Ethical slaughter of fish:

Practices from large-scale production of Atlantic salmon

Past, present and future slaughter methods

U. Erikson
SINTEF Fisheries and Aquaculture
7465 Trondheim, Norway

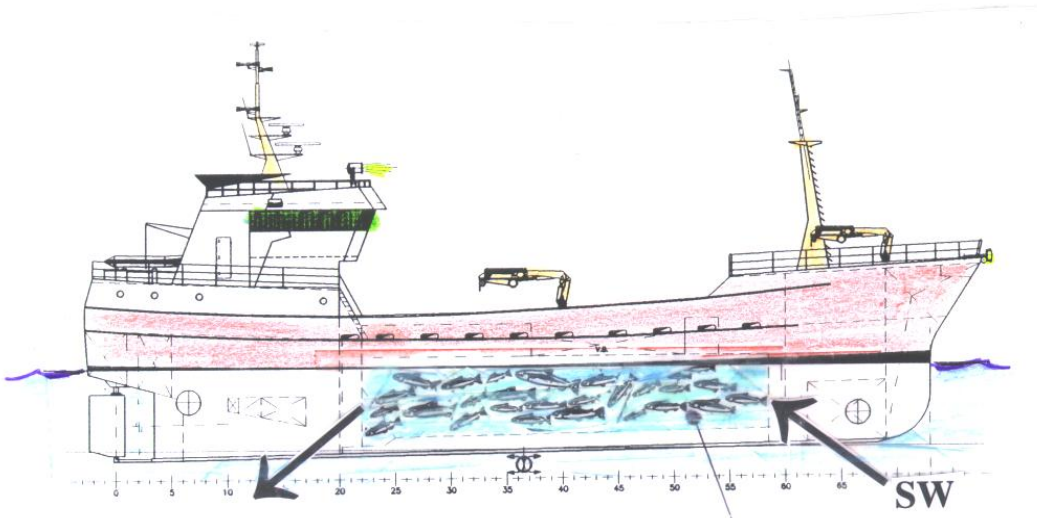
Animal welfare and fish harvesting

’From seacage to stunning/killing’ :
Some issues related to handling stress and fish welfare

- Common commercial practices
- Different stunning/killing methods
- Welfare indicators

Live fish transport

- Seacage to processing plant -



Typical well-boat

Hold: 500 – 1500 m^3
Biomass: 60 – 120 tons

Fish density: 100 – 250 kg m^{-3}
'Open valves' → good seawater quality

Live transport with well-boat

From seacage to processing plant

Today: 'Open system'

- Good SW quality
- 'Safe' transport (low mortality)
- Commonly without adverse effects on product (fillet) quality

Alternatively: 'Closed system'

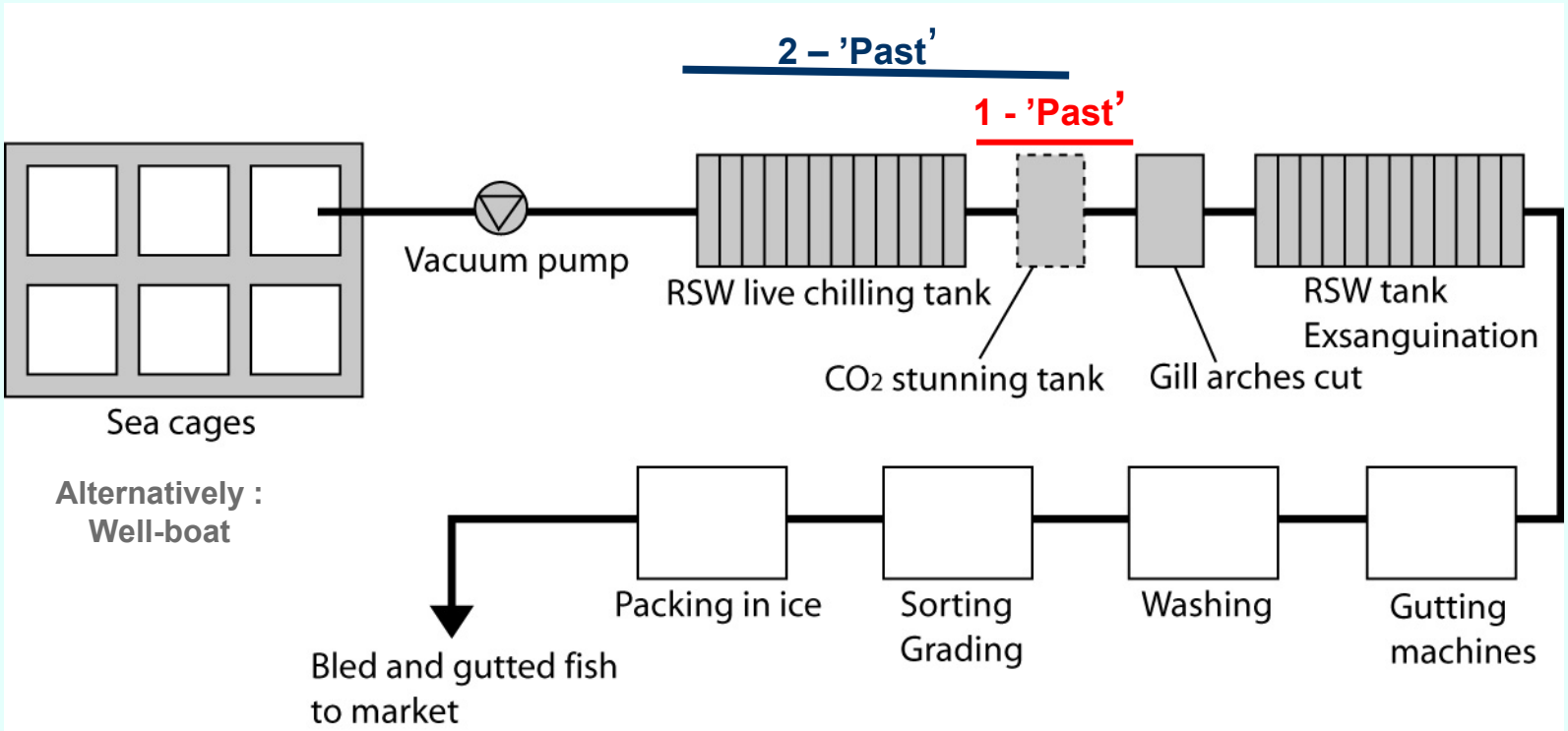
1. Transport through 'high-risk' waters (avoid infections/diseases or pollution)
2. RSW chilling of fish during transport

- SW quality deteriorates rapidly
- Transport may be risky (high mortality) – time dependent!
- Adverse behaviour

Typical processing line for slaughter of salmonids

4 – Future ?

3 - Present



Harvesting and processing of salmonids

Some typical key figures

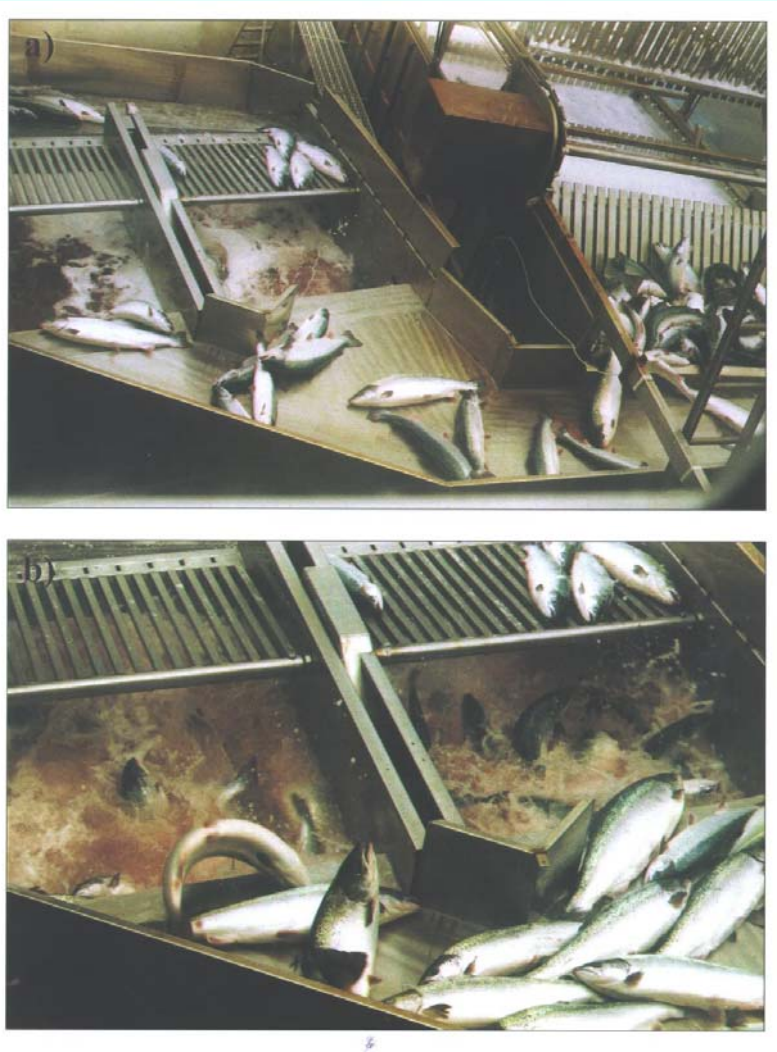
- Fish fasted for 1 – 2 weeks
- Fish weight 2 – 7 kg
- Biomass produced per shift (7h) 100 tons↑
  = 15 000 kg h^{-1} or 3000 individuals h^{-1} (mean weight 5 kg)
- Body (acclimation) temperatures 4 -18 ^{o}C

Carbon dioxide stunning

- CO_2 levels >> 400 mg l^{-1}
- 200 – 500 mg CO_2 l^{-1} necessary for complete anaesthesia of large Atlantic salmon (Iwama & Ackerman 1984, Bell 1987)
- Crowding effects
- Slaughtered fish exhausted

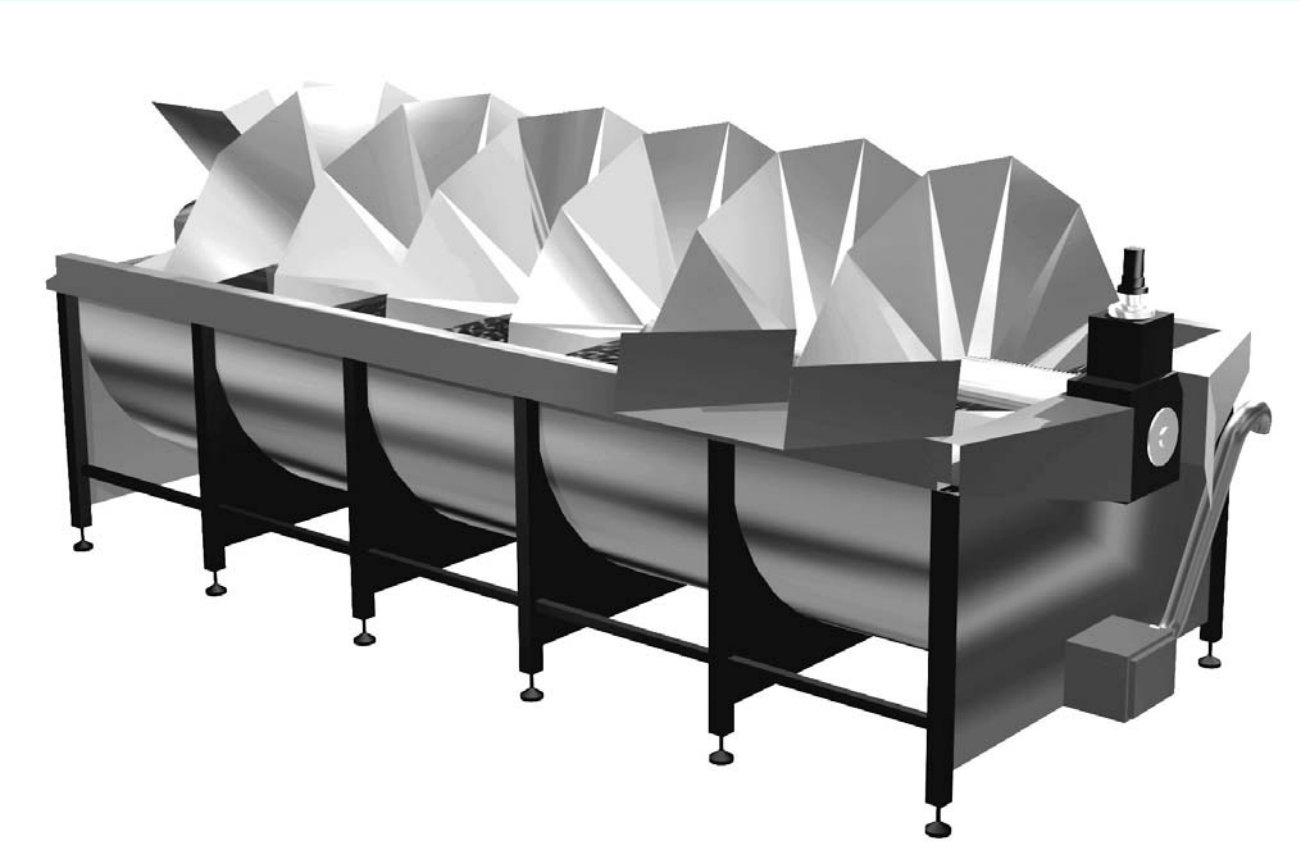
RSW live chilling followed by carbon dioxide stunning

Sedated (live chilled) fish transferred to CO_2 tanks became exhausted as before



Live chilling combined with mild carbon dioxide anaesthesia in oxygen-saturated RSW

Typical RSW tank 30 - 40 m^3



RSW live chilling

- Recirculated water: adverse water quality-

- Foaming (sometimes)
- Reddish water (blood?)

	Cage	RSW	
pH :	8.2	6.3 - 7.0	
NH_4^+-N (mg l^{-1}) :	0.0 - 0.1	2.1- 49.6	
NH_3 (µg l^{-1}) :	0.0	0.3 - 5.3	
Alkalinity (mmol^{-1}) :	2.2 - 2.3	2.5 - 3.0	
Colour (mg Pt l^{-1}) :	2 - 3	10 - 77	
Total Organic Carbon (mg l^{-1}) :	1- 3	11- 25	(mucus?)
Fe^{3+} (µg l^{-1}) (indices of haem) :	4 - 9	54 – 330	(blood)

- Histopathological evaluation of gill epithelia before and after live chilling showed that no damage was inflicted

Fish behaviour in closed systems

Adverse behaviour in a RSW live chilling tank

Oxygen supersaturation (160 %)
SW temperature 2°C

Reduced gill ventilation rate → hypercapnia and blood acidosis

RSW live chilling

- Control of CO_2 and O_2 levels ! -

- Carbon dioxide: 70 – 150 mg l^{-1}
- Dissolved oxygen: 70 – 100 % saturation
- RSW temperature: 0.0 ± 0.5 ^oC
- Fish anaesthetized after 2 - 3 min
- ΔT_{SW-RSW} : 4 – 18 ^oC (Instant chilling, i.e. no acclimation)
- Lethal temperatures for Atlantic salmon: - 0.7 ^oC (Saunders, 1986); -1.4 to -1.7 ^oC (Skuladottir et al., 1990)
- Fish holding time in RSW tank: 30 – 60 min

Future stunning methods

- RSW live chilling
- Percussion stunning (or *iki jime*)
- Electrical stunning
- Eugenol (AQUI-S^{TM})*

*Presently not allowed in EU and Norway

Percussion stunning

Fish are stunned/killed with a sharp blow to the head

(Capacity per stunner: >1 fish sec^{-1})

Future stunning methods

Electrical stunning

- Individual or bulk stunning
- Control of stunning parameters (eg. voltage, current, frequency, time) crucial!

Eugenol / AQUI-S^{TM}

- Anaesthetic added to a tank
- In principle, very simple method
- Withdrawal time (human consumption)

Research projects

- ’Ethical processing line for farmed cod’
- ’Ethical slaughter of salmonids:
  RSW live chilling *vs* percussion stunning’

Stress and welfare indicators

- Fish behaviour
- Blood samples (pH, Na^+, K^+, Cl^-, glucose, lactate, hematocrit, cortisol…)
- Muscle biochemistry – initial pH in white muscle. Indices of handling stress (struggling / escape behaviour)

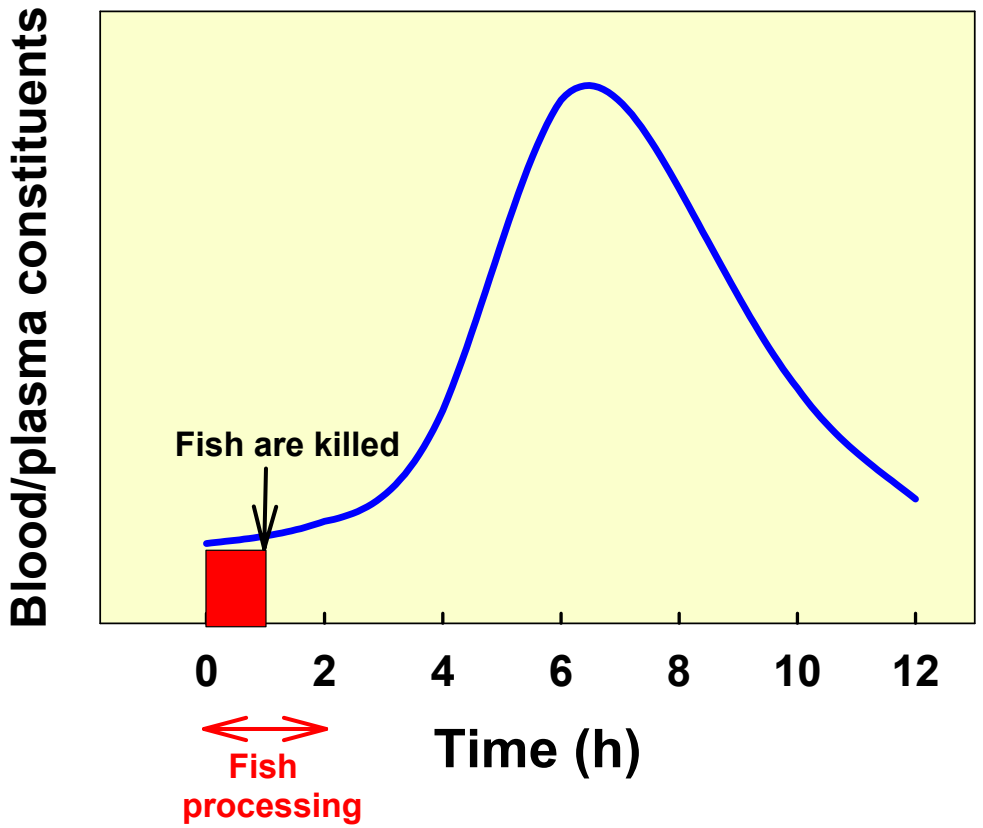
Blood samples and fish in processing lines

Rested and exhausted Atlantic salmon
(muscle pH)

- **Plasma chloride**
- **Plasma glucose**
- **Hematocrit**

- **No differences between groups [cage, pumping, live chilling (?), percussion stunning]**

- **Plasma values typical of rested fish**

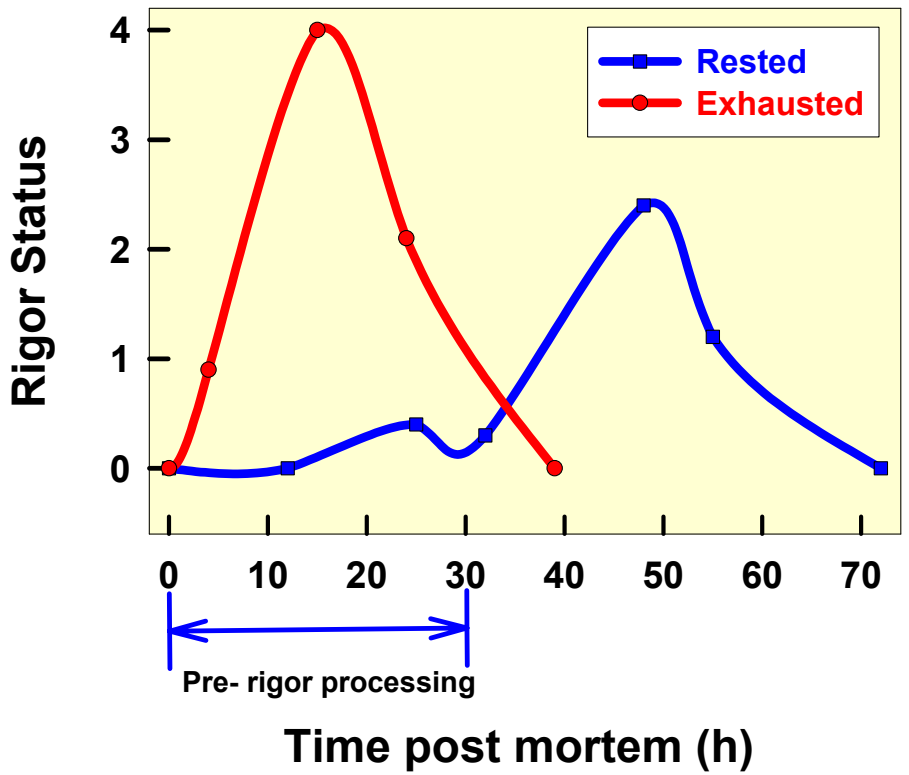


Stress indicators – White muscle pH at t =0h

pH range in live fish:

pH 7.4 ± 0.1 : Rested fish
pH 7.1 ± 0.1 : Partially stressed
pH 6.8 ± 0.1 : Exhausted fish

- **Directly linked to rigor mortis onset**
- **Affects fillet quality**



Conclusions

- **R & D is currently taking place to improve current fish slaughter methods from an animal welfare point of view** (’rested harvesting’, pumping, bleeding, time to rigor onset, reducing manpower)
- **Documentation of animal welfare (large-scale, commercial use) – how?**
- **Indicators of fish welfare – behaviour and extent of stuggling (escape behaviour). Other criteria?**