Fisheries
Publication details, including instructions for authors and subscription information:
http://afs.tandfonline.com/loi/ufsh20

Managing Expectations for Aquaponics in the Classroom: Enhancing Academic Learning and Teaching an Appreciation for Aquatic Resources

Emily R. Hart[a], James B. Webb[a], Craig Hollingsworth[b] & Andy J. Danylchuk[c]

[a] Department of Environmental Conservation, University of Massachusetts Amherst, Amherst, MA 01003

[b] Department of Extension Services, University of Massachusetts Amherst, Amherst, MA 01003

[c] Department of Environmental Conservation, University of Massachusetts Amherst, 160 Holdsworth Way, Amherst, MA 01003. E-mail:

Published online: 20 Nov 2014.

Managing Expectations for Aquaponics in the Classroom: Enhancing Academic Learning and Teaching an Appreciation for Aquatic Resources

Emily R. Hart and James B. Webb

Department of Environmental Conservation, University of Massachusetts Amherst, Amherst, MA 01003

Craig Hollingsworth

Department of Extension Services, University of Massachusetts Amherst, Amherst, MA 01003

Andy J. Danylchuk

Department of Environmental Conservation, University of Massachusetts Amherst, 160 Holdsworth Way, Amherst, MA 01003. E-mail: danylchuk@eco.umass.edu

ABSTRACT: *Exposing the next generation to nature can foster a stronger appreciation for aquatic resources, yet it may not always be possible to allow students to experience natural aquatic environments. Aquaponics, the combination of aquaculture with hydroponics, can be an effective tool in schools and classrooms to reunite students with plants and animals, promote systems thinking, and encourage hands-on learning. In this article, we bring awareness to aquaponics in education, its potential as a novel platform for learning, and the realities of aquaponics in order to guide educators in managing their expectations for an aquaponics system. Specifically, running an aquaponics system requires diverse knowledge and skills, which makes it appealing as a teaching tool but may also present day-to-day technical challenges. Additionally, educational settings may affect long-term care, available space, and funding. We present strategies for addressing these realities of aquaponics in education and highlight two educational aquaponics programs.*

Gestionando las expectativas de la acuaponia en el salón de clases: mejorar la apreciación de los recursos acuáticos en el aprendizaje y docencia académica

RESUMEN: *Exponer a la siguiente generación a la naturaleza puede generar un fuerte apego a los recursos acuáticos, sin embargo no siempre podrá ser posible permitir a los estudiantes estar en contacto con ambientes acuáticos naturales. La acuaponia, que es una combinación de la acuacultura y la hidroponía, puede ser una poderosa herramienta en escuelas y salones de clase para reunir a los estudiantes con plantas y animales, para promover sistemas de pensamiento y alentar el aprendizaje práctico. En este artículo se llama la atención sobre la acuaponia en la educación, su potencial como nueva plataforma para el aprendizaje y sobre las realidades de la acuaponia, con el fin de guiar los educadores en cuanto al manejo de las expectativas que se tienen en los sistemas acuapónicos. En específico, echar a andar un sistema acuapónico demanda de distintos conocimientos y habilidades lo cual lo hace atractivo como herramienta de enseñanza, pero también puede presentar desafíos en el día a día. Adicionalmente, el contexto educativo puede afectar el cuidado en el largo plazo, el espacio disponible y el financiamiento. Se presentar estrategias para abordar estas realidades de la acuaponia en la educación y se resaltan dos programas de acuaponia educativa.*

INTRODUCTION

Richard Louv coined the term “nature-deficit disorder” in his 2005 book *Last Child in the Woods*. As Louv explained, children growing up in today’s world are increasingly disconnected from nature, which may have profound effects on their healthy development and their concern for natural resources, including aquatics. Because environmental conservation and sustainability are defining issues of the 21st century, it is critical for today’s children to be reunited with nature and to embrace pro-environmental behaviors (Louv 2005). Collaborations between families, schools, environmental education programs, and educators involved in fisheries, aquaculture, and aquatic sciences will be essential to instilling an appreciation for natural aquatic resources.

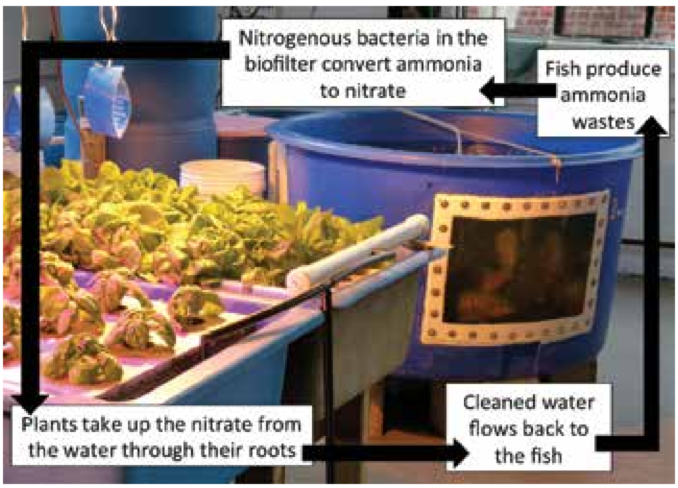
Authentic interactions with the natural world are important because such activities allow children to experience nature firsthand and gain practical skills and are more in line with how individuals learn (Kolb 1984). However, it may not always be possible for children to experience aquatic environments on a regular basis. In schools, logistical barriers such as transportation and safety, in addition to conceptual barriers like teacher attitudes, often limit the amount of time students spend in nature through formal educational systems (Ernst 2007). Furthermore, we also contemplate the broader question: Will a one-day field trip to a local farm or conservation area expose children to natural systems long enough to change their perceptions and enhance learning? To address these challenges and provide a complement to outdoor experiences, aquatic environments can be modeled in schools and informal educational settings to help reconnect children with natural processes, encourage hands-on learning, and cultivate systems thinking.

TEACHING AND LEARNING WITH AQUAPONICS

Aquaculture is the cultivation of aquatic organisms (Nash 2011), and hydroponics is a method of growing plants in water (Smith 2000). Aquaponics is another food production technology that combines both hydroponics and recirculating aquaculture (Figure 1). The naturally occurring process of nitrification is integral to biological filtration (i.e., biofiltration) in a recirculating aquaculture system, where toxic ammonia is oxidized to nitrite and then nitrate, a relatively harmless byproduct (Rakocy et al. 2006). In an aquaponics system, the plants absorb the nitrate byproduct as their preferred form of nitrogen (Bernstein 2011). In this way, it is possible to raise both fish and plants in a symbiotic relationship that closes the aquaculture waste stream and provides a second source of food from plant harvests.

Aquaponics can be used in educational settings to model natural aquatic systems and enhance academic learning. With an aquaponics system, students may explore biology through observations of animal and plant life cycles, investigate chemistry while analyzing water quality, employ math skills to calculate water flow rates, and practice finance by selling harvested products. For example, at an elementary school level, younger students can use aquaponics to observe organism life cycles and begin learning the fundamentals of the scientific method. At the postsecondary level, a small aquaponics system can provide a platform for analyzing system efficiency by measuring the flows of energy, water, and other resources, as well as the ongoing opportunity to use scientific methods of quantitative observation to manage system health. Although topics must vary with student age and ability, the continuing care required of aquaponics systems encourages responsibility, leadership, and teamwork at every level. Ultimately, using aquaponics in education allows students to have a tactile connection with living plants and animals, and hands-on learning through system care exposes them to the natural processes of ecosystems.

There has been an accelerated awareness of aquaponics in education over the past decade as more people learn of the technology. A *New York Times* article investigating the growing aquaponics phenomenon quoted Rebecca Nelson, of the aquaponics company Nelson and Pade, Inc., saying there "may be 800 to 1,200 aquaponics set-ups in American homes and yards and perhaps another 1,000 bubbling away in school science classrooms" (Tortorello 2010, D1). For example, teachers enrolled in the AgriScience Education Project at the University of Arkansas were loaned a small aquaponics system at no cost, plus an instruction manual and a set of student activities for using the system (Wardlow et al. 2002). Discussion of aquaponics in education is also occurring on the Internet, and an informal query of the Google search engine for "aquaponics in education" reveals approximately one million results with informational content on aquaponics, as well as ideas for lesson plans.



Aquaponics combines aquaculture and hydroponics in a symbiotic relationship where fish wastes provide nutrients for plant growth. UMass Amherst aquaponics system, photo by James Webb.

MOTIVATIONS

At the University of Massachusetts Amherst (UMass Amherst), we design and run small-scale, modular aquaponics systems.To raise awareness of aquaponics, we conduct public tours and workshops with interested students, educators, community members, and entrepreneurs. Our outreach work at UMass Amherst is linked to larger education projects that use aquaponics and aquaculture systems for agricultural development in Uganda and sustainability education in the United States. We have also collaborated with schools in New York, Hawaii, and Uganda to build versions of our modular aquaponics systems for educational use. These experiences have motivated us to further research aquaponics in education to assess challenges that educators may face (Hart et al. 2013).

We have witnessed growing excitement about aquaponics in education through our work on these projects. The number of schools with aquaponics systems appears to have increased, and there is a higher incidence of topics related to aquaponics in education on the Internet and in articles (Johnson and Wardlow 1997; Emmons 1998; Overbeck 2000; Nelson 2007; Lehner 2008; Johanson 2009; Milverton 2010). We have also heard many positive, as well as negative, anecdotes about classrooms and schools with aquaponics systems. However, there are few peer-reviewed articles about aquaponics in education (Nicol 1990; Emberger 1991; Wardlow et al. 2002; Hart et al. 2013), and the process of planning, building, maintaining, and using aquaponics in an educational setting has been unevenly documented and analyzed. Given this lack of information, this article brings awareness to aquaponics in education and its potential for connecting students with natural systems, promoting systems thinking, and encouraging hands-on learning. Although aquaponics is an artificial agricultural technology, the relationships among fish, plants, and nitrifying bacteria in an aquaponics system mimic a natural ecosystem. As a result, aquaponics allows for a more holistic system-like approach to aquatic education and active learning. Many of the ideas put forth in this article also apply to aquaculture education and other aquatic teaching tools. To this end, we have included information to consider and ideas for getting started with an aquaponics system, plus two examples of educational aquaponics programs. We encourage educators to address the potential benefits and challenges of aquaponics before embarking on a project and to adjust their expectations accordingly (Table 1).

EVERYDAY REALITIES OF AQUAPONICS

At first glance, growing fish and plants together may not seem difficult. However, the highly technical nature of aquaponics is often overlooked; to keep a system balanced, water levels, temperature, pH, and nutrients must match the physiological demands of all species, especially the nitrifying bacteria (Tyson et al. 2004; Rakocy et al. 2006). Nitrifying bacteria are essential to biofiltration in a healthy system and usually take between 4 and 8 weeks to become established, limiting initial ammonia remediation and the overall health of the system during that time. Crops and fish must also be managed at a ratio of nutrient inputs to outputs for optimum production, which varies according to species, system size, and cropping system (Rakocy et al. 2004). Aquaponics systems require daily care; even if automatic feeders and sensors are used, the system still needs to be checked for proper water flow and signs of poor species health. The reality is that aquaponics systems, even at small scales, are complex systems that rely on natural processes and require external care.

An educational setting also affects the logistics of building and running an aquaponics system (Hart et al. 2013). Space and location may be an issue; an aquaponics system requires a space that can get wet and the size may be limited by available classroom space. School hours may also limit access to the system, and existing infrastructure may affect access to necessary water, electricity, and heating or cooling technology. Many educational settings also require adherence to institutional policies for animal care and use to ensure animal health and safety. Furthermore, regulations may require permits for live animals, inspections of facilities, and precautions surrounding food safety. Building and maintaining a living system also requires ongoing inputs besides the initial construction materials: fish, feed, seeds, increased utilities, and miscellaneous incidentals. As a result, support is needed from administrators and other funding sources for initial project costs and for continued operating costs. Along the same lines, support from facilities and janitorial personnel may be helpful for installing, maintaining, and cleaning aquaponics systems. The living components of aquaponics systems also require regular care, including weekends, scheduled holidays, and extended school breaks. However, it is also these realities of aquaponics systems that challenge students to think critically and solve real-world problems, which makes aquaponics a valuable teaching tool.

Aquaponics systems present many details that need to be accounted for and success takes commitment, time, and sustained effort from everyone involved. In a survey of educators who use or have used aquaponics, participant responses indicated that passion for the process of building and using aquaponics in the long term is crucial given the need for a sustained effort (Hart et al. 2013). Similar to aquaponics, the literature on school gardens also reports that commitment to the garden from multiple parties is key to long-term success (Hazzard et al. 2011). These results suggest that educators who are excited about aquaponics and who recognize the realities are more

EXAMPLE 1. Aquaponics at Allegheny College, Meadville, Pennsylvania

www.foodforsustainability.com

In 2008, environmental science professor Thomas Eatmon, Ph.D. took his Allegheny College students to visit the Tom Ridge Environmental Center on Lake Erie. The students were so amazed by the aquaponics systems there that Eatmon was inspired to begin an aquaponics project at Allegheny College. In the five years since then, Eatmon has integrated aquaponics into his classes through service learning and as an interdisciplinary business, in addition to conducting his own aquaponics research. Eatmon and his students initially started with a 55-gallon tank and some plastic floating rafts along with the invaluable help of a local fish farmer. Currently, Eatmon and his students have a vertical system with about 600 gallons of water on one wall of their laboratory where they grow tilapia and lettuce, which they sell to their campus dining service. This system is used as a small-scale business so that students can explore economic and environmental efficiency. Work-study students are employed to care for the system by feeding fish, monitoring water quality, removing solid wastes, replacing lost water, breeding fish, germinating seeds, and harvesting the final products. In addition to managing their laboratory system and an ornamental system in their building lobby, Eatmon and his students are working with seven local classrooms in five area schools to help teachers and students learn about systems thinking with their own desktop aquaponics systems. The partnership allows Allegheny students to practice their skills as environmental educators by teaching students, as well as by providing curriculum support and weekly aquaponics maintenance that also benefits teachers. Through these partnerships and collaborations, Eatmon and his students hope to continue integrating aquaponics into their community to raise awareness of sustainable values, attitudes, and practices.

Table 1. Potential benefits and challenges of aquaponics in education presented to help educators manage their expectations.

Potential benefits	Potential challenges
Connect with nature, systems thinking, life cycle approach to learning	Time commitment spanning from planning, fundraising, construction, implementation to maintenance
Hands-on, active teaching and learning, production and product based	Technical difficulties, including plumbing, electronics, water chemistry
Multidisciplinary, including science, technology, engineering, and mathematics; business administration; sustainability	Space and resource limitations
Building community connections	Weekend/holiday/summer care, adequate training of support staff, and/or commitment from students
Growing trend in aquaponics as a food production system	Lack of readily available/accessible information

likely to have a positive and constructive experience. Furthermore, it is important to acknowledge that these realities offer many "teachable moments" in commitment, perseverance, and responsibility.

ADDRESSING THE REALITIES OF AQUAPONICS IN EDUCATION

A discussion of the realities and potential challenges facing aquaponics in education would not be complete without a subsequent discussion of workable solutions. To this end, we hope to provide educators who are interested in starting aquaponics projects with potential strategies to address the realities outlined above.

Aquaponics technology is complex and requires knowledge in a variety of fields: fish and plant health, water chemistry, physics, and construction. We recommend that educators who are interested in aquaponics research this information through articles, books, and the Internet. However, more importantly, we recommend that educators reach out to knowledgeable members of their community. Through connections with universities, schools, fish farms, community organizations, aquaponics hobbyists, state and federal fish hatcheries, businesses, and industry professionals, interested educators can learn new information and establish a supportive network that will be helpful throughout the project (Hart et al. 2013). Ideally, these community connections will grow into long-lasting, mutually supportive relationships.

It is also important to acknowledge that no two aquaponics systems are the same, making it especially challenging to prescribe concrete solutions for individual technical problems. However, this leaves room for the use of important critical thinking skills, by both educators and students, to develop creative strategies for addressing the everyday realities of aquaponics technology. For example, educators participating in a survey regarding aquaponics in education reported developing diverse solutions, including covering tanks with shower curtains, modifying pipe sizing from original designs, experimenting with different species, and using recycled materials such as plastic bottles (Hart et al. 2013). The development of these individualized solutions depends on a trial-and-error ethic, combined with expertise sourced from a supportive community, and is key for addressing the technical realities of aquaponics.

An aquaponics system must also match the situational realities and available resources in order for students to achieve maximum learning. For example, teachers in a traditional school setting may not have a classroom with a floor drain or the structural integrity to support 2 tons of water for a medium or large aquaponics system. In this situation, it is more realistic for a teacher to implement a tabletop system using a 20-gallon aquarium that grows plants in a floating raft above the fish. With a tabletop system, students are exposed to the principles of fish biology and basic water chemistry. After gaining confidence with a small system, interested educators and students who want to continue with aquaponics could develop a larger system in a more suitable location. Starting with a small system and tolerant species appropriate for the location will decrease the inherent learning curve.

An educational setting may also affect the logistics of building and maintaining an aquaponics system. Because of the academic schedule and potential bureaucratic constraints, we encourage educators who are interested in aquaponics to embark on a thorough planning process. In particular, educators should develop a clear vision for the project, tangible goals, a metric for measuring success, and a realistic timeline given academic schedules and potential technical limitations. As Hazzard et al. (2011) recommend for school gardens, stakeholders (e.g., teachers, administrators, students, and parents) should be involved in the planning process to delegate tasks, garner long-term commitment, and inspire enthusiasm. Reaching out to others in the school community, especially administrators, will also be essential for getting project funding and construction approval. We also encourage educators to develop contingency plans for unexpected outcomes. Though equipment failures, human error, and fish die-offs are expected events in the aquaponics industry, an educational setting can magnify these setbacks. However, contingency plans and an awareness of failure can turn these events into valuable learning opportunities for all involved.

Although small tabletop aquaponics systems may require less advanced planning than larger systems, educational aquaponics systems of every size still require care, resources, and plans for extended school breaks. Common summer break plans are to harvest and shut down an aquaponics system, to ask a student to bring a small system home to care for it, or to ask a year-round school employee to care for the system at the school (Hart et al. 2013). Many educators also assume full responsibility for system care over the summer, as well as winter breaks, weekends, and holidays. These plans are workable, although there may be unforeseen obstacles. For example, breaking down the system may require prematurely harvesting fish and plants, which may be an uncomfortable prospect for students. On the other hand, transportation of live fish and plants to a student's home may be logistically complicated. Though summer care for an aquaponics system may be challenging, advanced planning and contingency plans will be essential for a smooth transition between the school year and the summer. The challenge of daily care also presents opportunities for the development of creative, alternative models—for example, a mobile aquaponics system where teachers share the responsibility over school breaks. It may also be worthwhile to explore a model where systems are loaned out to schools by a central organization (e.g., nonprofit or university) that collects or manages them over the summer (Wardlow et al. 2002).

GETTING STARTED WITH AQUAPONICS IN EDUCATION

Armed with more information and the relevant language, we encourage educators to ask the questions necessary to plan for an aquaponics system because there is not one blueprint that

Table 2. Ten questions to guide educators in planning for aquaponics systems.

Questions to consider
Why do we want to use aquaponics in our classroom or school? What are our learning objectives for the system? (A specific answer to this question will help with project goals, timelines, and curriculum planning.)
What does success look like for this project (e.g., high number of students reached, a learning experience for all involved, systems used for 2 years, fish fry lunch, self-sustaining business)?
How does our vision of success translate into tangible goals for the system? What happens if we don't meet our goals or if they change along the way?
How can we get all stakeholders (e.g., schools, teachers, administrators, students, parents) on the same page about the project vision and goals? How will we clearly communicate at every stage of the project?
What is a realistic project timeline, given our goals, funding, personnel, and school year constraints? If this is a long-term project, how will resources and energy be maintained and refreshed? Keep in mind that biological filters take about 6 weeks to cycle and get established.
Given our goals for the system, our vision for success, and our realistic constraints, what is an ideal size for our system (e.g., tabletop aquarium versus small- to medium-scale versus commercial system)?
Is the space available properly equipped to meet our vision for success and accommodate the size of system we've chosen? Things to think about include climate and the need for heating and/or cooling, access during after hours, the availability of water and electricity, the structural integrity of the building and the weight of the water, and the probability of large water spills.
Who will be building the system? Will they have prior knowledge and training? Who else will be involved in building the system so that multiple individuals understand its functioning?
Who will be caring for the system on a daily basis? What training and support will they have or need? Will the system require care over short breaks (e.g., weekends and holidays)? How will system care be delegated?
Will the system require care over extended breaks (e.g., summer and winter)? If so, who will care for it? If it will be shut down, what happens to the plants and/or fish? Will they be moved or harvested and how?

EXAMPLE 2. Aquaponics at Cincinnati Hills Christian Academy, Cincinnati, Ohio

www.chca-oh.org | kevin.savage@chca-oh.org | gary.delanoy@chca-oh.org

At Cincinnati Hills Christian Academy (CHCA) in Ohio, high school teachers Kevin Savage, Ph.D. and Gary Delanoy teach biology, chemistry, environmental science, and sustainable agriculture through multiple classroom aquaponics systems. The teachers first started using aquaponics in 2011 when Savage's Environmental Science class built a five-column, vertical aquaponics system using a 65-gallon aquarium, recycled 2-liter soda bottles, and expanded shale media. Two individuals who had designed and built a similar system at a local restaurant used that system as a model to help the students understand the concepts behind aquaponics. Since then, the two teachers and their students have built other small aquaponics systems using different designs including floating rafts and media-filled beds in aquariums, deep water culture, nutrient film technology, and vertical tower systems. These systems have produced Channel Catfish *Ictalurus punctatus*, hybrid Bluegill *Lepomis macrochirus*, and Yellow Perch *Perca flavescens*, plus bell peppers, hot peppers, leafy greens, kale, basil, and lemon balm. Students are responsible for the aquaponics systems during the school year and have gained valuable experience in day-to-day aquaponics operations. Savage and Delanoy have fully integrated the aquaponics systems into the CHCA science curriculum, including a Research and Leadership program where upper-level students can pursue independent aquaponics projects. CHCA students are also involved in their community through aquaponics service learning projects. In 2013, Savage and Delanoy participated in building and maintaining aquaponics projects at the Cincinnati Park's Krohn Conservatory and the Cincinnati Zoo and Botanical Gardens. In the current school year, the teachers and their students are working with five local elementary and middle schools to help them establish and manage their own small aquaponics systems. Savage and Delanoy are also working to expand their aquaponics program with the installation of a large greenhouse, which will allow them to continue inspiring students toward environmental conservation and sustainable agriculture through aquaponics.

fits all situations (Table 2). It is important to keep in mind that programs and priorities will most likely grow and change over time. As a result, flexibility in planning will be helpful but a plan is still essential for a project of any scale. We recommend that educators who are interested in getting started with aquaponics begin by reaching out to form a supportive community to share knowledge and passion for aquaponics. From there, educators can work with other stakeholders and their community to develop a plan that fits their individual situation. With properly managed expectations, community connections, and a passion for the process, aquaponics can be an effective tool for inspiring appreciation for aquatic resources.

FUNDING

For financial and logistical support, we would like to thank the Allen Family Foundation, the Clarence and Ann Dillon Dunwalke Trust, the Western Massachusetts Center for Sustainable Aquaculture, the National Institute of Food & Agriculture, the U.S. Department of Agriculture, the Massachusetts Agricultural Experiment Station, the UMass Building Integrated Aquaculture Working Group, and the Department of Environmental Conservation (project number MAS00987).

REFERENCES

Bernstein, S. 2011. Aquaponic gardening: a step-by-step guide to raising vegetables and fish together. New Society Publishers, Gabriola Island, Canada.
Emberger, G. 1991. A simplified integrated fish culture hydroponics system. The American Biology Teacher 53:233–235.
Emmons, H. 1998. Aquaponics in the classroom. Pages 1–4 *in* J. S. Lee, editor. Aquaculture how to series. National Council for Agricultural Education, Alexandria, Virginia.
Ernst, J. 2007. Factors associated with K–12 teachers' use of environment-based education. The Journal of Environmental Education 38:15–32.
Hart, E. R., J. B. Webb, and A. J. Danylchuk. 2013. Implementation of aquaponics in education: an assessment of challenges and solutions. Science Education International 24:460–480.
Hazzard, E. L., E. Moreno, D. L. Beall, and S. Zidenberg-Cherr. 2011. Best practices models for implementing, sustaining, and using instructional school gardens in California. Journal of Nutrition Education and Behavior 43:409–413.
Johanson, E. K. 2009. Aquaponics and hydroponics on a budget. Tech Directions 69:21–23.
Johnson, D., and G. Wardlow. 1997. A prototype recirculating aquaculture-hydroponic system. Available: scholar.google.com. (Accessed January 2013).
Kolb, D. 1984. Experiential learning: experience as the source of learning and development. Prentice-Hall, Englewood Cliffs, New Jersey.
Lehner, M. W. 2008. One fish, two fish: growing lunch with aquaponics. Edible Nutmeg Summer:24–25.
Louv, R. 2005. Last child in the woods: saving our children from nature-deficit disorder. Algonquin Books, Chapel Hill, North Carolina.
Milverton, S. 2010. Aquaponics: an inquiry into a multi-sensory, differentiated learning project in Australasian and Asian Schools using aquaponics as a key focus. Pages 3719–3723 *in* Z. W. Abas, I. Jung, and J. Luca, editors. Proceedings of Global Learn Asia Pacific. Association for the Advancement of Computing in Education, Penang, Malaysia.
Nash, C. E. 2011. The history of aquaculture. Blackwell Publishing, Ames, Iowa.
Nelson, R. L. 2007. 10 Great examples of aquaponics in education. Aquaponics Journal 3:18–21.
Nicol, E. 1990. Hydroponics & aquaculture in the high school classroom. The American Biology Teacher 52:182–184.
Overbeck, J. 2000. A new wave of farming comes to Colorado, the bio building at Eagle Valley High School. Pages 287–290 in A. Knutson, editor. The best of the growing edge 2: popular hydroponics and gardening for small-commercial growers and hobbyists. New Moon Publishing, Inc., Corvallis, Oregon.
Rakocy, J. E., M. P. Masser, and T. M. Losordo. 2006. Recirculating aquaculture tank production systems: aquaponics—integrating fish and plant culture. Southern Regional Aquaculture Center, Publication 454, Stoneville, Mississippi.
Rakocy, J. E., R. C. Shultz, D. S. Bailey, and E. S. Thoman. 2004. Aquaponic production of tilapia and basil: comparing a batch and staggered cropping system. Acta Horticulturae 648:63–69.
Smith, R. 2000. What is hydroponics? Pages 8–9 in A. Knutson, editor. The best of the growing edge 2: popular hydroponics and gardening for small-commercial growers and hobbyists. New Moon Publishing, Inc., Corvallis, Oregon.
Tortorello, M. 2010. The spotless garden. The New York Times. Available: www.nytimes.com. (February 18 2010).
Tyson, R. V., E. H. Simonne, J. M. White, and E. M. Lamb. 2004. Reconciling water quality parameters impacting nitrification in aquaponics: the pH levels. Proceedings of the Florida State Horticultural Society 117:79–83.
Wardlow, G. W., D. M. Johnson, C. L. Mueller, and C. E. Hilgenberg. 2002. Enhancing student interest in the agricultural sciences through aquaponics. Journal of Natural Resource and Life Science Education 31:55–58

AFS SECTIONS: PERSPECTIVES ON AQUACULTURE

Perspectives from the Student Subsection and Education Section

In Response –The Use of Aquaponics in the Classroom

Daniel J. Dembkowski
Student Subsection Immediate Past President, Department of Natural Resource Management, South Dakota State University, Brookings, SD.
E-mail: daniel.dembkowski@sdstate.edu

Landon L. Pierce
Student Subsection President, U.S. Fish and Wildlife Service, Pierre, SD

Craig P. Paukert
Education Section President, U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Research Unit, Columbia, MO

Integration of aquaponics in educational curricula provides a valuable means of meeting the challenges of reconnecting younger generations with nature, renewing interest in fisheries and aquatic resources, and ultimately increasing recruitment of new Society members. The mission of the Society is to "improve the conservation and sustainability of fishery resources and aquatic ecosystems by advancing fisheries and aquatic sciences and promoting the development of fisheries professionals." Essential to this mission is education—continuing education of established and aspiring fisheries professionals and education of those who have yet to develop a full appreciation for fisheries and aquatic resources. Though the Society and its various factions typically focus their efforts on current and future fisheries professionals, the education of those who have yet to develop an appreciation for or interest in fisheries and aquatic resources is largely the responsibility of the primary, secondary, and postsecondary education communities. At its most basic level, integration of aquaponics in the classroom exposes students to and increases awareness of resources and ecological relationships that they may not otherwise be exposed to, providing the spark that may fuel the fire of lifelong interest in fisheries and aquatic resources, and complements other programs aimed at exposing students to aquatic resources (e.g., Trout in the Classroom; troutintheclassroom.org/). Because "nature-deficit disorder" is becoming increasingly prevalent among younger generations, creative strategies such as the integration of aquaponics in the classroom may be needed to bring younger generations back to nature, and we applaud those willing to take on these challenges.