On-growing facilities in aquaculture: welfare implications

Baeado no material de
Ian Mayer
Norwegian School of Veterinary Science

Norwegian School of Veterinary Science

On-growing facilities in aquaculture:
welfare implications

- Different types of aquaculture systems
- sea cage aquaculture in Norway - **salmon farming**
- Fish welfare: what are the major concerns

Norwegian School of Veterinary Science

Aquaculture systems

There are four basic types of aquaculture systems:

①ponds
②raceways
③recirculatory systems
④tanks and cages

Norwegian School of Veterinary Science

Aquaculture systems

1. Ponds

Fish pond in Thailand

Fish pond in Thailand

Norwegian School of Veterinary Science

Pond production

Shrimp ponds, Vietnam

Catfish ponds, Vietnam

Norwegian School of Veterinary Science

Pond production of catfish (*Pangasius hypophthalmus*) in the Mekong delta, Vietnam

In 2009, Vietnam produced ca. 1.8 million mt of catfish, and exported 650,000 mt of catfish fillets.

Norwegian School of Veterinary Science

Fish ponds: environmental impacts

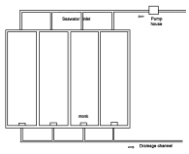
Rice paddy, Vietnam

Mangroves, Mekong river, Vietnam

- One of the major environmental issue surrounding the construction of ponds for fish/shrimp production is the loss of coastal zone habitat.
- There is particular concern over the loss of mangrove habitat for the construction of shrimp ponds.
- The construction of shrimp ponds has resulted in the loss of 3.7 million acres of coastal zone habitat, mostly mangroves.

Aquaculture systems

2. Raceways



Aquaculture systems

2. Raceways

Raceways are commonly used for trout production

- Generally 1-2 m deep, 2-6 m wide and 15-40 m long
- Water entering the raceway must be fresh or aerated (oxygen levels must be > 60% saturation).
- Major environmental concern is the large volume of water used.

Raceways can also be used for mariculture


Abalone farming in Taiwan

Aquaculture systems

3. Recirculatory systems

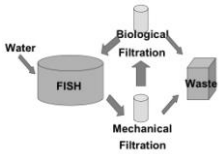


Diagram showing the principles of a recirculation system

Recirculatory system used for sea bream production

Aquaculture systems

4. Tanks and cages




Sea cage technology – motivation for new design

- Reduce the probability of escaped fish
  - tearing of nets during operation
  - damage to net cage due to abrasion from cage collar or weights
  - boat damage (propeller)
  - damage during severe weather
- New species, e.g. Atlantic cod
- Simplified production
- Easy operation
- Increased effective volume in current
- Improved fish welfare?

A new alternative - offshore cage systems

Offshore cage designs must provide the following:

- provide a reasonably stable cage shape to **avoid stressing the stock**, and to provide a stable working environment.
- provide adequate water exchange to **satisfy metabolic requirements** of the stock and to remove wastes from the sea cage.
- be able to absorb or deflect environmental forces so as to maintain the structural soundness of the system.
- provide an efficient and safe working environment, for routine husbandry, and where equipment and materials (feed and harvested fish) can be handled.
- maintain position, and provide a secure location, free from navigational hazards, etc.
- Keep capital and operating costs as low as possible.

Offshore cage systems

Three basic structural types:

- **Floating cages**
  - flexible structures
  - rigid structures
- **Semi-submersible cages**
  - flexible structures
  - rigid structures
- **Submersible cages**

Floating cages

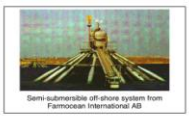
Dunlop/Bridgestone cages are the most widely used open sea cage worldwide.

Hexagonal cage

Octagonal cage

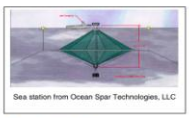
- Often linked together in rafts of 4 to 8 cages.
- Very large volumes possible.
- One Bridgestone sea cage used for salmon farming off the west coast of Ireland is 50 m in diameter, over 20 m deep and with a volume of 40,000 m^3

Development of off-shore systems

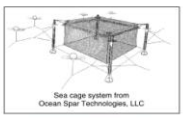


Semi-submersible off-shore system from Farmocean International AB

Fish farm platform from Marina System Iberica

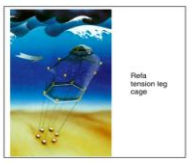


Sea station from Ocean Spar Technologies, LLC



Sea cage system from Ocean Spar Technologies, LLC

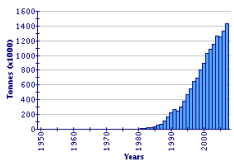
60,000 m^3



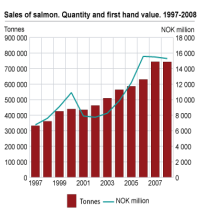
Refa tension leg cage

Cruive off-shore fish farm from Campbeltown Developments Ltd.

Intensive sea cage production of Atlantic salmon

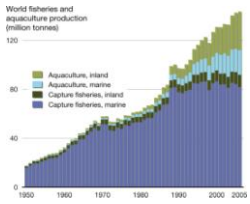


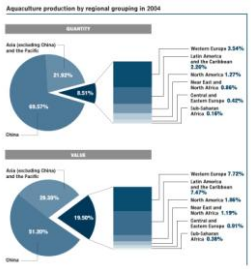
Global increase in farmed salmon production



- Norway produced close to 800,000 mt of salmon in 2009.
- This represents close to 50% of global farmed salmon production.
- Salmon farming is Norway's third largest export industry.

Global increase in aquaculture





- Rapid growth in global aquaculture production since the 1980s
- Global aquaculture production dominated by Asia, especially China
- Europe contributes 3.5%, with Norway contributing about 1.5% of global aquaculture production.

Impact of sea cage production on fish welfare

- General health and well being of fish - **good welfare**
- Exposure to both acute and chronic stress

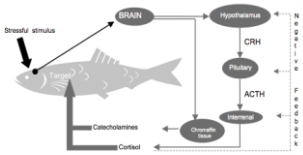
Sea cage farming of salmon

Welfare considerations

1. Acute stress
2. Chronic stress
3. Stocking densities
4. Inability to express normal behaviour
5. Disease and parasites
6. Inappropriate feeding regimes
7. Slaughter methods

1. Acute Stress

- Acute stress due to a variety of production procedures.
  - handling and grading
  - vaccination
  - transportation
  - sea lice treatment



Endocrine stress response in fish.

2. Chronic Stress

Consequences of chronic stress:

- **impaired growth**
- **impaired reproduction**
- **Immunosuppression**

Environmental factors that can induce chronic stress include:

- Temperature
- Low oxygen
- High CO_2, ammonia
- photoperiod

Photoperiod

Photoperiod manipulation is now commonly used in aquaculture

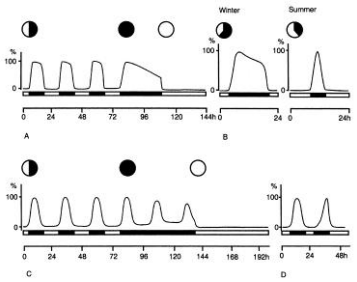
- **inhibit or delay early sexual maturation**
- **increase somatic growth**
- **advance or delay spawning**

Chronic stress - environmental factors

Photoperiod

constant light or extended photoperiods

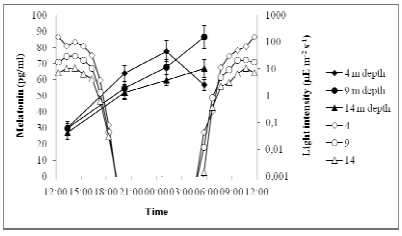
Rhythmic pattern of melatonin synthesis in the teleost pineal organ incubated under different photoperiod regimes (Ekström & Meissl, 1997).



rainbow trout

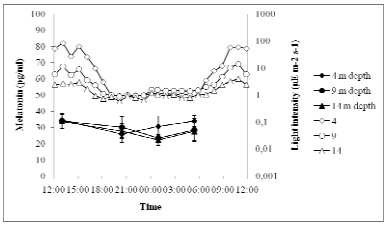
goldfish

Light intensity and plasma melatonin levels in Atlantic cod kept at three different depths in a sea cage (Skulstad et al., submitted)



Natural light regime

Light intensity and plasma melatonin levels in Atlantic cod kept at three different depths in a sea cage (Skulstad et al., submitted)



Constant light

Norwegian School of Veterinary Science

Sea cage farming of salmon
Welfare considerations

3. Inappropriate stocking densities

Stocking density will depend on a variety of biological and environmental factors, including
- species
- age
- water quality

For salmonids, common stocking densities are:
- Rainbow trout 20 – 120 kg m^{-3}
- Atlantic salmon, smolts 50 kg m^{-3}
- Atlantic salmon, sea cages 25 kg m^{-3} (150,000 salmon/sea cage)
- Atlantic salmon, organic 10 kg m^{-3}

Norwegian School of Veterinary Science

Sea cage farming of salmon
Welfare considerations

4. Inability to express normal behaviour

The Five Domains of Welfare

Brambell Report, 1965

Domain 4. Freedom to express normal behaviour.

- Animals should have sufficient space, proper facilities and where appropriate, the company of the animal's own kind.
- Fish should have the freedom to exhibit their normal repertoire of behaviours.

Sea cage farming of salmon

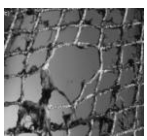
Welfare considerations

4. Inability to express normal behaviour

- New species
- Atlantic cod displays different behaviour compared to salmon
- Cod are farmed in the same way as salmon with no thought of its different behaviour.

Atlantic cod, *Gadus morhua*

Cod farming in Norway



escape behaviour

5. Disease and parasites

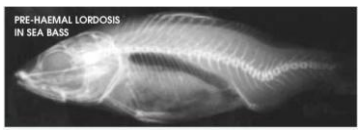
- Infectious salmon anaemia (ISA)
- ISA is a relatively new viral disease, first observed in salmon in 1984.
- ISA devastated the Chilean salmon industry in 2008-09.
- Sea lice

6. Nutritional deficiencies

Nutritional deficiencies (poor diets) can result in a number of developmental and structural deformities, including:

- Skeletal deformities
- Cataracts
- Fin rot
- Heart defects (heart hypertrophy)
- Impaired digestive physiology

Skeletal deformities



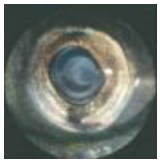
- Most intensively farmed fish, including salmon, raised under intensive culture conditions are prone to show various deformities, especially spinal deformities.
- Skeletal deformities are caused by a combination of genetic disposition, malnutrition (especially during the fast-growth periods), and environmental factors (especially temperature).

Skeletal deformities shown in farmed cod.

Deformities shown in farmed flatfish - halibut

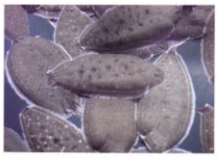
Cataracts

- High instances of this condition have been found since the mid-1990s. In a 1998 study conducted on Norwegian salmon farms, it was found that 80% of all salmon showed some degree of lens opacities, with 30% of them serious.
- Cataracts cost the Norwegian salmon farming cost the industry up to €55 million per year.
- Advanced stages of cataract can cause bleeding, damage to the cornea, as well as blindness.



Fin erosion (fin rot)

rainbow trout

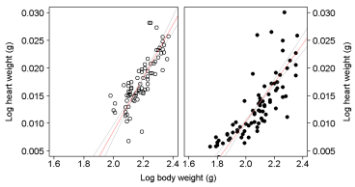


Dover sole

- Nutritional deficiencies
- Nipping and aggressive behaviour
- Abrasion – tank surfaces and fish
- Sunburn – exposure to *uv* light
- Water quality
- stress

Heart deformities

- Farmed salmon show a number of heart deformities
- These salmon are more prone to stress – both a production and **welfare issue**
- Heart hypertrophy also seen in other farmed species, such as Atlantic cod.



Mayer et al. unpublished

7. Slaughter methods

- Highly automated slaughter methods.

Slaughter methods for farmed salmon

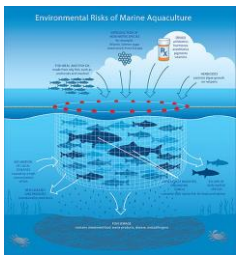
- percussion stunning/spiking
- carbon dioxide narcosis
- electrical stunning

Sea cage farming of salmon
Welfare considerations

Conclusions

- Aquaculture is the fastest growing sector of animal production, with an annual growth rate of 8%.
- The intensive production of high value species, mostly carnivorous, by means of sea cage farming is growing rapidly.
- Salmon farming methods are becoming more intensive, and dominated by a small number of multinational companies.
- There is a growing demand that more attention should be placed on addressing **welfare issues** in intensive aquaculture.
- In addition, the **environmental impacts** of intensive sea cage aquaculture should also be recognised, and addressed.

Environmental impacts of intensive aquaculture



Thank you