Sturgeon

AQUACULTURE CURRICULUM GUIDE

YEAR TWO
SPECIES MODULE

This is a project of the National Council for Agricultural Education, Alexandria, Virginia
with a grant from
United States Department of Agriculture

1995 Preliminary Edition

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This material is based upon work supported by the Cooperative State Research Service, U.S. Department of Agriculture, under Agreement No. 90-38816-5653.

Module Title: Sturgeon

Subtitle ~ Species - 5~C ~

Goal:
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The goal of this problem area is to help the student understand the taxonomy, natural history and marketability of sturgeon.

8pecific Learning Objective~: Upon completing this unit, the student will be able to:

1. Explain the taxonomy of the species of sturgeon and paddlefish. 2. Explain the natural history of the sturgeon. 3. Explain the natural habitat of the sturgeon. 4. Explain the status of sturgeon and paddlefish in today's market.

In~tructional Resources:

Essential:

Conte, F.S., et al. (1988). Hatch-erY manual for the white sturgeon, Acipenser transmontanus Richardson: with application to the North American acipenseridae, O.A.N.R., University of California, Pub. 3322, pp 104.

Transparencies and projector
U.S. map

Additional:

Barnabe, G., translation editor, J.F de L.B. Solbe (1990). Aquaculture. Vol. 2, Ellis Horwood, Chichester, pp 1104.

lnterest Approach:

Identify areas on the map to which sturgeon are indigenous. Speculate on how various species may have evolved their specific characteristics in the different areas.

Evaluation:

Evaluation will be based on class participation, quizzes and a final examination.

Rey Questions / Summary of Content

I. Family
A. Sturgeon Acipenseridae
B. Paddlefish = Polydontidae II. History
A. They are teleost fish that evolved about 250 million years ago.
B. They are chondrostean fish with mostly cartilogenous skeletons.
C. Known for their longevity and large size.
D. Have **protrusible** mouths that draw in benthic organisms for food.
1. Organisms are sensed by barbels beneath the snout. III. Natural habitat
A. Inhabit temperate waters of:
1. Europe
2. Asia
3. North America
B. Anadromous species live exclusively in a marine environment and return to freshwater only to spawn.
1. Atlantic
2. Green
C. Semi-anadromous species live primarily in estuaries of large rivers, are euryphaline and often form landlocked stocks in lakes and reservoirs, e.g., white sturgeon.
D. Fresh water species
1. Pallid
2. Shovelnose
3. Lake
4. Paddlefish
E. Are **iteroparous** they spawn several times in a lifetime.

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Rey Questions / Summary of Content

F. Females spawn at intervals from 2 to 8 years.
G. Usually spawn in area of swift current.
H. Eggs are large and demersal and adhesive.
IV. White sturgeon -
AciPenser transmontanus
Richardson
A. Habitat
1. Pacific coast - from Aleutians to Ensenada, Mexico.
2. Some are semianadromous and some live as landlocked fish living in fresh water.
B. Physical traits
1. Gray in color.
2. Has four barbels beneath a short brown snout.
3. Has 38 - 48 lateral bony plates.
C. Migratory habits
1. Swim upstream in fall and winter to spawn.
2. Migrate downstream in spring and summer.
D. Food
1. In general - benthic invertebrates.
2. larger fish are piscivorous.
V. Atlantic Sturgeon -
Acipenser oxyrhynchus
Mitchill
A. Two sub-species
1. A. o. oxvrhynchus found along east coast of North America.
2. A. o. desdotoi found in Gulf of Mexico and north coast of South America.

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Rey Questions / Summary of Content

B. Brownish black on top, pale on sides and white underneath.
C. 24 - 35 lateral plates.
D. Both are anadromous
E. A. o. Oxyrhynchus stay in fresh water until age 4 to 6, then migrate to sea.
F. Adults consume gastropods, shrimp, amphipods, and small fish.
VI. Lake sturgeon Acipenser
fluvescens (Rafinesque)
A. Habitat - lakes and rivers of Canada and the United States, south to Alabama and west to the Missouri.
B. A freshwater species.
C. Brown or gray above and mottled underneath.
D. 30 - 38 lateral plates.
E. In early spring, migrate smaller streams or shallow lakes to spawn.
VII. Shortnose sturgeon
Acipenser brevirostrum
(LeSueur)
A. Considered an **endangered ~pecies.**
B. Habitat - Canada to eastern Florida.
C. Some migrate to saline water on seasonal basis; others are anadromous.
D. Has short, blunt snout; mouth is wide. Dark on top, white underneath.
VIII Paddlefish Polyodon spa-
thula (Walbaum) - the
paddlefish is in the same
- order as sturgeon, but
belongs to a different
family.

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Rey Questions / Summary of Content

A. Two species
1. Psephurus gladius of the Yangtze River, in China.
2. Polodon spathula of the United States, which inhabits the Mississippi River Valley and Gulf slope drainage.
3. Was known in Lake Erie before 1903.
B. Paddle shaped rostrlm makes up 1 / 3 of entire length.
C. Gray green body without bony plates.
D. Eat plankton, insects and algae.
E. Migrate up river to spawn in spring and summer.
IX. Status of sturgeon and
paddlefish in U.S.
A. Populations are declining and they are protected by federal and state resource agencies in many locations.
B. The pallid is on the endangered species list.

TM 1.1

STURGEON FAMILY
STURGEON = ACIPENSERIDAE
PADDLEFISH = POLYDONTIDAE

TM 1.2

NATURAL HISTORY
ARE TELEOST FISH
ARE CHONDROSTEAN FISH
EVOLVED ABOUT 250 MILLION YEARS AGO
KNOWN FOR THEIR LONGEVITY AND LARGE SIZE
HAVE PROTRUSIBLE MOUTHS

TM 1.3

NATURAL HABITAT

TEMPERATE WATERS OF:
EUROPE
ASIA
NORTH AMERICA

TWO SPECIES ARE ANADROMOUS
ATLANTIC
GREEN

SEVERAL SPECIES ARE SEMI ANADROMOUS
OR LIVE ONLY IN FRESH WATER

ARE ITEROPAROUS

FEMALES SPAWN AT INTERVALS FROM 2 TO 8 YEARS

TM 1.4

WHITE STURGEON - Acipenser transmontanus Richardson

HABITAT- PACIFIC COAST

PHYSICAL TRAITS

GRAY IN COLOR

HAVE FOUR BARBELS BENEATH A SHORT BROWN SNOUT

HAVE 38 - 48 LATERAL BONY PLATES

MIGRATORY HABITS

SWIM UPSTREAM IN FALL AND WINTER TO SPAWN

MIGRATE DOWNSTREAM IN SPRING AND SUMMER

DIET

GENERALLY EAT BENTHIC INVERTEBRATES

LARGER FISH ARE PISCIVOROUS

TM 1.5

ATLANTIC STURGEON - Acipenser oxyrhynchus Mitchill

TWO SUB-SPECIES

A. o. oxyrhynchus
FOUND ALONG EAST COAST OF NORTH AMERICA

A. o. desdotoi
FOUND IN GULF OF MEXICO
AND NORTH COAST OF SOUTH AMERICA

PHYSICAL TRAITS

BROWN ON TOP, WHITE UNDERNEATH
24 - 35 LATERAL BONY PLATES
BOTH ARE ANADROMOUS

DIET

ADULTS CONSUME GASTROPODS, SHRIMP,
AMPHIPODS, and SMALL FISH

TM 1.6

LAKE STURGEON Acipenser fluvescens (RAFINESQUE)

HABITAT

A FRESHWATER SPECIES
LAKES AND RIVERS OF CANADA AND THE UNITED STATES

PHYSICAL TRAITS
BROWN OR GRAY ABOVE AND MOTTLED UNDERNEATH
30 - 38 LATERAL BONY PLATES

MIGRATORY HABITS
MIGRATE TO SMALLER STREAMS AND
SHALLOW WATERS IN EARLY SPRING

TM 1.7

SHORTNOSE STURGEON Acipenser brevirostrum (LeSueur)

CONSIDERED AN ENDANGERED SPECIES

HABITAT
CANADA TO EASTERN FLORIDA

PHYSICAL TRAITS
SHORT, BLUNT SNOUT
DARK ON TOP, WHITE UNDERNEATH

MIGRATORY HABITS
SOME MIGRATE TO SALINE WATER ON SEASONAL BASIS
SOME ARE ANADROMOUS

TM 1.8
PADDLEFISH Polyodon spathula (Walbaum)
TWO SPECIES
Psephurus gladius FROM THE YANGTZE RIVER, CHINA
Polodon spathula FROM THE MISSISSIPPI RIVER VALLEY
WAS FOUND IN LAKE ERIE UNTIL 1903

PHYSICAL TRAITS

PADDLE SHAPED ROSTRUM MAKES UP 1/3 OF ENTIRE BODY
GRAY GREEN BODY WITHOUT BONY PLATES

DIET
PLANKTON, INSECTS AND ALGAE

MIGRATORY HABITS
MIGRATES UP RIVER IN SPRING AND SUMMER

TM 1.9
CURRENT STATUS OF STURGEON AND PADDLEFISH
POPULATIONS ARE DECLINING
THEY ARE PROTECTED BY FEDERAL
AND STATE RESOURCE AGENCIES IN MANY LOCATIONS

Name

Quiz on taxonomy and habitat of sturgeon and paddlefish.

1. Using the English names, list the five aquaculturally important or potentially important species of sturgeon.

2. Using the rest of this page, briefly describe the **natural habitat of sturgeon.**

Answers to quiz on Taxonomy and habitat of sturgeon and paddlefish.

1. Using the English names, list the five aquaculturally important species of sturgeon.

White sturgeon

Atlantic sturgeon

Lake sturgeon

Shortnose sturgeon

Paddlefish

2. Using the rest of this page, briefly describe the history and natural habitat of sturgeon.

Sturgeon are teleost fish that evolved 250 million years ago. They are known for their longevity and large size (up to 100 kg.) They have protrusible mouths. They are native to temperate waters of Europe, Asia and North America. Several species are semi-anadromous. The females are iteroparous and spawn every 2 to 8 years. In general, their populations are on the decline. Both the shortnose and the pallid sturgeon are on the endangered species list.

Description: This module consists of the following five problem areas:

Module: Sturgeon

Problem Areas: Understanding Taxonomy, Natural History, and Marketability of Sturgeon
Understanding Hatchery Spawning Procedures and Care of Eggs
Understanding Development of Sturgeon Embryo and Larvae
Understanding Broodstock and Spawning Process
Understanding Care and Handling of Fry and Fingerlings

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

A. Understanding Taxonomy, Natural History, and Marketability of Sturgeon
- explain taxonomy of sturgeon and paddlefish species
- explain natural history of sturgeon
- explain natural habitat of sturgeon
- explain status of sturgeon and paddlefish in today's market

B. Understanding Hatchery Spawning Procedures and Care of Eggs
- explain gametogenesis of sturgeon
- explain oogenesis process of sturgeon
- explain how sturgeon eggs are fertilized
- discuss procedures for collecting and storing eggs and milt
- discuss procedures for performing de-adhesion of eggs
- explain milt extraction process
- explain egg extraction process
- discuss artificial egg fertilization process
- explain egg incubation process
- explain how to calculate number of eggs processed

C. Understanding Development of Sturgeon Embryo and Larvae
- explain effects of temperature on embryo development
- discuss embryo development sequence
- discuss larval development sequence

D. Understanding Broodstock and Spawning Process
- explain techniques for broodstock capture
- explain procedures for transporting and holding broodstock
- explain procedures for field examination of broodstock
- explain procedures for hatchery examination of broodstock
- explain how broodstock examinations are performed in nursery
- explain how spawning is induced
- explain male sturgeon's response
- explain female sturgeon's response

E. Understanding Care and Handling of Fry and Fingerlings
- describe 2 designs for sturgeon culture systems
- describe fry transportation systems
- describe fry storage tanks
- describe behavior patterns of early fry
- explain procedures for initiating feeding of fry

- explain criteria for selecting food
- list feeding rates and frequencies
- describe procedures for stocking fingerlings
- discuss health problems that sturgeon fry encounter

Teaching Plan:

Module: Sturgeon - Section A

Problem Area: Understanding Taxonomy, Natural History, and Marketability of Sturgeon

Goal: The goal of this problem area is to understand the taxonomy, natural history, and marketability of sturgeon.

Learning Objectives: Upon completing this unit, students will be able to:

explain taxonomy of the species of sturgeon and paddlefish
explain natural history of the sturgeon
explain natural habitat of the sturgeon
explain status of sturgeon and paddlefish in today's market

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

Essential:

Hatchery Manual for the White Sturgeon, *Acipenser transmontanus* Richardson: **With Application to the North American** *Acipenseridae*, by Conte, F.S., et al., O.A.N.R., University of California, Pub. 3322, p. 104, 1988.

Transparencies, projector, and U.S. map.

Additional:

Aquaculture, Vol. 2, by Barnabe, G., translation editor, J.F. de L.B. Solbe, Ellis Horwood, Chichester, England, p. 1104, 1990.

Content and Procedures

Preparation (Interest Approach):

To develop student interest in this module, identify areas on the map to which sturgeon are indigenous. Speculate on how various species may have evolved their specific characteristics in the different areas.

A. What are the families of the sturgeon and paddlefish?

Show TM A1 and discuss the families of sturgeon and paddlefish.

1. Sturgeon: Acipenseridae.
2. Paddlefish: Polydontidae.

B. What is the history of sturgeon?

Show TM A2 and discuss the natural history of sturgeon.

1. Are teleost fish that evolved about 250 million years ago.
2. Are chondrostean fish with mostly cartilogenous skeletons.
3. Known for their longevity and large size.
4. Have protrusible mouths that draw in benthic organisms for food that are sensed by barbels beneath the snout.

C. What is the natural habitat of sturgeon and paddlefish?

Show TM A3 and use a world map to identify areas to which sturgeon and paddlefish are native.

1. Inhabit temperate waters of:
   a. Europe.
   b. Asia.
   c. North America.

2. Anadromous species live exclusively in a marine environment and return to freshwater only to spawn.
   a. Atlantic.
   b. Green.

3. Semi-anadromous species live primarily in estuaries of large rivers, are euryphaline, and often form landlocked stocks in lakes and reservoirs, e.g., white sturgeon.

4. Fresh water species:
   a. Pallid.
   b. Shovelnose.
   c. Lake.

d. Paddlefish.

5. Are iteroparous: They spawn several times in a lifetime.

6. Females spawn at intervals from 2 to 8 years.

7. Usually spawn in areas of swift current.

8. Eggs are large, demersal, and adhesive.

D. What are the characteristics and habits of white sturgeon (Acipenser transmontanus Richardson)?

Show TM A4 and discuss traits of the white sturgeon.

1. Habitat:
   a. Pacific coast: from Aleutians to Ensenada, Mexico.
   b. Some are semi-anadromous and some live as landlocked fish living in fresh water.

2. Physical traits:
   a. Gray color.
   b. Have 4 barbels beneath a short brown snout.
   c. Have 38-48 lateral bony plates.

3. Migratory habits:
   a. Swim upstream in fall and winter to spawn.
   b. Migrate downstream in spring and summer.

4. Food:
   a. In general, benthic invertebrates.
   b. Larger fish are piscivorous.

E . What are the characteristics and habits of the Atlantic sturgeon (Acipenser oxyrhynchus Mitchill)?

Show TM A5 and discuss traits of Atlantic sturgeon.

1. Two subspecies:
   a. *A. o. Oxyrhynchus* found along east coast of North America.
   b. *A. o. Desdotoi* found in Gulf of Mexico and north coast of South America.

2. Brownish black on top, pale on sides, and white underneath.

3. 24-35 lateral plates.

4. Both are anadromous.

5. *A. o. Oxyrhynchus* stay in fresh water until age 4-6, then migrate to sea.

6. Adults consume gastropods, shrimp, amphipods, and small fish.

F. What are the characteristics and habits of lake sturgeon (Acipenser fluvescens Rafinesque)?

Show TM A6 and discuss traits of the lake sturgeon.

1. Habitat: lakes and rivers of Canada and the United States, south to Alabama, and west to the Missouri.
2. A freshwater species.
3. Brown or gray above and mottled below.
4. 30-38 lateral plates.
5. In early spring, migrate smaller streams or shallow lakes to spawn.

G. What are the characteristics and habits of the shortnose sturgeon (Acipenser brevirostrum Le Sueur)?

Show TM A7 and discuss traits of the shortnose sturgeon.

1. Considered an endangered **s**pecies.
2. Habitat: Canada to eastern Florida.
3. Some migrate to saline water on seasonal basis; others are anadromous.
4. Have short, blunt snout; wide mouth. Dark on top, white underneath.

H. What are the characteristics and habits of the paddlefish (*Polyodon spathula* Walbaum)?

Show TM A8 and discuss traits of the paddlefish.

The paddlefish are in the same order as sturgeon but belong to a different family.

1. Two species:
   a. *Psephurus gladius* of the Yangtze River in China.
   b. *Polodon spathula* of the United States, which inhabits the Mississippi River Valley and Gulf slope drainage.
   c. Were known in Lake Erie before 1903.

2. Paddle-shaped rostrum makes up 1/3 of entire length.

3. Gray-green body without bony plates.

4. Eat plankton, insects, and algae.

5. Migrate up river to spawn in spring and summer.

I. What is the status of sturgeon and paddlefish in the United States?

Show TM A9 and discuss status of sturgeon and paddlefish in the United States.

1. Populations are declining and they are protected by federal and state resource agencies in many locations.
2. The pallid are on the endangered species list.

Review:

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

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include class participation, quizzes, and a final exam. Example exam questions are attached.

TM A1

Sturgeon Family

- Sturgeon: Acipenseridae
- Paddlefish: Polydontidae

TM A2

Natural History

- Are teleost fish
- Are chondrostean fish
- Evolved about 250 million years ago
- Known for their longevity and large size
- Have protrusible mouths

TM A3

Natural Habitat

- Temperate Waters of:
  Europe
  Asia
  North America

- Two Anadromous Species:
  Atlantic
  Green

- Several Species:
  Semi-anadromous
  Live only in fresh water

- Are Iteroparous:
  Females spawn at intervals from 2 to 8 years

TM A4

White Sturgeon
(Acipenser transmontanus Richardson)

- Habitat: Pacific coast

- Physical Traits:
  Gray color
  4 barbels beneath a short brown snout
  38-48 lateral bony plates

- Migratory Habits:
  Swim upstream in fall and winter to spawn
  Migrate downstream in spring and summer

- Diet:
  Generally eat benthic invertebrates
  Larger fish are piscivorous

TM A5

Atlantic Sturgeon
(Acipenser oxyrhynchus Mitchill)

- Two Subspecies:
  A. o. Oxyrhynchus: east coast of North America
  A. o. Desdotoi: Gulf of Mexico and north coast of South America

- Physical Traits:
  Brown on top, white underneath
  24-35 lateral bony plates
  Both are anadromous

- Diet:
  Adults consume gastropods, shrimp, amphipods, and small fish

TM A6

Lake Sturgeon
(Acipenser fluvescens Rafinesque)

- Habitat:
  Freshwater species
  Lakes and rivers of Canada and the United States

- Physical Traits:
  Brown or gray above and mottled below
  30-38 lateral bony plates

- Migratory Habits:
  Migrate to smaller streams and shallow waters in early spring

TM A7

Shortnose Sturgeon
(Acipenser brevirostrum Le Sueur)

- Considered an endangered species

- Habitat:
  Canada to eastern Florida

- Physical Traits:
  Short, blunt snout
  Dark on top, white underneath

- Migratory Habits:
  Some migrate to saline water seasonally
  Some are anadromous

TM A8

Paddlefish
(Polyodon spathula Walbaum)

- Two Species:
  Psephurus gladius from the Yangtze River, China
  Polodon spathula from the Mississippi River valley
  Were found in Lake Erie until 1903

- Physical Traits:
  Paddle-shaped rostrum makes up 1/3 of entire body
  Gray-green body without bony plates

- Diet:
  Plankton, insects, and algae

- Migratory Habits:
  Migrates up river in spring and summer

TM A9

Current Status of Sturgeon and Paddlefish

- Populations are declining.
- They are protected by federal land and state resource agencies in many locations.

Quiz for Section A

Name:

Date:

Quiz on Understanding Taxonomy, Natural History, and Marketability of Sturgeon

1. Using the English names, list the five aquaculturally important or potentially important species of sturgeon.

2. Using the rest of this page, briefly describe the natural habitat of sturgeon.

Key for Quiz - Section A

1. Using the English names, list the five aquaculturally important species of sturgeon.

   White sturgeon

   Atlantic sturgeon

   Lake sturgeon

   Shortnose sturgeon

   Paddlefish

2. Using the rest of this page, briefly describe the history and natural habitat of sturgeon.

   Sturgeon are teleost fish that evolved 250 million years ago. \They are known for their longevity and large size (up to 100 kg). They have protrusible mouths. They are native to temperate waters of Europe, Asia, and North America. Several species are semi-anadromous. The females are iteroparous and spawn every 2-8 years. In general, their populations are on the decline. Both the shortnose and the pallid sturgeon are on the endangered species list.

Teaching Plan:

Module: Sturgeon - Section B

Problem Area: Understanding Hatchery Spawning Procedures and Care of Eggs

Goal: The goal of this problem area is to understand hatchery spawning procedures and care of the eggs.

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

explain gametogenesis of sturgeon
explain oogenesis process of sturgeon
explain how sturgeon eggs are fertilized
discuss procedures for collecting and storing eggs and milt
discuss procedures for performing de-adhesion of eggs
explain milt extraction process
explain egg extraction process
discuss artificial egg fertilization process
explain egg incubation process
explain how to calculate number of eggs processed

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

Essential:

Hatchery Manual for the White Sturgeon, *Acipenser transmontanus* Richardson: **With Application to the North American** *Acipenseridae*, by Conte, F.S. et al., O.A.N.R., University of California, Pub. 3322, p.104, 1988.

Additional:

Aquaculture, Vol. 2, by Barnabe, G., translation editor, J.F. de L.B. Solbe, Ellis Horwood, Chichester, England, p.1104, 1990.

Content and Procedures

Preparation (Interest Approach);

To develop student interest in this module, work in cooperation with the biology teacher and dissect a fish or two, preferably both a male and a female. Compare the internal organs of a fish with those of other animals the students might be familiar with. Also discuss the similarities and differences between fish eggs and those of other species, e.g., birds.

A. What are the techniques for fertilization in sturgeon?

1. Techniques for fertilizing sturgeon eggs differ from those used with salamoids because the sperm and egg structures are physiologically and biochemically different.
2. Females (F1 generation) have been used successfully at commercial and university facilities.
3. Domestically raised males routinely produce viable sperm.

B. What is gametogenesis?

Show TM B1 and lead a discussion about gametogenesis.

1. Definition: The production of mature germ cells.

2. Consists of 2 processes:
   a. Oogenesis: egg formation.
   b. Spermatogenesis: sperm formation.

C. What is oogenesis?

Show TM B2 and discuss the oogenesis process.

1. Germ cells start as oogonia (<0.15 mm).

2. During meiosis, oogonia become primary oocytes. This takes 2 years.

3. Yolk development, vitellogenesis, takes another 1 or 2 years.

4. During this period, the ratio of gonad weight to somatic tissue increases by 20-30%.

5. During spawning migration, females spawn ripe vitellogenic eggs. The previtellogenic eggs remain to ripen for the next spawn, which will occur several years later in the wild.

6. Once triggered by gonadotropin and maturation-inducing steroids, oocycte maturation and ovulation are preprogrammed.

7. In nature, all of these processes are controlled by the endocrine system and by environmental conditions (photoperiod, temperature, nutrition, etc.).

8. At the hatchery, the female is separated from the male and given injections of gonadotropin and gonadotropin-releasing hormones that initiate the response.

    a. This allows ovulation to occur sooner.
    b. Ovulation and spermiation are under the hatchery personnel's control so they will occur at the same time.
    c. Oviposition is an important indication of ovulation. Can cause problem of overripening of eggs. Because of the varying times of oocyte maturity, hatchery workers must strip eggs by hand or by C-section at the optimal time.

D. What factors are involved in fertilization of sturgeon?

Show TM B3 and discuss factors affecting fertilization.

1. Sturgeon eggs have 3 layers. Third layer secretes adhesive jelly that anchors egg mass, which is activated in water.

2. Unlike many other fish eggs, sturgeon eggs have numerous micropyles (3-15).

3. Sturgeon are broadcast spawners.
    a. In nature, eggs are spawned into fast-moving streams where they are dispersed over a large area.
    b. Sperm concentration is lower than with other fish.
    c. Sperm has longer duration of motility than that of many other fish. Motility is induced by contact with water. Is still only 2-3 minutes.

4. Longer motility and more micropyles compensates for large dispersal area of eggs.

E. How are sperm collected and stored?

Show TM B4 and discuss c**ollection** and storage of milt (sperm).

1. Because of the changes that occur due to contact with water, sperm collection must take place in a dry area.
2. Once the sperm is activated with water, fertilization must take place in 2-5 minutes.
3. Dry sperm, i.e., sperm not exposed to water, may be stored for later use, if properly stored.

F. How does de-adhesion of eggs occur?

Show TM B5 and discuss de-adhesion of eggs.

1. Use of Fuller's Earth (bentonite). For de-adhesion, bentonite is placed in a container and suspended in hatchery water at the same temperature as the eggs.

2. Chemical de-adhesion. Chemicals used:
    a. Urea and sodium chloride (NaCl) or sodium sulfide (Na_2SO_3).

b. This is followed by a tannic acid wash.
c. Advantage: quick.
d. Disadvantage: Too much can kill entire egg batch.

G. What is milt extraction?

Show TM B6 and discuss the milt extraction process.

1. The procedures:
   a. May be collected several hours before egg extraction or use stored sperm.
   b. Urogenital area is dried with towel, so no water is present.
   c. Milt is collected with a short length of tygon tubing and a syringe.
   d. The tube is inserted into the genital opening.
   e. Collection of milt is accomplished by massaging the genital area to force the collecting ducts.
   f. While doing this, the syringe tube is slowly withdrawn while moving the tubing back and forth in the genital opening.

2. Milt storage:
   a. May be stored up to 12 hours at 4°C in syringe for longer periods when aeration or oxygenation is used.
   b. Can also be stored in iced trays in 250-ml containers.
   c. Before using, check sperm viability with a microscope for mobility.

3. Sperm dilution.
   a. Because sperm has short life span in water, sperm is not diluted until the moment of fertilization, i.e., not until the eggs have been removed and preparations have been made for post-fertilization procedures.
   b. Use a dilution ratio of 1:200 milt to water.

H. What are the procedures for egg extraction?

Show TM B7 and discuss the egg extraction process.

1. This method is only used when a fish is presented as a gift by a fisherman. Generally, every effort is made to keep the fish alive.

2. Operation requires 4 people: 2 to strip the eggs and 2 to prepare eggs for incubation.

3. Procedure when female is sacrificed:
   a. Insures efficient removal of all the ova.
   b. First hold fish in tube net.
   c. Kill by administering a blow to the head.
   d. Hang fish by gill or mouth.
   e. Cut off tail and bleed fish.
   f. Put 3-5 l bowl under fish.
   g. Cut the abdomen open, starting at the vent and cutting upward.
   h. Eggs will fall from the belly into the bowl.
   i. Use fingers to gently scrape out any remaining eggs.
   j. Process takes 15-20 minutes.
   k. Will fill several bowls.
   l. Toward end, blood may appear. These eggs should be kept separate because blood may interfere with fertilization.

4. Procedure when female is not sacrificed, as is required by law.
   a. Preferred when working with endangered species.
   b. Fish is put in stretcher with water tube apparatus.
   c. An 8-10 cm incision is made in the abdomen.
   d. Eggs are gently removed with a spoon.
   e. Incision is sutured and disinfected.

I. What procedures are involved in egg fertilization?

Show TM B8 and discuss the egg fertilization process.

1. Perform de-adhesion procedure, as outlined above.
2. Pour off any coelomic fluid that remains in bowl.
3. Add diluted milt solution.
4. Mix for 3 minutes or until the first few sticky eggs are noticed.
5. Pour off excess liquid.

J. How are the total number of spawn measured?

Show TM B9 and discuss methods used for measuring total spawn.

1. Count by volume.
   a. Fill a 25-ml graduated cylinder with a subsample of spawn.
   b. Count by hand.
   c. Replicate 3 times.

2. Complete count using 1000-ml graduated cylinders.

3. Total number is derived by dividing the total volume by the average number from the 25-ml cylinders.

K. What occurs during the incubation phase using the MacDonald jar?

Show TM B10 and discuss incubation procedures using the MacDonald jar.

1. Incubation process:
   a. Sturgeon eggs are particularly sensitive to fungal and bacterial infections.
   b. They are also very sensitive to chemicals typically used to prevent fungal and bacterial diseases.
   c. Therefore, systems have to be used that prevent disease without the use of chemicals.
   d. A common solution is to continually agitate both the water and the eggs. This prevents the spread of disease. MacDonald jars do this well.

2. Incubation equipment:
   a. Batches of eggs from different females should be kept separate.
   b. Use modified trout egg barrels about 50 cm high x 20 cm in diameter. Use water treated by ultraviolet light. Water enters through gravel filter on bottom and exits at top, through screen.
   c. Modified MacDonald jars system consists of incubation jars, a head tan with ultraviolet-treated water, and a catch basin.

d. Incubation in modified trout barrels that are set up with water at 16°C. Eggs are loaded onto screen above gravel in the barrels. Water flow is set so that submerged eggs just barely move. Eggs are continually checked for fungus.
e. Eggs are kept here until neurulation about 58 hours.

3. Incubation in a modified MacDonald jar:
   a. Eggs are poured into jars. Water turned on to rate of 75% exchange per minute.
   b. As eggs mature, they become more buoyant, so water flow can be reduced but is kept high enough to avoid fungal infections.
   c. A safety precaution is to siphon off dead eggs periodically.
   d. When eggs near hatch stage, outflow water is directed to the fry collection tank.

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.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Example exam questions are attached.

TM B1

Gametogenesis

- Definition: The production of mature germ cells
- Oogenesis: Egg formation
- Spermatogenesis: Sperm formation

Process of Oogenesis

- Germ cells start as oogonia (<0.15 mm).
- During meiosis, oogonia become primary oocytes. Takes 2 years.
- Vitellogenesis is the period of yolk development. Takes 1 or 2 years.
- In nature, all of these processes are controlled by the endocrine system.
- In the hatchery, the female is separated from the male and given injections of gonadotropins and gonadotropin-releasing hormones.

TM B3

Fertilization

- Eggs have three layers. The third layer secretes an adhesive jelly, which is activated in water.

- Unlike other fish eggs, sturgeon eggs have numerous microphyles (3-15).

- Sturgeon are broadcast spawners.

Collection and Storage of Milt

- Because of the changes that take place due to contact with water, sperm collection must take place in a dry area.

- Once the sperm is activated with water, fertilization must take place in 2-5 minutes. Dry sperm can be stored for later use.

TM B5

De-Adhesion of Eggs

- Method Using River Silt:
  Silt is collected from river then dried and baked to kill organic matter.

- For de-adhesion, silt is placed in a container and suspended in hatchery water at the same temperature as the eggs.

- Chemical De-Adhesion:
  Use urea and sodium chloride (NaCl) or sodium sulfide (Na_2SO_3).
  Follow with a tannic acid wash.

TM B6

Milt Extraction

- Collect several hours before egg extraction.
- Dry urogenital area so that no water is present.
- Milt is collected using a tygon tube and a syringe.
- Tube is inserted into the genital opening.
- Massaging genital area forces milt from collecting ducts.
- Syringe and tube are withdrawn.

TM B7

Egg Extraction

- Operation requires 4 people: 2 to strip the eggs and 2 to prepare the eggs for incubation.

- When Female Is Sacrificed:
  Put fish in tube net.
  Kill by a blow to the head.
  Hang fish by gill or mouth.
  Cut off tail and bleed.
  Put bowl under fish.
  Cut the abdomen open.
  Eggs will fall from belly into bowl.
  Use fingers to scrape out remaining eggs.

- When Female Is Not Sacrificed:
  Preferred when working with endangered species.
  Fish put in stretcher with water tube apparatus attached.
  A 8-10 cm incision is made in the abdomen.
  Eggs are removed with spoon.
  Incision is sutured and disinfected.

Egg Fertilization

- Perform de-adhesion procedure.
- Pour off any remaining coelomic fluid.
- Add diluted milt solution.
- Mix for 3 minutes or until the first few sticky eggs are noticed.
- Pour off excess liquid.

TM B9

Measuring Total Spawn

- Fill a 25-ml graduated cylinder with a subsample of spawn.
- Count by hand.
- Replicate 3 times.
- Complete count using 1000-ml graduated cylinders.
- Total number is derived by dividing the total volume by the number from the 25-ml cylinders.

TM B10

Incubation in a Modified MacDonald Jar

- Sturgeon eggs are sensitive to infections and chemicals; therefore, systems must be used that prevent disease without using chemicals.
- Eggs are poured into jars.
- Water is turned on at rate of 30-40% exchange per minute.
- Set water flow so that submerged eggs just barely move.
- Check eggs continually for fungus.
- Eggs are kept in water until neuruslation (about 58 hours).
- As eggs mature, they become more buoyant, so water flow can be reduced.
- Siphon off dead eggs periodically when eggs near hatch stage.
- Outflow water is directed to the fry collection tank.

Quiz for Section B

Name:

Date:

Quiz on Understanding Hatchery Spawning Procedures and Care of Eggs

Complete the following statements by filling in the blanks with one or two words.

1. The production of mature germ cells is called_____.

2. The period of yolk development, which takes 1-2 years for sturgeon, is called_____.

3. Unlike other eggs, sturgeon eggs have numerous_____.

4. Sturgeon eggs are activated when they come in contact with _____.

5. De-adhesion of eggs is accomplished using either chemicals or _____.

6. Massaging the urogenital area of ripe male sturgeon causes the release of _____.

7. It is important to save the female sturgeon when collecting eggs if the species is _____.

8. It is necessary to mix the eggs and milt for 3 minutes when performing _____.

9. Incubation systems need to be able to prevent disease without the use of _____.

10. When using the modified MacDonald jar system, it is important to siphon off any_____.

Key for Quiz - Section B

1. The production of mature germ cells is called **gametogenesis.**
2. The period of yolk development in oocytes, which takes 1-2 years for sturgeon, is called **vitellogenesis.**
3. Unlike eggs of many other fish, sturgeon eggs have numerous **microphyles.**
4. Sturgeon eggs are activated when they come in contact with **water.**
5. De-adhesion of eggs is accomplished using either chemicals or **milt.**
6. Massaging the urogenital area of ripe male sturgeon causes the release of **milt.**
7. It is important to save the female sturgeon when collecting eggs if the species is **endangered.**
8. It is necessary to mix the eggs and milt for about 3 minutes when performing **egg fertilization.**
9. Incubation systems need to be able to prevent disease without the use of **chemicals**.
10. When using the modified MacDonald jar system, it is important to siphon off any **dead eggs.**

Teaching Plan:

Module: Sturgeon - Section C

Problem Area: Understanding Development of Sturgeon Embryo and Larvae

Goal: The goal of this problem area is to understand the development of sturgeon embryo and larvae.

Learning Objectives: Upon completing this unit, students will be able to:

explain effects of temperature on embryo development
discuss embryo development sequence
discuss larval development sequence

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

Essential:

Hatchery Manual for the White Sturgeon, *Acipenser transmontanus* Richardson: **With Application to the North American** *Acipenseridae*, by Conte, F.S., et al. O.A.N.R., University of California, Pub. 3322, p. 104, 1988.

Additional:

Aquaculture, Vol. 2, by Barnabe, G., translation editor, J.F. de L.B. Solbe, Ellis Horwood,Chichester, England, p. 1104, 1990.

Content and Procedures

Presentation:

A. What are the effects of temperature on the development of embryos and larvae?

Show TM C1 and discuss the effects of temperature on sturgeon embryos and larvae.

1. Higher temperatures, within development range, reduce time or development.
2. Optimum temperature for white, lake and Atlantic sturgeon is between 14 and 17°C.
3. Too high temperatures cause mortality.
4. Most critical time of development from fertilization through neurulation.

B. What is the sequence of embryology?

Show TM C2 and discuss the sequence of development of sturgeon embryos.

1. Eggs are polar, having an animal half and a vegetal (food source) half.

2. Unfertilized eggs:
   a. Are oval shaped.
   b. 3.6 mm x 3.3 mm.
   c. Grayish.

3. Fertilized eggs:
   a. Become colored by poles; half light and half dark.
   b. Become larger.

4. Early cleavage. Cell divisions in egg begin to become visible.

5. Late cleavage. Numerous cell divisions; eggs have a pebbled appearance.

6. Blastula. Eggs appear grainy, then smooth. Dorsal lips begin to appear.

7. Early gastrulation. Cell edges develop into furrows.

8. Yolk plug formation:
   a. Yolk sac begins to form.
   b. Embryo begins to form.

9. Neurulation: further embryonic development.

10. Heart formation.

11. Pre-hatch:
    a. Eyes become visible.
    b. Intestines form.
    c. Tails become distinct.
    d. Egg membranes become reddish.

12. Mass hatching. Larvae break free of egg membrane.

C. What is the sequence of larval development?

Show TM C3 and discuss the sequence of sturgeon larvae.

1. At 1 day post-hatch, pectoral fin bud and spiral shape of intestine appear.
2. At 2 days post-hatch, operculum flares out from head, mouth is open, and barbel buds appear.
3. At 3 days post-hatch, gill filaments begin to form.
4. At 4 days post-hatch, they become photophobic.
5. At 7-10 days post-hatch, depending on temperature, yolk sac turns into stomach and intestine.
6. At 10 days post-hatch, external feeding begins.
7. At 20 days post-hatch, larval development is complete.

Review:

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

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Evaluation will be based on class participation, quizzes, and a final exam.

TM C1

Effects of Temperature on Embryo and Larval Development

- Rate of development depends on temperature.
- Higher temperatures reduce time for development.
- Optimum temperature for white, lake, and Atlantic sturgeon is between 14 and 17°C.
- Most critical time of development is during beginning cleavage stages.

TM C2

Sequence of Embryology

- Eggs are polar. They have an animal and a vegetal (food source) half.
- Unfertilized eggs are grayish white and oval shaped.
- Fertilized eggs: Become colored by poles: half light and half dark and larger.
- Early cleavage: Cell divisions in eggs begin to become visible.
- Late cleavage: Numerous cell divisions; eggs have a pebbled appearance.
- Blastula appears grainy, then smooth.
- Early gastrulation: Cell edges develop into furrows.
- Yolk Plug Formation: Yolk begins to form then embryo begins to form.
- Neurulation: Further embryonic development.
- Heart formation.

- Prehatch: Eyes become visible. Intestine forms. Tail becomes distinct. Mass hatching: Larvae break free of egg membrane.

TM C3

Larval Development Sequence

- 1 day post-hatch: Pectoral fin bud and spiral shape of intestine appear.
- 2 days post-hatch: Operculum flares out from head, mouth is open, and barbel buds appear.
- 3 days post-hatch: Gill filaments begin to form.
- 4 days post-hatch: Larvae become photophobic.
- 7-10 days post-hatch: Yolk sac turns into stomach and intestine.
- 10 days post-hatch: External feeding begins.
- 20 days post-hatch: Larval development is complete.

Quiz for Section C

Name:

Date:

Quiz on Understanding Development of Sturgeon Embryo and Larvae

Circle a T if the statement is True or an F if the statement is False.

1.	T	F	Higher temperatures reduce the time needed for embryonic development.
2.	T	F	The most critical time of development is during the formation of the yolk.
3.	T	F	Sturgeon eggs have an animal half and a vegetal half.
4.	T	F	During early cleavage, cell divisions begin to become visible.
5.	T	F	The gills begin to form during the yolk plug formation.

Matching:

6.	___1 day post-hatch	A.	Larvae become active swimmers
7.	___2 days post-hatch	B.	External feeding begins
8.	___3 days post-hatch	C.	Gills begin to form
9.	___7-10 days post-hatch	D.	Eyes become apparent
10.	___10 days post-hatch	E.	External feeding begins
		F.	Yolk sac turns into stomach and intestine

Key for Quiz - Section C

1. T Higher temperatures reduce the time neededfor embryonic development.

2. F The most critical time of embryo development is during the early cleavage stage.

3. T Sturgeon eggs have an animal half and a vegetal half.

4. T During early cleavage, cell divisions begin to become visible.

5. F The yolk and embryo begin to form during the yolk plug formation. The gills form after post-hatch.

6.	D	1 day post-hatch	A.	Larvae become active swimmers
7.	A	2 days post-hatch	B.	External feeding begins
8.	E	3 days post-hatch	C.	Become photo-active
9.	F	7 -10 days post-hatch	D.	Eyes become apparent
10.	B	10 days post-hatch	E.	Gill filaments begin to form
			F.	Yolk sac turns into stomach and intestine

Teaching Plan:

Module: Sturgeon - Section D

Problem Area: Understanding Broodstock and Spawning Process

Goal: The goal of this problem area is to understand the broodstock and spawning process for sturgeon.

Learning Objectives: Upon completing this unit, students will be able to:

explain techniques for broodstock capture
explain procedures for transporting and holding broodstock
explain procedures for field examination of broodstock.
explain procedures for hatchery examination of broodstock.
tell how evaluation of broodstock is performed in the field.
tell how broodstock examinations are performed in the nursery
explain how spawning is induced
explain male sturgeon's response
explain female sturgeon's response

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

Essential:

Hatchery Manual for the White Sturgeon, *Acipenser transmontanus* Richardson**: With Application to the North American** *Acipenseridae*, by Conte, F.S. et al., O.A.N.R., University of California, Pub. 3322, p. 104, 1988.

Additional:

Aquaculture, Vol. 2, by Barnabe, G., translation editor, J.F de L.B. Solbe, Ellis Horwood, Chichester, England, p. 1104, 1990.

Content and Procedures:

Preparation (Interest Approach):

To develop student interest in this module, ask the students if they have had any experience with newborns. These could be brothers or sisters, or they could be pets or livestock on the farm. Ask them to discuss what they know about prenatal care for mothers and babies. Ask them if they have had experience with caring for expectant animal mothers.

Presentation:

A. Why are sturgeon eggs captured?

Show TM D1 and lead a discussion about the reasons for capturing sturgeon eggs.

1. First viable eggs obtained from F1 female broodstock about 1990.

2. Wild broodstock need to be captured. They are used primarily for study and comparison to F1 females.
   a. Can be captured as they are returning to spawn.
   b. Better to capture them 6 months early. Can be better prepared for handling them. Should know exactly how many you have to deal with.

B. How are sturgeon eggs captured from the spawning area?

Show TM D2 and discuss the procedures for capturing sturgeons in salt water. Show TM D3 and discuss procedures for capturing sturgeon in their spawning areas.

1. This is the primary method used by industry and government enhancement programs.

2. Capturing here insures greater numbers of reproductively active fish.

3. Snagging - seldom done now.
   a. Fish's skin is snagged with a hook. Small treble hooks are preferred.
   b. Hook attached to a retrievable line. Needs to be able to handle 100-kg fish.
   c. This is a practical method when there are a large number of fish. During herring runs, many white sturgeon gather to feed on herring eggs.
   d. Baited hooks are only efficient during spawning season.

4. Gill netting:
   a. Works best in spawning areas.
   b. Has higher mortality rate than snagging.
   c. Is labor and equipment expensive.

5. Hand netting - good for lake sturgeon in some areas.

C. How are sturgeon broodstock handled and transported?

Show TM D4 and discuss handling and transportation of sturgeon broodstock.

1. Because of their size, sturgeon broodstock need special handling facilities.

2. Specimens larger than 70 kg should be avoided because they can be easily injured by equipment needed to handle such weights.

3. Water quality in tanks must be of high quality, preferably from the river the fish was taken from.

4. Support equipment for individual fish.
   a. Tube net - a tube made of small mesh netting, 2.4 m long with hoop frames holding both ends open.
   b. Stretcher used to transport larger species over short distances. Made of smooth, nonabrasive, fiber-reinforced nylon. Wide enough to fold over fish and bring poles together. Hooded at one end to cover fish's head. Without a water tube may be held in stretcher for 10 minutes.
   c. Water tube - 2.5 cm diameter tygon tube connected to unchlorinated water. Goes through the hood and into the sturgeon's mouth.

5. Holding tanks.
   a. Short-term holding in nonaerated water for up to 30 minutes. Temperature should be between 15 and 17°C. Must be big enough to hold fish and prevent fish from turning in tank. Must be covered.
   b. Moderate-term holding. Use for several hours to several days. Rectangular about 2 m long x .75 m wide x .75 m deep; should hold about 1500-5000 l of water. Must maintain 5.0 mg/l oxygen. When using for transporting, a backup aeration system should be available.

6. Acclimation tanks used when bringing fish from salt water, which is seldom done with white sturgeon.
   a. Used for prespawning broodstock going from saltwater to freshwater for 2-3 days.
   b. Should be able to hold 25-30 fish.
   c. Should be about 1 m deep, with a capacity of 10,000 l.
   d. Water exchange rate should be about 57 l/min of both fresh and salt water.
   e. Aeration supplied by a forced air system.

7. Maturation tanks.
   a. Designed for long-term storage of fish.
   b. Recommended is a 6.1 m in diameter circular fiberglass tank with a center drain.
   c. Depth of .60 m gives working volume of about 20,000 l.
   d. Should be covered and away from disturbances.
   e. Water exchange rate of 10-15 volumes a day.
   f. Capacity - about 15 fish at 30 kg each.

8. Spawning tanks.
   a. Size depends on species.
   b. Should be big enough to allow the fish to move, but small enough to prevent it from turning around.
   c. Interior color of medium blue or green. Allows less penetration of light and easy visibility of eggs.

D. How are broodstock evaluated in the field?

Show TM D5 and discuss evaluating sturgeon in the field

1. Check maturity.

2. Determine sex. Sturgeon do not exhibit external sexual dimorphism, i.e., it is difficult to directly determine sex externally.

3. Secondary methods of determining sex.
   a. Best to collect fish from spawning area at height of spawning season.
   b. Females can be recognized by their swollen abdomens and enlarged girths.
   c . Males can be recognized by being freely milting or by applying pressure to their posterior abdomens, which causes them to discharge milt.
   d. It is more difficult to determine sex of fish taken from nonspawning areas.

4. Two surgical tests to determine stage of development of follicles and their receptiveness to hormone-induced ovulation.
   a. First test used for classification of late stage maturity of eggs based on egg polarization and on position of the nucleus, i.e., the Germinal Vesicle (GV). Used to determine if females are ready for spawning during present season.
   b. Second test determines ability of oocytes to respond to hormones administered during spawning induction. Used to determine if the female is ready to undergo induced spawning.

5. In transporting broodstock fish from capture area to hatchery, it is important to not allow the water temperature to rise more than a few degrees.

E. How are broodstock evaluated at the hatchery?

Show TM D6 and discuss broodstock evaluation at the hatchery. Inform the class that this is seldom done anymore due to fiscal constraints.

1. Nonripe broodstock refers to fish caught in nonspawning areas.

2. About 30-40% of wild caught fish that are brought into the hatchery will not successfully spawn because of stress. Therefore, further testing must be done.

3. When fish arrive at hatchery they are put in long-term holding tanks.
   a. Males and females are kept separate.
   b. May be held up to 9 months.
   c. Generally, captive sturgeon do not eat.
   d. Sturgeon have matured and been induced to spawn in captivity after 4 months without food.

4. Final selection based on in vito test of oocyte maturity.

5. Assay for determining spawnable females. NOTE: This is absolutely necessary to determine oocyte condition in FI broodstock.
   a. Need to incubate oocyte and examine for presence or absence of GV.
   b. Absence of GV is termed Germinal Vesicle Breakdown (GVBD)
   c. Percent of GVBD determines suitability for spawning induction.

F. What are the methods for inducing spawning incubation of broodstock?

Show TM D7 and discuss the methods used for inducing spawning. Inform the class that this section applies to fish taken from both spawning and nonspawning areas.

1. Two types of hormones:
   a. CCP - acetone dried carp pituitary.
   b. LHRHa - gland powder and mammalian gonadotropin releasing hormone analog.

2. Spawning induction requires two injections of the selected hormone.
   a. 12 hours between injections.
   b. Ovulation should start in 20-40 hours after second injection.

3. Ripe fish caught at the spawning area can be injected immediately or held for a short period, as necessary.

4. Induction hormones amount of hormone dependent upon fish weight.

G. What is the male sturgeon's response?

Males should start to milt at about 20 hours post-injection in water at 14-17°C.

H. What is the female sturgeon's response?

1. Ovulation should start within 20-40 hours after second injection of the GVBD.
2. First indication of initial ovulation is the appearance of a small number of eggs on the sides or bottom of tank.

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.

Evaluation:

Evaluation should focus on the extent to which students have achieved the objectives of the problem area. Example exam questions are attached.

TM D1

Reasons for Capturing Sturgeon

- Wild broodstock must be captured
- Can be captured as they are returning to spawn
- Better to capture them 6 months early

TM D2

Capturing Sturgeon in Salt Water

- Using 3 or more boats works best
- Must determine the sex
- Selected broodstock need a couple of days to get accustomed to fresh water
- Then broodstock are transported to hatchery by tank trucks

TM D3

Capturing Fish From Spawning Area

- Insures greater numbers of reproductively active fish

- Snagging:
  Fish's skin is snagged with a hook
  Line must be able to handle 100-kg fish
  Works well with a large number of fish

- Baited Hooks:
  Only efficient during spawning season

- Gill Netting:
  Works best in spawning areas
  Has higher mortality rate than snagging
  Labor and equipment expensive

TM D4

Handling and Transporting

Because of their size, sturgeon need special handling facilities, such as support equipment. Water quality is important. Size of spawning tank depends on species.

- Tube Net:
  Made of small-mesh netting, 2.4 m. long with hoop frames holding both ends open.
- Stretcher:
  Used to transport larger species over short distances. Made of nonabrasive, reinforced nylon hooded at one end to cover the fish's head.
- Water Tube:
  Connected to unchlorinated water. Goes through the hood and into the sturgeon's mouth.
- Holding Tanks:
  For short-term holding nonaerated water just big enough to hold fish. Must be covered.
- Moderate-Term Holding:
  For several hours to several days. Rectangular - about 5000 l of water. Must maintain 4.0 mg/l oxygen.
- Acclimation Tanks:
  Used for broodstock going from saltwater to freshwater for 2-3 days. Should hold 25-30 fish. Capacity of about 10,000 l. Water exchange rate of about 57 l/min of both freshwater and saltwater. Aeration supplied by a forced air system

- Maturation Tanks:
  For long-term storage. 6.1 m in diameter fiberglass tank; about 20,000 l. Must be covered and away from disturbances. Water exchange rate of 10-15 volumes per day.

TM D5

Broodstock Evaluation in the Field

- The purpose is to check maturity and determine sex.
- Sturgeon do not exhibit external sexual dimorphism.
- It is difficult to determine sex externally.
- Two surgical tests are used to determine stage of development of follicles and their receptiveness to hormone-induced ovulation:
  1st determines stage of maturity of eggs.
  2nd determines ability of oocytes to respond to hormones administered during spawning induction.

Broodstock Evaluation at the Hatchery

- For Fish Caught in Nonspawning Areas:
  30-40% will not spawn because of stress.
  Fish are put in long-term holding tanks.
  Males and females are kept separate.

- Selecting Induction Date:
  Test is based on in vito test of oocyte maturity.

- Assaying Spawnable Females:
  Examine for presence or absence of Germinal Vesicle (GV).
  Absence of GV is termed Germinal Vesicle Break Down (GVBD).
  Percent of GVBD determines suitability for spawning induction.

TM D7

Spawning Induction of Broodstock

- 2 Types of Hormones:
  CCP: acetone dried carp pituitary
  LHRHa: gland powder and mammalian gonadotropin-releasing hormone analog

- Spawning Induction:
  Requires 2 injections & 12-hour interval
  Ovulation should start 20-40 hours after 2nd injection

- Induction of Hormones:
  Amount depends upon fish weight

Male Response

Males should start to milt at 20 hours post-injection.

TM D9

Female Response

Ovulation should start in 20-40 hours injection of the GVBD.

Quiz for Section D

Name:

Date:

Quiz on Understanding Broodstock and Spawning Process

Circle a T if the statement is True or an F if the statement is False.

1. T F It is preferable to collect eggs from captive females.

2. T F About 20% of the sturgeon caught in salt water are actively spawning.

3. T F A good way to catch a sturgeon broodstock in a bay is to snag it with a hook.

4. T F Gill netting has a lower mortality rate than does snagging.

5. T F Because of their size, sturgeon need special handling facilities.

6. T F Water fed through tubes over the gills are essential when handling sturgeon for longer than 10 minutes.

7. T F Sturgeon can be held in holding tanks for up to 30 minutes without using aeration equipment.

8. T F Acclimation tanks are used for transporting large numbers of sturgeon.

9. T F Spawning tanks should be big enough to allow the fish to move, but small enough to prevent it from turning around.

10. T F One purpose for evaluating broodstock in the field is to check its sex.

11. T F Sex differences in sturgeon are easily observed in the field.

12. T F Final selection of broodstock is based on in vito testing of oocyte maturity.

13. T F Ovulation begins immediately after the 2nd injection of spawning induction hormones.

Key for Quiz - Section D

Circle a T if the statement is True or an F if the statement is False.

1.	T	It is preferable to collect eggs from wild females.
2.	T	About 20% of the sturgeon caught in salt water are actively spawning.
3 .	T	A good way to catch a sturgeon broodstock in a bay is to snag it with a hook.
4.	F	Gill netting has a higher mortality rate than does snagging.
5 .	T	Because of their size, sturgeon need special handling facilities.
6.	T	Water tubes are essential when handling sturgeon for longer than 10 minutes.
7.	T	Sturgeon can be held in holding tanks for up to 30 minutes without using aeration equipment.
8.	F	Acclimation tanks are used for prespawning broodstock going from salt to fresh water.
9.	T	Spawning tanks should be big enough to allow the fish to move, but small enough to prevent from turning around.
10.	T	One purpose for evaluating broodstock in the field is to check its sex.
11.	F	Sex differences in sturgeon are difficult to make in the field.
12.	T	Final selection of broodstock is based on in vito testing of oocyte maturity.
13.	F	Ovulation begins 20-30 hours after the 2nd injection of spawning induction hormones.

Teaching Plan:

Module: Sturgeon - Section E

Problem Area: Understanding Care and Handling of Fry and Fingerlings

Goal: The goal of this problem area is to understand the care and handling of sturgeon fry and fingerlings.

Learning Objectives: Upon completing this unit, students will be able to:

describe 2 designs for sturgeon culture systems
describe fry transportation systems
describe fry storage tanks
describe behavior patterns of early fry
explain procedures for initiating feeding fry
explain criteria for selecting food
list feeding rates and frequencies
describe procedures for stocking fingerlings
discuss health problems that sturgeon encounter

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

Essential:

Hatchery Manual for the White Sturgeon, *Acipenser transmontanus* Richardson: **With Application to the North American** *Acipenseridae*, by Conte, F.S., et al. O.A.N.R., University of California, Pub. 3322, p.104, 1988.

Additional:

Aquaculture, Vol. 2, by Barnabe, G., translation editor, J.F. de L.B. Solbe, Ellis Horwood, Chichester, England, p. 1104, 1990.

Content and Procedures

Preparation (Interest Approach):

To develop student interest in this module, ask the students if they have taken care of any newborns. Compare the care of sturgeon fry and fingerlings with the care of other newborns.

Presentation:

A. Why is fry and fingerling production important?

Show TM E1 and lead a discussion about the kinds of sturgeon culture systems.

1. Fry and fingerling production is a difficult part of sturgeon aquaculture practice.
2. The major culture system used is composed of self-cleaning circular tanks.

B. How are fry transported?

Show TM E2 and discuss the transportation of sturgeon fry.

1. Best to do long-range transporting while fish are in yolk sac fry stage.
2. Fish are shipped in double polyethylene bags that contain 80% oxygen by volume.
3. Bag should only contain 1% yolk fry.
4. Bags are shipped in insulated shipping containers.

C. How are fry stored?

Show TM E3 and discuss the various storage facilities for fry.

1. Circular tanks.
   a. Normal size about 122 cm in diameter by 46 cm deep.
   b. Has centered, screened standpipe and spray bar for water delivery.
   c. Need to maintain DO = or > 5.0 mg/l.

2. Rectangular tanks.
   a. Typical size is 61 cm x 152 cm x 61 cm deep.
   b. Water supplied by a single or double spray bar.
   c. Stocking density about 15-20 yolk sac fry per liter.

D. How do fry behave?

Show TM E4 and discuss fry behavior.

1. Fry will disperse throughout the water column.
2. Will have a slightly negative phototaxic reaction.
3. Within 5 days, fry develop a strongly negative phototaxic reaction and sink to bottom of tank.
4. About 4-6 days after hatching, depending on temperature, fry will begin feeding.

E. How is feeding initiated?

Show TM E5 and discuss methods used to initiate feeding.

1. Transition from yolk sac feeding to exogenous feeding is critical. Feeding should be initiated before yolk sac absorption is completed (between 5 and 10 days).
2. A small amount of feed is milked or squeezed in the water, to enhance the fry's ability to pick up on the scent of the feed.
3. Precautions should be taken to remove all uneaten food.
4. Once they begin feeding, they disperse throughout the tank.

F. How should food be selected?

Show TM E6 and discuss the importance of selecting food for fry.

1. No specific sturgeon feed has been developed yet, though some commercial feed companies are currently researching this.
2. Salmon feed works fairly well. Both moist and semi-moist food are being used.
3. Current debate over the formalization of prepared rations.
4. Research indicates that it is difficult to change fry started on a natural diet to one based on prepared feeds.
5. After 2 months, growth rate is better with prepared feeds.

G. What feeding rates and frequency are appropriate?

Show TM E7 and discuss feeding rates and frequencies for sturgeon fry.

1. Can feed by volume. Example: feed at rate of 25% of tank's total biomass.
2. Can feed by timing, i.e., every 2 hours, with frequent examinations.
3. Some feed by hand, others with automatic feeders.

H. How are fingerlings stocked?

Show TM E8 and discuss methods used in stocking fingerlings.

1. Optimum size is 15.0 cm long.
2. Prepare fry for new water by moving new water through transportation tank for 30 minutes before release.

I. What health problems do fry encounter?

Show TM E9 and discuss health care of sturgeon fry and fingerlings.

1. Common diseases:
    a. Mycobacteriosis and Columnaris.
    b. Costia - bacterial gill disease.
    c. External fungus.

2. Unidentified diseases:
    a. Internal fungus caused by *Saprolegnia sp.*
    b. Virus caused by Adenovirus.
    c. Liver disease.
    d. Gut inflation.

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 problem area.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Example exam questions are attached.

TM E1

Types of Sturgeon Culture Systems

- Feeding fry is a complex and difficult task.
- Design for Culture Systems:
  Self-cleaning circular tanks

TM E2

Fry Transport

- Do long-range transporting while fish is in yolk sac stage.
- Fish are shipped in double polyethylene bags.
- Bags contain 80% oxygen by volume.
- Bags should contain only 1% yolk fry.
- Bags are shipped in insulated shipping containers, often by overnight carrier.

TM E3

Fry Tanks

- Circular Tanks:
  Size: 122 cm diameter x 46 cm deep
  Must maintain AVO of 5.0 mg/l

- Rectangular Tanks:
  Size: 61 cm x 152 cm x 61 cm deep
  Water supplied by a single or double spray bar

- Stocking Density:
  About 15-20 yolk sac fry per liter

TM E4

Fry Behavior

- Fry will disperse throughout the water column.
- Within 5 days the fry develop a strongly negative reaction and sink to bottom.
- 3-5 days after this, fry will begin feeding.

TM E5

Initiation of Feeding

- Transition from yolk sac feeding to exogenous feeding is critical.
- Feeding should begin before yolk sac absorption is completed (between 8 and 14 days).
- A small amount of feed is milked in the water to enhance the fry's ability to pick up on the scent of the food.
- Precaution should be taken to remove all uneaten food.

TM E6

Selection of Food

- Salmon feed will work fairly well for sturgeon.
- Both moist and semi-moist food are used.
- Research shows that it is hard to change the diet of fry from a natural diet to one based on prepared feeds.
- After 2 months, growth rate is better with prepared food.

TM E7

Feeding Rates and Frequency

- Feeding by Volume:
  Example: Feed at rate of 25% of tank biomass

- Feeding by Timing:
  Example: Every 2 hours, with frequent examinations
  Can feed by hand or with automatic feeders

Stocking Fingerlings

- Optimum size: 15.0 cm long.
- Water from the source that the fry will move into should be circulated through transportation tank for 30 minutes before the fry are added to the stocking pond.
- Keep fry in floating screen for first 24 hours.

TM E9

Fry Health

- Common Disease:
  Mycobacteriosis
  Columnaris
  Costia

- External Fungi:
  Internal fungi caused by *Saprolegnia sp.*
  Virus caused by adenovirus
  Liver disease
  Gut infection

Quiz for Section E

Name:

Date:

Quiz on Understanding Care of Handling Fry and Fingerlings

Complete the following questions or statements by giving a short, written explanation.

1. What is the best design to date for a cultural system?

2. Explain the ideal way to transport sturgeon fry.

3. Explain what it means to milk feed into fry's water.

4. Explain why it is beneficial to start feeding sturgeon fry with a prepared feed.

5. List 4 common health problems associated with sturgeon fry.

Key for Quiz - Section E

1. What is the best design for a cultural system?

   The best cultural system design is one that uses a self-cleaning, circular tank**.**

2. Explain the ideal way to transport sturgeon fry.

   For transporting, fry should be shipped while in the yolk sac stage in double polyethylene bags that contain 80% oxygen and 1% yolk fry. These bags are then put into insulated shipping containers**.**

3. Explain what it means to milk feed into fry's water and why it is done.

   A small amount of feed is put into the fry's water, then is squeezed between the thumb and finger. This enhances the fry's ability to pick up on the scent of the feed.

4. Explain why it is beneficial to start feeding sturgeon fry with a prepared feed.

   Research shows that it is difficult to get sturgeon fingerlings to eat prepared food if they have been started on a natural feed as fry. This is important because after 2 months of age, the growth rate is better with prepared feed.

5. List 4 common health problems associated with sturgeon fry.

   The common health problems associated with sturgeon fry are bacterial diseases, external fungi, internal fungi, viruses, gut infections, and liver diseases.