

2015 Performance Review Program Introduction

Established in 1968, Washington Sea Grant (WSG) earned the University of Washington one of the first designations as a Sea Grant College. The program employs 30 staff, with outreach offices in 10 locations around western Washington. The region comprises forested watersheds, isolated ocean coasts and a densely populated urban estuary, and has a rich maritime culture and economy. WSG reflects this setting with activities ranging from teaching homeowners how to maintain septic systems to reducing seabird deaths in the nation's largest fisheries.

Critical Program Areas

Living Marine Ecosystems (LME): Understanding the marine environment and conserving marine resources while providing for sustainable use.

Ocean and Coastal Environmental Health (OCEH): Assessing and addressing the effects of human activities including pollution, habitat loss, and emerging threats.

Changing Oceans and Coastal Communities (COCC): Supporting coastal communities to ensure economic and environmental vitality and sustainability.

Ocean Literacy and Workforce Capacity (OLWC): Educating learners of all ages and strengthening workforce capacity.

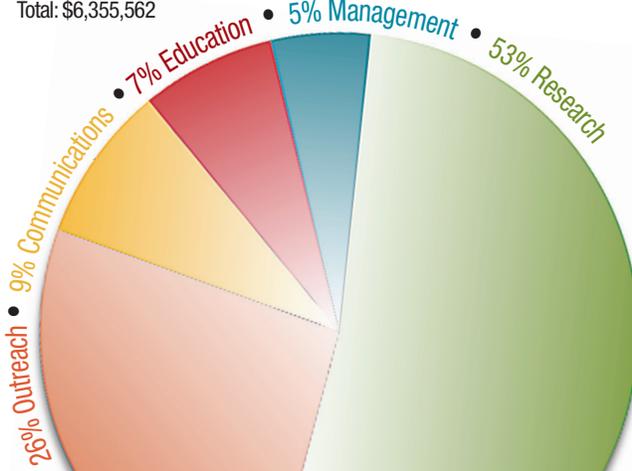
Strategic Plan Alignment

The Washington Sea Grant critical program areas cut across the National Sea Grant focus areas.

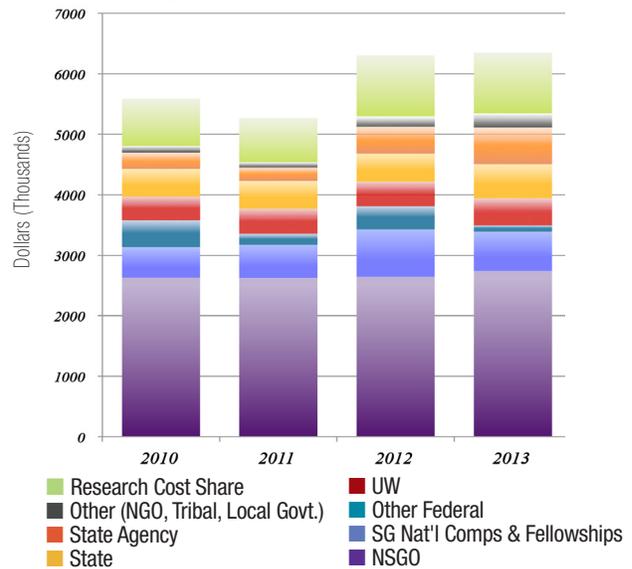
	HCE	SCD	SSSS	HRCC	OL
LME	✘		✘		
OCEH	✘		✘		
COCC	✘	✘	✘	✘	
OLWC		✘	✘		✘

2013 Funding by Program Area

Total: \$6,355,562



2013 Funding by Source



Program and Outreach Metrics, 2010-2013*

• Tools, technologies, and information services developed by WSG staff and researchers	228
• K-12 students reached	25,540
• Graduate and undergraduate students supported annually	100-150
• Middle school and high school students in NOAA Science Camp and Orca Bowl annually	200
• Fellows supported	48
• Total Knauss Fellows from program start	77
• Research, education, and outreach projects managed	102
• Liaison positions established with PMEL and NWFSC	3
• State and regional RFP pre-proposals/awards	164/33
• Partnerships and stakeholders	1,300
• Peer-reviewed journal articles	106
• WSG-sponsored events/attendees	1,310/42,039
• WSG staff presentations/attendees	1,043/36,936
• Volunteer hours	55,085
• Communication products	420
• Radio broadcasts	612
• Media mentions	378

*cumulative over 2010-2013 unless otherwise noted

Safe and Sustainable Seafood Supply

Seafood harvesting is a vital part of Pacific Northwest culture and commerce. From tribal fleets exercising their treaty rights to oyster farms in South Puget Sound, Washington's people are intertwined with the state's living marine resources. A 2007 NOAA report found 40 communities in the state to be significantly engaged in or dependent upon commercial fishing. Although only a fraction of the regional economy as a whole relies on the fishing industry, certain localities like Westport, Bellingham, and Neah Bay count on it. Fishery-dependent communities in Washington range from urban centers like Seattle to rural areas with populations of fewer than 500 people. More than half of the state's fishing communities have fewer than 5,000 residents.

A 2014 report on the U.S. ocean economy ranks Washington's living resources sector — commercial fisheries, aquaculture, seafood businesses — at the top nationally in terms of employment and total size. This distinction is due in large part to the state's role as homeport to the Alaska fishing fleet, the largest fishing enterprise in the nation. But it also reflects the richness of Washington's own diverse coastal and marine ecosystems, which support numerous species of fishes, crabs, bivalves, and other wildlife, as well as a vigorous aquaculture industry. Washington shellfish aquaculture leads the nation, accounting for one-quarter of total domestic production by weight. In 2013, NOAA reported that Washington's seafood industry was responsible for 60,995 jobs and \$7.5 billion in sales impacts, and it contributed \$3 billion to the economy. Residents and visitors purchased 347,000 recreational fishing and shellfish-harvesting licenses in 2011, contributing more than \$3.3 million in state revenue.

Commercial tribal and non-tribal fishery landings in state waters totaled 190,566 metric tons in 2012, worth more than \$302 million. The most valuable wild-capture commercial fishery operating in the waters of Washington is Dungeness crab, which has brought in an average of \$27 million in ex-vessel revenue each of the past five years. By volume, Pacific whiting is the largest Pacific coastal fishery, with landings in 2012 upward of 157,000 metric tons, mostly in Washington ports. Many coastal fisheries have faced severe conservation challenges, including closures of ocean salmon fisheries. And while coastal stocks of canary rockfish and petrale sole stocks have rebounded, other populations in the Pacific groundfish fishery have yet to be rebuilt.

In Puget Sound and other marine inland waterways, the condition of fishery resources is even more serious. Four Puget Sound salmonid populations are federally listed as threatened or a species of concern. More than half of the 19 stocks of Puget Sound herring are currently classified as depleted or unknown or have disappeared. Thirteen of the Sound's 28 rockfish species are considered at risk, and three populations are listed as threatened or endangered.

The complexity and range of Washington seafood issues demands an ecosystem approach that integrates ecological, social, economic, and institutional perspectives. WSG has tried to incorporate such a comprehensive approach throughout its work in the Safe and Sustainable Seafood Supply focus area, which now encompasses a third of our program funding. The focus area aligns with goals in all four WSG program areas: Living Marine Ecosystems, Ocean and Coastal Environmental Health, Changing Oceans and Coastal Communities, and Ocean Literacy and Workforce Capacity. WSG investment in the focus area has grown with the success of Washington investigators in national aquaculture competitions and the creation of a liaison with the Northwest Fisheries Science Center (NWFSC). WSG research and outreach activities focus on three major goals: support for sustainable shellfish aquaculture; management of Pacific ocean fisheries; and restoration of salmon and other Puget Sound fisheries. In addition WSG provides a variety of technical services throughout Washington to improve seafood products and the safety and economic security of the industry that provides them.

Supporting sustainable shellfish aquaculture

As the top U.S. producer of hatchery-reared and farmed shellfish, the Washington industry harvests about 40,000 metric tons each year valued at more than \$108 million and generates \$270 million in economic activity. Part of this success is due to a unique state legal framework that at one time authorized sale of 70 percent of all public tidelands into private ownership for shellfish culture. Another factor is the long and productive partnership among growers, landowners, scientists, and managers supporting economically and environmentally sustainable shellfish aquaculture. WSG has been a charter partnership member. Early WSG research pioneered Manila clam culture and

was instrumental in developing triploid oysters, valued for their year-round flavor. More recent projects covered topics such as public health-related oyster depuration, controlling invasive oyster drills, restoring native pinto abalone, and optimizing oyster cultch yields (I-17549).

Perhaps no effort better illustrates this traditional collaboration than WSG's geoduck aquaculture research program. During the past decade, geoduck farms have become a valuable seafood business and a highly contentious issue. The giant clams support an \$80 million harvest in Washington and British Columbia, supplying nearly half of the world market. But shoreline residents questioned the sustainability of planting young geoduck in mesh-covered plastic tubes and harvesting adults with pressurized water jets. Under the direction of the Washington legislature, WSG completed a comprehensive six-year research program in 2013 that assessed the effects of geoduck aquaculture in Puget Sound. WSG and UW scientists worked with legislators to identify priority information needs ranging from disturbances caused by farm operations to wild stock interactions to cumulative impacts. The program included five related research projects, a review of geoduck science worldwide, and a formal coordination process with state managers and an advisory group. To stretch available funds and ensure realistic results, the field science was conducted on commercial geoduck farms. Findings formed the core of a special edition of the *Journal of Shellfish Research* and are guiding state decisions on farm permits and geoduck culture expansion (I-18900; I-17366; A-17508; A-17367).

State and national decision makers also are engaged partners in supporting sustainable shellfish aquaculture. In December 2011, the Washington Governor and NOAA Administrator met at an oyster-packing plant in the small town of Shelton to announce the Washington State Shellfish Initiative, a joint two-year effort to enhance state shellfish resources. The initiative work plan incorporated WSG research on ocean acidification and harmful algal blooms, created the Governor's Blue Ribbon Panel on Ocean Acidification, and defined WSG's role in related outreach.

Consistent with the initiative and the state action plan on ocean acidification, WSG invested about \$1 million from 2010 to 2014 in examining acidification effects on shellfish and other marine species (I-17282). Researchers found that larval Pacific oysters and endangered pinto abalone appear more vulnerable than native Olympia oysters, geoduck, and Manila clams (A-18999). In addition, acidification appears to have generational effects on Pacific oysters, which show some

capacity for adaptation. Offspring of those exposed to acidification were more resilient than oyster larvae raised in milder conditions (I-20785).

Also part of the larger state initiative, WSG research has worked to combat increasingly frequent and severe blooms of harmful algae through better understanding of the toxic organism's complex life cycle. WSG researchers conducted the first integrated behavioral and metabolic study of the fish-killing *Heterosigma akashiwo*'s ability to suddenly emerge from deep-water stasis, swim to the surface, and form massive blooms. They found key genetic and metabolic factors, developing a toolkit that included genetic "fingerprints" for identifying *Heterosigma* strains worldwide (I-20747). Another research team investigated the emergence of the alga *Alexandrium* from dormant cysts to active red tides that cause deadly paralytic shellfish poisoning. Testing a common assumption that cyst abundance in sediments foretells future blooms, the team found that cyst viability was a more useful indicator (I-20791).

Building on WSG research outcomes, another team developed and tested remote, autonomous networked sensors that provide real-time counts and images of emerging harmful algae species. Using 3-D printing, the scientists reduced sensor size, improved optics and saltwater resistance, and lowered costs. By providing reliable bloom outbreak information, the project demonstrated to local growers that being forewarned can truly be forearmed (I-20792). Test sensors may be co-located with SoundToxins volunteers who monitor harmful algal species and test seawater samples at 24 Puget Sound sites. WSG works with NOAA to train and coordinate the 50-plus network volunteers and their current reliability allows state health officials to more effectively target resources towards areas where volunteers detect problems (I-18935).

Today, many WSG research projects and outreach activities are supported by national aquaculture funds and focus on economic and environmental challenges facing aquaculture:

- ◆ Developing a comprehensive economic picture of West Coast shellfish aquaculture (A-19359).
- ◆ Creating an integrated geospatial database that includes industry, management, and consumer information (A-20802).
- ◆ Evaluating South Puget Sound's shellfish production and ecological and social carrying capacity using farm- and ecosystem-scale models, including production, species metrics, and policies and regulations (A-20759).
- ◆ Developing, testing, and refining a software system

for net-pen aquaculture to model location-specific effects that will guide siting, improve efficiency, and minimize environmental impact (I-20812).

- ◆ Uncovering key life-history differences among Olympia oyster stocks that may affect restoration success (A-20813). The project also developed a useful oyster anesthetic and identified hatchery-spawning techniques that reduce costs while ensuring genetic diversity (I-21784).
- ◆ Making technical assistance and scientific data available to local businesses through a WSG regional aquaculture coordinator, including an annual conference for shellfish growers, technical reports, and service on industry boards and scientific committees (I-18901).

Managing Pacific fisheries

Washington, and Seattle in particular, is a national hub for fishery science, management, and industry. Besides being the business center for two of the most valuable fisheries in the world, Alaskan groundfish and crab, Seattle is home to NOAA Fisheries' West Coast Regional Office, NWFSC, and the Alaska Fisheries Science Center. This scientific and management capacity is complemented by academic fishery science and marine policy programs at nearby University of Washington. This fisheries hub serves as an informal center of excellence and facilitates WSG capability for bringing together research, outreach, and technical expertise to address difficult fishery issues.

One example of this confluence of experts is by WSG's 20-year program to save protected seabirds from being killed in fishing operations. The program has been extraordinarily successful — reducing takings of endangered albatrosses by 82 percent, saving an estimated 150,000 seabirds in 10 years, and preventing the closure of a \$245 million fishery. It has also become a paradigm for WSG efforts to integrate research and extension, as well as a cooperative model for engaging stakeholders, scientists, and managers to find a practical solution to a seemingly intractable problem. The list of partners has been extensive — all three local NOAA Fisheries entities, Alaska Sea Grant, several commercial fishery organizations, the Packard Foundation, seabird conservation organizations, academic scientists from three universities, and a number of Washington treaty tribes — and that covers only U.S. fisheries. The WSG-led work on streamer lines and other modifications began with the Alaska longline fleet and has since been extended to tribal and nontribal West Coast groundfish fisheries and Japan's South Atlantic tuna fleet (I-18896; A-18889). In 2012 the International

Agreement for the Conservation of Albatrosses and Petrels adopted streamer lines as a mitigation best practice, and the major tuna commissions moved for deployment on thousands of boats.

This geographic convergence also encourages WSG to explore application of ecosystem approaches to address emerging fishery concerns. In 2011 the Pacific Fishery Management Council began work on a fishery plan to address broader ecosystem considerations not covered in existing management plans. Concurrently, WSG and NWFSC co-lead a regional collaboration on an innovative framework for assessing West Coast fisheries' vulnerability to climate change, including habitat loss, shifts in marine species distribution, phenological changes, and increased incidence of ocean stressors. The effort culminated in a 2011 workshop attended by federal, state, and tribal fisheries management agencies and members of the fishing, nonprofit, and academic communities. Participants reviewed and discussed existing scientific information on climate exposure, stock and fishery sensitivities, and the adaptive capacity of four fisheries — canary rockfish, sablefish, Pacific whiting, and Dungeness crab (I-15662).

Close working relationships among university and agency scientists have been a key to the regional success of NOAA Fisheries-Sea Grant fellows. From 2010 to 2013 WSG supported five fellows projects included the following:

- ◆ Improved Bering Sea snow crab management capacity by developing a model for estimating crab abundance and exploitation rates that accounted for male crab migratory movements.
- ◆ Assessed models for setting catch limits for fish stocks with unknown natural mortality and found that assuming lower rather than higher mortality delivered better results.
- ◆ Used underwater robots to more accurately survey Pacific rockfish in rocky habitats that were difficult to sample using traditional bottom-trawl gear (A-15598).

WSG also worked jointly with NWFSC to strengthen consideration of human dimensions in resource management decisions. WSG added staff expertise in the social sciences through its new liaison, initiating a project to develop indicators of human well-being for marine management to use in the California Current integrated ecosystem assessment and marine spatial planning. The liaison also explored impacts of social and environmental change on tribal and other traditional marine resource activities such as subsistence harvesting (I-18911).

The Pacific groundfish fishery is the largest and most complex West Coast ocean fishery, covering more than 90 species, which are harvested with many different gears. Stocks within the fishery have been subject to overfishing. In 2010 limits on bycatch species were initiated and a catch share program was implemented in 2011 to assist in rebuilding the fishery. WSG worked with NOAA Fisheries to place plant monitors in time for the start of the 2010 fishery (I-6821). In addition, WSG joined with California Sea Grant to support a regional project examining the effects on fishing communities and fish populations of the new management measures. Project findings were surprising: with the exception of the sablefish sector, fleets took a far smaller share of their allotted quotas than expected — 30 percent versus 67 percent in the adjacent Canadian fishery. Fishermen appeared to be operating more cautiously to avoid costly missteps such as exceeding quotas or catching protected species (I-20664).

Pacific sardines are harvested in the West Coast's second largest federally managed fishery with landings valued at \$21.4 million in 2012. Working with NOAA Fisheries, WSG-funded scientists collaborated on a stock assessment model that was expected to confirm that ignoring spatial structure and movement in the population would bias stock estimates (A-17557). However, as the results of the joint project were being finalized, a precipitous decline in stock conditions resulted in closure of the fishery.

Restoring salmon and other Puget Sound fisheries

Despite the depletion of Puget Sound fish populations, recreational fishing is conservatively valued at \$57 million a year and commercial fishing at \$4 million. Four major causes have been widely blamed for the massive decline of Northwest salmon populations: destruction of essential habitats for each phase of salmon life history; construction of hydropower dams on major rivers; over-harvesting; and poor hatchery practices. In 2011, western Washington treaty tribes released *Treaty Rights at Risk*, detailing their concern that, although treaty harvest rights for salmon are well controlled, continued regional habitat loss threatens the well-being of treaty resources.

Because salmon are Pacific Northwest keystone species and cultural touchstones, several WSG research projects have focused on causes of their decline and pathways to recovery. The results are almost as diverse as the restoration challenges the species face. A recent study on governance of Puget Sound and Columbia River salmon recovery efforts identified lack of private sector involvement as a serious concern. The find-

ings suggested that failure to engage interests such as agriculture, timber, real estate, and construction could undermine their accountability and support for future efforts (A-20784). Looking at environmental challenges to recovery, another project examined the effects on young salmon reproductive development of migration through estrogen-polluted urban waterways. Yet another assessed the human health tradeoffs of eating fish rich in healthy fatty acids but also laden with persistent toxic chemicals (A-20789).

A major series of related projects has mapped significant parts of the Chinook salmon genome. The most recent has identified thousands of markers associated with growth and heat tolerance, two important factors in adaptation and population fitness. Hatchery operators and other managers are using the genetic tools developed to identify distinct salmon populations, track catches of protected fish amid healthy stocks — even when co-mingled — and maintain biodiversity and fitness in hatchery and natural populations (A-19009).

One growing environmental mystery related to restoring depleted Salish Sea salmon is why so few juvenile Chinook, coho, and steelhead successfully migrate to the open ocean, perishing instead in inland seas. WSG provided critical seed funding and supported a research project, which helped catalyze a five-year, \$20 million, international and multidisciplinary effort to find answers. The WSG research is completing an assessment of size-selective mortality in Chinook larvae from two key watersheds (I-19022).

The demolition of two dams on the Olympic Peninsula's Elwha River has been the largest dam removal in the United States and one of the biggest habitat changes in the region's recent history. Eight anadromous salmon and trout species that were segregated into landlocked and downstream populations now are migrating naturally past the former dam sites for the first time in more than 100 years. WSG-funded scientists have joined collaborators from tribal and other natural resource agencies and institutions to observe and learn from the Elwha's unprecedented salmonid recolonization experiment (A-20810).

Many other once healthy fish populations that supported local fisheries have declined drastically. WSG research is untangling elusive trends and providing information needed to design management and recovery plans. By combining oceanographic experiments with genetic parentage analysis, researchers developed the first estimates of larval dispersal for Puget Sound's depleted brown rockfish, suggesting marine protected areas as a restoration tool. Early work on Pacific cod populations in Puget Sound identified a unique, genet-

ically isolated stock that was listed in 2010 as a species of concern. Continued study led to identifying genetic markers that will allow managers of mixed stock cod fisheries to protect depleted populations. The research team also investigated seasonal cod movements and adaptation to warming ocean waters (I-20800).

Research on hypoxia has enhanced understanding of environmental changes that can affect fishery management. Hypoxia, or low dissolved oxygen, is a growing problem in Puget Sound's inshore marine waters, particularly Hood Canal. WSG researchers assessed movements of Dungeness crab and English sole in Hood Canal during summer to gauge the spatial extent of the ecological "footprint" produced by hypoxia. Data revealed little evidence of regional shifts by the tracked animals. However, crab made vertical shifts from deeper to shallower habitat, finding local refuges from hypoxia that made them more vulnerable to fishing (I-17586).

Safely producing healthy and high quality seafood

Commercial fishing is the nation's second-deadliest occupation, and severe North Pacific environmental conditions make it especially dangerous. Each year WSG trains more than 100 fishermen in safety, rescue, and cold-water survival, and conducts additional safety and survival classes for recreational boaters and tribal dive fishermen. Past participants credit WSG training with saving more than \$2 million in vessels and equipment and the lives of three fishermen who used the skills learned to survive a capsized. The Columbia River Inter-Tribal Fish Commission credits WSG's program with reducing fatalities in the Columbia River tribal gill-net fishery from an average of five deaths a year to none since classes began in 2010 (I-18906).

Safety training enables hundreds of fishermen to stay in compliance with Coast Guard regulations and continue working, anchoring their communities' economies. WSG also helps make fisheries more efficient, safe, and productive with classes around Puget Sound in essential marine mechanical skills, including refrigeration and diesel engine maintenance, marine electrical wiring, and corrosion prevention and repair; 54 fishermen attended in 2013. These courses save vessel owners thousands of dollars in maintenance bills, repairs, and towing, plus prevent costly down time (I-17273).

Programs that improve maritime safety can also yield economic and environmental benefits. From Washington to California, Dungeness crab is the coast's most valuable fishery. But crab grounds are high-traffic areas for oceangoing tugs and barges, which have often snagged crab-pot lines. Each year fishermen lost more than 5,000 expensive pots, plus valuable fishing time;

tug operators suffered dangerous vessel fouling, lost time, and costly repairs. WSG regularly assembles crab fishermen, vessel pilots, tug-and-barge operators, and the Coast Guard to negotiate safe lane separations. The resulting agreements have made towing safer and more efficient and opened 25 square miles of additional prime fishing grounds, with a total estimated annual savings of \$1.7 million (I-18907).

Seafood is a global commodity, and tribal and non-tribal fishing communities need sound business practices and financial savvy to compete successfully. But economic opportunities for local Washington fishermen are restrained by smaller catches and limited availability of nearby fish buyers, impelling them to create new outlets they can control themselves. For more than a decade, WSG has worked with the publishers of *Fishermen's News* to host an annual Wild Seafood Exchange, a conference for independent commercial fishermen that enables them to network and meet seafood buyers, restaurateurs, retailers, and finance and business experts. Hundreds of attending fishermen have learned about subjects such as branding, distribution, quality control, legislative and regulatory issues and, especially, how to market their catches directly (I-17276).

Seafood sales revenue is particularly important to tribal economies. The ocean fishery off the Olympic Peninsula earns the four Pacific coast tribes more than \$3 million a year. Farther north, the Lummi Nation's annual seafood production is worth \$8 million. But marketing catches and assuring product quality can present serious challenges in this relatively isolated area and tribal fishermen generally have had to sell to processors who dictate prices. WSG has partnered with the Affiliated Tribes of Washington since 2009 to train tribal fishermen in catch handling and storage and marketing strategies to boost profits (I-18903). In 2013, 42 Nisqually and 32 Quinalt fishermen attended two three-hour workshops. Over the years, WSG training has allowed the Nisqually to increase the value of their catch and extend their fall salmon fishery, typically increasing earnings by more than \$50,000 each year. In 2012, WSG helped the Lummi open their own retail seafood market and continues to provide training, which led to creation of three new jobs and higher catch prices. WSG also assists tribal fishermen in upgrading their catches and creating value-added products. For 12 years, WSG has supported the presentation by Makah and nontribal commercial troll fishermen of their distinctive marbled king salmon to chefs and food writers at a prestigious Seattle restaurant, building product reputation and adding \$66,000 a year to total catch value.

WASHINGTON SEA GRANT 2015 PERFORMANCE REVIEW

Shoppers everywhere tend to get their seafood information from workers behind store counters, but these workers are often ill informed themselves. Poor handling and inconsistent quality discourage consumption, costing Washington's seafood industry \$5 million a year in lost sales. In 2012 WSG created a 12-hour

course in seafood retail. Apprentice meat cutters at a local community college — 18 in 2013, representing 18 stores with \$1.4 million in total annual seafood sales — learn about product origin, safety, sanitation, sensory evaluation, quality preservation, and marketing and promotion (I-18904).

PIER PRP Program Focus Area Report

Washington Sea Grant

Safe and Sustainable Seafood Supply

Program Focus Area: Changing Oceans and Coastal Communities (SSSS)

Program Focus Area: Living Marine Ecosystems (SSSS)

Program Focus Area: Ocean and Coastal Environmental Health (SSSS)

Program Focus Area: Ocean Literacy and Workforce Capacity (SSSS)

Program Goals

1. Support conservation and sustainable use of living marine resources through effective and responsible approaches, tools, models and information for harvesting wild and cultured stocks and preserving protected species
2. Improve understanding and management of emerging and cumulative threats to ocean and coastal health
3. Sustain and enhance a highly trained workforce that supports the vitality of marine and coastal environments and communities
4. Reduce toxic, nutrient and pathogen pollutants in water and the marine food web and address their relationships to and impacts on human health
5. Assist coastal communities and marine-dependent businesses in planning and making decisions that provide local and regional economic benefits, increase resilience and foster stewardship of social, economic and natural resources

JUMP TO REPORT SECTION

[Full Text of Impacts](#)

[Program Performance Measures](#)

[Objectives](#)

Impacts and Accomplishments toward Program Goals

1. **Program Goal: Support conservation and sustainable use of living marine resources through effective and responsible approaches, tools, models and information for harvesting wild and cultured stocks and preserving protected species**

Impact(s)

- o [21784](#) - Washington Sea Grant-funded research leads to change in hatchery breeding practices
- o [20812](#) - Washington Sea Grant-supported research delivers software to improve siting and operation of fish farms and forecast their environmental effects
- o [20800](#) - Washington Sea Grant research identifies genetic markers for Puget Sound's dwindling Pacific cod population and other populations throughout the species range
- o [20664](#) - Less waste, higher revenues: Washington and California Sea Grant researchers measure catch share effects on West Coast groundfish fisheries
- o [19022](#) - Washington Sea Grant kickstarts international research on the low survival of young salmon and steelhead in the Salish Sea
- o [18901](#) - Washington Sea Grant helps growers produce shellfish safely, responsibly, and profitably
- o [18900](#) - Washington Sea Grant issues groundbreaking peer-reviewed report on geoduck aquaculture
- o [18896](#) - Washington Sea Grant is a leader in international efforts to reduce seabird deaths in longline fisheries
- o [17549](#) - Washington Sea Grant helps oyster growers get a bigger oyster crop by scattering shells just when larvae need them
- o [17366](#) - Washington Sea Grant documents environmental effects of geoduck aquaculture on eelgrass meadows and associated soft-sediment habitat
- o [6821](#) - Washington Sea Grant partnership with NOAA Fisheries trains fish plant monitors and helps protect overfished stocks

Accomplishment(s)

- o [20813](#) - Washington Sea Grant research investigates local adaptation in native oysters to predict impacts of their culture on restoration and commercial production
- o [20810](#) - Washington Sea Grant chronicles transformational encounters between salmon populations separated for nearly a century by the Elwha dams
- o [20802](#) - Sea Grant's national aquaculture initiative creates an integrated socioeconomic and ecological database on West Coast shellfish aquaculture
- o [20784](#) - Washington Sea Grant research investigates the effectiveness of stakeholder involvement in salmon recovery plans for Puget Sound and the Columbia River

- o [20759](#) - Washington Sea Grant investigates social and ecological carrying capacity for shellfish aquaculture
- o [19359](#) - Washington Sea Grant investigates economic impacts, expansion opportunities, and entry barriers in Pacific Coast shellfish aquaculture
- o [19009](#) - Washington Sea Grant research develops a genetic toolkit to survey the Chinook salmon genome and strengthen conservation
- o [18889](#) - Washington Sea Grant offers fishermen tools to reduce seabird deaths in U.S. longline fisheries
- o [17557](#) - Washington Sea Grant researchers develop a better model to evaluate Pacific sardine stocks and guide fishery management decisions
- o [17508](#) - Sea Grant-supported research investigates geoduck aquaculture's effects on intertidal community dynamics
- o [17367](#) - Washington Sea Grant researchers discover seasonal and geographic factors and molecular markers in newly identified geoduck diseases
- o [15598](#) - Washington Sea Grant-NOAA Fisheries Fellow uses underwater robots to improve rockfish surveys

2. Program Goal: Improve understanding and management of emerging and cumulative threats to ocean and coastal health

Impact(s)

- o [20792](#) - Washington Sea Grant research develops a low-cost monitoring technology to detect harmful algae before they bloom
- o [20791](#) - Washington Sea Grant research compares Alexandrium cyst appearance and viability, seeking a model for predicting harmful blooms
- o [20785](#) - Washington Sea Grant research reveals that the effects of ocean acidification on Pacific oysters may extend across generations and result in more resilient broodstock
- o [20747](#) - The double life of Heterosigma: Washington Sea Grant research explores the behavioral, metabolic, and genetic mysteries of a fish-killing toxic alga
- o [17586](#) - Washington Sea Grant research links hypoxia to crab fisheries with potential to prevent overfishing
- o [17282](#) - Washington Sea Grant builds momentum for state efforts to tackle ocean acidification

Accomplishment(s)

- o [18999](#) - Washington Sea Grant research finds bivalve winners and losers as the ocean acidifies

3. Program Goal: Sustain and enhance a highly trained workforce that supports the vitality of marine and coastal environments and communities

Impact(s)

- o [18906](#) - Washington Sea Grant classes save lives at sea
- o [18904](#) - Washington Sea Grant trains supermarket employees to provide customers with key knowledge about the seafood they buy
- o [18903](#) - Washington Sea Grant training and assistance enhance tribal fishermen's catch value and business skills
- o [17273](#) - Washington Sea Grant's marine technology training helps commercial fishermen save money and sustain their businesses
- o [6821](#) - Washington Sea Grant partnership with NOAA Fisheries trains fish plant monitors and helps protect overfished stocks

4. Program Goal: Reduce toxic, nutrient and pathogen pollutants in water and the marine food web and address their relationships to and impacts on human health

Impact(s)

- o [18935](#) - Volunteer monitoring of harmful algal blooms protects Puget Sound seafood resources and consumer health

Accomplishment(s)

- o [20789](#) - Washington Sea Grant investigates the effects of persistent environmental pollutants on salmon and human health

5. Program Goal: Assist coastal communities and marine-dependent businesses in planning and making decisions that provide local and regional economic benefits, increase resilience and foster stewardship of social, economic and natural resources

Impact(s)

- o [18907](#) - Washington Sea Grant-brokered lane agreements save crab fishermen and towboat companies \$1.7 million per year
- o [17276](#) - Wild Seafood Exchange brings fishermen, buyers and financial experts together to promote direct marketing and maximize catch value
- o [15662](#) - Washington Sea Grant brings together stakeholders to develop an innovative framework for assessing the vulnerability of West Coast fisheries to climate change

[Back to Top](#)

Full Text of Impacts and Accomplishments

21784 - Washington Sea Grant-funded research leads to change in hatchery breeding practices

Relevance: Hatchery breeding methods focus on efficient production of healthy seed that maintains fitness traits and is not maladapted. The assessment of breeding methods that are cost-effective and maintain genetic diversity helps shellfish producers determine how best to breed oysters for both commercial and restoration purposes.

Response: With funding from a national strategic initiative, Washington researchers completed a genetic analysis of two Olympia oyster-breeding methods. The first is a commercial or traditional mass-spawning approach. The second is a restoration method that deploys numerous batch spawns and uses more resources than the commercial method.

Results: Analyses demonstrated that the mass-spawning method provided as much genetic diversity as the small-batch spawning method. In several analyses, the researchers spawned Olympia oysters with no loss of diversity using mass spawning and fewer resources than the batch spawns required. These results are already beginning to effect change in industry practices. Switching to the mass-spawning approach, the Puget Sound Restoration Fund can obtain needed seed for restoration purposes with a significant reduction in staff hours.

RECAP: Washington Sea Grant-funded research discovers that mass spawning of oyster seed reduces overall hatchery costs without limiting genetic diversity, a finding that can be immediately applied to achieve cost savings in the shellfish industry. [Back to Goals](#)

20813 - Washington Sea Grant research investigates local adaptation in native oysters to predict impacts of their culture on restoration and commercial production

Relevance: Restoring native Olympia oysters is a key goal of the Puget Sound recovery plan, but cultured native shellfish plantings can affect the genetic makeup of nearby wild populations. Information about local adaptation in Olympia oysters would allow managers and practitioners to predict the performance of seed from different origins and address concerns about the interbreeding of wild and maladapted cultured stocks.

Response: With funding from a national strategic initiative, researchers evaluated fitness components and performance of seed from different origins in a reciprocal transplant experiment. They established grow-out sites at Dabob, Fidalgo, and Oyster bays to examine site-specific trait differences and characterize unique genetic and phenotypic markers. The transplant experiment examined differences in survival, maturation, and growth based on origin. Researchers also developed an anesthetic that induces oysters to open their shells so larval counts may be conducted without harming them.

Results: Researchers identified significant differences in life-history traits among Olympia oyster populations, reflecting adaptations that might be linked to environmental cues. Oysters from Dabob Bay—a relatively harsh, highly dynamic environment with low primary production—had greater survival rates when transplanted. Oysters from Oyster Bay—a lush site with lower habitat dynamics and high primary production—exhibited more reproductive activity when transplanted. Researchers are developing an instructional pamphlet and discussing the oyster anesthesia developed during the project with shellfish producers.

RECAP: Washington Sea Grant-sponsored research suggests the existence of Olympia oyster population structure within Puget Sound and provides information on selection of broodstock for restoration purposes. [Back to Goals](#)

20812 - Washington Sea Grant-supported research delivers software to improve siting and operation of fish farms and forecast their environmental effects

Relevance: One constraint on the contribution of marine fish farming to global food supplies is limited ability to predict site-specific environmental impacts. In areas with sufficient water flow, fish farms produce waste that is rapidly assimilated into marine food webs, preventing sea-bottom deposition. Until now, government and industry managers had no adequate modeling tools to accurately assess such effects and evaluate prospective sites for environmental and operational efficiency. Growers have had to configure and manage their operations through trial and error. ?

Response: A national strategic initiative, funded through Washington Sea Grant, is systematically testing and refining AquaModel, an accessible software tool that evaluates benthic and water-column effects of farm operations, determines regional carrying capacity, and helps configure and manage operations more efficiently. Researchers used field data and operational records from farms in Atlantic Canada and the Gulf of Maine to validate and calibrate AquaModel—correcting software bugs, adding and improving utilities, and simplifying user interfaces. Work continues in Chile and Hawaii.

Results: Testing resulted in optimal calibration and accurate predictions of sediment loading. A species-specific physiology submodel accurately simulated fish growth, physiology, and waste production. Modelers at NOAA's National Ocean Survey are relying on AquaModel as a primary tool to assess fish farm siting and feasibility in the U.S. exclusive economic zone. Asian, South American, and Canadian governments also are using it.

RECAP: Sea Grant-supported research improved and validated the first successful modeling tool for evaluating fish farm siting, environmental effects, and operational efficiency in diverse ecoregions and

flow conditions.

[Back to Goals](#)

20810 - Washington Sea Grant chronicles transformational encounters between salmon populations separated for nearly a century by the Elwha dams

Relevance: The removal of the Elwha River dams during 2012-2014 reopened fishes' access to highly productive habitat and raised fascinating scientific questions. What happens when landlocked and ocean-going populations of salmon and trout species come together after almost a century apart? What can we learn from their interactions, and how do they and a rapidly evolving physical environment influence each other?

Response: Washington Sea Grant-supported researchers joined a collaborative team of tribal, state, federal, and university scientists to gather extensive physiological, behavioral, and reproductive data on this complex ecosystem's numerous salmon and trout species. The team also gathered vital environmental baseline data, taking a multi-species approach to research on adult and juvenile life-history stages in the river, studies on various estuarine habitats, and work on feeding and seaward migration.

Results: Rapid change is still yielding almost as many questions as answers. But as the physical environment of the river transforms to a new equilibrium, fish populations are moving into habitats from which they were excluded for nearly a century. The partnerships developed as a result of the project will be lasting ones and have been essential to the success of the project. The team has completed six peer-reviewed papers that are now published or in press and made progress on 15 studies monitoring colonization activity by eight fish species. Accomplishments in research, community engagement, and educational outreach have exceeded team expectations.

RECAP: Washington Sea Grant-supported research explores multiple aspects of the rapidly recovering Elwha River system with findings that will inform future dam removals and large-scale salmon restoration efforts.

[Back to Goals](#)

20802 - Sea Grant's national aquaculture initiative creates an integrated socioeconomic and ecological database on West Coast shellfish aquaculture

Relevance: Shellfish aquaculture supplies a small but important portion of U.S. seafood demand, and state and national shellfish initiatives demonstrate government commitment to its expansion. Bivalve species culture also can be important for coastal restoration by filtering marine waters and rebuilding estuarine habitat function while supporting sustainable local businesses. Increasingly, however, aquaculture operations are competing with other coastal development activities. Decision makers must understand economic, ecological, and cultural values associated with aquaculture to balance it against multiple other coastal uses.

Response: A national initiative funded through Washington Sea Grant is gathering and analyzing data to illuminate such complex relationships in ten West Coast counties. Building on an initial survey of community attitudes toward aquaculture, researchers asked government, shellfish-industry, and conservation-group stakeholders about operations and development. They coordinated with relevant management agencies to gather and create metadata for 32 geospatial data layers representing shellfish production, recreation, and governmental regulation.

Results: Both stakeholder and community surveys elicited high response rates and more than half rated shellfish aquaculture "very important" or "extremely important" for creating and maintaining jobs. Many also cited water quality as a probable positive effect of shellfish aquaculture expansion. Project data will be incorporated into a coast-wide management application for spill response; they were shared with Oregon, Washington, and California coastal atlas programs. Findings have been widely cited and discussed by state policymakers.

RECAP: Washington-Sea Grant-supported research combines geospatial and survey data on shellfish aquaculture to support coastal management and marine spatial planning on the West Coast.

[Back to Goals](#)

20800 - Washington Sea Grant research identifies genetic markers for Puget Sound's dwindling Pacific cod population and other populations throughout the species range

Relevance: Pacific cod in Washington's inland waters form a genetically distinct population that was once abundant and commercially important. Today it is listed as a NOAA species of concern and a recent state trawl survey caught only a few dozen fish. While information about genetic makeup throughout a fish species' range is useful for both conservation and management, analysis becomes more complex when fish populations mix at sea. Mixed stock analyses are widely applied to salmon, relying on identification of fish origins to allow real-time management of diverse populations. But such analyses for other marine fish species were, until recently, unfeasible.

Response: Washington Sea Grant researchers initially intended to explore Pacific cod adaptability to a warming climate by examining genetic variation in the distinct Puget Sound population, which is at the southern limit of the species' range. Because Puget Sound fish were not available, the project scope was broadened to compare northern Alaska and southern Washington coastal populations. Researchers sought to identify genetic markers that correlate with environmental conditions and allow accurate identification of population of origin.

Results: Highly differentiated genetic markers were identified in Puget Sound and coastal cod, enabling the determination of the origins of individual fish and relative population distributions. Results will be used to investigate seasonal cod movements, safeguard against further depletion, and guide efforts to explore climate change implications.

RECAP: Washington Sea Grant-supported genetic research confirms selective differentiation in Pacific cod from Puget Sound and finds markers identifying fish population origin to support future conservation. [Back to Goals](#)

20792 - Washington Sea Grant research develops a low-cost monitoring technology to detect harmful algae before they bloom

Relevance: Harmful algal blooms (HABs) are a major environmental concern in every coastal state, causing illness, closing down aquaculture and fisheries, and costing the U.S. economy an estimated \$82 million a year. In Washington alone, NOAA scientists estimated that HAB-related harvest closures could result in as much as \$22 million in lost revenues for coastal counties. Timely, detailed, broad-scale data about algae distribution and characteristics would aid in addressing the threat of HABs.

Response: Washington Sea Grant-funded researchers developed and deployed high-resolution, low-cost, low-power, networkable micro-imaging technology using embedded microcomputers and high-definition cameras to detect, count, and identify swimming algal cells. Sensors were tested on *Heterosigma*, which causes fish kills in Puget Sound, and *Alexandrium*, which produces the toxin responsible for paralytic shellfish poisoning.

Results: Prototype sensors successfully detected and quantified emergent *Alexandrium* chains and identified several novel and significant *Heterosigma* traits, including surprisingly rapid emergence and varying strain efficiency. The researchers used new computing, imaging, and printing technologies to upgrade the sensors while bringing the unit cost down to \$500 and opening up other potential research applications. Student researchers leveraged project models and imaging techniques to investigate other planktonic phenomena, such as crab-larvae distribution and the effects of starvation stress and ocean acidification on echinoderm larvae and other marine organisms.

RECAP: Washington Sea Grant-funded research develops low-cost, high-resolution automated sensing technology to detect and measure emergent harmful algae in real time, a key step toward predicting and preparing for blooms and a new observation tool with wide applicability to other research. [Back to Goals](#)

20791 - Washington Sea Grant research compares *Alexandrium* cyst appearance and viability, seeking a model for predicting harmful blooms

Relevance: Dinoflagellate *Alexandrium* toxins can accumulate in shellfish and kill humans. Limited ability to predict *Alexandrium* blooms creates a significant threat to public health and shellfish aquaculture; information on *Alexandrium* cell distribution, viability, and germination could improve predictive model accuracy.

Response: Washington Sea Grant-supported researchers investigated *Alexandrium*'s dormancy and germination cycles, seeking key parameters for a bloom risk assessment model. They used image-analysis software to categorize cyst photographs from 23 Puget Sound sites based on "fullness" (size, granular starch accumulation) and the presence of red "eye" spots. Cyst fullness was compared with successful germination rates to determine whether appearance can predict cyst viability. Researchers also measured cyst abundance, sediment composition, vegetative cells, and monthly water column properties to assess whether winter cyst maps represented abundances year-round and to test surface-sediment cysts for secondary dormancy behavior.

Results: Appearance was not a useful predictor: no relationship emerged between fullness and viability. More cysts germinated in spring and summer than in other seasons. However, the trend was not consistent, nor was it clear whether it was a temperature response or secondary dormancy. Cyst abundance in sediments varied inversely with blooms throughout the year, with abundance lower in warm months. Sediment characteristics also changed from lower sand and higher clay content in winter to higher total organic carbon in summer, consistent with enhanced productivity.

RECAP: Washington Sea Grant research tests the relationship between cyst appearance and viability in harmful *Alexandrium* and documents seasonal variation in cyst abundance and sediment composition in Central Puget Sound. [Back to Goals](#)

20789 - Washington Sea Grant investigates the effects of persistent environmental pollutants on salmon and human health

Relevance: Although use of polybrominated diphenyl ether (PBDE) flame-retardants has been banned, these toxic chemicals are environmentally persistent and can affect human health. Elevated PBDE levels have been found in Puget Sound salmon and in the marine mammals that eat them, lending urgency to questions about possible health implications for local residents who eat PBDE-contaminated salmon.

Response: Washington Sea Grant-supported researchers investigated PBDE impacts by conducting long-term feeding studies using zebrafish, a cost-effective surrogate for other fish and human subjects. They analyzed the reproductive effects on adult zebrafish of dietary PBDE exposure and developed new

screening methods to assess molecular damage. They also used human cells to test for mitochondrial injury and explored the chemical protection of omega-3 fatty acids, which are associated with salmon consumption.

Results: Long-term PBDE exposures resulted in microscopic damage to zebra fish reproductive tissues. By contrast, there were no behavioral effects in zebrafish that were fed PBDEs. A new technology developed for rapid gene-expression analysis will be used to assess other contaminants in salmon. Project results have been incorporated into outreach programs for use by local people and organizations working with vulnerable Puget Sound communities including regional Environmental Protection Agency scientists, the University of Washington TEACH program that provides Native Americans with environmental health information, and the Duwamish River Clean Up Coalition.

RECAP: Washington Sea Grant researchers confirm that zebrafish exposed to persistently high levels of PBDEs showed damage to reproductive tissues, suggesting that humans who eat contaminated salmon might be at risk. [Back to Goals](#)

20785 - Washington Sea Grant research reveals that the effects of ocean acidification on Pacific oysters may extend across generations and result in more resilient broodstock

Relevance: While research has explored the effects of ocean acidification (OA) on shellfish larvae, limited work has examined either carryover effects from parent to offspring or the effect of larval exposure on performance in later life. Identifying resilient strains and their distinguishing genetic factors would allow selective breeding of commercially valued shellfish for OA tolerance.

Response: Washington Sea Grant-funded researchers examined the effects of high CO₂ levels on adult Pacific oyster reproduction, gametes, and larvae, and on survivors' subsequent performance. Broodstock and larvae were conditioned to high and low CO₂ levels. Researchers planted the offspring at three sites and measured survival after 6 and 18 months and yield by weight after 9 months. They also genotyped larval samples.

Results: Larvae whose parents were conditioned to high CO₂ levels and who were themselves raised in low levels (high-low) had the highest larval performance, survival, and yield at all three sites. Oysters fared worse within the three other treatment combinations-high-high, low-high, and low-low parent-larvae CO₂ exposures-with outcomes varying by experimental parameter. For example, paternal CO₂ exposure seemed to affect larval survival more than maternal exposure. These findings suggest that exposure to OA may result in significant cross-generational effects, with CO₂-stressed parents producing more resilient offspring. Taylor Shellfish, Washington's largest oyster producer, is considering using project-generated oysters as broodstock.

RECAP: Washington Sea Grant-supported research documents cross-generational effects of OA on Pacific oyster viability and yield, with CO₂-stressed parents producing more resilient offspring and, potentially, better-adapted broodstock lines. [Back to Goals](#)

20784 - Washington Sea Grant research investigates the effectiveness of stakeholder involvement in salmon recovery plans for Puget Sound and the Columbia River

Relevance: Salmon populations in the Northwest continue to face steep challenges, with half the salmon runs in Washington waters designated as threatened or endangered. Public discussion frames development of salmon recovery policies, and successful rebuilding efforts require contributions from diverse voices, ranging from tribal and state managers to conservation organizations to landowners and the private sector.

Response: Washington Sea Grant-funded researchers studied public discourse on salmon recovery by examining local newspapers in the Puget Sound and Lower Columbia regions. They examined 1,287 Puget Sound articles and 360 in the Lower Columbia articles, identifying 3,800 and 1,060 stakeholders, respectively, in the two regions. Results from two related research projects and a study comparing media coverage on salmon recovery in three regional newspapers also were used to augment the dataset.

Results: Analyses show that governmental entities and environmental groups dominated participation in salmon recovery planning and most of the public discourse. Preliminary results indicated that private interests-agriculture, forestry and logging, real estate, energy, construction, business advocacy organizations-have little input to salmon recovery planning and implementation. Of 2,300 comments on the Puget Sound Action Agenda for salmon recovery, only 79 came from the private sector. The lack of participation reflects the private sector's limited involvement and may result in recovery policies that fail to represent all community segments, undermine private-sector accountability, and reduce support for future efforts.

RECAP: Washington Sea Grant research identifies a significant lack of private sector involvement in discussing, planning, and implementing Northwest salmon recovery. [Back to Goals](#)

20759 - Washington Sea Grant investigates social and ecological carrying capacity for shellfish aquaculture

Relevance: Washington is the nation's leading producer of bivalve shellfish, with harvests of about 40,000 metric tons annually, and South Puget Sound is a major growing area. The region also is

experiencing rapid development, which has created conflicts between shoreline residents and shellfish growers and the need for tools and information to inform regional planning and management of sustainable shellfish culture.

Response: Funded through a national strategic initiative, Washington Sea Grant-supported researchers are conducting an evaluation of South Puget Sound's shellfish production and ecological and social carrying capacity. The research team is applying comprehensive farm- and ecosystem-scale models (e.g., FARM, EcoWin) to help shellfish farmers and harvesters, resource managers, and other interested parties identify, evaluate, and account for social and environmental considerations in shellfish aquaculture development.

Results: Researchers analyzed farm production records, shellfish species metrics, and aquaculture-related policies and regulations, and they completed a detailed review of regional industry constraints and incentives. They also examined nitrogen removal and natural shellfish recruitment. Information from a variety of sources has been compiled and incorporated into the models, which also build upon and complement ongoing and recently completed efforts elsewhere in the region. Model outputs assist in simulating and predicting future biomass, nutrient, and dissolved-oxygen conditions for a wide range of farming and harvest scenarios. All findings have been presented to stakeholders as completed.

RECAP: Washington Sea Grant-supported research investigates ecosystem conditions and perspectives-including human dimensions-that determine South Puget Sound's carrying capacity for shellfish aquaculture. [Back to Goals](#)

20747 - The double life of Heterosigma: Washington Sea Grant research explores the behavioral, metabolic, and genetic mysteries of a fish-killing toxic alga

Relevance: The single-celled alga *Heterosigma akashiwo* forms massive toxic blooms that have killed farmed salmon worth millions of dollars and, in 2014, ravaged a wild chum salmon run near Sequim, Washington. *Heterosigma* is enigmatic and resilient, resting for months in deep, cold waters until growth conditions improve. It then suddenly becomes active, swims back toward the surface, and blooms. *Heterosigma* distribution and bloom frequency appear to be increasing; understanding and anticipating toxic blooms is key to mitigating *Heterosigma*'s effects.

Response: Washington Sea Grant researchers used diverse techniques to analyze *Heterosigma* changes between active and resting states. These included high-resolution videography to track swimming behavior and a suite of instruments and biochemical procedures to measure lipid quantity and quality and examine transitions in metabolic pathways. The team partially sequenced the genome of another algal species as a proxy for the larger *Heterosigma* genome and used the database developed to explore its transcriptome.

Results: The only integrated study of the behavioral and metabolic responses of *Heterosigma*, this effort shows that lipid levels are key to swimming capacity. Genetic sequencing uncovered several novel biochemical factors controlling the metabolic shifts that insulate this alga from unfavorable conditions. Data, which suggest a sexual cycle in *Heterosigma*, can be used to build a testable model relying on cell-activation responses to predict bloom formation.

RECAP: Washington Sea Grant researchers develop a toolbox of diverse techniques-from gene sequencing to videography-to probe the elusive toxic alga *Heterosigma akashiwo* and uncover a metabolic key to predicting harmful blooms. [Back to Goals](#)

20664 - Less waste, higher revenues: Washington and California Sea Grant researchers measure catch share effects on West Coast groundfish fisheries

Relevance: The West Coast groundfish fishery is vast, valuable, complex, and overfished. Revenues rose after the Pacific Fishery Management Council implemented individual fishing quotas (IFQs). But questions about effects on fish stocks and fishing communities can only be answered by objective, authoritative data on IFQ ecological and social impacts and return on investment.

Response: Washington Sea Grant partnered with California Sea Grant to examine IFQ impacts on the groundfish fishery. Research focused primarily on fleet-wide catches, the status of fish stocks, and discard practices. Resources are being leveraged from the Moore Foundation and a Sea Grant-NMFS Fellowship to compare Northeast and West Coast IFQ experiences, assemble the best science about catch-share performance, and help guide future catch-share decisions. Analysis will continue through 2016.

Results: Findings to date are surprising because researchers and managers expected fleets to come much closer to filling their fishing quotas. However, except for highly valued sablefish harvests, total catches have changed little. West Coast groundfish fisheries discarded less bycatch than at any time in the previous decade but caught only small portions of their quotas of target species, averaging about 30 percent versus 67 percent in nearby Canadian fisheries. The apparent reason: U.S. fleets fish more cautiously to avoid costly problems like exceeding quotas for overfished stocks or taking protected species.

RECAP: Regional researchers are tracking ecological and economic effects of a new catch-share system

on West Coast groundfish fisheries, including surprisingly low harvest levels, to provide insight into developing more effective quota systems. [Back to Goals](#)

19359 - Washington Sea Grant investigates economic impacts, expansion opportunities, and entry barriers in Pacific Coast shellfish aquaculture

Relevance: From Ventura County, California, to Grays Harbor, Washington, shellfish harvesting is a vital part of the region's culture and commerce. Coastal communities seeking to develop productive, sustainable economies see new opportunities in shellfish cultivation. At the same time, local, state, and national agencies must accommodate or contend with this expanding industry in their shoreline management and marine spatial plans. All parties need better information about its economic impacts, opportunities for expansion, and barriers to entry.

Response: With national strategic initiative funding, Washington Sea Grant-supported researchers surveyed shellfish growers and interviewed key informants in three Pacific states on expenses and revenues and five categories of entry barriers. They used this data to develop a comprehensive input-output analysis of the industry.

Results: The data assembled provide the most comprehensive economic picture yet of West Coast shellfish aquaculture. In Washington the industry generated about 60 percent more jobs per million dollars spent than animal husbandry and 170 percent more than boatbuilding and forestry. Only 62 percent of the 30,000 acres permitted for nontribal shellfish aquaculture are in active production, suggesting significant expansion opportunities remain. For small growers, the biggest challenges were economic and production conditions, such as access to capital; for midsized growers, social conditions, such as use conflicts and litigation costs; and for large growers, regulation and permitting delays. The researchers have disseminated these and related findings via conferences and other presentations, industry media, and other publications. Local and federal economic-development officials have solicited further information.

RECAP: Washington Sea Grant-supported researchers quantified the economic impacts of West Coast shellfish aquaculture and documented entry barriers and expansion opportunities. [Back to Goals](#)

19022 - Washington Sea Grant kickstarts international research on the low survival of young salmon and steelhead in the Salish Sea

Relevance: Efforts to protect and restore depleted salmon populations in Washington and British Columbia are dogged by a new and disturbing mystery: After successfully emerging from their gravel nests, growing strong and reaching salt water, why are so many juvenile Chinook, coho and steelhead dying in the Salish Sea? Safeguarding other life-cycle stages will be futile if this link is broken.

Response: Washington Sea Grant provided early project funding for a cross-border collaboration coordinated by Washington's Long Live the Kings (LLTK) and Canada's Pacific Salmon Foundation to investigate and address this critical uncertainty. The grant enabled LLTK to hire a graduate student to assist with baseline data development and research planning.

Results: In 2013, LLTK launched a five-year, \$20 million, multidisciplinary Salish Sea Marine Survival Project. Today, more than 150 federal, state, tribal and academic experts are assessing the condition of juvenile salmon and steelhead and their environment. Fishermen and the Canadian Coast Guard have provided large vessels, field technicians are intensively collecting migrating fish, acoustic arrays have been installed to track fish movement and survival, gliders and buoys are monitoring ocean conditions, and new near-field identification technology is being developed to investigate marine-mammal predation. The Washington Sea grant-funded student assistant played a crucial role in launching the research, and after her graduation LLTK hired her as a full-time research ecologist supporting the project.

RECAP: Washington Sea Grant provides critical seed funding to launch large-scale binational research into the alarming loss of juvenile salmon and steelhead in the Salish Sea [Back to Goals](#)

19009 - Washington Sea Grant research develops a genetic toolkit to survey the Chinook salmon genome and strengthen conservation

Relevance: Nine populations of Chinook salmon are currently protected under the Endangered Species Act along the West Coast, and five are found in Washington waters. Genetic tools can provide important information for the conservation, recovery and protection of this iconic species, making it possible to track catches of protected fish in fisheries where healthy and depleted populations comele; guide hatchery management to protect population diversity and fitness; survey the Chinook genome for adaptations that support recovery; and set more effective conservation priorities.

Response: Washington Sea Grant-supported research has led to the mapping of a significant fraction of the Chinook salmon genome.

Results: The maps have significantly increased understanding of genetic variation within Chinook salmon, identifying thousands of gene loci, including regions associated with thermal tolerance and growth, two qualities of particular interest to managers. The research showed that the salmon genome underwent a recent duplication and has twice as many chromosomes as an ancestral species did. The genetic markers identified can be developed for a range of applications. Resource agencies are already using the maps to identify stocks, calculate effective population sizes, and identify the parts of the genome responsible for adaptive differentiation.

RECAP: Washington Sea Grant-supported research mapped a significant portion of the Chinook salmon genome, identifying markers for key survival and adaptation factors and providing powerful

tools for protection and recovery of this important species.

[Back to Goals](#)

18999 - Washington Sea Grant research finds bivalve winners and losers as the ocean acidifies

Relevance: Ocean acidification has arrived in the Pacific Northwest, at levels surpassing end-of-century predictions. Understanding its effects on ecologically and economically important marine shell-builders is imperative, especially in vulnerable early life stages, in adult reproduction, and via carry-over effects from parent to offspring.

Response: Washington Sea Grant-funded laboratory experiments examined the responses of five bivalve species (Olympia oyster, Pacific oyster, pinto abalone, geoduck clam, and Manila clam) to combinations of three stresses: dissolved carbon dioxide, elevated water temperature, and exposure to the bacterium *Vibrio tubiashii*. Researchers also used their work as the basis for a high school biology curriculum on acidification.

Results: As dissolved CO₂ levels were increased, *V. tubiashii* reached pathogenic bloom levels faster but did not show greater pathogenicity. Larval and juvenile Manila clams and juvenile geoducks did not show any adverse effects from increased CO₂ in the range tested. Exposed adult Olympia oysters saw delayed larval release and reduced fecundity. When broodstock were conditioned and held at the same CO₂ levels as their parents, they suffered no effects on survival, growth or shell morphology. However, a measurable change in gene expression suggests that growing up in more acidic environments may be energetically costly. Larval Pacific oysters and pinto abalone fared worst when matured under low CO₂ but exposed to high-CO₂ upwelling events; such events may be more stressful than gradual increases in CO₂. The curriculum the researchers developed helped more than 800 students understand acidification.

RECAP: Washington Sea Grant-funded research found that bivalve species exhibit different susceptibility to increasing CO₂ levels. Under the conditions tested, clams were relative winners and oysters losers. Educational outreach heightened student understanding of acidification. [Back to Goals](#)

18935 - Volunteer monitoring of harmful algal blooms protects Puget Sound seafood resources and consumer health

Relevance: Puget Sound shellfish harvests are valued at about \$70 million annually and much of its worth relies on the region's reputation for producing safe high quality seafood products. Harmful algal blooms (HABs) are a persistent threat to Puget Sound seafood safety, producing toxins that can be taken up by shellfish and sicken people who eat them. However, early detection of HAB organisms can give shellfish growers time to take action, reduce losses, and minimize health risks.

Response: In 2012, Washington Sea Grant teamed with NOAA's Northwest Fisheries Science Center to operate SoundToxins, a program that engages Puget Sound residents, shellfish growers, tribal members, researchers, nongovernmental organizations, and government staff in monitoring for early warnings of HAB events. WSG provides financial support and ensures volunteer coordination and training. Participants collect seawater samples from 24 sites around Puget Sound, examine the samples for HABs and report them in real time.

Results: SoundToxins data are proving so reliable that state health officials can substantially reduce testing in areas where volunteers report no observable HABs. In 2013, the Jamestown S'Klallam Tribe SoundToxin team identified rising levels of *Dinohpysis*, the organism that causes diarrhetic shellfish poisoning, and alerted Washington public health officials. The warning triggered enhanced shellfish tissue sampling and analysis and prevented any reports of illness.

RECAP: Washington Sea Grant partners to run a volunteer monitoring program that protects Puget Sound's shellfish economy and consumer health. [Back to Goals](#)

18907 - Washington Sea Grant-brokered lane agreements save crab fishermen and towboat companies \$1.7 million per year

Relevance: Oceangoing tugs and commercial crab fishing collided in Washington, Oregon and California in the late 1970s. Crab pots fouled tugs and barges, forcing costly repairs and substantial out-of-service time. With each missing crab pot costing about \$250 plus lost fishing time, nearly 1,200 commercial crabbers also suffered large losses.

Response: Since the late 1990s, WSG has taken a leadership role in annual lane negotiations between crab fishermen and tug and barge operators and in maintaining the cooperative relationship between them. WSG staff also led the development and distribution of electronic towlane charts and facilitated discussions between marine industry representatives and the National Weather Service and U.S. Coast Guard.

Results: The WSG-brokered agreements provide gear-free towlanes for tugs and designated fishing areas for crabbers. By reducing crab-gear replacement and towboat repair costs, these agreements save an estimated \$1.7 million each year. Recent adjustments have expanded the fishing area off the northern Washington coast by 25 square miles and allowed tug and barge traffic to use the inside lanes earlier in the year, saving thousands of dollars in fuel and operation costs. Electronic charts have greatly simplified entering and accessing navigational data, improving compliance. WSG-facilitated discussions with the maritime agencies have led to improved marine weather forecasting products and coastal-bar closure policies.

RECAP: Washington Sea Grant-brokered lane agreements and other facilitated improvements make West Coast sea lanes safer and more efficient, saving crab fishermen and towboat companies an estimated \$1.7 million per year. [Back to Goals](#)

18906 - Washington Sea Grant classes save lives at sea

Relevance: Today, commercial fishing ranks as the country's second most deadly job and the severe ocean environment in the North Pacific places West Coast and Alaska fisheries at higher risk than in almost any other region. In addition, Washington's commercial fishermen and recreational boaters often are unprepared for emergencies at sea and these combined factors can increase threats to crews and their vessels and endanger lives and property.

Response: In compliance with stringent federal requirements, Washington Sea Grant trained 134 fishermen in nine certified commercial fishing vessel safety courses and one tribal commercial fishing program. All participants received federally mandated certification for onboard drills and safety orientation. WSG also held a cold-water survival training course for 37 recreational boaters and hosted annual crabber/towboat meetings at which attendees learned about marine weather products and services.

Results: Following the courses, evaluations and interviews confirmed that all participating fishermen subsequently were able to upgrade their safety gear and operations. Past participants credit skills learned in class with saving three crewmen's lives and more than \$2 million in vessel and equipment costs. WSG's specialized tribal training is widely credited with preventing any loss of boats or lives in the 2013 Columbia River tribal gillnet fishery, which averaged five fatalities annually in previous seasons.

RECAP: Washington Sea Grant safety classes continue to save lives and help fishermen operate safely at sea. [Back to Goals](#)

18904 - Washington Sea Grant trains supermarket employees to provide customers with key knowledge about the seafood they buy

Relevance: Poor handling and inconsistent quality is widespread in seafood retailing and discourages consumption, costing Washington's seafood industry more than \$5 million annually in wasted product and lost sales. Consumers often have questions about whether the fish they eat are sustainably caught, a healthy food source, and clean and high quality - and their questions commonly are directed to workers behind supermarket seafood counters.

Response: Washington Sea Grant has offered an intensive 12-hour course in seafood retail since 2010 through the South Seattle Community College meatcutters apprenticeship program. Trainees learn about product origin, sensory evaluation, quality maintenance, safety and sanitation, marketing and promotion. Each receives a comprehensive training manual with waterproof pages for use at seafood counters. In 2013, the course trained 18 apprentice counter managers, representing 18 stores and seven grocery chains with more than \$1.4 million in total annual seafood sales. WSG also completed 12 one-hour radio programs on topics like seafood spoilage and seafood and health for Aberdeen's KBKW Radio.

Results: Training seafood counter managers helps ensure better, safer seafood for a substantial number of consumers. Together, the stores where the trainees work serve more than 3,500 seafood customers each week. After the course, participants reported that they had acquired more knowledge about seafood handling and safety and greater confidence. "Being more informed, I'm better able to answer my customers' questions," one trainee declared. "I can offer ideas to my customers to try seafood," wrote another. "They will have more confidence in buying seafood."

RECAP: Washington Sea Grant training gives grocery counter professionals and consumers the knowledge they need to make informed seafood choices. [Back to Goals](#)

18903 - Washington Sea Grant training and assistance enhance tribal fishermen's catch value and business skills

Relevance: Western Washington tribal communities traditionally relied on fish and shellfish 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 harvests.

Response: Since 2009, Washington Sea Grant has partnered with the Affiliated Tribes of Northwest Indians to train fishermen from several Washington tribes in improved catch handling and storage techniques, and marketing strategies to increase the profitability of their fisheries. For the past 10 years, WSG has helped Makah tribal fisherman market their marbled king salmon, presenting it at an annual "Lark Lunch" for chefs and food writers. In 2013, WSG staff trained 42 Nisqually and 32 Quinault fishermen at two three-hour workshops. WSG continued assisting the Lummi Nation in operating a new seafood market that opened in March 2012, by training tribal members in retail and seafood marketing, and helping tribal fishermen upgrade their catches and develop value-added products for sale at the store.

Results: Following Washington Sea Grant's training sessions, Nisqually fishermen were able to raise the value of their catch by 50 cents per pound and earn an additional \$67,000. The Lark Lunch continues to be effective in marketing marbled king salmon; since the initial event, 2013 adjusted prices have grown by \$1.10 per pound, increasing product value by approximately \$66,000. The Lummi Seafood Market provides an important outlet for tribal catches and is giving tribal members valuable retail and business experience.

RECAP: Washington Sea Grant business training and assistance help tribal fishermen operate new markets, upgrade their products, secure higher catch prices, and sustain economic growth and development. [Back to Goals](#)

18901 - Washington Sea Grant helps growers produce shellfish safely, responsibly, and profitably

Relevance: Washington leads national production of farmed bivalve shellfish, harvesting about 40,000 metric tons valued at \$108 million. Shellfish growers directly and indirectly employ more than 3,200 individuals and contribute an estimated \$270 million to the economy. Critical to industry success is

excellent water quality and, conversely, stresses like coastal development, pollution, algal toxins, pathogenic bacteria and ocean acidification threaten its health. To operate effectively in regional and global seafood markets, growers require an understanding of domestic and international health and safety regulations, as well as information on consumption patterns and markets for their products. Response: Working with federal, tribal and state managers and shellfish farmers, Washington Sea Grant aquaculture experts provided training, conferences and technical assistance to address industry needs and conducted a Northwest consumer survey on perceptions of shellfish quality and aquaculture sustainability. In 2013, activities included: (1) continued implementation of the Washington Shellfish Initiative; (2) funding for and reporting on relevant research; (3) post-production and outreach support for the documentary film series Willapa Bay Oysters; and (4) participation in the Pacific Rim Shellfish Sanitation Conference, Vibrio Research Network, and California Current Acidification Network. Results: In 2013, technical assistance enabled permitting and installation of nine floating upwelling systems at an urban marina for use as a nursery to grow out oysters and geoduck. The systems expanded critical shellfish "seed" supply, assuring nine small growers a seed source. Assistance to family-owned shellfish farms prevented the loss of 300,000 oysters from summer mortality and helped reduce levels of the disease-causing bacteria, *Vibrio parahaemolyticus*, allowing consumption of 500,000 raw oysters with no illnesses. In addition, WSG's 20th Conference for Shellfish Growers disseminated the latest information on shellfish health, seed shortages, seaweed cultivation, biosecurity, and harmful algal blooms to more than 100 producers and other participants. Finally, the consumer survey results showed that more than 85% of consumers are aware of shellfish growing operations and four out of five look for local products. Less than 30% had concerns with shellfish producers and 91% supported maintaining or growing Washington shellfish aquaculture. **RECAP:** Washington Sea Grant aquaculture extension is enhancing shellfish growers' production capacity, sustainability, and product safety. [Back to Goals](#)

18900 - Washington Sea Grant issues groundbreaking peer-reviewed report on geoduck aquaculture

Relevance: Geoducks are an \$80 million industry in British Columbia and Washington, supplying nearly half of the world's market. The region's farmed clams yield around 1.3 million pounds annually, or about 90% of global geoduck aquaculture production. Potential environmental impacts of aquaculture have created friction between shoreline communities and shellfish growers. The "planting" of small geoducks on intertidal beaches using tubes and nets to protect them from predators has been particularly controversial, as well as an intensive flushing system used to harvest animals. More information about aquaculture impacts was necessary for expanding aquaculture operations sustainably.

Response: In 2007, the Washington Legislature tasked Washington Sea Grant with carrying out a six-year research program to assess possible effects of geoduck aquaculture on the Puget Sound and Strait of Juan de Fuca environments and reporting back by December 2013. The WSG report contains new peer-reviewed research on geoduck aquaculture that substantially improves understanding of how industry operations might affect regional ecosystems. It also includes a literature review of more than 400 papers on shellfish aquaculture. The work relied on a diverse team of scientists, growers, managers, and funders, and is a model for successful collaborative research.

Results: This groundbreaking study is informing sustainable management of geoduck aquaculture, from planting to harvest, and is the basis for testimony at hearings on new farm permits. Researchers found that environmental changes caused by planting were limited to that phase and did not persist when protective tubes and nets were removed. Harvest disturbance had no statistically significant effect on the abundance or diversity of small bottom-dwelling animals. The magnitude of nutrient release during harvest at current levels of geoduck aquaculture is an inconsequential fraction of anthropogenic nutrient inputs into Puget Sound.

RECAP: Washington Sea Grant research is guiding sustainable development of geoduck aquaculture in Puget Sound and the Strait of Juan de Fuca. [Back to Goals](#)

18896 - Washington Sea Grant is a leader in international efforts to reduce seabird deaths in longline fisheries

Relevance: In 2012, BirdLife International reported that 28 percent of seabird species are globally threatened. Albatrosses are especially imperiled: 19 of 22 species face extinction and incidental death in fishing operations is among the largest concerns for the health of these bird populations.

International longline tuna and billfish fisheries, in particular, constitute an enormous threat to albatrosses and petrels. Managed by Regional Fishery Management Organizations or RFMOs, they extend over broad oceanic expanses and involve a huge number of vessels.

Response: Building on work in the United States, Washington Sea Grant has worked with longline fishermen internationally to develop, test, and promote fishing gear modifications that significantly reduce seabird bycatch. In 2013, WSG published peer-reviewed research containing the most comprehensive assessment to date of seabird-bycatch prevention in tuna fisheries. An acknowledged leader, WSG participated in several international working groups to share results and encourage adoption of seabird conservation measures across global tuna fisheries.

Results: This year marked the culmination of years of research and collaborative work, resulting in broad technology and policy changes. In 2012, the International Agreement for the Conservation of Albatrosses and Petrels (ACAP) adopted mitigation best practices for pelagic longline fisheries—a decision supported by the Japanese tuna industry that was based largely on WSG research results and recommendations. The ACAP advice was put into place, or scheduled for deployment, by all four major international tuna commissions in 2013. These actions are expanding the use of seabird bycatch mitigation measures to thousands of vessels and creating a new landscape for albatross and seabird

bycatch prevention in the world's tuna fleet.

RECAP: Washington Sea Grant techniques for reducing seabird bycatch were adopted by international tuna fisheries, positioning the fleet to significantly reduce its impacts on albatrosses and other seabirds around the globe. [Back to Goals](#)

18889 - Washington Sea Grant offers fishermen tools to reduce seabird deaths in U.S. longline fisheries

Relevance: Across the globe, 28 percent of seabird species are threatened, and 19 of 22 albatross species face extinction. Incidental capture in fisheries is a major conservation threat for albatrosses and other seabirds. In 2012, the U.S. Fish and Wildlife Service established limits on the number of short-tailed albatross that could be taken in West Coast groundfish fisheries, mirroring similar limits in Alaskan and Hawaiian longline fisheries.

Response: Washington Sea Grant has worked with Pacific longline fishermen for almost 20 years to develop, test, and promote fishing gear modifications that significantly reduce seabird bycatch. In 2013, WSG published research on the risk posed to endangered short-tailed albatross by West Coast groundfish and shrimp fisheries. Working with the industry, WSG fine-tuned seabird bycatch prevention mechanisms, redesigned streamer lines, and facilitated their distribution to West Coast longline vessels. Researchers developed education materials and resources and visited ports from California to Washington to continue building industry awareness and bycatch prevention efforts.

Results: Beginning in 2014, non-tribal longline vessels that are 55 feet or longer will be required to use streamer lines to keep seabirds away from their bait. By increasing awareness of the need for albatross conservation throughout the West Coast tribal and non-tribal longline fleet, WSG is ensuring that fishermen understand why the new requirements are necessary and that the fleet is well trained and ready to comply. The goal is to echo the legacy of Sea Grant research in Alaska, where seabird bycatch in longline fisheries remains dramatically reduced from earlier years.

RECAP: Washington Sea Grant has expanded training and information for the West Coast longline fleet, offering tools to reduce seabird deaths to low levels achieved in Alaskan longline fisheries. [Back to Goals](#)

17586 - Washington Sea Grant research links hypoxia to crab fisheries with potential to prevent overfishing

Relevance: Hypoxia or low dissolved oxygen has become a pervasive problem in Washington's inshore waters during the summer months, particularly in Hood Canal. Hypoxia's causes have been intensively researched, but its ecological effects have received relatively little study. Fish kills are its most visible impact, but sublethal ecological consequences may be far more widespread, potentially affecting food-web structure and species' movements, productivity, and vulnerability to fishing.

Response: Washington Sea Grant-funded researchers assessed the movements of Dungeness crab and English sole in two regions of Hood Canal during late summer periods of low dissolved oxygen. Using acoustic tags, stationary and mobile receivers, weekly tracking, and video surveys, they tracked the movement of animals locally (from deep to shallow water) and regionally (south to north) to avoid hypoxia.

Results: The research revealed greater species diversity in the less-hypoxic northern region but more faunal density, with less week-to-week variation, in the south. This suggests that relatively hypoxia-tolerant species in the southern area are finding unexpected refuges. There is surprisingly little evidence of regional movement. Sole travel extensively throughout Hood Canal, but these large-scale movements did not reflect changes in oxygen level. Crabs move to shallower water, where fishing is more intense, as oxygen levels decline. The results are being used to evaluate use of water quality as part of the harvest management strategy and will provide direct guidance for adapting the fishery to hypoxia-related changes in access to crab stocks. This will benefit coastal recreational and tribal crab fishermen by establishing safeguards to prevent overfishing.

RECAP: Washington Sea Grant-funded research found that Dungeness crab and English sole in Hood Canal do not move far to escape hypoxia. Crabs shift to shallower water where they are more easily caught, suggesting the need to reevaluate how the fishery is managed. [Back to Goals](#)

17557 - Washington Sea Grant researchers develop a better model to evaluate Pacific sardine stocks and guide fishery management decisions

Relevance: Pacific sardine, the second-largest federally managed West Coast fishery, is one of the most abundant fish species in the California Current. It is also important forage for many valuable and protected species. Sardine stocks have traditionally been assessed using a simple, spatially aggregated "bathtub model" that does not consider migration between regions or regional differences in age and recruitment. This has led to biased results. In 2008 the fishing industry challenged the assessments, and the Pacific Fisheries Management Council (PFMC) is now reevaluating its sardine harvest rules. More precise and accurate assessments are urgently needed.

Response: Washington Sea Grant-funded researchers used a spatially explicit model based on the 2010 sardine stock assessment to gauge the effects on population estimates of such factors as seasonal migration, spatial recruitment patterns, and the availability of fish-length data. They checked the sensitivity of their findings against the 2011 assessment and acoustic trawl surveys.

Results: The analyses showed that (a) spatially aggregated stock assessment methods can be biased when populations are spatially structured, especially when temperature affects migration, and (b) a spatially structured assessment method can reduce this bias. Researchers presented their results to the PFMC and are scheduled to lead a discussion of possible adjustments in harvest parameters at an upcoming Council meeting.

This model has been tailored to the Pacific sardine but could be modified to represent almost any

mobile coastal fish stock. The simulation framework used to evaluate estimation performance could be easily modified to evaluate harvest control rules.

RECAP: Washington Sea Grant research exposes bias in current Pacific sardine assessments and develops a spatially structured model that provides more accuracy and points toward changes in harvest rules. [Back to Goals](#)

17549 - Washington Sea Grant helps oyster growers get a bigger oyster crop by scattering shells just when larvae need them

Relevance: Natural larval settlement represents a variable but important source of seed oysters for shellfish growers and state reserves on Washington's Willapa Bay, which produces 10 percent of all U.S. oysters. Growers deploy post-harvest shells at times and places where larval settlement will soon occur, to take advantage of the larvae's preference for clean shell. They have only a brief window of time to obtain maximum settlement. The sooner they learn when larvae are ready to settle, the more shell they can distribute.

Response: A Washington Sea Grant-funded research team sampled bivalve larvae every three to five days and issued bulletins to a listserv of oyster growers, advising them of the best times to deploy shells.

Results: As larvae approached setting size in August 2012, their abundance was about an order of magnitude larger than it was in 2011, based on standardized spat collectors with 11 spat per shellface. This resulted in a commercially viable set, an estimated \$50,000 benefit to Willapa Bay oyster growers.

RECAP: A larval sampling program supported by Washington Sea Grant enabled oyster growers in Washington's Willapa Bay to place clean shells at the optimal time for young Pacific oysters to settle and grow on them. [Back to Goals](#)

17508 - Sea Grant-supported research investigates geoduck aquaculture's effects on intertidal community dynamics

Relevance: The expansion of geoduck aquaculture in Puget Sound has raised concern among managers, conservationists, and the public about possible environmental impacts. Sediment disturbance in intertidal areas caused by geoduck planting (using nets and tubes) and harvesting (using hoses to liquefy sediment) could affect a number of intertidal ecological functions, including fish distribution, benthic community dynamics, and food web interactions.

Response: A Sea Grant National Strategic Investment is supporting a two-year study to compare cultured geoduck areas to nearby reference beaches. Objectives are to characterize changes in benthic communities associated with geoduck planting and harvest; explore differences in fish abundance and movement between cultured areas and reference beaches; evaluate differences in fish diets in relation to prey abundance and availability; and determine the effects of diet shifts on fish growth and survival.

Results: In 2012, researchers completed sampling at cultured and reference beaches at three locations. They found that target fish abundance did not vary between the two types of sites, despite the greater habitat complexity of the cultured beaches, but fish appeared to grow faster on the cultured beaches than on the reference beaches. Fish did not move between cultured and uncultured plots. They consumed different types of prey in the two habitats, but their tissues were chemically similar, suggesting that food-web energy pathways remained similar in both despite some differences in prey chemistry.

RECAP: Sea Grant-sponsored researchers investigate the ecological effects of geoduck aquaculture by comparing fish abundance, movements, diets, and energy budgets on cultured and uncultured beaches. [Back to Goals](#)

17367 - Washington Sea Grant researchers discover seasonal and geographic factors and molecular markers in newly identified geoduck diseases

Relevance: A lack of baseline data on geoduck health, parasites and diseases has hindered management of this valuable shellfish, making it difficult or impossible to identify potential pathogens, trace the causes of disease, determine whether endemic or newly introduced microorganisms may be involved, and anticipate the effects of seasonal and environmental factors.

Response: In various seasons over three years, Washington Sea Grant-supported researchers sampled and screened hundreds of randomly collected wild geoduck from three Puget Sound sites. In 2012 they conducted in-depth statistical analyses, seeking to understand seasonal and geographic influences on parasite occurrence.

Results: The samples revealed several parasites previously unreported in geoduck, including the first molluscan microsporidian identified in the Pacific Northwest. The parasites' presence correlated with season and location, but varied among species in relation to water depth. The two most common, a Rickettsia-like organism in the gill and a metazoan in the siphon, occurred most often in summer, although metazoan trends varied among sites. A Steinhausia-like organism tended to occur in winter and spring when the clams mature reproductively. Another microsporidian-like organism occurred in all seasons. Preliminary molecular analyses suggest it will be possible to definitively identify geoduck parasites and develop diagnostic tools to screen for them. This will help state and tribal resource managers respond to outbreaks and plan stock transfers and farm sitings.

RECAP: Washington Sea Grant-funded research identifies previously unreported geoduck pathogens, seasonal and geographic factors influencing them, and molecular diagnostic tools to screen for disease. [Back to Goals](#)

17366 - Washington Sea Grant documents environmental effects of geoduck aquaculture on eelgrass meadows and associated soft-sediment habitat

Relevance: Puget Sound's eelgrass provides many ecological services: anchoring and enriching

substrates, removing acidifying carbon dioxide, and feeding and sheltering a wide range of fauna. Washington State considers it critical habitat and permits no shellfish culture in established meadows. But eelgrass and aquaculture inevitably interact, particularly when eelgrass colonizes already planted geoduck beds. An instance of such colonization in Samish Bay offered a large-scale natural experiment in geoduck aquaculture's previously unstudied impacts.

Response: Washington Sea Grant-supported researchers conducted 15 surveys of adjacent farmed and unfarmed areas, comparing sediment, eelgrass, and faunal characteristics at various stages in the growth and culture cycles.

Results: Harvest activity and the biofouling of predator-exclusion nets reduced and eventually eliminated eelgrass from the geoduck farm. Following harvest, the farm showed significantly lower sediment elevation and organic content than the unfarmed area. Sediment loss was greater around PVC tubes implanted to protect young geoducks, possibly suggesting increased scouring. Infaunal abundance was higher in the farmed than unfarmed area before harvest and lower afterward. Infaunal diversity was initially similar in the two areas; it subsequently increased in the unfarmed area but not in the farmed. Eelgrass and sediment both showed evidence of subsequent recovery. Sediment elevation appeared to recover within one year of harvest. Two years after net removal farm sediment showed higher organic content than unfarmed. Eelgrass began recolonizing the farm one year after net removal.

Findings are informing policies for protecting eelgrass habitat and regulating shellfish cultivation. The results will inform U.S. Army Corp of Engineers and Washington Department of Natural Resources in establishing buffer zones for eelgrass meadows.

RECAP: Washington Sea Grant-supported research determined the effects of geoduck aquaculture on eelgrass meadows and associated fauna, providing data to set state and federal buffer zones for eelgrass meadows near farm operations. [Back to Goals](#)

17282 - Washington Sea Grant builds momentum for state efforts to tackle ocean acidification

Relevance: Powerful upwelling and offshore winds bring carbon dioxide-laden deep water to Washington's coast, and land-based nutrient runoffs and discharges produce more dissolved CO₂. The resulting corrosive, low-carbonate waters have been implicated in oyster larvae die-offs, jeopardizing Washington's \$108 million shellfish industry. Impacts on other marine organisms and ecological communities are beginning to be documented as well.

Response: Washington Sea Grant has awarded more than \$1 million for field and laboratory research into acidification's effects on shellfish and on the zooplankton base of the marine food chain. The WSG-organized Symposium on Ocean Acidification in November 2011 provided an impetus for Governor Chris Gregoire to establish the Washington State Blue Ribbon Panel on Ocean Acidification, the first such state response nationwide. Sea Grant staff worked with the governor's office to identify panel members and obtained and administered panel financial support. WSG also coordinated the panel's logistics and proceedings and its working groups on science, adaptation and remediation, and education and outreach. Staff oversaw the preparation of the comprehensive science summary and materials for the final report and its public release in November 2012.

Results: The report spurred substantial executive and legislative initiatives and brought national attention and extensive media coverage to the acidification issue. Gov. Gregoire directed state agencies to implement the panel's recommendations and included \$3.3 million for acidification research in the state budget. A panel member introduced legislation to create a state board coordinating acidification research and action and authorize rural sewer systems to capture acidifying wastes. Responding to the governor's executive order, the U.S. EPA set out to review its criteria for water-body impairment and perhaps recognize acidification.

RECAP: As climate change and ocean acidification threaten Washington state's shellfish industry, Washington Sea Grant plays a central role in the state's Blue Ribbon Panel on Ocean Acidification. The final report generates national attention and catalyzes the state's commitment to curbing acidification. [Back to Goals](#)

17276 - Wild Seafood Exchange brings fishermen, buyers and financial experts together to promote direct marketing and maximize catch value

Relevance: Fewer fish buyers and smaller available catches limit Washington fishermen's opportunities in the conventional multi-tiered seafood sales structure. At the same time, many fishermen would like more control over the context and condition in which their products reach consumers, both out of commitment to product quality and in order to capture profits that go to buyers, wholesalers, and retailers. One solution is to market their catches directly. But doing so presents many challenges, requiring proficiency in quality control, processing, handling, and storage as well as marketing.

Response: For nine years, Washington Sea Grant has teamed with Philips Publishing (Fishermen's News) to host the annual Wild Seafood Exchange, the only conference for independent commercial fishermen. This forum helps West Coast and Alaska fishermen network and learn to launch or enhance direct marketing operations. Recently, its focus has expanded to include branding, distribution, and legislative and regulatory issues. In 2012 the Wild Seafood Exchange moved for the first time to Bellingham, Washington, attracting new attendees, and made plans to expand its reach to Oregon and California.

Results: In May 2012, Philips Publishing's president told Congress, "Sea Grant has been a solid partner" in educating more than 800 fishermen in direct marketing and business development, helping them identify markets and customers, achieve high public visibility, and drive up demand.

RECAP: Washington Sea Grant's Wild Seafood Exchange reaches out to new fishing communities,

continues to bring fishermen and buyers together, and teaches fishermen how to market their catches directly. [Back to Goals](#)

17273 - Washington Sea Grant's marine technology training helps commercial fishermen save money and sustain their businesses

Relevance: Boat maintenance and repairs cost the typical fisherman thousands of dollars each year, plus possible towing charges and costly fishing interruptions. Inadequate and malfunctioning vessel refrigeration systems can lower catch quality and the prices fishermen can command. Learning to perform their own repairs can significantly boost their income.

Response: Washington Sea Grant conducts workshops for commercial and recreational fishermen on boat engine maintenance, marine wiring and refrigeration. The refrigeration courses prepare commercial fishermen for Environmental Protection Agency marine refrigeration tests. Fishermen who pass can buy refrigerant and work on their own systems, potentially saving hundreds of dollars per vessel.

Results: In 2012, WSG trained 60 commercial and recreational fishermen in diesel engine maintenance, marine wiring, and refrigeration. The courses helped participants save an estimated \$10,600 in repairs and towing costs in 2012, and potentially even more in fishing opportunities that would otherwise have been lost.

RECAP: Washington Sea Grant workshops instill the expertise fishermen need to work on their own vessel systems, reducing their expenses and helping sustain an important state industry. [Back to Goals](#)

15662 - Washington Sea Grant brings together stakeholders to develop an innovative framework for assessing the vulnerability of West Coast fisheries to climate change

Relevance: Marine waters along U.S. West Coast are highly productive and support important fisheries, including salmon, whiting, sablefish, rockfish, Dungeness crab and oysters. More than 120 communities are dependent on or engaged in Pacific fisheries. Climate-related marine environmental changes have potentially serious consequences for West Coast fisheries that will add to existing challenges to their long-term sustainability. Among the potential impacts on marine life are alteration of coastal habitats as a result of sea level rise, shifts in abundance and distribution of marine species, phenological changes and increased incidence of harmful algal blooms and other nuisance species.

Response: With National Sea Grant support, Washington led a collaboration among the West Coast Sea Grant programs, NOAA West, the Moore Foundation and the University of Washington's Climate Impacts Group to develop an innovative framework for assessing vulnerability of fisheries to climate change. The effort culminated in a workshop attended by federal, state and tribal fisheries management agencies and members of the fishing, non-profit and academic communities. Sixty participants involved in four West Coast fisheries (canary rockfish, sablefish, Pacific whiting, and Dungeness crab) discussed climate exposure, stock and fishery sensitivities and the adaptive capacity of each fishery.

Results: Based on positive participant responses, the framework offered a useful starting point for evaluating the impacts of climate change for fisheries and, with a few alterations, could be a very successful management framework. The project laid the groundwork for West Coast fisheries managers and industry leaders to develop a more complete understanding and plan for management of the fisheries' vulnerability to climate change. NOAA Fisheries is discussing its application to other U.S. and international fisheries, and the Olympic Coast National Marine Sanctuary is building on this approach to develop its Climate-Smart Sanctuary Action Plan.

RECAP: Working with scientists, managers and fishermen, Washington Sea Grant led development of an innovative framework for evaluating the impacts of climate change on fisheries. [Back to Goals](#)

15598 - Washington Sea Grant-NOAA Fisheries Fellow uses underwater robots to improve rockfish surveys

Relevance: Pacific rockfishes (*Sebastes* spp.) are intensively managed on the U.S. West Coast. Many rockfishes prefer rocky habitats that are difficult to survey using existing bottom trawl gears.

Response: Sea Grant-NOAA Fisheries Fellow developed a new sampling method that includes information from autonomous underwater vehicles (underwater robots). The project tested sampling methods using simulation modeling and explored assumptions during a 2011 gear-comparison pilot study off the California coast.

Results: Simulation modeling showed that sampling involving these underwater robots could improve precision and accuracy of survey results, with resulting improvements for the management of many Pacific rockfishes. Results from the 2011 gear comparison study are still being processed.

RECAP: Washington Sea Grant-NOAA Fisheries Fellow led a collaborative effort to develop and test new sampling methods involving underwater robots, showing that these methods are a practical and potentially cost-effective method to improve fisheries management of rockfish off the U.S. West Coast. [Back to Goals](#)

6821 - Washington Sea Grant partnership with NOAA Fisheries trains fish plant monitors and helps protect overfished stocks

Relevance: The Pacific whiting is the single largest resource in the groundfish fishery off the coasts of California, Oregon and Washington, accounting for 84 percent of all 2008 West Coast groundfish landings. Bycatch limits for the fishery have been established to protect several species that may be

depleted, including Chinook salmon and canary, darkblotched and widow rockfish. Managers place limits on the whiting fisheries' incidental catch of such species to ensure that their populations can be rebuilt. During the fishing season, these bycatch limits are used to close a sector or sectors of the whiting fishery and can restrict the total whiting harvest. Accurate data from bycatch monitors at processing plants on the West Coast are instrumental in guiding management decisions about closures in the fishery.

Response: At the request of the NOAA Fisheries Northwest regional office, Washington Sea Grant coordinated training of Pacific whiting bycatch monitors at processing plants. Working with NOAA managers and scientists and seafood processors, Sea Grant developed a training manual, secured locations and materials for trainees and conducted two training sessions in 2010. Sea Grant also has assisted in the start-up training program for observers and monitors to implement individual fishing quotas for West Coast groundfish fisheries, beginning in January 2011.

Results: Through the program, 23 trainees passed their final exams and were deployed to West Coast processing plants in time for the start of the 2010 fishery. Data provided by the monitors is critical for maintaining the multi-million dollar fishery and preventing harm to overfished stocks.

RECAP: Washington Sea Grant partnered with NOAA Fisheries to train fish plant monitors required to operate the fisheries and protect overfished stocks. [Back to Goals](#)

[Back to Top](#)

Program Performance Measures (2010 - 2013)

Program Performance Measure	Program Plan Target (2010-2013)	Reported	Program Comments
Number of commercial and recreational fishermen and harvesters, resource managers and seafood processors who implement responsible or best management harvesting or processing techniques or practices as a result of Washington Sea Grant outreach, technical assistance, research or other activities.	1,300	13,202	2012 - 2012 includes more than 1700 fishermen who have implemented seabird bycatch mitigation measures and more than 200 tribal, non-tribal and recreational fishermen who have received training and assistance in responsible harvesting techniques. The significant increase in anticipated # for 2013 is due to an anticipated increase in use of seabird bycatch mitigation techniques in international tuna fisheries. 2013 - 2013 includes more than 9700 fishermen who have implemented seabird bycatch mitigation measures and more than 300 tribal, non-tribal and recreational fishermen who have received training and assistance in responsible harvesting techniques.
Number of producers, distributors and consumers of seafood who modify their practices using knowledge gained through Washington Sea Grant outreach, education, research or technical assistance programs relating to fishery sustainability, seafood safety or the health benefits of seafood.	1,100	5,734	2012 - 2012 includes more than 1300 consumers reached through radio programs and trained supermarket seafood counter employees nearly 150 managers modifying fishing practices to reduce seabird bycatch approximately 50 seafood distributors reached through events such as Wild Seafood Exchange and the Lark Lunch and more than 20 retailers trained in proper seafood handling. 2013 - 2013 includes more than 1000 consumers reached through radio programs and trained supermarket seafood counter employees nearly 600 managers modifying

fishing practices to reduce seabird bycatch
approximately 50 seafood distributors reached through events such as Wild Seafood Exchange and the Lark Lunch
and more than 20 retailers trained in proper seafood handling.

[Back to Top](#)

Program Objectives (2010 - 2013)

Program Objective	Achieved (yes/no)	Program Comments
By 2013, 2,000 seafood consumers will receive information to help them make more informed choices relating to sustainable seafood management practices.	Yes	2012 - (2010 = 129 2011 = 3326 2012 = 5600) Includes estimated number of seafood consumers reached through trained seafood retailers. 2013 - (2010 = 129 2011 = 3326 2012 = 5600 2013 = 3500) Includes seafood consumers reached through trained seafood retailers.
By 2013, 2,400 fishermen will gain a better understanding of or adopt practical and current approaches to reduce seabird or fish bycatch, increase the value of their catch, maintain their gear and vessels more effectively and efficiently, or respond to at-sea emergencies through Washington Sea Grant research, technical assistance or outreach.	Yes	2012 - (2010 = 885 2011 = 1379 2012 = 3642) Includes fishermen using seabird bycatch mitigation techniques and designated tow lanes to reduce gear loss and fishermen receiving marine technology training and safety at sea training. 2013 - (2010 = 885 2011 = 1379 2012 = 3642 2013 = 11,425) Includes fishermen using seabird bycatch mitigation techniques and designated tow lanes to reduce gear loss and fishermen receiving marine technology training and safety at sea training.
By 2013, 3,200 fishing industry members, boaters, planners, and coastal residents will better understand or engage in practices that mitigate stressors threatening wild fish populations as a result of Washington Sea Grant outreach, technical assistance, education, or research activities.	Yes	2012 - (2010 = 2098 2011 = 2511 2012 = 1946) Includes recreational boaters, marina operators, commercial fishermen, planners, and others reached with information and engaging in sustainable practices on topics such as water quality, small oil spill prevention, shoreline restoration and low-impact development. 2013 - (2010 = 2098 2011 = 2511 2012 = 1946 2013 = 1478) Includes recreational boaters, marina operators, commercial fishermen, planners, and others reached with information and engaging in sustainable practices on topics such as water quality, boat pumpout systems, shoreline restoration and low-impact development.
By 2013, 440 shellfish growers and tideland owners will better understand or implement sustainable harvesting, processing, monitoring, recreational or tideland	Yes	2012 - (2010 = 498 2011 = 898 2012 = 345) Includes shellfish growers and tideland owners reached through

management practices to support the viability of the Washington aquaculture industry.		technical assistance and the annual shellfish growers conference. 2013 - (2010 = 498 2011 = 898 2012 = 345 2013 = 137) Includes shellfish growers and tideland owners reached through technical assistance and the annual shellfish growers conference.
By 2013, 500 seafood and shellfish industry workers learn and understand techniques and processes that help ensure the production and delivery of safe and healthy seafood as a result of Washington Sea Grant training or technical assistance.	Yes	2012 - (2010 = 367 2011 = 130 2012 = 194) Includes seafood retailers and shellfish growers receiving training and technical assistance in seafood quality and proper seafood handling techniques. 2013 - (2010 = 367 2011 = 130 2012 = 194 2013 = 225) Includes seafood retailers and shellfish growers receiving training and technical assistance in seafood quality and proper seafood handling techniques.
By 2013, 670 tribal and non-tribal fishermen, seafood dealers, and seafood buyers contribute to the value or availability of the seafood supply as a result of Washington Sea Grant training, outreach, research or marketing events.	No	2012 - (2010 = 120 2011 = 147 2012 = 175) Includes tribal and non-tribal fishermen and seafood distributors and buyers receiving marketing and technical assistance. While activities in this area have significantly increased the value of the catch for those reached and resulted in a new tribal seafood market, we have reached fewer people than originally anticipated. 2013 - (2010 = 120 2011 = 147 2012 = 175 2013 = 187) Includes tribal and non-tribal fishermen and seafood distributors and buyers receiving marketing and technical assistance. While activities in this area have significantly increased the value of the catch for those reached, we have reached fewer people than originally anticipated (over the four years, we reached approximately 600 people).
By 2013, 7,300 seafood consumers receive information about the nutritional benefits or safety of seafood or the importance of product handling and storing methods to inform seafood purchases.	Yes	2012 - (2010 = 1629 2011 = 11,446 2012 = 11,840) Includes seafood consumers reached through trained seafood retailers, radio programs, newsletters and brochures such as "Gathering Safe Shellfish and Nutritional Value". 2013 - (2010 = 1629 2011 = 11,446 2012 = 11,840 2013 = 4400) Includes seafood consumers reached through trained seafood retailers, radio programs, newsletters and brochures such as "Gathering Safe Shellfish and Nutritional Value".