Biological harvest of plankton from aquaculture ponds is not a theoretical concept. Indeed, it is practiced worldwide and is more commonly known as polyculture. In addition to the primary culture species, polyculture ponds incorporate additional species to take advantage of feeding niches present but unused in monoculture ponds. Because phytoplankton and zooplankton offer the largest sources of potential food, filter feeding fish are stocked into polyculture ponds. Mollusks could also be used. Species that eat zooplankton, such as bighead carp, are combined with those that feed on phytoplankton, such as silver carp and tilapia. There are a variety of combinations that could be used in fresh or salt water, two possibilities are listed in Table 4. By removing plankton, filter feeders are indirectly recycling the nitrogen and phosphorus wastes released into the production pond. Nitrogen is converted to protein (muscle) and phosphorus is incorporated into ATP (adenosine triphosphate) and other organic compounds.

VI. MODIFIED POLYCULTURE

The traditional polyculture practice of allowing both zooplankton and phytoplankton feeders to roam freely in the same pond has some drawbacks. This technique can be inefficient and problems like those discussed for mechanical filtration exist. Species that feed on phytoplankton are filtering smaller particles from the water than animals that consume large zooplankton. Both types of filter feeders are grazing simultaneously, or parallel to one another. In addition to removing phytoplankton, herbivorous planktivores remove large zooplankton from the pond non-selectively, because they strain their food from water on the basis of size (i.e., small mesh screens vs. large mesh screens). The net effect is a lowered concentration of zooplankton which reduces the filtration efficiency and potential biomass of zooplankton feeders.

As with mechanical harvest, the most efficient method of plankton harvest would be to place zooplankton feeders in front of phytoplankton feeders and those animals that consume much smaller zooplankton. Each of the different species would have to be compartmentalized

TABLE 4
Examples of Potential Freshwater and Saltwater Polyculture Species and Their Respective Feeding Niches.

Freshwater	Saltwater	Food Niche
Catfish	Shrimp	Prepared feed
Paddlefish	Mullet	Plankton
Mussels/clams	Oysters	Plankton
Crawfish	(Shrimp) [a]	Detritus

[a] *Shrimp are detrital feeders as well as the primary culture species.*

according to the size of plankton they screen, flowing water past species that filter large particles first and those that feed on the smallest particles last. Pond water could be pumped into the first chamber and then to and from each successive chamber into the next, in a series arrangement of floating or land-based tanks (Figure 3).

In theory, reducing the standing biomass of plankton by half could significantly lower the oxygen demand in a production pond and increase the harvestable cash crop over two-fold. Employing this polyculture or plankton harvest concept, it might be possible to produce 5,000 kg/ha of channel catfish without aeration or high concentrations of waste nitrogen and phosphorus. However, the biomass (filtration rate) of filter feeders must be balanced with total phytoplankton and zooplankton productivity.

VII. CRITICAL CONSIDERATIONS

The aquaculture industry must be able to adapt if it is to survive and grow. The blueprint for modern industrial society may not work well as a template for developing nations. It may be necessary to alter production and market structures, recycle waste effluents, harvest plankton or reduce stocking densities. Transporting fish with a team of Clydesdales is no less practical than hauling beer. Does "Plan B" exist? Is rapid transition feasible?

Time scale is a crucial concern. The global population has been increasing exponentially. Competition for non-renewable resources continues to escalate. Regardless of the culture practice used, there are biological limits to production or environmental capacity. Time measures change, and change is inevitable.

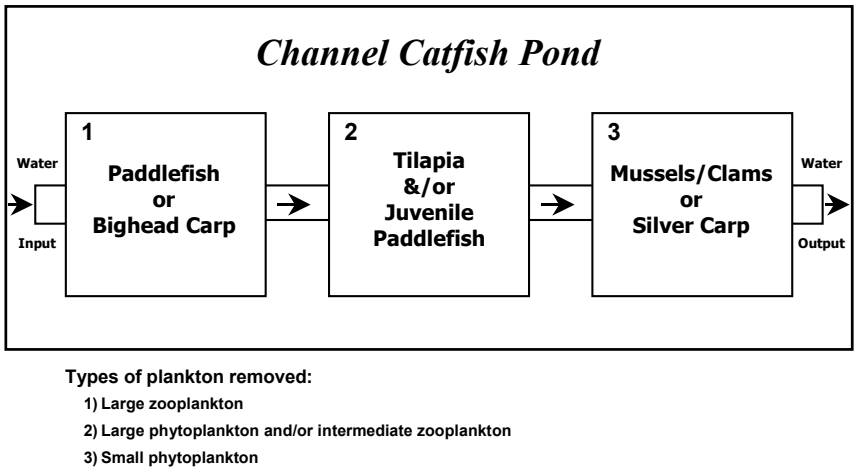

FIGURE 3. Compartmentalized polyculture places filter feeding species in a series arrangement to harvest plankton more efficiently.