Aquaculture Infusion Units

AIU Infused

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Course Description

Suggested Grade Level: 6 or 7 or 8 or 9 or 10 or 11 or 12

This document was developed to encourage Agricultural Education teachers to infuse aquaculture instructional units into their existing curriculum. Aquaculture is not a stand-alone course, and, therefore, bears no official course code.

Task Essentials Table

	Tasks/Competencies	
○	Explain the development of the aquaculture industry.	
○	Describe the importance of the aquaculture industry in terms of economics and sustainability.	
○	Explain state, federal, and international agencies' laws and regulations as they apply to aquaculture.	
○	Explain the importance of managing water quality.	
○	Identify characteristics of species.	
○	Diagram the anatomical parts of finfish, crustaceans, and mollusks.	
○	Explain the types of aquaculture operations.	
○	Identify the types of aquatic structures and equipment used in aquaculture operations.	
○	Define pond culture.	
○	Define cage culture.	
○	Define flow-through systems (raceways).	

○	Define recirculating systems.	
○	Record operation data.	
○	Identify methods for preparing feed and feeding various species in an aquaculture system.	
○	Identify common health problems of fish.	
○	Identify methods for prevention and treatment of fish health problems.	
○	Explain the harvesting of fish.	
○	Explain a post-harvest plan.	
○	Develop a marketing plan.	
○	Prepare aquaculture products for market.	
○	Explore careers in the aquaculture industry.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Introducing the Aquaculture Industry

Task Number 39

Explain the development of the aquaculture industry.

Definition

Explanation should include

- definition of aquaculture
- history of aquaculture
  - Chinese aquaculture
  - Egyptian aquaculture
  - Roman aquaculture
- international aquaculture
- United States (U.S.) aquaculture industry
- Virginia's aquaculture industry
- development of aquaculture industry as part of agriculture

- reasons for the development of aquaculture
- types of aquaculture
    - freshwater
    - marine (saltwater)
    - warm water
    - cold water.

Process/Skill Questions

• How does the aquaculture industry influence everyday life?
• Why is the aquaculture industry a necessity?
• What is the difference between aquaculture and capture/commercial fisheries?
• What is the history of aquaculture?

Task Number 40

Describe the importance of the aquaculture industry in terms of economics and sustainability.

Definition

Description should include the economic impact of the sustainable aquaculture industry around the world, in the U.S., in Virginia, and in local areas.

Description should also include the major aquatic species in the U.S. and their economic importance.

Process/Skill Questions

- What is sustainability?
- What are the economic implications of the aquatic industry?
- What would happen if the aquaculture industry did not exist?

Task Number 41

Explain state, federal, and international agencies' laws and regulations as they apply to aquaculture.

Definition

Explanation should include the role of

- federal, state, and local laws and regulations with respect to
    - invasive species
    - environmental degradation
    - unintended consequences
    - the effects of effluent

    - ground water usage
- U.S. Department of Agriculture (USDA)
    - Natural Resources Conservation Service (NRCS)
- U.S. Food and Drug Administration (FDA)
- Environmental Protection Agency (EPA)
    - U.S. Fish and Wildlife Service (USFWS)
- U.S. Army Corps of Engineers (USACE)
- riparian rights.

Process/Skill Questions

- How do laws protect aquatic resources in Virginia? In your community?
- What are Virginia's regulatory agencies with regard to aquatic life?
- How do regulatory laws work to protect the environment?
- How does a non-native species impact the environment?
- What are the legal consequences for violating the law?

Task Number 42

Explain the importance of managing water quality.

Definition

Explanation should include

- dissolved gases and oxygen
- carbon dioxide (CO2)
- nitrogen forms
    - ammonia (NH3)
    - ammonium (NH4)
    - nitrite (NO2)
    - nitrate (NO3)
    - nitrogen gas (N2)
    - sulfuric acid (H2SO4)
- phosphorous
- solids (dissolved and wastes)
- temperature
- salinity
- pH (alkalinity, acidity)
- dissolved oxygen (DO) cycle
- ammonia cycle (N)
- carbon dioxide (CO2) cycle
- pH cycle
- water management practices (avoid overfeeding, monitor DO, control unwanted organisms, prevent runoff from entering facility, add water to improve quality)
- stress caused by diminished water quality (shock, chronic, acute stress).

Water is the basis for life and is a source for oxygen, food, an excretory site, aids in temperature regulation, and can harbor disease.

Process/Skill Questions

- Why is oxygen the most important water quality indicator?
- What are the consequences of increases or decreases in pH? In nitrogen? Increased solids in the system?

Selecting Aquaculture Species

Task Number 43

Identify characteristics of species.

Definition

Identification should include environmental requirements of various species including

- marine
- fresh water
    - warm water
    - cold water
- crustacean
- bivalves
- mollusks
- aquatic plants.

Process/Skill Questions

- How are fresh water and marine species similar? How are they different?
- What are the environmental requirements for warm water vs. cold water species?
- What characteristics make certain species appropriate for production?

Task Number 44

Diagram the anatomical parts of finfish, crustaceans, and mollusks.

Definition

Diagramming should include

- morphology, anatomy, and physiology of aquaculture organisms
- anatomical features by species

    - internal
        - skeletal
        - muscular
        - digestive
        - excretory
        - respiratory
        - circulatory
        - nervous
        - sensory
        - reproductive
    - external (finfish)
        - mouth
        - nares
        - operculum
        - gills
        - pelvic fin
        - pectoral fin
        - anal fin
        - caudal fin
        - dorsal fin
        - lateral line
        - eye
        - vent
- scientific names
- common names
- life cycle.

Process/Skill Questions

- What are the differences between morphology and physiology?
- What are the differences between scientific names and common names?
- What are the external anatomical parts and their functions?
- What are the differences between a vertebrate and an invertebrate?

Comparing Types of Aquaculture Operations

Task Number 45

Explain the types of aquaculture operations.

Definition

Explanations should include the purpose and function of

- hatcheries
    - spawning facilities
    - egg management
    - broodfish (broodstock) management
    - fry and fingerling management
    - phases of fingerling production
- growout facilities
    - species selection
    - water quality
    - water oxygenation
    - disease prevention
    - feeding
    - regulations
    - use of therapeutants
    - discharge of effluent/environmental concerns
- harvesting (topping, total)
- marketing
    - assembling
    - grading
    - hauling
    - processing (e.g., minimal, medium, value added)
    - packaging
    - storing
    - wholesaling
    - retailing
    - advertising
    - change of ownership
- available markets
    - personal use
    - recreation
    - food
    - sell
    - processors
    - live haulers
    - fee fishing
    - direct to restaurants
    - aquarist trade
- baitfish industry
- ornamental fish production and management.

Process/Skill Questions

- What are the advantages and disadvantages of each type of aquaculture operation?
- What are broodfish?
- Why is it important to maintain a continuous stock of quality broodfish?
- What is effluent?
- What is a therapeutant?
- What are some factors that determine species selection?

Task Number 46

Identify the types of aquatic structures and equipment used in aquaculture operations.

Definition

Identification should include

- ponds
- cages
- flow-through systems (raceway)
- recirculating systems and aquariums.

Process/Skill Questions

- What are the advantages and disadvantages of each system?
- Why are specified aquatic structures selected for a particular species?

Defining Pond Systems

Task Number 47

Define pond culture.

Definition

Definition should include

- types of ponds (e.g., watershed, levee, and excavated)
- site selection water sources/availability
    - soil characteristics (clay content)
    - climate
    - topography (drainage, flooding)
    - runoff
- source and materials
- engineering/construction requirements
    - address given formulas and case situation
    - determine the size for a fish pond including acreage, shape, capacity, and depth maintenance
    - address dam inspection and repair

    - address the repair and maintenance of plant cover and clean water
    - address best practices for pond fertilization
- species selection for pond culture
    - tilapia
    - catfish
    - striped bass
    - hybrid
    - crawfish
    - redfish
    - carp
    - shrimp
    - milkfish
- preventive controls/biosecurity
    - best management practices (BMPs) for ponds
- advantages of ponds
- disadvantages of ponds
- stocking densities based on species and pond size
    - communication
        - delivery
        - buyer
        - management
    - water quality awareness/requirements
        - temperature
        - pH
    - importance of recording pond maintenance
    - necessary supplies for harvesting
        - nets
        - buckets
        - truck-to-pond
    - access to a pond and the necessary equipment to prepare the pond for stocking according to BMPs
- factors in production
    - feeding methods used with ponds (e.g., hand, mechanical, natural)
        - types of feed (e.g., floating, sinking, neutral buoyancy pellets)
        - frequency of feed
        - calculate amount of feed
    - oxygen management (aeration devices).

Process/Skill Questions

- What is a BMP?
- What would happen if you constructed a pond in a flood zone?
- What are the consequences of poor site selection?
- Why use a pond over another aquatic system?
- Why is maintenance important?
- What are some causes of crop loss?
- What are some preventative measures for reducing crop loss in ponds?
- How are fish acclimated to a new aquatic environment?
- What are the consequences of not following BMPs?
- What are some forms of stress fish might experience? (e.g., physical, chemical, perceived stressors)

- Why is record keeping and training personnel important?
- Why might a pond require oxygen supplementation?

Defining Cage Systems

Task Number 48

Define cage culture.

Definition

Definition should include

- factors in site selection (e.g., depth of water, water quality, prevailing winds, natural currents)
- source and materials
    - rearing aquaculture species inside confined enclosures (to include cages, net pens, baskets, etc.) in freshwater and marine environments
    - cage requirements (vary by species and location)
- engineering/construction (to incorporate cage design requirements)
- cage maintenance
    - clean fish cages in accordance with BMPs (routine scrubbing)
    - use anti-fouling materials
    - arrange and secure fish cages in the pond
- preventive controls/biosecurity
    - BMPs for cages
- advantages of cage culture
- disadvantages of cage culture
- stocking densities based on species and cage size
- factors in production
- species selection for cage culture
    - salmon
    - catfish
    - tilapia
    - trout
    - striped bass
    - red drum
    - bluegill
    - carp
- feeding methods for cages (feeding ring).

Process/Skill Questions

- What types of problems are associated with putting a cage in a pond vs. an ocean?
- What are the consequences of poor site selection?

- Why is security an issue?
- Why is maintenance important?
- What are some causes of crop loss?
- What are some preventative measures for reducing crop loss in cages?
- What are some of the environmental impacts caused by cage culture in different environments?
- How important is the feeding ring in cage culture?
- What are the causes, consequences, and solutions of fish cage fouling?
- What are the benefits of proper cage maintenance?
- How can you reduce stress on a species when cleaning the cage?
- How does fouling reduce water flow?
- How is water quality impacted?

Defining Flow-Through Systems

Task Number 49

Define flow-through systems (raceways).

Definition

Definition should include

- site selection
    - water sources/availability (management)
    - climate
    - topography
- essential materials
- engineering/construction
    - address given formulas and a case situation
    - determine the size for a flow-through system including shape, capacity, depth, and construction
    - design requirements
- maintenance
- preventive controls/biosecurity
    - BMPs for flow-through systems
- advantages of flow-through systems
- disadvantages of flow-through systems
- species selection
    - trout
    - salmon
    - catfish
    - striped bass
    - tilapia
- stocking densities based on species and size of flow-through system
- factors of production.

Process/Skill Questions

- What would happen if you constructed a flow-through facility in a flood zone?
- What are the consequences of poor site selection?
- Why use a flow-through system over another system?
- Why is maintenance important?
- What are some causes of crop loss?
- What are some preventative measures for reducing crop loss in flow-through systems?
- What are some water quality issues associated with a flow-through system?

Defining Recirculating Systems

Task Number 50

Define recirculating systems.

Definition

Definition should include

- types of recirculating systems (e.g., silo, circular tanks)
- site selection
    - water sources/availability
    - access to energy
    - effluent
- essential materials
- aeration
- removal of particulate matter
- biological filtration
- engineering/construction
    - address given formulas and a case situation
    - determine the size for a flow-through system including shape, capacity, depth, and construction
- maintenance
- preventive controls/biosecurity (BMPs)
- advantages of recirculating systems
- disadvantages of recirculating systems
- stocking densities based on species and size of recirculating system
- factors of production.

Process/Skill Questions

- What are the advantages and disadvantages of using a recirculating system vs. using a pond or raceway system?
- Why is maintenance important?

- What are some causes of crop loss?
- What are some preventative measures for reducing crop loss in recirculating systems?

Maintaining the Aquaculture Operation

Task Number 51

Record operation data.

Definition

Recording should include

- maintenance of structures and equipment
- importance of water quality management
    - prevention of oxygen depletion
    - turbidity
    - aquatic plant control methods
    - temperature
    - chemicals, compounds, and elements detrimental to water quality
    - methods for managing the pH cycle
    - general guidelines for water chemistry management
    - importance of nitrogen compounds in water quality management
- feed (e.g., type, amount, storage)
- stocking activity
- fish weight gain and loss
- production data
- financial information.

Process/Skill Questions

- Why is it important to keep records?
- What are the components of a complete and an incomplete record?

Feeding Species

Task Number 52

Identify methods for preparing feed and feeding various species in an aquaculture system.

Definition

Identification should include

- methods for preparing feed and feeding finfish in ponds, cages, tanks, and raceways
- relationship between feeding and dissolved oxygen (DO)
- importance of choosing appropriate aquaculture feeds from reputable sources
- importance of choosing quality and quantity of rations
- importance of planning the feeding schedule
- calculation of the cost of feed
- calculation of the amount of feed needed for a given species
- calculation of the feed conversion ratio (FCR)
- importance of understanding different feeding practices for different species
- importance of ensuring proper feed storage.

Process/Skill Questions

- What factors influence feed selection?
- What are advantages and disadvantages of live feed vs. commercial feed?
- How are feeds similar and different from each other?
- What happens if you feed one species food intended for another?
- What are the parameters for proper feed storage and why are they important?
- Why is it important that fish rapidly consume all of the feed?
- What methods are used to distribute feed to fish?

Maintaining a Healthy Stock in an Aquaculture System

Task Number 53

Identify common health problems of fish.

Definition

Identification should include types of fish disease and common stressors of fish that contribute to infectious and non-infectious diseases. They are as follows:

- stressors
    - chemical (e.g., poor water, pollution, diet, and metabolic waste)

    - biological (e.g., density, microorganisms, macroorganisms, and gases)
    - physical (e.g., temperature, light, and sounds)
    - procedural (e.g., handling, shipping, and treatments)
- infectious diseases
    - bacterial
        - symptoms
            - behavioral (e.g., lack of appetite, lethargy)
            - physical (e.g., lesions, discoloration, hemorrhaging)
        - contributing factors
        - prevention
    - viral
        - symptoms (e.g., behavioral, physical)
        - contributing factors
        - prevention
    - parasitic
        - symptoms (e.g., behavioral, physical)
        - contributing factors
        - prevention
    - fungal
        - symptoms (e.g., behavioral, physical)
        - contributing factors
        - prevention
- non-infectious diseases
        - symptoms (e.g., behavioral, physical)
        - contributing factors
        - prevention.

Process/Skill Questions

- What are some behavioral signs of a fish in distress?
- If a fish has lesions, what is the likely culprit (i.e., bacteria, fungal infection, etc.)?
- What are some examples of unusual fish behavior that may indicate disease?
- What are three management practices that prevent stress?

Task Number 54

Identify methods for prevention and treatment of fish health problems.

Definition

Identification should include

- BMPs for preventing disease
- stress reduction measures
    - regulating water quality (e.g., temperature, pH, oxygen)
    - managing stocking densities
    - avoiding poor nutrition

    - avoiding excessive handling
- general guidelines for treatment of fish disease
    - methods
        - dips/baths
        - flushes
        - injections
        - vaccines
- biosecurity
    - minimize pathogen introduction
    - ensure proper treatment of water
- environmental conditions

and treatment in accordance with veterinary consultation.

Process/Skill Questions

- What are some indicators that fish are under stress?
- What is biosecurity?
- How is biosecurity used to prevent disease introduction?
- How can biosecurity be improved?
- How can stress cause fish disease?

Harvesting Fish

Task Number 55

Explain the harvesting of fish.

Definition

Explanation should include

- methods of harvesting
    - seining (ponds)
    - draining (ponds)
    - crowding and collecting (tanks)
    - trapping (natural ponds and streams)
    - hooking
- time of harvest
- cooling method (and validation of the process)
- type of equipment used

- written instructions for harvest
- sanitation (equipment and personnel)
- storing aquatic crops

in accordance with BMPs.

Process/Skill Questions

- What is meant by the validation of a cooling method?
- Why is proper cooling critical for quality?
- Why is sanitation important to maintain quality?
- What should be cleaned and sanitized?

Task Number 56

Explain a post-harvest plan.

Definition

Explanation of a post-harvest plan should include

- using equipment
- fish handling
- proper storage practices (e.g., first-in, first-out [FIFO], allergen control, temperature)
- sanitation (equipment and personnel)

in accordance with BMPs.

Process/Skill Questions

- What is Hazard Analysis and Critical Control Points (HACCP)?
- What does FIFO mean?
- What can be done to ensure refrigeration of the aquatic crop in the event of a power outage? Why is this critical?

Marketing Aquaculture Products

Task Number 57

Develop a marketing plan.

Definition

Developing the marketing plan should include

- determination of the present situation
- determination of market goals
- development of plans to reach the goals
- importance of developing a marketing plan (market research and analysis)
- possible market outlets for the product
    - processing markets
    - recreational markets
    - retail markets
    - restaurant markets
- factors in selecting an appropriate market and implement marketing strategies (i.e., wholesale vs. direct-to-consumer vs. retail)
    - profitability
    - need for equipment
    - accessibility
    - species of aquatic crop
    - quantity
    - size and maturity
    - quality
- cost of marketing
    - transportation
    - grading
    - harvesting
    - packaging
    - storing
    - advertising
- process of marketing promotion
- quality control procedures (e.g., sanitary transport of product)
- activities associated with marketing
    - assembling
    - grading
    - transporting
    - changing ownership
    - processing
    - packaging
    - storing
    - wholesaling
    - retailing
- evaluation (action plans).

Process/Skill Questions

- Why is it important to have a marketing plan?
- How does seasonality impact an aquaculture product marketing plan?
- Why is sanitary transport important?
- What are some scientific skills required to maintain quality of fish and fish products?

Task Number 58

Prepare aquaculture products for market.

Definition

Preparation of finfish, crustaceans, and mollusks for market should include

- processing the product
    - receiving and weighing the live fish at the processing plant
    - holding fish alive until processed
    - stunning
    - de-heading
    - eviscerating
    - skinning
    - chilling
    - product form
    - sizing
    - grading
    - freezing or ice packing
    - packaging
    - warehousing
    - icing
    - shipping the finished product
- quality control procedures
- preparing carriers for hauling
- sanitary transport of foods (STF)
- loading finfish, crustaceans, and mollusks
- ensuring proper temperatures for shipment of product
- HACCP

in accordance with the aquaculture product marketing plan, international, federal, and state guidelines.

Process/Skill Questions

- How does processing maintain quality control?
- What causes off-flavor in catfish?
- What are the key elements of marketing an aquaculture product?
- What are five activities that are part of marketing?
- What are two product characteristics that affect buying decisions?
- What are six quality control functions?
- What is a food allergen plan and how is it implemented?

Task Number 59

Explore careers in the aquaculture industry.

Definition

Exploration should include

- supplies and service
- production
- inspection and monitoring (e.g., lab support)
- marketing
- research and development
- feed and supplies
- construction
- consulting
- training and education
- entrepreneurship.

Process/Skill Questions

- What are the different career opportunities within aquaculture?
- What level of education is needed for the various career opportunities within aquaculture?
- What types of skills are needed within an aquaculture business?

SOL Correlation by Task

39	Explain the development of the aquaculture industry.	English: 6.4, 6.6, 6.9, 7.4, 7.6, 7.9, 8.4, 8.6, 8.9, 9.3, 9.5, 9.8, 10.3, 10.5, 10.8, 11.3, 11.5, 11.8, 12.3, 12.5, 12.8 History and Social Science: WG.2, WG.4, WG.5, WG.7, WG.10, WG.12, WHI.6
40	Describe the importance of the aquaculture industry in terms of economics and sustainability.	English: 6.6, 6.9, 7.6, 7.9, 8.6, 8.9, 9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.15, GOVT.16, WG.4, WG.6, WG.7
41	Explain state, federal, and international agencies' laws and regulations as they apply to aquaculture.	English: 6.6, 6.9, 7.6, 7.9, 8.6, 8.9, 9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 History and Social Science: VUS.8, WHII.8
42	Explain the importance of managing water quality.	English: 6.4, 6.6, 6.9, 7.4, 7.6, 7.9, 8.4, 8.9, 9.3, 9.5, 9.8, 10.3, 10.5, 10.8, 11.3, 11.5, 11.8, 12.3, 12.5, 12.8 History and Social Science: VUS.8, WG.4, WHII.8 Science: BIO.1, BIO.2, CH.1
43	Identify characteristics of species.	History and Social Science: WG.4 Science: BIO.8
44	Diagram the anatomical parts of finfish, crustaceans, and mollusks.	English: 6.4, 6.6, 6.7, 6.8, 7.4, 8.4, 8.6, 8.7, 9.3, 9.6, 9.7, 10.3, 10.6, 10.7, 11.3, 11.6, 11.7, 12.3, 12.6, 12.7

		Science: BIO.4
45	Explain the types of aquaculture operations.	English: 6.6, 7.6, 8.6, 9.5, 10.5, 11.5, 12.5 Mathematics: 6.7, 6.12, 8.4
46	Identify the types of aquatic structures and equipment used in aquaculture operations.	
47	Define pond culture.	English: 6.4, 6.6, 7.4, 7.6, 8.4, 8.6, 9.3, 9.5, 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 History and Social Science: GOVT.1, GOVT.2, GOVT.13, WG.7 Mathematics: 6.7, 6.13, 8.7, A.1, A.4
48	Define cage culture.	English: 6.6, 6.9, 7.9, 8.6, 8.9, 9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.1, GOVT.2, VUS.1, WHII.2 Science: CH.1
49	Define flow-through systems (raceways).	English: 6.6, 6.9, 7.6, 7.9, 8.6, 8.9, 9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.1, GOVT.2, VUS.1, WHII.1
50	Define recirculating systems.	English: 6.4, 6.6, 7.4, 7.6, 8.4, 8.6, 9.3, 9.5, 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 History and Social Science: GOVT.1, GOVT.2 Science: CH.1
51	Record operation data.	English: 6.1, 6.7, 7.1, 8.1, 8.7, 9.1, 9.6, 10.1, 10.6, 11.1, 11.6, 12.1, 12.6 History and Social Science: GOVT.1, GOVT.2 Mathematics: 6.13, 8.4 Science: BIO.1, BIO.2
52	Identify methods for preparing feed and feeding various species in an aquaculture system.	Mathematics: 6.1, 7.2, 8.4, A.4, A.8 Science: BIO.1
53	Identify common health problems of fish.	Science: BIO.1, BIO.4
54	Identify methods for prevention and treatment of fish health problems.	
55	Explain the harvesting of fish.	English: 6.6, 7.6, 8.6, 9.5, 10.5, 11.5, 12.5
56	Explain a post-harvest plan.	English: 6.6, 7.6, 8.6, 9.5, 10.5, 11.5, 12.5
57	Develop a marketing plan.	English: 6.6, 7.6, 8.6, 9.5, 10.5, 11.5, 12.5

		History and Social Science: GOVT.15, GOVT.16 Mathematics: 6.13, 7.2, 8.4
58	Prepare aquaculture products for market.	English: 6.6, 7.6, 8.6, 9.5, 10.5, 11.5, 12.5 History and Social Science: GOVT.15, GOVT.16, WG.9
59	Explore careers in the aquaculture industry.	English: 6.6, 6.9, 7.6, 7.9, 8.6, 8.9, 9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.1, GOVT.14, VUS.1, VUS.14, WHII.1

Resources for Comparing Types of Aquaculture Operations

1. Explain the types of aquaculture operations.

- *Cage Culture of Channel Catfish in Virginia's Farm Ponds.* Nerrie.
- *Catfish Farming in Cages in Virginia's Ponds and Lakes.* Helfrich, Dean, et al.
- *The Freshwater Aquaculture Book.* McLarney.
- *What is Cage Culture?* Massey.

2. **Identify the types of aquatic structures and equipment used in aquaculture operations.**

- *Cage Culture of Channel Catfish in Virginia's Farm Ponds*. Nerrie.
- *Catfish Farming in Cages in Virginia's Ponds and Lakes.* Helfrich, Dean, et al.
- *The Freshwater Aquaculture Book*. McLarney.
- *What Is Cage Culture?* Massey.

Resources for Selecting Aquaculture Species

1. **Identify characteristics of fish.**
2. **Diagram the anatomical parts of finfish, crustaceans, and mollusks.**

- Peace Corps and Volunteers in Technical Assistance.
- Wildlife Conservation in Virginia, Unit 7, pp. 58-60, "Identifying Virginia's Fishes."

Resources for Defining Pond Systems

1. Define pond culture.

- *The Freshwater Aquaculture Book.* McLarney.
- *Freshwater Fish Pond Culture and Management.* Peace Corps and Volunteers in Technical Assistance.
- *Ponds-Planning, Design, Construction.* USDA Agriculture Handbook Number 590.

- Fresh Water Fish Pond Culture and Management. Peace Corps and Volunteers in Technical Assistance.
- Ponds-Planning, Design, Construction. USDA- Agriculture Handbook Number 590.

Resources for Defining Cage Systems

1. Define Cage Systems.

- *Basic Cage Construction Steps for Plastic Mesh Materials.* Newton.
- *Cage Culture in Maryland.* Harrell.
- *Cage Culture of Channel Catfish in Virginia's Farm Ponds.* Nerrie.
- *4-H Aquatic Science Project, Guide to Raising Catfish in a Cage.* Schwedler, Berry, and King.
- *The Freshwater Aquaculture Book.* McLarney.
- *What is Cage Culture?* Massey.
- *Catfish Farming in Cages in Virginia's Ponds and Lakes*. Helfrich, Dean, et al.

Resources for Maintaining the Fish Operation

1. Record fish operation data.

- *Virginia Aquaculture Plan.* Virginia Department of Agriculture and Consumer Services.
- *Agricultural Water Management. An International Journal.* *https://www.journals.elsevier.com/agricultural-water-management*

Resources for Feeding Fish

1. Identify methods for preparing feed and feeding various species in an aquaculture system.

- *The Freshwater Aquaculture Book*. McLarney.
- *Agricultural Water Management*. An International Journal. https://www.journals.elsevier.com/agricultural-water-management

Resources for Maintaining Fish Healthy Stock in an Aquaculture System

1. Identify common health problems of fish.
2. Identify methods for prevention and treatment of fish health problems.

- *The Freshwater Aquaculture Book*. McLarney.
- Wildlife Conservation in Virginia, Unit 9, "Fish Diseases," pp. 73-76.

Resources for Harvesting Fish

1. **Explain the harvesting of fish.**
2. **Explain a post-harvest plan.**

- *The Freshwater Aquaculture Book.* McLarney.

Resources for Marketing Aquaculture Products

1. Develop a marketing plan.
2. Prepare aquaculture products for marketing.
3. Explore careers in aquaculture industry.

- *The Freshwater Aquaculture Book*. McLarney.
- Wildlife Conservation in Virginia.

Suggested Learning Activities

Describe the aquaculture industry.

- Define *aquaculture, mariculture, pond culture, stocking, transplantation, recirculating system* and *trapping* (Handout 1.1a: What is Aquaculture?).
- Provide a brief history of aquaculture (Transparency 1.1a: Aquaculture in the Past).
- Describe the benefits of aquaculture (Handout 1.1b: Why Cultivate Fish?).
- Provide an overview of the aquaculture industry in the world and the (Transparency 1.1b: Overview of the Aquaculture Industry in the United States).
- Provide an overview of the Virginia Aquaculture Plan (Transparency 1.1c: The Virginia Aquaculture Plan).
- Create an aquaculture reading file for students.
- Arrange for interviews/visits with local aquaculture/hatchery operations and personnel.
- Have students research local fish marketing activities.

Describe the economic importance of the aquaculture industry.

- Define terms associated with aquacultural economics.
- Explain components of aquaculture production (Handout 1.2a: Components of Aquaculture Production Worldwide).
- Describe the local and statewide aquacultural economic situation (Handout 1.2d: Aquaculture Resources in Virginia, Handout 1.2e: Economic Trends in Virginia Aquaculture and Transparency 1.2b: Aquaculture in Virginia: Geographical and Market Factors)
- Describe the potential economic benefits of aquaculture (Transparency 1.2c: Aquaculture in the Future).
- Arrange visits to local aquaculture/hatchery operations.
- Obtain state census information on aquacultural economics.

Identify economic conditions for a fish operation.

- Define *fry* and *fingerlings*.
- Identify factors involved in selecting a type of fish operation (Handout 2.1a: Fish Operation Selection Factors, Transparency 2.1a: Growing Seasons for Fish in Virginia).
- Evaluate information on local economic conditions for producing fish.

- Evaluate the profitability of a fish operation (Handout 2.1b: Determining Operating Costs, Transparency 2.1b: Capital Costs of Producing Fish and Transparency 2.1c: Operating Costs of Producing Fish).
- Arrange for a local operator to describe the decision-making process for establishing a fish operation.
- Have students research market analyses and financial reports on fish operations (Handout 2.1c: Annual Budget: Cage Culture of Catfish).

Identify environmental conditions for a fish operation.

- Evaluate information on the environmental conditions of the area.
- Define culture as it pertains to growing fish.
- Describe the different types of fish operations (Handout 2.2a: Types of Fish Cultures).
- Describe the characteristics of cage culture (Transparency 2.2a: The Development of Cage Culture, Handout 2.2b: Cage Culture).
- List the advantages and disadvantages of open pond culture over other types of cultures (Handout 2.2c: Catfish Cage Culture).
- Arrange a field trip to observe types of fish operations.

Identify characteristics of fish.

- Identify anatomical features of a fish, such as gills, lateral line, and fins (Handout 3.1a: Fish Anatomy (male), Handout 3.1b: General Characteristics of Fish).
- Identify species of fish often found in Virginia.
- Differentiate between the various species.
- Invite a game commission fish biologist to talk about fish identification.
- Draw or photograph one of Virginia's sport fish and label its parts.
- Collect pictures of fish that typify characteristics of different species of fish.
- Describe the life cycle of fish (Handout 3.1c: The Life Cycle of Fish).
- Demonstrate how to set up an aquarium.
- Demonstrate how algae and plankton are produced.
- Demonstrate a technique for determining sex of fish.

Identify fish appropriate for production.

- Explain the factors involved in raising fish in a pond (Handout 3.2a: Choosing Pond Fish).
- Identify genus and species of fish used in pond culture (Transparency 3.2a: Scientific Names of Fish).
- Differentiate among the species used in pond culture (Handout 3.2b: Fish Used in Pond Culture (Common Carp), Handout 3.2c: Fish Used in Pond Culture (Tilapia), Handout 3.2d: Fish Used in Pond Culture (Trout), Handout 3.2e: Fish Used in Pond Culture (Bass), Handout 3.2f: Fish Used in Pond Culture (Catfish)).
- Invite a fish producer to discuss the feeding habits of various species such as bass, catfish, and tilapia.
- Compare characteristics of species.
- Research the advantages and disadvantages of cultivating a specific species.

Explain laws applicable to production of game fish.

- Determine certificate requirements for sale of some fish species.
- Determine regulations governing bodies of water for fish production.
- Identify regulations regarding interstate transport.
- Predict potential problems that may result in legislation.

Determine the site for a fish pond.

- Describe factors to consider in selecting a pond location (Handout 4.1a: Selecting the Site).
- Identify sources of water (Handout 4.1b: Selecting the Site: Water Supply).
- Observe three kinds of ponds that have been constructed for aquaculture operations.
- Contact various agencies to determine regulations affecting aquaculture activities in the locality (Handout 4.1c: Selecting the Site: Water Quality).
- Examine soil samples for texture and compactness (Handout 4.1d: Selecting the Site: Soil).
- Select an area to plan for an aquaculture operation (Handout 4.1e: Selecting the Site: Topography).

Determine the size for a fish pond.

- Define *impoundment, dugout, levee pond, seepage,* and *acre-foot.*
- Research and report on the advantages and the disadvantages of large and small ponds.
- Calculate the amount of evacuation necessary for a pond.
- Describe the characteristics used in determining pond size (Transparency 4.2a: Pond Acreage and Depth, Handout 4.2a: Pond Shape).
- Determine pond depth and capacity (Transparency 4.2b: Pond Capacity).

Describe practices for pond maintenance.

- Describe procedures for dam inspection (Handout 5.1a: Pond Inspection and Repair).
- Describe practices for dam repair (Handout 5.1a: Pond Inspection and Repair).
- Describe maintenance of plant cover.
- Identify practices for maintenance of clean water.
- Invite a Soil Conservation Service employee to talk about pond maintenance.
- Visit ponds with good and poor maintenance.
- Develop a plan for maintenance of a specific pond.

Describe practices for fencing ponds.

- Identify reasons for fencing a pond.
- Describe alternatives to complete fencing.
- Identify advantages and disadvantages of fencing (Transparency 5.2a: Pond Fencing).

Describe practices for pond fertilization.

- Describe the purpose of pond fertilization (Transparency 5.3a: Why Fertilize a Pond?).
- Make a Secchi disk (Transparency 5.3b: Make a Secchi Disk).
- Explain when to fertilize a pond (Transparency 5.3c: Testing Pond Fertility).
- Identify kinds and amounts of fertilizer for use (Handout 5.3a: Fertilizer Application).
- Explain ways to fertilize a pond.
- Explain why less fertilizer is needed during dry years and why more may be needed during years with above average precipitation.
- Discuss the effect of fertilizer as related to the following: four to five pounds of aquatic animals are needed to produce one pound of bluegill or red-ear sunfish. Further, four to five pounds of small sunfish are needed to grow a pound of bass.

Build a fish cage.

- Explain advantages and disadvantages of cage culture (Transparency 6.1a: Advantages of Cage Culture).
- Evaluate types of fish cages (Transparency 6.1b: Fish Cages).
- Observe the building of a fish cage.
- Visit a supply store that carries cage materials and investigate types and quality of materials for cage construction procedures (Handout 6.1a: Fish Cage Design and Handout 6.1c: Sources of Cages).
- Select materials and follow construction procedures (Handout 6.1b: Cage Construction Procedures).
- Make a video of a cage being constructed.

Clean fish cages.

- Describe procedures for cleaning fish cages (Transparency 6.2a: Cage Maintenance).
- Describe practices for inspecting and diagnosing disease.

Describe pond quality for fish production with cages.

- Explain factors that limit fish production capacity of cages.
- Describe water quality for fish production in cages (Transparency 7.1a: Pond Quality).

Arrange and secure fish cages.

- Identify factors in determining cage number and size (Transparency 7.2a: Guidelines for Deploying Catfish Cages in Farm Ponds).
- Invite a fish pond owner to talk about locations for fish cages (Handout 7.2a: Cage Deployment).
- Visit a fish pond with cages to determine if cages were placed correctly.
- Arrange cages in ponds.
- Anchor cages.
- Secure cages (Transparency 7.2b: Methods of Securing Cages).

Prepare the pond for stocking.

- Report on materials and poisons used to prepare a pond for stocking (Transparency 8.1a: Preparing to Stock).
- Prepare a visual (videotape or slides) on preparing the pond for stocking (Handout 8.1a: Cage Stocking).
- Prepare slides of different stocking sizes of fish.
- Determine the type and size of fish to stock (Handout 8.1b: Catfish Stocking).
- Determine the amount of fish to stock (Transparency 8.1b: Pond Stocking Rate Factors).
- Determine when to stock fish.

Stock a pond with fish.

- Prepare a field trip (or show a video of a trip) to a hatchery (Transparency 8.2a: Fish Hatcheries).
- Prepare slides of fish being loaded into a transport tank (Handout 8.2a: Transporting Fish).
- Obtain slides from a fish biologist depicting good and poor stocking techniques (Transparency 8.2b: Reducing Stress).
- Locate fish hatcheries.
- Transport fish.
- Handle fish (Transparency 8.2c: Handling Fish).

Record fish operation data.

- Maintain stocking records.
- Record fish weight gain and loss.
- Identify components of production records, including stocking, sample weight, number of fish removed, number of dead fish, weight gain, feed conversion rate, costs, income, and profit or loss.
- Prepare financial records.

Control the water quality of a fish pond.

- Discuss components of water quality, including pH levels, oxygen/carbon dioxide levels, chemicals, and aroma.
- Measure water temperature.
- Use an oxygen test kit to determine oxygen level of water.
- Determine causes of low oxygen level in water (Handout 9.2a: Oxygen and Water Quality).
- Use an aerator to determine the amount of oxygen added to the water (Handout 9.2a: Oxygen and Water Quality).
- Determine pH level of water (Transparency 9.2a: Water Quality pH Level).
- Describe causes of odors (Transparency 9.2b: Aroma).
- Have students research chemical sources of toxicity (Transparency 9.2c: Chemicals).
- Determine how algae and plankton are produced.
- Arrange for students to visit a site where water is being aerated.

Develop a feeding plan.

- Visit a feed store to copy information found on fish feed labels.
- Examine factors involved in feed selection, including protein needs, water temperature, and size of feed particles (Handout 10.1a: Feeding Fish: Overiew).
- Identify floating (extruded) and sinking (pelleted) types of feed (Handout 10.1a: Feeding Fish: Overiew).
- Select method for feeding fish (Transparency 10.1a: Feeding Methods).
- Select feeding site (Handout 10.1b: Feeding Sites).
- Determine number of days to feed fish.

Follow a feeding plan.

- Visit a fish farm and observe feeding of fish.
- Contact Virginia State University, Cooperative Extension Service, to obtain research studies on nutritional problems of fingerlings and food fish in ponds.
- Prepare rations for fish (Transparency 10.2a: General Feeding Schedule for Caged Channel Catfish).
- Calculate amounts of feed per feeding (Handout 10.2a: Calculating Feed Amounts and Transparency 10.2b: Lowering the Feeding Rate).
- Select proper time to feed fish (Transparency 10.2c: Feeding Times).
- Store feed (Transparency 10.2d: Feed Storage).

Maintain feeding records.

- Calculate the cost of feed per fish (Handout 10.3a: Calculating Costs).
- Prepare feeding records.

Identify common health problems of fish.

- Discuss the impact of fish disease both for the producer and for those indirectly associated (Transparency 11.1a: Overview: Fish Diseases and Parasites).
- Review causes of stress, including low oxygen, handling, transporting, poor nutrition, and crowding (Transparency 8.2b: Reducing Stress).
- Identify common fish diseases (Handout 11.1a: Types of Diseases and Parasites and Transparency 11.1b: Common Catfish Diseases).
- Ask a game fish biologist to explain how to look for fish parasites.
- Visit a fish pond to look for evidence of fish disease and parasites (Transparency 11.1c: Warning Signs of Disease).

Identify methods for prevention and treatment of fish health problems.

- Explain method for deterring fish suffocation.
- Describe treatment for common fish parasites and diseases (Handout 11.2a: Treatment of Fish Diseases, Handout 11.2b: Estimating Water Quantity, and Transparency 11.2a: Conversions for Water Treatments).
- Ask a Virginia State Water Control Board representative to explain methods used in investigating a fish kill.
- Identify preventive measures to deter the outbreak of diseases and parasites (Transparency 11.2b: Preventive Measures and Handout 11.2c: Controlling Diseases).
- Describe methods of diagnosis (Transparency 11.2c: Problems in Diagnosis).
- Identify information needed to aid in diagnosis (Transparency 11.2d: Aid in Diagnosis).

Plan the fish harvest.

- Identify harvesting equipment, such as seines, dip nets, baskets, boots or chest waders, scales, tractor-mounted booms, and fish hauling tanks.
- Explain the advantages and disadvantages of having buyers harvest the fish.
- Examine factors involved with live storage (Transparency 12.1a: Live Storage).
- Decide when to harvest fish (Handout 12.1a: Harvesting to Meet Customer Demand).
- Determine if the fish flavor meets consumer demands (Handout 12.1a: Harvesting to Meet Customer Demand).
- Select harvesting method (Handout 12.1b: Harvesting Methods and Handout 12.1c: Harvesting with Seines).

Follow a fish harvest plan.

- Take a field trip to see fish harvested.
- Demonstrate a method of fish harvesting.
- Record the fish harvest (Handout 12.2a: Harvest Record).

Develop a marketing plan.

- Use newspapers and telephone books to identify markets available for sale of fish (Handout 13.1a: Location of Markets)
- Contact the local market managers to determine if they will purchase fish locally.
- Determine fish size purchased by local markets.
- Visit a fish processing plant to determine how fish are graded.

- Demonstrate the use of a slotted tray to grade fish. Include placing the tray on or near the bottom of the tank, raising the tray; shaking the tray at the top of the water to cause small fish to fall back into the container; and removing fish of the proper size.
- Develop a marketing schedule (Transparency 13.1a: Developing a Marketing Plan and Transparency 13.1b: Harvest Schedules)
- Discuss research studies available from the Cooperative Extension Service at Virginia State University addressing handling, grading, and transportation techniques.

Prepare fish for marketing.

- Prepare carriers for hauling.
- Load fish (Transparency 13.2a: Loading Fish).

Additional Resources

Audiovisual Materials

CTE Resource Center Library
Title: *Aquaculture*
Publication: Alexandria, Va.: National Council for Agricultural Education, c2001.
Material 1 CD-ROM.
Summary: Resources on this CD-ROM include aquaculture "how to" manuals and species-specific manuals, aquatic information, promotional materials, 5-module core curriculum guide, and materials on model aquaculture recirculation system, applications of biotechnology in aquaculture, and aquaculture as sustainable agriculture.

Related Sites

- American Fisheries Society
- Aquaculture Network Information Center
- Aquaculture Outlook
- Southern Regional Aquaculture Center
- The Catfish Institute
- World Aquaculture Society

Periodicals

- *Aquaculture Magazine.* General trade magazine for United States aquaculture. Bimonthly. PO Box 2329, Asheville, NC 28802.
- *Farm Pond Harvest. General aquaculture in recreational ponds. Quarterly. PO Box 736, Mo, IL 60954*
- *Feed Management. Feed industry information. Monthly. 122 S. Wesley Ave., Mt. Morris, IL 61054-1497*
- *Farm Pond Harvest. General aquaculture in recreational ponds. Quarterly. PO Box 736, Mo, IL 60954.*
- *Feed Management. Feed industry information. Monthly. 122 S. Wesley Ave., Mt. Morris, IL 61054-1497.*
- *Fish Farming International. Monthly. Audit House, 260 Field End Road, Middlesex, HA4 9LT, England.*
- *Mollusk Farming USA. Bimonthly. Aquaculture Digest, 9434 Kearny Mesa Road, San Diego, CA 92126.*
- *Naga, the ICLARM. Quarterly. International Center for Living Aquatic Resources, MC, PO Box 1501, Makati, Metro Manila, Philippines.*

- *Salmonid. Focus on trout and salmon farming. U. S. Trout Farmers Assn., 506 Ferry St., Little Rock, AR 72202*
- *Seafood International. General seafood. Monthly. AGB Heighway Ltd., Cloister Court, 22-26 Farringdon Lane, London EClR 3AU, England.*
- *The Catfish Journal. Publishes catfish industry information. PO Box 34 Jackson. MS 39202.*
- *Water Farming Journal. Emphasis on U. S. Aquaculture. Monthly. 3400 Neyrey Dr., Metairie, LA 70002.*
- *World Aquaculture. Aquaculture information of world interest. Quarterly. World Aquaculture Society, 16 East Fraternity Lane, Louisiana State University, Baton Rouge, LA 70803.*
- *World Shrimp Farming. Bimonthly. Report on shrimp and prawn farming. Aquaculture Digest, 9434 Keamy Mesa Road, San Diego, CA 92126.*

Informational Systems

- *Aquatic Sciences and Fisheries Information System (ASFIS). An international bibliographic service covering the world's literature on aquatic sciences and fisheries, including aquaculture. FAO, Rome. Aquaculture Development and Coordination Programme (ADCP), FAO, Via delle Temme di Caracalla, 00100 Rome, Italy.*
- *Aquaculture Information System, AQUIS. AQUIS is connected to FAO's Aquatic Sciences and Fisheries Information System (ASFIS). Both conventional (bibliographic) and unconventional information are accessible.*
- *Selective Fisheries Information Service. Smaller system containing tropical finfish information. ICLARM MC, PO Box 1501, Makati, Metro Manila, Philippines.*

Abstracting Aids

- *Fisheries Review. Covers broad fisheries field but includes aquaculture. U. S. Fish and Wildlife Service. For subscriptions contact: Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402.*
- *ASFA Aquaculture Abstracts. Cambridge Scientific Abstracts, 7200 Wisconsin Ave., Bethesda, MD 20814.*
- *Sea Grant Abstracts. Publications from the nation's Sea Grant Program. Quarterly. Free. PO Box 125, Woods Hole, MA 02543.http://nsgd.gso.uri.edu/*

Statistical References

- *Virginia Shellfish Aquaculture Situation and Outlook Report. http://www.vims.edu/research/units/centerspartners/map/aquaculture/docs_aqua/2015_shellfish_aq_report.pdf*
- *Current Fisheries Statistics, Fisheries of the United States. Published by the National Marine Fisheries Service. Gives statistics for previous year. U.S. Government Printing Office, Washington, D.C. 20402. https://www.st.nmfs.noaa.gov/st1/publications.html*
- *Catfish and Trout Crop Reports. Both are USDA publications. Agricultural Statistics Service Publications, 341 Victory Drive, Herndon, Virginia 22070.*
- *FAO Yearbook of Fisheries Statistics. Gives world statistics on catches and landings. Aquaculture is included. Publication runs about 18 months after end of year reported. This and other FAO publications are available from: Aquaculture Development and Coordination Programme (ADCP), FAO, Via delle Terme di Caracalla, 00100 Rome, Italy. http://www.fao.org/fishery/statistics/yearbook/en*

Libraries

- *National Aquaculture Association. http://thenaa.net/*
- *American Alligator Farmers Association. 5145 Harvey Tew Rd., Plant City, FL 33565.*
- *American Fish Farmers Federation. PO Box 161, Lonoke, AR 72086.*
- *American Fisheries Society. 5410 Grosvenor Lane, Suite 110, Bethesda, MD 20814. https://fisheries.org/. Scientific organization of fisheries and aquatic science professionals. Has 15 sections including a fish culture section.*
- *American Tilapia Association.*
- *Aquaculture Association of Canada. Box 1987, St. Andrews, NB EOG 2XO, CANADA. Purpose: Aquaculture promotion and information exchange in Canada. Quarterly newsletter. http://aquacultureassociation.ca/*
- *Associated Koi Clubs of America, Inc. P.O. Box 10879, Costa Mesa, CA 92627. Annual Seminar. http://www.akca.org/.*
- *Catfish Farmers of America. 1100 Hwy. 82 East, Ste. 202, Indianola, MS 38751. Monthly Catfish Journal, monthly newsletter. http://www.catfishfarmersofamerica.com/*
- *European Aquaculture Society. Coupure Rechts 168, B-9000, Gent, BELGIUM. http://www.aquaeas.eu/*
- *International Association of Astacology. PO Box 44650, Univ. of Southwestern Louisiana, Lafayette, LA 70504-4650. Purpose: To promote scientific study and cultivation of crawfish. http://freshwatercrayfish.org/.*
- *National Fisheries Institute.1525 Wilson Blvd., Suite 500, Arlington, VA 22209. https://10times.com/organizers/national-fisheries-institute.*
- *Striped Bass Growers Association. PO Box 5452, Raleigh, NC 27650-5452. Promotes advancement of the commercial cultivation of striped bass and its hybrids. http://www.stripedbassgrowers.org/*
- *National Shellfisheries Association. Natural Science Division, Long Island University, Southampton, NY 11968. http://www.shellfish.org/*
- *United States Trout Farmers Association. PO Box 220, Harper's Ferry, WV 25425. Promotes trout industry in the United States. Annual meeting, quarterly magazine, monthly newsletter. https://ustfa.org/*
- *The United States Department of Agriculture National Agriculture Library: U.S. Department of Agriculture, Aquaculture Information Center,Room 304, National Agricultural Library, 10301 Baltimore Boulevard, Beltsville. MD 20705*
- *World Aquaculture Society. 143 J.M. Parker Coliseum, L.S.U., Baton Rouge, LA 70803. https://www.was.org/*

Technical and Educational Services

1. *The county Cooperative Extension Service office, usually listed under "County Government" in the telephone directory*
2. *State game and fish agencies*
3. *The United States Department of Agriculture Soil Conservation Service can assist in site selection and facility development, usually listed under "federal or United States Government" in the telephone directory*
4. *The United States Department of Agriculture's five Regional Aquaculture Centers:*

    - *Center for Tropical and Subtropical Aquaculture*

The Oceanic Institute
41-202 Kalanianaole Highway
Waimanalo, HI 96795

- *Northeast Regional Aquaculture Center*

Univ. of Maryland
2113 Animal Sciences Building
142
College Park, MD 20742-2317

- *North Central Regional Aquaculture Center*

2229 Lincoln Way
Iowa State University
Ames, IA 50011

- *Southern Regional Aquaculture Center*

Delta Branch Exp. Stn.
P.O. Box 197
Stoneville, MS 38776

- *Western Regional Aquaculture Consortium*

School of Aquatic and Fishery Sciences
University of Washington
Box 1122 NE Boat St
Seattle, WA 98195

Correlation of Aquaculture to Agriculture Courses

Infusion units are meant to compliment some Virginia agriculture courses. The following list represents the courses where a strong link between an infusion unit and task/competency exists.

Aquaculture Infusion Units

- 1.1 Describe the aquaculture industry.
- 1.2 Describe the economic importance of the aquaculture industry.
- 2.1 Identify economic conditions for a fish operation.
- 2.2 Identify environmental conditions for a fish operation.
- 3.1 Identify fish appropriate for production.
- 3.2 Explain laws applicable to production of game fish.
- 4.1 Determine the site for a fish pond.
- 4.2 Determine the size for a fish pond.
- 5.1 Describe practices for pond maintenance.
- 5.2 Describe practices for fencing ponds.
- 5.3 Describe practices for pond fertilization.
- 6.1 Build a fish cage.
- 6.2 Clean fish cages.
- 7.1 Describe pond quality for fish production with cages.

- 7.2 Arrange and secure fish cages.
- 8.1 Prepare the pond for stocking.
- 8.2 Stock a pond with fish.
- 9.1 Record fish operation data.
- 9.2 Control the water quality of a fish pond.
- 10.1 Develop a feeding plan.
- 10.2 Follow a feeding plan.
- 10.3 Maintain feeding records.
- 11.1 Identify common health problems of fish.
- 11.2 Identify methods for prevention and treatment of fish health problems.
- 12.1 Plan the fish harvest.
- 12.2 Follow a fish harvest plan.
- 13.1 Develop a marketing plan.
- 13.2 Prepare fish for marketing.

Correlation to Agriculture Courses

Natural Resources Business Management

- Unit 5.2

Small Animal Care I, II

- Unit 5, all
- Unit 6, all
- Unit 7, all
- Unit 9.1
- Unit 10.3
- Unit 11.1
- Unit 11.2
- Unit 13.1

Veterinary Science

- Unit 3.1
- Unit 10, all
- Unit 11.1

Introduction to Natural Resources III

- Unit 4, all
- Unit 9.2

Forestry, Wildlife, and Soil Management IV

- Unit 1.1
- Unit 2.2
- Unit 3, all

- Unit 5.1
- Unit 5.3
- Unit 8, all
- Unit 9, all
- Unit 10, all
- Unit 11.1
- Unit 13, all

Ecology and Environmental Management

- Unit 1.1
- Unit 2, all
- Unit 3, all
- Unit 4, all
- Units 5, all
- Unit 8.1
- Unit 9, all
- Unit 11, all

Biotechnology Foundations

- Unit 1.1
- Unit 11, all
- Unit 13.2

Biotechnology Applications in Agriculture

- Unit 5.3
- Unit 10.1
- Unit 10.3

Biological Application in Agriculture

- Unit 1, all
- Unit 2.2
- Unit 3, all
- Unit 4, all
- Unit 5.3
- Unit 8, all
- Unit 9.2
- Unit 10.1
- Unit 11, all
- Unit 12.1
- Unit 13, all

Agricultural Mechanics and Basic Animal Science II

- Unit 1.1
- Unit 2.1

- Unit 8, all
- Unit 10, all
- Unit 11, all
- Unit 12..2
- Unit 13.2

Agricultural Mechanics and Basic Plant Science

- Unit 1.1
- Unit 2, all
- Unit 5.1
- Unit 5.2
- Unit 8, all
- Unit 10, all
- Unit 11, all
- Unit 12.2
- Unit 13.2

Agriscience and Technology

- Unit 1.2
- Unit 2.1
- Unit 10, all
- Unit 9, all
- Unit 13, all

Agriscience Exploration

- Unit 1, all
- Unit 2.1
- Unit 3.1
- Unit 4, all
- Unit 5.1
- Unit 7.1
- Unit 9.2
- Unit 13.2

Introduction to Agriscience

- Unit 1, all
- Unit 2, all
- Unit 3, all
- Unit 4, all
- Unit 5.1
- Unit 5.3
- Unit 6.1
- Unit 7.1
- Unit 9.2
- Unit 10.1

- Unit 10.2
- Unit 11, all
- Unit 12, all
- Unit 13, all

FFA Information

The National FFA Organization is a national organization dedicated to the preparation of its members, providing them with a path to achievement in premier leadership, personal growth and career success through agricultural education. Local, state, and national activities, career development events (CDEs), and award programs provide opportunities to apply knowledge and skills acquired through agriculture education.

For additional information about the student organization, see the national FFA website at http://www.ffa.org and the Virginia FFA website at http://www.vaffa.org.

The following career development events are available for this course:

- Agricultural Communications
- Agronomy
- Environmental & Natural Resources
- Farm and Agribusiness Management
- Floriculture
- Food Science and Technology
- Forestry
- Marketing Plan
- Nursery/Landscape

Glossary of Aquaculture Terms

A

Acidic: Having a pH below 7.0
Acre-foot: The volume of water that will cover one acre (0.45 hectare) to a depth of 1 foot (0.3 meters); 325,851 gallons or 1,231,716 liters
Adipose fin: Small tab of fatty tissue found behind the dorsal fin on some fishes, including salmonids and catfishes
Aeration: Adding oxygen to water by spraying or bubbling air through the water
Aerobic: Requiring oxygen to sustain life
Algae: The plural form of alga. Green plants composed of only one type of cell, lacking true roots, stems, and leaves, ranging from microscopic species to giant seaweeds, and including the phytoplankton
Algaecide or algicide: Chemical used to kill unwanted algae
Alkalinity: The capacity of water to neutralize acids, measured as the amount of carbonates and bicarbonates
Anaerobic: Opposite of aerobic; lacking or not requiring oxygen
Anal fin: The single fin on the ventral surface of a fish, ahead of the tail
Anoxia: Total lack of dissolved oxygen

Antibiotic: Any of various substances such as penicillin and streptomycin, produced by certain fungi, bacteria, and other organisms that are effective in inhibiting the growth of or destroying microorganisms. The substance is widely used in the prevention and treatment of diseases.
Aqua: Water
Aquabusiness: Analogous to agribusiness
Aquaculture: The science that deals with the growing (cultivating) of animal and vegetable life in water. Aquaculture also deals with growing rice, seaweed, frogs, oysters, and other seafood.
Aquaria: The plural form of aquarium
Aquarist: Person who maintains aquaria, particularly an aquarium hobbyist
Aquatic: (1) Living in or frequenting water; (2) related to the fresh water environment
Aquatic food: Food produced for aquatic plants and animals
Aquatic plants: Plants that grow submerged in water
Aquiculture: Variant spelling of aquaculture
Aromagram: A measurement device used to determine the different flavors or odors that fish have

B

Barrage pond: Body of water made by damming a watercourse. See Impoundment.
Basic: Having a pH above 7.0
Biochemical oxygen demand: (B.O.D.) An index of the rate of consumption by natural processes of dissolved oxygen in a body of water
Biodegradable: Capable of being broken down by natural biological processes
Biomass: (1) The total weight of living organisms in a given environment or portion of an environment; (2) the total weight of living or non-living organic material. (The first definition is more common in aquaculture publications.)
Bloom: Dense and highly visible growth of microorganisms; usually applied to phytoplankton
Blue-green algae: Algae of the class Cyanophyta; usually, but not always blue-green in color
B.O.D.: Biochemical oxygen demand (see above)
Brackish water: Water having a salinity between that of fresh water and that of sea water
Buffer: A solution of weak acids and their salts that tends to stabilize the pH of water

C

Cage culture: Growing fish in some type of enclosure
Cast net: Type of net which is thrown over the water surface and closed by means of a drawstring
Caudal fin: The tail of a fish
Caudal peduncle: The muscular, flexible portion of a fish's body immediately forward of the caudal fin
Centrifuge: Machine using centrifugal force to separate particles of varying density
cfs: Abbreviation for cubic feet per second, a measure of flow rate
Closed system: System in which water is neither added nor removed during operation
Cold water fish: Fish whose optimal conditions fall below water temperatures of 70° F (21.1°C)
Colloidal mud: Semi-liquid mud, composed of particles from 0.005 to 0.2 microns in diameter
Colorimeter: Instrument for measuring the intensity of color; used in a variety of chemical tests of water
Complete feed: A feed which supplies 100 percent of the dietary requirements of an animal, used when there is little or no access to natural food
Conversion: Conversion ratio based on the complete dietary intake of an animal, including both natural feeds and those supplied by the culturist
Conversion ratio: Ratio of the weight of feed supplied to the amount of weight gained by the animal being fed
Crustacean: Member of the large Arthropod class Crustacea, including crayfish, crabs, shrimp, and many kinds

of zooplankton
Cultivated fish: Fish grown under observation
Culture: The breeding of animals or the growing of plants, especially to produce improved stock. Fish culture is one form of aquaculture.

D

Degree day: Measure of the difference between an arbitrarily selected base temperature and the temperature of a given place averaged over a day; used as a measure of the energy required in heating or cooling
Demand feeder: Device which dispenses small quantities of feed when activated by animals
Deoxygenation: Loss of dissolved oxygen from water
Depreciation: A decrease or loss in value because of wear, age, or other causes
Dispersing agent: Any of a number of salts that disperse clay particles in water; used in sealing ponds
Dissolved oxygen level: The amount of oxygen in the water; usually measured in parts per million (ppm)
Diversion pond: Pond constructed by diverting a watercourse
D. O.: Dissolved oxygen; a concentration usually indicated in milligrams per liter or parts per million
Dorsal: The back surface of an animal
Dorsal fin: One, two, or three fins located on the back of a fish, but not including the adipose fin
Dragline: A special rope pulled by a tractor; used in excavating
Dry feed: Feed with most of the water removed from the ingredients to improve storage qualities
Dry weight: The weight of a substance minus the weight of water in its natural makeup
Dugout: Pond constructed by excavating earth

E

Ecology: The science which deals with the relationships among living organisms, as well as their relation to non-living components of the environment
Ecosystem: A given physical environment, such as a pond, considered together with all the plants and animals which inhabit it
Embankment: Any raised earthen structure, including dams and levees, for the purpose of holding back or containing water
Emergency spillway: A channel cut in the top of a dam or levee so that in times of extremely high water, water passes over at only one point
Epizootic: Outbreak of disease affecting many individuals of a species at one time; epidemic
Essential element: Any one of the twenty chemical elements considered necessary for the maintenance of life
Estuary: The brackish water environment formed where a fresh water stream meets the sea
Eutrophication: The natural process of "aging" whereby a body of water becomes more fertile and usually shallower as a result of erosion and the death of plants and animals within it
Exotic species: Species not native to a given environment or region
Extensive culture: The opposite of intensive culture; characterized by relatively low population and little management or control by the culturist
Extruded: Floating

F

Farm pond: Artificially constructed pond, usually between 1/4 acre and 5 acres (0.1 and 2 hectares) in size, located on a farm and used for a variety of purposes, usually including recreational or subsistence fishing; characteristically stocked with largemouth bass (Micropterus salmoides) and bluegills (Lepomis macrochirus),

though other species may be used
Fecundity: Capability of producing offspring
Feeding ring: A band of fine mesh fastened around the inside of a fish cage near the waterline to prevent floating feed from being carried out of the cage
Fee fishing: Practice of charging admission, or charging for fish caught in a privately owned and stocked pond opened to the public for purposes of angling
Finfish: Any member of the class Pisces; includes the vertebrate animals commonly referred to as "fish," as opposed to the invertebrate shellfish
Fingerling: Young fish larger than a fry but not adult; not rigidly defined but usually denotes a fish between 0.8 and 10 inches (2-25 centimeters) long
Finishing: Practice of giving fish special feeds in the period just before slaughter, so as to produce desirable flavor or texture
Fishery biology: Science dealing with the exploitation of aquatic and marine animals by humans
Fishery products: Salable products of the commercial fishing industry, including whole and processed fish and shellfish
Farm fishing: Raising fish for profit
Float line: The top line of a seine, gill net or trammel net, supported by floats
Flow rate: The volume of water moving past a point in a given time, usually expressed in cubic feet per second (cfs) or liters/second
Food chain: A sequence of organisms, each of which provides food for the next, beginning with primary producers and extending to carnivores
Food web: The complex feeding relationships, made up of interlocked food chains, that exist in any natural system
Forage fish: Fish species stocked or cultured as food for other fish
Fresh water: Variously defined, but most commonly considered as water having a salinity of less than 0.5 parts per thousand
Fry: A fish that has just hatched until it reaches fingerling size
Fyke net: Net made up of a series of hoops of diminishing size, each with a funnel shaped entrance

G

Game fish: Fish commonly taken on hook and line for sport, especially species which can be taken on artificial lures
Genetics: The biology of heredity
Genital papilla: A small flap of flesh located just forward of the vent on some fishes; used in sexing
Gill arches: The cartilaginous arches that support the gills
Gill covers: The bony outer covers of the gills
Gill filaments: See gill lamellae
Gill lamellae: The thin-walled, blood-filled, visibly red filaments on a fish's gills which take up oxygen from the water
Gill net: A net hung vertically in the water so that fish attempting to pass through become caught by their gill covers
Gill rakers: The protrusions on the opposite side of the gill arches from the gill lamellae; used as a "sieve" by filter-feeding fishes
Gill slits: The openings at the back of the gills through which water is expelled
GNP: Gross national product; the total value of a nation’s annual output of goods and services
Grader: Device used to sort fish by size
Ground water: Water contained underground in an aquifer
Growing out: Practice of feeding fish until they reach a desired size for harvest

Growing pond: Pond used primarily to grow animals to harvestable size
Growth coefficient: Conversion ratio
Gular area: "Throat" region of a fish, on the ventral surface, just behind the gills
Gypsum: A white chalk used in the manufacture of fertilizer

H

Habitat: That portion of the environment where an organism normally lives
Harvest basin: A basin deeper than the rest of a pond, located near the outlet, so that when the pond is drained fish are concentrated to facilitate harvesting
Harvestable fish: Fish of size desired for harvest
Hatchery: An aquaculture facility where the main activity is breeding of animals and rearing of the early life stages
Heavy metal: Any of a number of chemical elements with toxic properties, including copper, lead, and mercury commonly found as pollutants in water, and capable of being concentrated in animal flesh
Herbicide: Chemical used to kill unwanted plants
Herbivore: Animal that eats plants
Hybrid: The offspring produced by breeding fish of different species
Hypolimnion: The bottom layer of a thermally stratified body of water. See thermal stratification.

I

Impoundment: Body of water made by damming a watercourse
Intensive culture: The opposite of extensive culture; characterized by relatively high population density and a high degree of management and control by the culturist
Invertebrate: Any animal without a backbone; any animal other than a fish, amphibian, reptile, bird, or mammal
Isothermal: Having a constant temperature

L

Landings: Fish captured from the sea
Larvae: Early, free-living stage of an animal, differing grossly in form from the adult (e.g., a caterpillar is a larval butterfly; a tadpole is a larval frog)
Lead line: The bottom line of a seine, gill net, or trammel net, held down by lead weights
Levee: An embankment constructed above ground level to serve as the wall of a pond
Levee pond: A pond totally or partially surrounded by levees
Limnology: The science of inland waters, including their biology, chemistry, geology, etc.
Liner: A thin sheet of plastic or rubber placed on the bottom of a pond or pool to prevent leakage
Live car: A mesh cage used to hold live fish temporarily; also called live box
Live hauler: Someone who purchases fish to be hauled alive to market
Low oxygen: An oxygen level of water lower than normal

M

Mariculture: The culture of marine organisms in their natural habitat
Market analysis: A study of customers, competition, and trends in the marketplace, all of which should provide objective, analytical information on which to base marketing decisions
Metabolism: The aggregate of processes in a living organism by which nutrition, respiration, and growth are

achieved
Metabolite: Any substance produced by an organism as part of its life processes
Metamorphosis: More or less abrupt physical transformation of an animal as, for example, when a tadpole metamorphoses to become a frog
Microbial: Having to do with a microbe, or microscopic organism
Microorganism: Organism too small to be seen with the naked eye
Milt: The secretion produced by the testes of male fish, including the sperm
Monk: A device for draining and regulating the water level of a pond, constructed in the pond rather than in the pond bank
Monoculture: Cultivation of only one species at a given time and place
Monosex hybrid: Offspring of a cross which produces 100% of one sex
Morphology: The study of the physical form and structure of organisms
Mud line: The bottom line of a seine specially designed to be used on very muddy bottoms; constructed of heavy rope without the usual lead weights

N

Natural fertilizer: Fertilizer in which the active ingredients are not chemically altered from forms found in nature
Niche: The precise and unique role played by a species in an ecosystem; includes habitat, feeding, and other aspects of behavior
Nitrification: The oxidation of nitrogen from ammonia through nitrite to nitrate
Nitrogen fixation: The process by which certain bacteria are able to take nitrogen from the air and "fix" it in soil or water

O

Oligotrophic: "Young" or "new" water condition stratagraphically undefined. See Eutrophication.
Omnivore: Animal that eats both animal and vegetable matter
Open pond culture: Growing fish that are not confined
Open system: Aquaculture system which participates in the natural hydrological cycle; i.e., inflow and outflow are only partially under the control of the culturist
Opercular lobe: Fleshy flap extending from the opercule of some fishes
Overflow: Device to permit water to escape from a body of water once a certain maximum level is reached
Oxidizing agent: Substance which uses up dissolved oxygen or speeds the process of oxidation
Oxygenation: The addition of oxygen to water by aeration or other means

P

Panfish: Any of a number of fishes, including the sunfishes, bullheads, and perches, commonly harvested at a size that will fit into an ordinary frying pan
Parasite: An organism that lives on or in another organism and obtains its food at the expense of that organism
Particulates: Small particles of matter suspended or floating in water
Pathogen: Organism causing disease
Pathology: Study of disease
Pectoral fins: The paired fins found on either side of a fish's body, just behind the gills
Pellet: A small, solid or densely packed mass of feed
Pelvic fins: The paired fins found on the ventral surface of a fish's body, between the pectoral fins and the single

anal fin
Pesticide: Chemical used to kill unwanted organisms
pH: The negative logarithm of the hydrogen ion concentration expressed in gram equivalents; used as an index of the acidity or alkalinity of water
Pheromone: Chemical substance released by an animal for purposes of communication with others of its species
Photolytic: Chemically changed by light
Photosynthesis: The process by which green plants produce food for their own growth, plus oxygen, from carbon dioxide and water, in the presence of light
Phytoplankton: Plankton made up of algae
Piscivore: An animal that eats fish
Plankter: An individual planktonic animal or plant
Plankton: A plant or animal organism that has little or no power of locomotion and gives water an off-flavor that is picked up in the meat of fish
Point discharge: Discharge of a substance into an aquatic system at a single definable point; as opposed, for example, to silt, which commonly originates as soil eroded from a wide area
Polyculture: Cultivation of more than one species in a single place
Pothole: (1) A small, shallow pond used for waterfowl breeding; (2) small, natural lakes occurring in the northern Great Plains, and used for trout farming
ppm: Abbreviation for parts per million, a common measure of concentration of chemicals in liquids; equivalent to milligrams per liter in water
Precipitation: Process occurring when a chemical is removed from solution in water and settles to the bottom in solid form
Predaceous, or predatory: Capturing and eating live animals
Production: The gain in weight accomplished by cultured organisms over a given period of time
Productivity: Capacity of a system to support production

R

Raceway: Aquaculture chamber through which water flows, usually rapidly, or at least fast enough so that the flow can be seen
Ration: A fixed portion of feed allocated to fish
Ration, balanced: A portion of feed which contains the necessary nutrients to sustain life for one day
Recirculating system: Aquaculture system in which at least some of the water is recycled one or more times
Respiration: Process by which chemical energy in food is transformed into other kinds of energy by plants and animals, as oxygen is consumed and carbon dioxide produced
Riprap: Rocks placed on the bank of a body of water to prevent erosion
Roe: The eggs of a fish, especially when considered as food
Roiling (of water): Dirtying, as by stirring up silt
Rosary ponds: Ponds set up in series, so that water passes from one into the next, and so on
Rotenone: A white crystalline compound extracted from the roots of derris and cube and used as an insecticide
Runoff: That portion of precipitation which does not soak into the ground but runs off, eventually entering bodies of surface water

S

S conversion: Conversion ratio based only on food provided by the culturist, omitting naturally available food
Salinity: Measure of the total amount of dissolved salts in water
Salmonid: Any fish of the family Salmonidae, including the trouts, chars, salmons, and graylings; since the whitefishes and ciscoes were added to the Salmonidae they may be called Coregonids or Salmonids.

Saturation: The maximum amount of a substance which can ordinarily be dissolved in water at a given temperature and pressure
Scap net: Square-cornered, shallow dip net used for rapid handling of a small fish
School: Strictly speaking, a school of fish is a permanent grouping; the members of the school exhibit the same behavior and respond to stimuli in the same way. Survival of a member outside the school is improbable. In common usage any sizable group of fish is referred to as a school.
Scientific name: The Latin name of an organism, consisting of the genus, species, and sometimes subspecies, in that order; for example Ictalurus nebulosus marmoratus
Secchi disk: A white disk used as a tool in measuring water transparency
Sediments: Solid matter which has settled out of suspension, found on the bottom of a body of water
Seine: A long narrow net with floats on the top edge, and usually with weights on the bottom, used by hauling it through the water
Semiclosed system: "Closed" system in which some amount of water is periodically lost or removed and then replaced
Shellfish: An aquatic animal having a shell or shell-like protective or supporting structure. Invertebrates used as food, including mollusks and crustaceans, excluding finfish
Silt: Soil particles less than 1/16 millimeter in diameter
Siltation: Deposit of silt on the bottom of a body of water
Slope: Ratio of the difference in elevation of two points to the horizontal distance between them
Sluice or sluice gate: A device built into a dam or channel for draining or regulating the flow of water
Snag hooking or snatch hooking: Fishing by casting out a hook and jerking it so that fish become impaled
Solar-algae pond: Transparent or translucent fiberglass cylinder designed as an above ground tank to maximize phytoplankton production
Solvent: Substance, usually a liquid, that can dissolve another substance
Spawn: To produce or deposit eggs, sperm, or young. Usually, but not always applied to aquatic or marine animals
Spawning mop: Synthetic "weeds" on which cyprinid fishes deposit their eggs
Species: A fundamental category of taxonomic classification, ranking after a genus and consisting of organisms capable of interbreeding
Spillway: Structure over which water passes at the outlet of a pond
Splash board: Flat surface off which water is splashed to oxygenate it on entering a pond
Spoils: Earth removed in construction of a pond
Spring-fed ponds: A natural formation or flow of water into a still body of water smaller than a lake
Standard length: Measure of fish length most often used by biologists; consists of the distance between the tip of the snout and the end of the caudal peduncle
Standing crop: The total biomass of a particular organism, or all organisms, present in a body of water at a given time
Station feeding: Practice of feeding at a single spot, so that fish are concentrated
Stratum: Layer distinguishable from other layers by its composition
Stridulation: Production of sound by rubbing together of hard body parts
Stress: Any condition inimical to the health or growth of an organism
Stripping: Process of artificially removing the eggs and milt from mature fish
Stunted: Condition of being undersized and not growing appreciably; this condition is usually permanent in warm-blooded animals but is reversible in cold-blooded animals.
Sublethal: A damaging or dangerous condition (of temperature, concentration of a chemical, etc.) but not reaching a level that, in and of itself, would result in death
Submerged plant: Plant which exists entirely underwater
Subsistence aquaculture: Aquaculture for purposes of food but not for sale or barter
Substrate: The bottom layer, on or in which benthic organisms are found

Subterminal mouth: Opening on the ventral surface rather than at the very end of the snout (terminal mouth)
Summerkill: Loosely used as a counterpart to winterkill; describes any mass mortality occurring during warm weather, but usually attributable to low D.O. Reflecting heavy B.O.D., warm water, and/or low water levels
Supersaturation: Condition in which a substance is present in amounts above that which can normally be dissolved in water at a given temperature and pressure
Supplemental feeding: Feeding not to provide a complete diet, but to enhance growth by qualitatively and/or quantitatively improving on the natural diet
Surface water: All water found on the earth above ground, including streams, lakes and the oceans
Suspended solids (also, in suspension): Particles of solid matter present in a water column
Swale: A shallow trench constructed around the perimeter of a body of water to collect solids carried by runoff
Swim-through feeder: Feeder designed so that small fish can swim in and out, but larger fish must feed outside
Synergy: The combined action of two substances or processes to produce a result that could not be obtained by means of either alone
Synthetic fertilizer: Fertilizer produced by a controlled chemical reaction resulting in substances not normally found in nature

T

Tailwaters: The water immediately below the outlet of an aquaculture system or natural or artificial body of water
Taxonomy: The science of classifying organisms
Temper: To blend or mix two bodies of water until they are both the same temperature
Teratogenic: Capable of causing deformity
Thermal shock: Shock resulting from sudden change of temperature
Thermal stratification: Condition found in some bodies of water, where there are three distinct layers, based on temperature. Layers are separated by a band that changes in temperature from its top to bottom, called the thermocline. The upper warm layer, usually well supplied with oxygen, is called the epilimnion. The colder, bottom layer is called the hypolimnion.
Thermocline: The middle layer of a thermally stratified body of water. See thermal stratification.
Tidal waters: Waters that are influenced by the gravitational attraction of the sun and the moon
Tile: Pipe installed in a field to collect runoff
Titration: Process of determining the concentration of a substance in solution in terms of the smallest amount of it required to bring about a given effect in relation to another known substance
Total length: Common measure of fish length used by fishers; consists of the distance from the tip of the snout to the farthest protrusion of the caudal fin
Toxaphene: A commercial chlorinated hydrocarbon insecticide ($C_{10}H_{10}Cl_8$) made by chlorinating camphene
Toxic: Harmful, destructive, or deadly
Trace element: Chemical element used by organisms in minute quantities, but believed necessary to their health
Trade deficit: Importing more of a product than is exported
Trade imbalance: Importing more or less than is being exported
Trammel net: Net similar to a gill net, but composed of two or more layers of netting between which fish become entangled
Transpiration: Loss of water to the atmosphere from the leaves of green plants
Trophic level: The position an organism occupies in the food chain
Tropical fish: Fish which cannot tolerate temperatures near freezing
Turbidity: Degree to which the penetration of light into water is limited by the presence of suspended or dissolved matter
Turnover: Process during which thermally stratified bodies of water become totally mixed at certain times of the year as a result of convection currents

U

Umbrella net: Rectangular net suspended from its four corners, placed underwater and hauled up rapidly when fish swim over it

V

Ventral: The lower surface of the body of any animal
Ventral fins: See pelvic fins
Vermiculation: Worm-like markings
Visual feeder: Animal that relies on vision to locate its food
Vitamin premix: Package of synthetic vitamins added to prepared animal feeds

W

Warm water fish: Fish that can tolerate freezing water as well as water above 70°F (21.1°C)
Watershed: The land area contributing to the water supply of a body of water
Wet weight: The weight of a substance in its natural state, including the weight of water
Winterkill: Die-off of fish in winter associated with snow cover or opaque ice cutting off both photosynthesis and surface uptake of oxygen
Zooplankton: Plankton made up of animals

The Virginia Aquaculture Plan

Background

After more than two years of coordinated activities, involving industry, government, support organizations, and the scientific community, the Virginia Aquaculture Plan has been completed and printed by the Virginia Department of Agriculture and Consumer Services (VDACS). Copies of the plan are available to industry producers, government agencies, financial institutions, and other user groups that have active roles in Virginia aquaculture.

Contents

The *Virginia Aquaculture Plan* consists of two documents:

- *The Executive Summary and Recommendations* outlines principal industry concerns and recommendations for change. It also provides industry overviews, production status, opportunities, and related information.
- *A Guide to Aquaculture Development and Industry Information* provides material on industry opportunities, resource contacts, economics, marketing and financial aspects, production potentials, and regulatory requirements for commercial aquaculture.

The *Virginia Aquaculture Plan* was compiled and edited by Dr. Scott H. Newton, Virginia State University, Petersburg, VA 23806 while on a two-year loan assignment to the VDACS.

Availability

For those seriously interested in commercial aquaculture ventures, copies may be obtained by contacting Maggie Beal Longest (804/786-1241) at the Virginia Department of Agriculture and Consumer Services, P.O. Box 1163, Richmond, VA 23218.

- In many cases, those seeking general industry information, and information on species production, and health, seafood safety, and regulations may need only one of the two documents: *Guide to Aquaculture Development and Industry Information*.
- For individuals interested in general reading and industry overviews presented in the *Virginia Aquaculture Plan*, copies are available in
  - the Library of Virginia (formerly the Virginia State Library), in Richmond
  - the National Agricultural Library, in Beltsville, MD
  - libraries of Virginia academic institutions that have aquaculture programs.

Academic institutions with copies of the Virginia Aquaculture Plan in their libraries and a resource contact include the following:

Academic Institution	**Contact for Aquaculture Plan**
Institute of Marine Science Gloucester Point	Mike Oesterling (804/642-7165)
Old Dominion University Norfolk	Anthony Provenzano (804/683-3972)
St. Paul's College Lawrenceville	James Nolting (804/848-2636)
Virginia Commonwealth University Richmond	Bonnie Brown (804/828-1562)
Virginia State University Petersburg	Brian Nerrie (804/524-5903)
Virginia Tech Blacksburg	Louis Helfrich (540/231-5059)

Handouts and Transparencies

Providing Economic Information on the Aquaculture Industry

Selecting the Type of Fish Operation

Selecting the Species to Use

Constructing Ponds

Maintaining Ponds

Maintaining Fish Cages

Deploying Fish Cages

Stocking Fish

Maintaining the Fish Operation

Feeding Fish

Maintaining Fish Health

Harvesting Fish

Marketing Fish

Defining Flow-Through Systems

Define flow-through systems (raceways)

- *The Freshwater Aquaculture Book.* McLarney.

Resources Recirculating Systems and Aquariums

Define recirculating systems and aquariums.

- *The Freshwater Aquaculture Book.* McLarney.

Resources for Introducing the Aquaculture Industry

1 .Explain the aquaculture industry.

- Aquaculture Outlook. U.S. Department of Agriculture. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1375
- The Freshwater Aquaculture Book. McLarney.
- Virginia Aquaculture Plan. Virginia Department of Agriculture and Consumer Services.
- Agricultural Water Management. An International Journal. https://www.journals.elsevier.com/agricultural-water-management

2. Describe the importance of aquaculture industry.

- Aquaculture Outlook. U.S. Department of Agriculture. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1375
- The Freshwater Aquaculture Book. McLarney.
- Aquaculture. The Ocean Review. http://worldoceanreview.com/en/wor-2/aquaculture/
- Aquaculture. Food and Agriculture Organization of the United Nations. http://www.fao.org/aquaculture/en/

3. Explain federal, state, and international agencies' laws and regulations applicable to aquaculture. The National Council for Vocational and Technical Education in Agriculture.

- Water Management. Farm Journal. https://www.agweb.com/farmjournal/water-management/
- Aquaculture and Marine Products. Virginia Department of Agriculture and Consumer Services. http://www.vdacs.virginia.gov/vagrown/aquaculture.shtml
- Aquaculture Facts and Figures. Virginia Department of Agriculture and Consumer Services. http://www.vdacs.virginia.gov/markets-and-finance-agriculture-facts-and-figures.shtml