

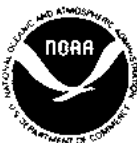
WASHINGTON SEA GRANT

2018 – 2020

PROGRAM DIRECTORY

RESEARCH, OUTREACH, EDUCATION
AND COMMUNICATIONS





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This publication describes research, outreach, education and communications activities for Washington Sea Grant (WSG) from 2018 through 2020. Project descriptions are organized under the four critical program areas identified in the WSG 2018–2022 strategic plan:

- ♦ **Healthy Coastal Ecosystems:** understand and manage ocean and coastal resources by applying science, local and traditional knowledge and ecosystem-based approaches to protect, enhance and restore habitats, ecosystems and living marine resources.
- ♦ **Sustainable Fisheries and Aquaculture:** facilitate aquaculture operations and shellfish harvests that are environmentally sustainable, economically prosperous and produce safe seafood and support fisheries that are safe, responsibly managed and economically and culturally vibrant.

- ♦ **Resilient Communities and Economies:** facilitate development and planning among coastal communities and maritime sectors that improve environmental, economic, social and culture well-being; improve understanding and ability to respond to coastal hazards and climate change; and support coastal water resources and activities that sustain human and ecosystem health.
- ♦ **Ocean Literacy and Workforce Development:** build an ocean literate public through formal and informal opportunities that reflect a diverse community and strengthen a future workforce skilled in disciplines critical to coastal and ocean economies and ecosystem health.

More information is available on the WSG website (wsg.washington.edu) and from project leaders and researchers, whose contact information is listed at the end of this directory.

ABOUT WASHINGTON SEA GRANT

For more than 45 years, WSG has served the Pacific Northwest and the nation by funding high-quality marine research and working with communities, managers, businesses, educators and the public to advance regional understanding and sustainable use of ocean and coastal resources.

Based at the University of Washington (UW), WSG is part of a national network of 33 Sea Grant colleges and institutions located in U.S. coastal and Great Lakes states and territories. The National Sea Grant College Program is administered by the National Oceanic and Atmospheric Administration (NOAA) and funded through federal–university partnerships.

WSG's location at the UW provides access to one of the nation's largest research universities and a leading recipient of federal science support. As one of 11 core units within the UW College of the Environment, WSG draws on the college's academic strengths in fisheries, marine science, engineering and policy. WSG also works with many other colleges and departments in the UW system, as well as other academic and research institutions throughout the Pacific Northwest, to support both faculty and students.

Working with a broad range of organizations focused on use and conservation of the marine environment and its resources, WSG supports the needs of an even larger set of stakeholders. Among WSG's primary partners are institutions of higher learning, NOAA and other federal and state agencies, local and tribal governments, nongovernmental organizations, K–12 educators and students, industries and businesses, news media and, most importantly, the public.

WSG organizes its activities around four core functions: research, outreach, education and communications. The integration of these four core functions is key to carrying out WSG's mission to help people and marine life thrive by supplying research, technical expertise and educational activities that support the responsible use and conservation of ocean and coastal ecosystems.

RESEARCH

Research sponsored by WSG combines scientific excellence and a focus on issues and opportunities faced by ocean users and managers in Washington and the Pacific Northwest. In a highly competitive selection process, top priority goes to projects that build regional scientific capacity and provide knowledge for use in the marine and coastal environment. From uncovering ocean acidification's effects on mussel threads and salmon olfactory function to investigating the recovery of coastal transportation systems after a tsunami, WSG supports a mix of basic and applied research. In addition, each WSG research project must include an outreach plan for making the results available to broader audiences. In 2018, the WSG research portfolio included approximately 35 ongoing projects supporting more than 100 investigators, 66 institutions and about 60 graduate and undergraduate students.

OUTREACH

Outreach experts provide scientific and technical information for use by coastal and marine communities. WSG helps Washington's marine workforce grow and develop the skill needed to compete for jobs through training, workshops and the development of new tools and technologies. WSG specialists 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 resilience. Based at UW and in field offices throughout western Washington, these specialists provide technical assistance and connect governments, tribes, marine businesses and coastal residents to the best scientific information available. Drawing on their own expertise in a wide range of fields, as well as a substantive pool of UW resources, WSG specialists work on water quality, ocean acidification, aquaculture, fisheries management and bycatch prevention, citizen science, habitat restoration, invasive species control, algal bloom monitoring, oil spill and other pollution prevention, maritime safety, coastal development, community sustainability and hazard resilience.

EDUCATION

By engaging learners of all ages, WSG's educational activities enhance the public's understanding and stewardship of marine resources and provide professional development opportunities that nurture and encourage ocean-related careers. WSG supports informal educational programs for K–12 students, including an annual science camp and a statewide ocean-sciences tournament for high school students. WSG also presents undergraduate, graduate and postdoctoral students with opportunities to compete for many different fellowship programs that expand horizons and enhance future careers. In addition, WSG-funded projects explore maritime workforce development and provide training for undergraduate, graduate and postdoctoral investigators. Many students work on issues of regional and national importance in state and federal resource agencies and on congressional staffs. Not only students benefit from WSG education, but adults of every age also engage in education activities through a variety of opportunities held throughout the year, including informal public events, conferences, festivals and beach tours.

COMMUNICATIONS

The WSG communications team maintains the program's commitment to providing unbiased, science-based information, while keeping the public informed on current research and technology and supports marine user needs for the latest news on relevant issues. Using a variety of communications platforms, WSG works to translate technical and scientific findings into useful information for a broad set of constituents. The team maintains the WSG website and social media channels, produces publications and materials supporting the range of WSG activities, and proactively responds to media inquiries about Sea Grant outreach and research. WSG consistently seeks to broaden output via new forms and forums, working to gain national awareness through regular reports to NOAA administration and the national network of Sea Grant programs. Throughout, three principles prevail: reliable and authoritative information, unbiased analysis and clear, concise expression.



I HEALTHY COASTAL ECOSYSTEMS

OCEAN ACIDIFICATION

OCEAN ACIDIFICATION INFORMATION FOR SCIENTISTS, POLICY MAKERS, STUDENTS AND THE PUBLIC

Meg Chadsey, Washington Sea Grant and NOAA Pacific Marine Environmental Laboratory liaison

Ocean acidification (OA) is an urgent issue in the Northwest. WSG addresses this important issue through education and outreach and by bridging the translational gaps between scientists and those who rely on their findings. To accomplish this, WSG produces an OA blog, co-produces the NOAA Ocean Acidification Program's SOARCE webinar series, conducts public presentations and media interviews, develops OA demonstration videos and other materials for K–12 classrooms, trains educators and communicators to use these and other OA resources, and coordinates a student program monitoring acidification in Puget Sound. WSG also plays a key coordination and outreach role in an innovative seaweed aquaculture project to counter acidification. This work bridges scientific and stakeholder communities and contributes to OA science, policy and outreach efforts at the local, state, tribal and federal levels.

HOW SALISH SEA PLANKTON RESPOND TO ENVIRONMENTAL CHANGE

Julie Keister, UW School of Oceanography; Carol Stepien, NOAA Pacific Marine Environmental Laboratory

Zooplankton and larval fish are important prey for larger invertebrates, fishes and marine mammals. They are also some of the most vulnerable species to ocean acidification and other environmental threats, including hypoxia and warming. This project advances understanding of how Salish Sea plankton communities respond to physical and biological changes using metagenomics—the study of genetic material collected from the environment. This alternative to traditional, more expensive taxonomic methods identifies species and captures concrete information on regional planktonic communities, shedding light on how natural and human-caused factors change the composition, diversity and relative abundance of Salish Sea plankton communities.

OTHER ENVIRONMENTAL THREATS

EARLY DETECTION AND MONITORING OF EUROPEAN GREEN CRAB

Jeff Adams, Emily Grason and Kate Little, Washington Sea Grant; P. Sean McDonald, UW Program on the Environment

Aggressive, adaptable and highly invasive, the European green crab has established U.S. populations on the east and west coasts, in many places disrupting coastal habitats and shellfish harvests. The species is classified as injurious by the U.S. Fish and Wildlife Service and as a Level 1 (highest risk) prohibited species in Washington state. Anticipating its entry into Puget Sound, WSG launched Crab Team, a citizen science early detection program, in 2015 to monitor vulnerable estuaries. WSG and UW scientists identified key monitoring sites, developed and piloted volunteer protocols, trained volunteers, engaged students and developed an outreach plan. WSG maintains the monitoring program, conducting intensive surveys where green crabs are detected and advising resource managers. In the process of monitoring for green crab, volunteers are also gathering valuable data on native species in understudied pocket estuaries.

TRANSMISSION OF HARMFUL ALGAL BLOOM TOXINS THROUGH THE FOOD WEB

Adrianne Akmaijian and Jonathan Scordino, Makah Fisheries Management

The Makah tribal usual and accustomed fishing grounds are located in the California Current, a highly productive feeding area for marine mammals, seabirds and fish, but that is also subject to harmful algal blooms (HABs) that produce toxins, such as domoic acid and saxitoxin. During HAB events, associated toxins can accumulate throughout the food web from zooplankton to fish, and even to marine mammals. This project focuses on how algal toxins are transmitted through the offshore coastal food web. The primary goal is to survey for domoic acid and saxitoxin in fish species that are caught in tribal commercial fisheries. The project will also survey the feces of nearshore feeding gray whales and survey their zooplankton prey. Data collected will inform managers and fishermen on current algal toxin concentrations in harvested fish and identify potential for exposure to humans and other mammals, such as gray whales.

INVESTIGATING WHETHER NATIVE EELGRASS AND PACIFIC OYSTERS SYNERGISTICALLY ENHANCE THEIR ENVIRONMENTS

Carolyn Friedman, UW School of Aquatic and Fishery Sciences; Brady Blake, Washington Department of Fish and Wildlife; Colleen Burge, University of Maryland; Meg Chadsey, Washington Sea Grant and NOAA Pacific Marine Environmental Laboratory liaison; Drew Harvell, Cornell University

In the 1930s, eelgrass wasting disease (*Labyrinthula zosterae*) caused eelgrass losses of more than 90 percent on the Atlantic Coast, and the disease continues to affect beds along the West Coast today. In the Pacific Northwest, eelgrass and shellfish cultures often grow in the same place. This project focuses on a potential benefit of co-culture: filtration services of oysters to improve health of eelgrass beds and potentially reduce pathogen loads and increase local water quality. The project serves two purposes: 1) it assesses the connections between marine disease, shellfish and marine habitats, with an eye to enhancing conservation and management of eelgrass beds, and 2) the researchers analyze targeted DNA molecules to detect specific disease strains of varying virulence. This data will provide the shellfish industry, tribes, resource managers and the public, with key diagnostic and genomic resources that will promote sustainable shellfish culture in Washington state.

MODELING THE VULNERABILITY OF SEABIRDS TO OIL SPILLS

Julia Parrish and Timothy Jones, UW School of Aquatic and Fishery Sciences

When oil coats a seabird's feathers, it causes them to mat and lose their waterproofing. Because of this and other factors, seabirds are among the most vulnerable animals to oil spills. This project takes a closer look at how oil spills affect different species of Pacific Northwest seabirds. The project employs two independent methods, one using historical data to assess the relative abundance of taxon groups in oil spill samples relative to beached bird baseline data (a method called hindcasting). The second method models the likelihood of particular groups of birds washing up on the shore by using cumulative spatiotemporal data on at-sea distribution, fine-scale ocean circulation modeling and the extent of how far and when a given spill spread. The project's long-term goal is to create a set of tools to simulate past spills and model the vulnerability of various groups of Pacific Northwest seabirds to future oiling.

SALMON

EFFECTS OF OCEAN ACIDIFICATION ON SALMON OLFACTION AND MAGNETORECEPTION

Evan Gallagher and Chase Williams, UW Environmental and Occupational Health Sciences; Shalin Busch, NOAA Ocean Acidification Program and NOAA Northwest Fisheries Science Center; Meg Chadsey, Washington Sea Grant and NOAA Pacific Marine Environmental Laboratory liaison; Andy Dittman and Paul McElhany, NOAA Northwest Fisheries Science Center

Evidence of ocean acidification on shellfish and some marine organisms native to the Pacific Northwest is well documented, but the effects on local fishes have largely gone unstudied. This research addresses a current gap in knowledge about possible harmful effects of increased CO₂ fish populations. In an ongoing study that focuses on Pacific salmon and sablefish, WSG researchers are finding that ocean acidification can diminish the ability of salmon to smell nearby predators. This investigation probes the mechanisms that underlie loss of smell, and expands the line of research to investigate the effects of increased waterborne CO₂ on navigational function, a function which allows salmon to find their way back to their home streams to spawn.

EFFECTIVENESS OF ENGINEERED LOG JAMS IN PROVIDING REFUGIA FROM HEAT IN SALMON RESTORATION

James Helfield, Western Washington University Huxley College of the Environment; Treva Coe and Michael Maudlin, Nooksack Indian Tribe

Engineered log jams (ELJs) are widely used in salmon habitat restoration to deflect streamflow and scour out deep pools that provide cool refugia for heat-stressed salmon. But the effectiveness of these and other salmon restoration measures have never been comprehensively assessed to inform future salmon conservation efforts and improve efficient use of funds. This project assesses the effectiveness of ELJs installed by the Nooksack Tribe along the South Fork Nooksack River that are intended to support threatened Chinook salmon. At 10 experimental ELJs, plus control sites, researchers will measure four key variables: streambed topography, cooling groundwater upwelling, stream temperature, and the density and diversity of fish presence.

HABITAT

EVALUATING THE PHYSICAL AND ECOLOGICAL OUTCOMES OF SHORELINE RESTORATION

Jeff Adams and Ian Miller, Washington Sea Grant; Jason Toft, UW School of Aquatic and Fishery Sciences

Each year, state and federal agencies spend millions of dollars on competitively selected projects to restore salmon and nearshore habitat in Washington. However, there is little funding available for assessing the effectiveness of restoration approaches or ensuring that ecological responses meet project goals. To address this need, WSG has worked with nearshore restoration and monitoring practitioners to develop the Shoreline Monitoring Toolbox—an online resource with standardized approaches for monitoring shorelines in Puget Sound. WSG is applying Toolbox protocols and other methods in conducting topographic surveys and beach transect surveys of sediment, slope and biological communities at several restoration sites. WSG also works with the U.S. Geological Survey, Lower Elwha Klallam Tribe and others to understand habitat changes in marine shorelines adjacent to the mouth of the Elwha River, where two dams were recently removed to restore access for salmon. At other sites WSG either conducts the field studies or trains and supervises volunteers, providing scientific oversight and analyzing the data collected. Results are being shared with others interested in shoreline restoration through publications, conferences and meetings.

USING AN ACOUSTIC CAMERA TO SEE HOW FISH RESPOND TO SEAWALL HABITAT ENHANCEMENTS

Jeff Cordell and Jason Toft, UW School of Aquatic and Fishery Sciences

This project builds on previous WSG-funded research to incorporate juvenile salmon habitat considerations into the construction of the Seattle seawall and provide managers with effective options for improving juvenile salmon survival and survival of adults returning to spawn. Investigators are expanding upon current Seattle Department of Transportation monitoring with additional funding that provides for snorkeling surveys and installation of acoustic cameras mounted under survey kayaks to image fishes in their environment. This approach improves and enhances data gathered about juvenile salmon in nearshore urban environments by providing data in areas and times of otherwise poor visibility (such as at night). This will be coupled with snorkeling surveys along Seattle's waterfront, conducted during the juvenile salmon spring out-migration period. The data will expand our understanding of how juvenile salmon are using these new habitat areas.

DEVELOPING BASELINE DATA ON NATIVE EELGRASS TO INFORM CONSERVATION STRATEGIES

Kerry Naish, UW School of Aquatic and Fishery Sciences; Cinde Donoghue and Jeffrey Gaeckle, Washington State Department of Natural Resources; Jennifer Ruesink, UW Department of Biology

Eelgrass is an important species that provides essential habitat to fish, such as Pacific herring and juvenile salmon, but is declining in many areas of Washington. Ongoing efforts to restore eelgrass often lack information about population structure and may not fully account for changes in the environment. This project will determine the population structure and the genetic basis of various traits in native Washington eelgrass (*Zostera marina*) populations and assess how genetically distinct populations respond to environmental stressors. The baseline data generated will be used to make the first comprehensive geographic map of state eelgrass population structure and describe the relationship between eelgrass population structure, phenotypic diversity, and local adaptation and resistance to environmental stressors. The geographic map and relational information will be used directly by planners to inform future eelgrass restoration efforts.

PROGRESS TOWARD A NEW SEDIMENTARY AND ECOLOGICAL EQUILIBRIUM: HABITAT MODIFICATION FROM ELWHA DAM REMOVAL

Andrea Ogston, UW School of Oceanography; Nancy Elder, U.S. Geological Survey; Ian Miller, Washington Sea Grant

The physical and ecological recovery of the Elwha River delta is underway, following the removal of two upstream dams. Physical changes such as sediment deposition during floods and redistribution by waves and storms continue as the system approaches a new equilibrium. Evaluating these processes and the associated ecological changes is essential to understanding the longer-term impacts of dam removal and other coastal management practices that affect sediments, such as de-armoring and beach replenishment. This project addresses fundamental, widely applicable questions about habitat change in coastal ecosystems. To correlate substrate character to ecological changes, researchers are sampling the seabed where state and federal researchers are surveying algae, invertebrates, fishes and other indicators. Water column profiling reveals the relationships between sediments delivered by the plume, re-suspended bottom sediments, grain size and light attenuation. Instruments monitor currents, waves, suspended sediment concentrations and ambient light at key sites.

ASSESSING SEAGRASS AS FISH AND BIRD HABITAT IN FIVE WASHINGTON ESTUARIES

Jennifer Ruesink, UW Department of Biology; Cinde Donoghue, Washington Department of Natural Resources; Tom Good, NOAA Northwest Fisheries Science Center

Seagrasses, which are protected locally and declining worldwide, have been proven elsewhere to provide valuable habitat for fishes and birds, but local studies documenting their value are surprisingly lacking. This project provides the overdue data that managers need to develop cost-benefit analyses and ecosystem-based protection and restoration strategies. It will document which fishes and birds use four habitat types—large meadows, smaller eelgrass patches, eelgrass-free patches and the edge zones between—in five representative estuaries from northern Puget Sound to Willapa Bay. Purse seines and remote sensors will identify the fish present. Remote sensing and trained volunteer birdwatchers will capture bird movements. Tethered prey will reveal predation pressure. Statistically analyzed and integrated, these observations should finally begin to fill the data gap.



A BLUE CARBON ASSESSMENT FOR THE STILLAGUAMISH RIVER ESTUARY: QUANTIFYING THE BENEFITS OF TIDAL MARSH RESTORATION

John Rybczyk and Katrina Poppe, Western Washington University

Carbon sequestration has emerged as an important consideration in coastal resource management and a prospective source of restoration funding through carbon finance mechanisms. But Northwest land managers and policymakers lack the site-specific and region-wide information they need to value sequestration. This project assesses the carbon stocks contained in regional tidal marshes and the rate at which they accumulate by estimating the amount of carbon sequestered following the restoration of a degraded marsh in Port Susan Bay. Researchers will measure carbon in aboveground plant biomass and in sediment cores from five zones ranging from healthy, undisturbed marsh to a regenerating, rapidly accreting restoration zone. They will continue monitoring changes in surface elevation throughout the estuary to validate long-term accretion rates obtained from soil-core chemical analyses. The results will enable managers and planners to incorporate blue-carbon accounting in their climate adaptation and coastal restoration strategies.

II SUSTAINABLE FISHERIES AND AQUACULTURE

FISHERIES

LOWERING THE RISK OF OVERFISHING WHILE INCREASING PROFITS FOR CALIFORNIA'S MOST VALUABLE FISHERY

Trevor Branch and Andre Punt, UW School of Aquatic and Fishery Sciences; Caitlin Allen Akselrund, UW School of Aquatic and Fishery Sciences and Sea Grant/NOAA Fisheries Fellow in Population and Ecosystem Dynamics; Anne Hollowed, NOAA Alaska Fisheries Science Center

Market squid is California's highest grossing commercial fishery, but it is only lightly regulated. The current management strategy is a fixed constant catch limit, which can result in low long-term catches and a high risk of overfishing. This project reviews the management strategy for evaluating the risk-reward balance and compares a fixed constant catch limit with other possible tactics. Market squid fishermen also catch other forage fish, including sardine, anchovy, Pacific mackerel and jack mackerel. Given this, the researchers are investigating possible harvest control rules both for California market squid independently and as part of a management strategy that includes the entire California forage fish complex.

HISTORICAL TRENDS IN THE ABUNDANCE OF KEY PUGET SOUND FISHES

Timothy Essington, UW School of Aquatic and Fishery Sciences; Correigh Green and Eric Ward, NOAA Fisheries Northwest Region; Dayv Lowry, Washington Department of Fish and Wildlife

Unlike most major U.S. estuaries, Puget Sound has not received long-term monitoring needed to determine success of restoration and recovery efforts. Evaluating the status of local fish populations requires a comprehensive synthesis of historical data, but such an evaluation has only been conducted for one forage fish, Pacific herring. Much less is known about the status and trends for other important species such as Pacific hake, cod, walleye pollock and spiny dogfish. This long-term historical assessment of key Puget Sound species provides the necessary baselines to gauge the fishes' population statuses and recovery potentials. The project integrates and analyzes nine datasets from university, state, federal and salmon-hatchery surveys from 1947 to the present. For the first time, this will make it possible to consider the relative roles of fishing, population growth and climate change in driving fish losses. Researchers are also gauging the impacts of predation by studying the growth of seal and sea lion populations. Once the analysis is complete, the data will be useful as a tool for managing ecosystems and restoring Puget Sound.

DOES PREDATION INFORMATION IMPROVE STOCK ASSESSMENTS?

Timothy Essington, UW School of Aquatic and Fishery Sciences; Elizabeth Ng, UW Quantitative Ecology and Resource Management and Sea Grant/NOAA Fisheries Fellow in Population and Ecosystem Dynamics; Jonathan Deroba, NOAA Northwest Fisheries Science Center

Single-species stock assessments are the primary scientific analyses used to evaluate the status of harvest populations and to set annual catch limits. Previous studies have suggested that these stock assessment models can be improved by more explicitly accounting for predation removals of the target species. However, this idea has not been specifically evaluated. Using the extensive time series data available for New England herring as a model, project investigators are researching the relative performance of stock assessments that do and do not include predation information. The project objectives are to: 1) evaluate how closely the diet composition of predators tracks the relative abundance estimates of prey species, 2) develop a model to simulate diet data and 3) evaluate the stock assessment and management advice under a variety of scenarios that include food habits and consumption data.

MARINE SAFETY TRAINING FOR FISHERMEN AND VESSEL OPERATORS

Sarah Fisksen, Washington Sea Grant

West Coast and Alaska fisheries have historically been the most dangerous in the country. The region's severe weather, cold water and rough seas require fishermen to work under adverse conditions, increasing risks for crews and vessels. From 2002 through 2014 the fatality rate in the West Coast Dungeness crab fishery (California, Oregon and Washington) was several times the national rate for the commercial fishing industry and exceeded the rate in Bering Sea crab fisheries. WSG helps Washington fishermen reduce these risks with port-based, Coast Guard-certified training in emergency evacuation, fire response, cold-water survival and rescue, first aid and other safety measures using the latest equipment and procedures. The courses have reduced fatalities and injuries in several targeted fisheries, including Dungeness crab and Columbia River salmon. WSG also trains recreational boaters in first aid and at-sea safety and survival.

MARINE TECHNOLOGY TRAINING FOR FISHERMEN AND VESSEL OPERATORS

Sarah Fiskien, Washington Sea Grant

Vessel system operations and technologies change constantly and many commercial and recreational boaters rely on informal training programs to keep up. WSG offers training on vessel maintenance and operation topics, including marine refrigeration, corrosion, diesel engine troubleshooting, computers and navigation. WSG workshops are led by a suite of professionals and designed for commercial fishermen and charter captains, but recreational boaters and others with close ties to the marine environment often participate. Ongoing trainings in boating maintenance, operations and technology keep boaters safe and fishermen in business.

EVALUATION OF PAST HERRING ABUNDANCE AND NATIVE AMERICAN USE OF HERRING FOR CURRENT RESOURCE MANAGEMENT

Lorenz Hauser, UW School of Aquatic and Fishery Sciences; Robert Kopperl, Willamette Cultural Resources Associates; Dana Lepofsky and Dongya Yang, Simon Fraser University Department of Archeology

Herring are a foundation of the Puget Sound food web, feeding marine life from hungry sea lions to spawning Chinook salmon. Pacific herring have also been a cultural touchstone for local Tribes for centuries. But herring populations in Puget Sound are declining, imposing significant economic and cultural losses on the Tribes. This project combines social and natural scientific approaches to examine the ways herring diversity and tribal uses have changed over time through a synthesis of traditional knowledge, archaeology and genetic research. The results will assist in evaluating management goals in Puget Sound and could lead to closer integration of tribal and state resource management.

LOCAL ADAPTATION AND SEASONAL DISTRIBUTION OF PUGET SOUND HERRING STOCKS

Lorenz Hauser, UW School of Aquatic and Fishery Sciences; Dayv Lowry and Todd Sandell, Washington Department of Fish and Wildlife

Puget Sound herring continue to decline, and longevity of the resource will require careful resource management, conservation and restoration—work that requires additional understanding of species populations. This project examines molecular genetic evidence for local adaptation of Puget Sound herring populations by resequencing entire genomes for six stocks. Genetic markers will be used to establish geographic and temporal distribution of genetically distinct populations outside their spawning season. The new information will allow resource managers to better identify causes for specific population declines, anticipate future threats and adjust management strategies to protect population diversity.

RECONSTRUCTING A CENTURY OF COASTAL PRODUCTIVITY AND TROPHIC DYNAMICS FROM BONE SPECIMENS

Gordon Holtgrieve, UW School of Aquatic and Fishery Sciences; Christopher Harvey and Eric Ward, NOAA Northwest Fisheries Science Center

As part of the California Current Large Marine Ecosystem, Washington coastal waters host some of the world's most productive fisheries. Fishermen and planners are interested in understanding what influences this regional productivity. The project provides an 80-year-plus perspective on food-web dynamics involving harbor seals, comparing changes in predator and prey abundances with shifting ocean productivity regimes. Using a novel technique called "compound-specific isotope analyses" to examine nitrogen isotope ratios in archived seal bone collagen, researchers will assess the role of increasing marine predator populations on coastal ecosystems.

ECONOMIC ANALYSIS OF A FISHERY'S QUOTA SHARE MARKET

David Layton, UW Evans School of Public Policy and Governance; Adam Hayes UW Evans School of Public Policy and Governance and Sea Grant/NOAA Fisheries Fellow in Marine Resource Economics; Alan Haynie, NOAA Alaska Fisheries Science Center

Catch shares are an increasingly popular method for managing fisheries, where fishing businesses are each allocated a certain percentage, or quota, of the pre-determined total allowable catch. Many catch-share policies allow fishery participants to buy and sell their harvest rights, which creates quota marketplaces. To better understand the economic behavior of these marketplaces, this project applies network modeling techniques using data from the Alaskan halibut fishery. The researchers analyze quota prices, trading behavior and measures of market efficiency. The investigation also tests the role of social and geographic economic vulnerabilities and whether new buyer/seller connections form to mitigate market inefficiencies.

BIOENERGETICS MODELS FORETELL CLIMATE IMPACTS ON DUNGENESS CRAB

P. Sean McDonald, UW Program on the Environment; David Armstrong (retired), UW School of Aquatic and Fishery Sciences

Climate change puts Dungeness crab, Washington's most valuable catch, at risk. Dungeness crab favor cooler water, while the less desirable graceful crab predominate in warmer parts of Puget Sound. Warmer temperatures can make crab grow faster, outstripping available resources. Males may molt earlier and reach harvestable size before reproducing. But little is known about how changing temperature and salinity and other climate-related factors will affect Dungeness

crab. Regulators need this information to determine fishing seasons and to set harvest size. This research conducts feeding trials on Dungeness and graceful crab to determine size-specific consumption rates. Bioenergetic models based on the results will help managers determine how future conditions may affect crab ecology and enable them to evaluate the robustness of current management strategies.

SEABIRD BYCATCH PREVENTION

Edward Melvin, Washington Sea Grant

Hundreds of thousands of seabirds, including protected albatrosses and petrels, are trapped and drowned in longline and trawl fisheries worldwide each year. Seabird avoidance measures developed and tested by WSG in collaboration with industry and management partners are now being applied to fisheries around the world. These measures have dramatically reduced avian bycatch in longline fisheries off Alaska and elsewhere, and at the same time reduced bait losses and improved fishing efficiency. WSG will continue documenting the success of seabird bycatch reduction measures and conducting outreach to facilitate their successful adoption in U.S. and international fisheries. In particular, WSG is promoting a coordinated effort to curb the accidental capture of seabirds in U.S. West Coast fisheries and in the Pacific whiting fishery. NOAA Fisheries trawl research used WSG protocols and advice, which could lead to new mitigation measures for preventing seabird deaths.

ADAPTING TO CHANGE IN CALIFORNIA CURRENT FISHERIES AND FISHING COMMUNITIES

Melissa Poe, Washington Sea Grant and NOAA Northwest Fisheries Science Center liaison

The livelihoods of fishermen are strongly influenced by the inherent variability of ocean ecosystems as well as change and uncertainty in fisheries management and coastal economies. The linkages between environmental variability and ecological, economic and social outcomes in fishing communities are poorly understood. Developing this knowledge is important to crafting fisheries management approaches that allow fishermen to adapt to change while mitigating ecological and economic risks. In this NSF-funded project, WSG brings ecologists, economists and social scientists together to better understand how environmental variability and fisheries management decisions are linked to social and ecological outcomes. The investigators are also exploring how fisheries management can enhance social and ecological resilience.

AQUACULTURE AND SHELLFISH

REVIVING THE PAST TO PROTECT THE FUTURE: DEVELOPING A SOCIAL-ECOLOGICAL SITE SELECTION MODEL FOR CLAM GARDENS

Julie Barber, Swinomish Indian Tribal Community Fisheries Department; Jamie Donatuto, Swinomish Indian Tribal Community

The Swinomish Indian Tribal Community is reviving an ancient mariculture practice by installing the first known present-day clam garden in the United States. Long-term goals are to enhance native clam populations, support local food security, provide ecological and cultural benefits, and promote integration of traditional ecological knowledge in contemporary resource management and climate change adaptation strategies. The project will complete steps toward developing a clam garden and apply a social-ecological decisions framework that considers both people and their environment. This site selection model will be used for future clam gardens.

IMPROVING OLYMPIA OYSTER RESTORATION EFFORTS THROUGH EFFECTIVE TRACKING OF LARVAL NATIVE OYSTERS

Bonnie Becker, UW Tacoma Interdisciplinary Arts and Sciences; Brian Allen and Betsy Peabody, Puget Sound Restoration Fund; Henry Carson, Washington Department of Fish and Wildlife; Andrés J. Quesada, Northwest Indian College Salish Sea Research Center; Brent Vadopalas, Washington Sea Grant

Historically, the native Olympia oyster played a key role in Puget Sound's ecology and economy. But despite cleaner water and an end to commercial harvests, it has failed to reestablish itself. An important question remains unanswered: to what extent does a restored oyster population self-seed, seed other sites and exchange larvae with other populations? Genetic analysis assesses these connections across multiple generations, but restoration occurs on much shorter time scales. This project uses the distinctive chemical signatures of seawater at different locations to more speedily and precisely decipher the connections between various Olympia oyster populations.

GROWING SUSTAINABLE SHELLFISH: UNDERSTANDING THE ECOLOGICAL ROLE OF SHELLFISH AQUACULTURE

Molly Bogeberg, The Nature Conservancy; Bridget Ferriss, NOAA Northwest Fisheries Science Center

Shellfish aquaculture is potentially one of the most sustainable means of food production. However, some stakeholders have raised ecological concerns regarding the expansion of shellfish aquaculture, as the natural near-shore environments would be converted into shellfish farms. This project evaluates whether the habitat provided by shellfish

farms is functionally different from natural eelgrass or mudflat habitat. Working with the shellfish industry, investigators are deploying GoPro cameras in the tidal waters of aquaculture and control sites around Puget Sound to understand how the various habitats contribute to fish and invertebrate communities. To address the barriers to sustainable aquaculture growth, such as public perception and the permitting process, the results of the project are being shared through a series of videos tailored to interested audiences and policymakers.

DEVELOPING PILOT-SCALE SABLEFISH AQUACULTURE

Graham Young, UW School of Aquatic and Fishery Sciences; Kurt Grinnell, Jamestown S’Klallam Tribe

Wild sablefish (also known as black cod) currently support a lucrative fishery, but their stocks are not likely to increase. This means that harvests from wild populations are unlikely to keep up with growing market demand. Aquaculture is a possible solution to boost the available sablefish supply. However, hurdles such as a lengthy, expensive production process present serious challenges to developing a sablefish aquaculture industry. WSG, the University of Washington, NOAA Manchester Research Station and the Jamestown Point Whitney Venture are partnering with the Jamestown S’Klallam Tribe on a pilot project to grow and harvest net-pen sablefish. The project utilizes new tools and production methods that reduce cost, improve egg quality and increase larval production. By hiring and coordinating with local fishermen and processors, this project supports the local fishing economy, from stocking to harvest. The pilot project seeks to successfully raise sablefish for commercial-scale production, paving the way to a native product that local tribes and industry can further develop.

PREPARING U.S. OYSTERS TO WITHSTAND A GLOBAL HERPES EPIDEMIC

Carolyn Friedman, UW School of Aquatic and Fishery Sciences; Brady Blake, Washington Department of Fish and Wildlife; Colleen Burge, University of Baltimore Institute of Marine and Environmental Technology; James Moore, California Department of Fish and Wildlife, Bodega Marine Laboratory

Oyster aquaculture contributes millions of dollars to the Washington state economy. But emerging, rapidly spreading diseases such as the *ostreid herpesvirus* (OsHV-1) call for tools that will enable regulatory agencies and industry to respond effectively to such outbreaks. Researchers are developing molecular and diagnostic tools and data for early detection of OsHV-1 and its variants. They are also conducting field and laboratory trials to identify which oyster lines grow well when exposed to the virus. The viral genomes used in infection trials will be sequenced to better understand how these diseases develop and to select resistant oysters.

DETERMINING HOW AND WHERE ROCK SCALLOPS CAN BE GROWN WITHOUT THREATENING WILD POPULATIONS

Lorenz Hauser, UW School of Aquatic and Fishery Sciences; Brent Vadopalas, Washington Sea Grant; Brady Blake, Washington Department of Fish and Wildlife; Jonathan Davis, Pacific Shellfish Institute

Prized flavor and the ability to thrive in widely diverse conditions make the native purple-hinged rock scallop a prime candidate for aquaculture, but Washington state rules restrict transferring broodstock for fear of harming wild populations. This project is quantifying genetic differences between populations from California to Alaska, comparing the resilience of different populations exposed to acidic ocean conditions, testing the adaptability of local populations through reciprocal transplant experiments, and integrating the results into a population model of local adaptation. The results will inform pending regulatory decisions and may contribute to the development of a new, sustainable, highly desirable native shellfish crop.

DEVELOPING GENETIC RISK ASSESSMENT TOOLS AND MANAGEMENT STRATEGY EVALUATIONS FOR NATIVE SHELLFISH AQUACULTURE

Lorenz Hauser, UW School of Aquatic and Fishery Sciences; Natalie Lowell, UW School of Aquatic and Fishery Sciences and Sea Grant/NOAA Fisheries Fellow in Population and Ecosystem Dynamics; Eric Ward and Robin Waples, NOAA Northwest Fisheries Science Center; Brent Vadopalas, Washington Sea Grant

Growing native shellfish holds promise to reduce the risk of invasive species while diversifying Washington State’s aquaculture industry. However, farming native species could threaten the genetic fitness of wild populations if captive and wild animals interbreed. This investigation studies the risk of interbreeding. The researchers are developing an open-source model to quantify the major genetic threats to wild shellfish populations by simulating genetic and demographic dynamics in a native shellfish farm and in two wild populations. The scientists are also working toward successful native shellfish management by soliciting input from stakeholders on potential strategies and carrying out an evaluation of management strategies used for native species. Once completed, the model will be applied to three native shellfish species—rock scallop, sea cucumber and geoduck—and could eventually be used by industry and regulators.

PURPLE ROCK SCALLOPS' AQUACULTURE POTENTIAL AND TOXIC ALGAL PROBLEMS

Bobbi Hudson and Dan Cheney, Pacific Shellfish Institute; Jerry Borchert, Washington State Department of Health; Jonathan Davis, Pacific Shellfish Institute; Steve Morton, NOAA National Ocean Service; Sandra Shumway, University of Connecticut Department of Marine Sciences; Brent Vadopalas, Washington Sea Grant

The native purple hinged rock scallop shows promise for aquaculture production, yet information on scallop biotoxin retention and detoxification is lacking. This is critical because toxins associated with potentially deadly paralytic shellfish poisoning are widely reported in bivalves along the North American west coast. Investigators are addressing regulatory and industry needs by improving the understanding of biotoxin uptake and depuration in rock scallop species. They are also helping to establish approved National Shellfish Sanitation Program lab tests for detecting marine biotoxins. Research results are anticipated to help improve understanding of optimal growout methods for purple hinged rock scallops in Washington State.

TECHNICAL ASSISTANCE FOR SHELLFISH AQUACULTURE

Teri King, Washington Sea Grant

Washington leads the nation in production of farmed clams, oysters and mussels with an annual value of more than \$130 million. Despite their successes, shellfish growers face multiple challenges from a changing environment, coastal development conflicts, and disease and toxin incidents that affect product safety. WSG works with shellfish producers and scientists to respond to emerging concerns and produce the information and practices needed to support sustainable shellfish aquaculture. A popular and effective feature of the program is the annual Shellfish Growers Conference, hosted by WSG for more than 25 years. WSG is also a leading participant in the Washington Shellfish Initiative, coordinated by the Governor's Office, which promotes collaborative efforts to tackle water quality issues, restore and enhance native shellfish populations and support sustainable shellfish aquaculture.

AN ECOSYSTEM-MODELING APPROACH TO INVESTIGATING THE EFFECTS OF GEODUCK AQUACULTURE EXPANSION

Glenn VanBlaricom (retired) and P. Sean McDonald, UW School of Aquatic and Fishery Sciences; Chris Harvey, NOAA Northwest Fisheries Science Center

Geoduck aquaculture is a valuable, fast-growing, but controversial Puget Sound industry. From 2007 to 2013 Washington Sea Grant conducted the first comprehensive study of geoduck aquaculture's environmental effects.

However, some stakeholders still expressed concern about broader impacts, particularly on iconic species such as salmon and eagles. This project integrates data collected from aquaculture sites and reference beaches into a food-web model for central Puget Sound. With guidance from a multi-stakeholder advisory panel, investigators are testing a spectrum of aquaculture scenarios and their potential impacts on habitat, fisheries, mortality and predator-prey interactions. The eventual findings will guide recommendations for future aquaculture operations.

SAFE, SUSTAINABLE SEAFOOD

BUSINESS, DIRECT MARKETING AND PRODUCT QUALITY TRAINING FOR FISHERMEN

Sarah Fiske, Washington Sea Grant

Fishing supports thousands of jobs throughout the state and is central to tribal and coastal cultures and economies. Declining harvest limits and competitive markets make smart business practices and fish-handling expertise essential to success in commercial fisheries. WSG provides training and technical advice that help tribal and nontribal fishermen earn larger profits by upgrading their seafood handling and business practices, developing value-added products and choosing successful marketing strategies. In recent years, WSG has provided support to the Wild Seafood Exchange, where fishermen learn from one another about direct marketing; WSG also co-hosts the prestigious Lark Lunch, introducing buyers and culinary leaders to distinctive, formerly discounted marbled salmon caught off Washington's northwest coast.

SOUNDTOXINS: MONITORING FOR HARMFUL ALGAL BLOOMS

Teri King, Washington Sea Grant; Vera Trainer, NOAA Northwest Fisheries Science Center

The human illnesses caused by eating shellfish affected by harmful algal blooms (HABs) can be debilitating or even fatal. SoundToxins, a partnership of WSG and NOAA Northwest Fisheries Science Center, helps make such occurrences much rarer today than in the past. Trained SoundToxins volunteers collect weekly samples from 31 sites throughout Puget Sound and the Strait of Juan de Fuca to provide an early warning of harmful algae species and sound an alert. These samples are then analyzed for salinity, temperature, nutrients, chlorophyll, phytoplankton species and marine biotoxins. The information is used to provide a warning system for HAB events to enable early or selective seafood harvesting. The program minimizes risks to human health and reduces economic losses to Puget Sound fisheries.

III RESILIENT COMMUNITIES AND ECONOMIES

HAZARD RESILIENCE AND CLIMATE ADAPTATION

TRAINING, TOOLS AND ADVISORY SERVICES TO PREPARE FOR COASTAL HAZARDS

Aaron Barnett, Nicole Faghin, Ian Miller and Bridget Trosin, Washington Sea Grant; Carrie Garrison-Laney, Washington Sea Grant and NOAA Pacific Marine Environmental Laboratory liaison

WSG works directly with stakeholders including local government, planners, community groups and individual property owners to prepare for coastal hazards and improve their resilience to destructive events. WSG conducts applied research on ways to improve coastal resilience, participates in Coastal Training Program courses on hazard preparedness, contributes to hazard mitigation and preparedness plans for coastal communities, and provides advice to shoreline property owners. Building on the model established by other Sea Grant programs, WSG is developing a guide to coastal hazards for Puget Sound residents. Its Witness King Tides program—coordinated in partnership with Washington Department of Ecology—encourages people to photograph coastal areas during twice-yearly extreme tides and severe winter storms, and share them via a website. The program educates coastal dwellers about the risks associated with sea-level rise and storm surge. Two new dimensions are being explored for WSG hazards outreach: 1) advising small ports, marina operators and vessel owners on keeping maritime assets safe and resilient, and 2) advising coastal brownfields projects on risks associated with sea-level rise.

SOCIOCULTURAL DIMENSIONS OF OCEAN CHANGE

Melissa Poe, Washington Sea Grant and NOAA Northwest Fisheries Science Center liaison; Meg Chadsey, Washington Sea Grant and NOAA Pacific Marine Environmental Laboratory liaison; Melissa Watkinson, Washington Sea Grant

The need to understand cumulative risks to the health and well-being of Pacific Northwest communities posed by climate shifts and coastal hazards is driving a new emphasis on climate-related social science research. As coastal and marine ecosystems change, there will be impacts on human health, psychological and cultural well-being, and quality of life. Communities that directly depend on affected species and habitats are likely to face disproportionate impacts. WSG engages in research to understand sociocultural vulnerabilities in coastal communities and follows up with assistance for community-led approaches to becoming more resilient. With tribal and nontribal collaborators, WSG has developed and tested a community participation “rapid appraisal” process that assesses culturally significant elements of ecosystems, such as important food species and a community’s sense of place. This tool will be used and further developed with new tribal partners, completing

an integrated assessment of ecological and sociocultural vulnerabilities of tribal communities on Washington’s Pacific Coast associated with ocean acidification.

BUILDING CAPACITY TO ENHANCE RESILIENCE IN COASTAL COMMUNITIES

Kevin Decker, Paul Dye, Nicole Faghin and Ian Miller, Bridget Trosin and MaryAnn Wagner, Washington Sea Grant; Carrie Garrison-Laney, Washington Sea Grant and NOAA Pacific Marine Environmental Laboratory liaison

Coastal flooding, wave damage and shoreline erosion are expected to increase as climate change raises sea-levels and creates more severe storms along Washington’s coast. Washington’s Coastal Resilience Project is a three-year effort to rapidly increase the state’s capacity to prepare for natural events that threaten the coast. The project improves risk projections, provides better guidance for land-use planners and strengthens capital investment programs for coastal restoration and infrastructure. These are the tools that coastal communities need to become more resilient to disasters. WSG and Washington Department of Ecology also coordinate Washington’s Coastal Hazard Resilience Network as an ongoing forum for technical experts and practitioners to share information, identify emerging issues and find collaborators for resilience-oriented research and community-based projects.

RESEARCH AND TECHNICAL ASSISTANCE FOR ECONOMIC DEVELOPMENT AND BUSINESS PLANNING

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

Nearly all coastal businesses are in some way susceptible to coastal conditions and affected by climate change, ocean acidification and natural hazards (tsunamis, coastal flooding, beach erosion, etc.) as well as ordinary economic cycles. WSG’s work in economic analysis has demonstrated a demand for local and region-scale economic research and analysis, assessments of risk associated with coastal hazards, resilience strategies and technical support in Pacific Coast communities. WSG combines economic analysis with training, networking and business development support to businesses in order to help them succeed in a changing coastal environment. In addition, WSG has collaborated with the Washington Department of Licensing and Northwest Marine Trade Association to provide the only publicly accessible online database of boat sales data for Washington. The information contained in the database helps dealers monitor sales trends in order to make informed business decisions. The database also includes annual recreational fleet data (size and characteristics) of the Washington recreational boating fleet, which helps planners, developers and state agencies locate and design marinas and other boating infrastructure.

UNDERSTANDING AND COMMUNICATING TSUNAMI RISKS

Ian Miller, Washington Sea Grant; Carrie Garrison-Laney, Washington Sea Grant and NOAA Pacific Marine Environmental Laboratory liaison

Washington's coastal region is vulnerable to tsunamis from local and distant sources. Communities on Washington's Pacific Coast are acutely aware of these hazards, but communities on the shorelines of Puget Sound are less aware of tsunami risks. WSG links Pacific Marine Environmental Laboratory's (PMEL) tsunami modelers with other tsunami research groups and end-users in coastal communities. The WSG and PMEL liaison supports communication and networking among tsunami experts at PMEL, WSG, Washington's Emergency Management Division, the Washington Geological Survey, U.S. Geological Survey and UW. This informal team collaborates to meet research needs and deliver the results in forms appropriate to end-users. WSG is also a member of the state's Tsunami Hazards Work Group, a multi-agency structure for coordinating tsunami-related assistance to communities, primarily those on the Pacific Coast. A second inner-coast work group focused on Puget Sound communities was also created to serve a similar inland need. WSG conducts tsunami-related research, advises community leaders and maritime groups on their preparedness and response plans and uses field trips and presentations to build awareness and preparedness among coastal residents.

COASTAL HAZARD PLANNING: THE ROLE OF GOVERNANCE IN COMMUNITY RESILIENCE

Clare Ryan, UW School of Environmental and Forest Sciences

Washington's coastal communities face a wide range of natural hazards, from periodic storms, landslides and erosion, to potentially catastrophic tsunamis and the long-term challenges posed by climate change. Many communities have begun to develop plans to mitigate hazards, reduce vulnerability, build resilience and protect critical facilities. But implementing these plans requires coordinating budgets and capital expenditures and other activities across various organizations. Little previous research has examined this collaborative hazard-mitigation process on Washington's coast. This project seeks to determine what factors facilitate or hinder the implementation of hazard-mitigation plans in Washington. It combines quantitative surveying and qualitative case studies to develop a multidimensional picture of local hazard planning, the factors that support and constrain it and the roles that incentives and perceived risk play in building resilience. Disseminated through various forums and electronic and official media, these findings will deepen coastal communities' hazard awareness and resilience.

MARINE AND COASTAL PLANNING AND MANAGEMENT

ADVANCING ECOSYSTEM-BASED MANAGEMENT IN WILLAPA BAY AND GRAY'S HARBOR

Kevin Decker, Paul Dye, and Brent Vadopalas, Washington Sea Grant

Interactions with eelgrass and burrowing shrimp increasingly limit shellfish production on privately owned and leased tidelands in Willapa Bay and Grays Harbor, two large and highly productive estuaries on Washington's Pacific Coast. Uncertainties about the future viability of shellfish farming and about ecosystem-scale impacts of alternative culture practices are creating tensions among shellfish growers and resource managers in the region. Building on documented research priorities for West Coast estuaries and shellfish aquaculture, the Washington Shellfish Initiative has called for development of an ecosystem-based management framework that addresses uncertainties about aquaculture impacts and supports resource management goals in the two bays. There is strong interest in synthesizing existing ecosystem information and developing habitat suitability indices as a starting point for such a framework. In consultation with resource managers, scientists and local growers, WSG staff have begun this project, with funding from the Washington State Legislature.

BROKERING LANE AGREEMENTS BETWEEN CRABBERS AND TOWBOAT OPERATORS

Kevin Decker, Washington Sea Grant

Commercial crab fishermen and ocean-going tugboat operators have traditionally shared the waters along the Pacific Coast, but crab pots frequently fouled tug propellers, forcing costly vessel repairs and down time for the tug operators. At one point interactions were also causing more than \$1.25 million a year in gear replacement and missed fishing opportunities for the crab fleet. Since the late 1990s, WSG has facilitated regular meetings of West Coast crab fishermen, the Columbia River Bar Pilots and tow companies. The groups review and refine gear-free towlane allocations, and WSG produces GIS-enabled digital charts of the lanes for navigation. WSG also facilitates annual discussions with the National Weather Service and the U.S. Coast Guard to make West Coast marine operations safer for fishermen and tugboat operators.

TRAINING AND PROFESSIONAL DEVELOPMENT FOR SHORELINE AND COASTAL PLANNERS

Nicole Faghin, Washington Sea Grant

Washington has more than 3,000 miles of marine coastline and a state management structure that relies in large part on city and county planning efforts and the expertise of local coastal planners. Communities, nongovernmental organizations and coastal businesses in western Washington need information to help them prepare for future coastal issues. WSG meets this need by providing training, outreach, network coordination and technical assistance to support shoreline and coastal planning. WSG and the Washington State Department of Ecology together coordinate WSG's Shoreline and Coastal Planners Group (SCPG) and Ecology's Coastal Training Program (CTP). The SCPG provides regular opportunities for coastal professionals to discuss policy concerns, new technologies, emerging issues and other relevant topics. WSG maintains the SCPG email list and website, coordinates regular group meetings, develops training opportunities for shoreline planning professionals, facilitates new partnerships and provides a network for exchanging technical information. It also coordinates conference presentations and training for planners on subjects ranging from climate change to coastal flooding.

WORKING WATERFRONTS AND WATERWAYS

Nicole Faghin, Washington Sea Grant

Marine waterfronts and waterways contribute about \$15 billion annually to Washington's economy and employ nearly 58,000 people. But water-dependent industries struggle to retain access to the water, especially where existing maritime operators face pressure from other sectors. WSG collaborates with local and national partners to promote and maintain working waterfronts' traditional maritime sectors and encourage public access. WSG is working to raise awareness of the importance of maritime jobs and collaborating with state agencies, public ports and maritime groups. WSG staff continue to serve as co-chair, editing and disseminating a quarterly newsletter.

SOCIAL SCIENCE FOR ECOSYSTEM-BASED MANAGEMENT

Melissa Poe, Washington Sea Grant and NOAA Northwest Fisheries Science Center liaison

A key tenet of ecosystem-based management (EBM) is the recognition and integration of human well-being into resource management frameworks. Although NOAA managers routinely collect economic information, the ability to measure other critical non-economic social factors is still in early stages of development. To address this need, the Northwest Fisheries Science Center and WSG initiated a joint project to develop social well-being indicators for marine management and established a social science liaison position to identify and develop tools for measuring social and cultural factors in integrated ecosystem assessments. Other activities include applying social science methods to identify and reduce coastal and fishing communities' vulnerability to ocean changes and increasing social science capacity in EBM, including fisheries management and conservation measures. Fisheries management and habitat conservation policies are especially relevant to human well-being in coastal Washington, where indigenous tribes retain treaty-protected rights as co-trustees and harvesters of fish, shellfish and other marine resources.

SHORELINE LIVING AND WORK

WATERSHED EDUCATION AND STEWARDSHIP PROGRAMS

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

People living and working in coastal watersheds are more likely to adopt the conservation practices that will protect the natural resources they appreciate and use. In partnership with Washington State University Extension as well as county and city partners, WSG has developed community-based programs to educate and motivate citizens by engaging them through their personal interests. For example, Bivalves for Clean Water uses people's interest in shellfish to educate shoreline property owners and recreational shellfish harvesters about coastal pollution, ecosystem health, and the water quality and shellfish management challenges along Puget Sound and Hood Canal. This multifaceted approach lets participants choose activities that fit their individual learning styles and interests. In Kitsap County, a suite of programs give volunteers a role in watershed and shoreline stewardship. Beach Naturalists are trained in shoreline processes, monitoring and sea life; Stream Stewards focus on watershed issues; and Salmon Docents learn about and educate others on Pacific salmon, their life cycles and conservation. In Whatcom County, the Whatcom Watershed Information Network hosts cruises, workshops, symposia, beach cleanups and other events that capture the public's interest and provide opportunities to build land and water stewardship skills.

ENCOURAGING SOFT-SHORE ALTERNATIVES FOR HOMEOWNERS

Jeff Adams, Nicole Faghin and Ian Miller, Washington Sea Grant

Shorelines provide a variety of ecological functions, ranging from spawning habitat for fish to natural barriers against storm surge and erosion. A long history of waterfront development and workarounds for many permitting issues means that shoreline armoring—structures such as bulkheads, seawalls and riprap—affects more than a quarter of Puget Sound’s shorelines. WSG is investigating rates of shoreline change, patterns of bluff erosion, possible effects of sea-level rise and how natural shorelines function compared to engineered barriers. It also participates in local programs that use a social marketing strategy of peer-to-peer contact and financial, technical and permitting incentives to promote the safe removal of shoreline armoring. WSG leads the Green Shores for Homes (GSH) program in Washington, working with local permitting jurisdictions to adopt voluntary incentives for ecologically sound shoreline development. Patterned after the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED) program, GSH provides a rating and verification system for individual homeowners with credits for such actions as removing armoring, increasing setbacks, maintaining or restoring riparian vegetation and granting conservation easements.

ENVIRONMENTAL AND ECONOMIC IMPACTS OF WEST COAST MOORAGE MARINAS

Christine Bae, UW Department of Urban Design and Planning; James Moore, University of Southern California Viterbi School of Engineering; Nathaniel Trumbull, University of Connecticut Department of Geography; Ji Young Park, State University of New York at Buffalo Department of Urban and Regional Planning

Recreational boat sales are trending upward: in 2016, the boat sales industry provided \$3.6 billion annually to the U.S. economy. With this growth, the contribution of moorage marinas to local economies has become increasingly important. However, very little environmental monitoring at marina sites is taking place, and coastal managers and marina operators have limited information to aid them in economic and environmental planning. This interdisciplinary study gauges the net economic impacts and investigates the environmental externalities of moorage marinas in southern California and western Washington. Following comparisons of economic impacts under baseline and alternative scenarios, the Washington team is investigating environmental impacts, with the goal of helping regulators and coastal communities develop smart, well-informed marina policies.

CLEAN MARINAS AND BOATER OUTREACH PREVENT SMALL OIL SPILLS

Aaron Barnett, Bridget Trosin and MaryAnn Wagner, Washington Sea Grant

Recreational boats and small fishing vessels have comprised the largest source of oil spills in Puget Sound for the past five years or more. These spills often result from lack of knowledge or inattention to proper vessel operation and maintenance. WSG partners with the Washington Department of Ecology to educate vessel owners and help them improve their operational procedures to reduce spills from commonly encountered sources. WSG also promotes spill reporting through the “Spills Aren’t Slick” campaign. In an ongoing partnership with the Washington Clean Marina program, WSG reviews and updates best management practices for boating facilities and inspects and certifies Clean Marinas. A *Pollution Prevention for Washington State Marinas* manual produced by WSG with partners is available to marina owners and boat operators statewide and a digital version is hosted on the WSG website. WSG also incorporates oil spill prevention into workshops for commercial fishermen and distributes free spill cleanup kits at marinas and boat shows.

CLEAN VESSELS, PUMPOUTS AND PREVENTING POLLUTION FROM BOAT SEWAGE

Aaron Barnett, Samantha Larson, Bridget Trosin and MaryAnn Wagner, Washington Sea Grant

Sewage discharge from boats degrade marine water quality, threaten human health and trigger closures of shellfish beds and swimming beaches. Nearly a quarter million vessels are registered in the state, and an estimated 20,000 recreational boats have systems with holding tanks for raw sewage. The Pumpout Washington program aims to make it easy and cost free to properly dispose of sewage rather than dump it overboard. In partnership with Washington State Parks, WSG educates boaters about the importance of proper sewage disposal and the location of pumpout stations, helps marina operators secure grants to install more stations and consults on deploying mobile pumpout services in heavily used waters. WSG reaches boaters through a robust communications campaign and direct outreach at events as well as personal contact with boating facility operators and boaters.

IV OCEAN LITERACY AND WORKFORCE DEVELOPMENT

OCEAN EDUCATION

SEA SCHOOL: AN INITIATIVE TO PROVIDE VOCATIONAL TRAINING FOR MARITIME CAREERS

Brandi Bednarik and Hali Boyd, Grays Harbor Historical Seaport

Washington's maritime sector makes an important annual contribution of more than \$21 billion to the state's overall economy. But the associated workforce is aging, with only 35 percent of the workforce now between the ages of 16 and 39. This project addresses the maritime workforce capacity needs by creating Sea School, an initiative that provides vocational training and outreach to inform young people about maritime careers. Sea School connects young people who would otherwise have difficulty accessing maritime training with a route into the industry. It does so by increasing the visibility of maritime work, providing free public education events around maritime work and removing barriers for those who cannot afford professional licensing. Sea School cadets are assigned to either the *Lady Washington* or the *Hawaiian Chieftain* for training, where they learn skills such as safe line handling, piloting, helmsmanship, emergency response, chart plotting, teamwork skills and communicating as part of a liveaboard crew.

GRADUATE AND POSTGRADUATE FELLOWSHIPS IN MARINE POLICY AND SCIENCE

Deborah Purce and Kate Little, Washington Sea Grant

A suite of WSG-supported fellowships help students find their vocations and jumpstart their careers in marine policy and science. WSG coordinates state applications for the national John Knauss Marine Policy Fellowships and Sea Grant/NOAA Fisheries Graduate Fellowships in Population Dynamics and Marine Resource Economics. It also offers a state marine policy fellowship that places graduate students in state and tribal agencies and marine-oriented organizations for one year to work on marine resource and management issues. Strong partnerships with host offices ensure high-quality experiences, productive contributions to their programs and frequent post-fellowship employment opportunities. WSG fellows go on to successful careers in academia, NOAA and other federal and state agencies, maritime and environmental groups and consulting firms.

MEASURING POLLUTION AND INITIATING STUDENT SCIENTISTS ON THE COLUMBIA ESTUARY

Gretchen Rollwagen-Bollens and Stephen Bollens, Washington State University, Vancouver School of the Environment and School of Biological Sciences; Tamara Holmlund Nelson, Washington State University, Vancouver College of Education

Rapid population growth has changed land use along the 146-mile Columbia River estuary in ways that may affect coastal ecosystems. It is critical to understand whether and how nutrients and organisms from upstream contribute to habitat degradation, eutrophication and the spread of invasive species. It is also important to determine how participating in scientific research affects students' ecological knowledge and outlook. Columbia River Estuary Science Education and Outreach (CRESCENDO) explores both these questions in a rare marriage of scientific and educational research. For two years, students at five estuary high schools will gather water samples and plankton tows, collect hydrographic data and help measure nutrients and phytoplankton and zooplankton populations (including harmful algae and invasive copepods). These data will help determine how conditions change as the river descends and how these conditions reflect local conditions such as land use, wastewater discharge and coastal upwelling. Researchers will then gauge what the students have learned about science and stewardship.

EXPERIENCE MARITIME PROJECT: A HANDS-ON INTRODUCTION TO CAREERS AND PATHWAYS IN THE MARITIME INDUSTRY

Sarah Scherer, Craig Bailey, Tom Crotty and Joe Schmitt, Seattle Central Community College; Frederic Stahr, Ocean Inquiry Project

Washington's \$21 billion maritime sector faces a workforce crisis, and limited school curricula are available to impart the skills these industries need. According to Seattle's Economic Development Council, limited industry leadership and fragmented maritime training organizations further hinder workforce development. To reverse these trends, the Experience Maritime Project at Seattle Central College's Washington Maritime Academy is developing a STEM-focused curriculum that introduces high school students to the challenges and rewards a maritime career can offer. The program combines instruction with hands-on experience, including a full day aboard the Academy's vessel *Maritime Instructor*. The project initiates teachers, guidance counselors and 240 high school students from Seattle and an outlying school district in the experience of working at sea each year.

NOAA SCIENCE CAMP AND JUNIOR LEADERSHIP PROGRAM

Maile Sullivan, Washington Sea Grant

Middle school offers a critical opportunity to engage young people in science and help them aspire to scientific careers, and hands-on experiences are especially effective. Exploring marine sciences helps high school students hone their career interests, building tomorrow's marine workforce. WSG offers summer science camps that engage middle and high school students and introduce them to the interdisciplinary nature of NOAA research. Five-day sessions at NOAA's Sand Point facility offer a diverse mix of sixth, seventh and eighth graders the opportunity to gain real-world learning while working with scientists on today's environmental issues. Participants are introduced to marine science and other science careers through hands-on activities that emphasize solutions to current problems. To keep older teens in the science pipeline, Junior Leadership Camp immerses high school students in youth leadership, inquiry-based science and career development. In a three-day session for sixth, seventh and eighth grade students, they build and test their own mini ROVs.

ORCA BOWL, WASHINGTON'S HIGH SCHOOL OCEAN SCIENCES TOURNAMENT

Maile Sullivan, Washington Sea Grant

High school students tackle rapid-fire questions that test problem-solving skills and cover all areas of marine science in this annual academic competition and ocean-literacy event. All students receive prizes for participating; top awards include scholarships to UW undergraduate programs. The winning Orca Bowl team competes in the National Ocean Sciences Bowl finals, with support from the Consortium for Ocean Leadership. The bowl program encourages new schools to participate, targeting underserved communities that would especially benefit from marine-science resources. With limited ocean and marine science offerings in most schools, Orca Bowl fills a critical niche in fostering interest in ocean-related studies and careers.

SCIENCE COMMUNICATIONS FELLOWSHIPS

MaryAnn Wagner and Deborah Purce, Washington Sea Grant

WSG nurtures and trains young writers, journalists and videographers who wish to focus on issues of ocean science and policy by providing science communications fellowships to graduate and undergraduate students. The fellowships support two pillars of WSG's mission: support for students pursuing marine-related careers and informal marine education for the public. The fellowships strengthen the student experience and expand WSG's reach to students throughout the state. It exposes

students to a broad range of communication vehicles including social media, video production, blog posts, press releases and feature articles for industry publications. They gain experience in science writing and the editorial process, build their portfolios and make valuable contributions to WSG communications, including WSG's popular newsletter *Sea Star*.

PUBLICATIONS, WEBSITE, VIDEOGRAPHY AND SOCIAL MEDIA COMMUNICATIONS

MaryAnn Wagner, Samantha Larson, Karen Morrill-McClure and Robyn Ricks, Washington Sea Grant

WSG communicators provide essential written and visual tools to support the program's mission. The team produces and disseminates print publications, websites, social media, official reports and other vehicles to share information about research, outreach and education programs. The *Sea Star* newsletter provides in-depth exploration of research and outreach topics. Media relations activities ensure that regional and national newspapers and blogs share program information, raising program visibility and public awareness of marine issues. Within the university community and among regional outlets, WSG collaborates with media on stories and news as it breaks. WSG's website serves more than 40,000 constituents annually, and the organization extends its reach through a radio program and social media via Facebook, Twitter, Instagram and YouTube.

MARINE EDUCATION EVENTS FOR STUDENTS AND THE PUBLIC

Washington Sea Grant outreach staff

To improve coastal residents' understanding of the importance of the marine environment, WSG organizes, sponsors and participates in many theme-based education events throughout Western Washington. These include the Kitsap Water Festival, NOAA Open House, public beach walks and community seafood and film festivals. The Whatcom Watershed Information Network, co-founded and assisted by WSG, hosts cruises, workshops, symposia, beach cleanups and other events. WSG partners with the Washington State University Extension in Whatcom County to produce public education and applied research programs focused on local waters and watersheds. It also creates an information network promoting stewardship, community awareness, access to partnerships and project coordination.

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