MASS PRODUCTION OF CALANOIDE COPEPODS AND POSSIBLE PRESERVATION OF COPEPOD EGGS FOR FISH FARMING.

PRESENTATION OF OVERALL RESULTS FROM THE FP5-CRAFT-PROJECT, POCEFF

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Aim of the project

- Development of new technology for breeding, harvesting and preserving copepod eggs. Test of the quality of the produced live feed.
- Advantages forseen:
  - Better nutritional composition of copepods relative to standard live food (enriched Artemia and rotifers) as start feed for marine finfish
  - Better quality of produced fish
  - Replacement of Artemia as standard live food

Project partners

Bio/consult as	Denmark	SME, Co-ordinator
Plagton Ltd.	Greece	SME
Galaxidi Marine Farm	Greece	SME
Maximus A/S	Denmark	SME
Venoe Fish Farm	Denmark	SME
Isidro de la Cal	Spain	SME
Fosen Aquasenter.	Norway	SME
Brandal Havbruk as	Norway	SME
Technological and Educational Institute of Epirus	Greece	RTD
University of Athens	Greece	RTD
SINTEF Fisheries and Aquaculture	Norway	RTD
NTNU, Norvegian Univ. of Science and Technology	Norway	RTD
RUC, Roskilde University	Denmark	RTD
DMU, Environmental Research Institute of DK	Denmark	RTD

Selection of Calanoid Copepod species

- To select of species from Northern and Southern Europe for use as
  - cultivated live food organisms in marine aquaculture
  - diapause/subitaneous egg providers
- Criteria for selection of copepod species
  - natural occurrence
  - type of spawning (free spawner/egg carrying)
  - daily production (dw eggs/dw female)
  - fecundity (eggs per female)
  - registered production of resting eggs

Copepod culturing techniques used

Culturing technique	**Culture volume**	**Species**	**Productivity** (eggs/day/l)
Semi-extensive	Large ponds/lagunes: 1.200 - 10.000 m^3	Denmark: Mixed cultures of *C.hamatus* and *Acartia* spp. Norway: *T. Longicornis*	‹50
Semi-intensive	Tanks: 200 – 300 m^3	Denmark: *C.hamatus and Acartia spp.*	‹100
Intensive	Flasks or tanks: 5-110 l	Greece, Norway: *A.tonsa*	Up to 6000 (500-6000)

Potentials for mass culture

	Copepod species	Culture	Daily production (from literature)	Type of spawning	Others
	Centropages hamatus	Semi-extensive Semi-intensive	High (0.25-0.31)	Free spawner	High fecundity in semi-extensive systems
	Centropages typicus	Intensive	Fairly high (0.01-0.34)	Free spawner	High fecundity in high densities in small cultures. Unstable in larger cultures
	Temora longicornis	Intensive	High (0.04-0.77)	Free spawner	High fecundity in high densities in small cultures. Eggs clustered
	Acartia clausi	Semi-extensive	High (0.14-0.70)	Free spawner	Low growth in high densities
	Acartia tonsa	Intensive Semi-extensive	High (0.19-0.72)	Free spawner	High growth rate in high densities Tolerant to fluctuations in water quality

Culture protocols

- Intensive protocols
- Semi-intensive protocol
- Semi-extensive protocol
- Mainly adjustments of existing protocols from small scale or semi extensive systems
- Adjustments of food concentrations (microalgae), levels, light regime, daily handling/filtration etc.

Mass production of eggs

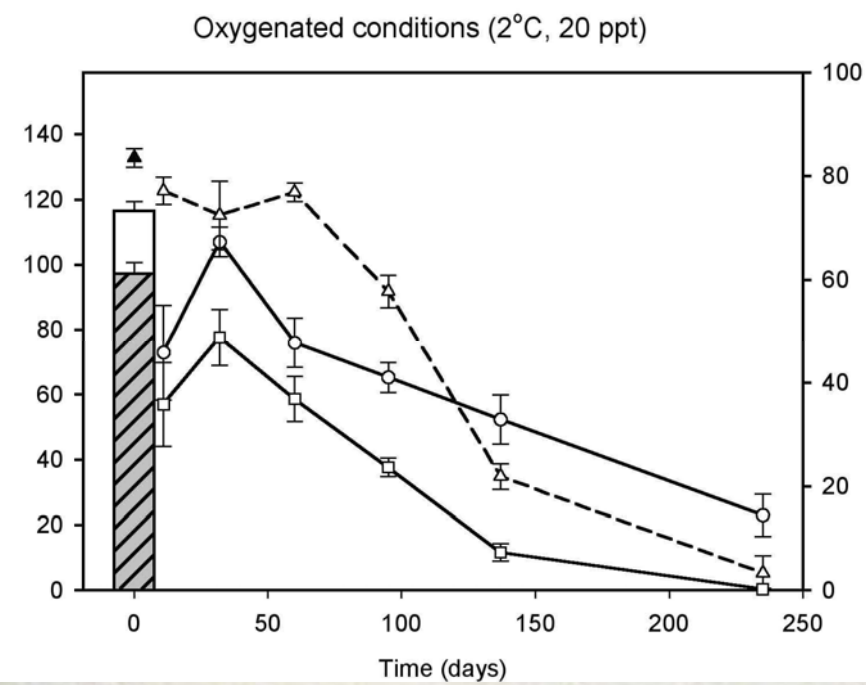
Semiextensive	**Egg production** (eggs $l^{-1}*d^{-1}$)
Centropages hamatus	37
Acaria tonsa	20

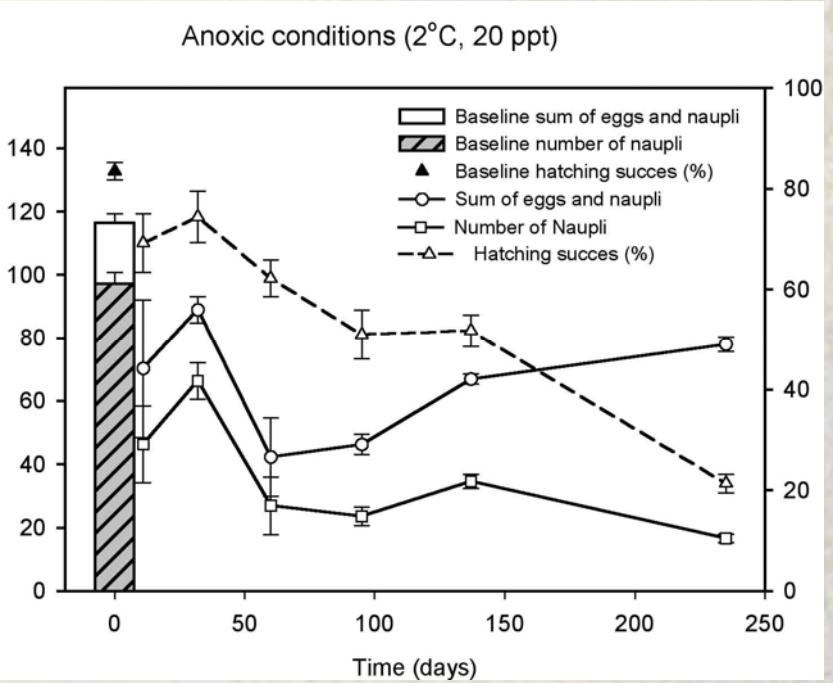
Intensive ***Acartia tonsa***	**Egg production** (eggs $l^{-1}*d^{-1}$)
Norway	500-2000
Greece	4000 – 6000

Production of Acartia tonsa

- Production of about 4-8,000 eggs/l/day was achieved in medium volumes (5-20L)
- Cultures of 50-120 L were feasible with maximal egg production about 6500/l/day

Hatching success for *A. tonsa* kept at anoxic/oxygenated conditions





Long term storage experiment showing numbers of surviving nauplii after storage at 2ºC, 20 ppt sea water at oxic and anoxic conditions.

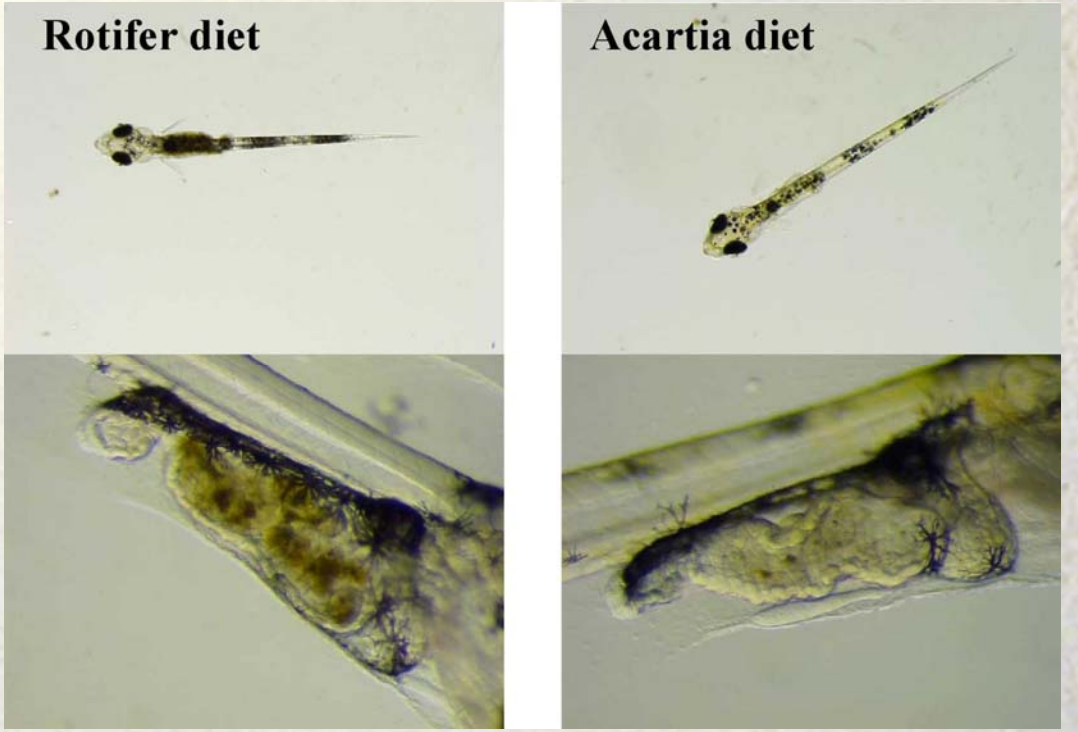
Optimal storage conditions for *A.tonsa* eggs

- Temperatures at or below 5ºC.
- A salinity of 10-20 ppt.
- Anoxic conditions.
- Even low sulphide concentrations should be avoided if storage is extended to last for more than 60 days. This is ensured by securing strict anoxic storage conditions.
- Storage in brine or high concentrations of glycerol is not an advantage for the survival and hatchability.

Feeding experiments with cod (*Gadus morhua*)

Upper pictures of whole larvae.

Lower pictures show intestine of cod larvae given rotifer diet (left) and copepods (right).

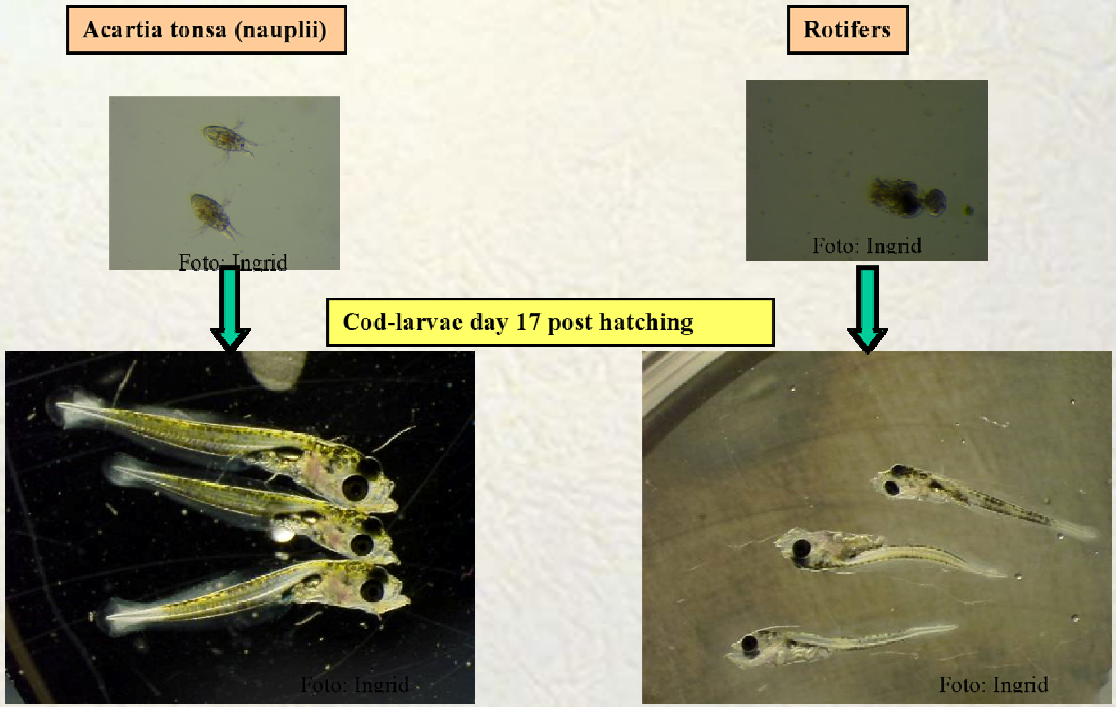


Cod larvae at day 7 post hatching.

Fotos: Ingrid Overrein, SINTEF.

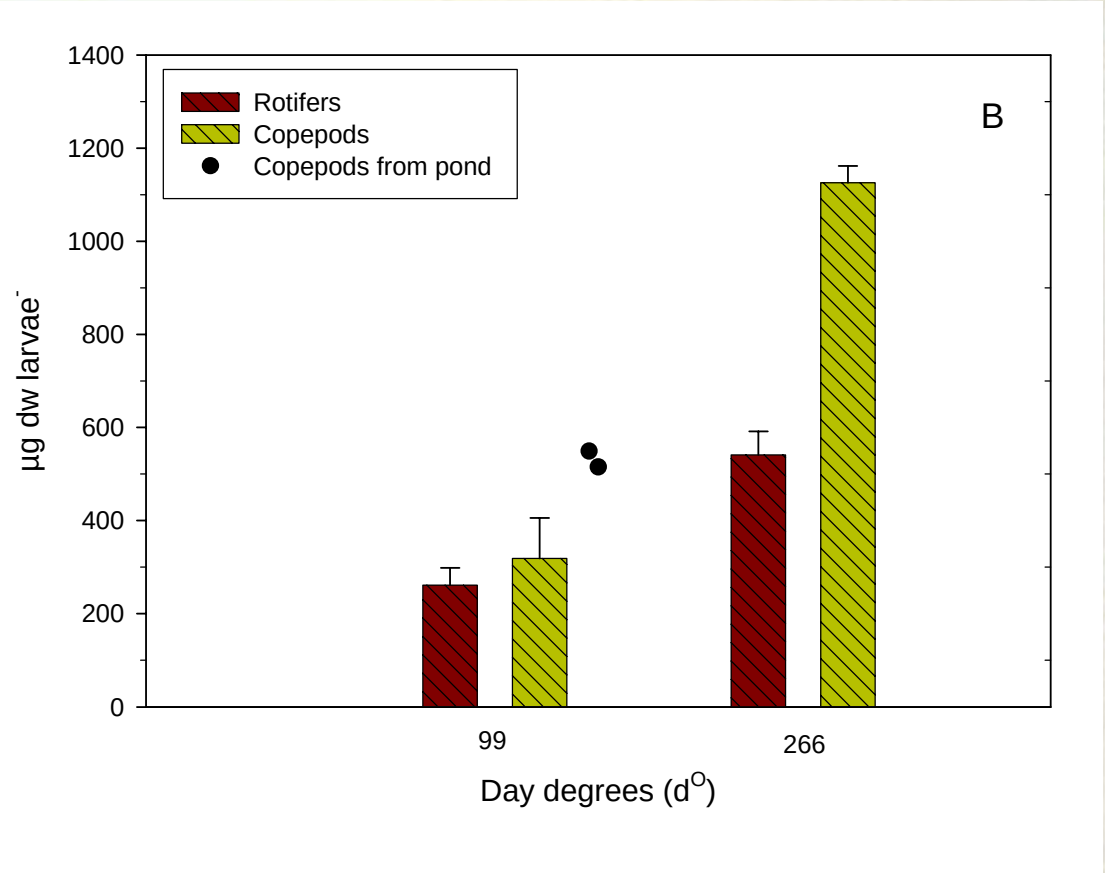
Cod feeding trials with A.tonsa or rotifers

Fotos: Ingrid Overrein, SINTEF.



Cod larvae at day 17 after hatching. Left picture shows *larvae given copepod diet,* and right picture larvae given rotifers diet.

Growth of cod larvae



Weight of codlarvae (µg DW larvae^{-1}) at 99 dº (day 11) and 266 dº (day 25) given rotifer-diet or copepods (Acartia tonsa nauplii). Weight of codlarvae given natural zooplankton from a pond in northern Norway is for comparison shown as dots.

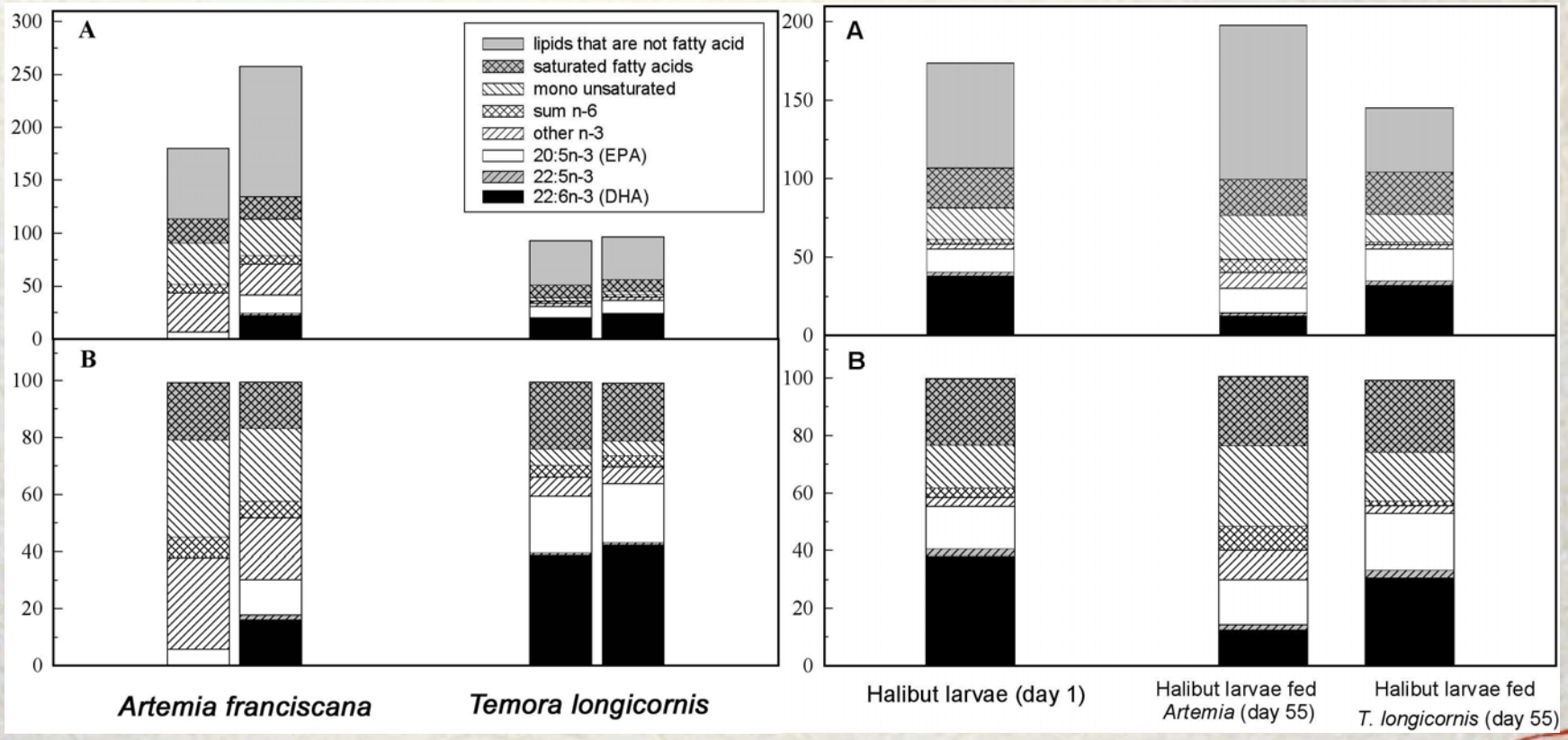
Cod feeding trials: Conclusions

- The feeding trials show that cod larvae fed copepods (*A. tonsa*) had better survival compared to the larval groups fed the standard feeding regime (rotifers).
- The pigmentation of cod larvae fed *A. tonsa* was more predominant the control group.
- Cod larvae fed copepods were more actively swimming after and catching prey organism.
- The growth rate of the cod larvae were higher when feeding with copepods.

Cultivation of halibut (*Hippoglossus hippoglossus*)

- Halibut larva have a long lasting live food period (55-65 days).
- The calanoid copepode *Temora longicornis,* grown in semi-intensive production, was used as first-feed.
- Enriched *Artemia* nauplii represented the standard feeding regime.

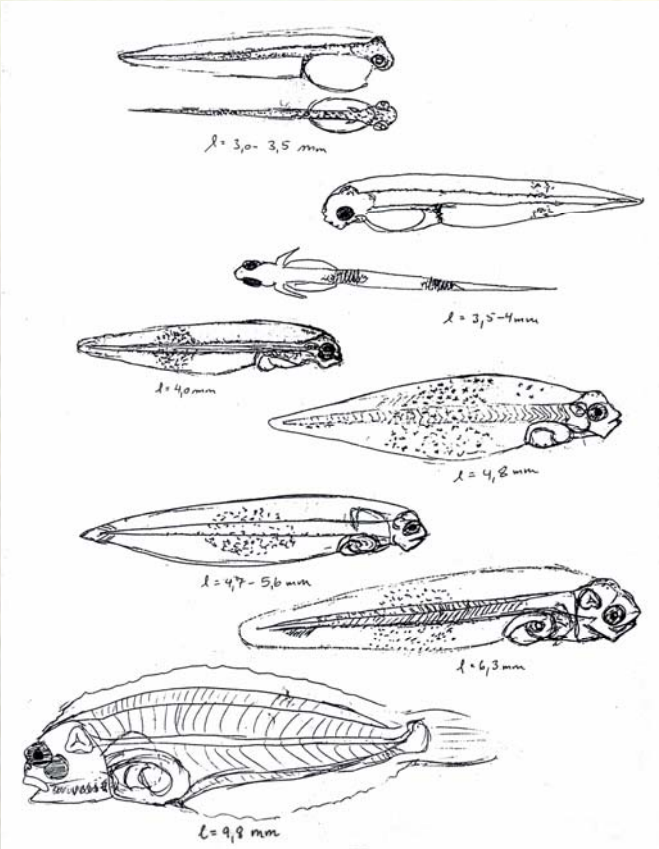
Fatty acid profiles of Copepodes, Artemia and Halibut larvae



Conclusions from Halibut feeding experiments

Feed	***Artemia***	***T. longicornis***
Survival	81.5 %	85.2 %
Malpigmentation	51 %	1 %
Incomplete eye migration	31 %	2 %
DHA	Low	High
Production costs	Medium	Relatively high

Cultivation of European flounder (*Platichthys flesus*)



- Outdoor semi-extensive copepod/flounder production
- Production in 300 m^3 green water tanks
- Relatively high densities of algae, copepods and flounder larvae (5 X “normal” semi-extensive densities)
- Larvae were produced as a part of a flounder restocking programme

Conclusions from European flounder production

- It is possible to intensify the outdoor flounder larvae production to some state of semi-intensive production level
- Average larval survival rate was 24 %
- 100.000 fry were produced
- All larvae were metamorphosed at harvest, had a length of 10-15 mm, had perfect pigmentation and no developmental failures. Weaning success > 98%.
- The system needs backup from alternative prey sources (copepods)

Cultivation of turbot (*Psetta maximus*)

Copepod based ”semi-intensive” turbot larvae production using of ”smaller” (300 cubic meter) production units with high densities of algae, copepods and fishlarvae

- Survival varied (3-30%)
- Fry had no developmental errors

Conclusions from turbot cultivation experiments

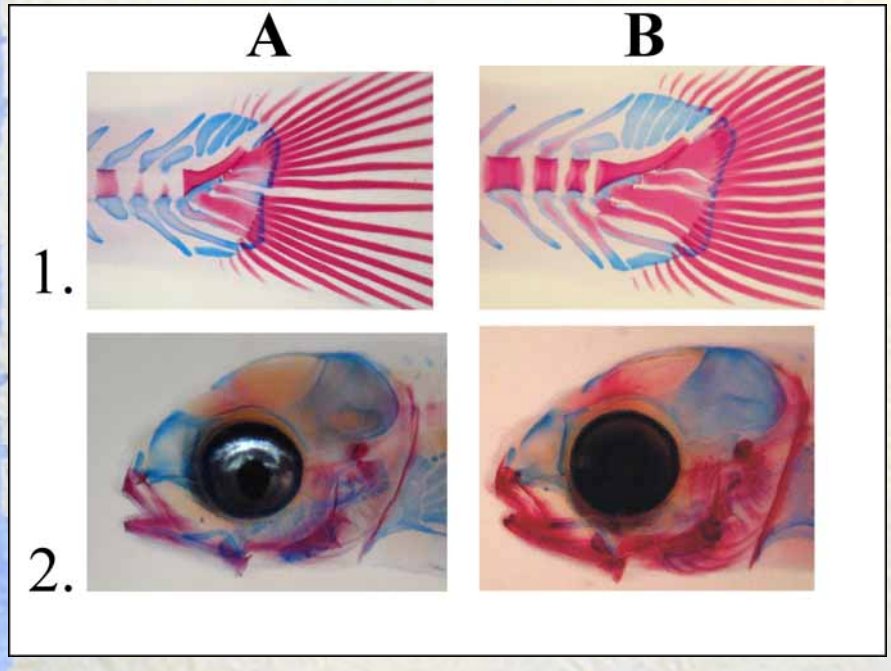
- Copepod based ”semi-intensive” turbot larvae production seems to be possible.
- The high densities of larvae might cause bacterial problems like in traditional intensive systems. This risk seems reduced at low temperatures.
- The system needs backup from alternative prey sources (copepods, rotifers, Artemia).

Cultivation of gilthead seabream (*Sparus aurata*)

•Fully or partly replacement of rotifers/*Artemia* in the diet of the finfish larvae of the Mediterranean marine aquaculture

Control (RotifersArtemia)	3 X Rotifers/Artemia
Co-feeding	2 X Rotifers/Artemia 1 X Nauplii/Copepodites
Copepods	3 X Nauplii/Copepodites

Conclusions from feeding trails



Fotos: G Koumoundouros, University of Patras

- Copepod feeding was proven feasible as the fish survived better than the control
- Comparison of bone structure between copepod fed and control fish
- Observed deformities concerned mainly abnormal caudal fin (1B) and short lower jaw (2B)

Results didn't present statistical significant differences between the two samples and need to be repeated.
The method can be valuable for quality control of larvae in the future.

Overall conclusions

- Intensive mass culture of copepods is possible.
- Eggs can be stored for up to 1 year under suitable conditions.
- The methods developed are used and further developed by the hatcheries involved.
- Copepods can be used with success either as sole live feed or mixed with traditional live feed for cod, turbot, halibut, European flounder and gilthead seabream.
- Copepods has proven superior to traditional food for cod and halibut.