# LEVANDELAGRING AV KVITFISK

## - EIT SAMANDRAG AV RESULTAT FRÅ FORSØK OG FULLSKALATESTING

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FHF-møte om kvalitet på Myre 13. Februar 2019

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# ELEKTRISK BEDØVNING

TØRRBINGE → EL-BEDØVER → IMMOBLISERING → BLØGGING → VIDARE PROSESSERING



BLØGGING

SINTEF

# TØRRBINGE VS VÅTBINGE

# ANALYSMETODAR

## Stress grunna fangst og levendelagring

- Blod kjemi (pH, glukose and laktat)
- Muskel biokjemi (start pH, twitch utsalg and rigor start)

## Kvalitets vurdering av filet

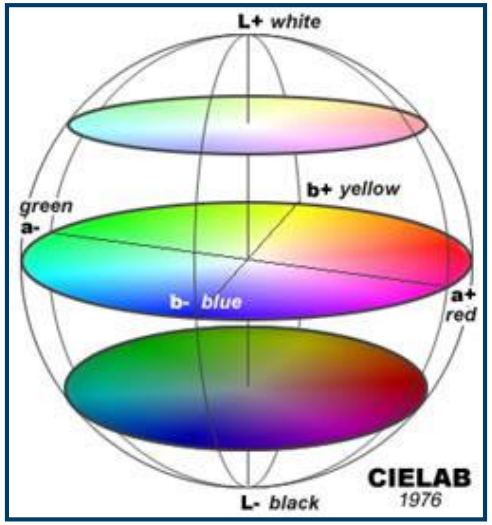
- Misfarging av loins og buk (0-2)
- Restblod i årer (0-2)
- Blodflekker (0-2)

## CIE L*a*b* farger ved maskinsyn

- Lysheit, L*
- Raudheit, a*
- Gulheit, b*
- Kvitheit, W = L* - 3b*
- Hue ($H^o$)
- Chroma (C*), fargemetning

## Videoanalyse av fiskeåtferd

- Aktivitet
- Balanse
- Respirasjon
- Respirasjonsstress



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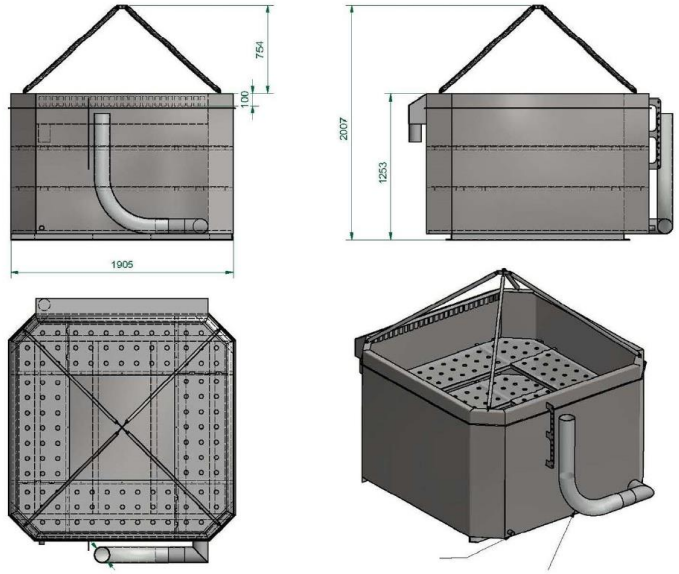
- Levendelagra torsk i opp til 6 timar vart samanlikna med tradisjonelt behandla torsk.

**5 ulike grupper:**

Levandelagra for:

- 0 time
- 1,5 time
- 3 timar
- 6 timar

Kommersielt produsert

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Full length article

## The on-board live storage of Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) caught by trawl: Fish behaviour, stress and fillet quality

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ABSTRACT

The aim of the present study was to assess the effects of the short-term live storage of Atlantic cod and haddock on residual blood in fillets. The fillet colour characteristics of fish sampled after 0, 1.5, 3 and 6 h of live storage were compared with fish subjected to current commercial processing procedures. Fish behaviour during live storage was also assessed, along with handling stress, by measuring the blood constituents (cortisol, glucose, lactate, pH and haematocrit), the initial white muscle pH, muscle twitches and length of time to the onset of rigor. The fillet colour in the CIE L*a*b* colour space was determined on fresh fillets (on-board) and the presence of discolouration was quantified by using a modified version of the Fillet Quality Index method. Fish behaviour analysis performed during live storage showed some signs of stress and that the condition of fish caught at greater depths was inferior to fish caught in shallower waters. The survival rate varied between the different trials (48.9–92.5%), and was likely impacted by the fishing depth. The blood chemistry data showed that the captured fish were somewhat stressed, but we were not able to clarify whether the fish were becoming gradually more stressed during the subsequent live storage, or whether the observed increase or lack of recovery were a result of a delayed response for the various stress parameters. The occurrence of blood spots and discolouration was low in fillets cut from both species of fish just after capture. Subsequent live storage did not change this scenario. The colour characteristics of fillets cut from dead fish after 4.5–5.5 h were only marginally inferior to fillets from all the other treatments.



### 1. Introduction

Atlantic cod (*Gadus morhua*) has traditionally been one of the most important commercial species in the northern part of the Atlantic Ocean, and it is an important species for food production in Norway. In the last five decades, as a result of technological advances the catch capacity of the fishing fleet has increased significantly (Standal and Sønvisen, 2015), and due to high labour costs the number of fishermen on each vessel has been reduced. Therefore, every fisherman has to handle increased quantities of fish, which poses a challenge with respect to both fish quality and human safety. During the last 30 years, technological progress regarding the processing of whitefish on board trawlers has been very slow. Today, there is a willingness to develop innovative on-board automated catch handling systems that safeguard the initial fish quality as well as the fishermen's HSE (Health, Security and Environment). Fish welfare has also become an issue in wild fisheries in recent years (Lambooij et al., 2012). As stated by the Norwegian Council for Animal Ethics, both the duration of harvesting and the length of time that fish experience high levels of stress, fear or pain should be shortened, aiming for gentle handling and minimal damage during capture.

Capture can affect fish in terms of injuries, excessive stress incidents and product quality. Gear-related injuries can result in compromised welfare as well as inferior product quality (Botta et al., 1987; Lowe et al., 1993; Esaiassen et al., 2004; Özyurt et al., 2007; Digre et al., 2010; Rotabakk et al., 2011; Olsen et al., 2014). Both weather conditions and the duration and size of the haul may affect the quality of fish caught by trawl or Danish seiners (Margeirsson et al., 2006). By the time the catch has been hauled on board, the fish are often stressed due to excessive muscle activity (escape behaviour), as can be identified by a low initial pH and elevated blood lactate levels (Digre et al., 2011; Olsen et al., 2013). Stress and inadequate on-board handling routines can result in poor bleed-out and thus reduced product quality (Botta et al., 1986; Olsen et al., 2013). In the Norwegian whitefish industry, adequate

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# FORSØK PÅ HELMER HANSEN I 2014

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| Trial No. | Fish | | | Water Quality | | |
|---|---|---|---|---|---|---|
| | Species | Survival rate (%) | Fish density (kg/m$^3$) | DO% | Temp °C | pH |
| 1 | Cod | 58.9$^{AB}$ | 118.6 | 99–113 | 5.2–6.1 | 8.1 |
| 2 | Cod | 48.9$^{A}$ | 405.2 | 76–120 | 5.2–5.6 | 8.0 |
| 3 | Cod | 68.1$^{BC}$ | 410.6 | 46[a]–107 | 4.2–5.0 | 8.0 |
| 4 | Haddock | 92.5$^{D}$ | 87.1 | 104–116 | 4.1–4.3 | 8.1 |
| 5 | Cod | 77.3$^{C}$ | 548.1 | 67–117 | 4.1–4.4 | 8.0 |

[a] 46–60% in a period of 2 h.


| Live storage (h) | Blood | | | | | Muscle | | |
|---|---|---|---|---|---|---|---|---|
| | Cortisol (ng ml L$^{-1}$) | Blood pH | Glucose (mmol L$^{-1}$) | Lactate (mmol L$^{-1}$) | Hct (%) | Initial pH | Twitch ability (Score 0–3) | Rigor onset (h) |
| Cod (n = 19–55) | | | | | | | | |
| 0 h | 62.6 ± 6.1$^{A}$ | 7.29 ± 0.04$^{AB}$ | 4.72 ± 0.3$^{C}$ | 3.41 ± 0.2$^{C}$ | 32.88 ± 0.71$^{B}$ | 7.11 ± 0.03$^{ABX}$ | 2.1 ± 0.1$^{AX}$ | <8.0 h |
| 1.5 h | 102.7 ± 7.6$^{B}$ | 7.21 ± 0.04$^{B}$ | 7.27 ± 0.67$^{B}$ | 6.18 ± 0.35$^{BX}$ | 36.32 ± 0.85$^{A}$ | 7.18 ± 0.04$^{ABX}$ | 1.6 ± 0.2$^{A}$ | <6.0 h |
| 3 h | 123.3 ± 7.9$^{B}$ | 7.30 ± 0.03$^{AB}$ | 10.15 ± 0.74$^{A}$ | 8.46 ± 0.35 $^{A}$ | 35.59 ± 0.76$^{AB}$ | 7.20 ± 0.04 $^{AX}$ | 1.8 ± 0.2$^{A}$ | <5.0 h |
| 6 h | 125.4 ± 10.0$^{BX}$ | 7.37 ± 0.04$^{A}$ | 9.56 ± 0.63$^{ABX}$ | 9.64 ± 0.74$^{A}$ | 32.70 ± 1.26$^{B}$ | 7.20 ± 0.04$^{AB}$ | 2.1 ± 0.2$^{A}$ | <5.0 h |
| Dead 5.5h | n.a. | n.a. | n.a. | n.a. | n.a. | 7.05 ± 0.03$^{BX}$ | 0.1 ± 0.0$^{B}$ | <5.0 h |
| p-value | 0.000 | 0.028 | 0.000 | 0.000 | 0.007 | 0.008 | 0.000 | |
| Haddock (7–12) | | | | | | | | |
| 0 h | 15.4 ± 4.2$^{A}$ | 7.26 ± 0.04$^{B}$ | 3.91 ± 0.3$^{C}$ | 3.66 ± 0.4$^{C}$ | 24.38 ± 1.24$^{ns}$ | 6.93 ± 0.03$^{BC}$ | 2.6 ± 0.2$^{A}$ | 9.5 h |
| 1.5 h | 26.7 ± 4.4$^{AB}$ | 7.37 ± 0.07$^{AB}$ | 5.21 ± 0.46$^{BC}$ | 4.80 ± 0.53$^{BC}$ | 22.14 ± 1.22$^{ns}$ | 6.96 ± 0.04$^{AB}$ | 2.0 ± 0.3$^{A}$ | 10.5 h |
| 3 h | 32.5 ± 7.6$^{AB}$ | 7.53 ± 0.04$^{A}$ | 6.63 ± 0.53$^{B}$ | 7.15 ± 0.65$^{AB}$ | 21.57 ± 1.27$^{ns}$ | 7.10 ± 0.04$^{A}$ | 2.2 ± 0.2$^{A}$ | >10.5h |
| 6 h | 41.0 ± 2.3$^{B}$ | 7.44 ± 0.04$^{AB}$ | 8.66 ± 0.49$^{A}$ | 9.12 ± 1.31$^{A}$ | 21.43 ± 0.97$^{ns}$ | 7.00 ± 0.03$^{AB}$ | 2.1 ± 0.3$^{A}$ | >7.5 h |
| Dead 4.5h | n.a. | n.a. | n.a. | n.a. | n.a. | 6.80 ± 0.03$^{C}$ | 0.0 ± 0.0$^{B}$ | 5.5 h |
| p-value | 0.004 | 0.003 | 0.000 | 0.000 | n.s. | 0.000 | 0.000 | |

**Rested fish (reference values)**
Blood ~ pH 7.8
Glucose ~ 3 mmol L$^{-1}$
Lactate ~ 0 mmol L$^{-1}$
Muscle ~ pH 7.6

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| Haul # | Capture depth (m) | Fish | | | Water | |
|---|---|---|---|---|---|---|
| | | n | Survival rate (%) | Fish density (kg $m^{-3}$) | DO (% sat.)* | Temperature ( °C) |
| 207 | 50 - 60 | 75 | 100 | 105 | 92 - 101 | 3.9 - 4.1 |
| 214 | 50 - 60 | 41 | 85 | 23 | 97 - 101 | 3.5 - 3.9 |
| 223 | 310 | 104 | 51 | 235 | 85 - 101 | 4.2 - 4.4 |
| 232 | 310 | 84 | 67 | 116 | 97 - 102 | 4.2 - 4.4 |

Større fangstdybde ⇨ Lågare overleving

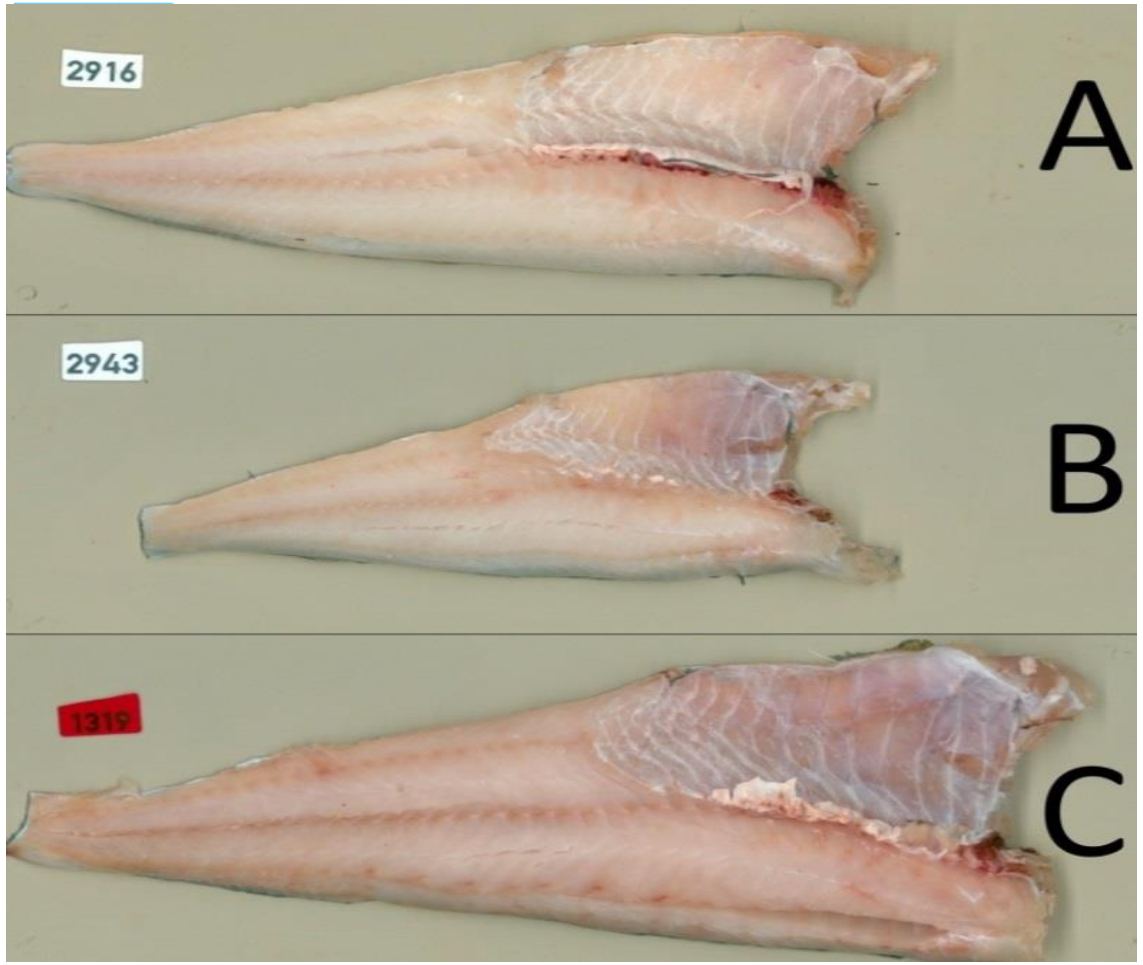
| Treatment | Blood | | | White muscle | | | | |
|---|---|---|---|---|---|---|---|---|
| | Blood $pH^{nsd}$ | Glucose (mmol $L^{-1}$) | $Lactate^{nsd}$ (mmol $L^{-1}$) | Initial pH | Temperature (°C)$^{nsd}$ | Twitch (0-3) | Time post capture (h) | $Rigor^{1)}$ (0-5) |
| LS 0h | 7.30 ± 0.02 | $3.3 \pm 0.2^{AX}$ | 4.6 ± 0.3 | $7.16 \pm 0.03^{A}$ | $4.7 \pm 0.1^{X}$ | $2.8 \pm 0.1^{A}$ | 0.5 | 0 |
| LS 3h | 7.25 ± 0.23 | $7.0 \pm 0.6^{BX}$ | 5.8 ± 0.3 | $7.21 \pm 0.03^{AB}$ | 4.8 ± 0.0 | $2.9 \pm 0.1^{A}$ | 0.5 | 0 |
| LS 6h | 7.56 ± 0.02 | $8.7 \pm 0.5^{CX}$ | 5.2 ± 0.5 | $7.31 \pm 0.03^{BX}$ | $4.7 \pm 0.0^{X}$ | $2.9 \pm 0.0^{AX}$ | 0.5 | 0 |
| DE 5h | *n.a.* | *n.a.* | *n.a.* | $6.96 \pm 0.03^{C}$ | $5.1 \pm 0.3^{X}$ | $0.2 \pm 0.1^{BX}$ | 5-7 | 1.3 |
| CP | *n.a* | *n.a* | *n.a* | *n.a* | *n.a* | *n.a* | 1-3 | 0 |

**Ustressa fisk (referanseverdiar)**
Blod ~ pH 7.8
Glukose ~ 3 mmol $L^{-1}$
Laktat ~ 0 mmol $L^{-1}$
Muskel ~ pH 7.6



*Erikson, U., Tveit, G.M., Bondø, M., Digre. H. (2019) On-board live storage of Atlantic cod (Gadus morhua): Effects of capture stress, recovery, delayed processing, and frozen storage on fillet color characteristics. Planned submission in 2019.*

# FORSØK PÅ HELMER HANSEN I **2015**

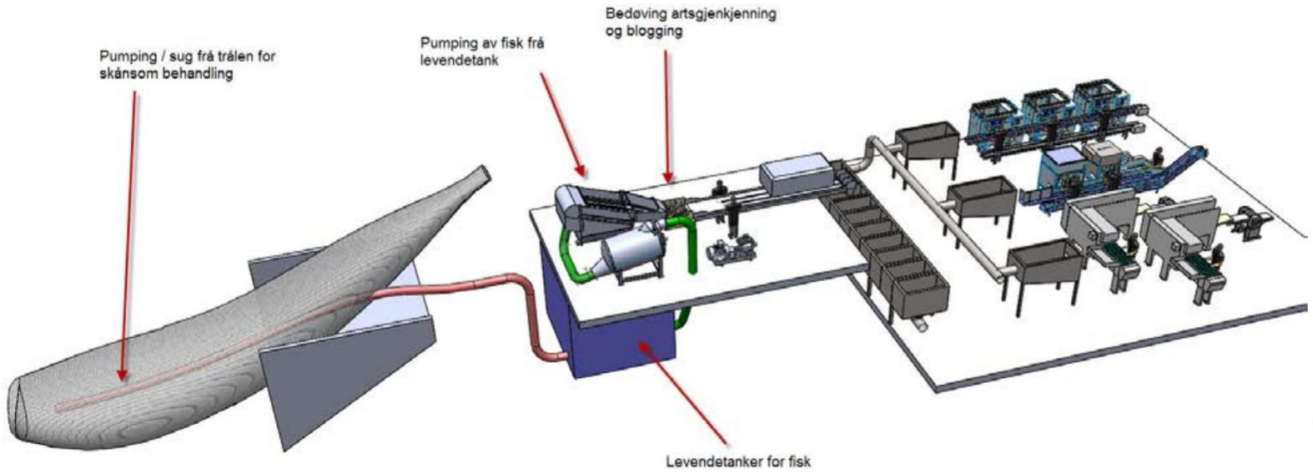



Like etter fangst (LS 0 h)
Liknande farge etter levandelagring i 3 og 6 timar

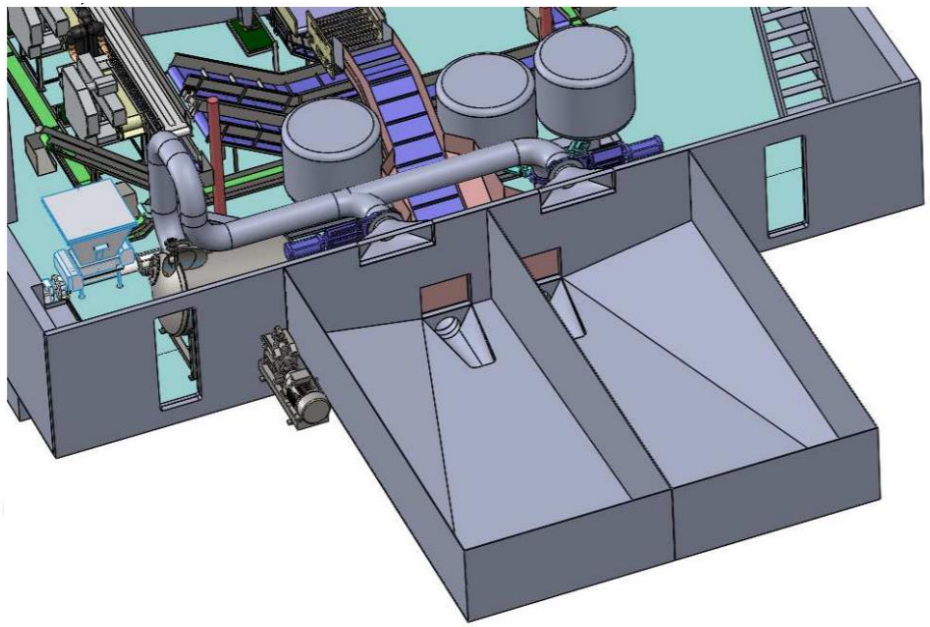
Beste resultat, utblødning av fisk 5 timar post-mortem (DE 5h)

Verste resultat, utblødning av fisk 5 timar post-mortem (DE 5h)

# LEVANDELAGRING OM BORD PÅ MOLNES




Slaktelinja om bord på Molnes, illustrasjon: Steeltech.



Mottak om bord på Molnes, illustrasjon: Steeltech.

FHF prosjekt (901097) "*Utvikling av teknologi for håndtering og ivaretakelse av kvalitet på levende trålfanget hvitfisk om bord i Mtr Molnes*".

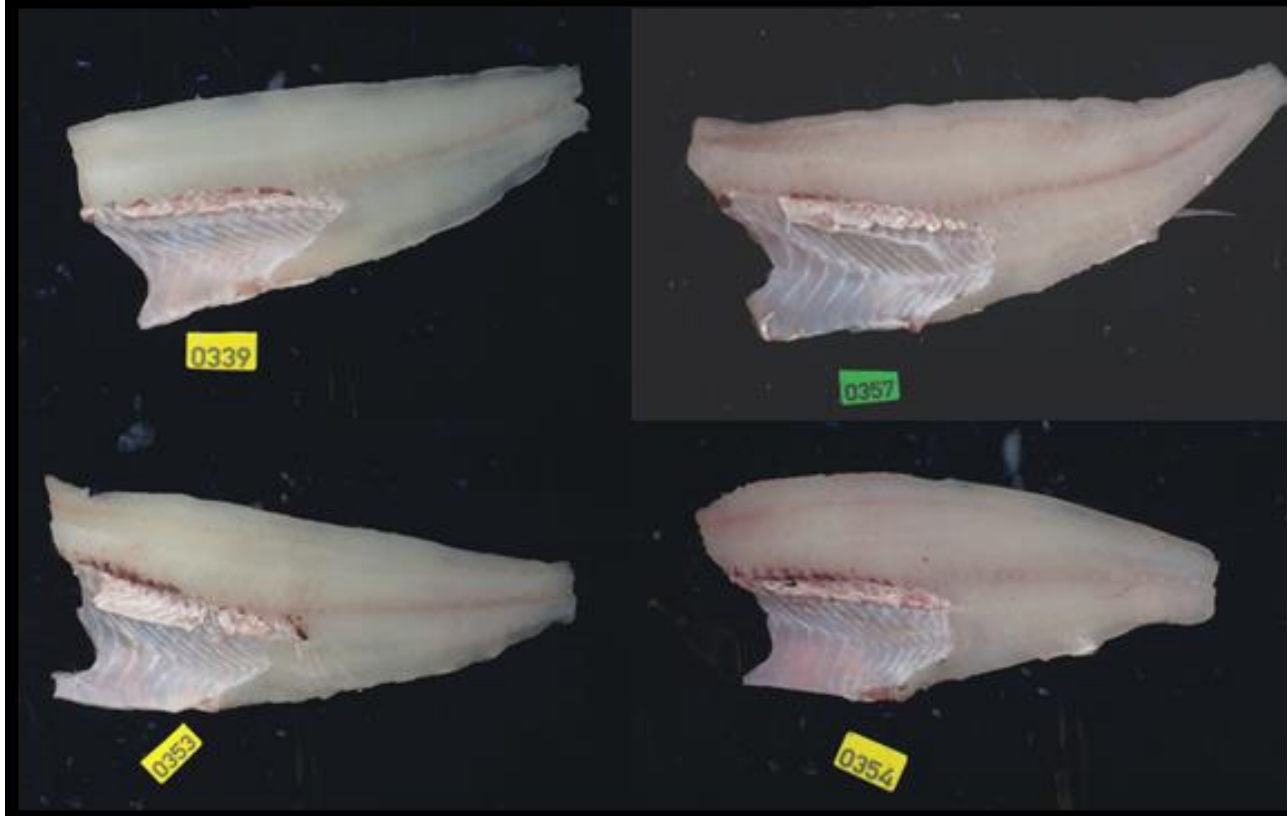
# FORSØK MED LEVANDELAGRING OM BORD PÅ MOLNES

- Forsøk med torsk og hyse
- 5 Grupper:
  - Levandelagring i 0, 1,5, 3 og 6 timar
  - Kontroll – sløyd etter 4-5 timar (tørt mottak)

QualiFish – *Market adapted production concepts for fresh and frozen/thawed cod* (Prosjekt no. 233709)

# FORSØK MED LEVANDELAGRING OM BORD PÅ MOLNES

- Kortidslevandelagring før bedøving og avliving er sannsynlegvis ein meir skånsam oppbevaringsmetode enn tradisjonell tørrbinge.
- Under gjeldande vilkår for fangst og levandelagring i desse forsøka vart ikkje fisken restituert etter stressbelastinga den vart utsett for ved fangsting.
- Fisk som vart levendelagra var lysare med mindre misfarging og raudheit samanlikna med fisken som representerte tradisjonelt prosessert trålfanga fisk, sjølv om forskjellane var små.



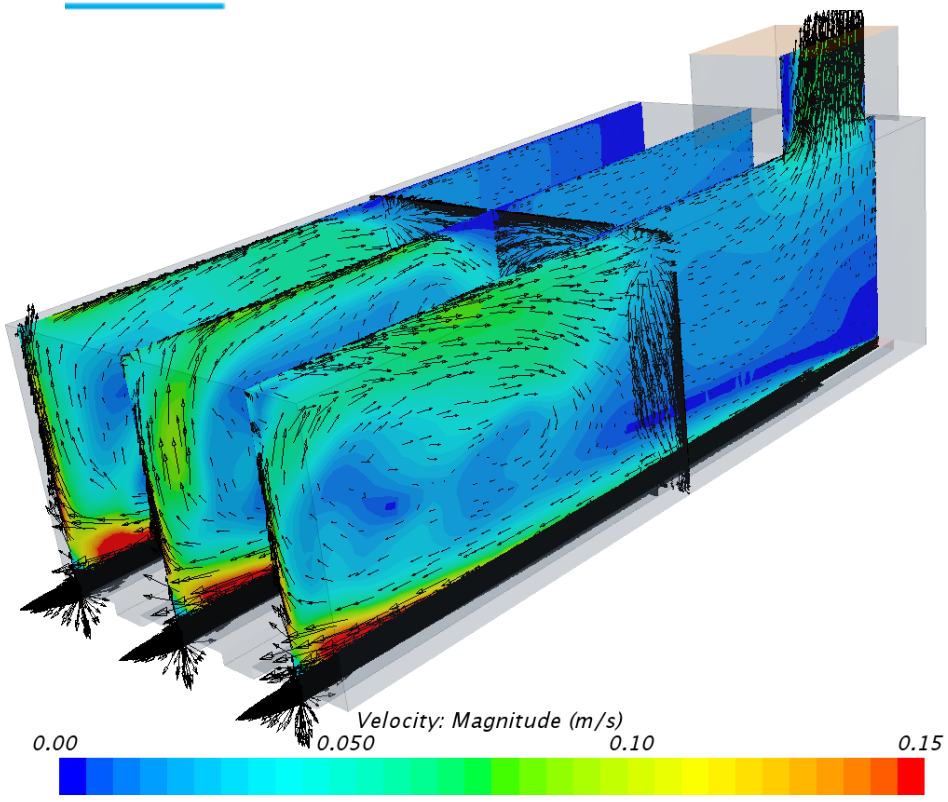


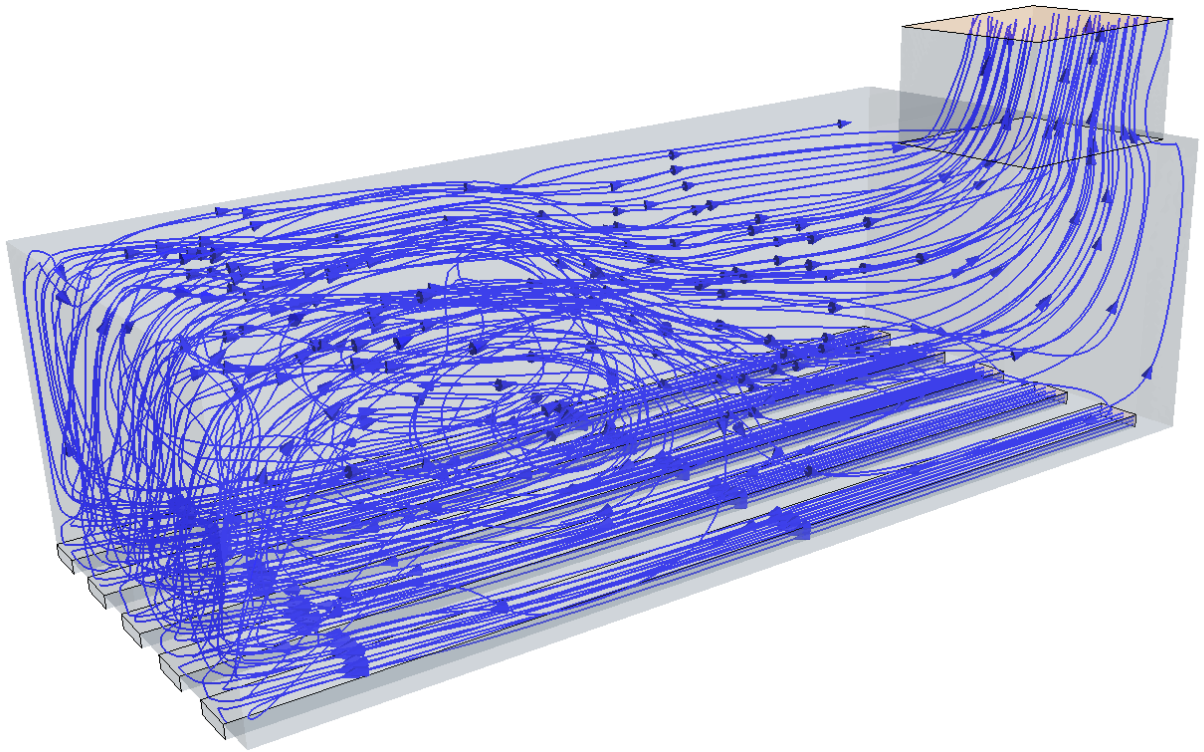

QualiFish

Forskningsrådet

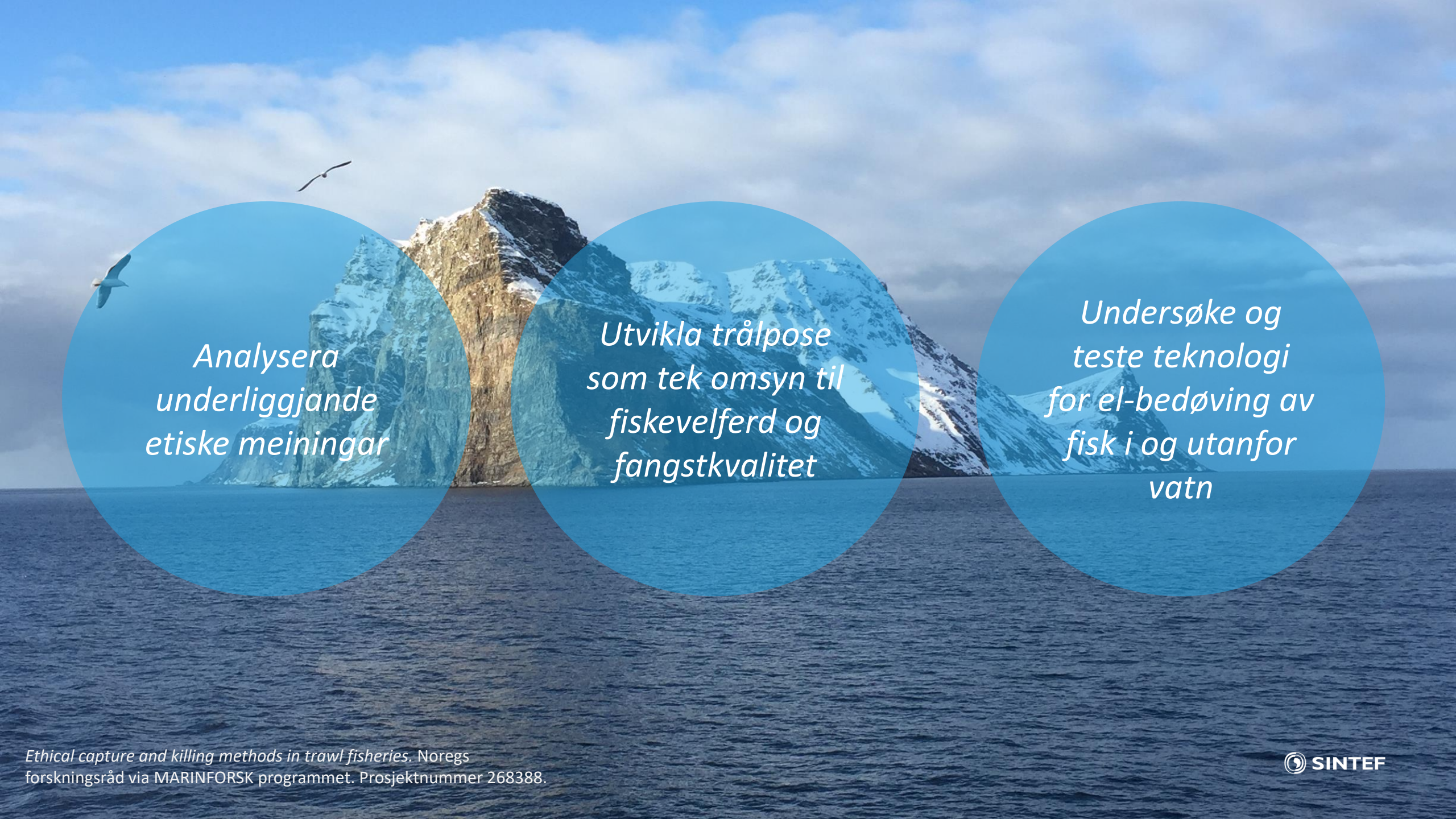
Nordic wildfish™
– fresh frozen at sea

# UTFORMING AV LEVANDELAGRINGSTANKAR



Utforming av levandelagrings tank om bord på Kransvik. Prosjekt frå Nordland fylkeskommune med Fiskeriparken Egga Utvikling AS og SINTEF Ocean (SINTEF prosjektnummer 302003995).




*Ethical capture and killing methods in trawl fisheries.* Noregs forskningsråd via MARINFORSK programmet. Prosjektnummer 268388.

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# TAKK FOR OPPMERKSAMHEITA