavily developed and provide critical habitat to a range of species. The chronically eroding Elwha River delta also supports significant recreational and commercial fisheries. The removal of two dams on the Elwha has generated interest in the possibility of shoreline restoration as a positive consequence of watershed restoration. WSG initiated several projects in 2011 focused on understanding how best to manage this important section of shoreline. Goals are to study physical and biological conditions on the Elwha River delta, evaluate the shoreline restoration opportunity presented by dam removal and provide high-quality information to tribal and nontribal decision-makers and managers. To date, WSG has organized and sponsored the Elwha Research Conference and conducted beach-monitoring efforts at four sites on the Elwha River delta.

Integrating intertidal habitat into the Seattle waterfront seawall (phase 2)

Jeff R. Cordell, Jason Toft and Charles Simenstad, UW School of Aquatic and Fishery Sciences

While seawalls provide essential protection for urban infrastructure in coastal cities, they also degrade habitat for fish and wildlife by transforming sloping, complex shoreline habitat into simplified vertical walls that do not support many natural ecological functions. The impending replacement of Seattle’s deteriorating seawall presented an opportunity to provide improved habitat. Given the importance of the area to juvenile salmon and other wildlife, the city is committed to incorporating fish-friendly designs in the new seawall, and this WSG project’s results will be integral in the seawall design process. During the first phase, large-scale panels were designed, built, deployed and monitored to test how different habitat designs could be incorporated into the new seawall and to document the initial responses of biota. The second phase continues monitoring to provide a more comprehensive evaluation of panel effectiveness in restoring nearshore habitat function.

Impacts of armoring on Puget Sound beaches: diverse effects on diverse scales

Megan Dethier, Friday Harbor Laboratories and UW Department of Biology

About a third of Puget Sound — roughly 800 miles — has armored shorelines and demand for shoreline hardening continues to increase. While there are widespread concerns that such alterations could disrupt many natural processes and cause cumulative physical and biological impacts in Puget Sound, surprisingly little is known about its effects. This project is using rapid surveys of pairs of beaches (armored and unarmored) in central Puget Sound to examine changes in shoreline physical features and ecosystem functions associated with armoring. Information is being collected on: physical features such as beach slope, grain size, and nearshore wave energy; backshore and low-tide terrace conditions; amphipods and insects associated with wrack on the upper shore; sediment biota such as juvenile clams; forage-fish spawning; and seasonal changes in many of these parameters.



IV. OCEAN EDUCATION AND PUBLIC AWARENESS

Citizen Engagement

Supporting and enhancing citizen science in Washington

Kate Litle, Washington Sea Grant

Public involvement in citizen science projects can increase knowledge, awareness and sense of place and inspire behavioral change. Citizen science can also provide rigorous, cost-effective data collection for research, monitoring and management needs. WSG's citizen science program has gathered information from scientists, natural resource managers, citizen science practitioners and volunteers and convened a Citizen Science Advisory Panel to develop recommendations for advancing citizen science to meet Puget Sound Action Agenda goals. The program is working to foster connections between scientists, managers, volunteer groups and others; provide consultation services for citizen science programs; and develop resources to help link citizen science projects to scientific research, monitoring and management needs.



State of the Oyster Study

Teri King, Washington Sea Grant

Shellfish depend on clean water to thrive. Pollutants can destroy shellfish beds, and toxins taken up by shellfish can sicken consumers. WSG's State of the Oyster Study provides important shellfish testing for waterfront property owners. At low tide on four days during the year, residents can gather clams and oysters from their beaches and bring them to WSG for laboratory testing. Samples are analyzed for the presence of harmful bacteria and bacterial indicators of contamination. WSG then helps participants interpret their test results and, if needed, works closely with them to identify and remedy the sources of contamination. Since 1987, the State of the Oyster Study has helped waterfront residents on more than 300 Washington beaches learn what makes for safer oysters and clams and how to minimize contamination in their waters.

SoundToxins: monitoring harmful algal blooms that taint shellfish

Teri King and Kate Litle, Washington Sea Grant

Shellfish are critical to the economy and culture of Puget Sound. The shellfish industry employs more than 3,200 people and contributes an estimated \$270 million to the economy, and shellfish are a regular part of the diet of many Puget Sound residents. Shellfish that are safe for human consumption require water that is free of toxins produced by harmful algal blooms (HABs). Of greatest immediate concern is the presence of algal toxins associated with *Dinophysis*, which can cause diarrhetic shellfish poisoning (DSP). The SoundToxins program uses citizens to monitor and provide early warning of HAB events. With adequate warning, aquaculture operators can selectively harvest their product, thereby reducing economic losses and minimizing risks to human health. WSG provides volunteer coordination and communication services for SoundToxins.

COASST volunteers add to data about coastal ecosystem health

Julia Parrish, UW School of Aquatic and Fishery Sciences

The bodies of beached seabirds can hold clues to coastal ecosystem health. The Coastal Observation and Seabird Survey Team (COASST) is a highly successful model of citizen science that focuses on beached birds. Almost 400 COASST volunteers in Washington — and hundreds more in California and Oregon — identify the remains of beached birds and generate baseline data to help assess patterns of seabird mortality due to natural and human-induced events across both time and space. Tribal, state and federal agencies and marine scientists use the data. To continue to improve data accuracy, COASST determined the need to supplement its current field guide with a more specific bird wing key. With funding from WSG, COASST produced a 13-page *Wing Key to the Seabirds of the West Coast* that includes 54 commonly found species.

Kitsap Beach Naturalists

Jeff Adams, Washington Sea Grant

People are more likely to use best-management practices to protect what they appreciate and use. WSG trains volunteers — Kitsap Beach Naturalists — to understand intertidal natural history and conservation and share their knowledge with the public. The Kitsap Beach Naturalists Program provides each volunteer with more than 100 hours of training on watershed and marine issues. Volunteers then engage others to share their understanding and communicate consistent messages linked to ecosystem stewardship goals. Continuing education opportunities are offered to build volunteer proficiency and enhance their understanding and appreciation of marine and watershed resources.



Ocean Literacy

Enhancing public understanding and engaging students and citizens

Jeff Adams, Sue Blake and Teri King, Washington Sea Grant

Washington's coastal and inland waters support diverse marine life and provide recreational and aesthetic benefits to the human population. A clean, predictable water supply and healthy, productive marine waters are essential to community wellbeing but are often sacrificed to growth and development. As people better understand the importance of clean water, they are more likely to become engaged in environmental stewardship activities. WSG Marine Advisory Service field agents organize, sponsor and participate in numerous theme-based local education events in communities throughout western Washington. Major events include Kids' Day at OysterFest in Mason County, the Kitsap Water Festival and Whatcom Water Week. WSG is a partner in Whatcom County Water Resources Education, which has produced a range of public education and applied research programs focused on local waters and watersheds. The Whatcom Watershed Information Network (WWIN) provides community awareness, lessons in stewardship, access to partnerships and project coordination. Throughout Puget Sound, WSG agents regularly host events designed to educate residents about proper septic system maintenance, low-impact landscaping, rain garden construction and other issues.

WOW: a marine education resources database

Nancy Reichley, Washington Sea Grant

Washington on Water (WOW) is a unique Web-based resource center with regional scope and impact that brings together K-12 educators, academia, government, businesses and nonprofit organizations in support of quality marine education. It provides Washington educators with a comprehensive and accessible source of information on regional marine science topics and opportunities for professional development and classroom sup-

port. WOW encourages a regional network of educators, scientists and field programs. The database includes Pacific Northwest regional education resources related to watersheds throughout Washington. Secondary emphasis is placed on access to national marine education that has relevance for the Pacific Northwest.

Future Ocean Professionals

Graduate and postgraduate fellowships in marine policy and science

Nancy Reichley, Washington Sea Grant

The future health of oceans and coastal areas depends on future leaders in marine policy and science. WSG offers fellowships that expand graduate and postgraduate students' horizons and enhance their future careers.

- The Dean John A. Knauss Marine Policy Fellowship sends graduate students to Washington, D.C., for a year to study national policy and its multifaceted relationship with marine resources.
- The Marc Hershman Marine Policy Fellowship places graduate students with state agencies and ocean organizations in Olympia, Tacoma or Seattle for one year, working on ocean and coastal science and management issues.
- The two-year NOAA Coastal Management Fellowship matches postgraduate students with state coastal zone management programs around the country.
- The Sea Grant-NOAA Fisheries Graduate Fellowship in Population Dynamics and Marine Resource Economics provides doctoral student fellows the opportunity to work with a NOAA Fisheries mentor on a management-relevant thesis topic.
- West Coast Sea Grant Fellows are supporting the West Coast Governors Alliance on Ocean Health (WCGA) in implementing the WCGA Action Plan.

Launching careers while reaching new audiences — science writing fellows and communications interns

David Gordon (retired) and Nancy Reichley, Washington Sea Grant

The impact of a marine science research project may depend on how the results of that research are communicated to a broad audience. Aspiring science writers can launch careers at WSG, where the staff helps science-writing fellows and communications interns earn credentials and gain entry-level positions in the field. The program draws potential fellows and interns from various disciplines across the UW campus and from other academic institutions. To build their portfolios, fellows and interns are encouraged to write feature-length articles and shorter news pieces for *Sea Star*, WSG’s quarterly newsletter. They may also contribute to a variety of Sea Grant communication projects geared for general audiences.

Collaborative scholarships and mentoring programs

Nancy Reichley, Washington Sea Grant

In addition to fellowships and internships, WSG provides opportunities for a wide range of university students interested in the sciences to enhance their learning experiences. Undergraduate Capstone students from the UW Program on the Environment (PoE) receive mentorship in the field from WSG Marine Advisory Services specialists. WSG also mentors graduate students working on their Keystone projects, an integral part of PoE’s Environmental Management Certificate Program. A WSG partnership with Washington NASA Space Grant Consortium offers undergraduate scholarships and summer research opportunities to students pursuing degrees in the marine sciences.

NOAA Science Camp and Junior Leadership Program

Maile Sullivan, Washington Sea Grant

Held at NOAA’s Seattle facility at Sand Point, five-day summer camp sessions offer opportunities for seventh and eighth graders to learn about marine sciences in an environment that stimulates interest in personal and professional growth. Participants are introduced to earth and ocean sciences and to science careers through hands-on activities emphasizing solutions to real-world problems. The camp brings NOAA scientists and staff together with educators and students to explore and solve an environmental mystery. To keep older youths in the “science pipeline,” NOAA Science Camp provides ninth and 10th graders with hands-on learning experiences in leadership and team building. This Junior Leadership program provides teens with skills to work with middle-schoolers, communicating science concepts, leading activities, designing curricula and promoting health and safety at camp.

Orca Bowl

Maile Sullivan and Raechel Waters, Washington Sea Grant

This academic competition and ocean literacy event is designed to challenge and recognize high-school students’ knowledge in science, math and technology in the context of the world’s oceans. Students tackle all areas of marine studies, facing rapid-fire short-answer questions and team challenges that test problem-solving skills. All students receive prizes for participation, with top awards that include scholarships and shipboard science experiences. The winning Orca Bowl team competes in the National Ocean Sciences Bowl finals, with support from the Consortium for Ocean Leadership.



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