Aquaculture Innovation Workshop
National Conservation Training Center
Shepherdstown, WV
January 17-18th, 2011

Sponsored by The Conservation Fund's Freshwater Institute, Tides Canada and the Gordon and Betty Moore Foundation

Tour of the Conservation Fund's Freshwater Institute

The meeting kicked off with a tour of the nearby Conservation Fund's Freshwater Institute and its fish culture facilities. The highlight of the tour was a 150 m^3 closed-containment recirculating aquaculture system containing 4 kg + Atlantic salmon cultured at a density of 80 kg/m^3 without the use of vaccines, pesticides, or harsh chemotherapeautants. A wide range of research projects were also on display including: a project analyzing the effects of photoperiod and strain on Atlantic salmon, Coho salmon, and Arctic char; a study conducted within six replicated recirculating systems testing the effects of high carbon dioxide (20 mg/L) vs. low carbon dioxide (10 mg/L) on Atlantic salmon performance; and a variety of waste treatment projects demonstrating sustainable methods to effectively treat aquaculture effluents and concentrate fish waste.

Keynote Presentation
* (Permission Granted to View Powerpoint)

By Elliot Entis

Following the tour, the group reconvened at the National Conservation Training Center for a social gathering and then dinner. The main course was farm-raised Atlantic salmon, recently harvested from closed-containment systems at the Freshwater Institute. Following dinner, Joe Hankins, director of the Freshwater Institute, introduced keynote speaker, Elliot Entis, who is President and CEO of the American Salmon Company (Waltham, MA) and cofounder and former CEO of AquaBounty Technologies, Inc. AquaBounty is a biotechnology company focused on developing genetically modified (GMO) Atlantic salmon, trout, and tilapia that grow at much faster rates than traditionally cultured fish. Elliot discussed the prospect for FDA approval of AquaBounty's GMO salmon in the United States and acceptance of this product by US consumers. He spoke about his theory that "belief trumps science," in other words, that media and activist groups can strongly influence public opinion and belief, in spite of scientific evidence. There is currently strong opposition by special interest groups and a small percentage of the general public to FDA approval of GMO salmon for human consumption in the United States and there is an ongoing debate whether GMO salmon should be labeled as such when packaged and presented to the US consumer. Although the FDA has yet to make an official ruling, they have stated that a GMO salmon is a salmon; that there is no difference in the flesh. Eliot optimistically referred to a potentially new era of aquaculture production that includes genetically modified animals as "the Blue Revolution", a marriage between engineering technologies and biological systems. The Blue Revolution would represent a movement away from “the old science” of selective breeding and hybridization to produce optimal growth, performance, and phenotypes to a “new science” of DNA and gene mapping and genetic engineering of cultured species. Elliot doesn’t believe that genetic engineering stops with modification for optimal growth. He believes that fish can be genetically engineered for other desirable traits, such as disease resistance. He also spoke of a gene known as “the Fat-1 Gene” that originates in a worm, but has the potential to increase omega-3 fatty acid levels in fish. Due to the controversy over potential escapement and interbreeding with wild salmon populations, AquaBounty has agreed that GMO salmon are to be sterile (triploid) and grown inland within closed-containment systems. Currently, one of the drawbacks of closed-containment systems is the relatively large capital and operating costs; however, production of GMO salmon that grow at approximately twice the rate of typical salmon would significantly reduce production costs and thus make these systems a much more feasible option for many fish farmers. Entis went on to site evidence from several polls that the majority of consumers are not concerned about the biological engineering of their food. Instead, consumers are most concerned about contamination of our food supply. He believes that acceptance of GMO seafood depends on approval and support by trusted food health and safety agencies like the US FDA and that the science related to GMO salmon must be sound and must not be misused or misrepresented.

Aquaculture Production Systems – Advances in Water, Genetics, Health, and Nutrition

* (Permission Granted to View Powerpoint)

By Jeff Silverstein

Day two of the workshop began with a presentation by Dr. Jeff Silverstein, National Program Leader on Aquaculture for the USDA Agricultural Research Service (ARS). Jeff overviewed USDA ARS research which operates 22 national programs, one of which is related solely to aquaculture. Within the aquaculture program various research sectors exist, including: genetic improvement; growth, stress, and reproduction; nutrition and feeds; and production systems. Jeff outlined the various forms of aquaculture production systems and discussed the importance of the aquaculture value chain, which not only includes the fish farm, but also the processors, value-added products, and the seafood market. Jeff provided a dramatic example of how the poultry industry serves as a good model for a relatively young aquaculture industry, because it was able to advance and improve through research, genetic selection, and development of value-added products. He stated that in the 1950’s it took approximately 40 weeks to grow a market-sized chicken and in recent years the time of production has been reduced to less than 900 hours. He concluded by stating that the aquaculture industry must maximize production efficiency through better genetics, better nutrition and health, and better system control (water quality, waste management, and biosecurity), and that there needs to be more integration with the value-added chain. An important comment was made following the presentation, stating that the chicken model has many advantages, but that the aquaculture industry also must recognize some of the disadvantages that have emerged from the poultry industry such as relatively poor waste management and pollution.

Advances in Closed-Containment Systems for Salmonids

* (Permission Granted to View Powerpoint)

By Steven Summerfelt

Dr. Steven Summerfelt, Director of Aquaculture Systems Research at the Freshwater Institute (FI), overviewed the advantages of closed-containment systems, discussed recent technological advances, as well as research projects taking place at the FI. Closed-containment systems (CCS) can be operated with limited water resources and effectively manage waste flows, thus protecting the environment while providing economic opportunity inland and close to seafood markets. Closed-containment systems also provide increased food security because their design enhances biosecurity and thus decreases pathogens and the need for chemotherapeutants. A variety of parameters can be controlled within CCS including water flow and velocity, oxygen, waste metabolites, water temperature, and fish swimming speeds; all of which can be tuned to the needs of the cultured species. Despite a dramatically lower dilution rate, CCS can maintain water quality that is equal to that of a single pass (flow through) system with respect to the parameters of concern for fish health. Due to the relatively large capital investment and operating cost of CCS, these systems and farms must usually be large to be economical.

The Freshwater Institute is currently working under a 5-year project plan entitled, "Improving the Sustainability of Land-Based Closed-Containment Systems for Salmonid Food Production." Thus far, FI has successfully grown Atlantic salmon within freshwater closed-containment systems to 4 kg in two years. These fish were given an artificial winter and smolted in their first year (i.e., S-zeroes) and grown only in freshwater. FI has also found that Atlantic salmon tolerate densities ≥ 80 kg/m^3 without fin erosion or other apparent welfare problems, a carrying capacity much greater than that typically used by industry. Further, FI has developed effective ways to manage the large and deep tanks that are required for "economies of scale", including the development of a mortality flushing system and harvesting technologies that use a clam-shell grading device to crowd and size-separate fish and then corral them to the culture tank's side box where they can be harvested quickly with minimal labor. Steve also overviewed the various unit processes and components necessary to create optimal water quality within CCS. He discussed the move from the traditional swirl separator to a radial flow separator for solids separation. He overviewed the use and effectiveness of large fluidized sand biofilters and mentioned another popular option, moving bed biofilters. He discussed the use of integrated carbon dioxide and oxygen unit processes to control gases in CCS and discussed the advantages of using ozone. Ozone creates very clear water and improves biofiltration and solids removal efficiencies even at very low water exchange rates. Steve also overviewed the waste management technologies that have been researched at FI that can be integrated with CCS including: gravity thickening cones, geotextile bags, inclined belt filters, and membrane biological reactors. Steve closed by stating that in recent years we are really beginning to see a lot of confidence in CCS technology, an increased scale of investment in CCS, more state and federal agencies using CCS, and an increase in new domestic fish farms using this technology.

Fish Health and Welfare in Closed-Containment Systems

* (Permission Granted to View Powerpoint)

By Christopher Good

Dr. Christopher Good, Director of Aquatic Veterinary Research at the Freshwater Institute, overviewed the advantages of CCS relative to fish health. Due to the enhanced biosecurity inherent in CCS, vaccination of fish may not be required, antibiotic and chemotherapeutic use can be reduced or eliminated, and environmental control of the culture environment (particularly water quality) can reduce stress and increase fish performance. Chris recommended the use of only certified disease-free eggs or fish within CCS, which arrive free of obligate pathogens, including detrimental viruses such as IPNV, IHNV, VHSV. Closed-containment systems allow for enhanced biosecurity, but there is no such thing as pathogen-free water. Opportunistic pathogens are a natural part of the aquatic environment and include bacterial gill disease, columnaris, fungus, and protozoans. Enhanced control of the culture environment provided by CCS prevents outbreaks of opportunistic pathogens. Chris overviewed types of stress that can lead to disease, including chemical (poor diet), biological (suboptimal water quality), physical (induced by suboptimal light, sound, temperature), and husbandry (handling, transport, and treatments).Chris overviewed important water quality parameters that can be optimized within CCS. For optimal salmonid growth: O_2 concentration should be maintained between 85 – 100% of saturation; CO_2 should be kept < 30 mg/L; and nitrite nitrogen should be kept < 1 mg/L and even lower in soft water. The unionized portion of ammonia (NH_3) is the toxic portion of the total ammonia nitrogen and should be monitored. Nitrate nitrogen, the end product of nitrification, has normally been thought to be non-toxic up to 1000 mg/L, but research at FI indicates that lower concentrations that can accumulate within CCS could be of concern. Temperature can be optimized within CCS based on the biology of the cultured species in order to optimize growth. However, if not maintained at optimal levels, temperature can also be detrimental to fish development increasing the incidence of deformities. The pH of the water influences a variety of other water quality parameters and affects metals toxicity. Closed-containment systems can be operated to control pH at optimal levels, typically from 6.5 – 8.5. Fish density should be maintained within species-dependent limits, to control stress and health. Optimal swimming velocity can also be controlled within CCS. Optimally exercised fish often grow faster, are less aggressive, have enhanced immunity, and improved flesh quality.

Chris also overviewed three current projects at FI:

1) A study evaluating the effects of high CO_2 (10 mg/L) vs. low CO_2 (20 mg/L) on Atlantic salmon and rainbow trout performance in replicated low exchange recirculating systems. He highlighted the economic component of such a study; i.e., if fish are not impacted by high CO_2, less water needs to be pumped.

2) A study evaluating the effects of strain and photoperiod on Atlantic salmon (also described by Steven Summerfelt).

3) A study evaluating the effects of swimming speed and oxygen concentration on salmonid growth performance. Preliminary results obtained from parr prior to smolt transformation indicate that fish cultured with saturated oxygen concentrations and optimal swimming velocities (2 body lengths/sec) grow significantly faster than fish continuously exposed to O_2 concentrations < 85% of saturation and swimming velocities of 0.5 body lengths/sec.

A question was raised at the end of the talk as to the potential difficulty in obtaining certified specific pathogen-free eggs for use in closed-containment systems, and if infected eggs could not be avoided then what would the consequences be of using these in water recirculation CCS? Chris acknowledged the difficulty in finding pathogen-free broodstock (especially with Pacific salmonid species chronically infected with *Renibacterium salmoninarum*). If potentially infected eggs could not be avoided, then the next two principles of biosecurity (prevention of pathogen spread within the facility, and prevention of conditions that promote clinical disease in infected fish) need to be emphasized to avoid serious production losses from morbidity and mortality.

Conceptual Design and Costs of a 2500 mt/yr Closed-Containment System for Atlantic Salmon

* (Permission Has Not Been Granted to View Powerpoint)

By Brian Vinci

Dr. Brian Vinci, Director of Engineering Services at the Freshwater Institute, overviewed the key elements of a current design being developed at FI for a commercial scale Atlantic salmon production facility using closed-containment systems, to be located in the eastern US. The design plan included important components such as site identification, a biological production plan, recirculating aquaculture system (RAS) design for each salmon life stage, and projected operational and capital costs. During site identification, key considerations included locating a water source that provided: 1) an ambient temperature of 12-15^{o} C to match the biological plan; and 2) a reliable flow rate that met the needs of the design plan. Some important considerations for the biological production plan included identification of certified disease-free eggs that could be obtained at least two times per year from a stock with a proven growth coefficient. The system design plan included details for each culture system based on life stage: incubation, fry rearing, pre-growout rearing, growout rearing, as well as depuration and processing. The basic design of each of these systems was similar to that of the RAS operated at FI. For each system, limits were set for a variety of water quality parameters; and the systems, flows, and unit processes were designed to meet these criteria. The following water quality parameters and design concentrations were used: total suspended solids (5 mg/L), total ammonia nitrogen (1.5 mg/L), carbon dioxide (15 mg/L), oxygen (100% saturation), nitrate nitrogen (75 mg/L), and temperature (12-15^{o} C depending on life stage). For each system, specific starting and end fish sizes was established, as well as density limits and percentage of flow to be recycled. Off-feed periods, surrounding transport of fish from one culture system to another, were included in the biological production plan. Shutdown time between cohorts was also considered for reasons such as system disinfection or repairs. A partial reuse system was applied to the depuration design. The depuration plan included a 10-day off-feed period prior to harvest. Brian also provided a breakdown of expected production costs. Feed accounted for 53% of the total production cost, followed by depreciation (21%), electricity (11%), labor, processing, and management (10%), and oxygen (5%). The preliminary estimated capital cost, which included the RAS systems, a processing plant, and all buildings, was $31 million. However, value engineering and reducing the cost of construction overhead might reduce fixed costs by several million dollars. Brian pointed out that some of these costs could be offset by locating the facility as close as possible to the end user (the markets) and through construction of an onsite feed mill to reduce/eliminate feed shipping costs.

Atlantic Salmon Breeding Program and Research on Harvest Quality

* (Permission Granted to View Powerpoint)

By William Wolters

Dr. Bill Wolters from the USDA Agricultural Research Service, overviewed the breeding program that he oversees at the Franklin, Maine facility, established in 2003. Genetic selection is being used at the USDA facility in order to develop an improved Atlantic salmon germplasm for commercial US production. Only disease certified North American stocks are used. Strict biosecurity measures are followed and are built into the building and system designs. In addition, fish evaluated under commercial conditions in net pens with industry collaborators are vaccinated. Recirculating systems are used at the facility. Separate systems are used relative to life stage including systems for: incubation, parr, smolt, ongrow, and broodstock. Multiple water sources with various salinities are available including a freshwater well, a brackish water well, salty well water, and full strength seawater. Only 123 gallons per minute of water are required to operate the entire facility, with 97.5% of the water being reused. When the salmon become smolts, they are transferred to sea cages, where they remain until they are three years old, at which time data is collected for length and weights, fillet attributes, and more. The data is then analyzed and breeding values are calculated and used to determine which fish from families kept in the bio-secure facility possess optimal phenotypic and heritable traits. Individuals are then selected from these families for continued spawning. Bill also provided results from a study evaluating the effect of various depuration times on the presence of off-flavor in Atlantic salmon cultured in recirculating systems. Off-flavor compounds (MIB and geosmin) produced by actinomycetes and cyanobacteria are often present in the flesh of fish cultured within RAS. These off-flavor compounds can be reduced or removed by placing fish in freshwater without feed. Results indicated that 10 days of depuration was optimal. A sensory panel indicated that no off flavor was detected when fish were depurated for 10 days. MIB was significantly lower 10-15 days into the study, but then increased slightly after 20 days of depuration. Bill noted that some weight loss occurred during depuration, i.e., approximately 4 % of the total body weight. In addition slight lipid loss and decrease in fillet yield occurred over the 10-day depuration period.

Sustainable Feed

* (Permission Granted to View Powerpoint)

By Frederic Barrows

Dr. Frederic Barrows, Lead Scientist and Nutritionist for the USDA Agricultural Research Service (ARS), outlined the feed development and evaluation process that is followed at the USDA facility in Bozeman, MT. This evaluation process includes analyses for the following: composition, palatability, digestibility, functionality (including durability and effect on water quality), and growth performance. Growth trials are conducted to evaluate feeds using several approaches. 1) An ingredient is removed and replaced with another. For example, fish meal is removed and replaced with soy concentrate. 2) Other trials remove fish meal and evaluate the effectiveness of a blend of alternative proteins. 3) Growth trials using these feeds are conducted on a pilot scale and also using third party validation. During such trials, a USDA-ARS derived feed formulation is produced commercially and then evaluated at an outside aquaculture facility, such as the Freshwater Institute. These trials have shown that feeds in which fish meal is completely substituted with plant-based proteins produce comparable growth rates in commonly cultured species such as rainbow trout. Rick outlined some recent developments in aquafeeds and some things that are on the horizon. The soy varieties that are being used in aquafeeds are improving. Digestibility of genetically selected soybean lines has improved from approximately 50% to 85-100%. Algae, particularly *Spirulina,* have shown promise as an alternative protein source for aquafeeds e.g. white sea bass exhibited a significant increase in growth and survival and improved FCRs when fed a fish meal free diet substituted with *Spirulina*. Rick also discussed the use of alternative feeds within recirculating systems. Feeds in which fish meal is replaced with plant-based proteins have tended to produce fecal pellets that are less stable. Fecal pellet stability is important within RAS because degrading solids can break into fine particles that accumulate within the culture system. One method to improve fecal pellet stability in plant-based feeds, used by the USDA lab and others, involves the addition of an ingredient called guar gum. They are also working to determine which ingredients exactly affect fecal consistency and to fine tune levels of amino acids and trace minerals, which could reduce the accumulation of total ammonia nitrogen and potentially harmful dissolved metals within RAS, respectively.

Following the presentation the question was posed, “Is fish oil still required within alternative protein feeds?” Rick responded by stating that fish oil can be reduced and replaced with some plant oils without reducing fish growth, but the omega-3 fatty acids are equally reduced changing the quality of the final product from a consumer point of view.

Status, Challenges, and Opportunities of Floating Closed-Containment Systems

* (Permission Granted to View Powerpoint)

By Sean Wilton

Sean Wilton, Director and Vice President of Technology and Business Development for Agrimarine Holdings (Vancouver, BC), described a very unique technology, i.e., floating closed-containment tanks, which could resolve many of the drawbacks that are inherent of traditional net pen operations. These tanks are made of double layer fiberglass over a foam core to give the tank the ability to float and withstand the marine service environment. The design, which has been in the making for 10 years, was originally tested in China within freshwater lakes and was found to be successful. The commercial scale design has a volume of 3,000 m^3 for the smaller tanks and 5,500 m^3 for the larger tanks. Water is pumped from depth outside of the tank at low head to provide turnover within the culture system. Water can be pumped from various depths if necessary to obtain a water temperature that is optimal for the cultured species. Oxygen can be supplemented to the floating system. The tank is equipped with a waste trap at the bottom to collect solids, which can be pumped to the surface for further thickening, as well as a monitoring system for wasted feed. The design also includes a mortality trap which airlifts dead fish to the surface to be removed from the system. The floating closed-containment systems are currently being used to grow Chinook salmon in China, as well as British Columbia . As opposed to a traditional net pen design the floating closed-containment system offers the following advantages: fish are enclosed within the solid-walled culture tank thus preventing escapement, the solid walls of the tank also prevent predation since other animals cannot see the fish, and solid waste is captured and thickened. Following the presentation, it was asked if any failure analysis had been conducted on the unit and if escapement had been assessed. Sean replied that escapement had not been assessed, but stressed that the tanks are completely enclosed, so they do not expect escapement, but suggested that theoretically birds could carry a fish away. Sean was also asked what size waves the units were designed to withstand? Sean replied that the units are equipped for waves approximately 1.5 m in height and that the units have 0.6 m of freeboard.

Aquaculture Innovation – A Producer's Perspective

* (Permission Granted to View Powerpoint)

By Per Heggelund

Per Heggelund, founder and President of Aquaseed Corporation (Sweetspring Salmon), overviewed the history of Aquaseed (Seattle, WA), production of their Coho salmon, and the marketing side of the operation. The Coho stock that is used for their operation originates from the Domsea pedigree stock, first domesticated in 1969. This stock was acquired by Campbell's Soup Inc. in 1979 and then by the current company, Aquaseed, in 1991. The original intention of Aquaseed was to operate as an international egg supplier. In the late 1990's the growing company became involved in salmon conservation, maintaining genetically diversified wild stocks. In recent years, Aquaseed has expanded its operation into full scale food fish production of Coho salmon. They use genetic selection to continue to improve their stock. This genetic selection program has spanned 19 generations of Coho over 38 years and they select from 40 families of fish. The stock that they produce is adapted to freshwater; thus, their production occurs within land-based closed-containment recirculating aquaculture systems. Aquaseed's mission is to sustainably raise Coho that meet the highest conservation standard. Evidently Aquaseed has been successful in that mission, as the Monterey Bay Aquarium recently labeled their product with the "Super Green Ranking". To obtain such a ranking the following criteria are considered: 1) the use of marine resources such as fish meal; 2) the risk of fish escapement into the wild; 3) the risk of disease transfer and impact on wild stocks; 4) the risk of pollution of natural habitats; and 5) the effectiveness of the management regime. Additionally, omega 3's must be > 250 mg/day and contaminant levels in the fish fillets must meet specific standards: i.e., mercury < 216 ppb and PCB's < 11 ppb. Per believes that approval by the Monterey Bay Aquarium has been critical for consumer approval and marketing of their product. Production of Aquaseed's fish occurs on two farms located in Washington State. Smolt production occurs within RAS operated with a 98% recycle rate. Optimal water temperatures for Coho production are maintained at approximately 15^{o} C. Growout systems are operated with 85% water reuse. The Coho are grown to approximately 1.5 kg and then harvested. The majority of their fish are processed and sold to Overwaitea, a Canadian supermarket chain that embraces seafood sustainability. Per believes that there is growing interest in the market for sustainably cultured seafood and that it is important to recognize and distinguish sustainably raised seafood in some way, whether it be through rankings such as the Monterey Bay Aquarium's, certification, or labeling. Safeway and Costco are becoming interested in the Aquaseed (Sweetspring) product, however Whole Foods would not allow special labeling as an Eco-friendly product. Per also believes that a change to the current Lacey Act, which requires permitting to ship wildlife between states and across US borders, needs to be redefined so that agriculture products such as cultured fish are distinguished separately, under which circumstances transport and sale of aquaculture products would be facilitated.

Innovation and Emerging Technologies: A Major Pillar of the New National Aquaculture Strategic Action Plan Initiative in Canada

* (Permission Granted to View Powerpoint)

By Eric Gilbert

Eric Gilbert was unable to provide the presentation due to a family emergency, but has given permission to circulate his powerpoint presentation.

Selective Breeding Programs in British Columbia

* (Permission Granted to View Powerpoint)

By Bruce Swift

Bruce Swift of Swift Aquaculture (Alberta) graciously provided an impromptu presentation in which he overviewed the genetic selection program of TRI-GEN Fish Improvement Ltd. for Coho salmon, Chinook salmon, Atlantic salmon, and rainbow trout. He discussed a variety of methods that are being used in the breeding program including: the Best Linear Unbiased Prediction (BLUP) model, Near Infrared (NIR) Technology, cryopreservation of gametes and embryos, and the use of ultrasound. Bruce also discussed the use of integrated freshwater aquaculture systems. He described a recycle system that cultured Coho salmon and also produced wasabi using the effluent from the fish system. The integrated aquaculture systems also included growth of a hybrid poplar tree that was used to produce tissue paper; as well as production of watercress, algae, crayfish, and edible flowers.

Innovation and Emerging Technologies

* (Permission Granted to View Powerpoint)

By Michael Rubino

Dr. Michael Rubino, Manager of the NOAA Aquaculture Program, overviewed NOAA's Aquaculture Program and discussed the current status of and future potential for marine aquaculture production in the US. Dr. Rubino described the "Triple Bottom Line" approach, which he believes is essential for successful marine aquaculture production. This approach suggests that sustainability must take into consideration economic, social, and environmental factors. In addition to being economically viable, aquaculture operations must mesh socially within the fabric of coastal communities; which includes supporting existing working waterfronts. Environmental sustainability also includes factors such as complying with environmental laws and regulations, as well as "smart designs," which include advanced technologies that minimize negative impacts. Currently in the US, shellfish represent 80 percent of commercial aquaculture. Dr. Rubino gave an overview of other existing marine aquaculture production and research efforts around the coastal US. A few examples include:

- Cod and Atlantic salmon culture in Maine;
- Research at the University of New Hampshire on net pen innovation;
- Black sea bass and red porgy culture in North Carolina;
- Recirculating aquaculture technology research in Florida;
- Research on bead filter technologies for recirculating systems in Louisiana;
- Stock replenishment efforts at Hubbs-SeaWorld Research Institute in California;
- Offshore finfish cage culture in Hawaii;
- Net pen, recirculating aquaculture, shellfish, and hatcheries in Washington State; and
- Hatchery-based salmon stock enhancement in Alaska.

In discussion of the future of marine and coastal aquaculture, Dr. Rubino delivered the following key points:

1. Coastal land comes with a very high value and working waterfronts are diminishing; thus, spatial planning will be critical in the future.
2. Stakeholders want to see more domestically grown seafood, protection of wild stocks and the marine environment, sound scientific research to support the industry, and aquaculture companies that support the coastal culture.

Panel Discussion – Aquaculture Innovation, Research Priorities, and Vision for the Future

Panel Members: Per Heggelund, Jeff Silverstein, Michael Rubino, and Steven Summerfelt

To wrap-up an excellent day of information sharing and discussion, a panel discussion/group participation session was held. The following summary of the Panel discussion has been prepared jointly by the Freshwater Institute and Tides Canada. While we believe it accurately reflects the discussion that took place, it is not intended to be viewed as the official position of the stakeholders represented at the meeting.

Sustainable Labeling: Distinguishing Wild-Caught vs. Aquaculture Product

To begin the session the questions were posed, "Where do we draw the line between fish farming and fishing? In the future how should this be dealt with and should the seafood products from these industries be separately defined or labeled?"

Varying opinions were offered in response to the question. Several believed that fish farming and fishing or more specifically farmed and wild caught product need to be distinguished. It was stated that the *Lacey Ac*t in the US needs to be amended to sever the link between wild and farmed fish. Several participants supported distinguishing farmed product from closed-containment systems, referencing the success at Aquaseed (Sweetspring) Inc. in marketing Coho salmon, cultured within closed-containment systems, and labeled as "sustainable" through the Monterrey Bay Aquarium. Other participants believed that such a hard-line distinction could further confuse the consumer. Complete separation of the two could also cause further social separation of industries working towards the common goal of supplying high quality seafood. No matter how the product is distinguished, it was agreed that conservation must be a focus of both wild-caught and farmed-raised seafood industries.

There was ample discussion regarding public awareness, opinion, and how do to a better job marketing sustainably cultured seafood. The question was posed, "How do we provide proper communication to the public regarding the seafood that they eat and where it comes from, in particular aquaculture products?"

It was also stated that the aquaculture industry hasn't been a profitable industry in the US. The US industry has not made a name on Wall Street for the general public to invest in and learn about. There is still a large percentage of the general public that hasn't even heard of aquaculture or is just now hearing about it. In addition, many participants expressed concern that historically investments in aquaculture have failed. It was noted that aquaculture farms in the US need private property rights associated with other farms to improve attractiveness to financial institutions. The success of the European aquaculture industry was referenced as a model that could be followed by the North American industry. A range of marketing ideas were discussed, such as engaging celebrity chefs. The industry seems to be ahead of the curve technically and scientifically, but below the curve relative to marketing.

Increasing Sustainable Production Domestically and as an Industry

The next discussion topic focused on the large discrepancy between imported and domestic seafood that is consumed in the US. Greater than 80% is imported, at a time when the food safety and environmental concerns have the general public wanting more locally grown seafood product and more domestic production. A possible approach to increase public and government awareness and influence opinion could be to link aquaculture to nutrition and feed research. Relative to increasing US domestic production, several commented that “seeing is believing”. The tour of the Freshwater Institute was used as an example. Seeing Atlantic salmon successfully cultured at 80 kg/m^3 in a land-based closed-containment system is dramatic and other industry leaders might adopt such a practice and be able to increase production if they were to see this in person. It was noted that from a business perspective, the risks associated with aquaculture are high, capital can be hard to obtain, and losses are hard to absorb. Historically, aquaculture has not been a profitable food production industry. Demonstrated innovation such as successfully operated closed-containment systems by smaller companies can encourage larger companies to adopt these new technologies. Recent developments were referenced that indicated that the industry could already be moving in this direction. Interest has been expressed by large aquaculture companies to increase the amount of time smolts are grown on land with less time in ocean net pens. [We note that subsequent to the meeting, recent news indicates that Norway is working to develop more sustainable aquaculture practices and has plans to begin growing smolts to approximately 1 kg before transfer to net pens.] It is important to demonstrate the commercial potential of closed-containment systems, as well as identify and utilize branding and profitable niche markets in the early stages of this technology.

It was observed that two groups of people have been particularly successful within the aquaculture industry – coastal fishing people that integrate wild and farmed fisheries and farmers with a close connection to animals. It was noted that economic return is important but is not always the only measure of value. Connection to our food supply, culture and local communities are important social values.

Alternative Protein Feeds: What Does the Future Look Like?

The development of cost effective alternative protein feeds is extremely important for the future of aquaculture. During the workshop, proposed budgets for prospective aquaculture operations indicated that feed costs exceed 50% of operational cost. It was stated that the new soybean varieties that are being used are more cost effective, but costs of ingredients are always changing. Beyond soy protein, the next best protein source for fish feed that has great potential is algae, specifically *Spirulina.* Algae has such potential because it represents a "de-novo" ingredient that currently is not being used significantly by other industries, particularly for other food production or as a fuel. Recent studies have shown that some algae-based proteins could provide the same benefits as fish oil, specifically omega-3 fatty acids. However, the algae industry is in its infancy and has a long way to go before it is ready to make a significant impact for alternative aquaculture feeds. It was also suggested that there is a lot of fish byproduct that goes to waste that could be utilized as a protein source in fish feed. It was emphasized that we do need to break the trend of fish being fed fish. Researchers supporting the aquaculture industry have proven that fish don’t need fish meal, which is essential knowledge for the industry as it moves forward to solve the problem of fish meal availability.

Vision for the Future: What's Next?

As the meeting concluded, the group provided the following recommendations for follow-up and next steps:

1) The workshop was very useful and it is important to keep the community of stakeholders that are gathered for this workshop connected and communicating.
2) The use of demonstration projects to prove technological, economical, and biological performance within closed-containment systems is an important next step. The information gleaned from demonstration projects does not need to be compared to other aquaculture systems, but more importantly needs to be further evaluated to determine the feasibility of CCS for food fish production.
3) The next workshop should continue the conversation around attracting financing and on downstream process, including processing, value-added products, and marketing. It would also be useful for diverse groups like the one gathered at the workshop to meet with key supermarkets and seafood distributors such as Wal Mart and Whole Foods to engage them in the conversation.
4) The focus should remain on the fish that are being cultured and on the continued sharing of research to improve culture methods and develop new technologies.
5) As we move forward, closed-containment systems and emerging technologies should be presented as new technology options. Care needs to be taken to continue with an open-minded approach, encourage new ideas, and nurture community within the broader industry.