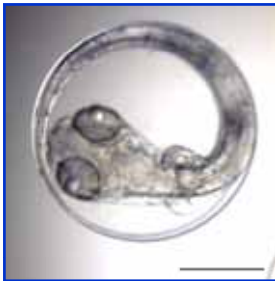


# Status and challenges in cod larval production



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# Overview:

- Cod juvenile production
  - Production from 2000-2009
- Challenges in 2009, and bottlenecks in cod larval production
- Research on high quality juveniles at SINTEF and NTNU
  - Eggs
  - Livefeed
  - Water quality
  - New technology
- Larval production in the future

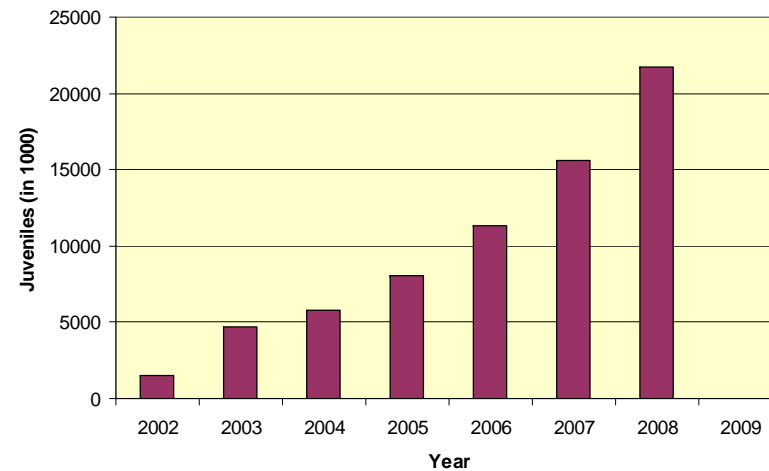
# Cod hatcheries in Norway: 2001-2009



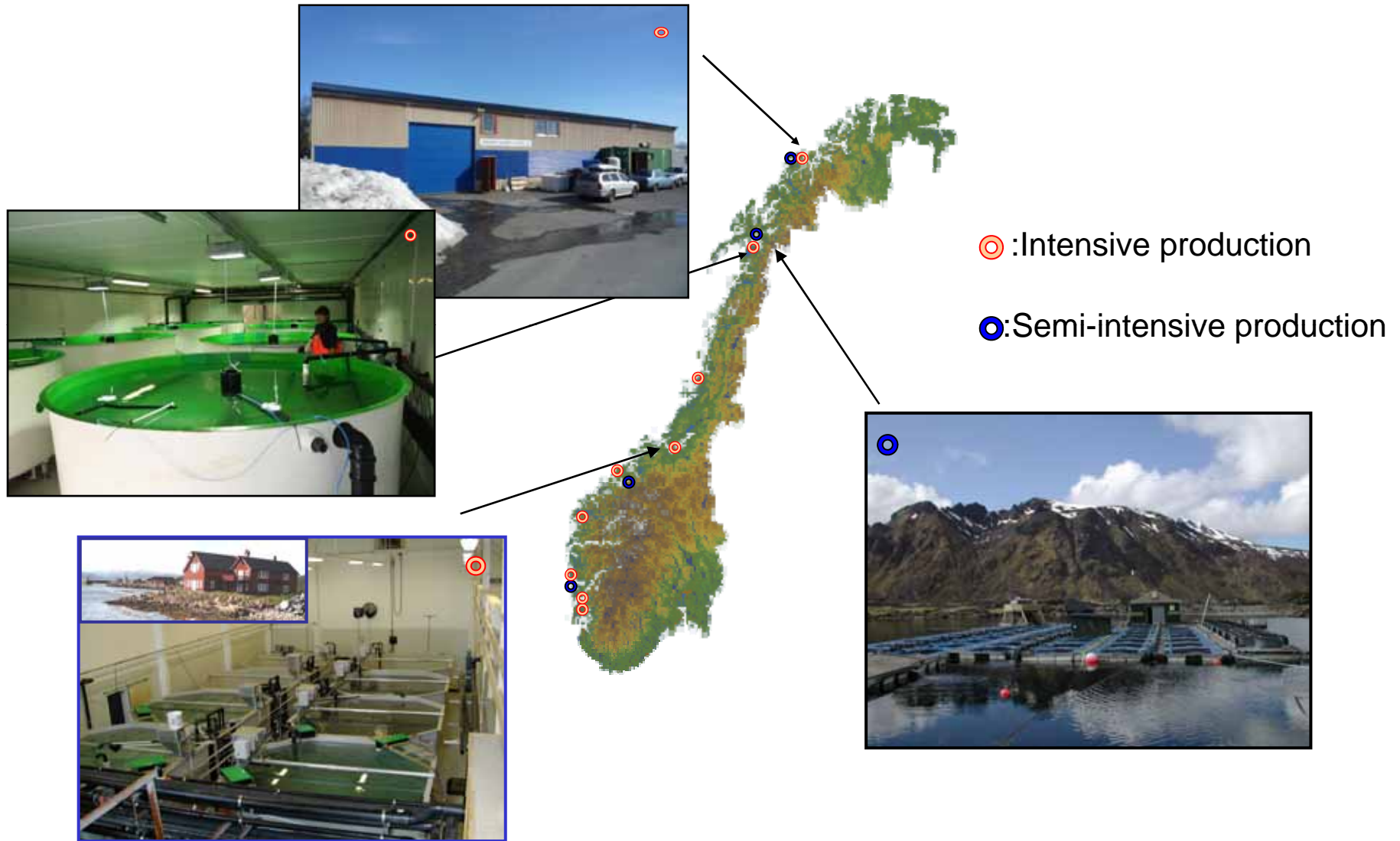
(Torskenettverket)

**2001: 8 hatcheries**  
**2007 : 13 hatcheries**  
**2009 : 8 hatcheries**

## Production of juveniles (in 1000)



# Juvenile production of Atlantic cod from 2001-2009



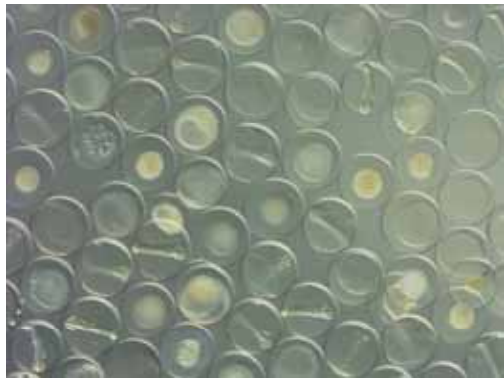
# Challenges in 2009

- The financial crisis
- Increased cod fishery and low prices
- Cod farming
  - High production costs
  - Variable growth and quality
  - High losses after transfer to sea cages
  - Early sexual maturation



# Bottlenecks in cod larval production

## Egg quality



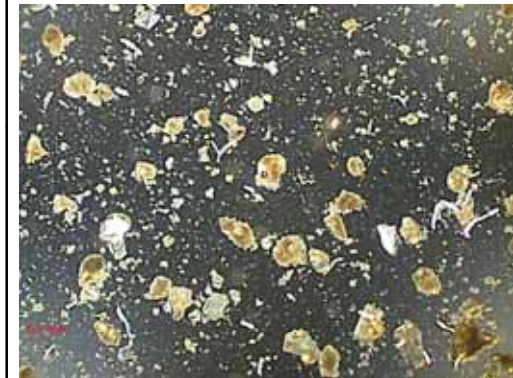
- Variation in hatching success
- Asynchrony hatching

## Live feed quality



- Nutritional quality
- Microbial quality in fish tanks

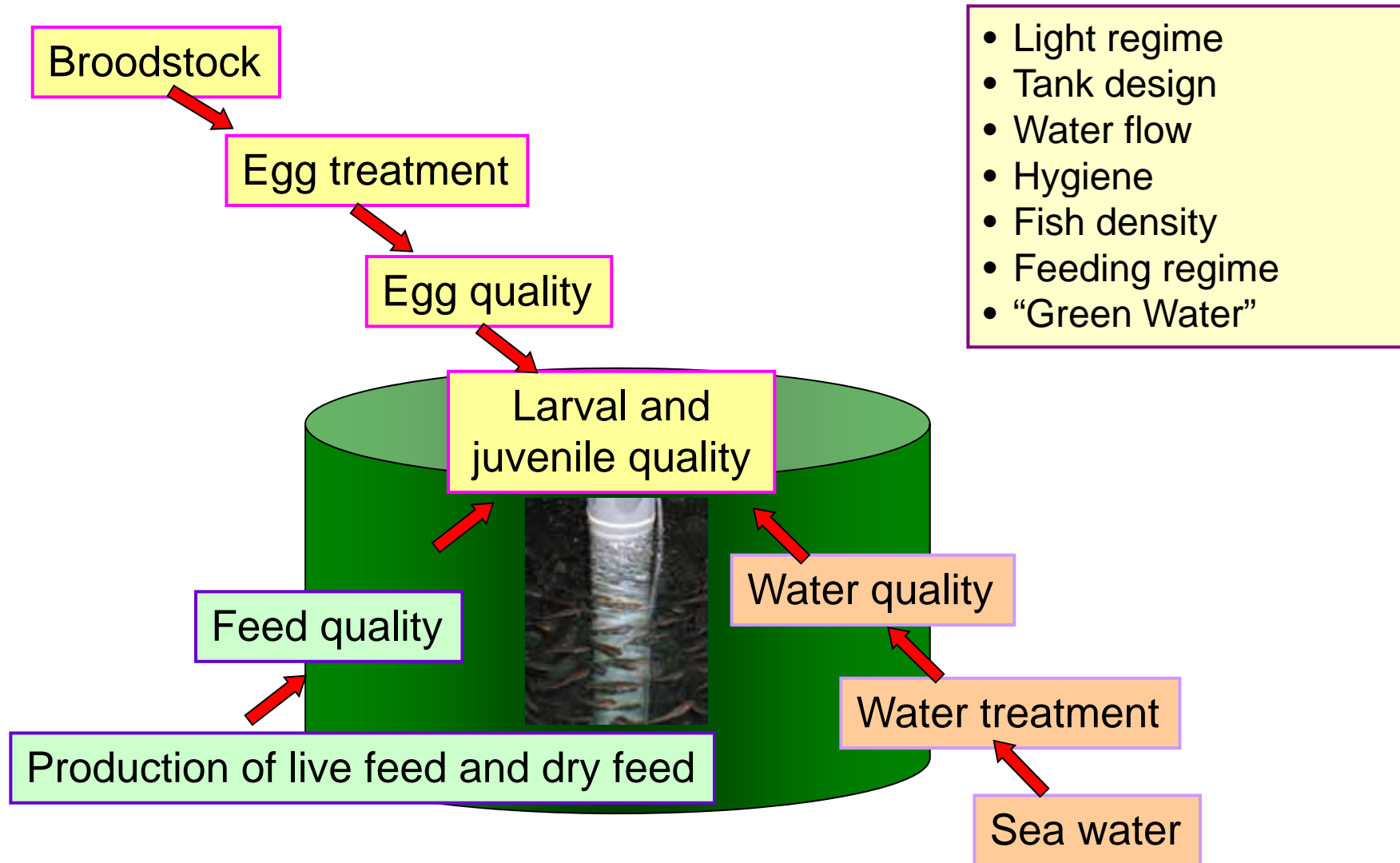
## Formulated feed



- Nutritional quality
- Microbial quality in fish tanks

Quality standards are lacking for eggs, live feed, larvae and juveniles

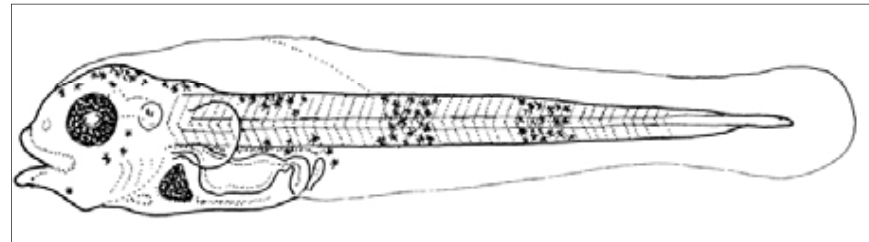
# Production of marine larvae and juveniles



# Egg quality criteria

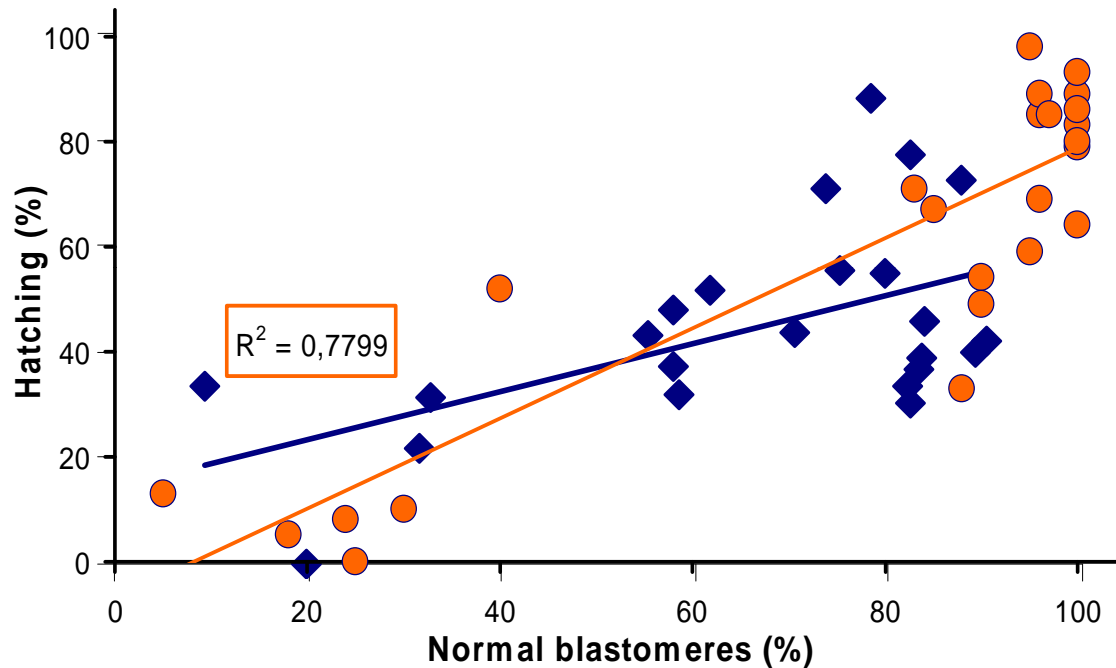
- **Eggs:**

- Egg size
- Fertilization rate
- Blastomere morphology
- Hatching rate





# Hatching success is positively correlated to normal blastomeres in cod eggs from individual cod spawning pairs

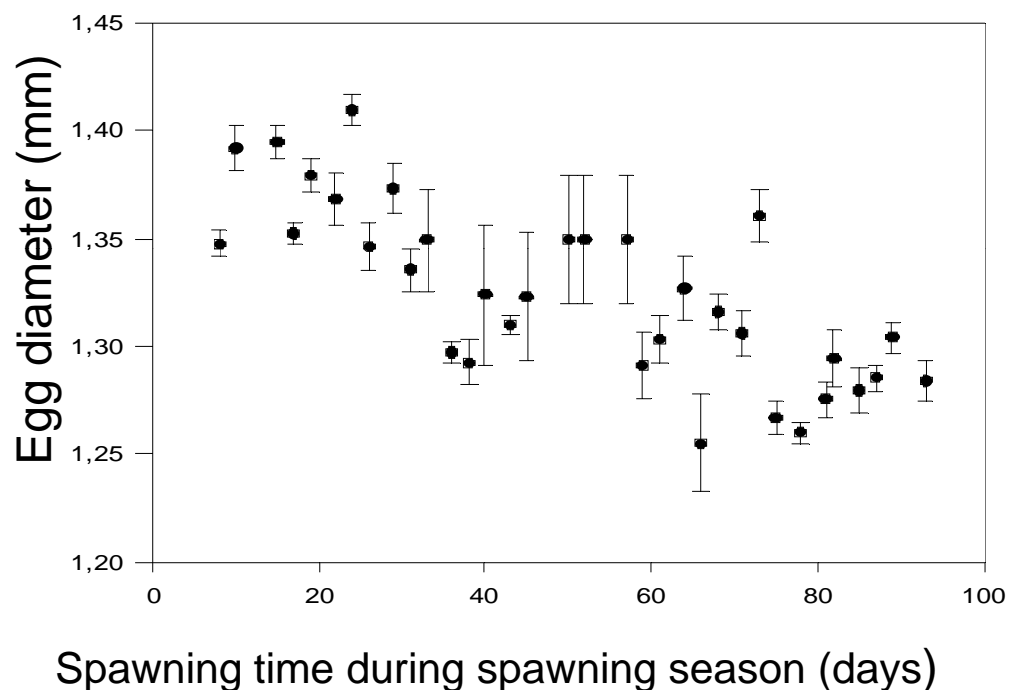


Similar results obtained for e.g.  
- halibut (Shields et al. 1997)  
- turbot (Kjørsvik et al. 2003)  
- wolffish (Pavlov et al. 2004)

Each point corresponds to one spawning batch from one female (two different years). Hatching success is the mean from 3 replicates (Kjørsvik, Thorvik, van der Braak, Tanem and Galloway, unpublished).

# Cod egg quality during a spawning season

- from a broodstock spawning tank with multiple spawners



- Egg size decreased during the spawning season

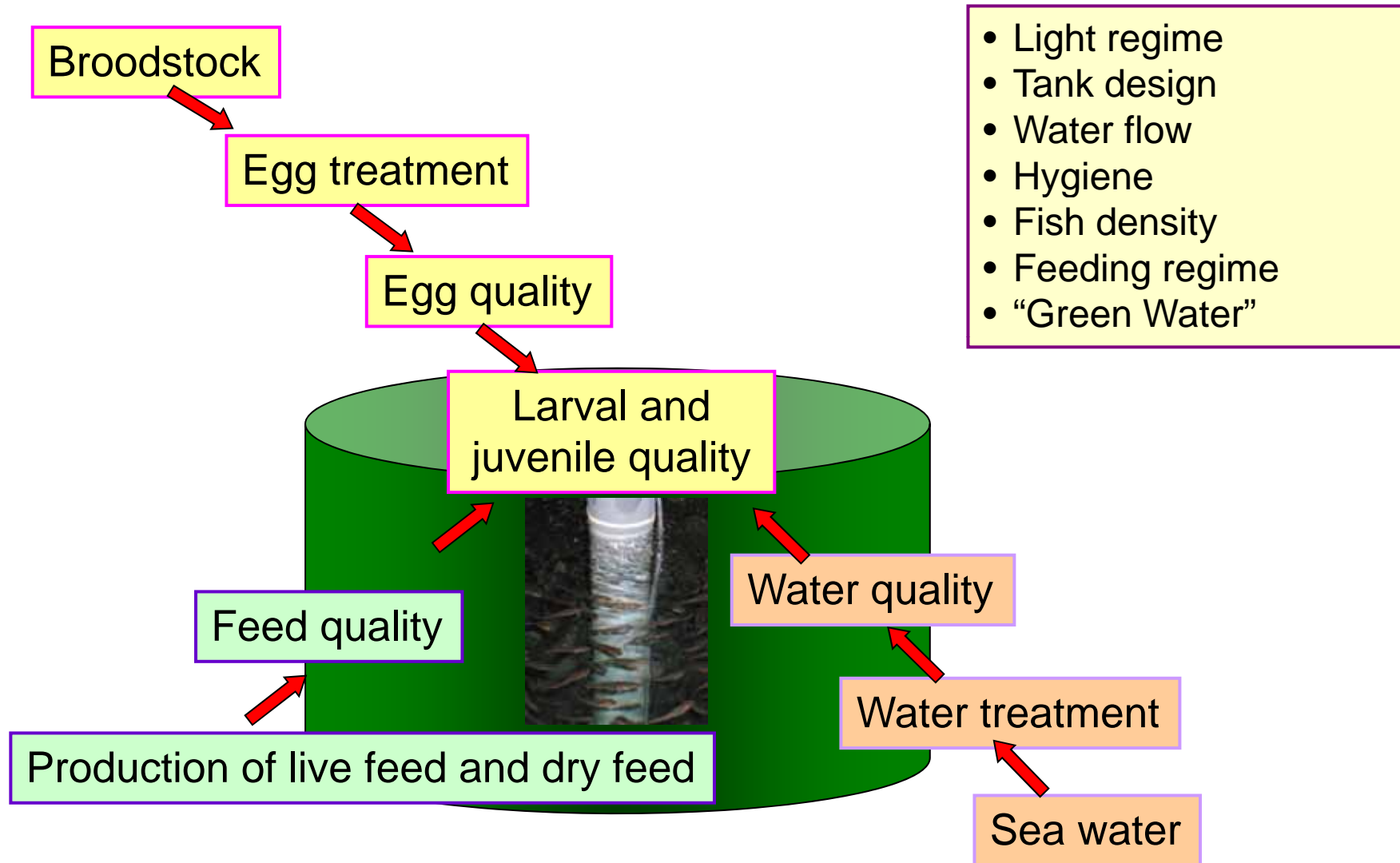
- Larvae from large eggs

- higher hatching success
- larger size at yolk-sac stage
- more active
- ingested more rotifers
- better survival

than larvae from smaller eggs

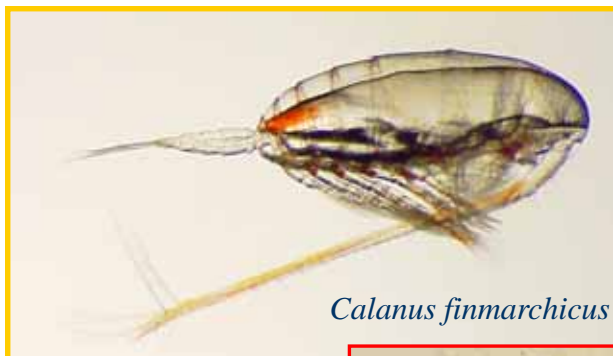
Kjørsvik, Lervik, Uglem, unpublished

# Production of marine larvae and juveniles



# Livefeed production and enrichment

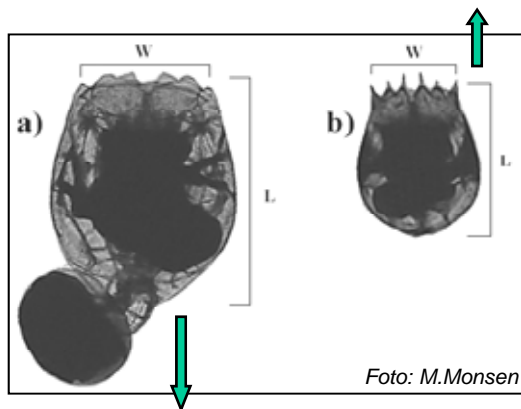
- Different microalgae and zooplankton species
- Cultivation methods and enrichment
- Microbial control
- New technology: automation and process control



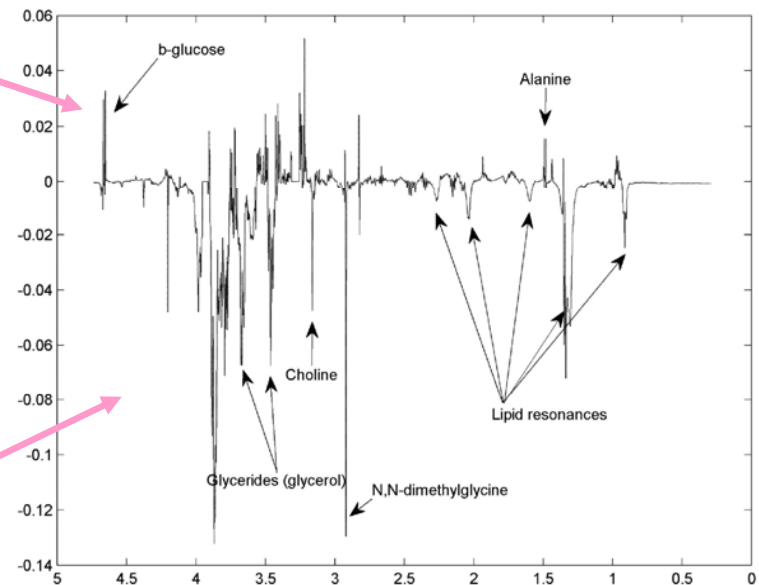
# Different nutritional value in *Brachionus plicatilis* (Nevada) and *Brachionus ibericus* (Cayman)

Experiment:  
*B.plicatilis* (Nevada) and *B.ibericus* (Cayman):  
-Similar cultivation conditions (8 days)  
-Similar feed type

Positive peaks:  
Higher amounts in *B. ibericus* (Cayman)



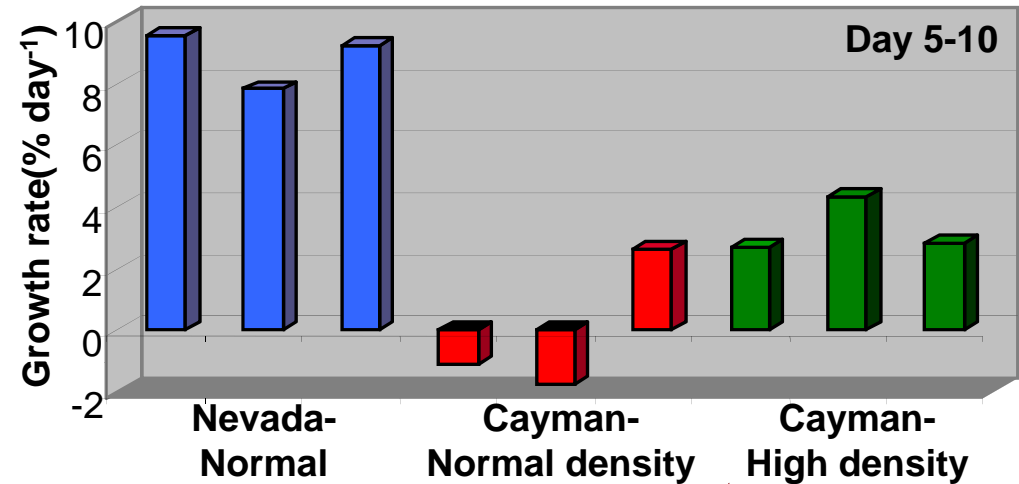
Negative peaks:  
Higher amounts in *B. plicatilis* (Nevada)



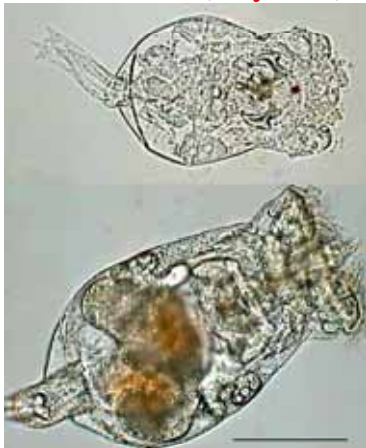
Loading plot from a principal component analysis of NMR metabolic profile from rotifer samples.

# Effect of rotifer size on first feeding of cod larvae

The firstfeeding experiment:  
 3 tanks: 5000 *B.plicatilis* (Nevada)/L  
 3 tanks: 5000 *B. ibericus* (Cayman)/L  
 3 tanks: 12000 *B.ibericus* (Cayman)/L  
 (same biomass)



*B. ibericus* (Cayman)

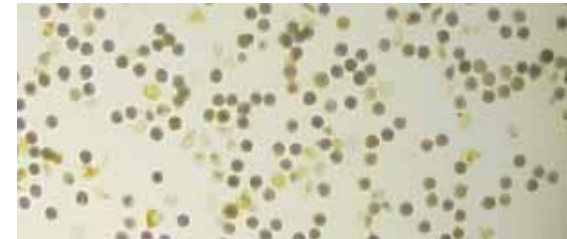
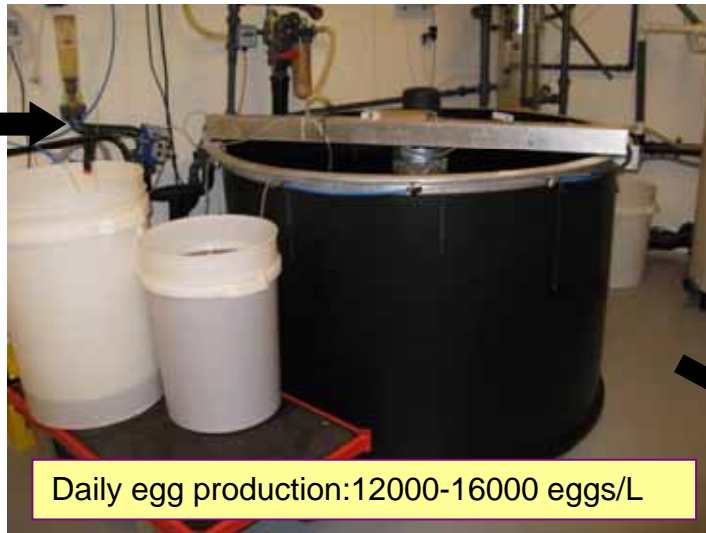


*B.plicatilis* (Nevada)

Results	Nevada Normal	Cayman Normal density	Cayman High density
Survival day 45 (% ± SE)	37±1	33±2	34±1
Growth rate day 5-10 (% day <sup>-1</sup> )	8.9	-0.06	3.3
Growth rate day 5-17 (% day <sup>-1</sup> )	10.6	5.9	8.9
Biomass, day 35 (µg DW larva <sup>-1</sup> )	1 335	1074	1157



# Production of *Acartia tonsa* eggs



Copepod eggs are harvested daily. The eggs can be stored for several months at low temperature

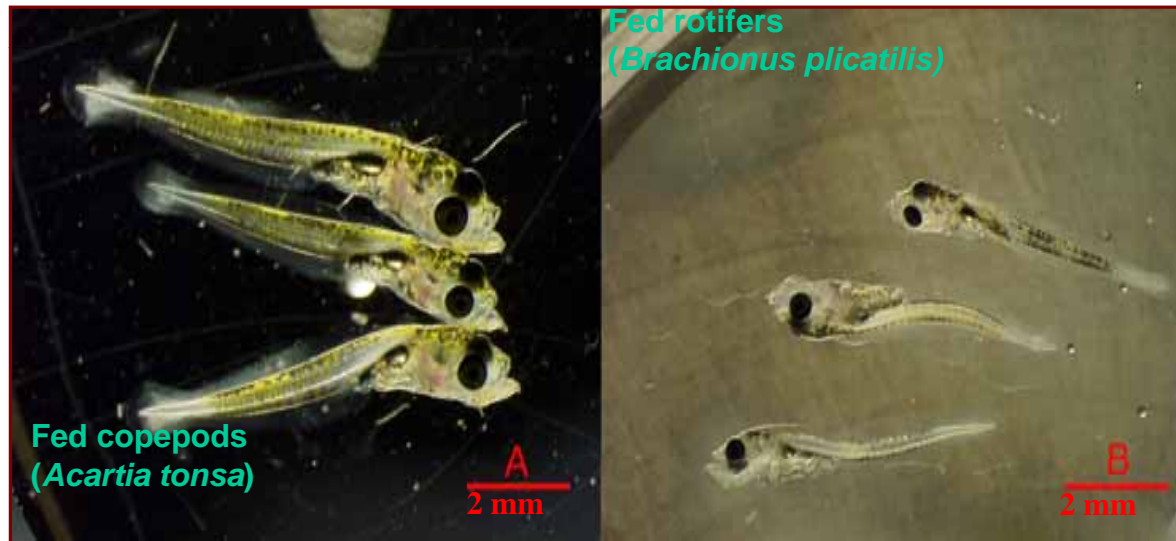


The eggs will be send to a hatchery. Hatching after 24 hours. Fed to fishlarvae in critical periods

(Financed by: Innovation Norway and cod hatcheries)

# Cod larvae fed cultivated copepod or rotifers

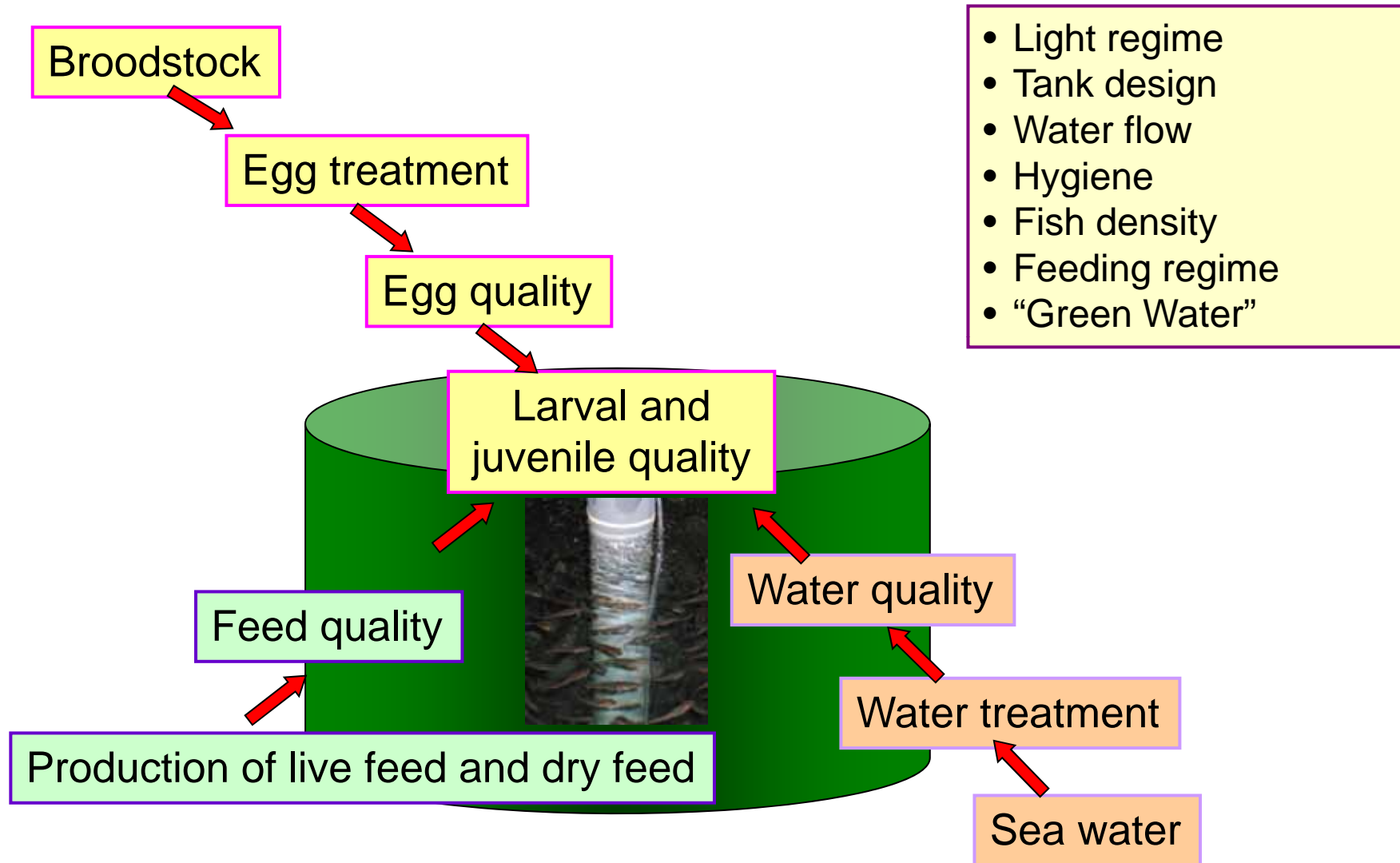
The firstfeeding experiment:  
2 tanks fed cultivated copepods  
2 tanks fed rotifers



Cod larvae 17 days after hatching

(Financed by: EU project No: Q5CR-2002-72468)

# Production of marine larvae and juveniles

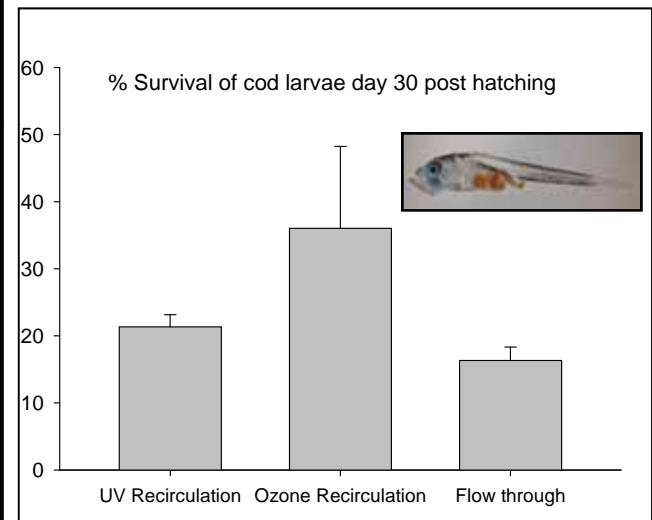


# Water quality in cod larval production

Our strategy is to have microbial stability in the water

The firstfeeding experiment:

- 3 tanks: Recirculation with UV
- 3 tanks: Recirculation with ozone
- 3 tanks: Flow through



(Attramadal et al. unpublished)

(Financed by CODTECH, A strategic University programme)

# Effect of live algae, algae paste or clay addition to cod larval tanks

The firstfeeding experiment:  
 3 tanks added *Nannochloropsis* paste  
 3 tanks added Clay  
 3 tanks added live algae (*Nannochloropsis*)



	Algae paste	Clay	Live algae
Survival at day 20 post hatching ± SE	35% ± 1,65	49% ± 2,53*	22% ± 3,19
Growth rate per day from day 5 to day 20 posthaching	8,12 %	9,09 %	8,91 %
Dry weight mg at day 20 post haching ± SE	0,22 ± 0,016	0,270 ± 0,015	0,250 ± 0,014
Total colony forming units	High	Low	Low
% Vibrio of total colony forming units	High	Low	Low
Dissolved organic carbon	High	Low	High
Particular organic carbon	High	Low	High

\*total mortality in one tank at day 13

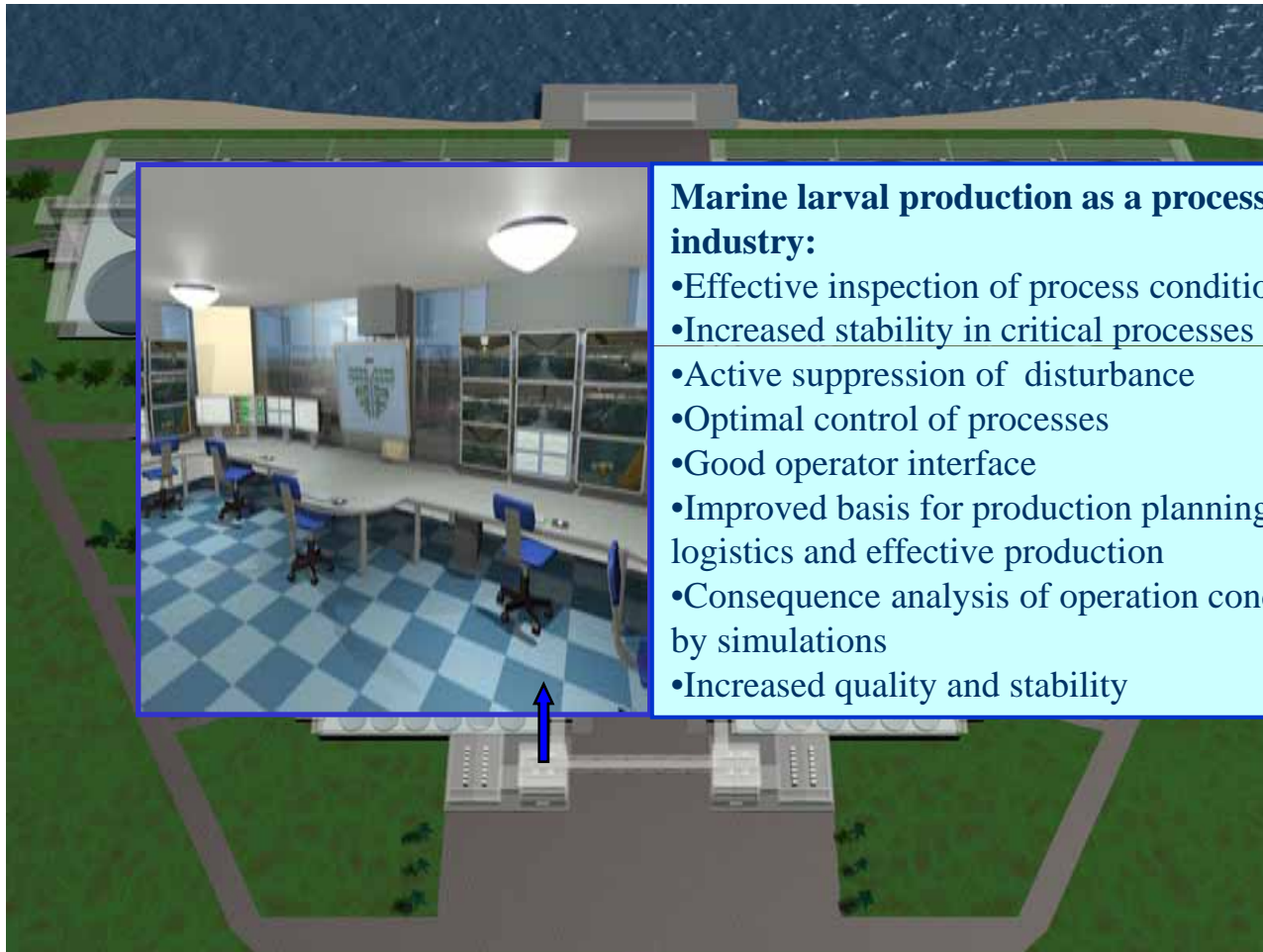
Similar results obtained for halibut (Naas, pers com)

(B.Tøndel, unpublished data)

(Financed by CODTECH, A strategic University programme)



# Cod juvenile production in the future



## Marine larval production as a processing industry:

- Effective inspection of process conditions
- Increased stability in critical processes
- Active suppression of disturbance
- Optimal control of processes
- Good operator interface
- Improved basis for production planning, logistics and effective production
- Consequence analysis of operation conditions by simulations
- Increased quality and stability



# Thank you for your attention



## Tanks to:

### SINTEF:

Jorunn Skjermo  
Werner Johansen  
Trond Størseth

### NTNU:

Olav Vadstein  
Bjørnar Tøndel  
Sunnviva Kui

All the cod hatcheries in Norway