

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
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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 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
Mouth brooders	Grass carp	80,000
	Silver carp	160,000
	Nile tilapia	2000 – 4000
Large eggs	Striped bass	220,000
	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

Egg layers and parental care

No parental care: fish freely lay their eggs and sperm and then abandon the eggs (e.g. Atlantic herring, tilapia zillii, cyprinids)

Modes of parental care:

- Nesting and guarding: (e.g. Nile tilapia, channel catfish, hornet tilapia)
- Fanning egg masses (e.g. channel catfish males)
- Mouth incubation: (e.g. Nile tilapia females – Banggai cardinal males)
- Guard young after hatching (e.g. bowfins males)

Passive care & special arrangements: (depending on species):

- Hiding eggs
- Eggs have oil droplets (globules) help larvae to float/utilized as a rich source of energy
- Some bottom-dwelling fishes produce eggs that sink
- Laying sticky eggs to attach to various objects (e.g. common carp)

Parental care



Spawning nest (tilapia)



Fanning egg mass
(channel catfish male)



Mouth incubation
(Nile tilapia)

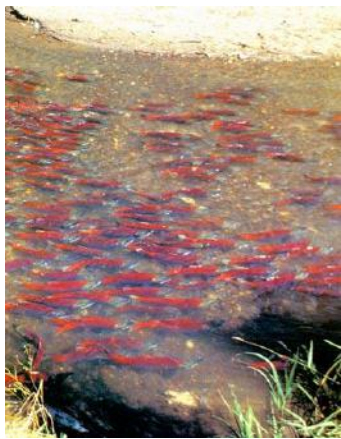


Hornet tilapia: deposit eggs in a hole dug by parents who attend their eggs until hatch



Taking fry in
(Haplochromine cichlids)

Organism and spawning runs & last stops



Salmon
Rivers (last stop)
anadromous

5000 –
6000
km trip



Eels
Sargasso Sea (last stop)
catadromous

Mullet
(no last stop)
catadromous



Mother Nature

Fry/graavid female collection



Black tiger shrimp

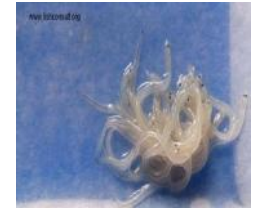


Milkfish



Mullet

Broodstock/graavid females



Glass eels



Mullet fry

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)



Freshwater prawn (a female carrying eggs)

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

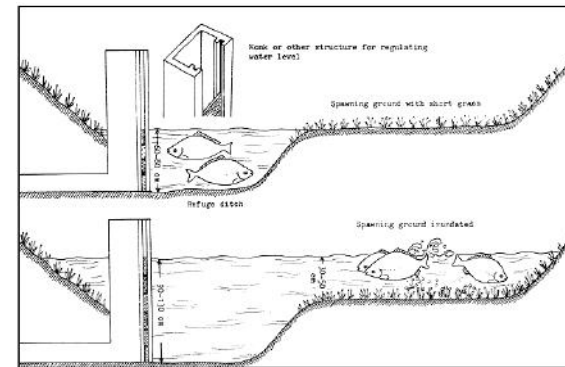
The Dubisch Pond has a raised center area that could be covered by water.

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 m² 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

Hatchery Broodstock

- Sources (wild – farm or hatchery)
- Domesticated versus wild

Has been covered in the lecture on genetics

- Efficiency under different environments (G x E)
- Genetic bottlenecks
- Number of spawns
- Understanding the effective breeding number N_e

Broodstock from the wild

Recommended:

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

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 or 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

Overwintering

Overwintering and species



Tilapia (Egypt)



Whiteleg shrimp (Peru)

Credit: Victor Hugo



Seabream – seabass
(Italy)



Indian shrimp (Iran)

Insulation level



A smart tilapia overwintering system in Egypt (fish can go in and out depending on outside temperature)



A highly controlled tilapia overwintering system in Japan



Credit: Samart Detsathit (Thailand)

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 fish 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:

Low in turbidity

High in DO

Low in CO₂

Extremely low in hydrogen sulfide (if any)

Not 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

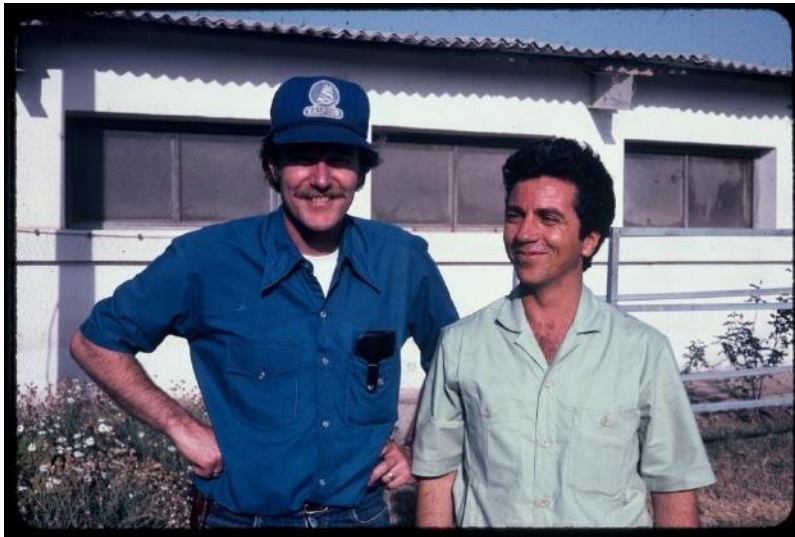
We need to consider:

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



Sexual maturity scale

Total spawners (8-point scale)

Virgin

Maturing virgin

Developing

Developed

Gravid

Spawning

Spent

Resting

Partial spawners (5-point scale)

Immature

Maturing virgin

Ripening

Ripe

Spent

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

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



Can be easy



Stage IV



Sexing and stage of maturation

May not be possible or may require additional work



Fish in the spawning run/grounds must be sexually mature



Sea urchin – sex is only known after they shed their gametes

Laparoscopy (surgical procedure) is used to determine the sex and stage of maturation in sturgeon



Egg sampling
a common practice with many marine fish species

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



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

Inserting other substances

Spawning induction of sea urchin

Potassium chloride injection and/or Acetylcholine injection have been used successfully to induce sea urchin spawning



Sea urchin, *Loxechinus albus*

Photo credit: Rodrigo Rivera
González (Chile)

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



Incision

Commercially adopted in the early 1970s

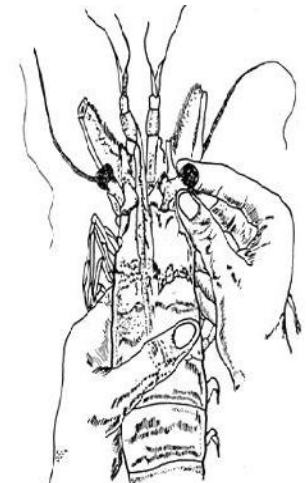
Eye stalk ablation removes x organ along with its contents of "Gonad Inhibiting Hormones"

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

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.



Rainbow trout

Credit: Wanna Thawinwan
(Thailand)

Mekong Giant Catfish



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

Artificial insemination (Whiteleg shrimp, *Litopenaeus vannamei*)

- Artificial inseminating is done when the mating between selected individuals is targeted
- Female shrimp should have full ovarian development; males should have full and healthy spermatophores
- Spermatophores are manually ejected until it slips out of the genital pore
- Spermatophores are placed/secured anterior and posterior to the thelycum of the ripe female
- Females are placed in spawning tanks in seawater with optimum salinity 25-36 g/l and temperature (26° - 30°)
- Spawning usually occurs within 1 to 24 hours after the insemination



Photo credit: Ahmed Shaheen
(Egypt)

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 <i>Pangasius sutchi</i>	28 - 29	23 - 25 h
Nile tilapia	28	4 d
<i>Clarias macrocephalus</i>	26 - 30	18 - 20 h
Cachama <i>Colossoma oculus</i>	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)

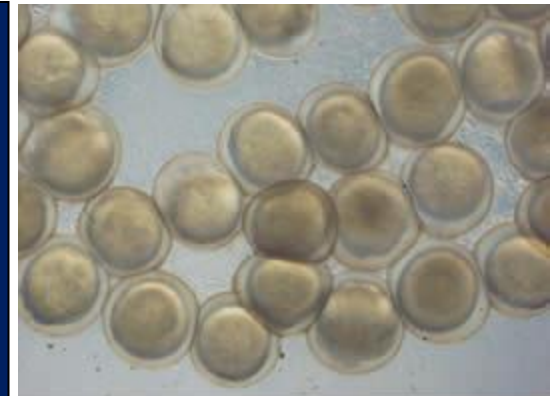


Large
Eggs
(salmon)



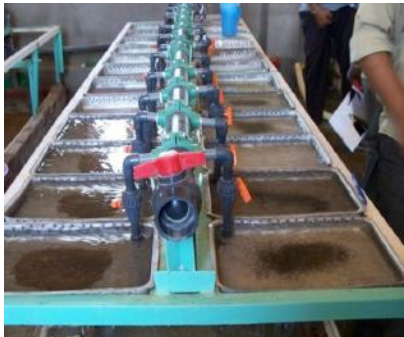
Loose
Eggs
(tilapia)

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



Incubators in relation to types of eggs

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)

Chinese-system incubators

For grass carp

Photo credit: Jorge Valdiviezo
(Mexico)



Incubating tanks are circular with outer and inner chambers. The inner chamber is adequately screened to allow only water to pass through. These tanks have outlets through which hatchlings pass through into the larval tanks. Water speed and direction assures favorable circulation and protection of incubated.



For Indian carps

Photo credit: G.V. Raju
(India)

Spawning Operations

Catheterization (egg sampling)

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

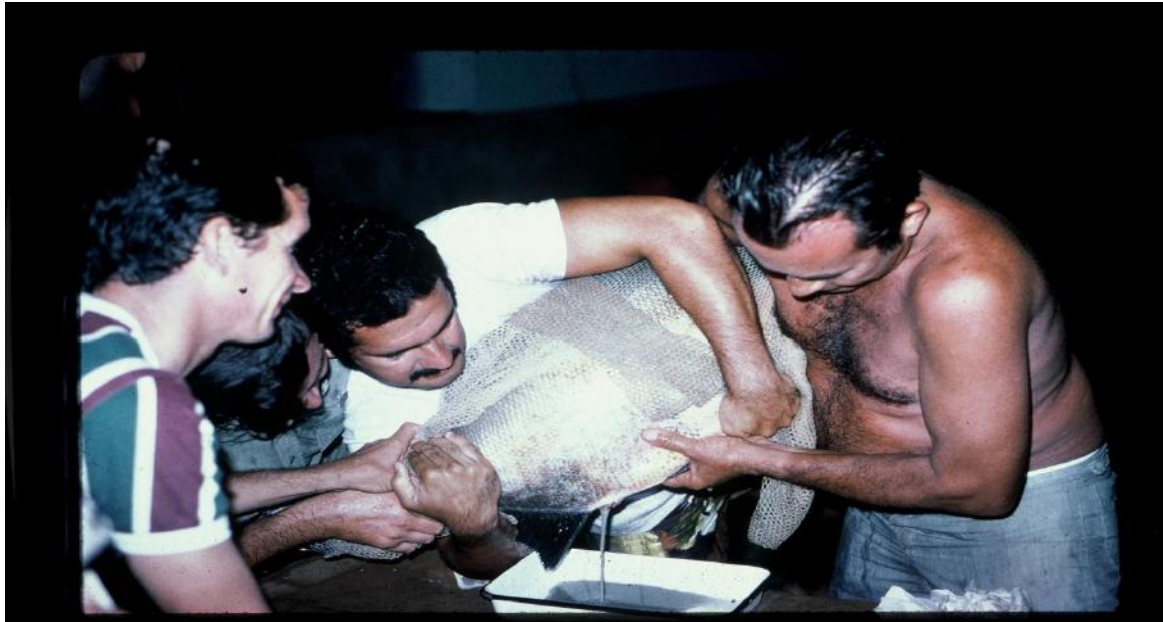
Careful manipulation and minimum force is needed to avoid the damage of **sphincter muscles**

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

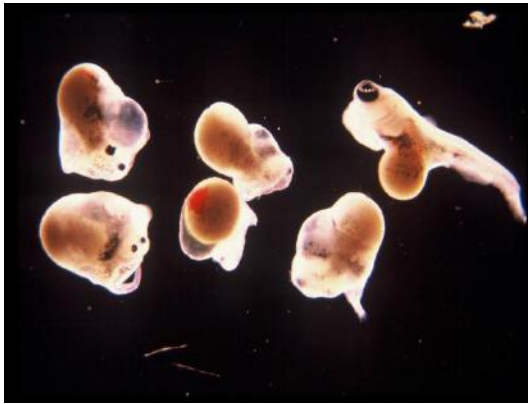


Photo credit: Roman
Aszkiełowicz (Poland)

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.

Oil trapping and swim bladder inflation of marine fish

Oil trappers (skimmers) are simple devices placed on the water surface in larval tanks

Skimmers trap oils originating from rotifers being fed an enrichment diet.

Trapping oil film is necessary for the inflation of swim bladder of fish larvae

For the survival and well-being, marine larvae have to gulp air to inflate their swim bladders. The existence of oily layer would interfere with the inflation process

Consequently, larvae develop negative buoyancy, abnormal swimming, reduced feeding and hence slower growth or might even die.

The surface skimmers trap the grease by blowing air at low pressure tangentially to water surface.

Skimmers are periodically cleaned several times/day using a soft paper foil. This process continues for several days during which the inflation of swim bladders takes place.



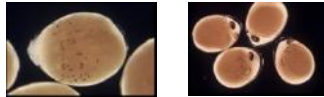
A larval tank for gilthead seabream and European seabass (Italy)

Embryonic Developments

Never mix different ages during incubation

Tilapia

Advanced stage



A colored tub for each stage

Credit: Muhammad Iqbal
(Pakistan)



Green eggs



Freshwater prawn



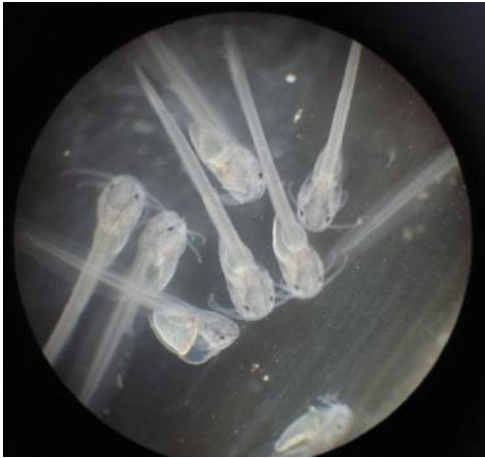
Good or Bad Eggs



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

Discard the whole bad batches

Embryonic Development

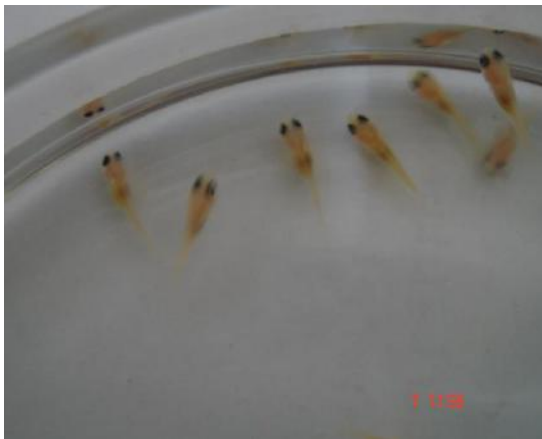
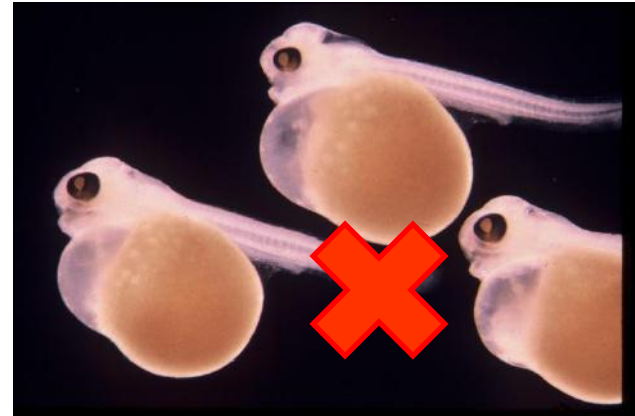


- Stable temperature is very important during incubation
- Proper hygienic condition of the system is influenced by the quality of fertilized eggs

Incubation/temperature

**It is much safer to incubate at highest
safe temperature
(refer to an earlier table)**

Hatchery Products (good or 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



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 $0.5^{\circ}\text{C}/\text{day}$ (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



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



A carrying-egg female of freshwater prawn

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



Management and scale of production

Usually apply to large hatcheries



Abbassa – 15 million fry/year



Aswan

Management and scale of production

Should also apply to small hatcheries



8-million tilapia fry



2-million tilapia fry

Extending the spawning season



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

Green houses help to produce tilapia at the time suitable to 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 - quality

Sea Bass
Sea bream
Soles
Shrimp



Multi-species concept
applies to freshwater
hatchers

Production of different
sizes of the same
species is possible if
economically visible



Screening for
disease causing
agents

Vaccination

Conclusion

- Hatcheries are not farms 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 biological application 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