Saltwater Shrimp

AQUACULTURE CURRICULUM GUIDE
SPECIES SPECIFIC MODULE

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Description: The module consists of the following four problem areas:

Module: Saltwater Shrimp

Problem Areas: Determining Opportunities in Shrimp Culture
Exploring Life Cycle of Saltwater Shrimp
Obtaining Seedstock - Spawning to Post-Larval Production
Growing Out Shrimp

Objectives: The objectives for each problem area are given below:

A. Determining Opportunities in Shrimp Culture
   • identify areas where shrimp occur naturally
   • list commonly cultured species
   • describe how shrimp reach consumer in the United States
   • describe economics of producing shrimp in the United States

B. Exploring Life Cycle of Saltwater Shrimp
   • describe how shrimp are cultured
   • list pros and cons for introducing new species
   • list environmental requirements of shrimp
   • list common cultured species
   • discuss reproductive characteristics of shrimp
   • discuss shrimp hatchery techniques
   • discuss shrimp growout techniques

C. Obtaining Seedstock - Spawning to Post-Larval Production
   • describe hatchery systems used to spawn and raise tropical shrimp
   • discuss factors affecting maturation/hatchery production
   • discuss procedures used in spawning shrimp
   • describe procedures used in larval rearing shrimp
   • describe procedures used in seawater treatment for hatcheries

D. Growing Out Shrimp
   • describe environments where shrimp are cultured
   • describe type of post-larvae needed for stocking
   • explain factors affecting stocking rates
   • explain what shrimp eat and how they are fed
   • list factors related to growth rate
   • explain environmental parameters critical to shrimp culture
   • discuss how to manage a shrimp pond
   • discuss how shrimp are harvested and marketed
   • discuss diseases and parasites that affect shrimp
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Teaching Plan:

Module: Saltwater Shrimp - Section A

Problem Area: Determining Opportunities in Shrimp Culture

Estimated Time: 2-4 hours

Goal: The goal of this problem area is to learn about the origins of shrimp culture, the worldwide culture of shrimp, and the possibilities for shrimp culture in the United States.

Learning Objectives: Upon completion of this problem area, students will be able to:

- identify the areas where shrimp occur naturally
- list commonly cultured species
- describe how shrimp reaches consumer in the United States
- discuss economics of producing shrimp in the United States

Resources: The following instructional resources are needed to complete this problem area:

Essential:

Copies of slides and transparencies.


Additional:


Aquaculture Situation and Outlook Report, Commodity Economics Div., Econ. Research Service, USDA.


Preparation (Interest Approach):

To develop student interest in this module, list the following advantages for working with saltwater shrimp: taste (good), texture (firm), keeps well frozen (can thaw and refreeze), market demand (high), price (high), nutritional benefits (high), interesting profession, feeding (commercial feeds can be used or natural food only), 342 different commercial species of shrimp worldwide, and protective shell helps protect meat while being processed and while in frozen storage.

Presentation:

A. How are saltwater shrimp classified?

Write order: Crustacea, family: Penaeidae, genus: Penaeus. Show slide #1, various types, sizes, and colors of shrimp.

1. All shrimp are classified in order: Crustacea and suborder: Natantia.
2. There are more than 300 species according to FAO.
3. Most saltwater shrimp are members of the family Penaeidae that are generally considered to be ocean spawners. There are other families, but Penaeidae is only discussed here.
4. *Penaeus* is most often cultured and 80% of the shrimp harvested worldwide are penaeid shrimp.
5. There are about 30 species that have been aquacultured successfully.
6. Shrimp are sometimes called prawns, but prawn refers to freshwater shrimp, *Macrobrachium*.
7. Most tropical shrimp are classified either as brown shrimp or white shrimp.

B. What is the distribution and history of penaeid shrimp?

Show TM A1 and discuss production and history of producing saltwater shrimp. Show slide #2. Using world map or slide #2, show students where most penaeid shrimp areas are found (inside the 15°C isotherm). Show slides #3 and #4, most penaeid shrimp found in near-shore waters.

1. Shrimp are distributed worldwide, but most are found near shore rather than in the very deep oceans.
2. Oldest record of Penaeidae is in Chinese history (between 8th and 2nd century B.C.).
3. Japanese literature referred to penaeids in 730 A.D.
4. First scientific record of a penaeid was in 1759, when Seba in Amsterdam named and figured a North American penaeid.
5. In 1815, Rafinesque recognized that penaeids were a distinct group within Decapoda and named them Penedia (corrected to Penaeidae by the International Commission on Zoological Nomenclature in 1955).
6. The work of Dr. M. Fujinaga (of Japan) in 1933 (Hudinaga 1935) led to modern shrimp farming, but it was only in the early 1960s that the first commercial farms were built in Japan (Seto Inland Sea). For hundreds of years shrimp farming had only been considered a secondary crop in traditional fish farming practices in many Asian countries.
7. In 1935 J.C. Pearson described the eggs of some penaeid shrimp and in 1939 he wrote the life histories of some American penaeids.
8. Commercial shrimp growout attempts were made in the U.S. starting in the late 1960s and early 1970s (first with local species, but in the early 1970s exotic shrimp proved to be easier to culture and more productive in the ponds). Therefore over time most commercial producers have concentrated on exotics mainly *P. vannamei* in the United States.
C. What are the penaeid shrimp fishing grounds in the United States and 3 main types of shrimp caught?

Show TM A2 and discuss aspects of shrimp aquaculture. Show slide #5, major penaeid shrimp fishing grounds in the United States. Show slide #6, main types caught.

1. White shrimp.
2. Pink shrimp.

D. What groups are commonly cultured worldwide?

Show pie chart (slide #7) and show slides of each species. Show slides #8 and #9, P. monodon (black tiger), slide #10, P. chinensis (Chinese white shrimp), slide #11, P. vannamei (western white shrimp), slides #12 and #13, P. stylirostris and P. japonicus (other important species), and slide #14, growth curve comparison.

1. Four groups of species most widely cultured worldwide are P. monodon (47%) P. vannamei (16%), P. chinensis (14%), and others (23%).
2. Eastern hemisphere mostly P. monodon and P. chinensis, whereas in the Western Hemisphere mostly P. vannamei are cultured.
3. P. monodon (black tiger) generally weigh 35 g after 120 days growth and P. vannamei (western white shrimp) weigh 20 g.
4. Specific Pathogen Free (SPF), or High Health animals, have been developed by USDA funding and are improving production.
5. Hybridizations have been attempted with P. setiferus vs. P. stylirostris, and P. schmitti, but their offspring were nonreproductive.
6. Some common names of saltwater shrimp are banana, Kuruma, yellowleg, western white, greasy back, Chinese white, brown, pink, black tiger, Pacific white, Pacific blue, and Mexican white shrimp.

E. Who in the world eats shrimp?

Ask students to guess where most of the farms are located around the world. Who eats shrimp? (Japan and the United States). Show slide #15 of where farms are 10° above and 10° below the equator and 3 major consumption areas (Japan, United States, and Europe). Show slide #16, the results of USDA survey. All sections of the United States prefer shrimp.

1. Sections in United States that prefer shrimp.

2. Shrimp exist in wild populations as well as in aquaculture environments.
   a. Shrimp are very popular seafood in Japan, the United States, and now Europe is developing a "heads on" market for shrimp.
   b. "Green headless" (heads off, shell on) shrimp are preferred in the United States.
   c. Japan prefers live shrimp, but also imports green headless shrimp.
   d. Worldwide, more than 700,000 metric tons are produced each year using aquaculture, combined with the wild harvested shrimp, equals 2.5 million metric tons (plus) world market for shrimp.

3. The United States imports approximately 2 billion dollars worth of shrimp each year.
F. What are the marketing channels for shrimp in the United States?

Show TM A3 and discuss where shrimp are cultured in the United States. If available, prepare shrimp and other species for a taste test. Show slide #18, shrimp fresh and boiled. It is suggested that tails, shells on, be boiled about 1.5 minutes (or until tails float) with salt, lemon, and seasoning added to the water.

1. Shrimp reach the consumer in several ways. They may be imported from producers in other parts of the world or they may originate from U.S. producers.
2. International producers market their products the same as seafood producers. Several multinational corporations are involved.
3. Most imported shrimp are sold green headless in 5-lb waxed boxes.

Show slide #19, 5-lb waxed box of frozen shrimp.

4. Some of the various methods used to produce value-added products (further processed products) are frozen meals, peeled and deveined shrimp, vacuumed packed, individually quick frozen, butterflied and battered or breaded, cooked and peeled, and cooked shell-on smoked shrimp, shrimp paste (surimi), shrimp crackers, shrimp in cocktail sauce, shrimp soups and stews.

Show slide #20, peeled shrimp.

5. Saltwater shrimp are durable and may be frozen, thawed, and refrozen without severely affecting flavor and texture.

G. Is it economically feasible to produce shrimp?

Show TM A4, TM A5, and TM A6 and discuss the economic of harvesting shrimp. Show slide #21 cost analysis per pound of shrimp tails.

1. Shrimp are produced in ponds, raceways, and tanks.
   a. Production costs vary ($2.50-5.00/lb) because of the varied output costs associated with each form of production.
   b. Feed, processing, and larvae are the three highest costs. It usually takes 2 lbs of feed to produce 1 lb of shrimp.

Show slides #22-28, how shrimp are cultured in ponds: #22, Philippines, #23, Thailand, #24, Taiwan, #25, Indonesia, #26 harvest in Indonesia, #27 and #28, China.

2. Principal economic problems with culturing shrimp in the United States:
   a. Availability of low-cost, high-quality feed.
   b. Short growing season. One crop only in some areas because of temperatures, high cost of land, labor, high operating costs (power etc.).
   c. Foreign competition.
   d. Price can fluctuate up to $1.00/lb weekly.

3. Because of the cold climate, outdoor culture in the continental United States is limited to 9 months in extreme southern regions.

Use slides to show where shrimp can be cultured in the United States: slide #29, Texas farms location map, #30, Harlingen (Texas farm), #13, Hung (Texas farm), #32 (South Carolina), #33 (South Carolina harvest), #34, Hawaii farm, #35, Hawaii round pond, #36, Hawaii farm “Pot of Gold.”
a. Even the climate in Hawaii can be somewhat limiting with tropical species. (Pacific ocean temperatures can be very cool in January.)
b. Other areas are in isolated situations where warm water is available (geothermal regions), indoor systems, underground aquifers.

4. The most recent farm-gate prices (or prices received by the farmer for heads-on shrimp in the size range of 31-35 count (31-35 shrimp/lb) averaged $3.00-4.10/lb.
   a. According to Mike Haby (seafood marketing specialist, Texas A&M University), the wholesale price for shrimp of this size ranged from $3.50-4.50/lb. from 1988-1992.
   b. Retail prices on the average for this size shrimp ranged from $4.65 to $5.00/lb. for the Mexican white shrimp according to Seafood Leader-Shrimp Update 1993.
   c. Therefore, the economics of shrimp culture in the United States does not appear to be very good on paper, but by maintaining the production levels higher than average, keeping overhead low, obtaining the highest possible farm-gate price (do a good job marketing), it is possible to make a profit from this business.

5. Roughly 40% of the body weight of shrimp is in the head.

Show slide #37, price breakdown.

a. Shrimp producers generally contract a processing plant to process the shrimp.
   b. An average of $.63/lb. was charged in 1992 for processing (icing, deheading, grading, packing, freezing in plate freezer, and cold storage for 1 month).

6. Production in ponds often ranges from 2,000-8,000 lbs/acre/crop in the United States with average U.S. pond production at 3,500 lbs/acre/crop.

Review:

Review by having students demonstrate their knowledge and understanding of the objectives for this problem area. Lead a discussion with students by asking questions that cause the students to explain the content that goes with each objective.

Application Activities:

Application can be addressed in several ways. Ask students to survey their parents and friends to determine when was the last time they ate shrimp. Obtain shrimp from a commercial source, prepare it, and conduct a taste test. A more advanced project could be done with freshwater shrimp. Obtain live shrimp and subject them to 0, 10, and 20 ppt salinity for an extended period. Then prepare the shrimp by boiling (without seasoning) and taste test. The higher salinity-held shrimp should be more flavorful while the shrimp held in freshwater should be bland tasting. The same test can be conducted with saltwater shrimp, but salinities should be higher (10, 20, and 35 ppt). The reason is that shrimp osmoregulate to adjust to salinity by building up free amino acids in the muscle when salinities are up. Some free amino acids are associated with taste.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of producing shrimp in an aquaculture environment, written reports, and written exams. Example exam questions are attached.
U.S. Production of Saltwater Shrimp

- In ponds
- Started in late 1960s and early 1970s
- Produce mainly exotic shrimp *(Penaeus vannamei)*
Major Aspects of Shrimp Aquaculture

- Maturation/reproduction
- Hatchery (larval rearing)
- Growout
Where Shrimp Can Be Cultured in the United States

- Extreme southern regions of continental United States
- Tropical areas such as Hawaii and Puerto Rico
- Geothermal regions
- Indoor systems
- Southwestern United States (brackish aquifers)
Economics of U.S. Production (Estimates)

- Production costs for heads-on shrimp at farm (31-35 count), $2.50-5.00/lb

- Average wholesale prices for 31-35 count from 1988-1992: $3.50-4.50/lb

- Tail yield: 60%

- Pond Yield:
  Range 2,000-8,000 lbs/acre
  Average 3,500/lbs/acre

- Average number of crops/year in U.S. = 1
## Cost Analysis per Pound of Shrimp Tails

<table>
<thead>
<tr>
<th>Operating Expense Items</th>
<th>Cost per lb</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>1.011</td>
<td>28.5</td>
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<tr>
<td>Processing &amp; Harvesting</td>
<td>0.630</td>
<td>17.8</td>
</tr>
<tr>
<td>Post-Larvae</td>
<td>0.549</td>
<td>15.5</td>
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<tr>
<td>Interest</td>
<td>0.393</td>
<td>11.1</td>
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<tr>
<td>Salaries &amp; Wages</td>
<td>0.361</td>
<td>10.2</td>
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<tr>
<td>Pumping Costs</td>
<td>0.170</td>
<td>4.8</td>
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<tr>
<td>Aerator Utilities</td>
<td>0.118</td>
<td>3.3</td>
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<tr>
<td>Management Consultant</td>
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<td>3.0</td>
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<tr>
<td>Supplies, Misc.</td>
<td>0.091</td>
<td>2.5</td>
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<tr>
<td>Maintenance</td>
<td>0.078</td>
<td>2.2</td>
</tr>
<tr>
<td>Land Lease</td>
<td>0.039</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3.545</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
Average Shrimp Processing Price Breakdown

Heading $ .22
Grade or pack .20
Boxes .05
Harvest labor .05
Trucks .03
Ice .08
$ .63 Total

(Price usually includes 1-month cold storage)
Quiz for Section A

Name:

Date:

Quiz on Determining the Opportunities in Shrimp Culture

Circle a T for True statements or an F for False statements.

1. T    F  Shrimp are the most desirable seafood in the United States.

2. T    F  Shrimp occur naturally in the tropical, subtropical, and temperate regions of the near shore waters of the world.

3. T    F  Shrimp were first produced in the northern United States.

4. T    F  Penaeidae is the most common family and *Penaeus* is the most common genus of saltwater shrimp.

5. T    F  The 3 most commonly cultured species of *Penaeus* are *P. monodon*, *P. vannamei*, and *P. chinensis*.

6. T    F  A cold-tolerant species is *P. chinensis* (*P. orientalis*).

7. T    F  All shrimp for human consumption is imported into the United States.

8. T    F  Most shrimp sold to U.S. markets is packaged green-headless in 5-lb waxed boxes.

9. T    F  The price paid to farmers for 31-35 count shrimp ranges from $5.00-7.00/lb.

10. T   F  It usually takes 2 lbs of feed to produce 1 lb of shrimp.
Key for Quiz - Section A

1. T
2. T
3. F
4. T
5. T
6. T
7. F
8. T
9. F
10. T
Slides for Section A

#1. Various types, sizes, and colors of shrimp.
#2. World distribution of Penaeidae (along equator north and south to 15-20°C isotherms). (Most species are found near shore rather than deep ocean.)
#3 & #4. Mostly near-shore areas of world where penaeid shrimp occur naturally.
#5. Major penaeid shrimp fishing grounds in United States.
#6. 3 major types of shrimp caught in United States (white, pink, and brown).
#7. World aquaculture production by species (pie chart).
#8. Giant Tiger shrimp (P. monodon).
#9. Giant Tiger shrimp (P. monodon).
#11. Western White shrimp (P. vannamei).

Other important species:

#14. Growth curve of 11 penaeid shrimp species under cultivation.
#15. Production and trade of farm-raised shrimp (where produced and consumed).
#17. U.S. shrimp catch (leveled off) and imports dollar value and pounds still climbing to $2 billion. Next to oil and automobiles, seafood is the United State’s 3rd largest trade deficit.
#18. Shrimp fresh without heads and boiled shrimp.
#19. 5-lb waxed box of frozen green headless shrimp.
#20. Peeled shrimp.
#21. Cost analysis per pound of shrimp tails.
#22. Ponds in the Philippines.
#23. Ponds in Thailand.
#24. Ponds in Taiwan.
#25. Ponds in Indonesia.
#27. Building ponds in China.
#28. Ponds in China.
#29. Location of Texas farms.
#30. Texas shrimp farm.
#31. Texas shrimp farm.
#32. South Carolina
#33. South Carolina harvest.
#34. Hawaii farm.
#35. Hawaii round pond.
#36. Hawaii - Hawaii farm (with rainbow) “Everyone looking for that pot of gold.”
#37. Price breakdown on shrimp processing.
Teaching Plan:

Module: Saltwater Shrimp - Section B

Problem Area: Exploring Life Cycle of Saltwater Shrimp

Estimated Time: 5-10 hours

Goal: The goal of this problem area is to understand the biology, life cycle, and cultural requirements of saltwater shrimp.

Learning Objectives: Upon completion of this problem area, students will be able to:

- describe how shrimp are cultured
- list pros and cons for introducing a new species
- list environmental requirements of shrimp
- list common cultured species
- discuss reproductive characteristics of shrimp
- discuss shrimp hatchery techniques
- discuss shrimp growout techniques.

Resources: The following instructional resources are needed to complete this problem area:

Essential:

Copies of the slides and transparencies.


Laboratory Manual for the Culture of Penaeid Shrimp Larvae, by Treece, G.D & M. Yates, Texas A&M University, Sea Grant, Publication #88-202, 95 pp., 1990.

Additional:


Content and Procedures

Preparation (Interest Approach):

To develop student interest in this module, ask the students the following question: What conditions are necessary to sustain the life of a person? List their answers on the board. Possible answers include air, water, food, shelter, clothing. How does this list differ when applied to shrimp? Discuss their answers. Explain that all living organisms have environmental requirements. Explain that the class is going to learn about the particular cultural requirements of shrimp so that we can understand how they can be aquacultured by humans.

Presentation:

A. Why are so much shrimp imported into the United States?

1. Nutritional benefits of eating seafood becoming known.
2. Demand is greater than supply in the United States.
4. The U.S. Customs Service reports that over 450 companies imported shrimp into the U.S. during 1992.

B. Where are shrimp distributed?

1. All over the tropical, subtropical, and temperate latitudes.
2. Different species have different requirements. Some are cold water species, some are warm water species, some tolerate high salinities etc.

C. What is the life cycle of penaeid shrimp?

Show slide #1, penaeid shrimp life cycle (choice of two life cycle slides 1a or 1b).

1. Juveniles and adults migrate offshore and in the stable environment of the ocean mature mate and spawn eggs in near shore or offshore waters.

Show slide #2, white shrimp as female matures and increases number of eggs. Show slide #3, white shrimp female mated.

2. Eggs sink, but hatch within 14 hours at 28°C.

Show slide #4, fertilized egg, and slide #5, egg ready to hatch.

3. The nauplius (1st larval stage) is attracted to light (plural is nauplii).

Show slide #6, nauplius stage.

4. One of three zoeal stages.

Show slide #7, 1 of 3 zoeal stages.

5. Post-larval stage.

Show slide #8, post-larval stage.

6. Larvae are swept to shore by currents where they find adequate food and habitats to grow up in approximately 4 months.
D. Why were exotic penaeid shrimp introduced into the United States?

Ask students why it concerns many people when a new species is introduced into an area outside its natural range. (It may compete with native species or have unintended consequences.)

1. *P. vannamei* and *P. stylirostris* were introduced to the U.S. from their normal range of Baja California to Peru in the Pacific.
   a. They were introduced when it was found that they grew faster, larger and could make aquaculture more economical than local species.
   b. The Pacific species seem to be "more forgiving" to the grower, meaning that they are harder and survivals are generally better.

2. Some biologists perceive exotic shrimp as threats to the environment and to native shrimp. There is evidence that shrimp can transfer viruses which prompted the development of SPF shrimp which are certified by a qualified pathologist to be free of specific diseases.

3. In most parts of the continental U.S. tropical exotic shrimp cannot establish a sustaining population because they die during the winter.
   a. This characteristic eliminates the overpopulation problem that can exist in southern states, Hawaii, and other U.S. territories and protectorates.
   b. Some biologists are concerned that tropical exotic shrimp will (if released in sufficient numbers) compete for habitat with local shrimp and after a cold winter, there will then be a shortage of both types of shrimp and will affect the livelihood of the shrimp harvest industry in the U.S.

E. What are the potential effects of aquaculture on the shrimp industry? Show slide #9 while discussing the effects of aquaculture on the shrimp industry. Show slide #10, cultured shrimp in total world shrimp production.

1. Aquaculture can help relieve some of the pressure being placed on world shrimp populations in the wild by fisheries.
2. Aquaculture has been increasing its percentage of the total world shrimp production.
3. Aquaculture is giving new life to a near-moribund shrimp processing industry worldwide.
4. Aquaculture is spawning a new spectrum of support activities related to the seafood industry.
5. Aquaculture is sending production volumes soaring and affecting the prices of shrimp worldwide.
6. Aquaculture is altering the composition of exports because more and more groups are working with value-added (cooking and peeling etc.) shrimp products.
7. Aquaculture also utilizes other industries (grain, etc., in feed) and provides jobs. A shrimp feed industry has developed because of aquaculture.

F. What are the advantages of cultured shrimp?

1. Preference of cultured shrimp by processors, exporters, and importers.
   a. Not as seasonal as wild-caught shrimp.
   b. Considered more reliable, more uniform in size, a higher quality, and a fresher product.
   c. Cultured shrimp can be predicted and planned for.

2. Allows industry to adapt to consumers' demand regarding species and size.

3. Shrimp can be provided live or near-live to restaurants that serve seafood.
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G. What are some of the environmental and cultural requirements to raise tropical (exotic) shrimp?

Show TM B1 and discuss cultural/environmental requirements of shrimp.

1. Tropical shrimp do not grow well below 24°C (68°F) and will experience stress below this temperature, will not eat, and will die at 50°F and lower.

2. Shrimp are omnivorous but are often described as primarily herbivorous.
   a. In an aquaculture situation, they are usually fed a grain-based prepared feed.
   b. In the pond and in the wild, different species of shrimp occupy different “niches” in the pond.
      (They feed or graze upon different organisms or plants [diatoms] in the pond.)

3. Tropical penaeid shrimp are naturally found in brackish water, but they can survive in freshwater. This environment, however, causes stress and sometimes soft shells.

4. Tropical penaeid shrimp look very much like local (endemic) species in the U.S.
   a. Generally a biological key is required to separate the species and obtain a positive identification.
   b. Normal color patterns include white, brown, and blue. *P. vannamei*, for example, are generally white with red antennae.

H. What species are commonly cultured?

Show TM B2 and TM B3 and discuss the various species of shrimp.

1. Penaeid species most widely cultured worldwide are *P. monodon*, *P. vannamei*, *P. chinensis*, *P. stylirostris*, *P. japonicus*, *P. penicillatus*, *P. merguiensis*, and *P. indicus*.

2. Researchers and farmers also work with a wide range of other penaeid shrimp species.
   a. In the Western Hemisphere: *P. subtilis*, *P. paulensis*, *P. setiferus*, *P. brasiliensis*, *P. duorarum*, *P. occidentalis*, *P. schmitti*, and *P. californiensis*.
   b. In the Eastern Hemisphere: *P. semisulcatus*, *P. latisulcatus*, *P. kerathurus*, and others.

I. What are some of the physical characteristics of penaeid shrimp?

Show slides #11, *P. setiferus*, side view, and #12, top view of adult.

J. What are some of the reproductive characteristics of penaeid shrimp?

Show slides #13 and #14, details of male and female reproductive systems. Optional activity: Keep tropical exotic shrimp in aquarium tank or pond if available. (Obtain proper permits if required in state.)

1. Grooved shrimp, brown shrimp, closed thelycum shrimp (e.g., *P. monodon*, *P. aztecus*) molt, mate, develop eggs, spawn.

2. Nongrooved shrimp, white shrimp, open thelycum shrimp (e.g., *P. vannamei*, *P. setiferus*) develop eggs, mate, spawn.

3. Grooved brown shrimp etc. can spawn several times on one mate or until animals molt and lose the sperm packet. (Sperm packet is held inside body and is deposited during mating, only after female has molted.)

4. Nongrooved, white shrimp, etc. spawn after spermatophore is placed externally during mating and generally spawn within hours after mating.

Show slides #15 and #16, details of reproductive system (spermatophore, etc.).
5. Once the eggs are spawned they may not all develop in the same manner. Some may develop abnormally.

Show slide #17, male reproductive system dissected.

6. Sexual maturity for male and female shrimp occurs as early as 34 g in size for *P. vannamei* and 60 g for *P. monodon*.

Show slide #18, egg development sequences.

   a. They may spawn numerous times during their mature lifetime.
   b. Smaller sized shrimp live approximately 1.5 years and the larger ones may live to 3 years.

K. What are the major factors controlling maturation/reproduction?

Show TM B4 and TM B5 and discuss reproductive/hybridization of shrimp.

1. Environmental conditions:
   a. 14 hours of light and 10 hours of dark is an average photoperiod used. The light is usually dim.
   b. Temperature is also critical and is species dependent. 28±1°C is preferred for most tropical-subtropical shrimp.
   c. Oceanic conditions maintained with stable salinity, high salinity (32-36 ppt), stable temperature, and good water quality.

2. Hormonal manipulations. Ablation, or removal of one of the female's eyes, damages a gland and causes the females to go into mass production of eggs. This generally lasts for 3 months or until egg quality begins to drop.

Show slides #20, ablation, and #21, large female, *P. monodon* ablated.


Show slides #22-#25, maturation foods, squid, preparing squid, and small shrimp, respectively.

   a. Worms - usually blood worms (*Glycera*) provide HUFA (High Unsaturatued Fatty Acids). Snails, bivalves, squid, and small shrimp.
   b. *Artemia*. Other crustaceans high in HUFA.

Show slide #26, *Artemia*, brine shrimp adults.

L. What are the other major aspects of penaeid shrimp aquaculture?

Show slide #27, major aspects of shrimp aquaculture (maturation, hatchery, growout).

1. Maturation - discussed earlier.
2. Eggs - nauplii - discussed earlier.
3. Sourcing (or obtaining adult or brood shrimp).

Show slides #28, shrimp boat, #29, brood boxed up, #30, fishing platforms for brood, and #31, brood animals in maturation system.

4. Larval rearing:
Show slide #32, shrimp hatchery. Optional activity: May follow exercises on larval rearing in Laboratory Manual for the Culture of Paned Shrimp Larvae (listed at beginning of Section B). Show slides #33, larval stages and feed, and #34, algae production rack. Show slides #35, commonly used algae types, and #36, algae room. Show slide #37 and #38, Artemia cysts collection, #39, Artemia cysts sold in can, #40, Artemia hatching stand and hatching cones, #41, stages of Artemia development, and #42, separating freshly hatched Artemia from debris before feeding.

a. Larval stages and feeding.
b. Growing and feeding algae.
c. Feed Artemia nauplii to later stages of penaeid shrimp.
d. Artemia cysts are collected commercially by numerous companies, cleaned, dried, processed, and sold to hatcheries.
e. Cysts are sold in cans and placed in seawater, aerated, and exposed to light and then they hatch. Artemia hatch and larvae (instars or nauplii) are fed immediately.

5. Post-larval holding: Post-larvae are held from 5 to 18 days before stocking in ponds.

Show slide #43, holding post-larvae in tanks and feeding until sold or stocked in ponds.


Show slide #44, adjusting conditions in larval transport container before releasing post-larvae. Show slide #45, transporting post-larvae to nursery (in-pond greenhouse), slide #46, typical nursery ponds. Slide #47, different sizes is species-related, and slides #48 and #49, harvesting P. vannamei.

a. Shrimp are placed in ponds or raceways for growout.
b. Post-larvae can either be stocked in nursery pond for 1 month or directly into a growout pond.
c. Sizes of shrimp vary (depending upon species and other factors).
d. P. vannamei average 20 g after 30 days in nursery and 120 days in growout.

Review:

Review by having students demonstrate their knowledge and understanding of the objectives for this problem area. Lead a discussion with students by asking questions that cause them to explain the content that goes with each objective.

Application Activities:

Application can be addressed in several ways. Students can conduct library research on various species of tropical shrimp. They can report their findings to the class. Students can also use reference materials to determine the pros and cons of introducing non-native species to a new environment, and report on regulations controlling their introduction. Examples include zebra mussels, common carp, nutria, and rabbits in Australia. Emphasize both the positive and negative results. An aquarium project with either tropical shrimp or other locally available shrimp could be conducted. If a tropical shrimp farm exists in the area, a field trip to the farm may be arranged.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of producing tropical shrimp in an aquaculture environment, written reports, and written exams. Example exam questions are attached.
Cultural Characteristics of Tropical Shrimp

- Temperature:
  28±1°C for good reproduction

- Diet:
  Squid, marine worms, clams
  Oysters, (mollusks), shrimp, krill, *Artemia*,
  Some other crustaceans high in HUFA

- Salinity:
  Oceanic 28-36 ppt

- Light:
  14 hours of light
  10 hours dark (dim light)

- For commercial production:
  Ablation or removal of 1 eye on female
Commonly Cultured Species of Saltwater Shrimp

- *P. monodon*  
  (Eastern Hemisphere)

- *P. chinensis*  
  (Eastern Hemisphere)

- *P. vannamei*  
  (U.S. & Western Hemisphere)

- *P. stylirostris*  
  (Western Hemisphere)

- *P. japonicus*  
  (Eastern Hemisphere mostly; has been grown in Western Hemisphere)

- *P. penicillatus*  
  (Eastern Hemisphere)
Other Cultured Tropical, Subtropical, and Temperate Shrimp

- *P. schmittii*
- *P. semiculcatus*
- *P. brasilensis*
- *P. paulensis*
- *P. setiferus*
- *P. subtilis*
- *P. duorarum*
- *P. occidentalis*
- *P. californiensis*
Attempts at Hybridization for Aquacultured Shrimp

The following crosses have been attempted and produced crosses that were genetically verified:

(setiferus x schmittii),
(setiferus x stylirostris)

But the crosses did not reproduce.

(University of California and Texas A&M University)
Reproduction Facts for Tropical Shrimp

- Brown shrimp first molt, mate, develop eggs, then spawn.
- White shrimp first develop eggs, mate, then spawn.
- Eggs hatch in approximately 14 hours at 28°C.
- Sexual maturity for females begins at 34 g in some species and larger (60 g) in others.
- 65-g females spawn about 100,000 eggs at a time and may spawn numerous times if ablated.
- Photoperiod in spawning: Need at least 14 hours of dim light with 10 hours of dark.
- 28±1°C is the best temperature for most tropical shrimp.
Quiz for Section B

Name:

Date:

Quiz on Exploring Life Cycle of Saltwater Shrimp

Directions: Write your answer in the space provided.

1. Where were tropical shrimp first cultured in the United States?

2. List 2 reasons why some biologist perceive tropical shrimp to be a threat to the native environment.

3. What is the major reason why tropical shrimp cannot establish a population in the United States?

4. Why aren't domestic shrimp cultured commercially?

5. What are broodshrimp fed (for a reproductive diet)?

6. What are the 3 most commonly cultured species?

7. What is another name for grooved shrimp?

8. What is another name for a nongrooved shrimp?

9. How many eggs does an averaged sized (65-g) female broodshrimp spawn?
Key for Quiz - Section B

1. Southern U.S. (Florida and Texas).
2. Spread of disease and competition.
3. Cold temperatures in winter.
4. They do not grow as rapidly and as large as exotics on the average.
5. Marine worms, squid, mollusks, shrimp, or other crustaceans high in HUFA.
6. *P. monodon*, *P. vannamei*, *P. chinensis*.
8. White shrimp.
9. 100,000.
Slides for Section B

#1. Penaeid shrimp life cycle (choice of two slides 1a or 1b).
#2. White shrimp maturing (Note: top 3 females with developing eggs; bottom is male).
#3. White shrimp female mated (Note: spermatophore or white mass on ventral or underside of female).
#4. Fertilized shrimp egg (approximately 210 microns in diameter, with clear membrane).
#5. Fertilized shrimp egg ready to hatch.
#6. Nauplius stage.
#7. One of 3 zoal stages (Note: development of pointed nose [Rostrum] and compound eyes).
#8. Post-larval stage of shrimp.
#9. The impact of aquaculture on the shrimp industry.
#10. Cultured shrimp in total world shrimp production (from FAO 1982).
#11. Lateral view of adult female P. setiferus.
#12. Dorsal view of adult shrimp.
#13. Details of male and female reproductive system (open theyicum type or nongrooved shrimp).
#14. Details of male and female reproductive system (open theyicum type or nongrooved shrimp).
#15. Details of male shrimp reproductive system.
#16. Details of male shrimp reproductive system.
#17. Male reproductive system (dissected). Visible are testis, vas deferens, and terminal ampoule (which houses the spermatophore on one side) is black because of infection.
#18. Penaeid shrimp egg development sequence (after Primavera).
#19. Major factors controlling maturation/reproduction.
#20. Eye ablation.
#21. Large female P. monodon with eye ablated.
#22. Maturation foods.
#23. Squid.
#24. Preparing squid removing pen, beak (mouth parts) and ink.
#25. Small shrimp are fed to broodstock.
#26. Frozen Artemia (brine shrimp) are often fed to provide HUFA.
#27. Major aspects of shrimp aquaculture (maturation, hatchery, growout).
#28. Sourcing or obtaining brood (shrimp boat).
#29. Brood boxed up for shipping.
#30. In some areas of the world fishing platforms and nets are used to catch brood (Indonesia).
#31. Brood animals in maturation system.
#32. Shrimp hatchery.
#33. Shrimp larval stages and feed.
#34. Algae production rack.
#35. Commonly cultured microalgae used as feed for shrimp larvae.
#36. Algae room.
#37. Artemia cyst collection by commercial companies.
#38. (Same as #37).
#39. Artemia cysts (eggs) sold in can.
#40. Artemia hatching stand and hatching cones. (Larger hatching containers are required in hatcheries.)
#41. Stages of Artemia development (Instar V stage is fed to penaeid shrimp larvae.)
#42. Separating freshly hatched Artemia from debris before feeding Artemia to shrimp larvae.
#43. Holding and feeding post-larval shrimp in tanks until they are sold or stocked in ponds.
#44. Adjusting conditions in larval transport container before releasing post-larvae into pond.
#45. Transporting post-larvae to nursery (in-pond greenhouse).
#46. Typical nursery ponds.
#47. Different sizes of shrimp after 100 days depend on species being cultured and other factors.
#49. (same as #48)
Teaching Plan:

Module: Saltwater Shrimp - Section C

Problem Area: Obtaining Seedstock - Spawning to Post-Larval Production

Estimated Time: 5-10 hours

Goal: The goal of this problem area is to understand spawning production of larvae and production of post-larvae.

Learning Objectives: Upon completion of this problem area, students will be able to:

- describe hatchery systems used to spawn and raise tropical shrimp
- discuss the factors affecting maturation/hatchery production
- describe procedures used in spawning shrimp
- describe procedures used in larval rearing shrimp
- describe procedures used in seawater treatment for hatcheries

Resources: The following instructional resources are needed to teach this problem area:

Essential:

Slides and transparencies.


Laboratory Manual for the Culture of Penaeid Shrimp Larvae, by Treece, G.D. & M.E. Yates, Texas A&M University, Sea Grant Publication #88-202 (R), 95 pp., 1990.

Additional:

Circular maturation tank (10-12 ft diameter). Can be easily constructed with 5 sheets of 1/4 in. plywood, overlapped and bolted, with stainless steel bands. A black plastic PVC liner, water inlet, outlet drain, and small light bank hung overhead. Water heater for maintenance of 28°C water (see slide A).

Larval rearing rack or stand made of wood (slide B). This stand can be easily made with 1-liter imhoff cones placed on a small wooden rack or a larger rack with ten, 5-gallon plastic drinking water bottles. The bottles are inverted with the bottoms removed as depicted in Figure 3 of Treece & Yates (1990) page 4 (slide C). The bottles are used to rear larvae and are equipped with heater, aeration and drain. See slide B for completed 10 bottle rack for larval rearing. The rack is equipped with air pump and valves and light.

A series of aquaria, preferably with flow-through system. Construct a wooden rack as seen in slide D or place aquaria on table built strong enough to support weight (water weighs approximately 8 lbs per gallon). Place screen over tanks. Place inlet and outlet as shown in slides E and F. Aquaria can be used to grow shrimp from the post-larvae to approximately 6 g in size. If available, a small aquaculture pond or raceway can be used for shrimp growout.
Preparation (Interest Approach):

To develop student interest in this module, ask the students the following questions: Where does one get the seed to plant tomatoes? Where does one get chicks to stock a broiler house? Where does one get pine seedlings to start a forest?

The answers should include both producing and purchasing the seed, chicks, or seedlings. Why would one choose to purchase seed rather than produce it? Answers should include that it is easier to purchase, less knowledge is needed to purchase, more economical to purchase, do not have the facilities to produce seed, do not have the time to produce seed, and purchased seed may be of higher quality than seed produced at home.

Finally, explain that shrimp seedstock is similar to the above. One can produce it (or in some countries harvest from the wild) and/or buy it from an outside source. Which is better? That depends on many factors that will be discussed in this topic area.

Presentation:

A. Where are shrimp post-larvae obtained for stocking in ponds?

Show slides #1 and #2, wild seed harvesting in Ecuador (not allowed in United States). Show slides #3-#5, shrimp hatcheries.

1. Wild harvest (seasonal).
2. Hatchery.

B. What hatchery systems are used to spawn shrimp?

Show TM C1 and TM C2 and discuss hatchery systems for shrimp. Show slides #6 and #7, extensive hatching tanks. Slides #8 and #9, intensive maturation/hatchery facilities in India and Indonesia.

1. In most aquaculture enterprises, obtaining spawns is one of the most difficult tasks the producer faces. Shrimp spawn easier under the right conditions. It is knowing the proper conditions and adhering to them which separates the good hatcheries from the nonproductive ones.

2. Hatchery systems for producing saltwater shrimp can be grouped into 2 general categories:
   a. Extensive: Animals are held in very low densities in tanks or ponds and allowed to spawn. Sometimes spawners are brought in from the wild or reared in ponds.
   b. Intensive: Animals are held in higher densities for longer periods with high water exchanges, high protein diets, and high water quality standards.

3. In ponds, extensive is the least complex.
   a. It is also the least efficient in terms of production for the volume of water used.
   b. Problems include low broodstock density, inefficient harvesting techniques, and possibly inefficient diet.
   c. Also in temperate climates, tropical animals must be overwintered or brought inside during the winter.

4. Hatchery systems using tanks can be managed more intensively for higher production. Tanks in a controlled environment are the most productive and are more commonly used to propagate shrimp.
C. What factors affect maturation/hatchery?

Show TM C3, TM C4, and TM C5 and explain factors affecting hatchery production. Show slides #10-#13, spawning tanks.

1. Intensive maturation production is normally conducted with a 1:1 male-to-female ratio. Stocking in 5m²-7m² (or approximately 25 males and 25 females in a 12-ft circular tank).

2. Environmental conditions, hormonal regulation, and nutrition are 3 major factors that affect shrimp maturation (discussed in Section B).

3. Biological and environmental factors affecting maturation results:
   a. Water temperature, photoperiod, light intensity, water quality, nutrition, age and size of broodstock, broodstock density, and sex ratio.
   b. Proper removal of female and placement in spawning tank, return of female to maturation tank after spawning, incubation of eggs, source of broodstock and stability of temperature (28±1°C) for most tropical species) and salinity (28-36 ppt). (Also discussed in Section B - but not in as much detail.)

4. Hormonal regulation involves ablation or removal of one eye of female broodstock to induce maturation. Unlike fish, there are no known hormone shots for shrimp used regularly in hatcheries.

5. Nutrition is the third major factor affecting maturation. Shrimp must be provided a high protein diet, with high steroids, and HUFA for good reproduction and viable egg production.

6. Additionally, an important recent research finding was that after animals have been in intensive maturation systems for a period of time, the female ovaries begin to bleach out from a bright red color, which produces a high-quality larvae, to a whitish color, with a 10-20% lower survival.

Show slide #14, female shrimp with egg mass and slide #15, soft-shelled female shrimp that turned blue.

   a. The female's shell often becomes soft and turns blue. The blue color has been diagnosed as a carotenoid deficiency, suggesting that there is not enough pigment in the broodstock diet.
   b. Carotenoid was incorporated into the brood diets with the addition of paprika (nature's highest source of the carotenoid, astaxanthin).
   c. Marinate the squid (fed to brood) in paprika before feeding. As a result, larval quality and survival, as well as female brood ovary color and shell hardness, improved.

7. The number of eggs is positively correlated with size of female broodstock. The larger the shrimp, generally the more eggs are produced.

8. Shrimp are found in natural environments in a 1:1 ratio and most hatchery managers use this ratio. If there is a problem with males, then a 2 males to 1 female ratio is used, etc.

9. Female shrimp can regenerate eggs and spawn again in approximately 5 days after a spawn and males can regenerate the spermatophores in a similar period of time.
Aquaculture Curriculum Guide

10. Fertilized eggs are allowed to remain in the spawning tanks until they hatch into the nauplius stage.
   a. They require aeration (high oxygen). Eggs normally sink but will remain in the water column as long as there is aeration.
   b. Over a 3-month period, an average of 50% hatch. Beginning hatches are generally in the 90% hatch range and taper off over time.

11. Most drugs are not approved for use by the FDA in production systems.
   a. Researchers and growers are attempting to gain approval for some therapeutics for aquaculture. Check with your state aquaculture extension specialist for current recommendations.
   b. EDTA is approved and is often used as a chelator (helps keep debris from adhering to eggs and larvae in the hatchery). A 2 ppm solution is used most often.

D. What is the most common method of spawning shrimp?

Conduct a discussion using slides and describe intensive maturation system. Show slides #16 and #17, maturation tanks. Show slide #18, cleaning maturation tanks. Show TM C6, length-to-weight conversion chart, and slide #19, searching for mated female shrimp.

1. Shrimp are typically spawned in intensive maturation systems.
   a. 12 ft diameter circular or oval tanks with dark sides, low light intensity.
   b. Approximately 200% per day water exchange to maintain oceanic quality.
   c. Feeding animals to satiation or ad libitum (everything they can eat with only a slight excess), stable temperature (28°C), and stable salinity (28-36 ppt).

2. Shrimp are fed 3-5% dry weight or 15-25% wet weight per day.

3. They gain weight at approximately 5 g per month.

4. They can be measured for length to obtain a quick estimation of size (by using a length-to-weight conversion chart). This minimizes stress to the animal due to handling.

5. Shrimp are stocked at 5/m² to 7/m² and females ablated.

6. 3 days after ablation, eggs develop.
   a. 1 week after ablation the first spawn generally occurs.
   b. 3 weeks after ablation, the tank should be in full production.

E. What are the larval rearing techniques used in intensive hatchery production?

Optional activity: Set up a tank (small 1-liter) in whole cone or 5-gallon plastic bottles. Place 100 shrimp nauplii in each cone for a class project. Follow temperature and other requirements listed in the module. May divide into groups depending upon how many tanks and students. Follow exercises II-IV in Laboratory for the Culture of Shrimp Larvae.

1. Incoming seawater is generally filtered down to 1 micron before using in larval rearing and algae production. To deal with large volumes of water for a large hatchery the following steps are usually taken.

Show slide #20, schematic of typical intake and treatment systems. Show slide #21, pipeline to carry water inshore to hatchery, #22, numerous pipes in Taiwan, and #23, settling and slow-sand filter. Show slide #24, results of treatment (before and after), #25, pressurized sand filters, #26-#27, diatomaceous filters, and #28, cartridge filters. Show slide #29, UV treatment and #30, ozone unit.
Saltwater Shrimp

a. Subsand intake to filter out large debris.
b. Pipeline to inshore (via pumping).
c. Settling and slow-sand filter.
d. Pressurized sand filter (\(-12\) micron).
e. Diatomaceous filter (\(-3\) micron).
f. Cartridge filters 5 to 1 microns.
g. UV treatment.
h. Ozone treatment is sometimes used.

2. Shrimp larvae are staged and classified according to their stage of development.

3. The larvae are then fed according to that stage of growth.

Show slides \#31 and \#32, typical method used in algae culture. Show slide \#33, algae production in plastic bottles, and slides \#34-\#35, algae production in Plexiglas cylinders.

4. Microalgae are grown using standard algae culture procedures and fed to beginning stages of shrimp.

5. Algae can be cultured in 5-gallon plastic drinking bottles.

6. Other larger containers may be used if greater quantities are required.

7. Algae are fed to larval shrimp and maintained at certain critical levels (above 35,000 cells/ml and below 200,000 cells/ml; average 100,000 cells/ml).


8. Algae have a typical growth curve. They typically pass through 5 phases. They are the best food source when fed only during the exponential growth phase (phase II of V on slide \#37).

Show slide \#36, typical phytoplankton culture growth.

9. At the late zoal and early mysis stage, shrimp larvae are fed Artemia nauplii per the quantities described in Larval Rearing Feeding Regime (slide \#32 of Section B).

10. Artemia cysts (slides \#37-\#42 Section B) are placed in seawater (5-g cysts/liter of water).
   a. Aeration and light source are provided.
   b. Allowed to hatch (usually within 24 hours).
   c. Freshly hatched nauplii are then separated from empty shells and debris by removing the aeration and allowing settling to occur.

11. Artemia cysts are usually disinfected with a dip into chlorine or they may be decapsulated using chlorine.


12. Shrimp larvae may also be fed Artemia flakes, freeze-dried Artemia, or a dry micro-encapsulated diet. These diets are considered best utilized as supplemental diets only and should be fed in combination with algae and live Artemia nauplii.

13. It takes approximately 18 days (including harvest, drain-down time, tank dry-out time, and refill) to make one larval run in the hatchery.
F. What are the most common characteristics of an intensive culture shrimp larval rearing tank?

Show slide #38, typical larval rearing tank.

1. Drains easily and completely so that all larvae are harvested. (Most have a gentle sloping bottom.)
2. Keeps all larvae and food suspended in the water column. Usually uses gentle aeration, and does not allow the buildup of metabolic wastes on the bottom or certain areas of the tank.
3. Comes in various sizes and shapes but usually has smooth surfaces so as not to damage larvae. Most are coated with gel coat of some type.

Show slide #39, various sizes and designs of larval rearing tanks.

4. Stocked with 100 larvae/liter.

5. Most are painted white to reflect light.

Show slides #40, ceramic tile rectangular tank in Ecuador and #41, cement rectangular tanks in Indonesia. Show slides #42, square cement tanks in China and #43, half-barrel tank in Ecuador. Show slides #44, double half-barrel tank in Ecuador and #45, circular, conical tank in Indonesia.

Review:

Review by having students demonstrate their knowledge and understanding of the objectives for this problem area. Lead a discussion with students by asking questions that cause them to explain the content that goes with each objective.

Application Activities:

Application can be addressed in several ways. If the class has access to a tank or suitable pond, a spawning project or larval rearing project would make an excellent application. A larval rearing project with shrimp would probably be the easiest and shortest project. Students can also do library work to locate current articles on spawning and producing shrimp. Students can do library work to see what other food can be fed to shrimp larvae. Students could design a hatchery system on paper to produce 1 million post-larvae each year.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of spawning shrimp in captivity by the method studied and rearing larvae in captivity, written reports, and written exams. Example exam questions are attached.
Hatchery Systems for Shrimp

- Extensive Systems:
  Ponds

- Intensive Systems:
  Circular or oval in controlled environment

- Wild-caught brood

- Domesticated (pond raised) brood
Spawning Shrimp in Intensive, Controlled Environments

- Most common method

- Advantages:
  More productive
  Allows shrimp larvae production year-round

- Disadvantages:
  Higher volume of water required
  Higher broodstock density: (5-7m²)
  Ablation required
  Brood animals are productive for 3 months Then must be replaced

- Stocking rate: 5 m²
  1:1 ratio of males and females

- Fed to satiation (or ad libitum)

- Tanks kept clean

- Oceanic-quality water

- Stability in salinity and temperature
Hatchery Production: 3 Major Factors Affecting Maturation

Efficiency is largely a function of:

- Environment maintained in hatchery: Oceanic conditions
  Water
  Temperature
  Light
  Water quality
  Salinity

- Nutrition provided to the animals

- Hormone regulation (ablation)
Biological and Environmental Factors Affecting Hatchery Production

- Salinity (oceanic 28-36 ppt)
- Water temperature (28±1°C)
- Photoperiod (14 light +10 dark)
- Water quality (oceanic)
- Nutrition
- Age and size of broodstock
- Broodstock density 5m²
- Sex ratio 1:1
- Female removal and return
- Incubation of eggs in spawning tank
Temperature, Photoperiod, Required Salinity for Spawning

- Most tropical shrimp require $28\pm1^\circ C$ for spawning
- Average 14 hours of light, 10 hours dark photoperiod
- Oceanic (28-36 ppt) salinity (stable)
**Penaeus vannamei and monodon**
Length-to-Weight Conversion

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Quiz for Section C

Name:

Date:

Quiz on Obtaining Seedstock - Spawning to Post-Larval Production

Directions: Answer in the space provided.

1. Which is the most common hatchery system used to produce shrimp?

2. What are 3 major factors affecting maturation?

3. What are the biological or environmental factors affecting hatchery production?
Aquaculture Curriculum Guide

Key for Quiz - Section C

1. (Intensive culture) tanks with intensive controlled environment

2. Environmental control, hormonal control, nutrition

3. Salinity
   Water temperature
   Photoperiod
   Water quality
   Nutrition
   Age and size of broodstock
   Broodstock density
   Sex ratio
   Female removal from maturation tank
   Female return to maturation tank (after removal from spawning tank)
   Incubation of eggs
Slides for Section C

A. Maturation tank (shop-made).
B. Larval rearing rack.
C. Inverted 5-gallon plastic bottle used for larval rearing.
D. Aquarium rack.
E. Flow-through aquaria.
F. Flow-through aquaria.
#1. Harvesting wild post-larval shrimp in surf.
#2. Harvesting post-larval shrimp with scissors net.
#3. Harlingen Shrimp Hatchery (Texas).
#4. Shrimp Hatchery in India.
#5. Hatchery in Indonesia.
#6. Extensive \textit{P. japonicus} hatching tanks (located in Hawaii, owned by a Japanese company). \textit{P. japonicas} mated females are brought in from ponds to spawn.
#7. Example of extensive (wild caught, mated female \textit{P. monodon} holding tanks in Indonesia).
#8. Intensive maturation/hatchery facility (India).
#9. Intensive maturation/hatchery facility (Indonesia).
#10. Shrimp spawning tanks (Indonesia for \textit{P. monodon}).
#11. Shrimp spawning tanks (Indonesia for \textit{P. monodon}).
#12. Shrimp spawning tanks (Texas for \textit{P. setiferus}).
#13. Shrimp spawning tanks (Caribbean for \textit{P. vannamei}).
#14. Female shrimp with egg mass, dark red in color.
#15. Soft-shelled, blue colored female shrimp in intensive maturation system, no carotenoid in diet.
#16. 12 ft diameter circular maturation tank.
#17. Oval or rectangular tank with rounded edges.
#18. Cleaning maturation tanks with siphon (swimming pool vacuum head-on rollers).
#19. Searching for mated female shrimp with flashlight and dip net.
#20. Schematic of typical water intake and treatment system for hatchery.
#21. Intake pipeline to carry water into hatchery.
#22. Numerous pipes in Taiwan.
#24. Results: before and after treatment.
#25. Pressurized sand filters.
#26. Diatomaceous filters.
#27. Diatomaceous filters.
#28. Cartridge filters.
#29. UV treatment system.
#30. Ozone treatment unit.
#31. Larval rearing feeding regime.
#32. Typical method of algae culture.
#33. Algae production in plastic bottles.
#34. Algae production in Plexiglas cylinders.
#35. Algae production in Plexiglas cylinders.
#36. Typical phytoplankton culture growth curve (feed in phase II-exponential growth phase).
#37. Micro encapsulated diet for supplemental feeding of shrimp larvae.
#38. Typical larval rearing tank.
#39. Various sizes and designs of larval rearing tanks.
#40. Ceramic tile rectangular tank in Ecuador.
#41. Cement rectangular tank in Indonesia.
#42. Square, cement tank in China.
#43. Half-barrel tank in Ecuador.
#44. Double barrel tank in Ecuador.
#44. Circular, conical tank in Indonesia.
Teaching Plan:

Module: Saltwater Shrimp - Section D
Problem Area: Growing Out Shrimp
Estimated Time: 5-10 hours
Goal: The goal of this problem area is to understand how to care for shrimp in a growout system.

Learning Objectives: Upon completion of this problem area, students will be able to:
- describe environments where shrimp are cultured
- describe type of post-larvae needed for stocking
- explain factors related to stocking rates
- explain what shrimp eat and how they are fed
- list factors related to growth rate
- explain environmental parameters critical to shrimp culture
- discuss how to manage a shrimp pond
- discuss how shrimp are harvested and marketed
- discuss diseases and parasites that affect shrimp

Resources: The following instructional resources are needed to complete this problem area:

Essential:
Copies of the slides and transparencies.


Pond if available. (An indoor raceway can also be used, but management of raceways will not be covered in this module.)

Additional:
Handbook of Shrimp Diseases, by Johnson, S.K., Texas A&M University, Sea Grant Publication #90-601, 25 pp., 1989.


Water Quality in Warmwater Fish Ponds, by Boyd, C.E. Auburn University, AL, 359 pp., 1979.
Preparation (Interest Approach):

To develop student interest in this module, propose the following situation with your students. A man phones you, the teacher, and asked if your class would like to have some live shrimp. He is the manager of a shrimp farm and knows that your class is studying new and emerging agricultural technologies. To keep from offending him, you agree to take the shrimp. He tells you that he will deliver them to the school in 3 weeks. You hang up the phone and realize that you know nothing about raising shrimp and you should have refused the contribution.

Now that you have agreed to take the shrimp, what is your class going to need to know to keep the shrimp alive? What are the questions that need answering? Answers should include the following: What do shrimp eat? How much do they eat? What kind of facility will be needed to house them? What water quality is required? What temperature do they require? Ask the class: Where do we find the answers? (Books, periodicals, producers, researchers, and experiences of others are suggested answers.) In this module, you will learn how most shrimp are cultured, and recent developments.

Presentation:

A. What are the different environments in which shrimp are cultured?

Show TM D1 and discuss culture systems (ponds, etc.). Show slides #1-#4, shrimp ponds. Show #5, shrimp raceway culture in Hawaii, and #6, shrimp culture inland, closed recirculating system.

1. Worldwide, the most common way shrimp are cultured is in pond systems.
   a. After pond systems, tanks and raceways are used.
   b. Many producers and researchers are experimenting with indoor, intensive, closed recirculating systems.

2. If an intensive system, such as tanks, raceways, or indoor systems, is to be used it must have the following characteristics:
   a. Smooth interior, self-cleaning, ability to supply high-water quality, made of nontoxic material and easily sterilized if needed.
   b. Low construction cost, good feed distribution, water flow, and adaptable to various stages of growth of the shrimp.

3. As explained earlier, shrimp exist naturally in brackish water in the tropical regions of the world. When they are cultured, it is most often through pond systems with extensive, semi-intensive, or intensive management techniques.

   Show slide #7, comparison of extensive, semi-intensive, and intensive cultures.

4. From the standpoint of commercial production of shrimp ponds, a semi-intensive stocking density and management level are most common, which is a middle ground or center of the road approach between both ends of the spectrum.

B. What type of post-larvae should be procured for stocking?

Show TM D2 and discuss post-larvae for stocking.

1. The best post-larvae (pl) to stock in ponds, raceways, or tanks have proved to be the most active, with good color, observed with full guts, clean shells, and good muscle development.
2. SPF, or High Health, post-larvae should be obtained if possible. (Permits must be obtained for exotics.)

C. At what rates are shrimp stocked in the various growout systems?

Show TM D3 and discuss rates shrimp are stocked at in various growing systems. Leave slide #7 up for this.

1. Stocking rates for shrimp will vary according to the type of growout system they will be placed in.
   a. In pond systems, stocking rates range from 5,000-500,000/ha (approximately 2,300-220,000/acre).
   b. Some producers stock nursery ponds at 2,000,000 pl/ha (approximately 1 million/acre) and after 1 month they transfer juveniles to growout ponds of considerably larger size.
   c. Most U.S. producers stock growout ponds at 150,000-200,000/acre and manage the ponds using intensive management techniques (increased water exchange, aeration etc.).

2. In systems other than ponds, it is difficult to determine average or recommended stocking rates.
   a. Much research is being conducted on this subject and the best answer lies with each specific system being used.
   b. Some producers suggest that in tanks the rate is about 100 pl/m$^3$ up to 1,000 pl/m$^3$.
   c. 5,000-6,000 pl/m$^3$ has been attempted but the lower stocking densities have proven more successful.

3. The question is not really how many shrimp can be stocked in a given system, but rather what is the most economical stocking density for the system employed and the level of management used.
   a. For tank systems, the question is how much feed can be fed on a daily basis without destroying water quality.
   b. When the stocking density is increased in a pond, the existing natural food supplies are depleted faster and water quality is stressed.
   c. Shrimp do not react well to stress and often develop secondary infections as a result of stress.
   d. They do respond well to good management and good nutrition. The limiting factor often is DO (dissolved oxygen), followed by ammonia toxicity.

D. What do shrimp eat, how is feeding managed by the farmer, and how are they fed?

Show TM D4 and discuss the nutrition of shrimp.

1. In a low stocking density situation (300 lbs/acre) there often is enough natural food for shrimp to survive.
   a. They eat diatoms, plankton, and/or detritus.
   b. On a dry weight basis, natural food can contain about 55% protein.
   c. To encourage natural food growth, ponds are often fertilized with organic and/or inorganic fertilizers.
   d. Researchers and producers have not agreed as to the amount of fertilization necessary or desirable. Research is being conducted on this subject.
   e. As the stocking density is further increased, not enough natural food is available and supplementary feeding becomes necessary.

2. Shrimp post-larvae can be weaned from Artemia to crumbled starter food (higher protein level than adult growout diet).

Show slide #8, shrimp feed label. Show slides #9 and #10, both on feed mills in China. Show slide #11, shrimp feed storage warehouse.
a. No one really knows the nutritional requirements of shrimp and much research is being conducted on the subject.
b. In other countries, producers have fed rice bran, broken rice, oil cakes, wheat flour, corn meal, and a variety of plant refuse.
c. In many countries of the world, excellent growout commercial feed formulas have been developed and proven effective, making feed the most expensive operating cost of a shrimp farm.
d. New methods have been found to stabilize vitamin C in diets and improve shrimp growth. New binders and increased levels of wheat as a binder have all proven to be successful.

3. Some producers begin feeding post-larvae with a 40-50% protein feed at a rate as high as 18-20% of body weight per day.

Show slide #12, post-larvae and juvenile on feeding tray. Show slides #13-16, feeding shrimp. Show slide #17, average shrimp feed conversion at 2:1, and #18, typical feeding schedule based on percent of estimated body weight and typical feeding curve. Show slide #19, feeding tray.

a. When post larvae weigh 1 g (in about 1 month) they are fed 15% of body weight/day, gain 1.2 g /week.
b. By the time they reach 18-20 g they are consuming about 3-5% of body weight/day.
c. Juveniles are fed commercial feeds (about 25-32% for P. vannamei and higher, 35-38%. for P. monodon). Their feed conversion is about 2 lbs of feed per pound of gain. A typical feeding schedule based on percent of estimated body weight and a typical feeding curve for P. vannamei can be seen in slide #18.

4. The feeding schedule is just a rough guideline to follow. A more accurate way to adjust feeding is by using feeding trays.

5. Semi-intensive feed management feeding trays. Feed twice each day:
a. 40% of daily ration in the morning.
b. 60% of the daily ration in the afternoon
c. After the feed is spread throughout a pond in the morning, the feed trays are lifted, cleaned and 100 ml of feed is placed on each tray.
d. Before feeding in the afternoon the trays are lifted and the quality of food remaining on each tray is recorded. Then an average is taken of the tray values for each pond.
e. System for recording the presence of food left on tray:

0 = no feed remaining.
1 = small amount remaining, less than 12.5%.
2 = medium amount remaining, between 12.5 and 25%.
3 = large amount remaining, more than 25%.

6. Guide for adjusting the daily feed ration (tray values):

<table>
<thead>
<tr>
<th>Average Value on Trays</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2</td>
<td>Reduce previous day's ration by 30%.</td>
</tr>
<tr>
<td>&gt;1</td>
<td>Reduce previous day's ration by 20%.</td>
</tr>
<tr>
<td>0.5-1</td>
<td>Feed same amount as the previous day.</td>
</tr>
<tr>
<td>&lt;0.5 for 3 days</td>
<td>Increase previous day's ration by 10%.</td>
</tr>
</tbody>
</table>
Note: If the ration exceeds 10% of the estimated biomass, increase the ration only after 3 days of feeding the same quantity with no food left on the trays.

7. Guide for adjusting the daily feed ration (dissolved oxygen in the morning):

<table>
<thead>
<tr>
<th>Level of DO</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥3.0</td>
<td>Feed ration calculated above.</td>
</tr>
<tr>
<td>≥2.5 &amp; &lt;3.0</td>
<td>Reduce calculated ration 50% and feed it all in the afternoon.</td>
</tr>
<tr>
<td>&lt;2.5 &amp; ≥2.0</td>
<td>No food that day.</td>
</tr>
<tr>
<td>&lt;2.0</td>
<td>No feed that day and draw down level of water to 90 cm or lower and start a continual exchange until the morning DO level is above 3.</td>
</tr>
</tbody>
</table>

Note: When the daily ration is reduced because of low DO, return to the normal calculated ration the next day that the DO level is above 3.0 ppm. Use the figure for the last day that the DO level was high.

E. How fast do shrimp grow and at what weight are they harvested?

Show TM D5 and discuss how fast shrimp grow.

1. Growth of shrimp varies greatly with species, stocking density, and food supply. Other conditions such as water quality and temperature are also major factors.
2. Under ideal conditions, *P. vannamei* can reach 20 g in 120 days whereas *P. monodon* attains 35 g in the same period. The normal weight at which shrimp are harvested in the U.S. is about 16-18 g (31-35 and 25 count).

F. What are the environmental parameters critical to the culture of shrimp?

1. No matter what type of system is used in culturing shrimp, certain environmental parameters must be met for shrimp to survive, grow, and reproduce:
   a. Salinity tolerance, temperature tolerance, oxygen tolerance limits, carbon dioxide, pH and alkalinity, turbidity, and excretory products (primarily ammonia toxicity).
   b. These parameters vary for different species.

2. Salinity.

Show slide #20, refractometer used.

   a. Penaeid shrimp are considered to be brackish water shrimp, but they grow up in bay sand estuaries of the world, which are subject to abrupt changes in salinity (and other parameters) due to freshwater or watershed runoff.
   b. These brackish water shrimp actually grow better when the salinities are lower (10-25 ppt) than the normal oceanic seawater (35 ppt).
   c. However, oceanic salinities and stable conditions are necessary for reproduction.

3. Temperature.
   a. Tropical shrimp tolerate only a small temperature range.
   b. Growth occurs from 23 to 34°C for most tropical shrimp; however, the reproduction temperature ranges are even more narrow (28±2°C for most tropical penaeid shrimp).
4. Shrimp do not tolerate low DO very well.

Show slides #21-#24, aeration devices, paddle wheels, etc.

a. Below 2.0 ppm DO begins to stress shrimp.
b. 0.1 to 1.5 ppm can be lethal to shrimp depending upon species and other parameters such as salinity, pH, temperature, etc.
c. A chronic low DO level can cause shrimp to stop eating, cause stress, and subsequently can cause the onset of secondary bacterial infections.
d. Pond aeration and water movement devices and pumping water are the treatments for low DO.

5. pH and alkalinity.

a. Low pH affects blood affinity for oxygen. pH levels of less than 5 affect growth negatively.
b. Shrimp can tolerate high levels of pH for a short time.
c. Phytoplankton often cause the pH in the pond to rise to 9 or 10, sometimes higher, during the day and when there is a heavy bloom in the pond.
d. A high pH converts more ammonia to the toxic un-ionized form.
e. A pH level between 6.5-8.0 is recommended for growout and 7.88.2 for maturation.

6. Turbidity is generally an indication of the phytoplankton bloom in the pond and is maintained with pumping and fertilizing procedures. It is generally read by using a Secchi disc and is kept at an optimum reading of 8-10 inches.

Show slide #25, Secchi disc.

7. Excretory products.

a. Culture systems should be designed and managed so that excretory products do not build up.
b. In ponds, most excretory products will break down.
c. In intensive systems, excretory products must be removed. Soluble metabolic by-products such as ammonia and by-products of organic materials breaking down to nitrates are a problem.
d. Nitrates above 0.1 ppm may cause problems with reproduction. Tolerance levels in growout are not well known but much higher levels have been recorded (.75-2 ppm at 8.3 pH) without mortality.
e. Some gill damage may occur when the level of un-ionized levels of ammonia go above .5 mg/l and when other stresses are present (low DO, handling, etc.). However, growth can be reduced at these higher levels.

8. Acceptable ranges for water quality parameters in shrimp ponds:

Show TM D6 and discuss water quality parameters for tropical shrimp ponds.

G. How is a shrimp pond managed?

1. Keys to good pond management:

b. Water management (including screening out predators).
c. Enhancing natural productivity.
d. Acclimation and stocking.
e. Feed management.

2. Preparation of pond bottom:
Days After Harvest  Activity
1  Flush organic debris from pond
2  Seal gates & perform maintenance
3-10  Expose bottom to air: mineralize organic matter & kill predators
7  Add lime (1,000 kg/ha)
8  Till bottom
9  Add organic fertilizer
10  Set boards & screens in place
10  Kill predators & competitors

Show slide #26, round pond is drained and allowed to dry in the sun. Show slides #27-#29, predator control.

3. Preparation of pond water.

Days Before Stocking  Activity
10  Let water into pond & raise to full level as rapidly as possible (using predator screens on inflow-0.5 mm mesh screen or .5 micron or screen with 52 sq/inch)
9  Add initial dose of inorganic fertilizers
8  Start monitoring daily parameters
7  Start regular program of fertilization

4. Water management:
   a. Know how much water is exchanged.
   b. Calculate volume, area, average depth, and mark structure in pond.
   c. Methods of exchanging water: flow-through, draw down, flowing water through gates.
   d. Arrangement of boards and screens. Discharge from bottom.

Show slide #30, effluent gate (boards and screen).

5. Benefits of deep draw-down and continuous exchange of water at the lower level to correct problem of low DO:
   a. The wind mixes water more effectively when the depth is shallow.
   b. The area below the surface layer that consumes more oxygen is reduced.

6. Photic zone: 0.5 m x 10,000 = 5,000 m².
   a. Consumption zone - At 1.2 m depth: 0.7 m x 10,000 = 7,000 m² = 140% of photic zone.
   b. At 0.8 m depth: 0.3 m x 10,000 = 3,000 m² = 60% of photic zone.
   c. The percentage of water exchanged is increased. At 1.2 m depth, 20 cm exchange = 16.7% of total water in pond.
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d. At 0.8 m depth, 20 cm exchange = 25% of total water in pond.
e. Water can be flowed through the pond when the pumps are not operating.
f. The quality of organic matter in the water is reduced when water is drained from the bottom.

7. Suggested programs for daily water exchange.

Show slides #31-#35, intake canal, pumps, pumping and water exchange.


<table>
<thead>
<tr>
<th>Day</th>
<th>CM Exchange</th>
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<tbody>
<tr>
<td>-10 to -4</td>
<td>+15</td>
</tr>
<tr>
<td>-3 to 0</td>
<td>0</td>
</tr>
<tr>
<td>0 to 10</td>
<td>+3</td>
</tr>
<tr>
<td>11 to 16</td>
<td>±3</td>
</tr>
<tr>
<td>17 to 30</td>
<td>±6</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>Rate determined by stocking density</td>
</tr>
</tbody>
</table>

#Stocked/ sq m CM Exchange

<table>
<thead>
<tr>
<th>sq m</th>
<th>CM Exchange</th>
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<tbody>
<tr>
<td>8</td>
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<td>9</td>
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<td>19</td>
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<td>18</td>
<td>20</td>
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</tbody>
</table>

8. Programs of fertilization:
a. Organic: Chicken manure - 1,000 kg/ha to pond bottom during preparation. Plant meal: soybean, sorghum, cottonseed - 200 kg/ha to pond bottom during preparation. 22 kg/ha to water every 3 days until feeding with pelleted feed starts.
b. Inorganic: Initial dose - urea- 28 kg/ha. Triple superphosphate (TS) 3.2 kg/ha. Urea - 24.5 kg/ha diammonium phosphate (DAP) 3.2 kg/ha. Maintenance dose - Divide the initial dose by 7 and add daily when the preceding day’s transparency reading is 40 cm or above and the pH is less than 7.8.

H. How are shrimp harvested and marketed?

Show TM D7 and TM D8 and discuss harvesting and marketing shrimp. Show slides #36, pond drained harvested, and #37, shrimp caught in net and placed in 100 lb. boxes. Show slides #38 and #39, shrimp harvested with a fish pump. Show slide #40, harvest net.

1. In a pond culture situation, harvesting is usually done by draining the pond. Sometimes cast nets and seines are used. Traps are used with P. japonicus.

2. Usually they are caught in a net as the water passes out the sluice gate.
3. In most places in the world where shrimp are cultured, it is processed (deheaded) and frozen green headless and sold to U.S. or Japan.

Show slides #41, green headless frozen in 5-lb box, #42, plat freezer used to freeze shrimp, and #43, frozen heads on for European market.

a. The U.S. prefers frozen. Japan prefers fresh or secondly green headless frozen.

b. A number of large food processors in the U.S. market frozen shrimp through grocery stores.

c. Some shrimp farms market their own shrimp, but most are sold to a broker or processing house.

d. The European market prefers a head-on product (frozen mostly because fresh is not economical).

I. What diseases and parasites affect shrimp?

Show TM D9 and discuss diseases that affect shrimp.

1. Diseases and parasites are somewhat less of a problem in shrimp growout than in the hatchery phase.

a. Although there are few chemicals allowed for the treatment in the U.S. shrimp hatcheries, they are not as heavily restricted in other countries that culture shrimp.

b. Antibiotics are allowed to be placed in shrimp growout feed in the U.S., but this is also heavily regulated.

c. Most countries require that antibiotics be withdrawn from the shrimp feed 15-21 days before harvest if the shrimp are for human consumption.

2. Protozoans often attach themselves to shrimp. Some protozoans are Acimeta, Ephelota, Zoothamnium, Epistylis, and Lagenophrys.

3. Bacterial diseases that affect shrimp include Vibrio and filamentous bacteria.

4. The best treatment for diseases seems to be in prevention.

a. Water quality, temperature, keeping stress low, and good nutrition are vitally important to preventing diseases.

b. Purchasing post-larvae from a reputable source is also necessary. If possible obtain High Health stock.

5. Viruses such as IHHN, Baculovirus, Parvovirus, etc., have caused various negative effects (runt, size variation, deformities) in penaeid shrimp. The development of High Health shrimp helped in the control and hopefully the eventual eradication of these diseases.
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Review:

Review by having students demonstrate their knowledge and understanding of the objectives for this problem area. Lead a discussion with students by asking questions that cause them to explain the content that goes with each objective.

Application Activities:

Application can be addressed in several ways. If the class has access to a tank or suitable pond, a growout project would make an excellent application. An aquarium growout project with shrimp can also be substituted. There is great potential for further knowledge in this area. Current periodicals are a must to keep up with the developments in shrimp culture.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of spawning shrimp, written reports, and written exams. Example of exam questions are attached.
Cultural Systems for Shrimp

- Pond: Most popular, worldwide
- Tank
- Raceway
- Indoor
- Intensive
- Closed recirculating
Penaeid Shrimp Post-Larvae

- Best for stocking in ponds:
  - *P. vannamei* pl 5-10
  - *P. monodon* pl 18
Stocking Rates

- No set answer
- Depends upon each individual system
- Depends on level of management
- Average stocking rates
- Extensive: 1-5/m²
- Semi-Intensive: 5-25/m²
- Intensive: 30-75+
- Common average: 12-17
What Do Shrimp Eat?

• Zooplankton (copepods, rotifers, etc.), diatoms from benthos and detritus, marine worms and other creatures small enough to capture and consume

• Water can be fertilized to encourage natural food growth

• Will eat supplemental feeds

• Various organic products and grain

• Many producers use a shrimp feed with 27-35% protein for *P. vannamei* growout and 35-38% protein for *P. monodon* growout

• Many producers feed a reducing feeding scale

• Starting at 18-20% body weight per day when first stocked

• Body weight is cut down to 2-3% by the end of the growing system
How Fast do Shrimp Grow?

- Growth rates are highly variable

- From egg to post-larval 5 (5-day-old pl) takes approximately 18 days at 28°C

- From pl 5 (stocking in nursery) they will be an average of 1 g within 30 days

- From a juvenile stocked into a growout pond (1 g) (under optimum conditions) after 120 days of growth:
  - *P. vannamei* will be 20 g
  - *P. monodon* will be 35 g
### Water Quality Parameters for Tropical Shrimp Ponds

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum (Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>Growth: 23-25° (33-34°)</td>
</tr>
<tr>
<td></td>
<td>Lethal: 12-15° (34-38°)</td>
</tr>
<tr>
<td>Salinity* (ppt)</td>
<td>Growth: 0-10 (30-40)</td>
</tr>
<tr>
<td></td>
<td>Lethal: NA (Unknown)</td>
</tr>
<tr>
<td>pH</td>
<td>Growth: 7.0-7.5 (10-11)</td>
</tr>
<tr>
<td>Dissolved* ** Oxygen (ppm)*</td>
<td>Growth: 2.0-3.0</td>
</tr>
<tr>
<td></td>
<td>Lethal: 0.1-1.5</td>
</tr>
<tr>
<td>Secchi Disc</td>
<td>8-10 (inches)</td>
</tr>
<tr>
<td>Un-ionized</td>
<td>(0.1)</td>
</tr>
<tr>
<td>Ammonia (ppm)</td>
<td></td>
</tr>
<tr>
<td>Total Ammonia</td>
<td></td>
</tr>
<tr>
<td>Nitrogen (ppm)**</td>
<td>1-40</td>
</tr>
</tbody>
</table>

* Species-specific minimum and maximums  
** Weight-specific minimum  
*** Function of pH, temperature, and salinity
How Are Shrimp Harvested?

- From Ponds:
  Draining mostly
  Seining
  Cast netting

- From Tanks or Raceways:
  Netting
  Seining
  Draining
How Are Shrimp Marketed?

- Normally, shrimp are sold green headless (frozen, shell on, head off) to U.S. market and Japanese market.

- Japanese market also prefers fresh or if possible live in sushi bars.

- The European markets prefer heads on so they are usually frozen with the heads on.
Diseases and Parasites

- Diseases and parasites are somewhat less of a problem in shrimp growout than they are in the hatchery phase.

- Parasites that are found on shrimp include epicomensal protozoans (*Zoothanium, Epistyliis*, etc.).

- Diseases that affect shrimp include bacterial infections and viruses.

- The best treatment for diseases seems to be in prevention.

- Water quality, temperature, and good nutrition are vitally important in preventing diseases.

- Purchasing post-larvae or broodstock from a High Health dealer is recommended.
Quiz for Section D

Name:

Date:

Quiz on Producing/Marketing Shrimp

Circle a T for True statements or an F for False statements.

1. T F The most popular cultural method for shrimp in the world is pond systems.
2. T F The best type of post-larvae to stock are called High Health.
3. T F Post-larvae should be pl 5-10 for *P. vannamei* before stocking and pl 18 for *P. monodon*.
4. T F Shrimp will not consume supplemental feed.
5. T F Stocking rates depend on the cultural system used and the level of management employed.
6. T F Shrimp are normally harvested from ponds by draining the pond.
7. T F In the U.S. shrimp are normally marketed when they reach about 5 g.
8. T F Shrimp are immune to disease.
9. T F The best treatment for diseases is prevention.
10. T F Many producers feed shrimp supplemental feed at the rate of 20% body weight per day to start and taper off to 3%.

Fill out the chart using your notes:

Water quality requirements for tropical shrimp - optimum.

Temperature (°C) ____________

Dissolved Oxygen (ppm) ____________

pH ____________

Un-ionized Ammonia (ppm) ____________

Total ammonia ____________

Secchi disc in inches ____________

Turbidity (ppm) ____________

Salinity (ppt) ____________
Key for Quiz - Section D

1. T
2. T
3. T
4. F
5. T
6. T
7. F
8. F
9. T
10. T
Slides for Section D

#1. Shrimp ponds Hawaii.
#2. Shrimp ponds Indonesia.
#4. Shrimp ponds Texas.
#5. Shrimp raceway culture - Hawaii.
#6. Shrimp culture in inland, closed recirculating systems.
#7. Comparison of extensive, semi-intensive, and intensive shrimp culture strategies.
#8. Shrimp feed label from Ecuador.
#9. Feed mill in China.
#10. Feed mill in China.
#11. Shrimp feed storage warehouse.
#12. Post-larval and juvenile shrimp on feeding tray.
#13. Feeding shrimp by hand from a boat - Ecuador.
#14. Feeding shrimp from boat (amphibious vehicle) - Texas.
#15. Feeding shrimp from bank with feed blower - Texas.
#16. Feeding shrimp from bank with feed blower - Texas.
#17. Average shrimp feed conversion rate (FCR) is 2:1.
#18. Typical feeding schedule based on % of estimated body weight and typical feeding curve.
#19. Feeding tray.
#20. Refractometer used to read salinity.
#22. Aeration devices.
#23. Aeration devices.
#25. Secchi disc (for reading turbidity level in pond).
#26. Round pond being dried in the sun.
#27. Predator screen (sock placed over inflow).
#28. Screen box used for predator control on inflow.
#29. Inlet gate; copper sheet with holes drilled in it for predator control at later stages of shrimp culture.
#30. Arrangement of boards and screens on effluent gate, the purpose is to adjust the flow and screen is to keep shrimp in the pond. (screen size changes with shrimp growth).