

AQUAPONICS



California Aquaculture

UNIVERSITY OF CALIFORNIA, DAVIS

Introduction: Aquaponics can be defined as the symbiotic cultivation of plants and aquatic animals in a balanced recirculating environment. The symbiotic relationship is that the fish provides nitrogenous waste, which serves as a nutrient for the plants, and the plants remove the nitrogenous compounds thereby cleaning the water for the fish. Although the term aquaponics is relatively new, the concept was made very popular in the 1970's through efforts of the New Alchemy Institute, whose legacy can be visited at <http://www.thegreencenter.net/>. A popular book written for backyard aquaculturists based on the New Alchemy approach is, "*The Freshwater Aquaculture Book: A Handbook for Small Scale Fish Culture in North America*" by William McLarney. Over the past 35 years, the number of books, videos, and websites providing information on aquaponics has grown tremendously. Some useful web sites can be found at the end of this article under Aquaponic Resources.



Aquaponic vegetables
(Photo courtesy of Nelson and Pade, Inc., www.aquaponics.com)

By any definition, aquaponics is one of the fastest growing segments of aquaculture, and is extremely popular in California. Aquaponics' current popularity stems from people's interest in participating in sustainable and urban applications of agriculture and the concept of "grow your own organic food." Organic vegetables are already commanding a large segment of California's food market and have well established regulations relative to the definition of organic. This information can be found at the California Department of Food and Agriculture web site at http://www.cdffa.ca.gov/is/i_&c/organic.html. Currently, there is no legal definition for organic fish in California. California is waiting for the USDA's National Organic Standards Board (NOSB) to establish national organic standards for fish before it establishes its own state standards. Until then, it is illegal to produce and market fish as organic in the state. Information of the NOSB can be found on the USDA web site at <http://www.ams.usda.gov/AMSv1.0/NOSB>

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Scale of Operation: California's aquaponic growers range from small garage and backyard operations to commercial endeavors employing large tank systems for culturing fish, combined with greenhouse and open-environment systems for plant production. Most of the inquiries we receive at the University of California, Davis concerning aquaponics are from potential growers who want to begin a pilot aquaponics project for home consumption, then scale up to a commercial venture. Small-scale aquaponics for home consumption is easily manageable. If successful, the returns on investment most frequently range from break-even to slightly ahead of the game to even being able to provide the extras for a few friends and relatives. The greatest rewards come from growing and controlling your own food source. However, the leap from small-scale home consumption to a commercial venture involving profits capable of supporting living wages and supporting a family unit entirely from the sale of fish products and plants is immense. Most aquaponic operations not only market food and ornamental products, but also market aquaponic systems, system designs, consulting services, short courses, books, information media, and an array of other products. Without a doubt, aquaponics will make a valuable and major contribution to food production.

Plants: Popular aquaponic plant crops include Asian vegetables, lettuce, tomatoes, cucumbers, and herbs. Actually, most any edible or ornamental plant can be grown in aquaponic systems. The list of edible aquaponic plants include any crop that the grower feels will provide a return on investment, or that might suit their table and palate. Table 1 provides a partial list of edible plants that are commonly grown in aquaponic systems. A link to Asian vegetable seeds can be found at the website Asian Vegetable Seeds-Evergreen Seeds at <http://www.evergreenseeds.com/asveqlis.html>.

Watercress	Bok Choy	Butter beans	Onion
Chives	Broccoli	Sage	Tomatoes
Chilies	Cabbage	Lemongrass	Cucumber
Celery	Cucumber	Yarrow	Lettuce
Snow peas	Mizuna	Comfrey	Basil
Egg plant	Coriander	Rockmelon	Chard
Watercress	Garlic	Spinach	Parsley

Fish: The most popular fish grown in aquaponic systems are tilapia. Tilapias are a robust fish that do extremely well in recirculating systems. Many states have restrictions on the culture of tilapia as they are non-native fish and resource agencies do not want the fish established in natural waters if they were to escape aquaculture systems. California, for example, has restrictions on where tilapia may be cultured in the state, and most tilapia culture is restricted to southern California in counties located south of the Tehachapi mountain range that separates southern California from the Great Central Valley. The State's resource agency originally stocked tilapia in southern California as they once believed that the fish could not reproduce, or even survive the cool winter temperatures. Tilapia not only survived, but successfully reproduced, even in the high salinity inland Salton Sea. The restrictions are in place now to prevent tilapia from being introduced in the watersheds north of the Tehachapi mountain range.

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Currently, *Oreochromis hornorum*, *Oreochromis mossambica* and *Tilapia zilli* are the only three tilapia species that are allowed by California Department of Fish and Game (DFG- Lead Agency) to be raised in specific counties of southern California. The specific counties are Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Imperial counties. *Tilapia zilli* is allowed only with a Restricted Species Permit obtained from the CDFG. If you live in one of these six counties and plan to raise tilapia in an aquaculture or aquaponics system, you must register as an aquaculturist with the CDFG. If you plan to import tilapia into California, you will need an importation permit from CDFG. You can obtain more information on aquaculture in California on the CDFG Aquaculture webpage at: <http://www.dfg.ca.gov/Aquaculture/>, or call CDFG at (916) 445-0826.



Tilapia in an aquaponic system
(Photo courtesy of Nelson and Pade, Inc., www.aquaponics.com)

Aquaponic operations north and south of the Tehachapi mountain range use other fish species besides tilapia in their culture systems. Table 2 is a partial list of common fish used in aquaponic systems. All fish should be purchased from a licensed fish breeder and, if imported, the buyer by law must obtain an importation permit from the CDFG.

Table 2. Partial list of fish and crustacean species commonly grown in aquaponic systems.	
Tilapia sp.	<i>Oreochromis hornorum</i> , <i>Oreochromis mossambica</i> and <i>Tilapia zilli</i> (Allowed in specific counties in southern California)
Channel Catfish	<i>Ictalurus punctatus</i>
Common Carp	<i>Cyprinus carpio</i>
Hybrid Carp	<i>Cyprinus carpio</i> x <i>Carassius auratus</i> (cross)
Goldfish	<i>Carassius auratus</i>
Ornamental Koi	<i>Cyprinus carpio</i>
Minnnows	<i>Gambusia affinis</i> , <i>Notropis lutrensis</i> , <i>Notemigonus crysoleucas</i>
Largemouth Bass	<i>Micropterus salmoide</i>
Bluegill	<i>Lepomis macrochirus</i>
Red Swamp Crayfish	<i>Procambarus clarki</i>
Freshwater Shrimp	<i>Macrobrachium rosenbergii</i>

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At this time, the CDFG policy concerning aquaponics, by their own admission, is evolving. The CDFG has said that it is reviewing their current policy, but at this time, anyone who raises any fish species or other aquatic species in an aquaculture or aquaponics system for human consumption is required to register as an aquaculturist with the Department of Fish and Game. However, if the fish are part of an aquaponics system but are not being sold or consumed, then an aquaculture registration would not be required. In this instance, the owner/operator would be required to obtain a Private Stocking Permit. Future consideration may allow one or two species of tilapia to be used in an aquaponic system north of the Tehachapi mountain range if they are purchased from a certified fish vendor. For this to occur, the proposal would have to be reviewed and approved by the Fish and Game Commission. Until then, tilapia species are restricted to southern California.

Primary Steps: All prospective aquaponic growers should become familiar with the regulations and necessary permits required to operate a legal aquaponic operation in California, or their resident state. A second step is to carefully consider the scale of their operation; either home consumption or commercial venture. If the target is a commercial operation, planning should include ancillary products and services that might provide cash flow until food and ornamental products sold can support your income needs. A quick review of the companies listed at the end of this article will show that these companies market a large variety of support products and client services as income to support their operations.

Define your markets for your fish products. The vast majority of California's traditional aquaculture industry does not have a processing industry, and with the exception of sturgeon flesh and caviar), abalone and other shellfish products, aquaculture products are primarily sold to the recreational fishing markets or in live-haul sales to live fish markets in metropolitan areas. Some small sales are through local farmers' markets, local retail outlets and local restaurants. The vast majority of the fish and shellfish products consumed in California are imported from other states or from other countries.

Define and understand your plant markets. Aquaponics is building a reputation for safe wholesome food products. If you are producing edible plant products, establish conversations early with potential buyers so that you will be able to meet their expectations. Some commercial buyers are concerned about their liability related to marketing vegetables grown in "fish water". Although there have been no reported incidences of contamination, be prepared to address food safety issues with potential buyers, and be prepared to initiate monitoring or testing protocols for *E. coli* or *Salmonella* if these concerns arise.

Obtaining Assistance and Aquaponics Information: Currently, the University of California does not have an aquaponics program, nor is the University researching aquaponics technology. However, we do work with aquaponic producers, providing basic aquaculture information on animal biology and culture technology, basics of recycle systems, and troubleshooting when problems arise. Specialists do work directly or indirectly through consultants, with some large commercial producers, and also provide contact information to clientele for people and institutions that have more experience with aquaponic systems. University personnel do not endorse any particular aquaponic systems. Most aquaponic producers either have adopted their own system designs, or have purchased aquaponic designs or systems from other established producers that market these products. However, we do

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provide basic recommendations, such as being able to reduce the risk from contaminating the system in event of a fish disease, or treating fish without impacting the integrity of the plants.

As in many developing aquaculture industries, many large commercial aquaponic companies are proprietary. When University personnel work with these companies, they have to respect the proprietary nature of the information exchanged, and cannot transfer proprietary information to another entity. We often receive requests to arrange tours of aquaponic operations, but can only suggest that requests be re-directed to companies that promote educational activities and information exchange.

Whether you are looking for a source of fish, a system design, aquaponics information, short courses, tours, or aquaponic supplies, one of the greatest sources of aquaponic information is the Internet. The resource list provided at the end of this publication will provide you with contacts that provide these services. The list is made up of companies that have either captured our attention, or whom we have worked with over the years. It is by no means all-inclusive, and additional resources will be added over time. I encourage you to examine what each company has to offer, and I also encourage you to provide feedback based on your experience with their services.

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AQUAPONICS RESOURCES

Professional Aquaculture Services

559 Cimarron Drive
Chico, CA 95926

PAS is operated by Tony Vaught, who has over 30 years' experience in production aquaculture. PAS offers a **source of fish** in their Aquaponics System Starter Package for those establishing a new aquaponics system, consulting services and trouble-shooting consultation for system design, feeding and fish health.

Phone: (530) 343-0405
tvaught@proaqua.com
<http://www.proaqua.com/>
<http://www.aquaculturedirect.com/>

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The Aquaponic Source

3980 Broadway, Suite 103-142
Boulder, CO 80304

The Aquaponic Source is operated by Sylvia and Alan Bernstein. The Aquaponic Source sells aquaponic supplies, small and large aquaponic systems, and is a resource for everything the home or backyard aquaponics gardener needs.

Phone: 303-720-6604

<http://theaquaponicsource.com/>

Nelson and Pade, Inc.

PO Box 761
Montello, WI 53949

The company is operated by Rebecca Nelson and John Pade, who have been involved in soilless culture and controlled environment agriculture since the mid 1980s and aquaponics since the early 1990s. They offer training workshops, consulting, complete aquaponic system packages for all applications, tech support and growing supplies. They also operate a 5,000 sq. ft. demonstration greenhouse and have continuously published the Aquaponics Journal since 1997. In partnership with the University of Wisconsin-Stevens Point, they are offering the first full semester, 3-credit hybrid aquaponics course, beginning Spring, 2012.

Phone: 608-297-8708

Email: info@aquaponics.com

Journal: <http://aquaponicsjournal.com>

Blog: <http://www.aquaponics.com/blog/>

<http://www.aquaponics.com>

Friendly Aquaponics

PO Box 1196
Honoka'a, HI 96727

The company is operated by Susanne Friend and Tim Mann. They offer training courses, internships, a wonderful aquaponics e-newsletter, aquaponics information. They also sell designs and plans for aquaponic systems. The farm is located on the highway from Hilo to Waimea on the Big Island of Hawaii.

<http://www.friendlyaquaponics.com>

Backyard Aquaponics, LLC

Chino Valley, Arizona

The company is operated by Cindy Stanley and Jerry English. They provide basic aquaponic information and sell aquaponic designs for potential growers.

Phone: 866-536-1408

<http://www.tilapiaaquaponics.com/index.html>

NorCal Aquaponics

The company is operated by Max Meyers.

NorCal Aquaponics offers commercial aquaponics training, system designs and consultation. NorCal Aquaponics is currently working with the agriculture department at Ukiah High School to construct an aquaponics system on campus that will serve as an educational model, working farm, student run business and revenue source for the UHS Agriculture Department.

Phone: 707-841-7087

info@norcalaquaponics.com

<http://norcalaquaponics.com/>

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Portable Farms Ltd. Aquaponics Systems

The company is operated by Colle Davis, CEO and Phyllis Davis, President; and the operation is located in Escondido, California.

Portable Farms Ltd sells systems, system designs, and offers aquaponic training. The operators have 40 years experience with aquaponic systems.

Phone: 760-208-2663.

<http://portablefarm.com/farm/>

Colorado Aquaponics

Colorado Aquaponics offers online aquaponics courses.

Other services include trainings, workshops, custom home aquaponic systems, and aquaponic consulting for small scale to commercial sized projects.

JD Sawyer at JD@coloradoaquaponics.com

Tawnya@coloradoaquaponics.com

<http://www.coloradoaquaponics.com/>

Farming with Fish

Farming with fish is an information source operated by Richard Fox of Oceanside, California

A place where you can read, watch, and learn about aquaponics.

Phone: 760-802-5947

<http://farmingwithfish.com/>

Aquaculture in the Classroom

The University of Arizona has extensive experience in hydroponics. They are an excellent source of hydroponic information and are expanding their interest in aquaponics.

<http://aq.arizona.edu/azaqua/extension/Classroom/home.htm>

<http://aq.arizona.edu/azaqua/extension/Classroom/Aquaponics.htm>

The Aquaponic Gardening Community: A Community and Forum for Aquaponic Gardeners. Operated by Sylvia Bernstein of "The Aquaponic Source"

<http://aquaponicscommunity.com/>

Aquaponics Library

<http://aquaponicslibrary.20megsfree.com/aquaphon.htm>

Aquaponics Related Links

<http://www.i55mall.com/aquaponics/links.shtml>

Asian Vegetable Seeds-Evergreen Seeds

<http://www.evergreenseeds.com/asveglis.html>

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