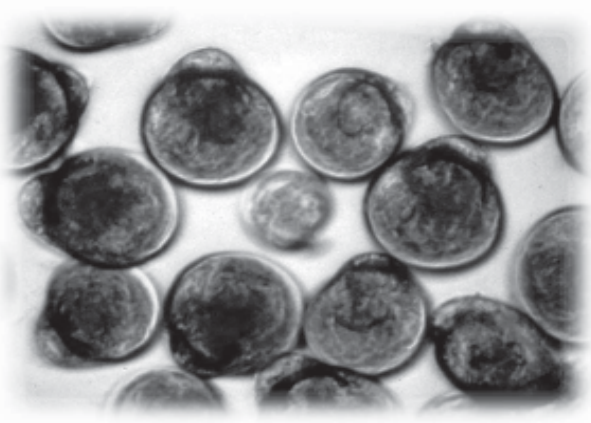
West Coast Shellfish Research and Education 2015 Goals and Priorities



Pacific Shellfish Institute
Pacific Coast Shellfish Growers Association
National Shellfisheries Association/
Pacific Coast Section

Prepared by the
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Olympia, Washington
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Introduction

The West Coast shellfish industry, tribal entities and fisheries agencies are faced with numerous opportunities and challenges in the new millennium. Recent advances in shellfish hatchery, nursery and grow-out technologies provide for the enhanced production of currently cultured species, the culture of new species and restoration of wild stocks. These are made possible by combined private, tribal and public sector research, education and training efforts. Coupled with technological advancements are international and national policies and programs calling for the support and development of robust, environmentally sound aquaculture practices.

In light of these opportunities and challenges, the Pacific Shellfish Institute (PSI) encourages shellfish growers, tribes, agencies, and the shellfish research community to establish goals for the year 2015 and the research priorities necessary to achieve them. These goals and priorities are used by the PSI Board of Directors as they coordinate PSI's research, education and training efforts. They are also circulated by the PSI to various research institutions, granting entities and resource management agencies with a request for their assistance in completing the initiatives and research priorities. PSI is a 501(c)(3) private nonprofit organization created in 1995 to develop and disseminate scientific and technical information of value to the general public, shellfish farmers, and public officials in connection with shellfish-related environmental and animal/human health and safety issues.

This document began in 1999 as the 2010 Goals Initiative, prior to this there was little effort to identify and prioritize shellfish research needs. Research institutions were criticized for not responding to public and private sector needs. Yet, with the limited input from industry, tribes and agencies that these institutions received, this criticism was probably not well deserved. The 2015 Research and Education Goals and Priorities report is an update and expansion of the 2010 document.

To this end, round table efforts and smaller group workshops were facilitated. The first was at the October 1998 joint annual meeting of the Pacific Coast Shellfish Growers Association (PCSGA), British Columbia Shellfish Growers Association and the National Shellfisheries Association (Pacific Coast Section) in Nanaimo, British Columbia. Follow-up west-coast meetings were held in 1999, in early to mid-2003, and again in late 2005 to early 2006 with input from industry, tribal, research, and government agency leaders from up and down the coast. During the initial meetings, breakout groups representing different categories of research needs established goals and priorities. These were revised and updated in subsequent meetings.

This document will continue to evolve as research needs are met and/or re-evaluated. Researchers interested in addressing priority shellfish research projects are encouraged to contact PSI, their state Sea Grant or aquaculture extension representative, local shellfish grower/harvester, tribal organization, and other appropriate parties. PSI maintains a catalog of grant funding sources for shellfish related research which can assist in research planning.

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Note: Research needs or initiatives following each stated goal are prioritized as: High (H), Medium (M), Low (L), or Pending (highlighted).

1. Domestication of Established Shellfish Species on the West Coast

1.1. GOAL – Continue to build an effective Pacific oyster breeding program with selective breeding and/or crossbreeding and more fully support it by the industry.

Rationale

This research is crucial for maintenance and expansion of the shellfish industry. Two USDA-funded oyster breeding programs are either ongoing or transferred to industry in addition to the USDA-ARS program on shellfish genetics based at the Hatfield Marine Science Center (OSU). Both breeding programs, one focused on selection (MBP) and the other on crossbreeding of inbred lines have shown excellent results. Parts of these programs will need to be financially supported by industry to ensure long-term genetic improvement of oyster broodstock. The adoption of the breeding program by industry may entail a continuation of the use of facilities at the Hatfield Marine Science Center (OSU) or the establishment of a broodstock/breeding center located at a new (or existing) commercial facility.

Industry facilities are also placing greater emphasis on triploid oysters. Triploid oysters produced from tetraploids have demonstrated increased growth as they are an established part of commercial production. Continued research on developing lines of tetraploid oysters as a part of ongoing genetics programs is needed.

Research Needs/Initiatives (priority in parenthesis)

1.1.1 (H) Support breeding programs to enhance resistance to disease and summer mortalities, yields, shellstock characteristics and marketability of Pacific oysters for the commercial oyster industry. Include funding and political support to maintain current programs.

1.1.2 (H) Support genomic research, QTL-mapping, development of markers for selection and purging of deleterious mutations, development of BAC libraries and micro-arrays, sequencing the Pacific oyster genome and other biotechnology research on improving oyster broodstock.

1.1.3 (H) Support research on improvement of tetraploid oysters to develop genetic lines, enhance their performance, stability of chromosome number (3N), and use for producing all triploid oysters.

1.1.4 (H) Expand outreach programs via State Sea Grants, PSI, PCSGA and other organizations to enable determination of the performance of genetic lines as they pass through the hatchery, nursery and grow-out to market, including improvements in line testing technologies.

1.1.5 (M) Develop a commercial repository for genetically valuable broodstock to increase their availability and use by commercial interests including the means to cryopreserve and store sperm, eggs and embryos.

1.2. GOAL - Establish techniques for increasing the level of domestication for other shellfish under cultivation by the shellfish industry.

Rationale

Improvement of non-native shellfish other than Pacific oysters currently under cultivation by the shellfish industry is desired and include Kumamoto oysters (*Crassostrea sikamea*), Eastern oysters (*C. virginica*), Suminoe oysters (*C. ariakenesis*) and European flat oysters (*Ostrea edulis*), Manila clams (*Tapes phillipinarum*) and Mediterranean mussels (*Mytilus galloprovincialis*). Long grow-out periods, losses due to disease and other mortality factors, and seasonal problems with marketability of product contribute to high costs of production, product loss and reduced market share on an annual basis.

Research Needs/Initiatives (priority in parenthesis)

1.2.1. (H) Maintain the genetic integrity and diversity of commercially important species that comprise small populations. These include Eastern, European flat, Kumamoto and Suminoe oysters.

1.2.2. (H) Develop an industry-based breeding program, focusing on selection and/or crossbreeding and polyploidy, for developing lines of higher yielding Manila clams.

1.2.3. (H) Develop an industry-based breeding program focusing on selection and/or crossbreeding and polyploidy for developing lines of higher yielding Kumamoto oysters.

1.2.4. (M) Develop methods to produce mated triploid (from tetraploid) Manila clams for sale during the summer months.

2. Shellfish Health, Disease Prevention and Management

2.1. GOAL -- Develop disease prevention, surveillance and treatment strategies to ensure the production of high health shellfish which meet domestic and international health standards and maximize production efficiencies.

Rationale

The ability to grow healthy, disease-free shellfish is of basic importance to any successful commercial shellfish operation. However, many tasks remain to be completed in order to better identify, understand, and control the disease processes affecting shellfish in hatcheries, nurseries, and growout beds and to ensure that healthy shellfish can be transported freely to meet market demand. Examples include: 1) increasing production efficiency in hatcheries and nurseries and ensuring the products are disease free; 2) conducting risk analysis and risk management assessments of reportable shellfish diseases and better understanding of the actual risk of spread and impact of such diseases; 3) maintaining the system and healthy shellfish which permit products to be exported to foreign markets and sold in domestic markets including the industry sponsored Shellfish High Health Program Guideline; 4) reducing mortality losses of Pacific oysters and other species and developing strategies to manage healthy shellfish production under a variety of environmental conditions.

Research Needs/Initiatives (priority in parenthesis)

2.1.1 (H) Determine the specific nature of hatchery and nursery pathogens of all types, including viruses, fungi, bacteria and parasites, of all important cultured shellfish species and provide means to diagnose the type, source and hatchery location of these pathogens. Include evaluation of hatchery methods, protocols and nutrition on shellfish larval and seed health.

2.1.2 (H) Determine prevention and management methods for hatchery and nursery bacterial pathogens including: development of probiotics, assessment of water quality factors that influence pathogens, nutrition, and hatchery methods that can be used to prevent and manage infectious diseases in shellfish hatcheries and nurseries. Emphasize the development of preventative measures to promote hatchery health and devise specific strategies for maintaining healthy animals in hatcheries.

2.1.3 (H) Develop a protocol for testing shellfish larvae for infectious diseases to demonstrate their disease free status and ensure their specific pathogen free certifiability. Determine if larvae can, in fact, carry diseases of concern that occur in adult shellfish.

2.1.4 (H) Develop a strategy for and implement research to establish a hatchery stress test to predict future survival. Test for dissolved oxygen tolerance, salinity tolerance and other parameters of importance for various species.

2.1.5 (H) Develop, and encourage regulatory authority acceptance and application of established risk assessment and risk management procedures for shellfish transfers and disease assessment.

2.1.6 (H) Develop a test site for Denman Island disease prevalence determination, using a site identified as positive and use this site for an eradication test and test of Denman Island disease to disease free oysters. Careful consideration should be given to selecting an appropriate site.

2.1.7 (H) Determine how Denman Island disease is transmitted and if it is a disease only of old oysters in the natural environment.

2.1.8 (H) Establish a more certain and effective PCR test for Denman Island disease and conduct research to consolidate pathogen tests in order to reduce cost of testing.

2.1.9 (H) Conduct shellfish disease risk assessment and risk management evaluations for haplosporidiosis and other infectious diseases known to occur in West Coast shellfish populations, with priority given first to OIE listed

diseases and secondly to other diseases of concern either to state or federal management agencies or to the industry. Develop a priority list of diseases for risk assessment prior to conducting the risk assessment and management process.

2.1.10 (H) Maintain the regional capability for the prevention and management of infectious shellfish diseases that is necessary to maintain export certification for live shellfish larvae, seed and broodstock. Maintain the working relationship with the Animal and Plant Health Inspection Service (A.P.H.I.S.) of the U.S. Department of Agriculture to facilitate export of disease free live shellfish products.

2.1.11 (H) Continue efforts to improve interstate coordination in regard to health and certification requirements for shellfish movements in order to promote the sale of disease-free larval, seed and brood stock shellfish. Expand this effort to include shellfish grower outreach, including information and education for growers in regard to interstate health and certification requirements.

2.1.12 (H) Determine the role of algal toxins both in oyster production areas and in hatcheries as they are related to mortality and poor performance.

2.1.13 (H) Continue and expand the monitoring of adult and seed shellfish diseases in growing areas. Continue and expand oyster monitoring program to sites in all West Coast states and continue for several years. Develop similar programs for other species, specifically clams and mussels. Include the development of area specific mortality prevention in this task. This includes several items:

- Continue oyster mortality study
- Develop clam mortality study
- Develop mussel mortality study

2.1.14 (M) Develop better methods for parasite and commensal disinfection of shellfish seed as a means to improve quality and facilitate interstate transport.

2.1.15 (H) Conduct wild stock surveys for infectious diseases in order to determine true geographic distribution and aid in management of the diseases.

2.1.16 (M) Determine disease resistance of true lines of oysters in comparison to hybrid lines. Include development of methods and testing to determine susceptibility to infectious diseases and to differentiate animals with disease resistance. This may be a very important issue but would be most useful once there is a more definitive identification of lines of oysters selected by the industry.

2.1.17 (M) Use PSI web site for dissemination of information on shellfish mortalities. Include existent PSI data and continuously add new data that is generated by PSI.

3. Shellfish Ecology

3.1. GOAL --Promote and implement an industry Environmental Management System (EMS) patterned on the International ISO 14001 program. Establish and maintain a reputation as responsible stewards of the estuarine environment with the public, resource management agencies, tribes and the environmental community.

Rationale

The West Coast shellfish industry is under ever increasing regulatory scrutiny as a result of salmon listings under the Endangered Species Act, the Sustainable Fisheries Act and associated identification and protection of essential fish habitat (EFH). Increasingly, the general population is demanding that forests, riparian areas, beaches and other wildlife habitats be preserved and enhanced. The animals that are cultured by the shellfish industry are an integral part of the marine ecosystem, and commercial shellfish growers are clearly dependent upon a healthy ecosystem. The British Columbia Shellfish Growers Association and the Native American Tribes have expressed a strong interest in being involved in any shellfish ecology efforts as well. The Environmental Management System (EMS) consisting of an Environmental Policy (EP) and an Environmental Code of Practice (ECOP = Best Management Practices) prepared by PCSGA in 2002 will be crucial to the survival and continued prosperity of the shellfish industry.

Research Needs/Initiatives (priority in parenthesis)

3.1. GOAL - Promote the shellfish industry Environmental Policy (EP)

Rationale

The Environmental Management System (EMS) consisting of an Environmental Policy (EP) and an Environmental Code of Practice (ECOP = Best Management Practices) prepared by PCSGA in 2002 will be crucial to the survival and continued prosperity of the shellfish industry.

3.1.1 (H) Promote and implement the shellfish industry Environmental Code of Practice (ECOP = Best Management Practices) which implements the EP and addresses regulatory, environmental and tribal concerns and supports sustainable aquaculture. Provide training opportunities and certification for growers, possibly through services of PSI, using a variety of tools such as brochures, hands-on workshops, and multi-lingual presentations.

3.1.2 (H) Promote waste reduction and recycling procedures for the shellfish industry that are linked to on-going production methods and proactive public/NGO organization education. Expand participation with marine-focused organizations (such as tribes, environmental groups, marine resource committees) in beach clean-ups throughout Puget Sound, most notably to retrieve and recycle or properly dispose of all derelict or lost shellfish aquaculture equipment and materials.

3.1.3 (M) Implement an outreach program, including web page, workshops, and educational “field days” to educate growers and resource managers on ECOP. Outreach to the public through PCSGA events and regional forums with growers.

3.1.4 (M) Establish a process to monitor implementation and evaluate effectiveness of the ECOP. Train growers to implement ECOP, certified under the Pacific Coast Shellfish Certification Council. Using a brief summary form tailored so a range of employees can understand, include different languages.

3.1.5 (M) Establish a process to periodically update the ECOP as science and technology find new economical and environmentally sensitive practices.

3.2. GOAL – Improved regulatory stability for the shellfish industry.

Rationale

The Endangered Species Act and other regulatory vehicles have resulted in uncertain futures for shellfish farmers. The rules and regulations being applied to commercial shellfish growers can change frequently. As regulations become more numerous and compliance more costly there exists the possibility that growers, especially the smaller operations, will find it an economic impossibility to remain in business. There is a critical need for regulatory stability and predictable futures for this predominantly small business industry.

Research Needs/Initiatives (priority in parenthesis)

3.2.1 (H) Explore options under the Endangered Species Act (ESA) Sections 7 and 10, to develop a regional general permit in cooperation with the Army Corps to provide growers with protection from prosecution under the ESA, Clean Water Act, Rivers and Harbors Act and Marine Mammal Protection Act. Educate growers on acceptable/preferred practices related to culture methods possibly through a grant by PCSGA. Consider options and funding for PSI to host periodic training sessions that would be targeted at growers and their employees.

3.2.2 (M) Establish connections to the regulatory community through a special committee within PCSGA. Logical first steps might include:

- Contacting Washington Department of Ecology's Permit Assistance Center (PAC) . Encourage grower members to be trained or informed of new guidelines and regulations at workshops or the annual PCSGA meeting, and 'on line' through PSI and PCSGA.
- Seek a streamlined process for local, state and federal permits and request PSI to engage regulators in this objective.
- Educate the regulatory community about the various growing techniques, harvesting and processing measures used by the industry to assure product safety and maintain a sustainable business.Growers might consider a uniform and recognizable way to mark their ground, such as buoys or marker-stakes.

3.3. GOAL - Ecological impacts (positive and negative) associated with shellfish growing and harvesting, should be documented, understood, and incorporated into the shellfish industry Environmental Management System (EMS).

Rationale

Cultured shellfish are an integral part of estuarine ecology. Much of the existing West Coast research examining the role that shellfish play in the estuary has focused upon the negative impacts associated with commercial shellfish culture. Much of the current research is targeting burrowing shrimp control and eelgrass impacts. Little is understood about the positive effects that shellfish culture activities have on estuarine ecology such as its role as possible EFH. It is crucial to the development of an effective EMS that industry and resource managers have a clear understanding of the role these cultured shellfish play in the ecosystem. In particular, this work must focus on issues and problems where the industry is most vulnerable.

Research Needs/Initiatives (priority in parenthesis)

3.3.1. (H) Establish a research data base related to shellfish ecology. Document benefits and problems associated with different growing methods commonly used by the shellfish industry. Collect biological and other scientific data that's relevant and associated with different growing practices using best available science. Publish the data in scientific journals, and make the information available on PSI and PCSGA's web sites. Seek opportunities to inform the resource managers and elected officials at such venues as research conferences, public meetings, grower conferences and agency work sessions.

3.3.2. (H) Identify gaps in current understanding of shellfish ecology specific to West Coast ecosystems and pursue research to fill those gaps. The final goal is to gain a clear understanding of the ecological impacts associated with:

- Oyster culture - bottom, rack and bag, bag, intertidal longline, stake, suspended (longline, tray, lantern net, bag), mechanical dredge harvesting as well as culture of native Olympia and assorted non-native species.
- Clam (Manila & native) culture - bottom and bag, hand and mechanical harvesting.
- Mussel culture - suspended raft & long line, *Mytilus galloprovincialis* and *M. trossulus*.
- Geoduck culture - intertidal, subtidal, hydraulic harvesting (intertidal geoduck), predator exclusion.
- Other species not yet commonly grown for aquaculture purposes.
- Integrated Pest Management (IPM) of burrowing shrimp, European green crab, red rock crab, Dungeness crab, shore crab, diving ducks, starfish, oyster drills, gulls, crows and moon snails by the use of deterrents, exclusion or destruction.
- Substrate modification (cultching, graveling, tilling, harrowing, mowing).
- Carrying capacity - modeling of intensively cultured estuaries and an understanding of key phytoplankton species affecting growth, health and survival of shellfish (look at models developed in France, New Zealand, and Maine).

3.3.3 (L) Determine optimal densities for beach seeding of clams in regard to sustaining production and beach condition (particularly in reference to geoducks). This has potential regulatory implications in regard to geoduck seeding regulations. This could move to a higher priority as the geoduck grow out industry develops.

3.3.4 (H) Determine appropriate substrate for growing clams (focusing on Manila clams initially). Currently clams can be grown in a wide variety of substrates but it has yet to be determined which is optimal

3.3.5 (H) Verify environmental benefits using science not public perception.

3.4. GOAL – Establish "In-house" capability for the industry to evaluate water quality, currents, and general marine biological conditions in hatcheries and growing areas.

Rationale

Growers need to be able to identify possible water quality problems within their watersheds. They also need the ability to economically evaluate ambient environmental conditions and water quality parameters as they establish new growout beds, intensify cultivation levels, and expand hatchery/nursery production.

Research Needs/Initiatives (priority in parenthesis)

3.4.1. (H) Make available monitoring equipment (current, salinity, temperature, dissolved oxygen, plankton etc.) to growers with technical assistance to use it.

3.4.2. (H) Establish a centralized data base/web page for water quality data - link to state shellfish control authority's water quality data from certified growing waters. PSI to establish a database and link to web sites for water quality information. Examples might be to link to Washington Department of Health's shellfish growing water status and trends, Washington Department of Ecology's Marine Water Quality Monitoring and the University of Washington's marine water quality investigations.

3.4.3. (M) Coordinate with programs and projects designed to collect water quality data, and make marine species observations. Encourage PSI and interested growers to connect with citizen groups that collect data/make observations of marine life, macro-algae, temperature and salinity (where possible), unusual plankton blooms.

3.4.4(M) Study and evaluate the acute and chronic effects of upland restoration projects on hatcheries, nurseries and growout areas downstream. Short term water quality effects may have large scale effects on early, middle and late life stages of shellfish.

3.5. GOAL – Prepare the industry for oil spills by training, education, the development of contingency plans and the inclusion of shellfish beds into state and federal response plans.

Rationale

Adult shellfish, their larvae and food are vulnerable to the effects of oil spills from tainting to mortalities. Growers need to be aware of ways to prevent and mitigate these effects by increasing their knowledge on oil spill prevention, response and cleanup. Since all spills can have an effect, growers need to be responsible for reducing and cleaning up their own spills.

3.5.1 (H) Provide spill prevention training/equipment to shellfish growers to enable them to eliminate and respond to their own spills/leaks.

3.5.2 (H) Provide information sessions/training describing current oil spill response strategies and possible pre-emptive measures.

3.5.3 (H) Complete GIS layer of shellfish beds and incorporate into state and federal response plans.

3.5.4 (H) Assist growers in adding current and relevant data for post spill claims.

3.5.5 (H) Offer Hazardous Waste and Emergency Response (HAZWOPER) training and provide oil spill drills for growers to enhance their spill response skills and ensure their safety. These training workshops will be held in key shellfish farming areas across the state.

3.5.6 (H) Help growers develop specific oil spill response plans for their harvest area.

4. Aquaculture, Enhancement and Restoration of Native Shellfish

4.1 Goal – Establish hatchery, nursery and grow-out techniques for rearing shellfish species with current or emerging potential for private, public and tribal shellfish aquaculture, enhancement, restoration and mitigation.

Rationale

Hatchery techniques need to be developed and refined to rear native species of shellfish for purposes of aquaculture, enhancement and restoration. Development of maturation and conditioning techniques, spawning and larval rearing, nursery techniques and planting/distribution methods are critical to establish prior to large-scale seed production by public and private hatcheries. For stocks intended for ecological restoration, genetic integrity of native stocks should be investigated and preserved, and strategies developed to minimize any negative hatchery impacts on wild populations from stocks. Recent research indicates that shellfish (especially bivalve mollusks) contribute greatly to the overall health of near-shore environments by providing habitat to other organisms and by serving as a means of cycling nutrients through the system. Consequently, hatcheries are facing new demand for native shellfish species, both for increased quantities and a greater variety of species. More work is needed to determine the effectiveness and feasibility of using hatchery produced shellfish in mitigation and restoration projects and methods for determining the carrying capacity of embayments supporting shellfish culture and wild fisheries.

Research Needs/Initiatives (priority in parenthesis)

4.1.1 (H) Conduct studies to evaluate the genetic structure, distribution and temporal changes in populations of Olympia oysters, native clams (butter, native littleneck, horse, razor and geoduck), cockles, scallops and other native species including abalone, in order to evaluate the risk of using hatchery-propagated seed for aquaculture, enhancement and restoration purposes.

4.1.2 (H) Develop culture techniques for producing native species not currently available for commercial aquaculture or enhancement purposes that minimize the risk of genetic interactions between hatchery propagated and wild populations. The development of triploids and other means for sterilizing adults are important to pursue.

4.1.3 (H) Develop hatchery, nursery and grow-out techniques for the large-scale enhancement of public and tribally controlled tidal and near-shore habitats, including the development of methods for mass marketing of shellfish produced for enhancement purposes.

4.1.4 (H) Investigate use of hatchery-cultured shellfish as a means of contributing to the effectiveness and efficiency of mitigation and restoration efforts in tidal and near-shore habitats.

4.1.5 (H) Investigate effects of culturing hatchery derived geoduck clams on native geoduck stocks, including research on age of first reproduction, the effects of triploidly for inducing sterility and the use of selective breeding in triploid geoduck for potential stock improvement.

4.1.6 (H) Quantitatively document water quality improvements that result from shellfish aquaculture, i.e. nitrogen removal, benthic/pelagic coupling, nutrient recycling, reduced turbidity.

4.1.7. (H) Develop a PCSGA Farmer Assistance Program to partner in the creation of “new species” development.

4.1.8 (M) Conduct studies to document the ecological benefits of native shellfish enhancement and restoration (i.e. the “oyster-salmon connection”).

4.1.9 (L) Identify and address other potential risks associated with reintroduction of native species, i.e. disease and impacts on other native species.

5. Pest/Predator/Prey Control, Monitoring and Interactions

5.1. GOAL - Manage burrowing shrimp on shellfish tidelands.

Rationale

An Integrated Pest Management (IPM) plan will enable the shellfish industry to manage burrowing shrimp in an effective, ecologically sound, and economically feasible manner. A comprehensive framework for the plan was developed in April 2003 that includes descriptions of relevant concepts, definitions and goals, references, lists of principal authorities and policies, and five interconnected key IPM elements: 1) funding, 2) research & development, 3) implementation, 4) evaluation/regulatory compliance, and 5) dissemination. A place for timelines toward IPM development and implementation was included but not complete in the April 2003 framework. In short, the IPM plan is designed to be a "living document" as directed in the original Memorandum of Agreement between the Growers Association and several state agencies that mandated its development. A political agreement to terminate the use of carbaryl to manage burrowing shrimp by 2012 has promoted all IPM initiatives to high priority levels. While recent research initiatives have enhanced the ability to address this goal, it remains a high priority for continued work.

Research Needs/Initiatives (priority in parenthesis)

5.1.1 (H) Evaluate alternative (biological, physical and chemical) tactics and their impacts to manage burrowing shrimp under a controlled experimental regime.

5.1.2 (H) Increase accuracy and precision of monitoring techniques. Expand monitoring program to better assess and forecast shrimp densities on all commercial beds.

5.1.3 (H) Investigate burrowing shrimp ecology to increase knowledge about potential control mechanisms, document the impact of burrowing shrimp on shellfish culture and existing communities, and determine underlying reasons for increased burrowing shrimp populations.

5.1.4 (H) Determine the economic thresholds and action levels associated with differing burrowing shrimp densities, sediment types, control techniques, and oyster culture methods.

5.1.5 (H) Develop a strategy featuring reduced rates, alternative delivery systems, or spot treatment to transition from conventional carbaryl-based management towards the developing IPM plan.

5.1.6 (H) Respond to and integrate regulatory requirements into the plan.

5.1.7. (H) Implement the plan using newsletters, grower workshops, and surveys.

5.1.8. (H) Disseminate the plan to the general public.

5.2. GOAL - Eradicate Spartina from Willapa Bay, Puget Sound and Grays Harbor.

Rationale

Spartina is a non-native invasive plant that is well established in several California embayments and is rapidly colonizing portions of Puget Sound, Grays Harbor, and Willapa Bay. Infestations in the latter are currently high enough to generate a seed source that could accelerate the spread of Spartina throughout the northern Pacific coast. Due to the particular nature of West Coast estuaries, Spartina encroaches on shellfish and wildlife habitat, alters tidal flow and promotes sedimentation of shallow intertidal areas. Spartina expansion has been moderately suppressed using conventional herbicides applied using traditional technologies. Current and future research includes the assessment of novel herbicides, more accurate and precise herbicide application technologies, and mechanical and biological controls.

Research Needs/Initiatives (priority in parenthesis)

5.2.1 (H) Promote and continue research on methods to reduce the size and rate of *Spartina* infestation, including biological control and advanced physical and chemical controls.

5.2.2 (M) Examine process and ability to re-claim land after *Spartina* has been removed

5.2.3 (M) Support and contribute to IPM plan development.

5.3. GOAL – Work toward preventing the spread and establishment of invasive non-native species.

Rationale

The introduction and establishment of the invasive non-native species in the U.S. is a serious and complex problem that needs to be addressed in a comprehensive and coordinated fashion.

Research Needs/Initiatives (priority in parenthesis)

5.3.1 (H) Support and encourage coordinated state and local programs to monitor and control current non-indigenous specie invasions and to prevent the introduction of new unwanted species in West Coast states.

5.3.2 (L) Develop alternative control methods to limit the spread and colonization of green crab populations and minimize impacts on other species.

5.3.3 (H) Coordinate the public education activities for preventing the establishment of invasive non- native species by producing fact sheets and informing the media of new developments.

5.3.4 (L) Determine the timing of settlement by green crabs using larval collectors near likely settlement areas.

5.3.5 (L) Determine possible impacts of green crabs to oyster and clam culture and study ways which various culture practices can be used to reduce or eliminate these impacts. Coordinate the public education activities for preventing the spread of green crab and establishment of other non-native species.

5.4. GOAL - Incorporate monitoring and control of shellfish pests, predators, seagrasses and macroalgae into an all encompassing Integrated Pest Management Plan (IPM) and examine emerging Ecologically Based Pest Management (EBPM) ideas and methods.

Rationale

Research is needed to develop better methods of preventing the colonization and spread of native and exotic pests as well as the predators of cultured shellfish. The other pests and predators which require varying levels of control by farmers include various species of crab, oyster drills, slipper shells, starfish, moon snails, perch and waterfowl.

Urbanization of shorelines surrounding traditional shellfish growing areas and the resulting nutrient runoff from yard fertilizers, domestic animal waste, failing septic systems and sewage treatment plants is theorized by some scientists to be generating increased blooms of macroalgae. Sea lettuce (Ulva spp.) and Enteromorpha spp. are opportunistic users of nitrogen and are coating the beaches and shellfish crops during the summer months with increased frequency, causing loss in shellfish crops.

Eelgrass (*Zostera marina* and *Z. japonica*) beds are dynamic colonizers and respond to a variety of physical and environmental variables. While some farming practices adversely impact eelgrass, others, including control of burrowing shrimp, promote the establishment of both eelgrass species. Growers and researchers have observed the presence of the exotic eelgrass, *Z. japonica*, to be increasing on many traditional shellfish beds. Current resource management policy inflexibly protects all eelgrass beds, including shellfish beds colonized by eelgrass as a result of the culture activities. The policy requires commercial growers to adopt more expensive cultural tactics, or even abandon traditionally vigorous beds. In such cases, the eelgrass may not survive those changes.

Research Needs/Initiatives (priority in parenthesis)

5.4.1 (H) Investigate and implement methods to identify and quantify the impact of pests, predators, and their indigenous natural enemies.

5.4.2 (H) Evaluate environmentally sensitive and relevant management tactics, beginning with the establishment of a data base of current investigations world-wide.

5.4.3 (H) Work with federal, state, local, and tribal resource management agencies to establish a seagrass policy which recognizes both the positive and negative aspects of grower activities. This new policy should provide for the management of beds based on the conservation and protection of estuarine habitat rather than the traditional policy based on no net loss of eelgrass. Educate public and resource agencies regarding the differences between native (marina) and non-native (japonica) eelgrass and assure policies do not require protection of non-natives.

5.4.4 Distribute catalog of control mechanisms and alternative tactics that have been tested.

6. Human Health and Shellfish

6.1. GOAL – Develop an ability to predict changes in toxic phytoplankton and bacterial levels in the water and sediments.

Rationale

Toxic phytoplankton and excessive bacteria levels can close shellfish growing waters very quickly. Occasionally toxin or bacteria levels increase so rapidly that contaminated product escapes detection, getting into the market place and causing illnesses. Once detected these products need to be recalled. The illnesses and recall process not only erode consumer confidence in the products but also represent a considerable expense for the shellfish grower. Inexpensive tools which would allow the early and rapid detection or prediction of developing blooms or increasing bacteria levels would prevent unnecessary illnesses and recall situations. It would also allow growers the opportunity to manage around the closures by shifting to new harvest areas or by supplying alternative product.

Research Needs/Initiatives (priority in parenthesis)

6.1.1 (H) Communicate economic impacts of marine biotoxins to funding sources to encourage additional research funding.

6.1.2. (H) Develop rapid identification tools for toxins such as PSP, including field kits.

6.1.3 (H) Expand Pacific Shellfish Institute/ISSC project to identify *Vibrio parahaemolyticus* triggers, abundance and implications for management of harvesting.

6.1.4 (M) Collect information about virulent species, abundance and prevalence. Build comprehensive database for phytoplankton occurrences.

6.1.5 (M) As commercial or recreational energies are focused on new shellfish species, assure that the harmful algae bloom relationships in these species are understood. Identify how HABs affect them, and how absolute levels of toxins differ among shellfish species.

6.2. GOAL - Improve public understanding of shellfish pathogens and good shellfish handling practices.

Rationale

Many shellfish borne illnesses are the result of individuals mishandling shellfish after they have purchased it in a retail outlet or harvested it recreationally. A public education campaign could reduce the number of illnesses associated with this mishandled product.

Research Needs/Initiatives (priority in parenthesis)

6.2.1 (H) Improve public understanding of shellfish pathogens and good shellfish handling practices.

6.3. GOAL - Improve food handlers' understanding of shellfish pathogens and good shellfish handling practices.

Rationale

The National Shellfish Sanitation Program (NSSP), which governs the activities of commercial shellfish operators, ensures that commercial growers possess a reasonable understanding of good shellfish handling practices. Retail marketers and restaurant workers often do not have this same level of understanding. Shellfish-borne illnesses are often associated with mishandling of the product once it is in the distribution system.

Research Needs/Initiatives (priority in parenthesis)

6.3.1 (H) Improve food handlers understanding of shellfish pathogens and good shellfish handling practices. Work through local health departments and the Conference for Food Protection to disseminate this information.

6.3.2 (H) Transporters, retailers and consumers need to be educated on means to reduce time temperature abuse of shellfish.

6.4. GOAL - Improve tools to identify specific pollution sources.

Rationale

When growing areas are impacted by fecal coliform bacteria, it has historically been very difficult to determine the source and to quantify it. The result is a broad, expensive, slow, non-targeted assault on all non-point source pollution (birds, waterfowl, livestock, failing septic systems, storm water runoff etc.). Recently new microbial source tracking methods are being used to trace fecal coliform bacteria back to the source. While this has been helpful, there is not yet a technique available which can be used to quantify the contribution, nor does it assess the human health risk associated with the source. These techniques have advanced in the last few years and quantification is now possible, although it is still in the research phase.

Research Needs/Initiatives (priority in parenthesis)

6.4.1 (H) Support on-going and new research to identify specific pollution sources (for protection and restoration/remediation).

6.4.2 (H) Support research that determines the human health risk associated with various sources of pollution.

6.5. GOAL -- Improve indicators of contamination to identify potential for human health impacts.

Rationale

Fecal coliform bacteria, the current indicator organism used to classify shellfish growing waters, is present in the feces of all warm blooded animals. This indication does not, however, correlate well with the presence of human pathogens and human health risk. Indicators that are more directly representative of human health risk have been desired by the industry for many years.

Research Needs/Initiatives (priority in parenthesis)

6.5.1 (H) Promote and monitor progress of indicator studies. Obtain EPA study of 2004 to identify and prioritize additional research needs as appropriate. Monitor state protocols to determine value of enterococcus for shellfish growing areas.

6.5.2 (M) Determine if water quality monitoring for fecal coliforms is a good indicator of bacterial and viral safety of product.

6.6. GOAL - Improve epidemiology/reporting systems to identify accurate level of problems so the effectiveness of management controls can be identified.

Rationale

Typically, only a small percentage of shellfish-borne illnesses are reported. Many shellfish illnesses result in gastroenteritis and individuals often are not ill enough to seek medical attention. When they do report an illness to a local health authority, they are often reluctant to submit a stool sample, which is essential for verification. Different states have different reportable diseases resulting in inconsistent reporting. Reporting problems exacerbate the epidemiological investigation of the illness outbreaks and complicate assessment of the effectiveness of management controls.

Research Needs/Initiatives

6.6.1 Encourage the institution of a nationwide policy, based upon that of Washington State, which requires mandatory reporting of shellfish-borne illnesses to local health departments and the State/Provincial shellfish authority by healthcare workers.

6.6.2 Review Wastewater Treatment Emergency notifications (WWTP), and closure and recall protocols to make sure they are being followed by all partners including state and local health jurisdictions. Recommend mock exercises.

6.6.3 Determine what types and numbers of illnesses are associated with shellfish products. What pathogens European and Asian countries are monitoring for, and whether their requirements equivalent to the US?

6.7. GOAL - Improve understanding of dynamics of Paralytic Shellfish Poisoning (PSP) accumulation in geoducks and other bivalve shellfish species.

Rationale

Since 1996, Washington Department of Health (DOH) has utilized the visceral ball of the geoduck in the PSP analysis. Prior to that time, only the siphon had been tested, as this was thought to be all that was consumed. Because the visceral ball of clams concentrates PSP toxins to a far greater degree than does the muscle tissue - and since it is now known that a segment of the market consumes the gut ball as well as the siphon - DOH determined it was necessary to use the visceral mass as the more conservative basis of the PSP test. The result has been increased closures and a high degree of variability in PSP results within the same harvest lot. During 1998 there were eight product recalls in Washington related to PSP infected geoducks. A clearer understanding of PSP dynamics in geoducks and other bivalve shellfish species is essential to adequately protect public health and minimize economic impact to the industry.

Research Needs/Initiatives (priority in parenthesis)

6.7.1 (H) Encourage further research on PSP in geoduck, looking at variables such as depth, harvesting effects, seasonality, water column, intertidal vs. subtidal, cultured vs. wild, and age variability.

6.7.2 (H) Encourage further evaluation of the risk assessment associated with PSP and other toxins levels currently established in the National Shellfish Sanitation Program and current methods of testing.

6.7.3 (H) Conduct ecosystem based studies to provide insight into increased PSP toxin levels in all bivalve species, as a tool to identify mitigation methods.

6.7.4 (H) Encourage further research on PSP retention and depuration for geoduck clams and other bivalve species.

6.8. GOAL - Improve understanding of dynamics of domoic acid accumulation in all bivalve shellfish species.

Rationale

Currently, domoic acid poisoning has been affecting more and more shellfish crops in the Puget Sound as well as being a chronic problem in coastal areas of all West Coast states. The geographic extent of this toxin has been spreading as it moves down into central and south Puget Sound.

6.8.1 (H) Encourage further research on domoic acid accumulation into all commercial bivalve species.

6.8.2 (H) Encourage further research on domoic acid retention and depuration for all commercial bivalve species.

6.9. GOAL – Support research directed at developing effective methodologies to control the impacts of marine biotoxins, bacteria, viruses, and heavy metals in live shellfish.

Rationale

Toxic marine algae, *Vibrio* spp. and other marine bacteria, and viruses are public health risks associated with West Coast shellfish. Monitoring of shellfish meats and growing areas is expensive and growers are economically impacted by closures, product recalls and lost consumer confidence. While depuration is a proven technology for eliminating harmful bacteria from shellfish, it is not effective at eliminating viruses or marine biotoxins. The development of post harvest treatments for live shellfish that are effective at eliminating marine biotoxins and viruses as well as bacteria would improve public health protection and reduce the associated economic impacts to the industry.

Research Needs/Initiatives (priority in parenthesis)

6.9.1 (H) Conduct research to identify possible inactivation or removal (depuration) of marine biotoxins from live shellfish.

6.9.2 (H) Conduct research to develop an effective process for the removal of viruses from live shellfish.

6.9.3 (H) Conduct comparisons of heavy metal accumulation in bivalve species, possibly using oysters as a "sentinel" species, and processes to reduce concentrations.

6.9.4 (M) Conduct research on technology to eliminate or control the growth of bacteria in live shellfish

6.9.5 (H) Investigate the cause of sporadic cases of *Vibrio parahaemolyticus* (Vp) associated with low tdh+ and tlh numbers. Determine the role and significance of different strains, and need or potential for a different pathogenicity indicator.

6.9.6 (M) Assess new shellfish depuration technologies and the potential for their application to facilitate harvest from restricted or prohibited harvest areas.

7. Protection, Enhancement and Restoration of Water Quality in Shellfish Growing Areas

7.1. GOAL - Respond to water quality problems in grower watersheds in a coordinated, knowledgeable constructive manner.

Rationale

With coastal populations on the rise, shellfish growing areas are threatened with degrading water quality from failing on-site sewage systems, storm water runoff, domestic animal waste, increased recreational use without adequate facilities, and increasing population densities in the Puget Sound watershed. Existing commercial dairy and livestock are frequent sources of pollution to shellfish growing waters as well. Collectively, growers have considerable knowledge on these various problems and solutions. Responding in a coordinated, cooperative fashion could prevent future growing area classification downgrades. It will also reduce the time necessary to resolve problems and upgrade polluted growing areas.

Research Needs/Initiatives (priority in parenthesis)

7.1.1 (H) Establish a water quality standing committee within PCSGA to respond to water quality problems in West Coast shellfish growing areas. This committee should:

- Draw on the collective experiences of growers in areas that have been plagued by water quality problems;
- Be familiar with water quality law [Clean Water Act (Total Maximum Daily Load's (TMDL's), 303d list), Shellfish Protection Districts (Revised Code of Washington 90.72) etc.];
- Consider revisiting the shellfish protection district legislation to make it more responsive to emerging problems, "enforceable", and more sustainable; and
- Be involved in local and regional watershed plan development and implementation (i.e. The Puget Sound Action Team's Puget Sound Conservation and Recovery Plan and the Northwest Marine Straits Marine Conservation Initiative).

7.1.2 (M) Seek grant funding to collect oyster condition index in different growing areas throughout the year.

7.1.3 (M) Form alliances between growers and marine resources committees (MRCs)/watershed groups/tribes to provide a stronger focus on shellfish growing water quality.

7.1.4 (M) Promote new methods to assess historic water quality conditions (such as recent analyses of sediment core samples -- ffi: Yongwen Gao, research scientist, Makah Nation, and Eric Crecelius, Battelle Marine Sciences Laboratory, Sequim).

7.2. GOAL – Encourage community shellfish farms and backyard shellfish gardening as a strategy for investing the community in the health of local waters and galvanizing broader community support for pollution control projects.

Rationale

State statutes that require local governments to create shellfish protection districts following shellfish downgrades provide a structure within which locally appointed committees identify potential pollution sources and recommend specific fixes. Similarly, state laws that require local governments to create operation and maintenance programs for on-site septic systems provide the authorization needed to implement local programs. These statutes do not, however, guarantee that local elected officials act on these recommendations and fund infrastructure improvements and pollution control projects critical to the restoration of water quality and shellfish harvesting. Even with shellfish growers advocating for local water quality improvements, broader community support is needed in order for local elected officials to allocate scarce dollars to shellfish restoration. Promoting community

shellfish farms and backyard shellfish gardening is an effective way to expand the ranks of shellfish and water quality advocates at the local level – people who insist to their elected officials that water quality in a particular bay or inlet should be improved in order to maintain or restore shellfish harvesting. As more and more shellfish growers are discovering, getting the community involved in shellfish gardening and other forms of community-based shellfish operations serves both the industry and the resource. It creates allies in the community who are helping to elevate shellfish as a funding priority AND the shellfish that are planted improve the health of local waters and near-shore ecosystems through biofiltration and nutrient cycling.

Research Needs/Initiatives (priority in parenthesis)

7.2.1 (H)

7.2.2 (H)

7.2.3 (M)

8. Aquaculture Training, Education and Outreach

8.1. GOAL - Provide aquaculture training for industry and tribal employees.

Rationale

Staff training is a critical requirement for new and existing employees. New employees often have backgrounds unrelated to the shellfish business with little understanding of shellfish culture, safe food handling practices, a business/managerial background, or other skills required by the industry and tribes. In addition, there is a need to provide people interested in becoming shellfish farmers or involved in shellfish restoration with a "tool box" of information that will help them enter the profession.

Priorities/Initiatives (priority in parenthesis)

8.1.1 (H) Develop and provide information on the availability, type and cost of aquaculture training on the West Coast and at other locations.

8.1.2 (H) Establish a short-term training program including on-the-job training (i.e. algae culture methods, BMP outreach, restoration methods, business management and personnel issues) with links to professional organizations, meetings or workshops.

8.1.3 (M) Develop risk management strategies for oyster farmers.

8.1.4 (M) Develop distance learning curricula (with associated video tools, CDs and web-pages) in association with an accredited college/university for in-house employee training.

8.1.5 (M) Work with local universities or technical colleges to adapt existing USDA aquaculture technical modules for employee training.

8.1.6 (L) Evaluate and promote longer-term continuing education offerings, similar to the Washington Agriculture-Forestry program or specific course-work at local colleges, to provide more extensive aquaculture training.

8.2. GOAL - Continue support for formal undergraduate and graduate training in aquaculture centers and laboratories at community colleges, universities, tribal and other research facilities

Rationale

Continued advances in the shellfish industry and shellfish restoration programs require a substantial commitment by research institutions. New students and faculty are required to support these programs. The industry and the private sector research and consulting community will need students with training in shellfish biology, marine ecology, culture techniques, aquaculture business and management, and related disciplines. In addition, some fraction of the student and faculty effort should be directed toward meeting applied research priorities.

Priorities/Initiatives (priority in parenthesis)

8.2.1 (H) Promote recruitment to bring new students and faculty into these programs especially to fill positions left vacant by faculty who have retired or moved into more administrative duties.

8.2.2 (H) Ensure there is significant shellfish industry participation in strategic planning efforts at universities and colleges.

8.2.3 (H) Promote the continued development of aquaculture research and training programs at the high school, technical school, and college levels.

8.2.4 (M) Develop course curricula to match the 2015 research program goals.

8.2.5 (H) Establish community college-based certification programs for farm managers to include both aquaculture and business management skills.

8.2.6 (M) Assess possible direct support by the industry *and* non-profit organizations of students and faculty in on-campus training and teaching programs.

8.3. GOAL - Offer "hands-on" education programs at leading industry, community and tribal facilities.

Rationale

Formal academic training and laboratory exercises cannot replace experience gained in working in the field or commercial sector. Short-term to long-term (i.e. more than 1 month) study with industry and field research/agency partners, as well as community and non-profit foundations, should be encouraged as part of the educational experience. In addition, regulators in state and federal agencies should be encouraged to participate in short internships to better understand the challenges facing the shellfish industry and programs involved in shellfish restoration.

Priorities/Initiatives (priority in parenthesis)

8.3.1 (H) Work with the industry and tribes to develop intern opportunities.

8.3.2 (H) Provide funding to support short-term internships.

8.3.3 (H) Provide universities and colleges with information on internships for students at industry, research, and tribal facilities.

8.3.4 (H) Facilitate involvement in community and demonstration projects.

8.3.5 (H) Develop a web-site to facilitate the placement of student and professional interns at farms or organizations involved in shellfish restoration.

8.4. GOAL - Promote shellfish education in public schools, FFA/4-H program, tribal schools, marine science centers, public / private aquaria

Rationale

Schools and other centers of marine education for children provide an opportunity to educate a wide range of students in classroom, laboratory and field settings. Students gain entrepreneurial skills and an understanding of the biological and water quality requirements of shellfish culture and restoration.

Priorities/Initiatives (priority in parenthesis)

8.4.1 (H) Integrate aquaculture product marketing concepts into selected school business courses.

8.4.2 (M) Incorporate FFA/4-H aquaculture instructional packages and curricula for high school students.

8.4.3 (M) Encourage students to attend regional and national meetings and competitions sponsored by the Future Farmers of America.

8.4.4 (M) Work with PCSGA, non-government organizations (NGOs), foundations and individual growers to develop opportunities for high-school students.

8.4.5 (M) Further expand and distribute shellfish club curriculum developed for the Quilcene-Brinnon High School shellfish science program.

8.4.6 (L) Work with an existing public display aquarium to create working shellfish culture exhibits.

8.5. GOAL - Aquaculture information available and outreach should be made to the shellfish industry, tribes, and regulatory agencies.

Rationale

Many growers have requested creation of shellfish library dedicated to the shellfish industry. Information resources should be made available in the PCSGA web-page or other accessible location.

Priorities/Initiatives (priority in parenthesis)

8.5.1 (H) Assist industry and tribal staff in improvement and cataloging of a reference collection of scientific and public publications, a video library, and materials for training.

8.5.2 (H) Improve and expand on the PCSGA web-page or develop a stand-alone PSI web-page to electronically distribute information.

8.5.3 (M) Create an aquaculture information database cataloging existing information relevant to the shellfish industry and link it into web-pages of interest such as those of the PCSGA/PSI and WRAC.

8.5.4 (M) Develop a readily available “tool-box” of information for people interested in learning how to become an oyster farmer or to become involved in shellfish restoration.

8.5.5 (H) Continue to encourage tribal and agency personnel to attend the annual Pacific Coast Shellfish Growers Association (PCSGA) conference as well as the conference put on by Washington Sea Grant.

8.5.6 (H) Expand educational efforts to tribal and agency personnel regarding the beneficial ecological effects of shellfish aquaculture.

9. Farming, Harvesting and Processing: New Methods and New Products

9.1. GOAL - Work with the Washington Department of Ecology (WDOE) to transition industry from individual National Pollution Discharge Elimination System (NPDES) permits to "general permits" and assure that effluent tests required are relevant.

Rationale

NPDES permits are currently required to discharge water used in shellfish processing to surface waters of the state. These permits are very cumbersome and expensive. They require frequent and expensive testing of effluent (sometimes for irrelevant constituents) and the periodic submission of discharge monitoring reports. Washington has a general permit option for groups of dischargers that possess similar, low impact, effluent discharges that are comparable to the discharges produced by the shellfish processing industry. The general permit would simplify permitting and reduce the cost to the industry.

Research Needs/Initiatives (priority in parenthesis)

9.1.1 (H) Develop innovative, economical, and environmentally-sound wastewater disposal processes for the shellfish industry (i.e. the Taylor Shellfish Farm hybrid poplar/cottonwood irrigation).

9.1.2 (H) Pursue a general permit to replace the NPDES permit for shellfish processors. Negotiate with WDOE to assure that effluent testing evaluates only relevant constituents.

9.2. GOAL – Establish optimal processing and handling techniques for live and processed geoduck.

Rationale

Geoduck culture is a rapidly expanding component of the aquaculture industry and the wild geoduck fishery is currently producing several million pounds of product annually. Most of this product has historically been exported "whole" in the shell to Asian markets. Despite the high value of the product and the quality conscious market receiving it, relatively little is known about optimal product handling from harvest, through processing, packing and shipping. With PSP closures becoming an increasing problem, processed meats are a product that will likely emerge but, as with the whole shelled product, little is known about optimal processing and handling techniques to maintain maximum product quality for this market Develop a manual especially for handling and shipping live geoduck

Research Needs/Initiative (priority in parenthesis)

9.2.1 (H) Research and develop guidelines for optimal product handling for live geoduck and other bivalves from harvest through shipping.

9.2.2 (L) Research and develop protocols for the optimal shucking and packing of geoduck meats.

9.2.3 (M) Research on the use of time/temperature monitors and the shipping of geoducks.

9.3. GOAL – Continue development trials of High Hydrostatic Pressure processing for oysters and other shellfish species.

Rationale

Recent commercial applications indicate that High Hydrostatic Pressure (HHP) is effective at releasing the adductor muscle from both shells without changing the texture or other characteristics of the meats. The process also appears to effectively kill bacteria (*Vibrio* spp.). Promising commercial results indicate further exploration of this technique is merited.

Research Needs/Initiative (priority in parenthesis)

9.3.1 (H) Investigate the effects that HHP processing has on product shelf life, *Vibrio* bacteria, various toxic phytoplankton (PSP, domoic acid, DSP), viral pathogens (human) and spoilage microbes. Research in HHP has been done and papers published: 1) Calik, H., Morrissey, M.T., Reno, P., and An, H. 2002. Effect of high pressure processing on *Vibrio parahaemolyticus* strains in pure culture and whole oysters. J. Food Sci. 67: 1506-1510; 2) He, H., Farkas, D., Adams, R., and Morrissey, M.T. 2002. The use of high hydrostatic pressure to shuck oysters and extend shelf-life. J. Food Sci. 67: 640-45.

9.3.2 (H) Develop National Shellfish Sanitation Program guidelines for HHP treatment for the control of *Vibrio parahaemolyticus*.

9.4. GOAL – Evaluate other value-added processing methods for use by the west coast industry.

Rationale

It is essential that the oyster industry move toward new product development for improved safety and opening of new markets. The sales of shucked oyster meats have been relatively flat over the past decade and there is a critical need to introduce new consumers (younger generation) to oysters. Recent successes such as the 'oyster shooter' product made for retail and foods service has shown the potential of developing new products. Conduct a consumer survey so that value-added products are market driven not production driven. Understanding consumer needs both in the domestic and the international arena is critical for developing successful products in the marketplace.

Research Needs/Initiative (priority in parenthesis)

9.4.1 (H) Freezing -- Determine time/temperature parameters for freezing shellstock and shucked oyster meats. Measurements should include sensorial, chemical and microbial determinations over extended shell-life storage. Freezing will also decrease bacterial count (especially *Vibrios*) and the effect on specific pathogens should be determined. Freezing will also lend itself to new value-added product development with oysters as the main ingredient.

9.4.2 (M) Irradiation -- E-beam radiation has been shown to be effective in eliminating pathogens without adversely affecting the sensory quality of oysters. Additional work is needed for shelf-life determination. E-beam radiation has been approved by FDA 2005 as a process for oysters and there continues to be great interest in this method. Preliminary data has shown it can affect texture and quality of whole oysters; more research is needed to determine the tradeoffs between *Vibrio* inactivation and sensory changes.

9.4.3 (M) Other -- Thermal pasteurization of value-added products will eliminate potential pathogens and expand opportunities for new product niches. Time/temperature parameters and measurement of sensory, chemical and microbial indicators are essential for this research.

9.4.4 (H) Packaging – There has been a revolution in packaging technology over the past decade and new packaging options for fresh and processed products should be researched as potential options for new and value added products. Modified Atmosphere Packaging (MAP) is currently being used in Europe for shellfish value added products and needs to be explored in the U.S. However, FDA has concerns regarding the use of MAP and this needs to be addressed as well.

9.5. GOAL -- Establish a library of processing, seafood handling, and value added developments to be maintained by PCSGA/PSI

Rationale

Currently, information regarding the different aspects of shellfish production and processing is widely distributed among various research facilities and public agencies. A centralized library of information pertinent to commercial shellfish culture would be of great value to researchers and commercial growers. In addition, trips (both domestic and international) should be setup for growers to plants to view new processing techniques for

value added products as well as infield demonstrations to see new equipment and innovative technologies for production and handling techniques.

Research Needs/Initiative (priority in parenthesis)

9.5.1 (M) Investigate feasibility of establishing and maintaining a library focused upon the production and processing of shellfish under the auspices of PCSGA or PSI.

9.5.2 (M) Maintain current information regarding alternative food processing/sterilization from other food industry literature. Evaluate applicability of these alternatives to shellfish production, particularly as they apply to the live shellfish market.

9.7. GOAL – Identify optimal design and materials of harvest implements and mechanical equipment.

9.8. GOAL – Research ergonomic devices specifically oriented towards reducing harvest-related wear and tear.

10. Marketing and Promotion of Shellfish Culture

10.1. GOAL - Develop a marketing strategy to increase demand and price for species currently under cultivation and identify market opportunities for new species.

Rationale

Recent marketing of West Coast shellfish products has relied largely on the efforts of individual companies. Shucked oyster meat prices drop annually due to aggressive competition for a limited traditional market based on oyster dressing for Thanksgiving and Christmas turkeys. Substantial increases in New Zealand greenshell mussel production, East Coast hard clam production and eastern Canadian blue mussel production appear to be dampening demand and price for West Coast clams and mussels in the traditional "steaming" market. A straw poll conducted at the 1999 annual general meeting of the Pacific Coast Shellfish Growers Association indicated considerable support for developing a coordinated industry marketing strategy.

Priorities/Initiatives (priority in parenthesis)

10.1.1 (H) Investigate examples of organized marketing efforts (i.e. programs developed by the Alaska Seafood Marketing Institute, the Beef Institute, the various agricultural commodity commissions and the Sustainable Agriculture Program).

10.1.2 (H) Continue to identify funding options to support the development and implementation of a marketing program.

10.1.3 (H) Conduct a market survey to identify amongst other things, market potential for new and existing product forms, new packaging and new species.

10.1.4 (H) Continue to participate in promotional activities such as the San Francisco Seafood Show and the Shellfish Lovers Ultimate Rejuvenation Party (SLURP).

10.1.5 (M) Continue to update and produce promotional information regarding environmentally sound culture techniques, shellfish quality, handling, nutritional and product safety for distribution (brochures, flyers, table tents, recipe cards) in retail outlets, trade shows, county fairs, farmers markets, press releases and on the PCSGA/PSI/SG/Cooperative Extension web-pages.

10.1.6 Develop marketing strategies that:

- Promote use by restaurants and retail seafood counters of portable oyster shucking machines such as "Aw Shucks" machine.
- Provide the industry with more access to federal export marketing grants and trade programs.
- Re-establish cooperative marketing relationship with Washington Wine Institute.

10.2. GOAL - Conduct studies or analyses to assess marketing opportunities and constraints in shellfish aquaculture.

Rationale

The West Coast shellfish industry needs to stay abreast of marketing trends and consumer demands to help guide farming activities.

Research Needs/Initiative (priority in parenthesis)

10.2.1 (H) Compile and review past shellfish marketing initiatives and their outcomes and relate this information to recently reported changes in demographics on the West Coast.

10.2.2 (H) Collect and report on data regarding new species preferences, changes in preferred market presentation of product, consumer profiling (e.g. ethnic markets), organic labeling and consumer preferences, and emerging markets.

10.2.3 (H) Evaluate and compare marketing strategies in relation to projected marketing needs in the west coast shellfish industry. Report on the impact of global opportunities and competition with respect to the region.

10.2.4 (H)Investigate the feasibility of marketing partnerships and/or cooperatives (local and regional) among producers, wholesalers and retailers to expand marketing opportunities both domestically and abroad.

10.2.5 (L) Perform consumer survey tied to objectives in section 10.0 dealing with new products.

10.2.6 (M) Conduct economic baseline data for each commercial shellfish species. This is needed to establish a starting point for subsequent marketing strategies: 1) Input/Output analysis and 2) Marketing assessment study.

10.2.7 (L) Need more specific nutritional profiles of various commercial shellfish products from West coast such as Faye Dong's Sea Grant publication.

10.2.8 (H) Perform a consumer survey to include questions on: preferred package size (ounces of shucked meat, lbs. or dozens of live shellfish); opened on ½ shell vs. live in shell, frozen vs. fresh; alternative shucked meat containers ("dyno" pack, square jars); tamper evidence; shelf life (shelf stable); safety; value added (smoked, marinated, ½ shell with toppings); ease of cooking and handling; and PCSGA label.

10.3. GOAL - Educate the general public, consumers, waterfront owners, resource managers, boaters, and others regarding the benefits of shellfish, shellfish culture and the industry's need for a clean healthy environment.

Rationale

Farmers and shellfish processors share a common need to educate a wide array of people on a variety of topics. Some of these needs include educating the general public, consumers and resource managers on topics ranging from proper handling and preparation of their products and nutritional information to environmentally sound culture practices and the industry's need for a clean healthy environment in which to culture their shellfish.

Priorities/Initiatives (priority in parenthesis)

10.3.1 (H) Develop a list of experts and a speaker pool for public presentations, general meetings, etc. -- include agency, industry, tribal and academic representatives.

10.3.2 (M) Develop educational information for inclusion in printed materials, informational kiosks, interpretive center displays, and on the PCSGA/PSI/SG/Cooperative Extension web-pages.

10.3.3 (L) Develop videos showing strengths of industry, tribal and research interactions, important elements of shellfish production/harvesting, and environmental interactions.

10.3.4 (M) Encourage and promote public education and water quality awareness through such activities as community shellfish gardens and retail seed sales.

10.3.5 (L) Promote shellfish as a healthy food for both adults and children.

10.3.6 (H) Promote and educate the public, government agencies, and decision-makers on the ecological benefits shellfish culture is providing to the marine environment.

10.3.7 (L) Create and promote "virtual" shellfish farm programs on the internet as an educational tool similar to *the* Irish shellfish industry and the Federation of European Aquaculture Producers (FEAP).

11. Policy and Regulation

The West Coast shellfish industry is under ever increasing regulatory scrutiny as a result of salmon listings under the Endangered Species Act, the Sustainable Fisheries Act and associated identification and protection of essential fish habitat (EFH). As regulations continue to become more numerous and compliance more costly there exists the possibility that growers, especially smaller operations, will find in an economic impossibility to remain in business. In addition many researchers, tribal biologists, and government agency personnel, as well as the general public, have not been completely informed about the many positive effects of shellfish culturing on the marine ecosystem. Nationally there is a critical need for regulatory stability and predictable futures for these predominantly small business industry, the recognition that shellfish culture is good for the environment needs to be expanded.

11.1. GOAL – Promote the shellfish industries Environmental Policy

Rationale

The Environmental Management System (EMS) consisting of an Environmental Policy (EP) and an Environmental Code of Practice (ECOP = Best Management Practices) prepared by PCSGA in 2002 will be crucial to the survival and continued prosperity of the shellfish industry**.**

Research Needs/Initiatives (priority in parenthesis)

11.1.2 (M) Implement an outreach program, including web page, workshops, and educational "field days" to educate growers and resource managers on ECOP. Outreach to the public through PCSGA events and regional forums with growers.

11.2. GOAL – Encourage more effective risk assessment and risk management by agency personnel which recognizes the positive beneficial effects of shellfish aquaculture for the environment.

Research Needs/Initiatives (priority in parenthesis)

11.2.1 (H) Conduct shellfish disease risk assessment and risk management evaluations for haplosporidiosis and other infectious diseases known to occur in West Coast shellfish populations, with priority given first to OIE listed diseases and secondly to other diseases of concern either to state or federal management agencies or to the industry.

11.2.2 (H) Maintain the regional capability for the prevention and management of infectious shellfish diseases that is necessary to maintain export certification for live shellfish larvae, seed and broodstock. Maintain the working relationship with the Animal and Plant Health Inspection Service (A.P.H.I.S.) of the U.S. Department of Agriculture to facilitate export of disease free live shellfish products.

11.2.3 (H) Develop, and encourage regulatory authority acceptance and application of established risk assessment and risk management procedures for shellfish transfers and disease assessment.

11.3 GOAL – Establish a seagrass policy which recognizes both the positive and negative aspects of grower activities.

Rationale

Eelgrass (*Zostera marina* and *Z. japonica*) beds are dynamic colonizers and respond to a variety of physical and environmental variables. While some farming practices adversely impact eelgrass, others, including control of burrowing shrimp, promote the establishment of both eelgrass species. Growers and researchers have observed the presence of the exotic eelgrass, *Z. japonica*, to be increasing on many traditional shellfish beds. Current resource management policy inflexibly protects all eelgrass beds, including shellfish beds colonized by eelgrass as a result

of the culture activities. The policy requires commercial growers to adopt more expensive cultural tactics, or even abandon traditionally vigorous beds. In such cases, the eelgrass may not survive those changes.

Research Needs/Initiatives (priority in parenthesis)

11.3.1 (H) Work with federal, state, local and tribal resource management agencies to establish a seagrass policy. This new policy should provide for the management of beds based on the conservation and protection of estuarine habitat rather than the traditional policy based on no net loss of eelgrass. Educate public and resource agencies regarding the differences between native (marina) and non-native (japonica) eelgrass and assure policies do not require protection of non-natives.

11.4. GOAL - Foster a positive regulatory and social environment which supports environmentally sound shellfish culture.

Rationale

International, national and state policies exist which support the development of environmentally sound aquaculture. Unfortunately, as local, regional and state governments have developed coastal zone management plans there has often been limited support for aquaculture development. Competing user groups and waterfront homeowners dominate planning processes or aquaculture siting hearings and frequently prevail. To reverse this trend the Department of Commerce and its affiliated agencies (NOAA, NMFS, Sea Grant, etc.), the United States Department of Agriculture, the Joint Subcommittee on Aquaculture, state resource management agencies and growers associations need to coordinate an advocacy program that communicates to citizens and governments the merits of environmentally sound shellfish culture.

Research Needs/Initiatives (priority in parenthesis)

11.4.1 (H) Promote the development of a multidisciplinary Pacific Aquaculture Caucus that can support and advocate for the development of an environmentally sound shellfish culture industry at the local level.

11.4.2 (H) Streamline the state and local permitting and approval process for siting of environmentally sound shellfish culture projects.

11.4.3 (H) Advocate state and local laws, codes and policies that support and promote environmentally sound shellfish culture.