Sustainable Mussel Culture: A Millennial Perspective

Carter R. Newell

Growth in the past decade in the supply of and demand for high quality mussels has been fueled by improvements in technology and cooperative approaches to solving problems. This has resulted in opportunities for those involved in mussel spat collection, grow-out and processing. However, integration of other users of the coastal zone, such as commercial fishermen, into mussel aquaculture is required before there will be widespread acceptance of such activities. Selection of culture sites that have the characteristics required for seed collection and grow-out are based on local knowledge and an approach that uses knowledge of oceanography and mussel biology. Over the past 15 years, flow modeling has resulted in advancements in site optimization by controlling stocking densities, site selection for new lease areas, and the prediction of impacts and beneficial interactions with benthic and pelagic ecosystems. Detailed knowledge of the behavior of larval and bysally-drifting mussels, the effects of currents and food concentration on mussel pumping behavior, energy flow diagrams of mussel populations, and studies of food supply and demand within suspended and bottom culture systems has aided in the development of new culture technologies and further growth of the industry. An environmental code of practice, continued modeling efforts, and cooperation with respect to technology transfer within the industry and the scientific community should help launch the mussel industry in North America into the next century with continued sustained growth.

Introduction

For any type of aquaculture to be profitable, four key elements are necessary:

1. The right species must be cultured for a given area. In North America, the edible mussels are *Mytilus edulis, Mytilus trossulus* and *Mytilus galloprovincialis.* Using native species provides the advantage of reducing the cost of spat collection.
2. Growers should choose the right farm environment (either shallow or deep coastal waters, or offshore). For *Mytilus edulis*, maximum temperature should be below 20°C to prevent summer mortalities. It is preferable for the site to be protected from exposure to wave action, ice, and predatory sea ducks. High primary production is desirable, as are low amounts of inorganic silt and clay. Currents should be adequate to supply the mussel farm with sufficient food to match consumption rates, but not so high that the currents interfere with feeding or attachment of the mussels to cultivation ropes or socks.
3. Cost-effective culture techniques are important, and range from bottom culture to longline culture and raft culture. Improvements in culture technology (continuous longline systems, specialized vessels, cranes and conveyors) are key to decreasing the cost of production to make the product competitive.
4. Production of high quality product and effective marketing are important to provide the consumer with mussels that have high meat yields, are of a uniform size, have no byssal threads (debyssed mussels) or breakage, and a long shelf life. These qualities will increase the price of cultivated mussels for both the growers and the processors.

Developing a business growing mussels requires a number of skills. Usually the work on the water involves skills that commercial fishermen already have and can apply to mussel farming. The process of growing mussels involves a range of activities, including seed collection, seeding (attaching mussels to ropes or socks), maintenance of the farm (setting moorings, predator control, thinning), and harvesting.

Often, local knowledge about currents, ice, predators, bottom type, wave conditions, navigation, pollution sources, political climate, and local patterns of fishing activity will be important in ensuring the farm succeeds. In addition, those who are practical in orientation will be more likely to succeed as they will come up with clever ideas on how to make processes run more smoothly, how to increase efficiency, and how to reduce labour costs.

A key element in the development of a new industry such as mussel culture in North America is the willingness of growers to share information with each other. When a bottleneck in cultivation is experienced (e.g., harvesting through the ice), some individuals will inevitably find a solution and if the breakthrough is shared with a group of like-minded growers, the whole industry will benefit. This "shellfish exchange mentality" is the key to rapid industry development and is in sharp contrast to the capitalist concept that ideas should be kept secret to gain competitive advantage. The driving force within the industry should be that there is a huge demand for high quality shellfish, so everyone gains when new developments are shared.

Shellfish farmers become stewards of local water quality because they require pristine areas for shellfish cultivation. In Maine, growers have teamed up with volunteer water quality samplers to help maintain the status of shellfish growing waters and identify pollution sources to be remediated. Certified samplers are involved in collecting nearly 50% of the water samples used in classifying growing areas, which reduces the cost to regulatory agencies and results in the opening of new areas for cultivation.

The role of mussel processors is also critical to the development of the industry. Farmers must be given a fair price for their product, and incentives for increasing yield and meat yield will lead to a better product. Processors need to continually strive to increase the shelf life, reduce breakage, and provide a fair weight to consumers. New regulations with respect to HACCP (hazard analysis and critical control points) help to assure shellfish safety and allow the industry to be pro-active with respect to problem areas. The cost of complying with the new regulations, however, must be absorbed by the industry, which reduces profitability.

Financing and business management are very important aspects in developing mussel aquaculture. While venture capitalists may require 20% interest for high risk investments, low interest loans are important for the farmers and processors to be able to make the necessary investments to develop their farms. While this concept is well understood in Canada, it is still a hard sell in the United States.

Site Selection for Seed Collection and Grow-Out

In order to grow more mussels, the industry needs more sites. Good site selection is a major factor in industry development. Site selection depends on the cultivation phase: areas of good seed collection and areas for good grow-out of mussels should be chosen carefully. Our studies in Maine on seed collection[1,2] demonstrate the importance of hydrodynamics on the concentration of mussel larvae and juveniles (up to 1 mm) that drift using a drifting byssal thread. Areas that are good for seed collection and growth and survival of spat to a size which can be attached to ropes or socks (about 10-35 mm shell length) are not necessarily the best places for grow-out of mussels to market size. In addition, areas with high spat densities (> 100 000 per meter) result in slower growth of the seed mussels than areas with moderate densities (i.e., 10 000 per meter). Where currents provide good vertical mixing, spat will attach to lines over 10 m long, but where currents are slow and there is vertical stratification of the water column, spat may be concentrated in the upper 2 to 3 meters.

Selection of good sites for the grow-out of mussels depends on the type of cultivation. For bottom culture, mean current speeds of 15 to 20 cm/s are necessary to support moderate grow-out densities (i.e., 200-400/m^2)[1,3-5] of mussels in Maine. This is because of the reduction in current speeds near the bottom of the benthic boundary layer, and the tendency of water to become depleted of phytoplankton and detritus in the downstream direction over regions of mussel tissue biomass of 1 kg/m^2. For longline culture, lower currents (5 cm/s) are adequate due to the generally large spacing between the longlines. For raft culture, moderate currents (10-15 cm/s) are necessary to prevent depletion of over 50% of the food to the mussels in the inside of the rafts. Current speeds above 25 cm/s may have a negative effect on mussel growth and attachment to lines in suspension culture, while they may be fine for bottom culture, especially in deep water.[6]

Aquaculture structures such as rafts and longlines, and even mussels seed spread on the bottom, also may affect ambient current speed and direction. In the case of bottom culture, mussel beds extending up to 12 cm off the bottom increase bottom roughness and vertical mixing, improving their food supply. In longlines, large arrays may reduce flow through a site. For rafts, increased flows under and around the rafts generate vertical mixing and complex vortices. Understanding these flow effects aid in developing sites for mussel aquaculture. In addition, ambient hydrodynamics play a large role in the carrying capacity and holding capacity of a site (see next section).