The Agriculture of Aquaculture: A STEM Unit

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Introduction

As a Biotechnology teacher I am constantly trying to bring new technologies and resources into my agricultural-focused classroom. During my short time as a teacher one area that has piqued my interest and the interest of my students is aquaculture. Aquaculture is the raising of aquatic animals (fish, shrimp, mussels, etc.) and aquatic plants (seaweed) for food. Fortunately, within the Biotechnology 3 curriculum there is adequate time for a new unit to fit into the curriculum structure. Therefore, I have developed a new unit for my classroom called The Agriculture of Aquaculture.

Curriculum Background

As the Earth's population explodes there is an ever-growing strain placed on the natural resources that humans have relied heavily on for centuries. One of the most stressed ecosystems on Earth is our water, specifically our oceans and seas. As the number of fish and other marine resources we extract continues to grow the stress that is placed on this fragile ecosystem will cause it to crumble.

"Give a man a fish and you feed him for a day. Teach a man to fish and you feed him till stocks run out. Teach a man to grow fish and you feed him for a lifetime." (1)

Food security is an ever-increasing concern as the Earth's population rapidly approaches 8 billion people. Scientists are constantly working to find new and innovative ways to provide healthful food to people around the world. One area of interest for many scientists is aquaculture, aquaponics and hydroponics.

Traditionally, fish have been caught wild from the ocean and then brought to market; however, there are numerous negative effects that fishing has on the environment. Fishing, especially overfishing of a species, can completely alter trophic relationships that exist in the ecosystem (2). For example, an overfishing of saltwater shrimp can decrease their numbers by enough to impact their predators – octopi, squid and cuttlefish. This in turn can impact the predators of these animals. This imbalance in the predator / prey relationship can last long beyond just one year. Overfishing can impact the number of spawn that are produced and therefore have compounding effects on the environment for decades to come. These long-term effects can alter the biomass of an ecosystem causing species to struggle or even become extinct.

As the global demand for food increases, especially the need for protein, a search for the most efficient and effective way to raise food is upon us. Pound for pound, fish is one

of the most efficient animals to raise for food. To increase the weight of cattle by one pound, it must be fed 7 pounds of food. To increase the weight of a pig by one pound it must be fed 4 pounds of food. To increase the weight of poultry by one pound it must be fed 2 pounds of food. By comparison to gain one pound of fish growth only 1.5 pounds of food is needed. This shows the sheer efficiency of aquaculture based on just the pounds of food placed into the system (3). Currently 37% of the grain harvested worldwide is used to produce animal protein (4). If we can lessen the demand on grain for the production of protein, we cannot only increase the amount of protein available, but also the amount of grains available.

In the United States about 10% of the farmed fish we eat is produced domestically. More than 60% of the fish we eat that is farm-raised is imported from China (5). In order to increase our independence in acquiring this "in demand" source it is important to have students explore this burgeoning science.

Aquaculture is the only known way to increase domestic food production and is becoming a more important business as the world's wild populations are quickly diminishing (6). Over the past 40 years the per capita consumption of fresh fish in the United States has increased from 11 pounds to about 16 pounds and by 2025 it is predicted that the per capita consumption will reach 25 pounds per year. This increase in the demand for fish, coupled with the exponentially increasing population, is creating a strain on natural resources (7).

Aquaculture has literally exploded over the past few years. While it is an old science, it is relatively new to the United States (8). In the United States from 1983 to 2005 the pounds of U.S. aquaculture production increased from about 300 million pounds to over 800 million pounds and the value of this business has increased almost eight fold (9). Many different regions within the United States are known for certain aquaculture production. For example, Mississippi is known for its production of catfish, while Idaho is known for its trout production. The production of catfish accounts for almost 50% of all U.S. aquaculture production. Worldwide, trout, salmon, crayfish, oysters and bait / tropical fish make up 90% of all aquaculture production (10).

As an agricultural biotechnology teacher I am constantly striving to find new ways to relate the science and manipulation of agriculture to my students. I have noticed that if students do not have an interest in the topic it is difficult for them to access the science behind it. One topic that my upper level biotechnology students have expressed great interest in is the science of hydroponics, aquaponics and aquaculture. Last year, students and I visited Delaware State University, which has a state of the art aquaculture facility. This visit sparked great interest in my students and they expressed the interest to learn more about this ever-developing science. My unit for the Delaware Teacher's Institute will harness this intrinsic motivation of my students in order to foster their STEM skills in my Biotechnology 3 class.

After this unit, my goal is to begin to transition my students from the study of aquaculture to the science of aquaponics. Aquaculture is the raising of aquatic animals

(fish, shrimp, mussels, etc.) and aquatic plants (seaweed) for food. Hydroponics is growing terrestrial plants without soil by using nutrient rich water. Aquaponics is the marriage of these two ideas and creates a closed system where the waste from the aquaculture system is cycled into the hydroponics system and then the waste from the hydroponics system is cycled back into the aquaculture system. These 3 alternate ways to farm are becoming more popular worldwide, as not only our oceans begin to become overfished, but also as we begin to run out of arable land. Furthering my students' understanding past aquaculture and into aquaponics will continue to take my students' education to the next level and allow them exposure to new technologies.

School and Classroom Background

I teach at Thomas McKean High School in Wilmington, Delaware. McKean High School serves students who reflect the following demographics: 20% Special Education, 6% English Language Learners and 73% from low income homes. In addition, 29% of the students are African American, 35% of students are Hispanic and 35% of students are Caucasian. I teach a Career and Technical Education Course (CTE) called Biotechnology. In the Delaware State Standards, Biotechnology falls under the Agricultural Pathway of the Career and Technical Education Umbrella (CTE). As a CTE course, I strive to create an engaging curriculum that has real world application for my students. Therefore, in this unit, I constantly want to reinforce the material with real world examples that students may encounter in future careers or in their personal lives.

One challenge I will face and have faced during this unit is my own lack of background knowledge of this topic. In my undergraduate and graduate school studies I was not exposed to hydroponics, aquaponics or aquaculture, therefore, I have had to engage in a lot of self-teaching and trial and error in order to learn about these complex and expansive subjects.

This unit will be taught to a Biotechnology 3 class at McKean. This course is an upper level CTE course and students must have passed both Biotechnology 1 and Biotechnology 2 in order to be enrolled in Biotechnology 3. Students are in 11^{th} or 12^{th} grade. In Biotechnology 1 and 2 students explored the way that Biotechnology can enhance food production for land crops and animal production. They also learned about the environmental impacts that these scientific advancements have on the environment locally and worldwide. In order to expand this base of knowledge, students will begin to explore the science of aquaculture, hydroponics and aquaponics. This unit will allow students to first explore the environmental impacts of fishing, then to design their own aquaculture facility on a mini-scale and finally to assist in the planning of a school-wide aquaponics facility.

The state standards for Biotechnology state that students in Biotechnology must be able to design and conduct labs that follow the scientific method and research emergent technology in the fields of animal science, plant science and food science. The science of aquaculture, hydroponics and aquaponics is a perfect marriage of these advanced topics

and provides a vehicle for students to learn more about agricultural advancements and the scientific method.

In order for students to be able to understand this unit they must learn and understand a wide variety of information. First, students must understand the demand for and the economics of fish and fish products. Understanding this background information will make it clear to students why overfishing has become such a worldwide issue. Second, students must discover the environmental impacts that overfishing can lead to and why these problems can so greatly impact the ecosystems of the world. Students must also understand the fish life cycle and the plant cycle so that they can successfully raise these two kinds of organisms. Students must also have a firm foundation of chemistry, physics, math and biology so that they are able to successfully build and maintain the aquaponics units and produce edible fish.

At McKean High School there is a Culinary Arts CTE course. It is my hope that the Biotechnology classes will be able to provide some fish to the Culinary Arts Pathway. This will create a unique working partnership that will further show students the real world application of aquaculture and aquaponics.

Objectives

I have three overarching objectives for this unit. Each of these larger objectives can be broken down into smaller more concrete understandings. The first main objective is that students will understand the environmental impact of overfishing and the economic promises that commercial farming of fish presents. Secondly, students will be able to successfully create a mini-aquaculture unit in the classroom and then apply these scientific and mathematical principles to a large-scale outdoor system. Lastly, students will be able to explain the ethical, legal and health differences between farm raised fish and wild caught fish.

In order to provide context to why aquaponics is such a necessary technology students must understand the problem that is plaguing the world's oceans –overfishing. Without this understanding students will not understand the urgency with which we must solve this world's problem nor will they be able to fully see the real world applications of aquaponics. In this objective students will also need to understand and explain the type of fish that they consume on a regular basis and explain why these fish are present in their diet. This will allow them to understand how overfishing could directly impact their lives and food systems. Students must also understand the regulations (both domestic and internationally) that guide commercial fishing and aquaculture.

Students must be able to apply the STEM concepts they are learning to the actual creation of a working aquaculture unit. Students will first create small-scale aquaculture systems so that they are able to practice their skills on a smaller scale. Then students will take the skills they have learned and apply them into a large system that we will create as a class. Students must understand the chemistry and biology that contributes to the healthy farming of fish so that they are able to successfully grow this organism. This

includes being able to calculate the amount of food and other chemicals that a closed system will need in order to maintain plant populations. Learning to operate an aquarium on a small-scale teaches many of the principles of aquaculture that students will need to use for larger scale production.

Students will need to understand the ethical, legal and health issues that are associated with aquaculture. Fish farming is a hotly debated topic nationally and internationally and students must be able to sort through this information in order to understand these issues at a deeper level. Students will need to understand the health benefits, ecological impacts and other factors of farm raised fish versus wild caught fish.

Connection to Standards

In the state of Delaware for Career and Technical Education Classes we have specific state standards that we use in conjunction with the Common Core State Standards. There are numerous biotechnology standards that directly connect to my objectives. Students will be asked to "explore and discuss research in biotechnology as it relates to agriscience," to "understand the importance of biotechnology in sustaining and improving the quality of life," and "describe technology related to advances in the field of animal science, plant science, environmental science and food science." Lastly, in the state standards students are asked to "examine consumer concerns related to advances in biotechnology." All of these standards will be addressed in varying degrees of depth during the curriculum unit.

This unit truly embodies the spirit of STEM education while using a real world problem to pique student interest. Students will be expected to integrate science concepts such as chemistry, physics and biology as well as use mathematic skills to design and engineer a working aquaponics system that involves the latest technologies available in the aquaponics field.

While planning my unit, I kept both the Delaware State Standards and the Common Core Standards in mind to ensure the success of my students.

Teaching Strategies

Collaborative Pairs / Groups

In many of the activities that I have created for this unit students are working in collaborative pairs or groups. Working in collaborative groups is important, especially for individuals working in the science field. In collaborative groupings students must work together in order to achieve a final goal. This helps teach students how to work respectfully with each other while listening to other's opinions and ideas. Students often feel more comfortable sharing their unique ideas and opinions in smaller groups and these collaborative groups foster that safe feeling that allow students to take risks with their educational experience. In addition to allowing students feel safer when expressing their ideas, collaborative pairs / groups also help scaffold work for students when reading

articles. In collaborative pairs / groups stronger readers are paired with readers that struggle so that all learners are supported.

Students will work in collaborative pairs and groups during many of the activities during this unit including Activity 1 where students will read the article *Still Waters: The Global Fish Crisis,* Activity 3 where students will create one-pagers from jigsawed articles and during the actual creation of their aquaponics system.

One-Pagers

A one-pager is a students' or a groups' response to a reading that expresses their unique understanding of that document. One-pagers allow students to visually represent a text so that they can more efficiently process the information that was presented to them. One pagers can include quotations, visuals, reactions to the text, questions that still exist about the text and a brief summary. The goal of a one-pager is to have students do more than just summarize an article but to make the text visually come alive so that other individuals can learn from the one-pager. Students will be asked to create a one-pager in collaborative groups after they read one of the articles from activity 3.

Jigsaw

Typically jigsaws ask groups of students to look at different passages from a single text and then to share and exchange information. For the jigsaw method I will use, however, students working in collaborative groups will read different articles about a similar topic and then share information from these different articles with other members of the class. This will allow students to become experts on a certain article or point of view and then share this information with other collaborative groups. Students will use this jigsaw method when reading articles from activity 3.

Classroom Activities

This section will highlight just a few of the lessons that I plan to teach during my unit. Aquaculture is an in-depth and complicated subject that requires more activities than can be outlined here. If you would like more information about the other activities that were a part of this unit, any of the materials, or worksheets that I created for activities that are not included in this unit plan please feel free to contact me.

Introducing Overfishing

The first activities of this unit will introduce students to the problems that are facing the world's oceans because many of my students may not be familiar with the depth of the damage that is being caused by overfishing. In order to help students see how overfishing will impact them and their environment they must first understand the problems that are occurring. It is often hard for students who live in somewhat isolated communities to understand the impact that their actions have outside of their immediate world. For this

first set of activities students will be asked to answer the following essential questions at the end of the activities:

- What is commercial fishing?
- How does commercial fishing work?
- What fish do I consume on a regular basis and how are these fish harvested?
- What fish are being overfished and why are these fish being targeted?
- How does my consumption of fish impact the ecosystem?
- How does overfishing impact ecosystems and the economy?
- What steps can be taken to prevent overfishing and to ensure the biodiversity of the ocean ecosystems?

Activity 1

Objective: Students will understand the demands that fishing place on ecosystems.

Materials Needed: Computers, Internet Access, "Online Fishing Simulations" Worksheet

Estimated Time Needed: 50 minutes

During this activity students will engage in online fishing simulations that will allow them to experience what it would be like to be a commercial fisherman or woman. In the first online simulation students will act as fishermen – they will independently engage in two different online fishing simulations. The first simulation will ask students to collect as many fish resources as possible so that they are able to defeat the other 3 online players. Students will be told that if they are able to defeat the other three online players during this short simulation that they will earn candy. Students will then interact with the game as real fishermen interact with the oceans – they will want to collect as many fish as possible for short term gratification without realizing the long term impacts of their actions. As soon as the game ends students will be asked to react to their experience playing the game and the rationale they used while they were fishing to gain resources. Students will then see that not only were they being rated on how many fish they were able to collect, but also on the way that they fished, or in other words, the online simulation ranks the "sustainability" of their fishing. Students will then be asked to play the game again now that they understand that not only will they be ranked on the number of fish they collect, but also on how they fish. At the end of the second round of the simulation students will be asked to compare the mindset they used to fish the first time and the mindset they used the second time (11).

The second online simulation asks students to attempt to catch as many fish as possible in 10 days. In this simulation students will examine the way that fish replenish themselves and the responsible way that fishermen must treat their resources in order to ensure that they don't overfish an area while still collecting the resources that they need in order to support themselves. Students will then be asked to reflect independently after this activity and then as a class these ideas and reflections will be shared (12). The "Online Fishing Simulations" Worksheet can be found in Appendix A.

Activity 2

Objective: Students will understand and be able to explain the ways that overfishing are impacting resources.

Materials Needed: Articles, "Still Waters: The Global Fish Crisis Graphic Organizer"

Estimated Time Needed: 45 minutes

I have never taught an aquaponics unit before, therefore I think it is important to emphasize for students the reasons that aquaponics is so important in this day and age. Over 100 million tons of fish are being extracted from the ocean each year and students need to understand the way that this extraction impacts them both directly and indirectly (13). To first introduce this topic all students in the class will read an article titled "Still Waters: The Global Fish Crisis" written by Fen Motaigne (14). This article highlights the overfishing that is taking place by highlighting fish that students have had exposure to in their daily lives – Bluefin tuna and sharks. Students will read this article in small groups and be asked to create a three columned page in their Aquaculture Notebooks. The columns will be labeled "current problems," "solutions presented in the article" and "our possible solutions." While students are reading they will be asked to extract information from the text to complete the first two columns. After the groups have completed reading the articles they will brainstorm possible solutions that could address the problems presented in the article. Groups will then be asked to share their possible solutions and we will create a master solution list that will be a working document for the classroom throughout the entire unit. As new information is learned we will add to this master list and remove any ideas that we learn may not be feasible. The "Still Waters: The Global Fish Crisis Graphic Organizer" can be found in Appendix B.

Activity 3

Objective: In cooperative learning groups students will create a one-pager about the environmental issues that are caused from overfishing by reading articles.

Materials Needed: Article, Markers, Blank Paper

Estimated Time Needed: 120 minutes

Now that students have a basic understanding of the overfishing problem students will be divided into groups again to read and then share information from a variety of text sources. I have found 6 articles written from 5 different sources that will continue to educate students about the problems of overfishing. Each group will read the article they have been assigned and then as a group be asked to create a one-pager to share their articles information with the rest of the class. These articles are located in the end of this unit in the bibliography section.

Introducing Aquaculture

Now that students have an understanding of the problems facing the oceans in terms of overfishing, the idea of fish farming or aquaculture will be introduced. Students will be introduced to this topic by watching a few videos about fish farming from the National Ocean Service Website, links to these videos can be found in the bibliography and the video produced by the Food and Agriculture Organization of the UN video. After these videos introduce the concepts, we will begin talking about the needs of aquaculture systems. Essential questions that will be addressed in this unit are:

- What is aquaculture?
- How is aquaculture used to relieve the pressures that overfishing places on the environment while still positively impacting the economy?
- What is needed in order to create a successful aquaculture system?

Activity 1 – Introduction to Aquaculture using Videos

Materials Needed: Projector, Speakers, Computer with Internet Access, "Videos: Investigating Aquaculture" Worksheet

Estimated Time Needed: 45 minutes

Students will be introduced to the topic of aquaculture by watching a series of videos as a whole class. These videos will create common background knowledge for all my students. The National Ocean Service and the Food and Agriculture Organization of the United Nations have both created very informative videos that will be used to introduce this topic to students. These resources can be found in the bibliography at the end of this unit. Students will most likely need to watch the video created by the National Ocean Service two to three times through because it is short and moves quickly. Students will answer questions during the videos and once the videos are complete. The "Videos" Investigating Aquaculture" worksheet can be found in Appendix C.

Building Aquaculture Units

The crux of the unit will be spent on students actually building and experimenting with building their small-scale aquaculture units. These units will be built in pairs so that students have the most exposure to the science, math, engineering and technology that it takes for these units to be successfully created and maintained. Students will address many of the learning objectives I have set during this section of the unit, such as:

- What are the necessary components to create a successful aquaculture unit?
- What environmental factors must be controlled in order to ensure health of the fish?
- What is the most efficient way to measure fish health and growth within our aquaculture units?

Activity 5 – Aquaculture and Math: How Many Fish Can the Tank Hold?

Objective: Students will be able to figure out the size of tanks that they need to have a healthy aquaculture system and they will also calculate the amount of food that is needed to keep this system healthy.

Materials Needed: Calculators, Pencils, PowerPoint Presentation, "Aquaponics and Math: How Many Fish Can the Tank Hold?" worksheet

Estimated Time Needed: 90 minutes

The first portion of building a successful aquaculture unit is to figure out the amount of "stuff" necessary to build a healthy unit – this "stuff" includes water, fish, the amount of food needed and bacteria. The normal operating idea is that tanks should be able to successfully support one pound of fish (500g) for every 5 to 10 gallons of water for at home operating units (15). For this first portion of the math unit students will be asked to investigate a variety of scenarios regarding the number of fish that they can fit into their unit.

In this activity, students will receive direct instruction on how to complete aquaponics math. For this activity, direct instruction using an interactive PowerPoint might be the most successful way to inform students of the mathematical processes. At the end of direct instruction students should be able to complete the "Aquaponics and Math" worksheet that can be found in Appendix D.

Possible Field Trips

Based on my experience in taking students to Delaware State University, I strongly suggest that teachers try to take their class to a working aquaculture or aquaculture facility. Many colleges and universities have working systems even if they are on a smaller scale. In addition, you may decide to take your students to commercial fish farms in order for students to see large-scale fish production. This sort of exposure to real world applications of what they are learning in the classroom will help students become more involved in the curriculum and intrinsically motivated. I have greatly enjoyed being able to take my students to Delaware State University to see their innovated and exciting aquaculture facilities.

Conclusion

These activities are meant to help students understand real world applications of biotechnology and agriculture through science, math, engineering and technology (STEM).

These activities are meant to help students deepen their understanding of exponential patterns, functions, and expressions. I have seen students struggle with these topics often in mathematics. I believe the difficulty occurs because students memorize the form of exponential functions and exponent rules and don't learn why they work or where they come from. A great way for students to strengthen their understanding is to connect the

ideas of exponential functions to that of linear functions since often students do have a good grasp of why a relationship is linear and how to model it with an algebraic function. In order to simplify exponential expressions, students must understand why we are able to simplify an expression. Memorizing rules of exponents will not be beneficial for kids because they will simply forget them later on unless they have a conceptual background to go with it. My unit allows students the opportunity to use problem solving in order to understand exponential relationships.

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13. Fen Montaigne, "Still Waters: The Global Fish Crisis," *National Geographic*, December 26, 2014, http://ocean.nationalgeographic.com/ocean/global-fish-crisis-article/.
14. Ibid, http://ocean.nationalgeographic.com/ocean/global-fish-crisis-article/#page=2.
15. Sylvia Bernstein, *Aquaponic Gardening: A Step-by-Step Guide to Raising Vegetables and Fish Together,* (Canada: New Society Publishers, 2011), 125.

Appendix A

Online Fishing Simulations

Background:

According to the National Institute of Food and Agriculture, funded by the U.S. Department of Agriculture it is recommended that individuals eat seafood at least two times a week. Seafood is a nutrient dense food that has high amounts of protein, vitamins and minerals. One of the most sought after nutrients in seafood is a fat called omega-3 fatty acids DHA and EPA. Both DHA and EPA have a variety of scientifically proved health benefits that include reducing the risk of heart disease, promoting brain health and vision development and lowering cholesterol.

In order to obtain these fish we clearly have to catch fish! Today you will simulate being a fisherman or fisherwoman in order to help meet the ever-growing demand for this nutritious and delicious food source!

Objective:
Complete two online simulations in order to understand the way that commercial fishing works in the environment.

Simulation 1:
For this simulation you will visit http://www.ecoocean.de/play-online/ and play the online simulation game. During this online simulation you will be operating the red boat, which starts in the upper left hand corner. Each hexagon represents a different fishing location. When you click on a hexagon your fishing boat will move to that location. In order to fish that area click on the hexagon again once your boat is sitting on top of it. Your goal is to collect more fish than the other 3 fishing boats in the allotted 2 minute time. If you see a fish skeleton that means that you have overfished that area and it no longer contains fish resources. If you collect more fish than your opponents you will earn candy as payment for your successful fishing.

Questions:

1. What was your goal during this simulation? How did you attempt to accomplish this goal?
2. How many fish did you catch? How many did the other 3 boats catch?
3. How could you change your fishing technique to increase the number of fish that you caught?
4. There was a surprise factor that I didn't warn you about before you started fishing. What was this factor? How did this factor impact your fishing success?
5. Now that you know about this additional factor you are going to complete the fishing simulation again. How are you going to change your fishing practices?
6. After your second simulation how many fish did you catch? How did you place in comparison to the other boats?
7. Why do you think it is important to consider both the number of fish that you caught and your sustainability rating when scoring this game?

Simulation 2:

For this simulation you will visit http://cloudinstitute.org/fish-game. Your goal is to catch as many fish as you can in 10 days without depleting the fish population. Before beginning the simulation read the introduction underneath the heading "Play the Fish Game Online."

Questions:

1. After playing through the game once, explain your methodology for fishing. How many days did you last and how many fish did you catch?
2. Before you play the game a second time explain how you are going to change the way you fished to increase your success.
3. After completing the game the second time how many days did you last? How many fish did you catch? Did you new game plan work? Why or why not?
4. You are going to play the fish game until you reach the goal of catching 18 fish or more. How do you plan on succeeding in this mission?
5. How long did it take you to catch more than 18 fish?
6. How do you think this simulation relates to real life fishing?

Post Activity Questions:

1. Now that you have completed both online simulations explain how your viewpoints of fishing have changed due to these simulations?
2. What do you still want to learn about fishing and the environment?

Appendix B

"Still Waters: The Global Fish Crisis" Graphic Organizer

Current Problems	Solutions Presented in this Article	Our Possible Solutions

Appendix C

Videos: Investigating Aquaculture

Before Watching the Videos

Before watching these videos, fill out the column of what you know so far about aquaculture and what you want to know about aquaculture.

Know	Want To Know	Learned

During "Fish on a Farm"

1. What is the "new farmer" that the video talks about?
2. How much of the seafood that the U.S. consumes is imported?
3. How much of the seafood we import is farmed?
4. What are fingerlings?
5. Explain in your own words what happens once the fish are large enough to leave hatcheries.
6. What are the environmental concerns associated with fish farming?
7. How are these environmental concerns being combatted?

During "Turning Points in Modern Aquaculture"

1. How does the video say that aquaculture helped the members of the remote village in Vietnam?
2. Where did aquaculture begin?
3. When was the first global conference on aquaculture? Why was this an important event?
4. What did the Kyoto Declaration on Aquaculture do?
5. TRUE or FALSE: Aquaculture is now the fastest growing food production sector.
6. How does aquaculture help to create more jobs worldwide?

7. What are some negatives of aquaculture that are listed in the video?
8. What is the "second turning point" of aquaculture?
9. What is the "third turning point" of aquaculture?
10. What is the "fourth turning point" of aquaculture?
11. What is the next large hurdle that aquaculture must overcome in the new millennium?

Appendix D

Aquaponics and Math:
How Many Fish Can the Tank Hold?

Objective: To be able to determine the number of fish that a tank system can safely hold. In other words, producing the maximum number of fish possible while still keeping them alive!

Part 1:
In order to calculate how many fish we can safely house in a tank we must first know how much space we have in our tank! The internal space of a tank (or the amount of water that fits within the tank) is called the volume. In general there are two different shapes of tanks that we will be using – rectangular and cylindrical. In order to find the volumes of these areas we use two different equations:

Volume of a Cylinder = π x radius squared x depth or sometimes you will see it abbreviated $V = \pi r^2 d$

Volume of a Rectangle = length x width x depth or sometimes you will see it abbreviated $L = lwd$

These volumes will be in terms of cubic inches or cubic centimeters (depending on what measurements you use). Cubic inches and cubic centimeters are not very useful when we are talking about tank size. Normally when we talk about tanks we talk about their volume in terms of gallons! Now we need to convert our cubic inches or cubic centimeters into gallons.

231 in^3 = 1 gallon	**OR**	1 in^3 = 0.0043 gallons
3,785.4 cm^3 = 1 gallon	**OR**	1 cm^3 = 0.0002642 gallons

Using this information solve the questions below.

Questions:
1. If a tank is 689 in^3 how many gallons is that tank?
2. If a tank is 37,854 cm^3 how man gallons does this tank hold?

3. If Jordan wants a tank to hold 300 gallons, how many cubic inches should the volume of the tank be?
4. If Taylor wants a tank to hold 125 gallons of water, how many cubic centimeters should the volume of the tank be?
5. Stacey wants to build an aquaculture system, however, she doesn't know how much water her system can hold. She has a cylindrical system that has a radius of 30 cm and a depth of 60 cm. What is the volume in cubic centimeters?
6. Using the volume you obtained above in cubic centimeters, determine what the volume of the tank is in terms of gallons.
7. Malik wants to build an aquaculture system and he wants to build a square tank that is 50 gallons. If the length of the tank is 40 inches and the width of the tank is 30 inches, what is the depth of the tank?
8. Tyair knows that he wants to create a square tank that can hold 600 gallons of water. Determine the dimensions in inches that would create a 600 gallon tank .

Curriculum Unit Title	The Agriculture of Aquaponics: A STEM Unit	**Author**	Stephanie Matson

KEY LEARNING, ENDURING UNDERSTANDING, ETC.

Students will be able to explain the environmental impact of overfishing and the economic promises that commercial fish farming presents. Students will also be able to create mini-aquaculture units within the classroom and then apply these principles to create a large-scale classroom model. Students will be able to explain the symbiotic

ESSENTIAL QUESTION(S) for the UNIT

1. How does the increased worldwide demand for fish impact the overfishing of ecosystems and how can this environmental impact be rectified?
2. How is aquaculture used to relieve the pressures that overfishing places on the environment while still positively impacting the economy?
3. What are the necessary components that are needed to create a successful aquaculture unit?

CONCEPT A	CONCEPT B	CONCEPT C
Introducing Overfishing	Introducing Aquaculture	Building Aquaculture Units
ESSENTIAL QUESTIONS A	**ESSENTIAL QUESTIONS B**	**ESSENTIAL QUESTIONS C**
How does the increased worldwide demand for fish impact the overfishing of ecosystems and how can this environmental impact be rectified?	How is aquaculture used to relieve the pressures that overfishing places on the environment while still positively impacting the economy?	What are the necessary components that are needed to create a successful aquaculture unit?
VOCABULARY A	**VOCABULARY A**	**VOCABULARY A**
Commercial fishing, ecosystems, overfishing	Aquaculture, economy	Fishmeal, fingerlings,

ADDITIONAL INFORMATION/MATERIAL/TEXT/FILM/RESOURCES

Text: Aquaponic Gardening by Sylvia Bernstein; Aquaculture Science by Rick Parker

Online Ideas and Websites: Aqua Project (http://www.ctsa.org/files/publications/Aqua_Curriculum.pdf); Arizona State University (http://ag.arizona.edu/azaqua/ista/ISTA7/RecircWorkshop/Workshop PP & Misc Papers Adobe 2006/4 Culture Tank Design/Culture Tank Design.pdf); and PBS (http://www.pbs.org/emptyoceans/educators/activities.html)

Online Videos: Food and Agriculture Organization of the UN (https://www.youtube.com/watch?v=4eAXwk2orY0&feature=youtube) and National Ocean Service (oceantoday.noaa.gov/fishonafarm/welcome.html