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AQUACULTURE PRODUCTION SYSTEMS

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Aquaculture can be generally categorized into four types of production systems: open, semiclosed, closed, and hybrid (Tidwell, 2012). These categories are differentiated based upon the intensity of management in terms of nutrient input, labor, stocking density, oxygenation, and waste removal. Systems with less inputs are referred to as extensive, and systems with high inputs are referred to as intensive. High levels of input and management typically result in larger and more consistent sized harvests.

Woman showing prawns caught from her hatchery in Khulna, Bangladesh. *M. Yousuf Tushar/WorldFish*

OPEN SYSTEMS

Open systems are operated within natural systems and rely completely upon natural processes for control of temperature, oxygenation, and waste removal (Tidwell, 2012). Two examples of open systems are ranches and enclosures.

Ranches are systems where fish are stocked into relatively large (>100 ha) aquatic resources to forage upon natural food items with minimal reliance upon commercial diets. Fish are harvested when they reach a marketable size. System constraints include having to stock larger sized individuals to avoid predation, which typically results in smaller and more variable harvests.

Enclosures are systems where fish are stocked into a confined area, such as a cage or net pen, within a larger water body. Enclosures serve to retain targeted culture species and exclude nuisance species. Water quality in enclosures are maintained by exchange with the surrounding water body. Therefore, routine cleaning and use of maximum mesh sizes and deployment in areas of water movement improve water exchange. System constraints include net fouling, damage from drifting debris, and reduced site accessibility.

SEMICLOSED SYSTEMS

Semiclosed systems are structures that largely rely upon natural processes for control of temperature, oxygenation, and waste removal (Tidwell, 2012). Two examples of semiclosed systems are ponds and raceways. These can be excavated in suitable earthen substrate or constructed out of concrete, fiberglass, polymer, and other materials. Ponds typically utilize static water, and raceways utilize flowing water.

Ponds usually range in size from 100 m^2 to 4 ha. System constraints include higher construction investments (e.g., capital, expertise and labor) and diminishing water quality (e.g., dissolved oxygen and nutrient loading).

Raceways are typically divided into sections with decreasing elevation to facilitate efficient water transfer and re-oxygenation. System constraints include the elevated risks of disease transmission and diminishing water quality (e.g., dissolved oxygen and nutrient loading) when raceways are used in succession.

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CLOSED SYSTEMS

Closed systems are structures that recirculate water and rely completely upon human intervention for the control of temperature, oxygenation, and waste removal (Tidwell, 2012). Two examples of closed systems are recirculating aquaculture systems and indoor biofloc systems.

Recirculating aquaculture systems are an assemblage of specialized components that are required to meet the demands of intensive culture (e.g., removal of suspended solids, biofiltration, disinfection, oxygenation, carbon dioxide removal, systems monitoring, and biosecurity). System constraints include the necessity for a high level of technical expertise in operation, a high cost of construction, dependable electrical power and the demand for an immediate response in the case of system malfunction.

Biofloc systems flocculate suspended biotic material, such as particles of algae, bacteria, zooplankton, feed particles, and fecal matter, into larger "biofloc" particles. Bioflocs provide supplemental nutrition to some filter feeding culture species (e.g., shrimp and tilapia). They can rapidly remove ammonia through direct uptake by heterotrophic bacteria, can provide substrate for nitrifying bacteria, and often contain photosynthetic algae. System constraints are based on the tolerable level of bioflocs to culture organisms, with excessive concentrations inhibiting gill function, and these systems can have very high oxygen demands (Browdy et al., 2012).

HYBRID SYSTEMS

Hybrid systems are the product of separating production systems into functional groups to capitalize on respective system advantages (Tidwell, 2012). Two examples of hybrid systems are in-pond raceways and aquaponic systems.

In-pond raceways capitalize on the advantages of higher stocking density, improved water quality, waste collection, precise disease treatment and better control of feeding, grading, harvest, and other tasks (Masser & Lazur, 1997). System constraints include the necessity of a high level of technical expertise, a high cost of construction and the demand for an immediate response in the case of system malfunction.

Aquaponics incorporate recirculating aquaculture systems with horticulture. Plants utilize excess water and nutrients from aquaculture systems and improve water quality for aquatic culture organisms. The combination of production of aquatic animals and terrestrial plants diversifies harvest. System constraints include the necessity of a high level of technical expertise, a high cost of construction, and potentially a higher cost of operation.

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ABOUT THE FISH INNOVATION LAB

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