Northeastern Regional AQUACULTURE Center

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A Review of Operating Economics and Finance Research Needs

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Context

The aquaculture industry in the US Northeast Region ("NR") produced annual farm-gate sales of $130 million (M. Lehan) in 2001. By any measure, this is a minor industry in the Northeast region. Despite increased overall regional demand for seafood, despite fertile waters, and despite abundant easily accessible scientific and operational expertise, the NR aquaculture industry is growing at a slow rate, if at all.

As unemployment persists, tax revenues decline, and the US trade deficit increases ($7 billion deficit in edible seafood alone in 2002), there is interest in both public and private sectors to build the NR aquaculture industry. NRAC is mandated to direct research funds to areas that will most encourage the aquaculture industry in the region. The criterion against which NRAC performance must ultimately measured is the health and expansion of the **commercial** aquaculture industry, with attendant increase in private sector jobs and earnings.

Given NRAC's mandate, the major task for the Operating Economics and Financing White Paper team was to provide information to NRAC decision makers so they could effectively answer the following question: **What actions in the area of economic knowledge or financing can NRAC take to increase the NR aquaculture industry?** The White Paper team decided to inform future allocation of NRAC research resources as regards aquaculture economics and financing, by surveying public (non-proprietary) knowledge to answer the following two-part question:

Is there enough information available to determine:

1. Are there any good businesses in the NR? - What aquaculture businesses are, or would be, economically viable? Is lack of economic information holding back aquaculture ventures in the NR? What businesses are worth investing in by operators and/or financiers using criteria such as profitability and return on capital? **Is there sufficient information to allow operators and financiers to project economic performance?**

2. Is capital available for good businesses? - What capital sources are, or could be, available for economically viable aquaculture businesses in the NR? **Can worthwhile businesses find avenues for financing for growth?**

The paper does **not** purport to be a summary, review or analysis of all the economic and / or financial information that has been published for each of the species and sectors that were required to be considered. It **does** claim that the authors surveyed available literature to determine whether or not NRAC could justify using public funds to undertake economic and / or financial research into aspects of each of the areas. A representative, non-exhaustive list of references is included.

To illustrate the distinction with an example - The authors learned from a broad search that there are scores of extension brochures, manuals, academic articles and industry-generated studies of trout farming relevant to the northeast region. This conclusion and examples of the resources available are included in the paper. Direct discussion with operators by the authors also made it

clear that trout farms in the NR are being sold in many cases because the price of real estate has risen so that the owners rationally choose to sell to developers. It also became clear that operators and investors have ample written information available plus a multitude of extension, university, and industry experts available to guide their decisions in the trout farming industry. The authors therefore did **not** in this paper review, compare, contrast, summarize, or even exhaustively list every available article, book, brochure, or manual concerning trout farming, because that can be done on an as-needed basis by operators, or by any interested university economics department. The authors **did** assess whether NRAC should or should not invest funds, which are intended to benefit the development of the aquaculture industry, to trout farming economic and / or financial research. (In the case of trout farming the authors concluded that such research would not be justified.) The difficulty of making accurate assessments for so many species is acknowledged and admitted, and the authors will be grateful for corrective and augmenting feedback from the aquaculture community in industry, academia, and government. Reader feedback as to how NRAC can best encourage the growth of the regional aquaculture industry will be appreciated by this and by other White Paper teams.

PART 1. Operating Economics

The following survey of potential NRAC research activity in aquaculture operating economics and finance is organized by species and by business area (recreation, biotechnology, etc.) rather than by state. Economic considerations are relatively similar throughout the region, although the value of specific economic variables such as prices of real estate and labor obviously vary. Species are discussed in this section in descending order of their current economic importance in the NR. The sections for each specie and sector discussed below generally cover:

- What businesses are or could be operating in the NR,
- Whether supporting economic information is currently available, and
- What further research would be useful.

Salmon

The $92 million (M. Lehan) NR salmon farming industry is located in Maine, is owned and operated by European and US companies, and produces a small fraction of the farmed salmon consumed in the US. Imports of farmed salmon in 2002 totaled $818 million (USDA-LDP-AQS-17, March 14, 2003). The scale of the production in the exporting countries (primarily Chile, Norway, and Canada) reflects the serious effort made by those countries to build their industries. Despite legal and regulatory behavior towards the salmon industry in Maine, which to the financial community is reminiscent of certain poorly organized third-world countries, large vertically-integrated foreign aquaculture companies have made significant investments in the Maine salmon industry where there is both fresh water for the hatcheries and seawater for the net pens. Public and private hatcheries in the region produce Atlantic Salmon for stocking.

Much non-proprietary economic and financial information exists for the salmon industry. Many of the leading companies are listed on public stock exchanges, which require public disclosure of financial results and economic concerns. Publicly available fish management software packages such as AquaFarm (Ernst, Douglas H., John P. Bolte, and Shree S. Nath, Oregon State University, Corvallis) provide formats for exploring sensitivities of economic factors.

The economics research community has intensely studied the global salmon market as well as regional salmon markets, examining supply and demand and elasticity relationships, forecasting, econometric modeling, and national and regional market descriptions. This is a well-documented and much-analyzed market because the volumes are so large and the price shifts so dramatic. The sophistication of economic work available for the salmon industry is demonstrated by a Norwegian linear programming-based model by O.I. Forsberg 1999, of the inter-relationships between salmon prices, growth rates and harvesting planning. The model showed that, given the input assumptions, size grading prior to harvest is preferable to harvesting the full range of sizes at any one time. Although the report of the model provides full description of the functions and parameters, the model itself is not offered via a website, greatly reducing its value for the commercial community because the internal logic and conclusions cannot be double-checked.

The economics of salmon raising systems that are alternatives to the common hatchery-to-net-pen system inspired interest and public sector research by the Province of British Columbia's Environmental Assessment Office, which in 1997 published a study entitled "Salmon Aquaculture Review". In Chapter 11, "Alternative Salmon Aquaculture Technology", enclosed at-sea systems and on-shore re-circulating systems were discussed, and a summary of an economic study commissioned from Simmons Environmental was presented. (See website http://www.intrafish.com/laws-and-regulations/report_bc/v1chp11.htm). They concluded that operating costs for on-shore systems were 5% higher than sales prices. Addition of capital costs brought the breakeven selling price to an unfeasible $5.09 to $5.84 per pound. Finally, the negative experiences achieved by such systems in Scotland, Norway and Iceland were cited as additional evidence of the unfeasibility of on-shore systems given current technology and market prices.

Seafood Business magazine (October 2002) reported that AgriMarine Industries of British Columbia produced 28,000 salmon as the start of a five-year pilot program testing on-shore salmon farming. The fish were sold exclusively through the Thrifty Foods supermarkets, a chain renowned for its innovative salmon marketing. This sort of experiment bears watching, but does not justify the desirability of repeating the experiment at public expense in the NR.

The global salmon aquaculture industry is intensely competitive, and the difference between success and failure can be a matter of a few cents per pound of product. Time variation in price is especially important in this industry, so economic forecasting techniques are commonly used. Guttormsen, in a 1999 study of weekly salmon prices tested six prediction methods and concluded that two standard methods, Classical Additive Decomposition and Vector Auto-regression provided the best results for price movements and for accuracy respectively.

The salmon companies operating in the NR understand the economics and financing of the industry with a degree of precision and sophistication comparable to that of the poultry industry. Knowledge of salmon farming in the NR is not likely to be enhanced by general economic and financial research undertaken by NRAC.

(Economic and financial issues relating to businesses serving the salmon farming industry are discussed under different categories below; see Marketing Services and Biotechnology.)

Freshwater Trout

Freshwater trout farming in the NR generated $15 million of farm-gate revenues in 2001 (M. Lehan). In the NR, the main freshwater trout species are the rainbow, brown and brook trout with 1998 revenues of $9 million, with the majority coming from Pennsylvania. Other states produce trout in government and private hatcheries and in grow-out facilities using ponds, raceways, or tanks, mostly for pond and stream stocking. Trout farming, for both food and sports fishing, exists in most countries where there is suitable water and some European, especially British, influence. Trout farming was the first form of fish farming in countries as diverse as the US (150 years ago) and Zimbabwe (60 years ago).

Actual operating results of private companies are rarely available directly to the public. Costs of government operations are published however; for example, an assessment of the four Rhode Island state fish hatcheries / nurseries (O'Brien 1997) concluded that 132,000 10" to 12" trout cost $3.71 each to produce and deliver to the public waterways. For operators and financiers conducting Due Diligence or benchmarking however, there are ample sources of information. Vendors of fish farm management software are often able to provide normative information. "FishMakers" emphasizes database capabilities and effective user interfaces, so that the software is effectively adapted to different operations. For a description, please see the website at http://www.softmakers.com/acquacoltura/english/default.htm . Suppliers to trout farms (e.g. feed and supplies) are familiar with norms and variations for their inputs. Economic information is also available from extension agents or university departments in most states, as well as many countries, for ponds, race-ways, and fee fishing operations. A simple Google search or phone call to an extension agent can get a new farmer or investor technical details and economic projections. A good example is the seventy-page manual on Rainbow Trout farming from UC Davis extension, sponsored by a private feed company (Nelson & Sons Inc., of Utah): http://aqua.ucdavis.edu/dbweb/outreach/aqua/TROUTMAN.PDF

Another type of readily available economics-oriented trout research is the industry overview, as exemplified by "*Socio-Economic Model for the UK trout industry*" by Nautilus Consultants (Scotland), 2001. The authors did not review this, but the summary states that a questionnaire survey was used to generate a component model of the industry, an assessment of the economic effects on the rural areas, and recommendations as to future on-going data collection and analysis. Such studies, while valid as pure research, are not oriented towards helping the private sector succeed and create employment and should therefore be avoided by NRAC.

In 2000, the Strategic Plan for Newfoundland Aquaculture recommended the encouragement of Steelhead Trout farming, but no economic justification or business plan was presented. (The report can be seen at http://www.gov.nf.ca/fishaq/pdf/summary.pdf, written by Burke Consulting Inc. and Resource Development Associates). To the contrary, the report stated that to be competitive, costs of production would need to be reduced and that government sector support would be needed. The report is not useful for private industry, and instead recommends more government research. NRAC should not support similar research.

Economic studies can usefully be undertaken when considering expansion of trout farming into a new region because the first limitations on trout farming feasibility in a specific location are usually the economic consequences of chemistry and volume of available water, followed by limitations from prevailing weather. An example of how such a study can be done thoroughly and presented in a format useful for private sector operators and financiers is a West Virginia University project led by Gerard D'Souza, 2003, which was designed to inform the expansion of aquaculture into the 'hill country of West Virginia'. The study focused on trout but also assessed alternative species, both food and sport fish, and considered various farming methods. The paper provides estimates of production and investment costs for specific operations in formats that the private sector can utilize. D'Souza et al. do not hesitate to recommend business strategies based on their research, which is an aspect of their

work that should be emulated by any future NRAC economic research in order to translate the research more readily into commercial growth. The following quote from the posted summary shows the practical yet wide-ranging approach taken in their research:

> "Preliminary results from previous phases reveal, for example, that while trout production
> can be highly profitable under a wide range of circumstances, it is risky as well. This
> persuaded us to identify specific risk-management strategies such as combining fee
> fishing and raising food fish, with the chosen proportions of the two activities depending
> upon the producer's attitude toward risk. Key variables influencing profitability tend to
> be type of production system (e.g., tank vs. raceway), feed conversion ratio and size of
> operation. In addition, product mix is found to be a key variable influencing profitability
> of trout processing. Thus, relatively low volume trout processing (from a few thousand
> to a few hundred thousand pounds, typical in WV, for example) can be profitable if used
> with an appropriate product-mix strategy, identified in our research. Results also show
> that economies of size occur in both production and processing, a finding that is
> relatively important considering the notion that the aquaculture industry in hill country is
> poised for growth."

For a summary, see http://www.wvu.edu/~agexten/aquaculture/2003forum/Ecosummary.pdf**.**

It is the authors' opinion that there is no need for NRAC to sponsor general economic and financial studies of the fresh-water trout industry.

Similarly, NRAC should not invest in general economic or financial research concerning the (oceanic) Steelhead Trout industry. The large multi-national, vertically integrated Maine salmon companies also currently produce Steelhead Trout, in Europe as well as Maine, and are already fully conversant with the commercial realities of the industry.

Clams

Clam farming revenues in the NR were about $15 million in 2001 (M.Lehan), just less than the revenues from freshwater trout, and one-sixth the revenues from salmon.

In the U.S. in 1998, Florida with clam production of 76 million clams and Virginia with 70 million dwarfed the output of the next three leading states, which are all in the NR: New Jersey with 9 million, and Massachusetts and Connecticut with 6 million each. The limitation on growth in the NR is widely agreed to be access to water, rather than marketing, technical, economic or financial issues. The excess of demand over supply is so large that substitution by mahogany clams from Maine and vacuum-packed clams from China and New Zealand is increasing.

In all the coastal NR states, private individuals and businesses are farming, or else seeking space to farm, hard clams and sometimes soft-shell steamer clams. The most ambitious plan is that of the Mohegan Aquaculture team. Further south, interest in Delaware Bay has been sparked by the hope of replacing oyster revenues lost to disease. Rutgers research into polyploid clams is another source of future promise. New Jersey aquaculture efforts are primarily directed to hard clam, as private businesses and for public seeding of beds. Rhode Island has the potential for a large clam farming industry, and when the political will develops, it can achieve this. Maine farms both hard clams and soft shell clams. Innovative business models have been reported in other states, for example, "Dig Your Own Clams" was developed in North Carolina by a clam farmer, Kevin Midgett, and by Jim Murray of North Carolina Sea Grant in 1996. The existing research is available to NR operators.

Software has been written to assist with managing and analyzing the operational and economic variables of clam farming. Similar to the AquaFarm software for fish described earlier, there is a program from New Jersey Sea Grant called ClamFarm, which was adapted from PEI mussel farming software by Gef Flimlin with support from NRAC and NJ Sea Grant. An added benefit to these programs is that they can facilitate communication between operators and financiers concerning risk and planning. Although the software is probably not of interest to Mom-and-Pop growers, it can be useful to standardize reference points for extension agents, larger growers, and the financial community.

The number of clam farming manuals is large and can be accessed with a Google search or visit to an extension agent. The Martha's Vineyard Private Aquaculture Initiative and the Darling Center programs in Maine perform education and extension services similar to those provided by Harbor Branch in Florida, which launched the Florida clam farming industry. The Delaware Aquaculture Resource Center (http://darc.cms.udel.edu/) provides access to clam farming information. The North Carolina Department of Agriculture offers spreadsheets and business plan information for clams (and for catfish, trout, hybrid striped bass, and other NR species. See http://www.agr.state.nc.us/aquacult/pubs.html .

Many suppliers to clam farmers provide economic and technical information as a service to customers and in an effort to expand their market. A good example of this can be found at the Bishop Aquaculture Technologies website, http://www.fukuina.com/articles/sept_oct97.htm , where technical and economic information from a working Manila clam farmer is presented.

The relationships between price and volume are so erratic that growers tend to use their own money, with no banks and no insurance. Some refuse to participate in USDA programs for uninsured farmers because “it turns farmers into liars” (Personal communication). Prices of clams are affected in New Jersey by rainy weekends, by 9/11, by news reports that somebody in Miami has eaten a bad clam, etc. Cape Cod prices may be $ 0.25 per clam, while in New Jersey the price is $ 0.17.

The authors conclude that, given the demonstrated widespread knowledge of clam farming economics and financial issues, there is no need for NRAC to fund general research in clam economics or finance. However, an extension report with detailed Bill of Material information

and line item expenses for different scale operations should be prepared using published extension documents from Canada, the US, and industry suppliers.

Oysters

Annual oyster farming revenues in the NR have declined in the last decade to $5 million. For comparison, in 1992, Connecticut and New York produced about $70 million of farmed oysters. Oysters (along with carp, clams, mussels, salmon, shrimp, and tilapia, according to AgExporter, January 2003) are among the most commonly raised aquaculture products in the world, so there is ample expertise and experience concerning the economics of this species throughout the world.

The NR will most likely recover its oyster industry. The admirably ambitious efforts of the Mohegan Aquaculture company to reverse the oyster industry's downward trend has gained news attention, and there are numerous smaller companies that have successfully operated for years, earning their owners a living and expanding. The internationally renowned Milford Laboratory continues research and training. In the Chesapeake Bay, research is being conducted on non-native disease resistant Crassostrea ariakensis. Companies of one or a few operators are expanding in Maine, Massachusetts and Rhode Island, limited by access to water more than by any other constraint. Restoration of public beds with disease-free spat is being attempted by hatcheries such as the Horn Point Hatchery in Maryland, the Martha's Vineyard Shellfish Group, and numerous small town efforts along the coast. Research was conducted at Rutgers in New Jersey on polyploidy and other methods to accelerate growth and survival. The creativity of individual companies shows that, with access to water and some capital, new ideas will continually be generated, such as the efforts of a private Maryland company to grow oysters in fishponds.

In the NR, universities, extension agents, and private operators possess a wealth of knowledge about oyster farming. As is usual, suppliers of products and services provide education and consulting as a means of marketing. The example mentioned in the Trout section of a trout manual produced by a feed company is mirrored in the oyster farming area by the missionary efforts of, for example Bishop Aquaculture Technologies (Don Bishop, www.fukuina.com/) which provides supplies, advice and networking assistance to North American and overseas oyster farmers. An example of a supplier that is essentially trying to offer franchise-like assistance is "Circle C Oyster Ranchers Association". The companies plan can be viewed at the website **http://www.oysterranching.com/contact.html.**

Progress made in other states also contributes to the NR knowledge base. In North Carolina, Tipper Tie Inc. and NC Sea Grant collaborated to define, test, and publicize a system of oyster farming named the "Chub Ladder Method". The Martha's Vineyard Private Aquaculture Initiative and the Darling Center programs in Maine perform education and extension services similar to those provided by Harbor Branch and others in Florida that launched the Florida clam farming industry. For a description of the "Chub Ladder Method", please see the website (http://www.aquanic.org/publicat/state/nc/chub.htm).

Simple but specialized software is freely available to help oyster farmers manage their businesses, for example, New Jersey Sea Grant's *Shellfish Farm Spreadsheet and Economic Analysis Software Package*
http://www.aquafarm.com/aqua-soft/DesignAndPlanning/Economic_Planning_and_Analysis.htm .

An example of a recent effective economic study is the "Small-Scale Oyster Farming for Chesapeake Watermen - A Sustainable Business Marketing Plan" by Robert Kallen, Kevin Morse, Daniel Grosse, and Dorothy Leonard of TerraAqua Environmental Science and Policy, LLC, 2001. In addition to succeeding as a competent marketing plan, the report also provided, at a practical level, an economic and implied financial plan. The detailed start-up costs are low enough that personal savings or 'family and friends' could provide the seed capital. The economic results based on various simple parameters are presented in a simplified Profit & Loss format. The spreadsheet generating the exhibits could presumably be supplied by the authors or else be reconstructed from the exhibits by a reader.

On surveying the regional, national and global knowledge of oyster farming economics and financial issues that resides in the private, public, and academic sectors, the authors conclude that NRAC should not invest any research funds in general studies of oyster farming economics or finance. However, an extension report with detailed Bill of Material information and line item expenses should be prepared using published extension documents from Canada, the US and industry suppliers.

Mussels

In 2001 the reported dollar value for farmed mussels in the NR was only $1.4 million (M.Lehan). In other parts of the world, even as close as PEI, the growth of mussel farming has been dramatic, because the initial investment required and farm maintenance costs are relatively low. The New Zealand mussel farming industry grew from nothing in 1985 to about $100 million fifteen years later. The relatively small country of Thailand has a total farmed mussel production about the same as Netherlands and New Zealand combined. The examples of other countries indicates that the NR could support a large mussel farming industry.

Mussels are one of the most commonly farmed species in the world. The technology and economics of mussel farming have been documented for many countries in the world, and the global mussel farming industry has been expanding vigorously. Spanish mussel farming companies have proven willing to invest in Mexico and Chile, and to explore investments in the US. Within the past two decades an Irish mussel company was interested in investing in a Canadian operation, and a French conglomerate attempted to purchase a US mussel company.
According to SeaFood Business Magazine (1999), US consumption of mussels steadily grows by 15% annually. Current consumption is 25 thousand tons, which is only 8% of European consumption. Eventually, global mussel farming will achieve a state of over-supply, but it is difficult to predict when, because markets continually expand as prices fall and better product forms are invented. Local producers of processed mussels will always need to remain competitive with product imported from farms in China, Chile, Thailand, New Zealand and other

major producers. Producers of fresh (alive) mussels will need to adjust to falling prices affected by increased production in Atlantic Canada and in the NR.

Interest in offshore mussel farming in the NR is a promising development. As part of the University of New Hampshire Open Oceans Aquaculture Demonstration Project, a team from Woods Hole Oceanographic Institution prepared a "*Business Planning Handbook for the Ocean Aquaculture of Blue Mussels"* (P. Hoagland, H.L. Kite-Powell, and D. Jin, 2003). The report included a simple profitability projection (although without providing details of cost calculations) and concluded that the concept was viable at dockside prices as low as $0.50 per pound. The paper is available at the Open Ocean Aquaculture website of UNH, http://ooa.unh.edu . The goal of the Project, under Richard Langan's leadership, is to put fishermen to work growing and selling mussels.

Earlier research by a private company in 1988 and by WHOI in 1999 had also indicated that the off-shore farming of mussels could be profitable. John Bonardelli, a Canadian mussel farmer who collaborated with WHOI, remarked that he could not understand why southern New England, where mussels grow two to three times faster than in Canada, had not already built a massive mussel industry that would displace PEI (personal communication, Murray). Kite-Powell et al., in "*Economics of Open Ocean Grow-Out of Shellfish in New England: Sea Scallops and Blue Mussels*" analyzed the WHOI 1999 results with a model that predicted that offshore mussel farming could be profitable at dockside prices between $0.65 and $0.80 per pound.

There are no significant technical or knowledge barriers facing the NR mussel farming industry, that have not been solved elsewhere in the world. There are numerous manuals available on how to farm mussels, and one can buy turnkey systems from Canadian, Spanish, and British suppliers. SEAFDEC, the FAO, and other overseas extension services have also published manuals and offer training.

Closer to home, the Canadian Center for Fisheries Innovation (CCFI) in 1998 sponsored training and publication of 'Best Practices' in mussel farming for would-be mussel farmers in Newfoundland. PEI has excellent training materials as well as software written by Dr. Jeff Davidson, Atlantic Veterinary College, PEI. (This is the program that was adapted by Jeff Flimlin in New Jersey for clam farming.) The Newfoundland Aquaculture Industry Association (NAIA) also provides excellent training materials and a software package "Mussel Farm Management Inventory System (Mussel Farm - MIS)". Great Eastern Mussels, the Darling Center, and other groups in Maine have introduced mussel farming to that state.

In light of the extensive knowledge base that exists, and because investment from foreign and private sources will be available for farming of this well understood bivalve, the authors conclude that NRAC should not fund research into the economics and financing of mussel culture in the NR. However, an extension report with detailed Bill of Material information and line item expenses should be prepared using published extension documents from Canada, US, Europe and New Zealand, and from industry suppliers. In addition, cost details already collected (but unpublished) from the UNH and WHOI off-shore long-line projects should be included.

Mussels grow especially well in the NR and there are strong possibilities for import substitution and gaining export markets.

Use of mussels for environmental mitigation, either alone or in conjunction with existing fish farms, would be enhanced by a proof-of-concept study that included detailed line item information, Bill of Material capital budgets, and on-line availability of the resulting model and backup data.

Tilapia

In 2001, Tilapia production in the NR was only $1.3 million (M. Lehan). Tilapia (along with carp, clams, mussels, salmon, shrimp, and oysters) are among the most commonly raised aquaculture products in the world, so there is ample expertise and experience concerning the economics of this species throughout the world (AgExporter, January 2003).

Imports from China, Taiwan, Ecuador, Costa Rica, Indonesia, and many other warm countries have pushed NR Tilapia producers into the live fish trade. Although the volume of production in the NR is miniscule, Tilapia seems to be grown to some extent in every NR state except Rhode Island. Tilapia is a forgiving 'starter-fish', being hardy, prolific and fast-growing. Maryland's Department of Agriculture estimated Maryland's Tilapia production to be 1 million pounds in 1996. In Massachusetts, Tilapia have been grown for sale to diverse environments ranging from swimming pools within a former textile factory to sophisticated hydroponics / fish-culture facilities. In recent years, Fingerlakes Aquaculture Inc. in New York obtained over $4 million in capital for its indoor tilapia facility and according to news reports is apparently undergoing current expansion this summer, partly financed by public funding.

There is widespread knowledge concerning Tilapia and excellent training and management tools are available. Universities, agencies and institutes (FAO, SEAFDEC, ICLARM, HBOI, etc), Sea Grant and extension services have manuals and booklets with technical details of hatching and raising Tilapia.

SRAC (NRAC's sister organization for the south) published a most useful extension aid, at http://aqua.ucdavis.edu/dbweb/outreach/aqua/456FS.PDF titled "*The Economics of Recirculating Tank Systems: A Spreadsheet for Individual Analysis",* SRAC Publication Number 456, November 1998, by R. Dunning, T. Losordo, and A. Hobbs. This allows fish farmers to analyze existing or prospective operations by entering variable values appropriate to the specific situation.

Using African data, a consulting organization has developed a MATLAB-based model to be used to analyze different pond management plans including the economic results of each strategy. A summary description is available at http://www.nefisco.org/downloads/TILAPIA_MODEL.pdf . This model is of use to farmers in the Northeast Region.

There are many other models for Tilapia raised alone or with shrimp or catfish in Africa, in Asia, and in other locations. A prospective Tilapia farmer seeking a model would probably find one adaptable to her needs regardless of how unique the proposed design appeared to be. The authors recommend the SRAC version as being practical and sufficiently general.

The authors do not believe that NRAC should support additional research into the economic or financial factors of Tilapia farming in the NR. There are numerous private operations and capital is available, albeit usually from sources that are not familiar with the seafood or aquaculture businesses.

Catfish

The production of catfish in the NR is very low due to low temperatures. The USDA 1998 aquaculture census reported $254,000 of sales. Maryland Department of Agriculture estimated 78,000 pounds of catfish in 1996. Pennsylvania reported 5 farms with sales of $44,000 total in 1998. Rhode Island does not grow any catfish (or any fish at all), but in May of 2003, the DEM invited the program director of the New Hampshire Aquaculture Association, Melvin Murrel, to speak to any Rhode Islanders interested in aquaculture. Among the interesting perspectives offered was that New Englanders consume $3.5 million of catfish annually, indicating a possible local niche business. Murrel sells his catfish (hornpout) for food, for bioassays to a pharmaceutical company, and for sludge remediation.

The economics of channel catfish in the US and of various Clariaid catfish in Asia and Africa have been intensively studied and widely published. Manuals and computer models are obtainable and could be adapted by NR region farmers. As an example of unexpected adaptation of catfish farming, the African catfish which is usually farmed in ponds and even puddles in Africa is now grown in intensive recirculating systems in Europe.

The authors believe that there is already ample catfish information and extension assistance available in the public domain, and that NRAC should not invest funds in research on its economics or financing in the NR.

Hybrid Striped Bass (HSB)

The USDA 1998 census estimated "striped bass" culture in the US to total $7 million, almost all of which was produced by Kent SeaTech in Southern California. In contrast, there are no large and successful HSB companies in the NR, due to its less favorable climate (according to operators and extension agents).

Kent SeaTech is the ideal model of HSB success. It was formed by two scientists, and capitalized sufficiently so that they could survive not just one but several false starts. The company achieved enough progress to be purchased by a large food company team, the Kents who had built Orville Kent. Kent SeaTech has remained at the forefront of technological progress for Hybrid Striped Bass.

There are small HSB operations in New Hampshire, Vermont, and Pennsylvania. The universities, state extension services (e.g. http://www.agr.state.nc.us/aquacult/pubs.html), and extension oriented research institutes such as Harbor Branch Oceanographic Institute (see http://www.hboi.edu/aqua/pdfs/HSBass.pdf) offer technical and economic information and bibliographies that can guide operators and financiers entering the HSB farming business. SRAC has published a pond system enterprise budget (http://srac.tamu.edu/3000fs.pdf). Turn-over in the business affords opportunity to find experienced employees and to examine existing operations (e.g. AquaFuture in MA and Purewater Farms in NC).

In the authors' opinion, due to the existing economic information available about HSB culture, NRAC should not invest funds for general research concerning the economics or financing of HSB. According to extension agents (e.g. Donald Webster) who have worked with HSB companies, a primary need is for assistance in economic analysis and decision-making.

Shrimp

According to NMFS import statistics, the shrimp consumed in the US is mostly imported from Thailand, Mexico, India, Ecuador, China, Indonesia and Africa.

The bulk of shrimp farming economic research has been performed on outdoor systems. The Texas A&M / Texas Sea Grant model and financial statement generating software (*The Shrimp Farming Financial Analysis/Spread Sheet,* by W.L.Griffin & G.D. Treece) is an excellent example of software formatted for the practical user. There are numerous manuals available from overseas as well as from US universities, research institutions, and agencies. Unfortunately, these manuals are not especially useful to the NR region, which will need to use indoor recirculating systems. Just as US farmers of Tilapia are largely limited to the live fish market, so it appears that US (and therefore NR) farmers will be limited to the (truly) fresh shrimp markets.

The trailblazing work of Harbor Branch, associated Florida companies, University of Southern Mississippi Gulf Coast Research Laboratory, and others in the southern US in developing in-door shrimp production is applicable to the NR. The issues are technical at this point, and it would be wise to let any economic or financial research be conducted by the current commercial and research participants in Florida.

Freshwater shrimp has also been thoroughly researched and publicized, and public information has been available for decades. BioShelters reportedly grows or grew it. NRAC should not invest funds in economic or financial research for freshwater shrimp species.

Algae / Seaweed

The authors were not able to find economic analyses of seaweed farming that were relevant to the NR. We did not exhaustively check all extension agents and university departments, so the

information may be available somewhere, and is almost certainly available by word of mouth or by collaboration with Canadian sources. There are many manuals and simple economic studies available for tropical waters, but these are not applicable to the US or Canada due to large differences in climate and in labor costs per pound.

The seaweed industry in the NR used to be based on wild harvesting for Marine Colloids. MC processes the wild harvest into standard carrageenans, alginates, and agars. Currently the mass wild harvesting and farming occur in Africa, South America, and Asia where labor is cheaper and seaweed growth rates are faster. These overseas sources of seaweed are developed and assisted by the major companies such as FMC-Marine Colloids. So although there is still processing at MC's plant in Rockland, Maine, the source of supply is overseas.

The surviving seaweed producing companies in North America, Phycogen in Maine and Acadian Seaplants in Nova Scotia, are focusing on high quality food items and products for pharmacological use. In Florida, Harbor Branch is following a similar path, exploring the value of a genetically engineered Gracillaria with a high carrageenan content.

There is no call for NRAC to fund research into mass production for the hydrocolloid industry which is now supplied from overseas. If there were an economically viable means of farming seaweeds in the Northeast Region to supply the major processors, then it would be reasonable to expect that the corporations would already be operating in the NR. Currently, FMC-Marine Colloids establishes farms and source networks overseas to benefit from faster year-round seaweed growth rates, easier access to water, and lower labor rates which are important for seaweed, a labor intensive crop. If farming for the mass market were viable in the NR, then we would expect that the surviving pair of companies would be in that business. If the local companies need additional supply of specially grown seaweeds, then their leadership will be needed to establish training and local contracting arrangements.

The authors recommend that NRAC not invest in research into the economics and financing of seaweed culture in the NR **unless** the economic research is a component of a proof-of-concept study or demonstration study. The challenges of the primary production end of industry are to find space and anchorage and protection from vandalism, which are issues of technology, so the bulk of seaweed farming research efforts should be directed there.

Two proof-of-concept studies were suggested; both of which should include economic results, at the level of detail of individual line items and Bill of Materials components.

- Addition of seaweed producing gear within salmon net pen plots, which already have solved the space, anchorage and vandalism problems.

- Land-based algal production as a remediation measure for land based aquaculture or animal husbandry systems.

Food Plants

Like aquaculture, hydroponics has generated much research and study. The NR contains many examples of this concept ranging from BioShelters to a wood-stove heated operation in Vermont which produces only a few pounds daily. Combination hydroponic / aquaculture systems have inspired many descriptions, manuals, pamphlets, and models. Scores of courses and tours are offered by operators, and word-of-mouth advice is freely available.

A 1999 analysis by P.A. Chaves et al., concluded that the addition of hydroponics to a recirculation fish system did not change the internal rate of return significantly. The study is a useful model to adapt for specific situations.

Although producing food plants within recirculating systems is a natural fit for the NR, the authors judge that NRAC should not spend funds in another general economic study of this subject because there are already many studies and working systems that combine aquaculture and hydroponics.

Ornamental Fish and Plants

Florida's aquaculture revenues surpassed $100 million in 2001. Surprisingly, $42 million was from the culture of ornamental fish and $24 million from culture of ornamental plants. In the NR, the leading region for ornamental aquaculture is probably Maryland with approximate sales ((100 farms estimated at $50k each) $5 million, with the rest of the states producing a few million dollars of additional sales. Florida's success was originally based on warm waters, cheap land, and access to airports. Its continued success has probably been due to growth of 'centers of excellence', first near Miami, and then around the Tampa airport. The local universities and extension services in Florida are excellent, and the general attitude among the citizens and government alike is to support agriculture, including its water variety. The Florida industry has survived competition from cheaper farmed imports from Asia, but the pressure is noticeable. As land increases in value, older farmers retire by selling out. There is probably an opportunity for the NR to take advantage of its proximity to large population centers and access to abandoned manufacturing locations which could make ideal locations for indoor ornamental fish and plant farms.

Many manuals, books and pamphlets have been prepared by universities, extension agents, fish breeders, and private authors presenting the basic facts and expected economics. A subjective impression is that experienced employees are more important in this sector as compared to shellfish and food fish farming, due to the variety of ornamental species sold.

Marketing is done through fairly straightforward specialized distributor networks that reach pet stores, pond and garden stores, and other retail outlets. Retailers will often sell ornamental fish and plants at the same location. Koi and ornamental water plants such as lotus, lilies, and water grasses are apparently grown in New England and sold through the horticulture and / or garden pond supply trade.

The authors do not think that NRAC-supported general economic or financial studies of the ornamental fish and plant business would accomplish as much as direct communication between farmers and distributors, facilitated if necessary by extension agents.

Baitfish

The baitfish business, like the ornamental business, offers evidence that Calvin Coolidge's dictum should be updated to say - "The business of America is … entertainment."

The US market for baitfish and feedfish (for aquarium fish) generate revenues in excess of one billion dollars annually. Recent estimates of national farmed baitfish sales are on the order of $50 million, most of which is from Arkansas. Many university and government researchers have described the industry. For the purposes of this paper concerning NRAC's future economic and finance research priorities, the relevant facts are that the market is large, fragmented, erratic, seasonal, fickle, wasteful, and supplied mostly by fish raised in warm-water ponds, with high variable costs of $1.00 per pound. The four dominant farmed baitfish species are fathead minnow (*Pimephala promelas*), golden shiner (*Notemigonus crysoleucas*), white sucker (*Catostomus commersoni*), and goldfish (*Carassius auratus*), per Avault 1996.

The most relevant study for purposes of this review is *"A White Paper on the Status and Needs of Baitfish Aquaculture in the North Central Region"* by Jeffrey Gunderson and Paul Tucker, University of Minnesota, for North Central Regional Aquaculture Center, March 2000. Of the eight critical limiting issues for the industry identified in the study, none concerned lack of economic information or access to capital.

There are many manuals and books providing economic and technical factors concerning baitfish farming which have been produced by extension services, universities, and fisheries departments. Just a few examples from scores are:

- *"Raising Mudminnows"* by Kirk Strawn, Peter W. Perschbacher, Robert Nailon and George Chamberlain, 1992, Texas A&M, publication number TAMU-SG-86-506;
- *"Baitfish Production: Enterprise Budget"*, by Engle, Carole R. and Nathan Stone. 1996, Southern Regional Aquaculture Center, SRAC Publication No. 122;
- *"An EconomicAnalysis of Baitfish Production in Arkansas"* , by Pounds, Gayle L., Larry W. Dorman and Carole R. Engle. 1991. Arkansas Agricultural Experiment Station, University of Arkansas;
- *"Baitfish Culture in Arkansas: Golden Shiners, Goldfish, and Fathead Minnows"*, by Stone, Nathan, Eric Park, Larry Dorman, and Hugh Thomforde, 1997, Arkansas Cooperative Extension Publication MP 386;
- Adams, Chuck and Andy Lazur, 2001 *" Economic Considerations for the Prospective Mudminnow Culturist in Florida",* by Adams, Chuck and Andy Lazur, 2001, EDIS FE#309, University of Florida, Institute of Food and Agricultural Sciences. This last article presents a clear technical bibliography and economic estimates in a format that can be easily adapted to situations outside of Florida (http://edis.ifas.ufl.edu/BODY_FE309).

Since so much material on this industry is readily available, the authors judge that no purpose would be served by NRAC sponsorship of general economic or financial studies concerning baitfish farming.

Scallops

Bay Scallop (Argopecten irradians) and Sea Scallop (Pecten megellanicus) farming has been discussed, tried, and studied, and has generated many studies, but has not yet succeeded in the NR, although other countries with different economic characteristics, especially lower labor costs and easier access to water, have succeeded.

An economic study that could be adapted for NR conditions is *"The economic feasibility of small-scale, commercial culture of the southern bay scallop (Argopecten irradians concentricus)"*, by University of Florida researchers Charles M. Adams, Leslie Sturmer, Don Sweat, Norm Blake and Bob Degner. This is an excellent and detailed study that examines sensitivity of labor costs, market prices, and other factors. Although only one size operation is modeled, the authors discuss the necessary alterations of results to adjust for scaling effects. The authors conclude that the modeled operation is only "marginally profitable".

A recent relevant study made basic economic comparisons of alternative approaches to sea scallop culture (Kite-Powell, Hoagland, Jin, and Murray, *"Economics of open ocean grow-out of shellfish in New England: sea scallops and blue mussels"* Pages 293-306 in Bridger, C. and B. Costa-Pierce, eds., *Open-Ocean Aquaculture: From Research to Commercial Reality*. Charleston, SC: World Aquaculture Society, 2003). Using baseline scenarios and sensitivity analyses, the authors concluded that the method of seabed seeding could be profitable, but that lantern cages, bottom cage trawls and bottom stage clusters would not be economically viable.

Dalhousie University researchers constructed a well-designed software model ("SCALOP") for scallop farm management that was constructed so as to be applicable for other shellfish species. They published a detailed description of the database design, GUI, parameters, and mathematical relationships. They also discussed results and sensitivity analysis, but did not offer the model itself or source code to the readers. This omission obviates the value of the work for the financial community who cannot use the software or check its internal logic. (Cyrus, J. Pemberton and Ronald Pelot, Dalhousie University. *A site management system for shellfish aquaculture.* Aquaculture Economics and Management, December 1998. Volume 2, Issue 3, page 101.)

The authors judge that NRAC should not fund general economic or financial studies concerning scallop farming because sufficient information exists that can be adapted by an interested operator, and because small scale operators in the NR have gained practical knowledge of costs and potentials. The challenges in the NR region for scallops seem to be technical ones that need to be solved with experimentation by operators and by technical scientific research.

Cod

Major Norwegian companies are moving into cod production, Canadian growers have gained experience, SeaFish (UK research agency) has grown cod on a pilot scale, and Scottish cod farms are facing the early calls for "more study" prior to obtaining leases. Here in the NR, Great Bay Aquaculture ("GBA") in New Hampshire has moved to the forefront of cod farming innovation, this year successfully producing hundreds of thousands of fingerlings for Canadian growers, for the UNH Open Ocean project, and for its own use. The progress on cod indicates that this will become a multi-billion industry like shrimp or salmon.

Cod farming in Canada is being pioneered by salmon farmers (working with GBA) who are able to use their existing fixed assets to shift to cod. From a biological and technical viewpoint, this would also be an attractive industry in Maine.

Surprisingly, despite much searching, the authors did not locate detailed public studies of cod farming economics. There may be a Norwegian study, but this is not yet located (per C. Duffy, GBA).

Kite-Powell et al., in *Open Ocean Grow-out of Finfish in New England: A Bioeconomic Model*, compared the economic feasibility of cod, salmon and flounder using optimal harvesting and stocking strategies. The model shows clearly the importance of feed costs and other factors on profitability and highlights the challenges that offshore cod farming in particular will face. The authors state that the utility of the model will be in evaluating specific business proposals, which implies that would be operators or financiers should contact the authors for a copy of the model.

The management at Great Bay Aquaculture prepared an estimate of the economics of an innovative approach to cod farming and marketing based on meeting the market for live and for scrod cod. This was presented privately to salmon growers at St. Andrews in 2002. The projection showed that cod farming could be a profitable alternative to salmon farming. Some of the growers agreed, and are working with Great Bay Aquaculture to implement a cod farming program.

A general interest periodical in PEI, *Navigator Magazine*, November 2001, interviewed Newfoundland cod experts and quoted a "working and operating capital" requirement of US$2,400 per tonne of farmed cod production capacity. The private companies that are starting in cod farming in Norway, Scotland and Canada apparently judge that the economics could be favorable. Any new investor or operator entering the field would need to construct their own projections anyhow, based on their own Due Diligence research.

The easiest initial entry into cod farming would be by conversion of existing salmon farming assets. Expansion of cod farming beyond that will need to expand into offshore federal waters (Pers. Communication, C. Duffy, GBA) due to warmer water temperatures in winter at depth and due to political factors. Accordingly, economic studies of offshore net pen farming of other species can be useful to operators contemplating cod farming offshore.

The Mississippi Sea Grant Extension Program and Mississippi State University are conducting a multi-year program to test commercial off shore finfish aquaculture. Dr. Benedict Posadas has

published a series of papers about the economic implications of the ongoing results of the program. The most recent paper, *"Economic Feasibility of Offshore Aquaculture in the Gulf of Mexico"*, (Posadas, Benedict and Christopher Bridger) projected offshore cage economics for cobia, red snapper, and red drum based on a 12 cage system, 36,000 cubic meters (Ocean Spar Sea Station pens). Three cases were presented: a base case, a case with prices increased by $1/kg, and a case with 25% greater growth of fish. In all three cases, only the cobia was feasible. The relevance of this study for the NR is that this base level presentation could be adapted to NR species. This basic level of study, which incorporates both experimentally derived values and assumed values of variables, is helpful for sensitivity analyses and to direct research attention to economically important factors. Finally, this model format familiarizes the financial community with the concept of offshore pen culture. The report provides summarized line item and Bill of Material information, which implies that potential commercial users could contact the authors for the level of detail needed for private sector research and Due Diligence. A PowerPoint summary presentation of this research is posted at:
http://www.msstate.edu/dept/crec/publish/offshore%20aquaculture%20economics%202003.pdf
Further information on the offshore program is available at
http://www.msstate.edu/dept/crec/aquaoffspubs.html .

Two useful papers are published in the 1996 Proceedings of Open Ocean Aquaculture. In *"Cost and Market Realities in Open Ocean Aquaculture"* John Forster provides cost information for offshore salmon farming. In *"Economic Feasibility of Sea Farming: Operational Perspectives"* Tom Croker of Ocean Spar provides background on the costs incurred by offshore farming.

Another useful example of a net pen economic research is a comprehensive bio-economic model of seabream. The principal parameters are described and the mathematical relationships are listed. Once again however, the otherwise excellent study is rendered useless for financial due diligence because the model is not offered, so there is no way for the reader to independently verify that the conclusions reached are consistent with the equations and parameters presented.
(Gasca-Leyva, Eucario; Carmelo Leon, Juan Hernandez. *Management Strategies for Seabream Sparus aurata Cultivation in Floating Cages in the Mediterranean Sea and Atlantic Ocean.* Journal of the World Aquaculture Society, Vol. 34, No. 1, March 2003)

The authors do not believe that a high-level, non-detailed general study of offshore cod farming economics should be undertaken by NRAC because results would not be sufficiently useful for commercialization. However, targeted economic research would benefit the establishment of the industry, which would ask:

- Is cod farming viable? - This would be a validation report written for the financial community.

- What is the economic effect of stocking fingerlings smaller than 100 grams?

- What is the economic effect of harvesting some or all of the cod when they are smaller than the usual "legal" fillet size fish?

These studies could be done separately, or as a single comprehensive study. To achieve all three objectives, a cod farming economics model would be constructed at a level of detail that is useful, testable, and can be updated. The general description of the proposed study follows:

1) Data Sources:
   a) Norwegian study (if it exists)
   b) Farms in Norway, Canada, and UK
   c) Great Bay Aquaculture
   d) Mississippi and New Hampshire offshore pen studies
   e) Existing salmon net pen farm models and reports
   f) Existing Mediterranean net pen farm models and reports

2) Inputs must encompass fingerling options of 1.5 g., 50 g., and 100 g.

3) Outputs must be able to cover harvest size range of scrod / live (0.75 kg. to 1.0 kg) through fillet size range (2.5 kg. to 5.0 kg.)

4) Model design should be modular so that embedded functions and assumptions can be changed separately, and so that differential harvest scenarios can be easily simulated.

5) Presentation should be in format usable by operators and commercial sector (hence in Excel and Lotus), even if developed in MATLAB or Simulink. This should be posted and down-loadable.

6) Reports should include projected Profit and Loss, Balance Sheets, and Cash Flows in great detail so that line item expenses and Bill of Material components can be viewed and updated with new information. The proposed reports, to be beneficial to the commercial sector, will need to learn from the three offshore projects that have been undertaken so far: the Mississippi project discussed above, and the New Hampshire and Woods Hole projects mentioned in the mussel section. None of these projects reported or posted detailed economic results or detailed projections that can be taken to the line item expense level or the Bill of Material level. If a future study does include full line item and Bill of Material detail, then the following desiderata can be achieved:
   a) The logic of the underlying calculations can be tested, and errors caught quickly by the wider community. This brings the benefits of open-source development to aquaculture model building.
   b) Discrete changes in the cost of a single component can be incorporated into the model.
   c) Commercial users can use the model because the degree of ground-truth can be ascertained.
   d) The aquaculture community can provide meaningful and real-time feedback or input to the research community.

7) A simplified budget report should also be prepared from the study that could be used as a third-party validation for the financial community of the concept of cod farming.

In addition to the specific economic studies mentioned above, the authors recommend that any NRAC support for research on other aspects of cod farming should be contingent on the provision of cost data regarding cod farming. Furthermore, as a minor part of the grant, researchers should be required to estimate the costs of the aspect of cod farming most closely related to the research project. The grantees should also be required to provide a line item estimate of cod farming economics based on the judgement and experiences of their team and colleagues in the industry.

Biotechnology

In the NR, the many universities and medical / biotech industry centers provide a source of spillover innovation for applications in the aquaculture field. These companies follow the high tech pattern of being based near intellectual centers, but serving clients and competing globally. Phycogen, the Maine company using seaweed to produce biotechnology products, has been mentioned earlier. Micro Technologies, a laboratory in Maine serving the research and seafood industry, is seeking to develop fish vaccines, which are obviously of global interest. Sea Run Holdings, also in Maine, produces fish blood products such as serum, proteins and reagents for biotechnology companies. A/F Protein, in Massachusetts, has developed products based on insect and fish 'anti-freeze' proteins and is known for the Aqua Bounty Farms subsidiary plans to supply transgenic salmon eggs.

Many other potentially exciting biotech aquaculture companies have been vetted privately by local venture capitalists. Two of their stories are summarized here:

One Maine company has received much publicity and can be used as an example of the usual high-tech venture capital model being applied to aquaculture bio technology. MariCal was able to attract seed stage capital from about sixty "high net worth individuals" to create proteins that enhance growth and the shift to seawater for anadromous fishes. It also attracted critical early stage seed capital from the Maine Technology Institute. With this seed stage capital, which may have been about $4 million, MariCal was able to develop to the first-product, first-customer stage. Two Norwegian venture capital companies then invested a total of $3 million to fund marketing of the first product and development of product extensions. MariCal's first customer (licensee) is a Canadian salmon company with US and Chilean subsidiaries.

Advanced BioNutrition, a Maryland company, was spun out in 2001 from Martek, a provider of nutrition supplements for infants. The first closing of the Series A financing of $2.6 million was led by Eastbourne Capital Management, a California VC, which invested $900,000. Another $1,700,000 came from the State of Maryland and private investors. The Series A was extended by an additional $900,000 led by Sherbrooke Capital Partners, a Massachusetts VC firm. This is a validation that the regular VC community sees potential in serving the aquaculture industry which is focused on nutrition supplements and vaccines.

There is no need for NRAC to sponsor a general economic and financial study for aquaculture biotechnology, because each proposed business plan must be judged as a unique biotechnology deal.

Niche Food Markets

The concept of producing unique ethnic food fish in inland isolated recirculating systems has periodically been proposed. For example, farmers could produce milkfish for the Filipino community or certain African fish like Clarias gariepinus for the African Diaspora that came to the US during the recent West African wars. There are ample studies of the economics of producing these fish in their native lands. There are also many reports of the economics of recirculating systems here in the NR. The authors do not recommend that NRAC sponsor research in this area because there is already enough public information to allow an entrepreneur with a niche concept to generate economic estimates applicable to that particular situation.

Live Fish Holding Facilities

The dividing line between live-storage and farming should not be a barrier to profitable use of existing facilities. The former AquaFutures (MA) has reportedly been purchased by a dealer who intends to convert it to a live storage operation. A large multi-level live-storage shellfish warehouse was built decades ago in Barcelona, Spain and smaller live-storage facilities have operated successfully for years in Canada and the US. Some mussel farm operations in Europe can more accurately be considered short-term live storage. The live-fish trade in New York and Toronto has examples of live fish haulers / dealers who are essentially live fish storage operations. Dr. Bob Valenti in Long Island operated a storage operation during the 1990s. Successful farms ideally should be linked to on-shore live-holding facilities as is common in Europe and Canada, and as American Mussel Harvesters is doing to a degree in Rhode Island.

The economics of live-storage operations are well understood and not difficult to calculate. NRAC need not fund research into these systems, although a simple validation report study and / or extension report should be prepared with full detail and posted on-line so it can not only benefit operators, but be useful to the financial community. The development of profitable live fish holding businesses will reduce risk of existing farmers, benefit farmers in other regions, and encourage development of new foodfish, baitfish and ornamental operations by providing buffer inventory capability between the farming and the sales functions.

Education and Recreation

The idea of focusing on aquaculture as a sub-set of the education, entertainment, and tourism industries is appropriate for the NR. Aquaculture can offer both "the sizzle and the steak" because it is inherently interesting and approachable for people. Watching children thrill to the mad rush at the top of a tank after they have thrown feed out is a joy to the operator and to the parents.

The U-Rake-It clam farm concept has been mentioned in the Clam section. Such a venture provides entertainment and education, and saves the farm labor, packaging and distribution costs.

Recreational fee fishing applies the 'pick-your-own-apples' concept to fishing. The farmer can sell bait, refreshments, tours, filleting services, and of course the fish also. State extension services provide advice regarding tourist management and marketing of fee fishing. Examples of introductory pamphlets are:

- SRAC # 479, "*Fee Fishing: An Introduction*", 1994 (http://srac.tamu.edu/479afs.pdf)
- SRAC # 480, *"Fee-Fishing Ponds: Management of Food, Fish, and Water Quality",* 1993, (http://srac.tamu.edu/480fs.pdf)
- Bogash and Kays, "*Developing a Fee Fishing Enterprise: An Opportunity in Recreational Tourism*", 1994, University of Maryland FS-754

In the 1990s, Jim Tassinari, an inspired textile plant engineer in New Bedford began growing Tilapia in tanks in one of his mills, and then worked with a creative vocational school professional to use the growth of Tilapia for education. Local public school teachers also began using these Tilapia as teaching tools.

Similarly, the Gila River Juvenile Detention and Rehabilitation Center in Arizona has built a pond and cage culture system to help train the tribal youth. A general interest article in Indian Country magazine (http://www.indiancountry.com/article/1034778953) describes how the school's fishfarming system has become valuable for the larger community also. This study is applicable to the NR.

A Google search for "aquaculture curriculum" produces a plethora of free or inexpensive curriculum plans, information and contacts of use to teachers. For instance, for $25 a teacher can purchase the *Aquaculture Curriculum Guide for Teachers* described as follows: "The Maine Aquaculture Innovation Center and the Univ. of Maine College of Education, with production and editing assistance from Susan White of Maine Sea Grant, have developed a comprehensive 232-page guide to aquaculture. It provides information and activities on aquaculture throughout the world, region, and state; water quality testing; and setting up a classroom aquarium, among others." This information is available at http://library.kcc.hawaii.edu/praise/educ/guide.html . Two other examples indicate the variety of available curricula:

- http://www.ksuaquaculture.org/Kthru12.htm provides a lengthy list of contacts for K-12 teachers interested in including aquaculture in their curricula.
- http://www.seacentr.org/programs/curric.html provides a free password to a fun online curricular game teaching critical thinking as it addresses four questions: "1. What is aquaculture? 2. Will it affect the nature and environment of Flounderin Island? 3. Will we make or lose money? 4. Overall, what will aquaculture mean to Flounderin Island?"

Unless NRAC is working with a specific park, school or private enterprise on a specific project which has not already been developed, the authors do not recommend that NRAC support general economic or financing studies of this approach to aquaculture. People seeking to explore the area of educational or recreational applications for aquaculture can refer to existing extension studies as well as to existing literature concerning the costs and marketing potential of curriculum development.

Compliance Services

The authors recognize that the service sector to aquaculture includes the provision of compliance documents. If the aquaculture industry does begin to grow in the NR, then support services will need to increase. Existing consulting and engineering firms that currently work for land developers, contractors, and the aquaculture industry in other US regions and countries will probably expand their capabilities to be able to serve NR aquaculture companies. However, demand from aquaculture companies may grow large enough in the NR that niche specialists based in the NR could succeed.

Once standards of performance in an industry are accepted, consultants offer services to assist companies to achieve those standards. The plethora of ISO 9000 consultants is a good example of this phenomenon. Aquaculture is strongly trending in this direction. The most well known example is probably the "Codes of Practice for Responsible Shrimp Farming", prepared by C. E. Boyd, Global Aquaculture Alliance, 1999. The concept of the organization has been extended to the formation of the Aquaculture Certification Council, Inc., which sets standards, certifies certifiers, and then attempts to have the certification process translate to benefits to the companies that undertake the process.

The state of Florida in 1999 united several disparate regulatory agencies into a single Division of Aquaculture. In addition, the state began to develop "BMPs", Best Management Practices, which when followed obviate the need to acquire environmental permits. This is similar to the HACCP concept for food processing plants, and to the "safe-harbor" concept used in tax and securities regulation. (http://www.florida-agriculture.com/news/081999.htm)

In 1999, the EU as part of a project "MARAQUA", designed a environmental certification project for aquaculture companies called "Eco-Management and Audit Scheme" or "EMAS". This was subsequently adopted, and is used as an extension of the existing ISO 14001 environmental standard. The MARAQUA project is described at
http://www.lifesciences.napier.ac.uk/maraqua/iandoli.htm

Although the authors are confident that the Compliance sector will grow in the NR, the authors do not recommend that NRAC support economic research into this area. Service to the aquaculture sector is merely an extension of the existing professional services industry, which is accustomed to researching and working with new sectors. The consulting industry has proven itself capable of aggressively selling (and sometimes over-selling) the benefits of standards such as ISO 9000, HACCP, Baldridge Award and other standards.

Environmental Restoration and Mitigation

There have been many proposals to use aquaculture to protect or restore the environment. A massive unplanned demonstration of the concept has occurred due to zebra mussels. Maine salmon farmers have spoken of emulating New Zealand and Chile by placing mussel farms near salmon pens to mop up excess feed and nutrients. Natural mussel beds in Sweden clean polluted seas (Haamer, J. and J. Rodhe, "*Mussel Mytilus edulis filtering the Baltic Sea outflow through*

the Oresund - an example of natural, large-scale, ecosystem restoration", Journal of Shellfish Research, 2000).

Use of aquaculture for environmental restoration or for mitigation of harmful effects is a good idea and is sometimes implemented. The beneficial effects are almost always mentioned during the pre-lease hearing ordeal in the US. However, mitigation or restoration through aquaculture remains a good idea, or a method to be used, but it is not yet a business. No private company or organization has successfully been formed to apply aquaculture to environmental mitigation or restoration in a manner that is sustainable for the organization, thus allowing the organization to improve over time and to expand the scale of its activities. Even if a team were to use aquaculture to remove hundreds of tons of nutrients from eutrophied waters or save an eroding piece of shoreline, there would be no direct way for the team to be paid for that service other than erratic grant-funding.

One solution to the problem would be to collectively decide, at the government level, to create a market for the benefits. Environmental economists are studying the feasibility of "nutrient removal credits" as a means of monetizing the benefits provided by remediation. The EPA conducted an experimental program in 1996 and in January 2003 issued and updated "Water Quality Trading Policy" (http://www.epa.gov/owow/watershed/trading/2003factsheet.html). A study at Brown University reviews various proposed schemes and then proposes a system for Rhode Island. The thesis is summarized at the website
http://envstudies.brown.edu/Thesis/2002/caton/Trading%20Elements%20pages/elements_RI.htm .

There is a chance that innovative salesmanship can start the mitigation business prior to the launch of a governmentally sanctioned market. An entrepreneurial citizen of Osaka (Japan) has formulated a plan in which individuals pay to sponsor the clean-up of the local river via pearl producing oysters - simultaneously purchasing a chance to obtain a pearl. At the time of the newspaper article, he had sold an initial $32,000 of subscriptions at $40 each
(http://www.oysterranching.com/japan.html).

The authors recommend that NRAC consider supporting an economic or financial component in research concerning mitigation with aquaculture, only if the research breaks new ground, truly creates a business, and includes a detailed (line item and Bill of Material) level of analysis and reporting. Particular studies mentioned by several operators and extension agents include the concepts of nutrient utilization by seaweed and shellfish, near net pen arrays or in on-shore effluents.

Marketing and Sales Services

Farmers on land or water face over-production such as occurred recently in the global salmon industry and in the market for Florida clams. A growth sector of aquaculture is therefore sure to be marketing and sales services.

Co-ops can allow farmers to achieve economies of scale. An example from Texas is the Texas Aquaculture Cooperative formed in 2001 by twenty-six Texas fish farmers who have already

started construction of a processing plant that will give them direct access to the market. http://www.texascooppower.com/tcp/703catfish.html

Another approach is to form regional brands such as the Aleutia brand based on the specially handled salmon catch of twenty-eight fishing boats. This brand was developed by the Alaska Fisheries Development Foundation. Sales volume was increased and the ex-vessel price almost doubled for this high-quality salmon product. This is an example of effective extension work. http://www.afdf.org/marketing_quality.html

The most helpful example of the opportunities available to the marketing and sales service sector is that of Star Group, an advertising agency in Cherry Hill, NJ. The agency identified the Jimmy Buffet concert attendees as the target segment; then developed a product for them - Margaritaville Shrimp; and then found a manufacturer (FPI) to supply the product. Thus instead of casting about for a client, the agency created a client for itself. FPI expects to generate $50 million of sales with the new brand. This is an example of effective free enterprise, without any assistance from government funded economic or marketing studies. The story can be read at http://www.philly.com/mld/inquirer/6214380.htm.

Although marketing is clearly an important component of any successful aquaculture business, the economics of the marketing sales and brokerage of seafood products is already well understood. NRAC need not fund economic studies of the sales, brokerage, or marketing sector that will necessarily grow along with aquaculture production.

Effect of Regional Factors

The authors expected to locate academic studies analyzing regional characteristics or existing commerce in order to project future aquaculture opportunities in the NR. We did not find any. Although not rigorously quantified or justified, the consensus view in articles and discussions concerning the economics of Northeast Regional aquaculture is that the regional advantages are rich and abundant waters, proximate markets, and abundant scientific expertise. The regional disadvantages are usually stated to be governments' and citizens' orientation against manufacturing or primary industry, high cost of waterfront land, and ignorance of agriculture and fisheries in the financial community.

Although no studies were found supporting this hypothesis, it does seem to the authors that the NR region possesses the commercial sectors that in other parts of the world often expand into aquaculture:

- Fishermen into aquaculture
- Land farmers into on-shore aquaculture
- Shore front processors and distributors backward integrate into aquaculture
- Transportation companies aggregating aquafarm supplies

Although no studies were found that addressed the effect of current macro-economic trends on NR aquaculture, many articles cited the trade deficit as a factor increasing the attraction of aquaculture.

The authors recommend that NRAC not support research on the effects of general regional economic factors on aquaculture because the studies would be descriptive only and not result in actionable plans.

PART 2. Aquaculture Finance

Knowledge of past, present and future financial structures of regional aquaculture sector businesses could assist decision-makers in formulating and implementing business plans. The authors sought studies that addressed:

- The capital structure of existing enterprises
- Past and present sources of capital
  - For working capital
  - For fixed asset investment
  - For research and development
- Availability of capital as it relates to factors such as:
  - Stage of business life-cycle
  - Scale of operation
  - Age and background of management
  - Structure and terms of investment, projected revenue streams and ROI

The results of a literature search on this subject are easy to summarize:

1. Although lack of access to capital is often cited as one of the most important constraints to aquaculture in the NR, no studies were found quantifying this assessment, or testing whether the problem was any worse than exists for small businesses in other sectors.

2. Although knowledge of the capital structures of existing businesses, and of the sources of capital that built the businesses in the first place, would be helpful to both operators and financiers, no such studies were found.

3. Although a list of all sources of available capital would assist both operators and financiers, the articles found listed only government financing sources.

Although the studies searched for were not found, the authors did find that, in their judgment, there is sufficient publicly available information on aquaculture financing in the NR region for conclusions to be reached as to NRAC's possible role in aquaculture finance.

In the next part of the report the authors address Capital Structures of Existing Enterprises, Sources of Capital available to the Aquaculture Industry in the NR, and Observations on Aquaculture Financing in the NR, followed by recommendations for use of NRAC funds in the area of capital and finance.

Capital Structures of Existing Enterprises

Most aquaculture operations in the NR, from the "Hobby Farm" stage through to "Medium-Scale Farms", are financed by the operator through an existing company, or with personal savings or assets, or with funds raised from individual investors. Any bank loans are usually securitized and / or guaranteed, or made on the strength of non-aquaculture income and assets. This assertion is supported by personal knowledge of the authors, by consensus views of colleagues in the industry, and by almost every reference in the media that describes capital structure of specific aquaculture operations.

In some cases, companies that have reached the "Large-Scale Farm" size have investment from financial institutions or corporations such as companies mentioned in this review.

Sources of Capital

There is a large amount of publicly available information regarding sources of capital for aquaculture in the NR. The financing world is fluid and influenced to a surprising extent by fashion. A prominent US venture capitalist confided to one of the authors that "Too often, we are lemmings". The non-profit world is also influenced by changing fashions, which are labeled as priorities. The operator and financier must assess the financial climate and candidate investors based on the specific details of their project and the prevailing fashion in the for-profit and non-profit finance sectors. Following are brief assessments of some capital sources currently found via an Internet search.

Venture Capital Funds

Conversations with the financial community suggest that attracting significant amounts of global capital into the NR for aquaculture will require that our citizens decide that they want jobs and economic growth and also encourage the courts and regulatory agencies to become more predictable. It is a competitive world, as brashly expressed by a Chilean urging Norwegians to invest in Chile rather than in North America: From Intrafish (http://www.intrafish.com/intrafish-analysis/chile_15-11-2000_eng/feat16.php) *"Norway's experience in other places hasn't been good. You are the ones who created salmon farming, and built up the industry in Scotland and the USA. And how were you repaid? They accused you of dumping. You were dumped from the USA market due to a remarkably small number of farmers in Maine. We in Chile had incredible luck. We gained admission to the USA market when you were thrown out."*

Teknoinvest Management AS, Oslo Norway, invests in IT and in Life Sciences companies (http://www.teknoinvest.com/) . Ferd Venture (http://www.ferd.no/ferd/index.jsp) is a venture capital division of a Norwegian industrial group. These funds co-invested $3 million into MariCal in Maryland as described above in the Biotech section.

A specialist aquaculture venture capital fund has been formed in Australia. As the only specialist aquaculture fund in that part of the world, **Aquaculture Investments International Limited** is positioned to select the best seed-capital opportunities, as well as to buy and combine vulnerable

operating companies and to provide consulting and financial services to others. The fund's goal is to profit by expanding and consolidating a fragmented industry. While international in range, the fund concentrates in its own region because the market and regulatory environments are favorable. The website is:
http://www.aquaculturеinvestments.com/html/main.html .

The Jessie Smith Noyes Foundation acts partly as a venture capital fund in that a portion of their assets are allocated to venture capital and private placements. They invested in BioShelters.
The website is www .noyes.org/ .

Venture Capital Networks and Forums

These are mentioned because they provide access to investors. They consume time and often claim more success than they achieve, but can be helpful. An example of a VC network is Empire State Venture Group, Inc. Details can be seen at www.esvg.org. The group selected Fingerlakes Aquaculture (NY) to make a presentation at their 'SmartVentures' forum and later announced that Fingerlakes had found funding. Our reading is that the new funding came from existing investors and from NY government programs, which would indicate that the company deserves the credit rather than the forum,

In the tech industry, presentations at forums, even when they do not directly raise money, sometimes generate unacceptably dilutive investment offers that then encourage present shareholders to protect their positions with follow-on investments.

Foreign Direct Investment and Joint Venture Partnerships

The Norwegian company Marine Farms ASA in October 2002 purchased a minority interest in the major intensive marine hatchery in Florida, the Aquaculture Center of the Florida Keys. The agreement provides for eventual 100% ownership by Marine Farms, and immediate assumption of operating management. This type of investment is helpful in that it fills a gap left by absence of local capital, it provides potential exit strategies for early stage investors, and it can bring global management and technical skills into the NR.

Another approach is for foreign companies with technical expertise to provide turn-key proposals for US operators and for US or foreign investors. An example of this approach is the attempt by the Hebei Fisheries Research Institute of China to share technology for a multi-species hatchery in return for a minority equity share of the resulting business. I doubt anybody accepted the offer, but the structure has potential. The advertisement for this deal can be seen at http://en.cappma.com/business/readzs.asp?zsid=19 .

Federal Government Programs

Many federal programs provide financing assistance to aquaculturists who want to build a company. There are websites that provide lists of websites that in turn provide lists of programs. Government employees have written helpful papers to navigate the abundance of programs. Entrepreneurs and financiers seeking co-investment from the government will find many choices

via the web, their regional Aquaculture Center, and their local extension agents. The plethora of government programs is enticing, but in most cases disappointing to the operator. Before listing a few specific sources of information regarding government financing, some general points should be noted:

- The following words from the NOAA Aquaculture Information Center hold true for most of the government programs: *"If you are interested in "startup" funding, please remember that the majority of financing for any new, independent, business venture will be from the aquaculturist's personal assets and private loans."*

- The successful aquaculturist must learn to understand the interests of the multiple parties covered by the label "government". As one aquaculturist observed: "*The various government departments seem to be doing isometric exercises, pushing against each other, using lots of energy, and not moving"*. He was referring to the fact that some agencies, and some non-profits dependent on government grants, energetically oppose or passively delay aquaculture. Other departments and non-profits actively assist aquaculture. In some circumstances the aquaculture bureaucracy is an invaluable champion and advocate. In other cases the aquaculture bureaucracy can unnecessarily slow progress. If one wishes to build an aquaculture company, one needs to plan on an initial outlay of funds and time to deal with government issues. After initial savings have been expended in overcoming government resistance, there is no direct way to re-coup some of the lost funds for example by way of grants, because the grants go mostly to researchers, not to operators. Companies that are successful at using government funds to grow have learned to design projects that fulfill research, training, surveys, or other such goals - while also keeping the employees paid and making progress on the business plan. As a company gets stronger and less in need of government help, it finds that help becomes more easily available from the government.

To give an order of magnitude view of federal government activity, according to the Draft National Aquaculture Development Plan, Table 1, 1995, the total federal assistance to aquaculture in 1994 was $122 million, mostly from Interior, Commerce and Agriculture departments. Approximately $61 million was spent on government hatcheries, $50 million on research, $7 million on regulation, and $4 million on other aspects of aquaculture (http://aquanic.org/publicat/govagen/usda/dnadp.htm). In the words of the Plan:

> *"Research is directed toward the development of private, commercial aquaculture and to support enhancement of natural fishery resources."*

A text-only version of *"Table 1. Direct Federal Aquaculture Expenditures in FY 1994 (values in millions of dollars)*". Source: Office of Technology Assessment, 1995." was used to reconstruct the following table:

Direct Federal Aquaculture Expenditures in FY 1994
(Values in millions of dollars)

Agency	Research	Hatcheries	Other	Regulation	TOTAL
USDA	25.2		2.3	0.5	**28.0**
USDOC	13.9	18.6	1.5		**34.0**
USDI	7.0	39.0		0.03	**46.03**
BIA		2.9			**2.9**
FDA				6.0	**6.0**
USAID	1.5				**1.5**
USDOE	1.2				**1.2**
NSF	1.1				**1.1**
EPA				0.5	**0.5**
TVA	0.5				**0.5**
DOD-COE				(b)	**0**
Other		(b) (c)			**0**
TOTAL	**50.4**	**60.5**	**3.8**	**7.03**	**121.73**

NOTES TO TABLE:

(a) Figures for "Other Support" and "Regulations" may significantly underestimate aquaculture-related expenditures by Federal agencies which do not generally separate out aquaculture expenses in these areas.
(b) Amount not available or amount is less than $0.1 million per program/agency.
(c) Includes Community Development Block Grants Program (administered by HUD); Farm Credit Administration (independent agency); Office of Job Training Program (Department of Labor); and Rural Housing and Community Development Service (administered through USDA).

A good starting point for approaching the government sources of financing is a paper that is still relevant today although it was written back in 1991: *"Financial Sources of Aquaculture"*, Eileen McVey, Aquaculture Information Center, (http://aquanic.org/publicat/govagen/nal/funding.htm). McVey not only lists available aquaculture programs, but also lists the larger and often more helpful Small Business Administration programs. She covers some of the realities of the private sector sources and the various foundation investors. In addition, McVey in a separate document has compiled a helpful bibliography covering finance and related issues. "Aquaculture Finance, Tax and Insurance Issue", Aqua Topic June 1995, Aquaculture Information Center National Agricultural Library, (http://www.lib.noaa.gov/docaqua/myoldfinpub.html).

A valuable follow up study which updates and expands on McVey's work is *"Federal and State Support for Aquaculture Development in the United States"* by Denise Jarvinen, 2000. The paper is helpful for commerce because the focus is on programs directed to the private sector. In addition, the author describes the programs available in eight states (MS, CT, ME, MA, RI, NC, SC, and HI) and shows that the state level of assistance is often inadequate to deal with regional (multi-state) issues.

A more recent summary of US federal support for aquaculture is the chapter "*Current Status of Aquaculture in North America*" by Paul Olin, University of California Sea Grant, in a UN/FAO book titled Aquaculture in the Third Millennium, 2001. The coverage is less detailed than McVey's due to the global scope of the chapter and the book. The North American chapter is posted at (http://www.fao.org/DOCREP/003/AB412E/ab412e23.htm).

Two excellent sources of aquaculture finance (and other) information are:

- Aquaculture Information Center - DOC/NOAA whose website serves as a valuable resource at http://www.lib.noaa.gov/docaqua/financial.html. This gives lists of lists and describes programs which are directly targeted at aquaculture and those which can be used by aquaculturists (i.e. Native American, women's business, rural development)

- "AquaNic" Aquaculture Network Information Center http://aquanic.org. This site includes sources, extension, references, advice, and topic discussion groups

An example of the sort of federal grant that might tangentially benefit a company hoping to do some aquaculture is $219,000 awarded to Garden State Ethanol, Inc., in New Jersey, to do a feasibility study and develop a business plan for a farmer-owned bio-refinery, greenhouse, and aquaculture facility. This was a "2002 Value-Added Agricultural Product Market Development Grant" from the USDA to encourage rural development.

State Grant Programs

Each state has grant programs targeted at aquaculture as well as at other objectives. For example, Massachusetts has many environment-related grants, including an aquaculture research program. A good example of an effective research grant that was obtained by a working operator (as opposed to an academic staff member) to directly increase his business is a $32,000 grant to a southern Massachusetts cranberry grower to try to farm largemouth bass. Brad Morse contributed $28,000 of his own funds and already owned the cranberry bog land. The full list of grants awarded by this program can be viewed at http://www.state.ma.us/czm/environmentalgrants.pdf .

Another example of a state-level aquaculture grant was a $450,000 grant to the University of Pennsylvania for a feasibility study of an aquaculture and processing facility in the former Philadelphia Navy Yard. The grantor was the Delaware River Port Authority. From a financial or an operating viewpoint, this grant did not generate value. A summary can be seen at http://www.vet.upenn.edu/schoolresources/communications/publications/bellwether/39/articles.html

The Maryland Industrial Partnerships (MIPS) program provides grants to match funds for joint research between companies and the University of Maryland. MIPS has provided assistance to numerous aquaculture industry companies, the best known of which is Igene Biotechnology, a large supplier of natural Astaxanthin pigment for salmon feed. MIPS has also worked with a group of shellfish farmers and assisted them in forming a profitable cooperative. From a financial and operating viewpoint, the MIPS program does create value. The website for MIPS is http://www.erc.umd.edu/MIPS/ .

State Venture Funds

State Venture Capital Funds are often more helpful than grant programs for research, training, etc, because the company can openly declare that its goal is to become solid, earn profits, and provide secure opportunities for the employees. The state VC funds are a relatively new concept.

The Small Enterprise Growth Fund of Maine invests between $150,000 and $350,000 per company. The fund is only $8 million in total, but that can make a large difference in a state the size of Maine by addressing the key need to provide early stage capital. The website with further details is http://www.segfmaine.com/ .

In response to an SBA program, 'New Markets Venture Capital', a non-profit in Maine, Coastal Enterprises, Inc., formed a for-profit subsidiary. This is CEI Community Ventures, which was capitalized for $10 million with SBA funds and funds from foundations and a bank. The fund invests $100,000 to $500,000 in businesses in low-income regions of northern New England. The Coastal Enterprise Institute has arranged other targeted loan funds which can be relevant to aquaculture - the Fisheries Revolving Loan Fund, the Maine Shellfish Growers Revolving Loan Fund, and the Working Waterfront Loan Fund. The website is:
http://www.ceimaine.org/fisheries/finance.htm .

In Rhode Island, the Slater Center for Marine and Environmental Technologies is a venture capital fund, financed annually by the state with $3 million, which should be a model to states or regions seeking to actually create jobs and economic strength. The full details are available at www.SlaterMarineEnvironmental.com. The center has made at least one aquaculture biotech investment. The center provides business advice and support, as would any private VC, and can fund pre-seed, seed capital, or early stage businesses.

Rhode Island also has an Aquaculture Initiative Mini-Grant program that provides up to a few thousand dollars for specific benefits to local small companies, such as processing machinery purchase or trial attempts to grow a new species of clam.

Another example of a useful fund is the Natural Capital Investment Fund (NCIF), a West Virginia 'Community Development Financial Institution'. The $5 million fund was started in 2000 and invests in local environmentally sound natural-resource based businesses. More information is available at http://www.wvncif.org/.

In Pennsylvania, the Ben Franklin Technology Partners Fund invests in technology businesses. They invested $206,000 into W.J. Aquaculture, which built a recirculating system. The website of the fund is www.benfranklin.org .

Observations on Aquaculture Financing in the NR

1. No financial service group in the NR specializes in aquaculture. No team has specialized in financing or working with aquaculture company managements, whether they are at the seed capital - start up phase, the follow-on venture capital stage, or the mature company stage seeking normal banking relationships. The lack of NR-based venture capitalists and / or bankers has not prevented the NR industry from operating, although it inhibits growth. Operators must spend great effort on educating their financiers. Investors often make illogical decisions due to their ignorance of the true risks and possibilities of the industry. Many venture capitalists will understandably not invest in a management team that they cannot physically visit easily. At the very least, the aquaculture sector is a venture capital / financial services niche that is currently available for exploitation.

2. The standard venture capital (VC) deal structure is unsuited to the usual behavior of the public and regulators in the NR. The usual pattern for a venture capital investment is to agree on terms and a schedule of investment and benchmarks, then staff the organization, and then push for rapid progress against the business plan. Progress in aquaculture in the NR however is difficult to schedule due to the heavy involvement of the protest industry and regulators in the process. Accordingly, an ideal investment structure is for follow-on investment to be pre-arranged so that it is available when certain benchmarks are reached, however many years ahead that may be. Meanwhile, the aquaculture company should not be pressured into incurring overhead costs of management or office until they are absolutely needed. The need for intelligent money to be made available years after the initial plan was agreed upon, limits the potential investment sources to the following: savings; existing on-going companies; or individual investors with an unusual degree of constancy. To summarize this point, what is needed is not up-front investment as much as capital which can be committed in advance and be reliably available after the team slowly works its way through the regulatory process. The current sources of capital that act this way are the Mohegan Tribe, existing seafood companies, and individuals (especially fishing families) who have "day jobs" with enough flexibility to allow spending time and money on their aquaculture project as needed.

3. The effect of economic knowledge and financing differs at each growth stage of NR aquaculture businesses:

    - **Idea Stage** - Initial interest and ideas to attempt are abundant in our region. However, more people might be interested in exploring the industry if they realized how much expert assistance and knowledge was available.

    - **Backyard experimental stage** - Although experimentation by operators is discouraged in the NR in most cases by regulations, it is the authors' subjective opinion that more people would undertake hands-on experiments if they knew how much technical and economic information and advice is available.

- **Business Plan stage** - This step is not a limitation as most people understand the need to plan.

- **Family, friends and wealthy individual investment stage** - This step is not a limitation in the NR. There is sufficient wealth and interest in aquaculture concepts that many ideas are being financed.

- **Venture Capital stage** - Investment from venture capital firms is only available for businesses that serve aquaculture and are also tech businesses. There have been few to no examples (depending on definition) of venture capital or institutional investment into NR primary aquaculture.

- **Bankable business stage** - This also does not exist. No NR banks have specialist aquaculture groups. This is to be expected given the small size of the total NR aquaculture sector and the small scale of most aquaculture businesses in the NR.

PART 3. Recommendations for NRAC

Context of Recommendations

Discussions by the authors with industry participants, extension agents and university researchers indicate that there are three distinct sets of audiences and objectives for economic and financial study. To avoid confusion, the recommendations are categorized accordingly. The third column contains the authors' recommendations for future NRAC activity.

Audience	Objectives	NRAC?
Financial Community	• Independent validation studies for businesses, including proof-of-concept studies	***YES***
Operators	• Training of operators in economic and financial planning and presentation • Financial training for extension agents • Economic and Financial advice, directly or via extension agents • Detailed Bill of Material and Line Item cost and yield reports such as produced by North Carolina extension service, both for information and for common format • Third Party validation studies for financial community • Economic component of proof-of-concept studies for financial community	***YES***
Research and policy community	• Research projects • Retrospective analyses of effects of past research and government policies	***NO***

NRAC Support Targeted at the Financial Community

The financial community, which includes the capital budget approval departments of large operating companies, makes decisions based primarily on specific proposals from an operating department, independent company or entrepreneur. NRAC cannot directly generate such specific plans. However, NRAC may be able to share expertise with the operator or with the involved extension agent to prepare accurate and convincing proposals.

In addition, financial decision-makers seek independent, third party reports to validate the concept behind the specific proposal or to provide a benchmark against which to compare the specific proposal. This need for third-party reports is based mostly on a rational desire to understand the situation. There is also a need within large corporations and financial institutions to create a paper trail to justify a decision, known colloquially as “CYA”. NRAC can usefully, at low cost, generate such third-party verifications.

NRAC Support Targeted at Industry Operators

From the literature review and from conversations with operators and suppliers, the authors conclude that there are the following possible roles for NRAC in the areas of economics and finance:

- Economic and financial training would benefit many operators, extension agents, researchers and regulators.

- While preparing specific proposals or annual plans, some operators and extension agents would value access to advice or economic information.

- Some operators (and extension agents) would appreciate a series of Bill of Material level pamphlets or reports (such as produced by many extension agencies e.g. North Carolina). These reports would be used to provide common formats to allow operators to benchmark against each other, identify best practices, share information, and communicate with their financiers.

- Operators of existing business units that must apply for financing stated that their bankers, investors or corporate headquarters would make more intelligent decisions if there were independent third-party sources of economic information from a reputable entity. NRAC was stated to be an ideal institution for this need because it is regional, not tied to a particular crop or interest group and has access to top talent on an as-needed basis.

- Operators presenting proposals for new ideas or extension of current operations stated that proof-of-concept studies that included detailed Bill of Material level economic information would encourage acceptance of new ideas by corporate headquarters and by the financial community.

What NRAC should NOT support:

1) As a general policy, NRAC should **not** fund general economic research **unless** the proposal:

    a) would produce information that is not available or transferable from other similar production or market situations, and which
    b) would be of direct and substantial benefit to a significant number of existing or prospective aquaculture ventures in the NR, and
    c) is not one that a private company or a research institution should undertake as part of its on-going business, and
    d) ensures that the work to be performed will benefit from community feed-back by posting any models and calculations in detail during and after completion of the study. The aquaculture research community should be able to experience some of the productivity benefits that the open-source software development community achieves.

2) Aside from creating extension reports or third-party validation studies as requested by industry, NRAC should **not** fund research papers that attempt to calculate the costs of producing any of the target species or industry segments, **unless** the information to be developed does not exist and will be of use to a potentially broad group of industry users in the NR. In many cases, sufficient work has already been done by the extension and academic communities. In many other cases, the information is readily available to the users and potential users of such information, i.e. the operating businesses or financiers. Those in business already know the costs and variables, as they must develop their own models and estimates during the Due Diligence process. Those contemplating going into business must find relevant costs by adapting existing information to their specific sites and plans. In most cases, there is already sufficient information available for this to be done effectively.

3) As a general policy, NRAC should avoid funding economic research that is primarily of theoretical academic interest.

Recommended Program

This review so far has mostly recommended that NRAC **not** fund economic and financial research of the sort that has been funded, mostly by other granting agencies, in the past. The fact remains however that the NR industry could be enhanced by actions relating to economics and financing. The following recommendations repeat and expand upon the recommendations of positive actions that NRAC should undertake.

EXTENSION AND VALIDATION REPORTS

NRAC should spearhead the preparation of a series of reports, and offer them electronically and in print in conjunction with standard software model formats that would be downloadable. Ideally, NRAC or some other group would be able to host the programs as ASPs and/or offer messaging or comments of users and readers to be posted concerning the reports. The reports would be presented in two formats, for two audiences:

- Extension Report for Operators - To allow existing operators to benchmark themselves, to have common reference points and terms, and to find existing extension material and reports gathered into one place and interpreted as appropriate for the NR. As an extension agent phrased it, "The information (for oysters in the NR) is out there, but not all in one place." The format would be similar to the North Carolina extension reports referenced earlier in this paper, with more detailed cost information in some cases.

- Third-Party Validation Reports for the Financial Community - To augment the Due Diligence files of financiers and to improve the decision-making of the financial community.

Based on the degree of interest and activity noted during preparation of the first part of this report, the subjects of the Extension and Validation Reports would be:

- NR Tilapia farming for the live fish market

- NR Ornamental fish, using proximity to the NR market to advantage
- NR Baitfish farming, using proximity to the NR market to advantage
- NR Clam farming
- NR Oyster farming
- NR Mussel farming
- NR Live-Holding facilities - food fish, shellfish, ornamental fish, baitfish
- NR Tourism and Aquaculture - Fee Fishing, Dig Your Own, and Other Examples
- NR Education and Recreation

PROOF-OF-CONCEPT RESEARCH

NRAC should not fund economics-only research that purports to explore the feasibility of farming of a new species in the NR. Proof-of-concept studies however are different, in that they have passed a preliminary technical and economic screening, and have been shown to work at a pilot scale or in a similar environment. Any proof-of-concept research that is conducted should include, in addition to the technical research, strong economic and financial analysis components. To repeat the points made earlier, for the economic components of the studies to be valuable for the commercial sector, they must be at the level of detail of individual line items and Bill of Materials components. The base data and the models must be available on-line so that the research and commercial community can test and verify the logic.

Topics that were suggested to the authors by operators and extension agents, and that seemed fruitful, for proof-of-concept studies are:

1. Is Seaweed Farming a viable extension of existing or future offshore net pen operations? The major seaweed farming constraints are space, anchorage and vandalism, all of which are already expensed in existing net pen operations.

2. Is Shellfish Farming a viable extension of existing or future offshore net pen operations?

3. Can seaweed and / or shellfish be used to remove nutrients from on-shore farming operations such as nurseries or trout hatcheries?

4. Cod farming questions - (See the "Cod" section for a summary of a proposed study)
   - What are the economics of cod farming using existing salmon infrastructure
   - What are the economics of building new cod farms offshore?
   - What are the economics of stocking cod fingerlings at different sizes?
   - What are the economics of harvesting cod at different sizes?

5. In general, for any NRAC research study, the authors recommend that the grants be contingent on the researcher providing cost information concerning the aspect of culture in question. Furthermore, as a minor part of the grant, researchers should be required to estimate the costs of their component to the aspect of farming related to their research. They should attempt to provide a line item estimate of the impact of their conclusions to farming

economics based on the judgement and experiences of their team and colleagues in the industry.

SUMMARY OF RESEARCH RECOMMENDATIONS FOR NRAC:

	Economic Information Available?	Economic or Proof of Concept Research Needed?	Extension or Validation Reports Needed?	NRAC Priority*
Salmon	Yes	No	No	
Freshwater Trout	Yes	No	No	
Clams	Yes	No	**Yes**	**High**
Oysters	Yes	**Yes**	**Yes**	**High**
Mussels	Yes	**Yes**	**Yes**	**Very High**
Tilapia	Yes	No	**Yes**	
Catfish	Yes	No	No	
Hybrid Striped Bass	Yes	No	No	
Shrimp	Yes	No	No	
Algae / Seaweed	Yes	**Yes**	No	**High**
Food Plants	Yes	No	No	
Ornamental Fish and Plants	Yes	No	**Yes**	
Baitfish	Yes	No	**Yes**	
Scallops	Yes	No	No	
Cod	**No**	**Yes**	**Yes**	**Very High**
Biotechnology	Yes	No	No	
Niche Food Markets	Yes	No	No	
Live Fish Holding Facilities	Yes	No	**Yes**	**Very High**
Education and Recreation	Yes	No	**Yes**	
Compliance Services	Yes	No	No	
Environmental Restoration and Mitigation	Yes	No	No	
Marketing and Sales Services	Yes	No	No	
Effect of Regional Factors	Yes	No	No	

* Priority based on subjective assessment of the probability of research success times the expected size of the aquaculture sector to be researched.

TRAINING

NRAC should spearhead economic and finance training for extension agents, current and potential financiers, government personnel, academic researchers and operators. Curricula and precedents exist, and the level of training required is not sophisticated. A possible curriculum could be *"Financial Planning and Analysis for Aquaculture Enterprises"* by Charles Cole et al., a ninety-five-page notebook used for seminars in the last decade. Another possible approach would be to adapt a business-training curriculum used by Vermont Banks to improve the management practices of their dairy-farming clients. Throughout the world, it has been found that such training sessions are most effective if taught largely by operators. The importance of training extension agents is two-fold; they need the knowledge to be able to serve their clients "on-demand", and they can in turn train the operators as needed.

ADVISORY SUPPORT

NRAC should organize a volunteer cadre of individuals who will work with extension agents and operators on an as-requested basis. In many situations, the assistance in preparing time-sensitive and case-specific economic and financial information is valuable to operators who wish to expand, to would-be operators preparing business plans, and to financiers assessing aquaculture projects. The terms of assistance should be that any general economic or financial findings that are non-proprietary would be submitted as a publicly available report. The envisioned cadre would be similar to groups organized by the SBA and Chambers of Commerce that have available volunteer business people who will donate a fixed number of hours to the benefit of their community or industry. Maryland Sea Grant extension arranged for MBA students to assist aquaculture operators.

A service of reviewing aquaculture-related Business Plans could be offered, similar to the grant proposal review process. It could be formalized, and result in comments and a "Grade" both of which would be of use to operators and to potential investors.

As a related but different concept, if there is no other regional forum NRAC might usefully serve as a meeting point for the extension agents in the region. This would benefit NRAC because NRAC would gain better ground-truth feedback of the economic and financial challenges and opportunities in the region.

PUBLICITY TO FINANCIAL COMMUNITY

NRAC should send a short quarterly newsletter or press release to banks and financial institutions in the NR highlighting the experiences of global aquaculture financial institutions and news of the industry in the NR. The goal will be to set a positive background climate so that the financiers will consider aquaculture as a valid, current, mainstream industry as opposed to a 'good idea for the future'. The benefit to the industry is that operators may receive more informed feedback from an up-to-speed financial community.

In a few years, after the other programs are in place, NRAC should organize a venture capital forum for regional aquaculture. A vigorous attempt should be made to attract the European and Asian financiers who are already expanding in the industry. Possible benefits would be:

- Operators gain expert foreign partners.
- Local financiers realize that they are ignoring an opportunity.
- Local media and public learn that they are suppressing jobs by suppressing aquaculture.
- Aquaculture can be seen accurately as a mainstream global business.

OVERALL CRITERIA OF PERFORMANCE

The recommended research and extension oriented programs should be judged for effectiveness based on jobs created and on earnings newly developed for the region.

Authors' Comments

During the preparation of this paper, the authors' view of the NR aquaculture industry shifted progressively from a state-by-state view, to the regional view, and finally to seeing the Northeast US regional industry as a tiny sub-set (0.15%) of the global industry. Similarly, the problems of the aquaculture industry in the NR came to be seen as specific applications of the same problems affecting other industries in the region.

The authors' initial expectation was that there would be too little economic information concerning current and potential aquaculture businesses in the NR, but this was proven to be utterly incorrect. It is unfortunately true that the NR (which again is a mere 0.15% of the global industry) is wasting its human resources and natural advantages by not participating in the global aquaculture industry in a meaningful way. However, it is useful to remember that there exists in the other 99.85% of the global industry ample knowledge and willingness to invest in promising businesses in the NR. The examples of Norwegian acquisitions of Maine salmon farms demonstrate this fact.

Cedar Key clam farmer Sue Colson was quoted in the Tampa Tribune, June 2, 2003, in a moment of terse candor:

> *"If we don't plan for the future, we will blow it all. We will all be working in restaurants and motels and importing our seafood from China."*

This is very true. Equally true however is that the abundance of information, resources, and talent reviewed for this paper left the authors with a strong sense of expectation that the barriers are falling and the possibilities are increasing so that aquaculture can thrive in the Northeast Region.

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