Fish Hatchery Management

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Contents of this lecture

- Aquatic organisms (fact sheet)
- Modes of fish reproduction
- Naturally collected fry/broodstock
- Sexual maturation and broodstock management
- Fish hatcheries and hatchery technologies
- Nursing
- Conclusion

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 living fish species and their mode of reproducing (cold water, warm water, freshwater, marine water)
- Vary significantly in regard to the mode of their reproduction

Fish fecundity

Notes:

Fecundity of fish species with large eggs (e.g. salmonids) is lower than fishes with small eggs.

Generally, mouth brooders like Nile tilapia have low fecundities compared to substrate spawners such as *Tilapia zillii*.

Live bearers such as mosquito fish give birth to small number of embryos

Comments	Species	Estimates of relative fecundity estimates (no. eggs/kg of female)
Live bearers	Mosquito fish	50 (embryos)/fish
	African catfish	80,000
	Common carp	150,000
	Grass carp	80,000
	Silver carp	160,000
Mouth brooders	Nile tilapia	2000 – 4000
	Striped bass	220,000
Large eggs	Rainbow trout	2,200
Catadromous fish	European eels	1.8 – 3.0 million
	Black tiger shrimp	1.5 –2.2 million

Modes of fish reproduction

Egg layers - examples

Substrate spawners

Prawn carrying eggs

Oviparous

Majority of fish

Mouth brooders

Egg retainers

Ovoviviparous

Each embryo develops in its own egg in female's body until hatch. Embryos depend on their yolks

Live bearers (female or male)

When male seahorse gives birth

mother retains the eggs and nourishes the embryos till they are born

Commitment to death

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

Cuttlefish: Laid eggs are tended by the female until eggs hatch, and then 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.

Credit: Dr. Sagiv Kolkovski

Parental care

Spawning nest (tilapia)

Fanning egg mass (channel catfish male)

Mouth incubation (Nile tilapia)

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

Taking fry in (Haplochromine cichlids)

Mother Nature
Fry/gravid female collection

Black tiger shrimp

Milkfish

Mullet

Broodstock/gravid females

Glass eels

Mullet fry

Freshwater prawn (a female carrying eggs)

Collection of broodstock/fry from nature is done in case of:

- Naturally available/abundant (milkfish – mullet)
- No hatcheries/limited facilities
- Reproductive cycle is not closed (eels)
- Economic reasons (cheaper)

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 development of aquaculture, the establishment of hatcheries become necessary

Old hatchery practices
Setting the stage (Common carp) – Dubisch pond

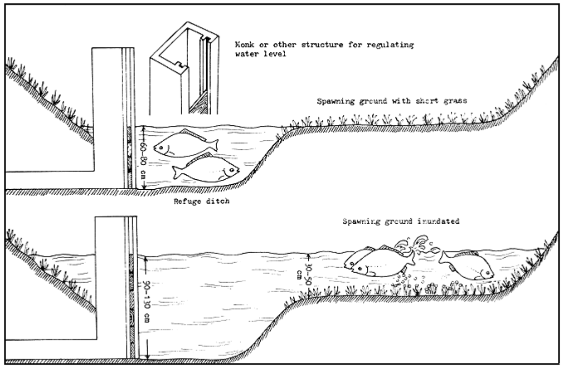
The Dubisch Pond has a raised center area that could be covered by water.

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

Source of broodstock
From the wild

Recommended:

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

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

Source of broodstock

From other hatcheries/fish farms

More reliable

More domesticated (for aquaculture)

Possible application of breeding programs

Possible conditioning for extended spawning seasons

Better understanding of broodstock history (depending on the availability/quality of book keeping systems)

Broodstock Maintenance
Feeding

Over-feeding with carbohydrate rich or fatty diet should **be avoided**

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

Broodstock – 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

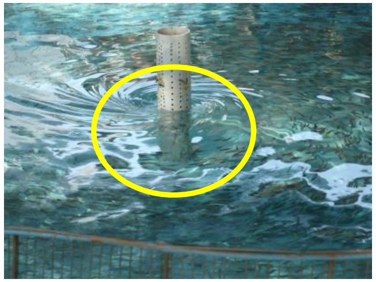
A recovery pond for spent females **is a must**

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 (e.g. toxic paint)

Water flow should be adequate to fish biomass **(not excessive)**

Proper design allows self-cleaning

Tanks are either covered or enough free board should be secured

Air supply from oil-free air pumps

Hatchery Management – Water

Quantity

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

For 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-saturation 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

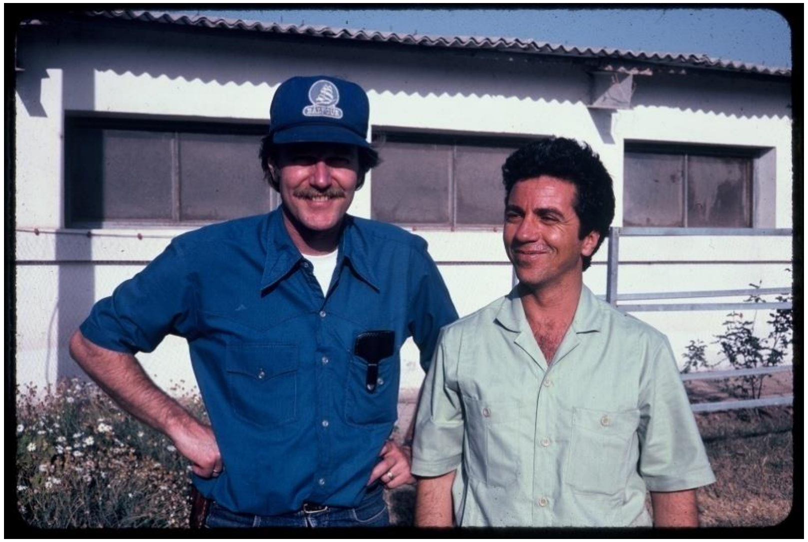
UV system – oyster hatchery Morocco

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)

Hatchery management
Started complex (Cases)



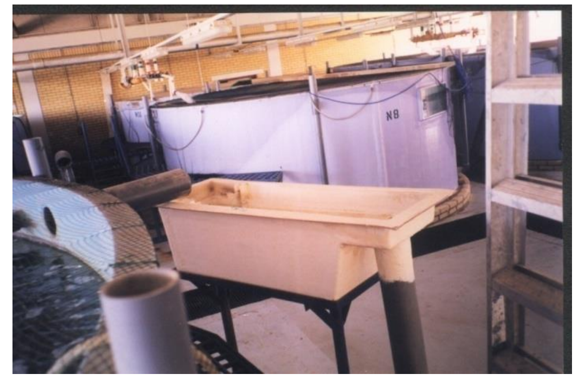
1980 – Abbassa (common carp)

1982 – Sète/France
(seabass, seabream)

Hatchery management

Turned easier- more towards natural systems

Open spawning system
Marine hatchery - Cyprus



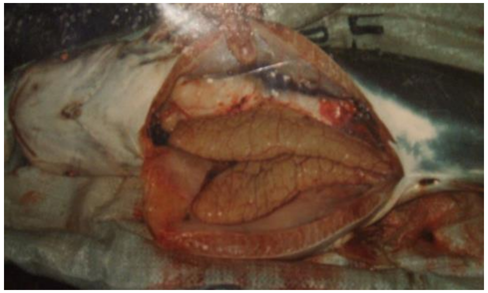
Egg collection system
Marine hatchery - Kuwait

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 favored light & temperature, salinity, flood conditions, 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 sorting
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

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

Stage IV

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

African catfish

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 allow its artificial spawning 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

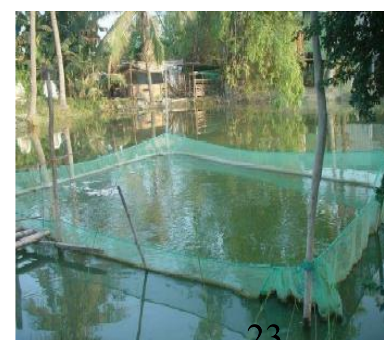
Fish responsibility is to:

Get the work done

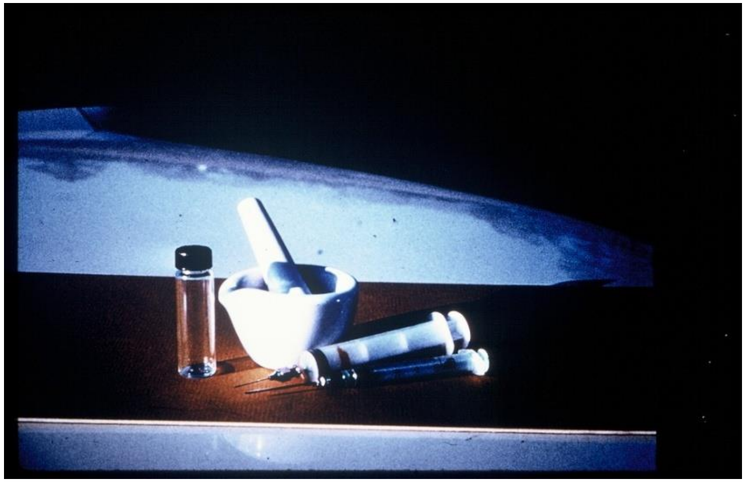
European Seabass

Channel catfish

Tilapia



Artificial Spawning



Even the spawning is artificial, biological parameters still control

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

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 used by count and not by weight)

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

- 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

↓

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 the extended period of spawning

Full Spawners

Batch Spawners

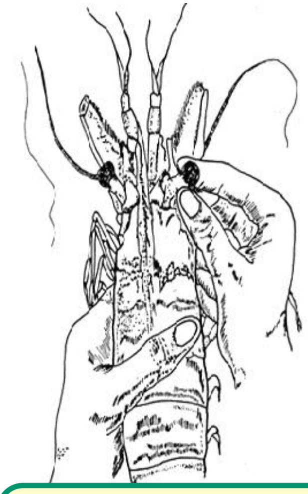
Specific hormonal induction & eyestalk ablation in marine shrimp

X organ

GIH
MIH

ligature-style ablation of Penaeus vannamei

Photo credit: David Kawahigashi - Vannamei10



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

Incision

Press

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

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)

Ovulation & stripping

African catfish

Eggs are flowing freely/un-interrupted

Colossoma sp.

Mekong Giant Catfish

Credit: Wanna Thawinwan (Thailand)

Rainbow trout

Credit: TROUTLODGE (USA)

Fertilization

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

Done through:
Direct use of live males
Use of sacrificed male testes (African catfish)
Preserved milt

Good quality milt
=
High rate of fertilization

One male or more?

Genetic considerations

Preserving milt

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

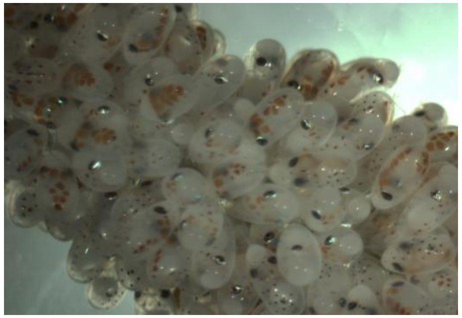
Temp C	**Incubation period (days)**		
	Rainbow trout	Brown trout	Nile tilapia
1.7		156	
4.4	80	100	
7.2	48	64	
10.0	31	41	
12.8	24		
15.6	19		
24.0			5-6
28.0			4
30.0			3

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

Types of fish eggs in relation to:
incubation or treatment

Mass (Channel catfish)

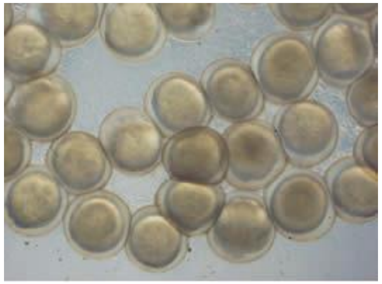
Large Eggs (salmon)



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



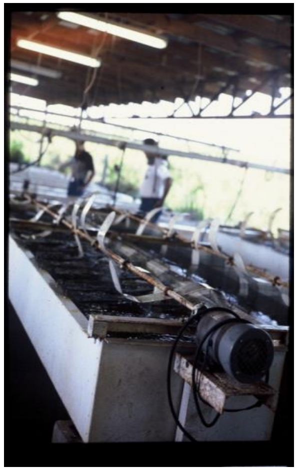
Incubators in relation to egg types

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)

Spawning Operations
Catheterization (egg sampling)

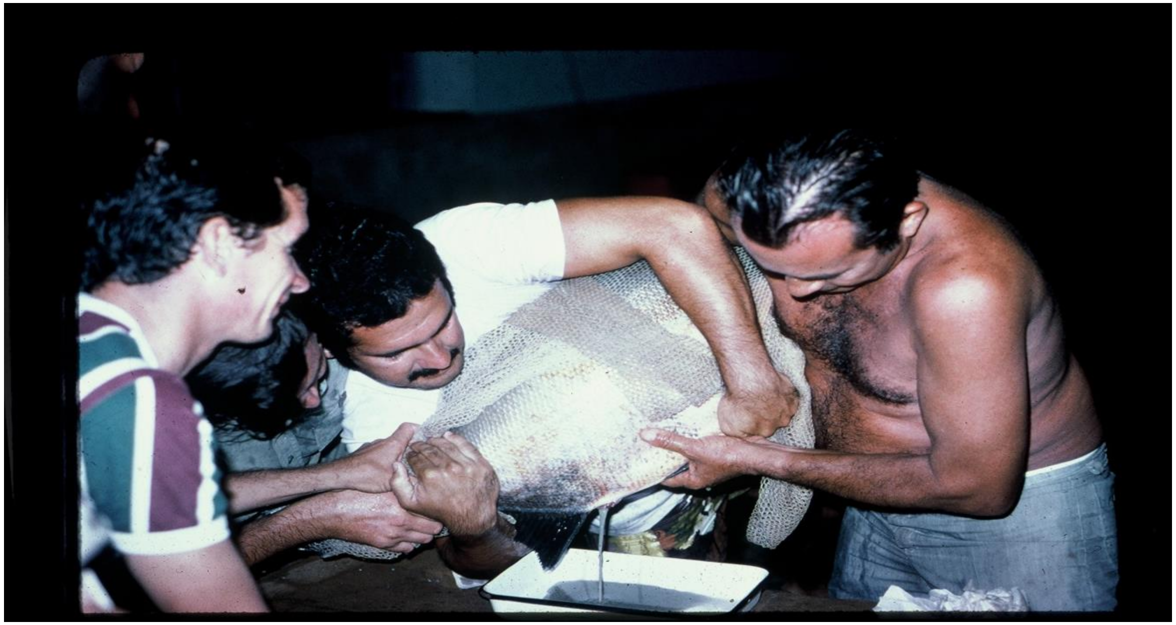
Catheter should be of adequate size to match fish size and the urogenital pore

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

Stripping (female size, handling)



A female with a size as such should be anesthetized

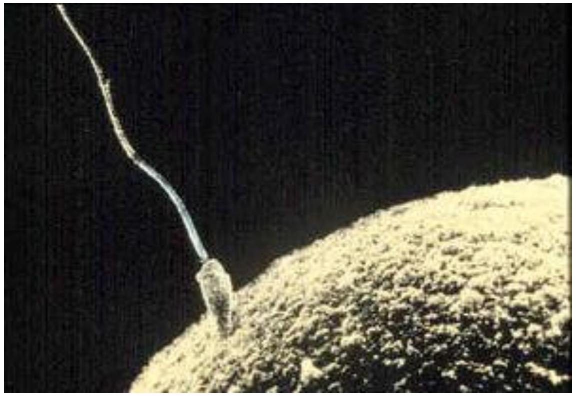
Watch for the effect of anesthesia on the sperm

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 reducing the rate of fertilization

Placing eggs in 0.6% salt solution (fertilization solution) makes the protein to go back into solution



Extending Solution (Ringer)

In 100 ml of water:

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

+

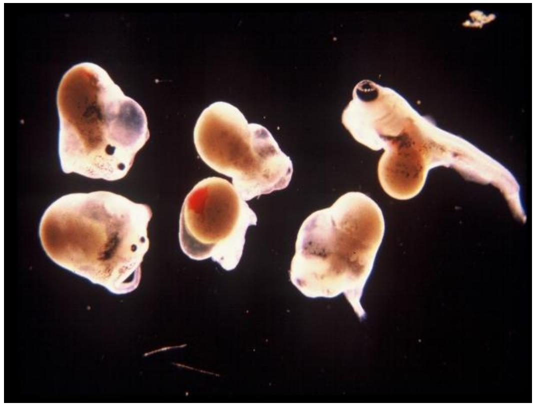
100,000 units of penicillin
100 mg of streptomycin

Photo credit: Roman Aszkiełowicz (Poland)

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

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

Deformity/Gas bubble disease



Due to temperature fluctuation

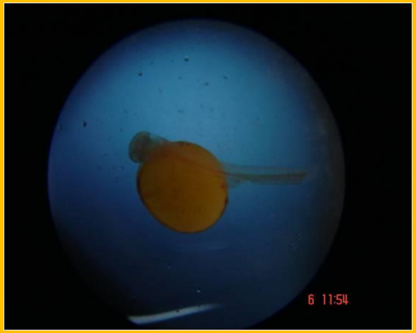
Check for Water Quality

Use de-aerating devices (can be simple)

Pop Eyes

Spawning operations
Synchronize 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.

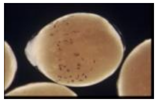
Embryonic Developments

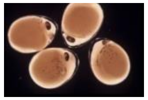
Never mix different ages during incubation

Tilapia

Freshwater prawn

Advanced stage





Green eggs

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

Good or Bad Eggs

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

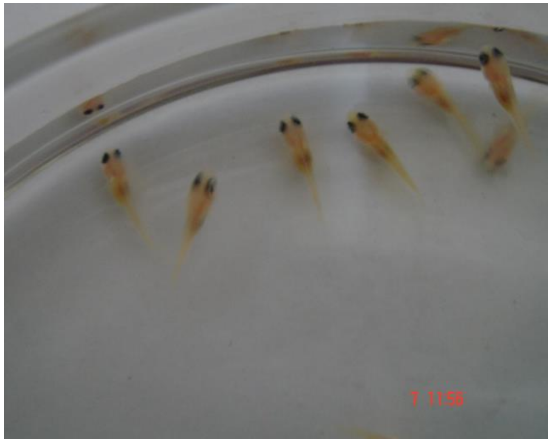
Discard the whole bad batches

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

Replacing oldest age group

OR

Annually change 33%

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)

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 as starvation is a major cause of larval mortality

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 facility begins by incubation

A carrying-egg female of freshwater prawn

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

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

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

Extending the spawning season

Green houses help to produce tilapia at the time suitable to farms (Egypt)

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

- 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 – enhanced quality

Sea Bass
Sea bream
Soles
Shrimp

Multi-species concept applies to either freshwater or marine hatchers

Production of different sizes of the same species is possible if technically and/or economically feasible

Screening for disease causing agents

Vaccination

Conclusion

- A hatchery is not a farm in regard to management and specific targets
- Quality of hatchery products is often seen on the farms
- For production economics, proper hatchery facility never means over-equipped hatchery
- Hatcheries are the place of genetics applications
- 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 or **Drop the idea**
- Competition, economics, quality control are issues to be considered in order for the hatchery activity to remain sustainable