Chariho Regional School District - Science Curriculum
September, 2016

AQUAPONICS I CURRICULUM

Unit 1: Aquaculture Basics and History

OVERVIEW

Summary

In this unit, students will be exposed to the topics and terminology required to be knowledgeable about aquaculture and begin the process of examining the aquaculture industry, from both an international and domestic approach. A direct comparison is made between land and water farming with a focus on species of major economic importance. The history of aquaculture is examined across many cultures, along with specific contributions that have been made to the industry.

Content to Be Learned

- Concept of aquaculture.
- Brief history of aquaculture across cultures.
- Species of economic importance.

Practices

- Analyzing historic and current trends in the aquaculture industry.
- Evaluating the growth process of any agriculture industry.
- Comparing and contrasting land and water farming.
- Evaluating the development of major aquaculture species.

Crosscutting Concepts

- Cause and effect.
- Influence of science, engineering and technology on society and the natural world.

Essential Questions

- How has the aquaculture industry developed throughout history?

Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards

- AS.O1. Performance Element: Analyze historic and current trends impacting the animal systems industry.
- AS.01.01. Performance Indicator: Evaluate the development and implications of animal origin, domestication and distribution on production practices and the environment.
    - AS.01.01.01.a. Identify the origin, significance, distribution and domestication of animal species.
    - AS.01.01.01.c. Evaluate the implications of animal adaptations on production practices and the environment.

- AS.01.01.02.a. Research and summarize major components of animal systems.
- AS.01.01.02.b. Describe the historical and scientific developments of different animal industries and summarize the products, services and careers associated with each.

- AS.01.02. Performance Indicator: Assess and select animal production methods for use in animal systems based upon their effectiveness and impacts.
  - AS.01.02.01.a. Identify and categorize terms and methods related to animal production.
- AS.06. Performance Element: Classify, evaluate, select and manage animals based on anatomical and physiological characteristics.
- AS.06.01. Performance Indicator: Classify animals according to taxonomic classification systems and use.
  - AS.06.01.02.a. Compare and contrast major uses of different animal species.
  - AS.06.01.03.a. Identify and summarize common classification terms utilized in animal systems.

Next Generation Science Standards

- HS-ETS1-1. Analyze a major global challenge to specific qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Students who demonstrate understanding can:

HS-ETS1-1.	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**
HS-ETS1-2.	**Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.**
HS-ETS1-3.	**Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**
HS-ETS1-4.	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.
- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)
- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems
- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)

ETS1.B: Developing Possible Solutions
- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)

ETS1.C: Optimizing the Design Solution
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)

Crosscutting Concepts

Systems and System Models
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

Unit 2: Current Events and Trends in Aquaculture

OVERVIEW

Summary

Students will continue an examination of economically important aquatic species of the current day. International and domestic production and consumption patterns will be observed, however, a major focus will be on the regional successful production of shellfish. Environmental and health considerations of each area of production will be examined.

Content to Be Learned

- Categories / purpose of aquatic species.
- Economically important species: international, national and regional.
- Consumer and environmental concerns of aquatic farming.

Practices

- Asking questions about what concerns exist regarding farm raised aquatic species.
- Analyzing current trends in the aquaculture industry.

Crosscutting Concepts

- Cause and effect.

Essential Questions

- What are the costs and benefits of popular farm raised aquatic species?

AFNR Career Cluster Content Standards

- AS.O1. Performance Element: Analyze historic and current trends impacting the animal systems industry.
- AS.01.01. Performance Indicator: Evaluate the development and implications of animal origin, domestication and distribution on production practices and the environment.
  - AS.o1.o1.o1.c Evaluate the implications of animal adaptations on production practices and the Environment.
  - AS.01.01.02.a Research and summarize major components of animal systems.
  - AS.01.01.02.b. Describe the historical and scientific developments of different animal industries and summarize the products, services and careers associated with each.
  - AS.01.01.02.c. Predict trends and implications of future developments within different animal industries on production practices and the environment.
- AS.01.02. Performance Indicator: Assess and select animal production methods for use in animal systems based upon their effectiveness and impacts.
  - AS.01.02.01.a. Identify and categorize terms and methods related to animal production.
  - AS.01.02.01.b. Analyze the impact of animal production methods on end product qualities.
  - AS.01.02.02.a Research and examine marketing methods for animal products and services.

Unit 3: Aquatic Structures

OVERVIEW

Summary

Each commonly raised aquatic species requires specialized structures for optimal production, however their basic needs are all the same. In this unit, students will determine the basic needs of all aquatic plant or animal species, then examine how these needs are met when farmed. Students will identify the name and function of classroom equipment, construct a closed recirculating system for the purposes of classroom husbandry, and determine a maintenance plan to ensure proper health. A direct correlation between the function of each classroom structures and those used on the commercial production level will be made.

Content to Be Learned

- Housing needs of aquatic species.
- Identification of a variety of aquatic equipment.
- Maintenance for equipment to ensure the health of animals.

Practices

- Obtaining, evaluating, and communicating information regarding equipment used by aquaculture and the organizations that support them.
- Operating a closed recirculating system to allow for classroom aquaculture.

Crosscutting Concepts

- Cause and effect.
- Systems and system models.

Essential Questions

- What are the housing requirements of aquatic species, and in what way are the requirements similar and/or different for a variety of species?

AFNR Career Cluster Content Standards

- AS.O2. Performance Element: Utilize best-practice protocols based upon animal behaviors for animal husbandry and welfare.
- AS.02.01. Performance Indicator: Demonstrate management techniques that ensure animal welfare.
  - AS.02.01.01.c. Implement and evaluate quality-assurance programs and procedures for animal production.
  - AS.02.01.02.a. Research and summarize the challenges involved in working with animals and resources available to overcome them.
- AS.05. Performance Element: Evaluate environmental factors affecting animal performance and implement procedures for enhancing performance and animal health.
- AS.05.01. Performance Indicator: Design animal housing, equipment and handling facilities for the major systems of animal production.
  - AS.05.01.01.a. Differentiate between the types of facilities needed to house and produce animal species safely and efficiently.
  - AS.05.01.02.a. Identify and summarize equipment, technology and handling facility procedures

used in modern animal production.

- PST.01. Performance Element: Apply physical science principles and engineering applications to solve problems and improve performance in AFNR power, structural and technical systems.
- PST.01.02. Performance Indicator: Apply physical science and engineering principles to design, implement and improve safe and efficient mechanical systems in AFNR situations.
  o PST.01.02.02.a. Identify the tools, machines and equipment needed to construct and/or fabricate a project in AFNR.
  o PST.01.02.02.a. Examine owner's manuals to classify the types of safety hazards associated with different mechanical systems used in AFNR.
  o PST.01.02.02.b. Select, maintain and demonstrate the proper used of tools, machines and equipment used in different AFNR related mechanical systems.
- PST.02. Performance Element: Operate and maintain AFNR mechanical equipment and power systems.
- PST.02.01. Performance Indicator: Perform preventative maintenance and scheduled service to maintain equipment, machinery and power units used in AFNR settings.
  o PST.02.01.01.a. Maintain the cleanliness and appearance of equipment, machinery and power units used in AFNR power, structural and technical systems to assure proper functionality.
  o PST.02.01.01.b. Develop a preventative maintenance schedule for equipment, machinery and power units used in AFNR power, structural and technical systems.
  o PST.02.01.02.a. Examine operator's manuals to determine recommendations for servicing filtration systems and maintaining fluid levels on equipment, machinery and power units used in 1 AFNR power, structural and technical systems.
  o PST.02.01.02.b. Service filtration systems and maintain fluid levels on equipment, machinery and power units in accordance with operator's manuals.

<u>Next Generation Science Standards</u>

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-1. Analyze a major global challenge to specific qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Students who demonstrate understanding can:

HS-ETS1-1.	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**
HS-ETS1-2.	**Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.**
HS-ETS1-3.	**Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**
HS-ETS1-4.	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	**ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4) - - - - - - - - - - - - - - - - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

Unit 4: Water Requirements for Aquaculture

OVERVIEW

Summary

The single greatest limiting factor of aquaculture is water and water quality. An in-depth examination of water quality requirements for aquaculture will be carried out in the classroom and applied to commercially raised species. The correlation between different water quality requirements will be explored with special consideration given to the parameters for safe culture.

Content to Be Learned

- Water chemistry.
- Parameters for the healthy culture of aquatic species.
- Effective use of measurement equipment.

Practices

- Determining and using best practices best practices when performing water quality tests.

- Comparing the effectiveness of a variety of water quality test methods.
- Analyzing and interpreting data generated by water quality testing in the classroom culture tank.

Crosscutting Concepts

- System and system models.
- Cause and effect.
- Structure and function.

Essential Questions

- What is the relationship between water chemistry and the health of cultured species?

AFNR Career Cluster Content Standards

- AS.08. Performance Element: Analyze environmental factors associated with animal production.
- AS.08.02. Performance Indicator: Evaluate the effects of environmental conditions on animals and create plans to ensure favorable environments for animals.
    - AS.08.02.01.a. Research and summarize environmental conditions that impact animals.
    - AS.08.02.02.a. Identify and summarize methods for ensuring optimal environmental conditions for animals.
    - AS.08.02.02.b. Implement and evaluate the effectiveness of methods to ensure optimal environmental conditions for animals.
    - AS.08.02.02.c. Devise and improve plans to establish favorable environmental conditions for animal growth and performance based on a variety of factors.
- ESS.03. Performance Element: Develop proposed solutions to environmental issues, problems and applications using scientific principles of meteorology, soil science, hydrology, microbiology, chemistry and ecology.
- ESS.03.03. Performance Indicator: Apply Chemistry principles to environmental service systems.
    - ESS.03.03.02.a. Examine and summarize how chemistry affects water quality and function (e.g., oxygen saturation, pH, biomagnification, etc.).
    - ESS.03.03.02.b. Analyze the water chemistry of a sample.
    - ESS.03.03.02.c. Evaluate a sample's water chemistry and assess how the results may impact considerations in environmental service systems.
- ESS.05. Performance Element: Use tools, equipment, machinery and technology common to tasks in environmental service systems.
- ESS.05.02. Performance Indicator: Perform assessments of environmental conditions using equipment, machinery and technology.
    - ESS.05.02.01.a. Research and summarize methods used to determine water quality and determine if a source of water has been contaminated.
    - ESS.05.02.01.b. Assess different measurements of water quality to determine their effectiveness and limitations.
    - ESS.05.02.01.c. Evaluate a sample of water to determine its quality and if it has been contaminated.

Next Generation Science Standards

- HS-LS3-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Students who demonstrate understanding can:

HS-LS4-1. **Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]

HS-LS4-2. **Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [*Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.*]

HS-LS4-3. **Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.** [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [*Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.*]

HS-LS4-4. **Construct an explanation based on evidence for how natural selection leads to adaptation of populations.** [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

HS-LS4-5. **Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-LS1-5 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

HS-LS1-5. **Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Connections to other DCIs in this grade-band:
HS.PS1.B ; HS.PS3.B

Articulation of DCIs across grade-bands:
MS.PS1.B ; MS.PS3.D ; MS.LS1.C ; MS.LS2.B

Common Core State Standards Connections:
ELA/Literacy -
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-LS1-5)*

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.