Fish Hatchery Management

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Contents of this lecture

- Aquatic organisms (fact sheet)
- Modes of fish reproduction
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- Sexual maturation and broodstock management
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Aquatic organisms (fish)
Introductory fact Sheet

- Cold Blooded Animals with the exception of a known species (Great white shark)
- Highly fecund animals compared to other animal groups even for low-fecund fish species
- Highly diversified group (finfish, crustaceans, molluscs, …)
- Living environments determine the inhabiting and their mode of reproduction (cold water, warm water, freshwater, marine water)
- Vary significantly in regard to their reproduction (egg layers, egg retainers, live bearers, etc.)

Fish fecundity

Notes:

- Fecundity of fish species with large eggs (e.g. salmonids) is lower than fishes with small eggs.
- Mouth brooders like Nile tilapia have low fecundity compared to substrate spawners (e.g. *Tilapia zilli*i.
- Live bearers such as mosquito fish (gambusia) give birth to small number of embryos; Manta ray gives birth to only one

Comments	Species	Relative fecundity estimates (no. eggs/kg of female)
Live bearers	Mosquito fish	50 (embryos)/fish
	Manta ray	One/fish every two years
Egg layers	Common carp	150,000
	Grass carp	80,000
	African catfish	80,000
Mouth brooders	Nile tilapia	2000 – 4000
Large eggs	Rainbow trout	2,200
Catadromous fish	European eels	1.8 – 3.0 million
Crustaceans	Black tiger shrimp	1.5 –2.2 million

Absolute fecundity may reach extremely high (>300 million an ocean sunfish (*Mola mola*)

Modes of fish reproduction (examples)

Egg layers – (Oviparous)

Substrate spawners
Green tilapia (*Tilapia zillii*)

Adhesive eggs are laid/fertilized upon a flat substrate (rock, crevices, etc.)

Eggs are often small with less yolk

Non-adhesive eggs are laid/fertilized and picked up into oral cavity by female

Eggs are often larger with more yolk

Mouth-brooders
Nile tilapia (*Oreochromis niloticus*)

Freshwater prawn
(*Macrobrachium rosenbergii*)

Female carrying eggs

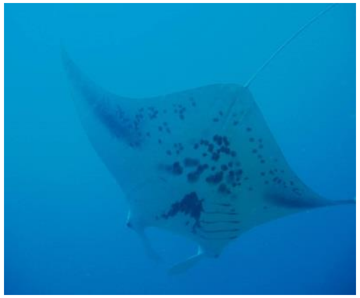
Modes of fish reproduction (examples)

Ovoviviparous - Egg retainers

Each embryo develops in its own egg in female's body until hatch.

Live bearers (female or male)

A female manta ray gives birth



Credit: NOAA

A male seahorse gives birth

Credit: Samart Detsathit

Modes of fish reproduction (examples)

Viviparous

Like most mammals, eggs in viviparous fish receive its nourishment is directly from the mother and not from the egg (e.g. some sharks and surfperches)

Lemon shark (*Negaprion brevirostris)*

Gives birth to 4 – 17 live free swimming pups of 24-26 inches at birth after 10-12 month gestation period. (Credit: Wikipedia)

Unique modes of fish reproduction (an example)

Credit: GreenPeace

- Sponges are hermaphroditic (both sexes in one), but an animal acts as either male or female
- They have no gonads; sperm and eggs are produced through specific arrangements
- Fertilization occurs internally and eggs are retained internally until they hatch

There are numerous examples for reproduction patterns of aquatic organisms which are out of the scope of this lecture

Parental care

Nile tilapia
Spawning nest 30-60 cm diameter

Mouth incubation (Nile tilapia female)

Hornet tilapia: deposit eggs in a hole dug by parents who attend their eggs until hatch

Fanning egg mass
(channel catfish male)

Arapaima: Guard eggs & offspring until disperse

Notes on fish reproduction

Spawners	Parental care	Notes
Oviparous vast majority of teleosts Pelagic spawners Demersal spawners	Vary Zero care Hiding eggs Nest building Mouth breeding Fanning eggs Guarding eggs/young	Eggs are released in water before fertilization by male's spermatozoa An egg membrane is present, and the embryos are nourished entirely by the yolk. In sea water, the sperm activity depends on Ca/Mg ions, which allows sperm to remain active in salt water for up to an hour as opposed to about a minute in freshwater
Ovoviviparous In most Sharks and Rays, as well as species of Rockfish and sea horse	Very High	eggs are fertilized inside of the female and develop within her body allowing for a greater degree of protection from predators and harsh environmental conditions during incubation
Viviparous (e.g. some sharks and surfperches)	Maximum care Eggs are within the mother throughout development	Nourishment is from the mother and not from the egg 10 - 40 young of well-developed juveniles are born of about 50 mm in length. Male progenies of at least one surfperches species are born sexually mature, although they are not fully grown

Commitment to death

Pacific salmon (*Oncorhynchus* spp.): They dig in the gravel of streambed to lay their eggs then fertilize it and die.

American and European eels (genus *Anguilla*): Mature eels migrate from their freshwater rivers to the spawning grounds of their birth (Sargasso Sea in the Atlantic Ocean); females lay eggs that are fertilized by males, then both males and females die.

Cuttlefish: Female attends her laid eggs until hatching – afterwards both patents die.

Common Sydney octopus: Eggs laid are incubated by females for 25-45 days until eggs hatch, then female dies; during the incubation period females do not feed.

Both parents die

Only mother dies

Credit: Dr. Sagiv Kolkovski

Mother Nature
Collection of gravid females and/or young

Black tiger shrimp

Mullet

Milkfish

Glass eels

Mussel spat

Mullet fry

Freshwater prawn (a female carrying eggs)

Nature and fish reproduction
Disturbing mother nature

Human activities (over fishing)

Pollution (mass/selective effects)

Political conflicts (sturgeon & shared stocks)

Construction of dams (block migration)

Fish ladder
how effective?

Therefore

For the sake of sustainable aquaculture development, the establishment of hatcheries become necessary

Essential components of fish hatcheries

Hatchery facilities

Broodstock

- Collection
- Husbandry

Hatchery operations

Nursing of produced fry/post larvae

Hatchery facilities (ponds/tanks)

Ponds

Having sufficient number of broodstock ponds will help avoid too many fishing and so reduce stress and possible decline in the potency of fish

Good match between outdoor ponds and indoor facility should be maintained

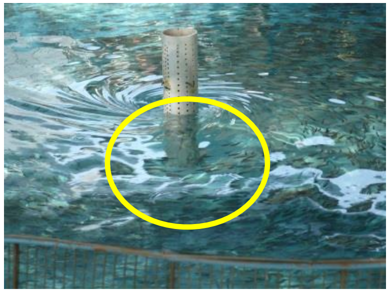
A recovery pond for spent females **is a must**

Depending on hatchery plan, a pond for common carp may be considered (donor to pituitary gland)

Why common carp?

Mature earlier than many fish species
Less costly to produce, maintain & sacrifice

Tanks



Neither tank material nor paint should carry any harm to broodfish/fry

Water flow has to be adequate **(not excessive)**

Self-cleaning tanks is preferred

Air has to be supplied from oil-free air pumps

If heaters are used, temperature range should be minimum

Depending on species, lightning system installation has to match the species needs

Hatchery Management – Water

Quantity

For a freshwater hatchery
Ponds of 5-ha require 40-50 l/second of water

For a marine hatchery
Pumping capacity/h 50% of water volume

Quality

Hatchery water should be:

- **L**ow in turbidity
- **H**igh in DO
- **L**ow in CO_2
- **Extremely low** in hydrogen sulfide **(if any)**
- **N**ot super-saturated with nitrogen or other gases
- **Salinity (level & range)**: close to optimum
- **Temperature**: close to optimum with minimum fluctuation
- **Heavy metals**: case by case

Water Quality

Turbidity

Sand filter – oyster hatchery Morocco

Suction pump – backyard prawn hatchery – Thailand

Sterilization

UV system – oyster hatchery Morocco

We need to consider:

What could be accepted in a farm may not be tolerated in a hatchery

Copper and Zinc are damaging elements (no copper pipes, no zinc containers)

Water Quality (biosecurity)

Egypt

Importing certified disease-free broodstock of whiteleg shrimp and spawn them in bio-secure facilities has been done in 2018/2019 in order to tackle the collapse of shrimp production due to the spread of disease

Broodstock

From the wild

Recommended for/in:

- For First time ever
- For stock enhancement programs (release) (Fish for natural systems are not the same fish for aquaculture)
- Fish does not mature in captivity (until now)
- Limitation in hatchery facilities (cannot handle the whole operation)
- Economic reasons (eliminating the cost of their maintenance in captivity)

BUT

- Less reliable – could be affected by environmental factors
- Abundance still have limits and could be affected by overfishing or higher demand
- we have to accept what we get – no opportunity to perform breeding programs

Broodstock

From other hatcheries/fish farms

Advantages <u>when done properly</u>:

- More reliable
- More domesticated (suits aquaculture better for general husbandry requirements)
- Possible applications of breeding programs
- Possibility for extending the spawning seasons is known
- Better understanding of broodstock history (depending on the availability/quality of book keeping systems)

Broodstock collection From the wild or from hatcheries/fish farms

Genetic consideration

In order to ensure a proper operation of the genetic component of the target hatchery, the followings are considered:

Number of mature and/or future broodstock

Sex ratio of collected fish whenever applicable

Spatial and seasonal coverage (wild collected)

The collecting of hatchery broodstock targets to establish a gene pool with enough variability sufficient for eliminating possible genetic problems – This is discussed in a special lecture on the applications on genetics in aquaculture

Broodstock maintenance
Feeding

Over-feeding with carbohydrate rich or fatty diet should **<u>be avoided</u>**

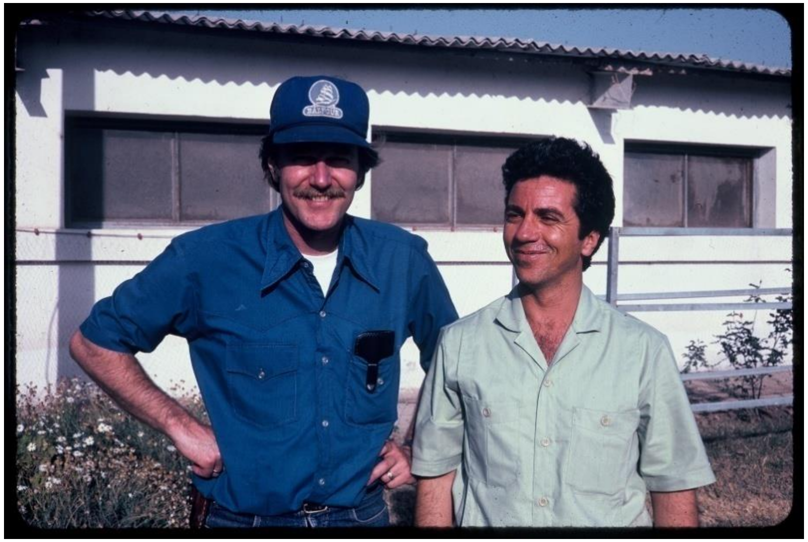
The visceral fat in Indian carps and grass carp affected ovary development and impaired their response to artificial reproduction practices

Placing fish in weedy habitats helped them to shed visceral fat allowing fish to spawn

Mixing artificial feed of marine broodstock with squids/snail is believed needed for successful spawning

For Asian seabass (Vietnam)
Photo credit: Ahmed Shaheen - Egypt

Hatchery management
Started complex (Cases)



1980 – Abbassa (common carp)

1982 – Sète/France
(seabass, seabream)

Hatchery management

Turned easier- more towards natural systems

Open spawning system
Marine hatchery - Cyprus

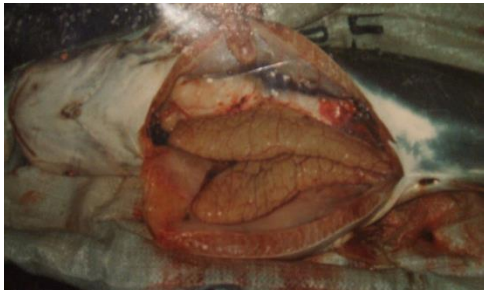
Egg collection system
Marine hatchery - Kuwait

Hapa system
Tilapia hatchery - Egypt

Broodstock
Gonadal Development

- Gonads develop to a certain stage and remain dormant
- Further development will be triggered as suitable conditions exist producing ready to spawn
- Triggering factors include light & temperature, salinity, flood conditions, level of moon light, presence aquatic plants, presence of opposite sex
- Dormant stage continues if environmental changes are not too strong
- If environmental conditions get worse, the absorption of eggs takes place

Ovary



Testes

Broodstock
Size of mature eggs (examples)

Species	Diameter in mm
Whiteleg shrimp (*Litopenaeusvannamei*)	≥ 0.22 mm
Brazilian flounder (*Paralichthys orbignyanus*)	≥ 0.40 mm
Gilthead seabream (*Sparus aurata*)	≥ 0.50 mm
Grey mullet (*Mugil cephalus*)	0.6 – 0.8 mm
European seabass (*Dicentrax labrax*)	0.65 mm
Cobia (*Rachycentron canadum*)	0.70 mm
Common carp (*Cyprinus carpio*)	0.9 – 1.2 mm
Pikeperch (*Sander lucioperca)*	0.95 mm
African catfish (Clarias Gariepinus)	1.0 – 1.6 mm
Nile tilapia (*Oreochromis niloticus*)	1.3 – 2.2 mm
Sturgeon (*Acipenser* sp.)	3.5 – 4.0 mm

Broodstock sorting
(based on gonad development)

Females:

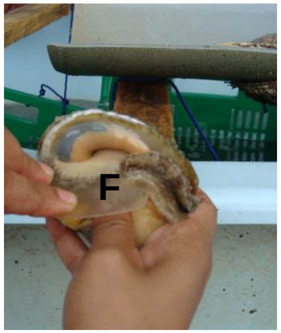
- Ripest (ready to spawn)
- Promising
- Not different from males (discard)

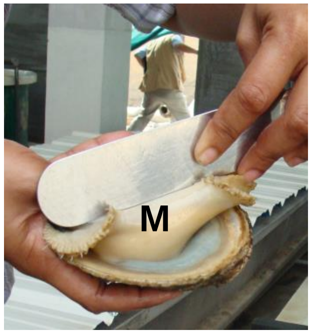
Males:

- Ready
- Unready (discard)

Male readiness of African catfish

Sexing and stage of maturation





Abalone

Sexing & stage of maturation can be quite easy like these or may require additional work (e.g. catheterization)/ Laparoscopy (sturgeon)

Shrimp
(Stage IV)

African catfish

Roughness of the dorsal surface of pectoral fins (male of grass carp

Tilapia

Hatchery technologies

Chosen reproduction methodology is based on:

- Fish species & reproduction requirements
- Available hatchery facilities
- Economics

Fish spawning could be classified as:

Natural: Tilapia, common carp, African catfish

Some artificial: Tilapia, some marine species, shrimp, others

Artificial: Chinese carps, common carp, some marine species, African catfish, & others

The relatively low fecundity of tilapia does not justify the hormonal induction on commercial scale

Natural Spawning

African catfish
(shading & substrate)

Sticky eggs of common carp

Our responsibility is to:

Choose the ready broodstock

Furnish the required facilities & environments

Watch for the spawning

Fish responsibility is to:

Get the work done

European Seabass

Channel catfish

Tilapia

Old hatchery practices

Setting the stage (Common carp) – Dubisch ponds (1860)

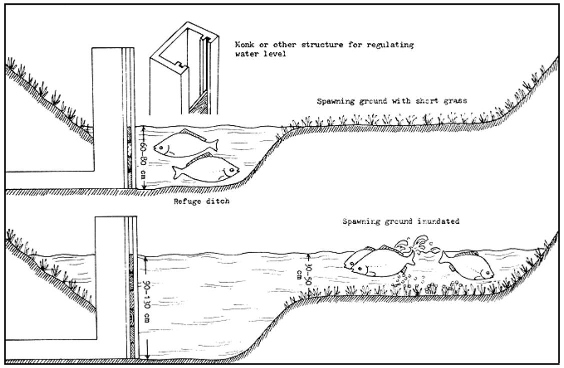
Dubisch Pond has a raised center area that could be covered by water.

This area is covered with a spawning medium such as trimmed grass.

Selected pairs of broodstock once stocked, they spawn on the raised section – eggs stick to the grass.

Immediately after spawning, water is drained down; breeders move to the deep water where they are scooped.

The pond is filled again. As eggs hatch and grow to adequate size, they are collected for further nursing.



Source of the sketch: FAO

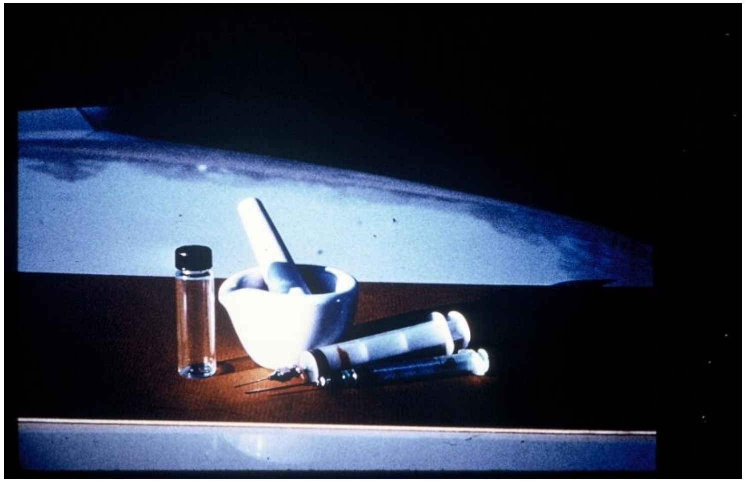
Dubisch ponds are typically 120 to 300 m^2 in surface and have an average depth of 30 – 60 cm

The relative shallowness and small area of the pond allow the water to warm quickly after filling

The shallow depth encourages the emergent grass which act as a substrate

Artificial Spawning

Hormonal administration



Even the spawning is artificial, biological parameters still control

A broodstock **must be ready** in order to respond to the hormonal induction

Catheterization (egg sampling)

- Catheter should be of adequate size to match fish size and the urogenital pore
- Careful manipulation and minimum force is needed to avoid the damage of sphincter muscles
- If sphincter muscles got torn, eggs at the posterior end of the ovary will water-hardened, and the plug is formed

Improper catheterization may result in hemorrhage and clotting & blocking of egg flow during ovulation

Credit: Italo Bardales (Peru)

Pituitary gland

- First use was in 1934 in Brazil
- Should be taken from sexually mature male or female
- Will be more effective when taken just prior to the spawning season
- One kg of common carp has a pituitary weighs 3 mg dry weight (pituitary is usually counted and not weighed)

Artificial Spawning
(related to hormonal/other substances injection/)

- Emphasizing: hormones used for induced spawning **do not -by itself- produce** gametes (eggs or sperm)
- Hormones only trigger the release of fully developed gametes
- Fish must not only be sexually mature but should also be in the advanced stage of sexual development before induced spawning will be successful
- Sources of hormones could be the pituitary gland or other hormones (e.g. Human chorionic gonadotropin-HCG, Luteinizing Hormone Releasing Hormone - LHRH)
- HCG is a reliable marker of pregnancy in human
- Other substances rather than hormones may be used

Hormonal Administration

IF:

Fish are selected properly **and**

Hormones are administered at the right time with the proper dose

After the ripening period

↓

Ovulation is expected

The overall protocols of hormonal induction vary from a species to another even for the same species

For batch spawners (e.g. gilthead seabream), slow release implants are used to release the hormone over an extended period of the spawning

Full Spawners

Batch Spawners

Ripening period & temperature

Common carp

Temperature (C)	Ripening time (h)
15 - 16	24 - 26
18 - 19	15 - 16
22 - 23	12 - 15
25	10
28	08

African catfish

Temperature	Ripening time (h)
20	20
25	10
30	07

Source: FAO: Manual on seed production of African catfish (Clarias gariepinus)

Ripening period (time between final hormonal dose and ovulation/stripping)

Ovulation

- Time of ovulation need to be watched
- Indicator fish may tell
- If eggs were not stripped at the appropriate time they turn overripe
- Over-ripe eggs do not fertilize
- Time between final injection and ovulation is ripening time (hour-grade)

Over-ripening

Notes

Once ovulation starts it cannot be stopped or reversed

Eggs must be spawned or stripped at the proper time once ovulation starts

Failing to do that, eggs turn over-ripe

Over-riped eggs are no longer fertilizable

In general, the eggs of warm water fish turn overripe more quickly after ovulation compared to those for cold water fish.

Approximate time after ovulation within which 50% of the eggs in the ovary become overripe

Species	Minute/hour/day
Common carp	50 – 80 min
Grass carp	30 – 40 min
Silver carp	30 – 40 min
Bighead carp	50 – 80 min
Sturgeon	2 hours
Rainbow trout	7 days

References: Woynarovich, E. and L. Horváth, 1980 The artificial propagation of warm-water finfishes - a manual for extension. FAO
R.W. Rottmann, J.V. Shireman, and F.A. Chapman, Techniques for taking and fertilizing the spawn of fish

Stripping

African catfish

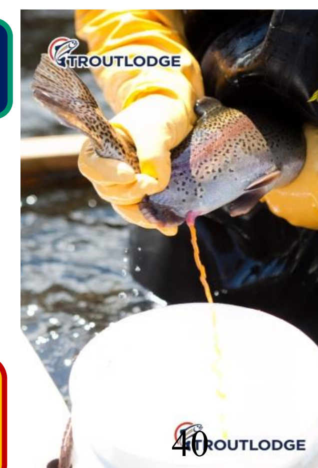
Eggs are flowing freely/un-interrupted

Colossoma sp.

Mekong Giant Catfish

Credit: Wanna Thawinwan (Thailand)

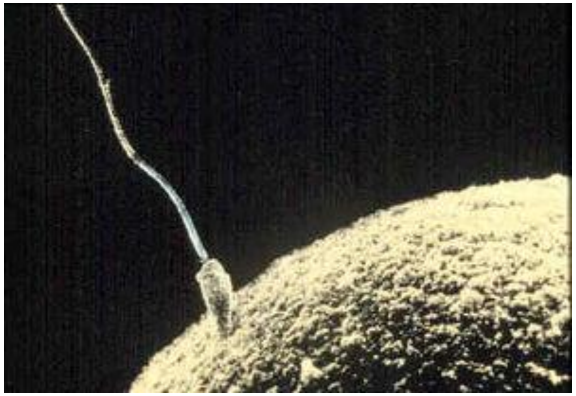
Rainbow trout



Credit: TROUTLODGE (USA)

Stripping (Cont.)

- Blood or broken eggs resulting from improper handling will reduce the rate of fertilization
- Protein from blood or broken eggs will coagulate and plug the micropyle and hence reducing the rate of fertilization
- Placing eggs in 0.6% salt solution (fertilization solution) makes the protein to go back into solution



Collecting sperm

Done through:

Use of live males

Use the testes of sacrificed male (African catfish)

Preserved milt

Saving a male (African catfish)

Saving a male (African catfish)

In situations where losing a male catfish after another is not tolerable, surgical approaches could be in practice through:

- Drawing sperm from testes or sperm duct through a small incision **OR**
- Ablation of about ¾ of male testes

Notes: Wounds are stitched using veterinary materials

Removed testis regenerate and so the re-use of the same male is possible after about 45 days post-surgery

Photos' credit: Mouhamed Hosni Kouotou (Cameroon)

Specific spawning induction

Eyestalk ablation in marine shrimp

X organ

GIH
MIH

Incision

ligature-style ablation of Penaeus vannamei

Photo credit: David Kawahigashi – Vannamei 101

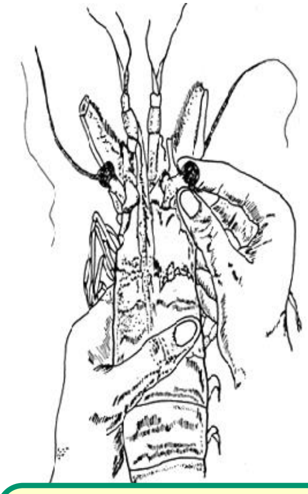
Commercially adopted in the early 1970s

Eye stalk ablation removes x organ along with its contents of "Gonad Inhibiting Hormones"

Ablated shrimp has to be when hard-shelled, or in pre-molt stage

Final ovarian development/spawning within 3-10 days

Hopefully one eye stalk only



Press

Source of diagrams: FAO, shrimp hatchery, design, operation and management

Artificial insemination – Mating of selected individuals

Marine shrimp

Used to obtain a regulated supply of fertilized eggs as well as for various genetic programs

Male spermatophores are manually ejected

The thelycum of the ripe female is exposed

The spermatophore is placed and secured in the thelycum

Under optimum condition, the spawning takes place within about 1 to about 24 hours after the insemination

Milt cryopreservation & Extending Solution (Ringer)

Ringer solution

In 100 ml of water:

Sodium chloride	592 mg
Potassium chloride	172 mg
Calcium chloride	079 mg
Magnesium sulfate	031 mg

+

100,000 units of penicillin
100 mg of streptomycin

Fish milt –<u>and not</u>- ova could be cryopreserved using liquid nitrogen (-198°C)

Usually done in breeding programs and in gene banks

Cryopreservation of tilapia milt
Credit: Kevin Fitzsimmons (USA)

The practice allows better management of egg fertilization
The sperm/solution could be stored for few days in a refrigerator
Sperm quality could be microscopically checked before use

Sperm/Ringer need to be exposed to room temperature before use – otherwise they may undergo a thermal shock

Fertilization

Natural selection of sperm quality

If a female cuttlefish mates with several males, she stores the sperm individually in her mantle before deciding which male will be the father of the progeny.

After the completion of fertilization, (dry or wet method), fertilized eggs should be incubated till hatching

Good quality milt
=
High rate of fertilization

One male or more?

↓

Genetic considerations

Incubation – duration & facilities

Affected by:

Species

Type of eggs

Environmental conditions

Key environmental factors are temperature and light

In general, incubation period could be as short as hours, few days for some species or as long as several months for other species

Incubation period (examples)

Selective warm water species Source: FAO

Species	**Incubation temperature (C)**	
	Optimum	Days/hours
Common carp	20 - 22	3.5 - 4 d
Grass carp	22 - 25	1 – 1.5 d
Catla	24 - 30	14 – 20 h
Asian catfish *Pangasius sutchi*	28 - 29	23 – 25 h
Nile tilapia	28	4 d
Clarias macrocephalus	26 - 30	18 – 20 h
Cachama *Colossoma oculus*	25 - 26	18 – 19 h

Incubation & temperature

Source: Earl Leitritz, trout & salmon culture

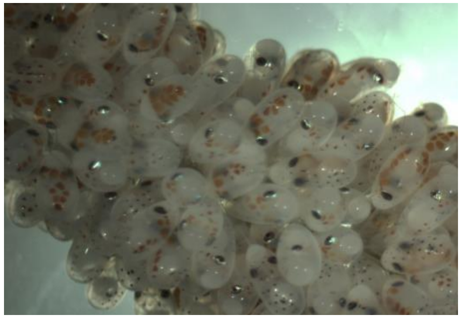
Temp C	**Incubation period (days)**		
	Rainbow trout	Brown trout	Nile tilapia
1.7		156	
4.4	80	100	
7.2	48	64	
10.0	31	41	
12.8	24		
15.6	19		
24.0			5-6
28.0			4
30.0			3

Note: the optimum thermal range for reproduction falls **within** survival range

Types of fish eggs in relation to treatment

Mass (Channel catfish)

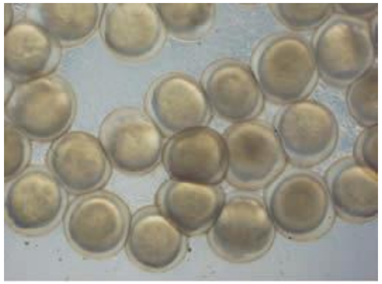
Large Eggs (salmon)



Eggs of common Sydney octopus (2-mm eggs attached to 10-12 cm long string)
Credit: Dr. Sagiv Kolkovski

Loose Eggs (tilapia)

Sticky eggs (carps)
Tannin is used to dissolve the adhesive material



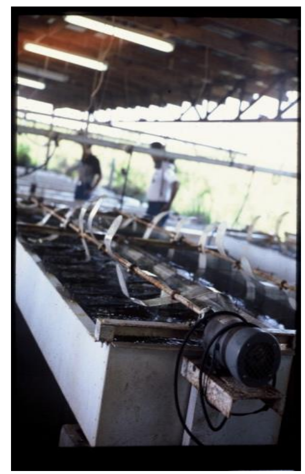
Incubators in relation to egg types

Tilapia

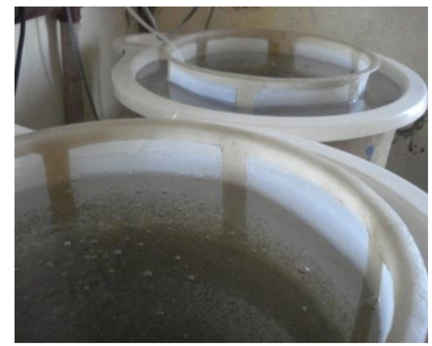
African catfish

Simple and efficient incubator
Credit: Grace Charway (Ghana)

Channel catfish

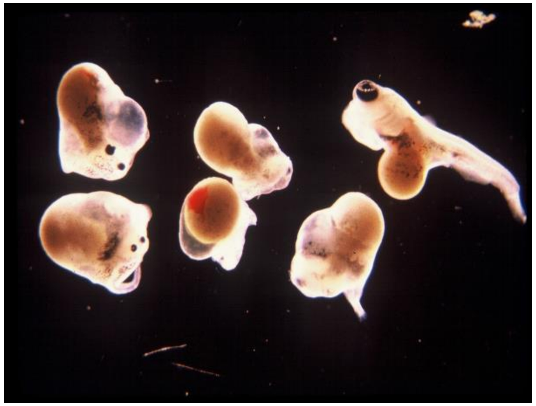


Black catfish



Large size incubator for highly fecund fish
Credit: Claudia Gravina (Uruguay)

Deformity/Gas bubble disease



Due to temperature fluctuation

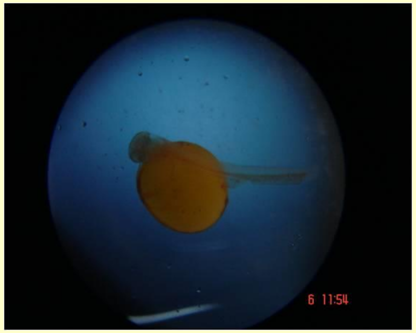
Check for Water Quality

Use de-aerating devices (can be simple)

Pop Eyes

Force hatching

Artificial (forced) hatching: this is done by drastically reducing water flow for few minutes), a normal flow of water must be restored immediately.



The delay can lead to suffocation and loss of the hatched embryos.

Synchronize hatching

Use of Independent temperature controlled incubators

Each single incubator in thermally controlled

This unique incubator's establishment enables synchronizing the hatching of rainbow trout embryos

Hatching occurs at the same time for groups of different ages

Photo credit: Troutlodge Inc.

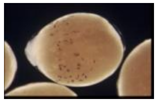
Embryonic Developments

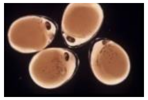
Never mix different ages during incubation

Tilapia

May hatch anytime

Photo credit: Mutasim Yousef (Sudan)





A colored tub for each stage
Credit: Muhammad Iqbal (Pakistan)

Green eggs

Freshwater prawn

Good or Bad Eggs

If eggs are heavily infected with fungus and other batches could be obtained:

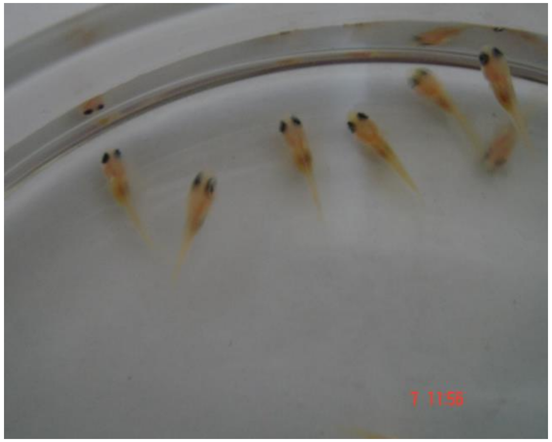
Discard the whole bad batches

Incubation/temperature

It is much safer to incubate at highest safe temperature

(refer to an earlier table)

Hatchery products (good <u>or</u> bad)



Replacing hatchery broodstock

Facts:

Young broodstock produce more eggs/g (relative fecundity), with shorter spawning intervals & much easier to handle. Replacing old broodstock by younger ones is often recommended

No Fixed Rule

Annual change of oldest potion (e.g. 1/3)

OR

All-in & all-out

Compensating the missing sex & correcting the skewed sex ratio (in changing sex species – e.g. gilthead seabream: males change into females)

Management & species

While management may apply to almost all species

Because in biology nothing is exact

Modification in hatchery operations may take place according to species

Some steps may be omitted, others may be added

In brief, study your species

When hatchery practice begins with incubation

A carrying-egg female of freshwater prawn

Incubating the fertilized eggs of all-female of rainbow trout
Credit: Troutlodge (USA)

Incubating fertilized eggs of sturgeon hybrids in Uruguay
Credit: Alejandro Perretta (Uruguay)

Stages before the current one were developed elsewhere

Management and scale of production
Usually apply to large hatcheries

Abbassa – Egypt
(15 million tilapia fry/year)

Aswan - Egypt

Management and scale of production

Should also apply to small-scale hatcheries (e.g. tilapia hatcheries)

Chipata - Zambia

Fayoum - Egypt

Enhancing Hatchery Efficiency
Extending the spawning season

Chilling, heating and light manipulation are used in marine hatcheries (Italy)

Greenhouses target the production of tilapia at the time that suits the farms (Egypt)

- Manipulating of photoperiod and/or temperature are the key factors for extending the spawning season outside the natural season
- The technique is in practice for several fish species
- This allows the production of seeds according to marketing and/or farming needs

Enhancing Hatchery Efficiency

Multi-species & Multi-sizes

Ideally, compatible species have over-lapping spawning seasons

Species combinations could be spawned using the existing hatchery facilities

Additional or modification of existing facilities if needed, should be economically justified

The production of multi-size fingerlings is a valid approach for enhancing hatchery efficiency if found economically feasible

Enhancing Hatchery Efficiency
Improved quality

Certified disease-free facility and so the product – occurred in Egypt in 2018/2019

Photo credit: Vannamei 101

Genetically improved strains

Screening for disease causing agents

Vaccination

Early nursing (environment – feeding)

Water temperature is the most important single factor

Temperature range is acceptable; severe fluctuation should be avoided. (some species cannot tolerate temperature fluctuation that exceeds **0.5**° C/day (seabass, seabream)

Light regime is critical for some species

No matter where a larvae stays or moves, Its food should be there

The onset of the first larval feeding is a crucial step in the young fish life; starvation is a major cause of larval mortality

Feeding ratios do not apply during early nursing

Conclusion

- A hatchery is not a farm in regard to management and specific targets
- Quality of hatchery products is often seen later on the farms
- For production economics, proper hatchery facility never means over-equipped hatchery
- In the planning process, target species, possible additional species and hatchery products (e.g. fry, fingerlings, fertilized eggs), should be clearly defined
- Any change/improvement in the hatchery applications has to be economically justified otherwise **<u>Drop the idea</u>**
- Competition, economics, quality control are issues to be considered in order for the hatchery activity to remain sustainable