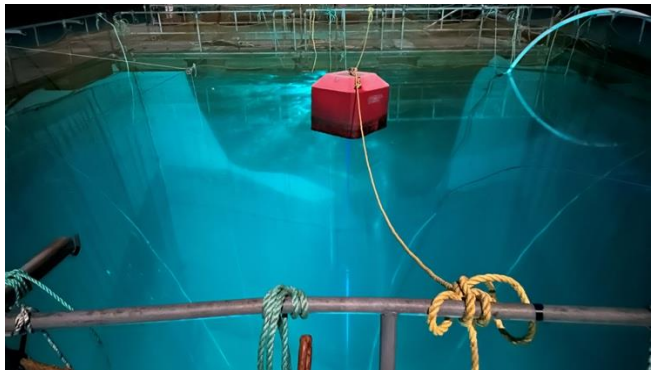
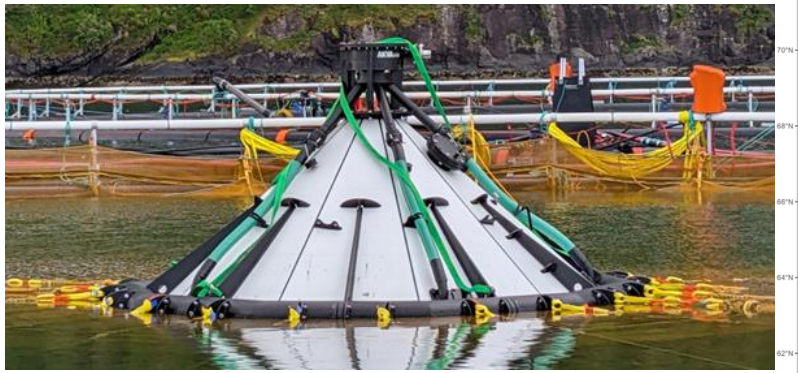
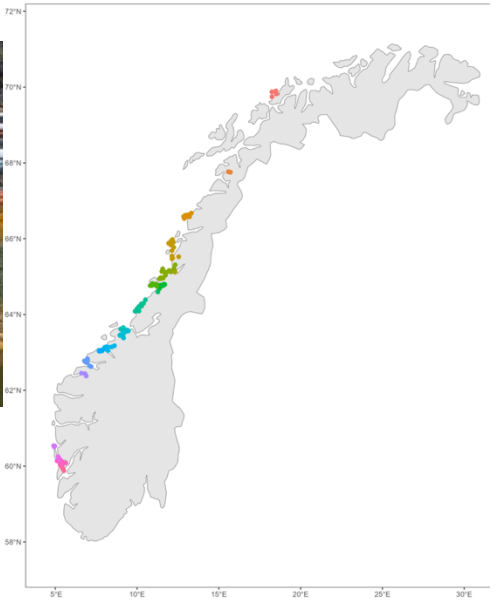





Effektivitet og utfordringer i nedsenket produksjon av laks

Frode Oppedal

Luke Barrett, Ole Folkedal m.fl.

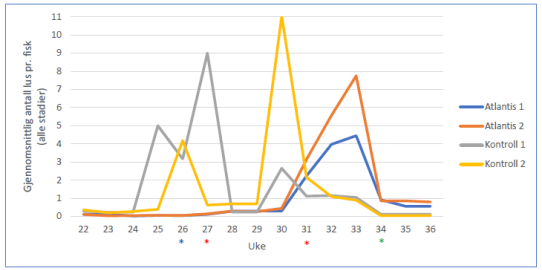
FHF dialogmøte Nedsenket drift, 18.11.26, Scandic Flesland Airport hotell

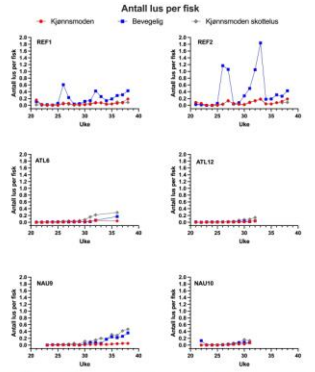
Agenda

- Kommersiell nedsenket drift - effekt
  - Lusedata per merd (master I, II, III,)
  - Strukturerte intervju (hvem, hva, hvor, hvordan, utfordringer?)
  - Rapporterte lusedata (MT/ Barentswatch – per anlegg)
  - Modell
- Dypere lus?
- Utfordringer?

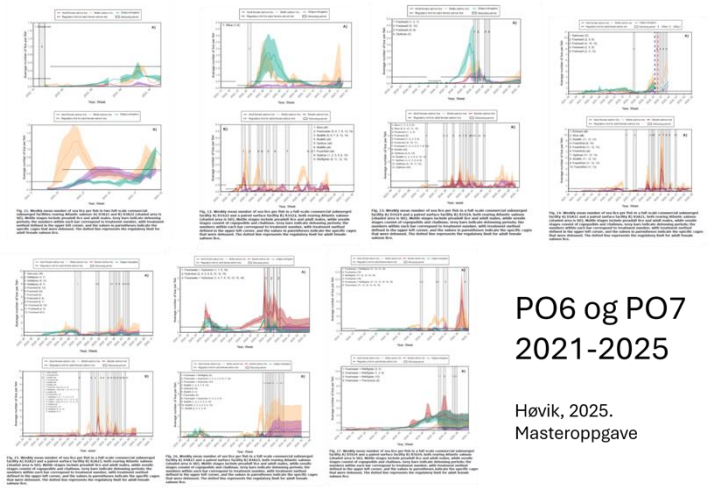
Reduksjon i lus - merddata

- 95–99 % i Atlantis – null behandling (Olafsen et al 2021)
- 80–96 % i Nautilus/ Atlantis – null behandling (Lysø, 2023)
- 56, 57, 62, 73, 78 og 83 % redusert lus (omregnet Høvik, 2025)
  - Behandlingsfrekvens per merd
    - Nedsenket 0/ 0/ 0,1/ 0,3/ 0,6/ 0,9/ 1,3/ 3,9
    - Overflate 3,8/ 4,4/ 5,4/ 6,7/ 7,0/ 12,3 (ca 7×)
- AOF – Ingen/ noe behandling …
- Regnbueørret: 73% redusert behandlingsfrekvens



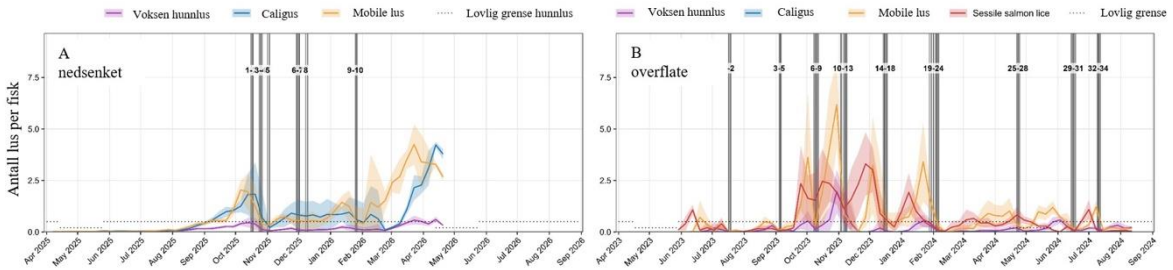


Figur 3.16: Antall lus per fisk på samtlige forsøksmerder fra nullpunkt til slakt. Referansemerd (REF1, REF2) med høyt innslag av bevegelig lakselus, totalt fire lusebehandlinger. Nedsenket fisk (ATL6, ATL12, NAU9, NAU10) med luseverdier under grenseverdier for avlusning.



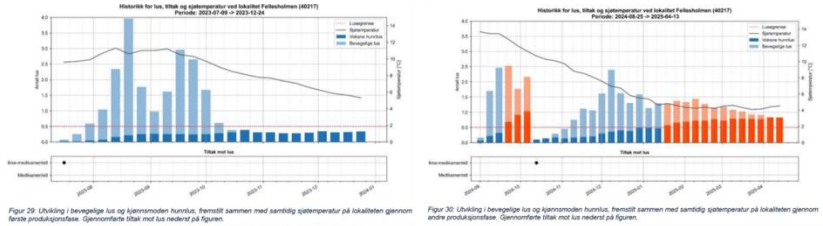
PO6 og PO7
2021-2025

Høvik, 2025.
Masteroppgave



Regnbueørret

Myklebust, 2026





Arctic Offshore Farming
Fellesholmen

Sluttrapport AOF, 2025

Design

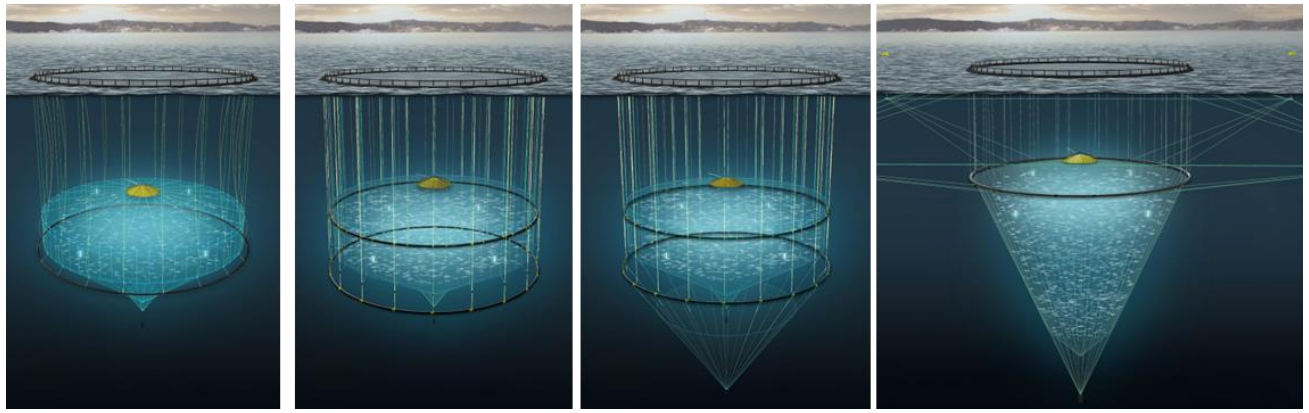
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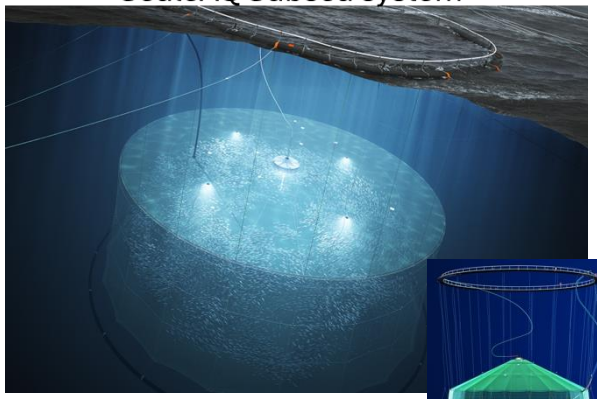




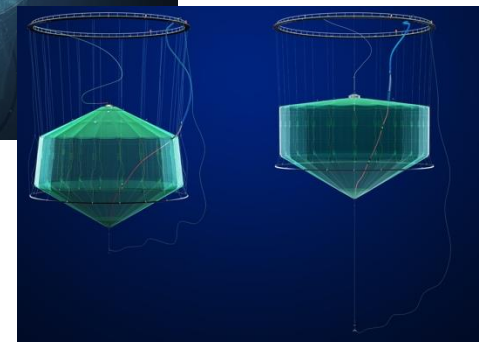
Nautilus >400



ScaleAQ Subsea system >42?







SMIR Oceanis – Skogsholmen, >7?





https://www.akvagroup.no/sjobasert/dypdrift-lusebekjempelse/nautilus/

https://scaleaq.no/produkt/subsea-system/

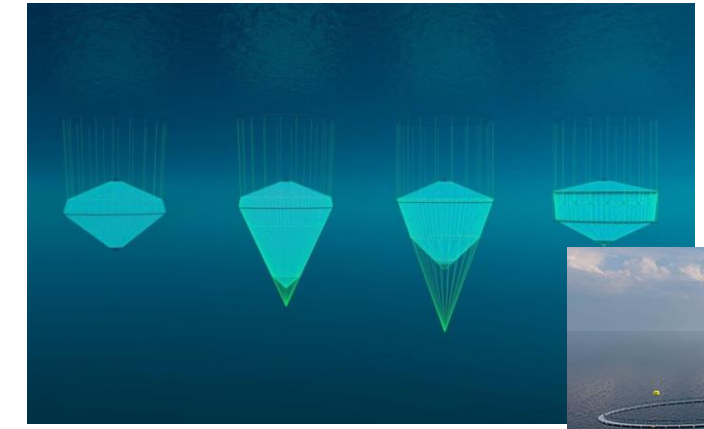
https://www.arcticoffshorefarming.no/

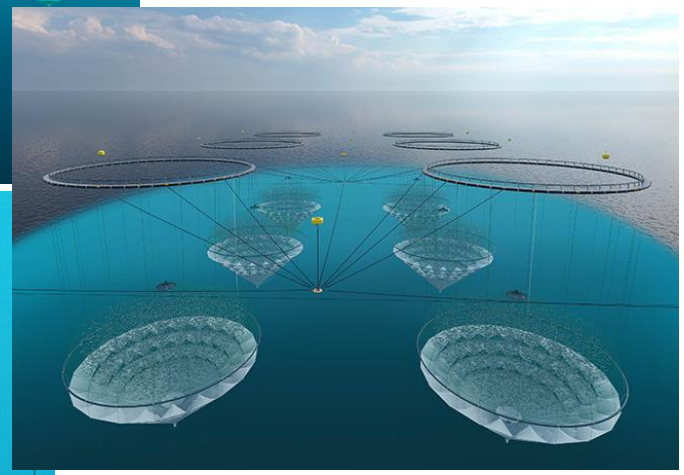
https://selstad.no/produkter/akvakultur/dypdrift/

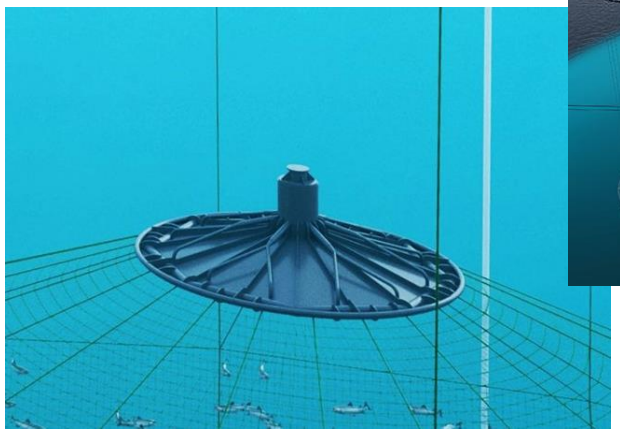
https://www.smir.no/produkter/oceanis

Luftkuppelmerder på vei…

Selstad (?)







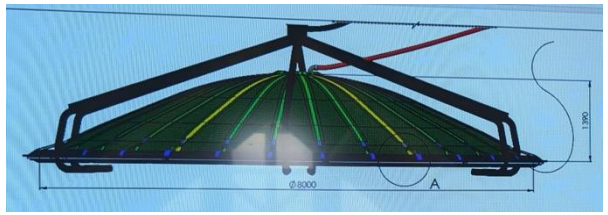
https://selstad.no/produkter/akvakultur/dypdrift/

Luftkupler i bruk i dag

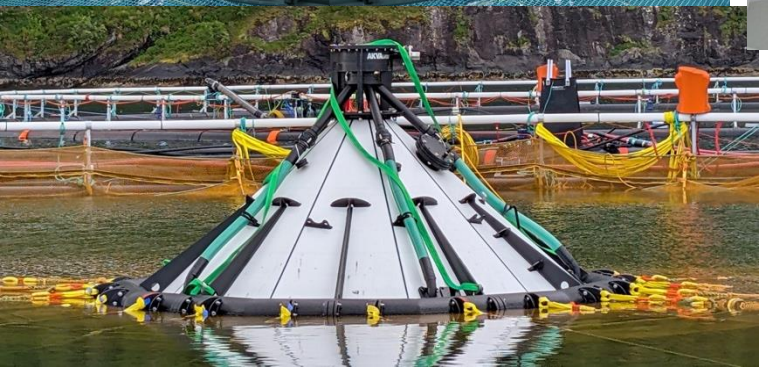
Dyp (m): 10-20-23-25 og dypere

Nautilus









SinkaBerg_Nærøysund



SMIR Oceanis

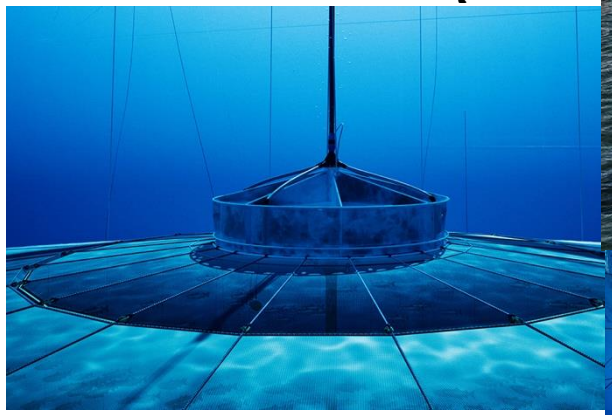


Arctic Offshore Farm (10m*10m)

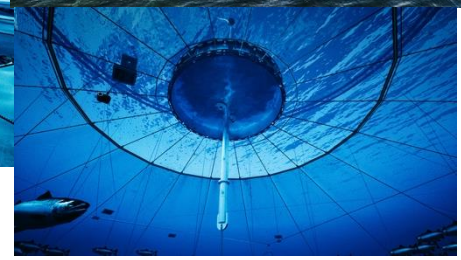




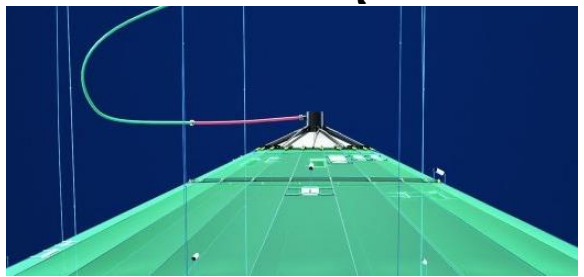
ScaleAQ 1.0





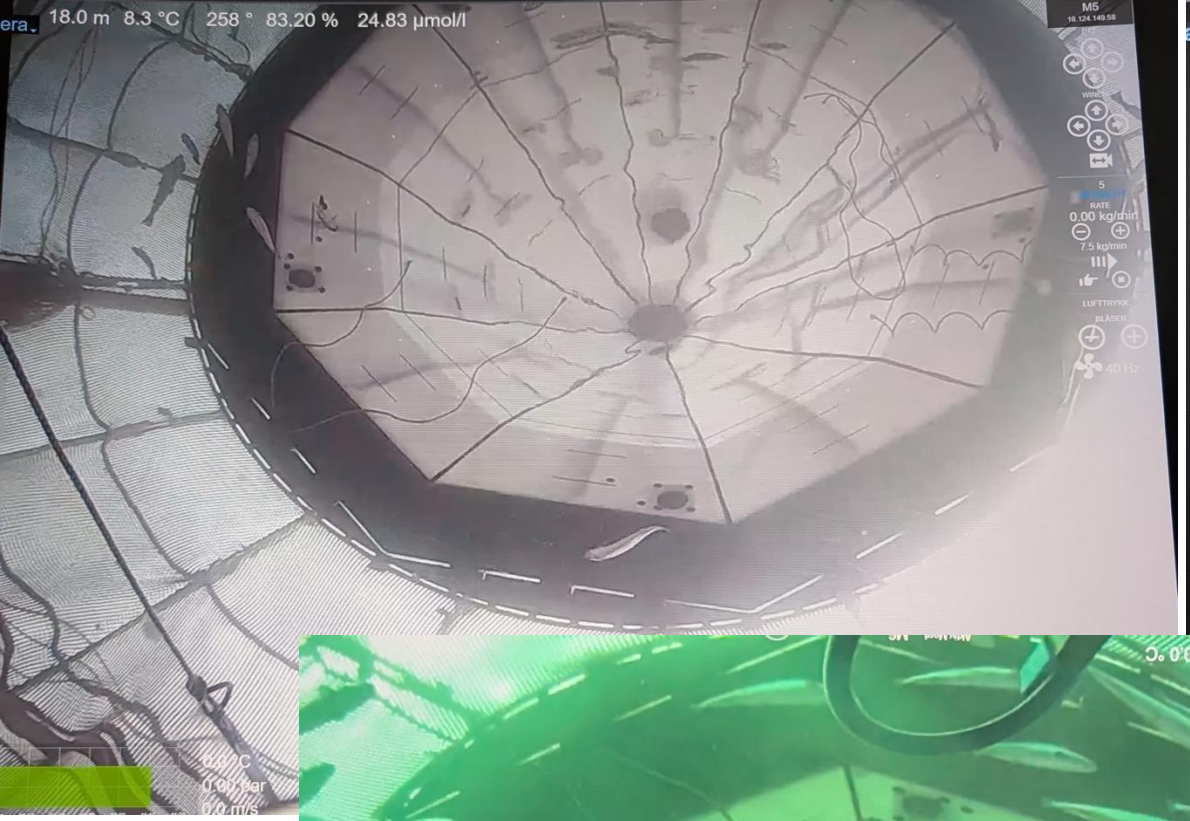


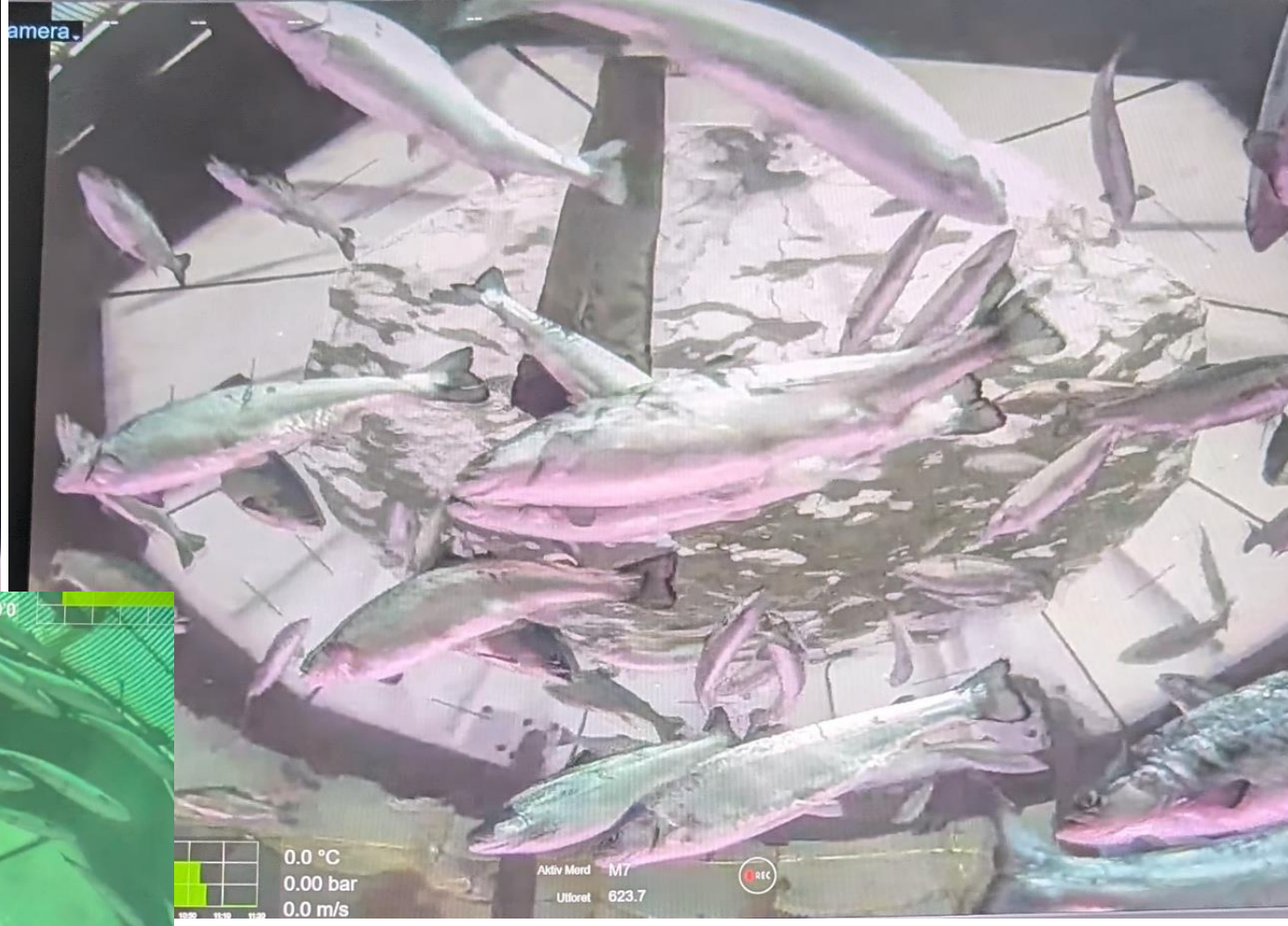
ScaleAQ 2.0

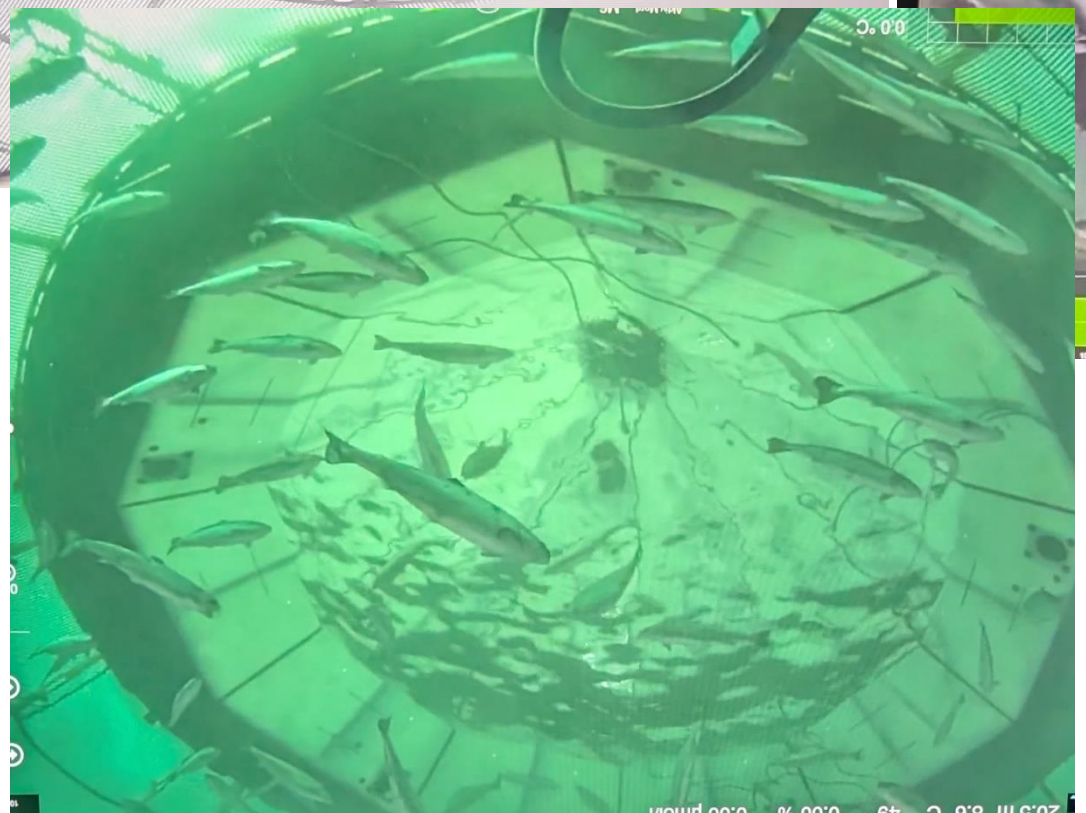


Diameter opp til 5 m (10...)

Lufthøyde: 0/0.4-1 m


18.0 m 8.3 °C 258 ° 83.20 % 24.83 µmol/l
M5
RATE
0.00 kg/min
7.5 kg/min
LUFTTRYKK
BLÅSER
40 Hz


amera
0.0 °C
0.00 bar
0.0 m/s
Aktiv Mærd M7
Utført 623.7
REC


0.0 °C
0.00 bar

Intervjuer - erfaring

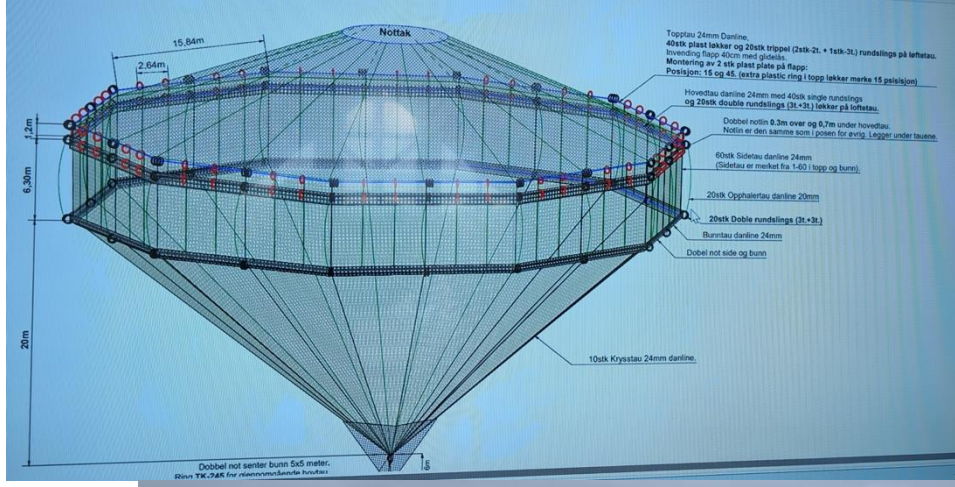
- 65-100% reduksjon i behandlinger når det fungerer
  - Men ved noen lokaliteter fungerer nedsenket dårlig mot lus
    - >2 anlegg har gått bort fra nedsenket drift

- 2025G: 73% reduksjon i behandlinger
- Ca 70% reduksjon
  - Variasjon med lusepress (men alltid redusert påslag…)

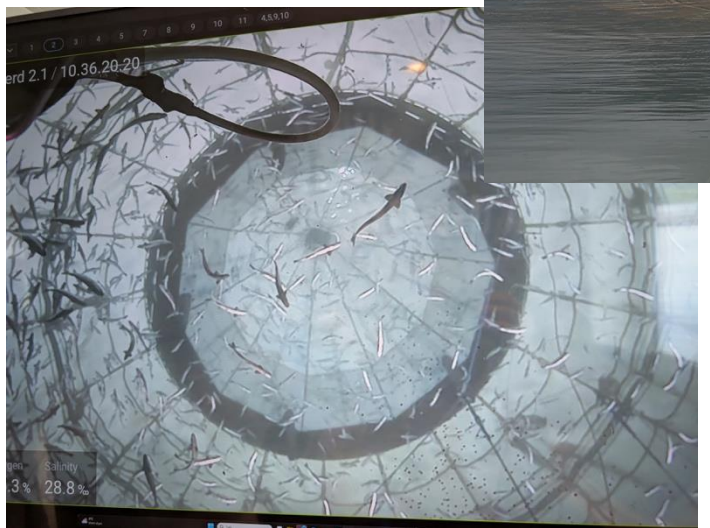
- Kan ikke få full oversikt på merdbasis…. Endres over tid

Nedsenket drift

- Smoltutsett best, men …
- Rullefylling (sjelden hopp)
- Atferd (hastighet, tilt, gruppe)
- Produksjon
  - Tilvekst følger temperatur med færre avlusingsavbrudd
  - Lik eller bedre slaktekvalitet
  - Lavere dødelighet …
  - Økt FCR
- Normal velferd hvis ikke hendelser
- Kamerabasert observasjon
  - Fôring
  - Velferd
- Lys



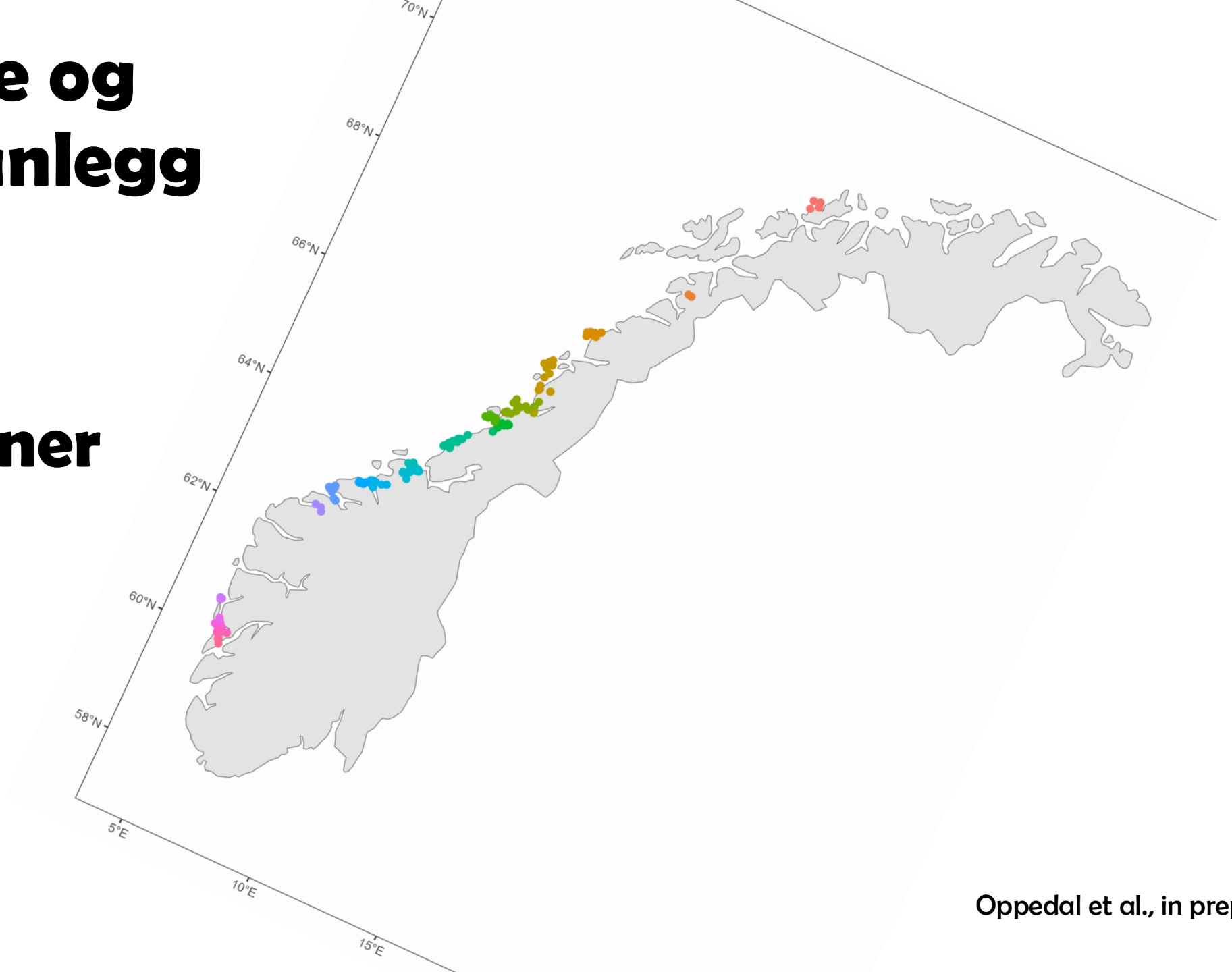




Nedsenkete og referanse anlegg

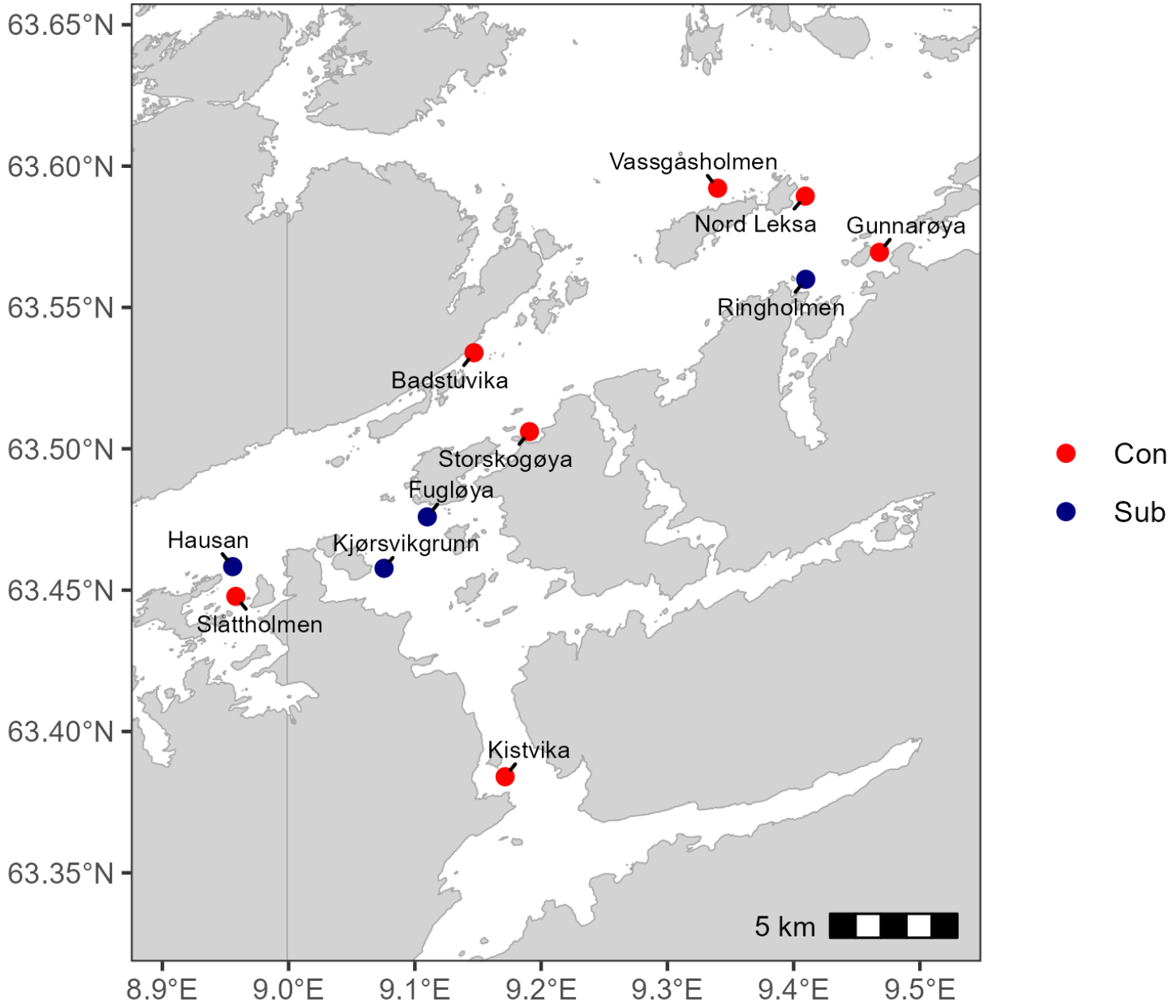
21 anlegg

42 produksjoner



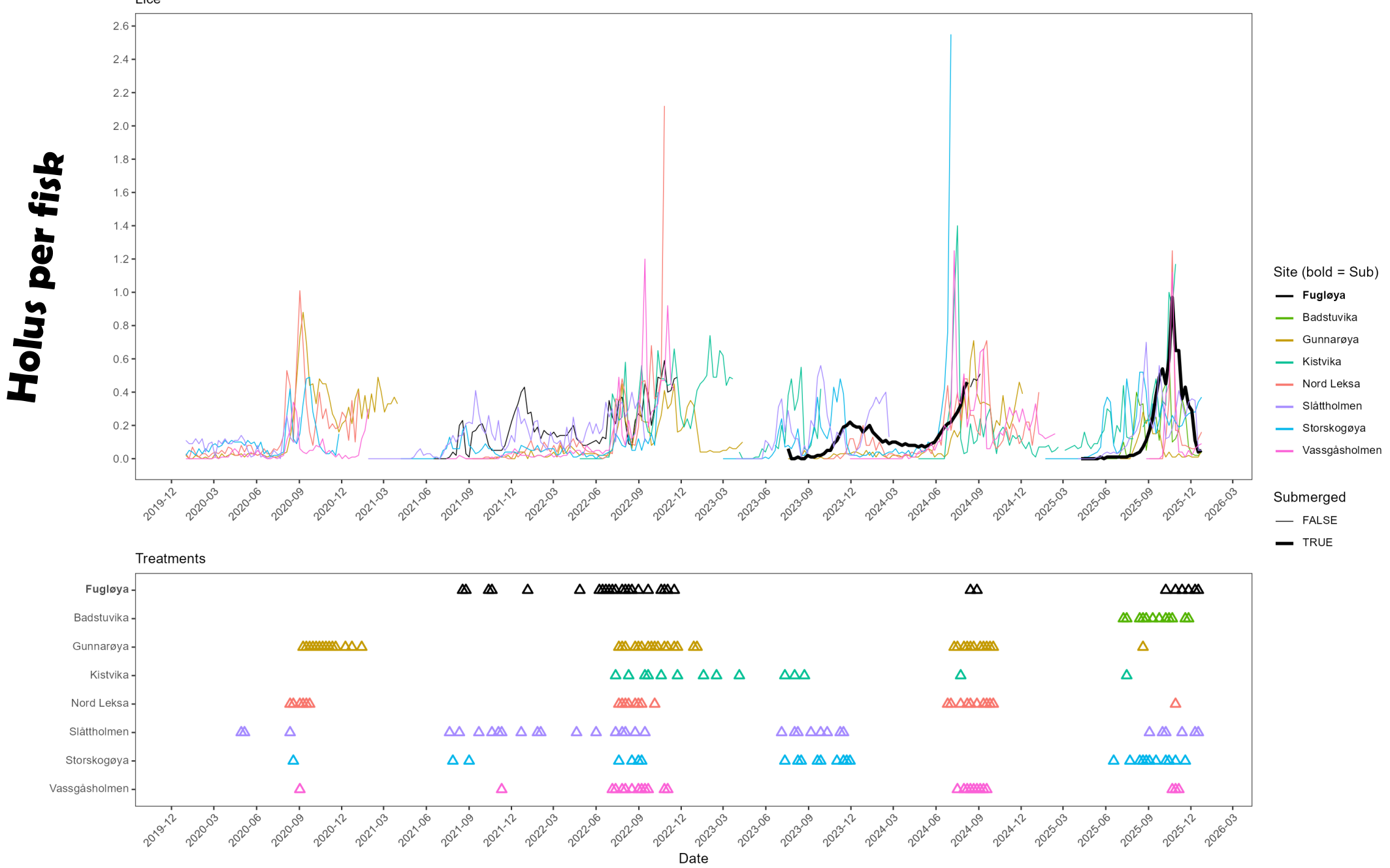
Oppedal et al., in prep

Fugløya



Oppedal et al., in prep

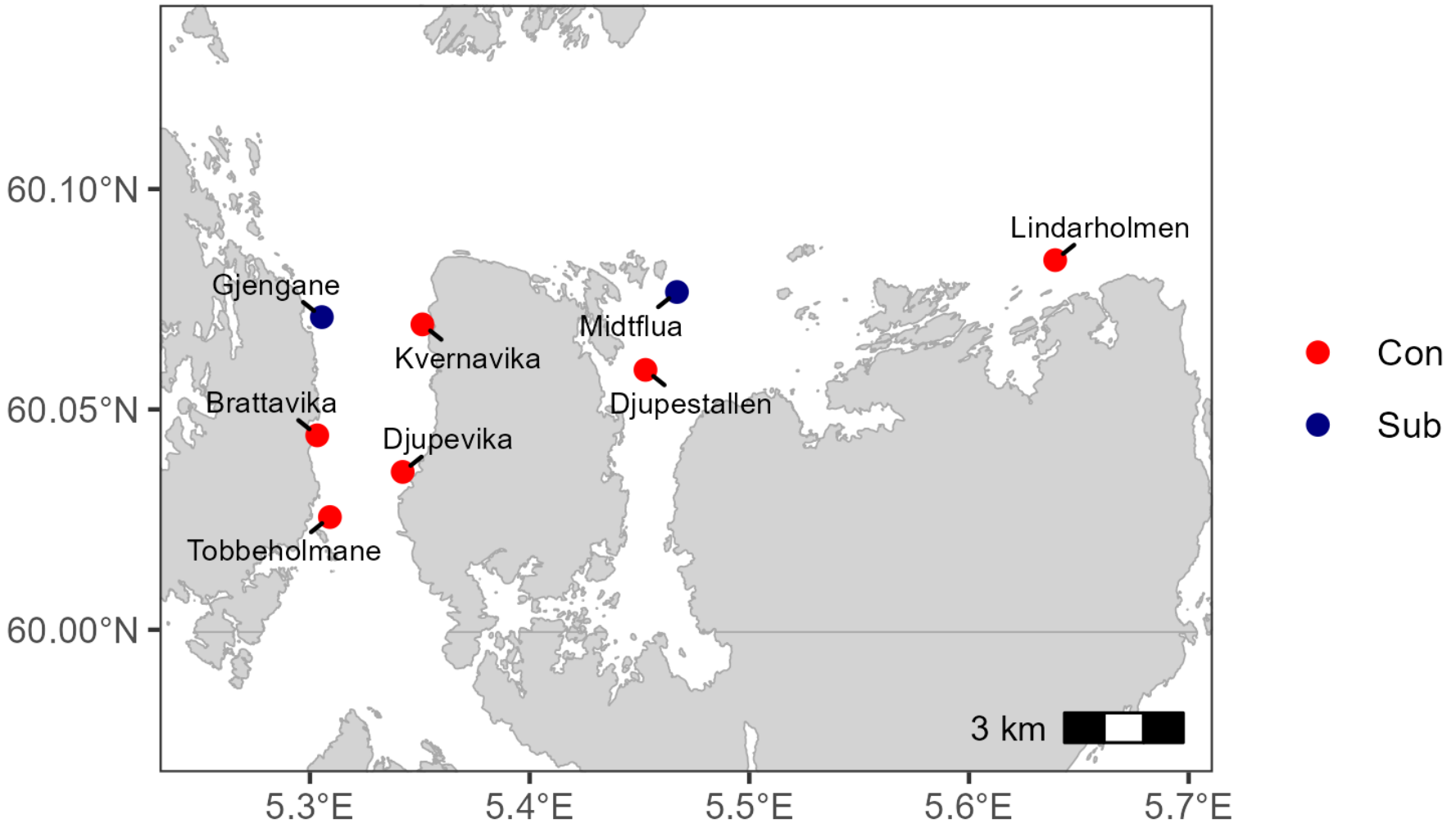
Fugløya



Behandlinger

Oppedal et al., in prep

Gjengane

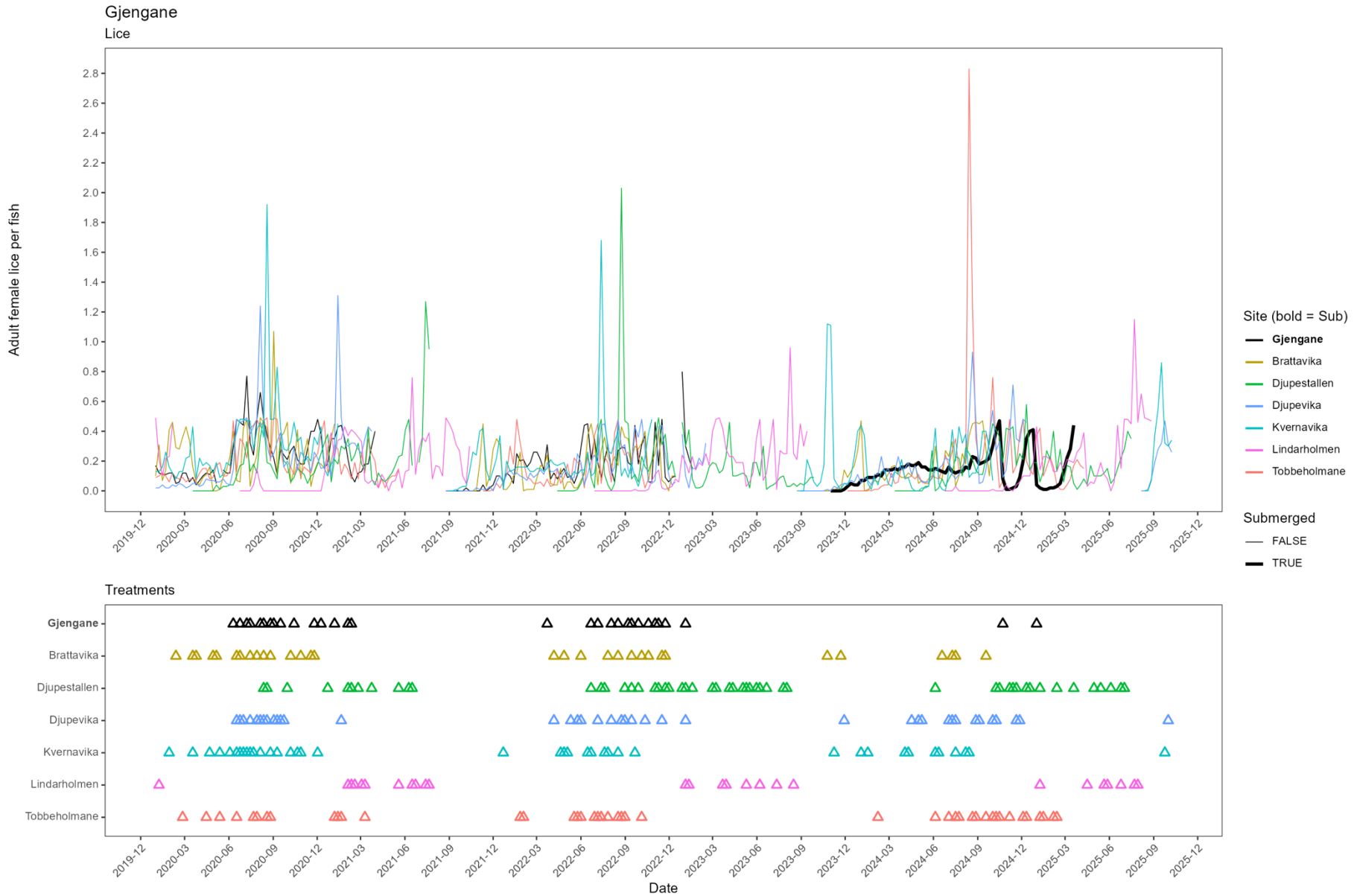


Oppedal et al., in prep

Gjengane

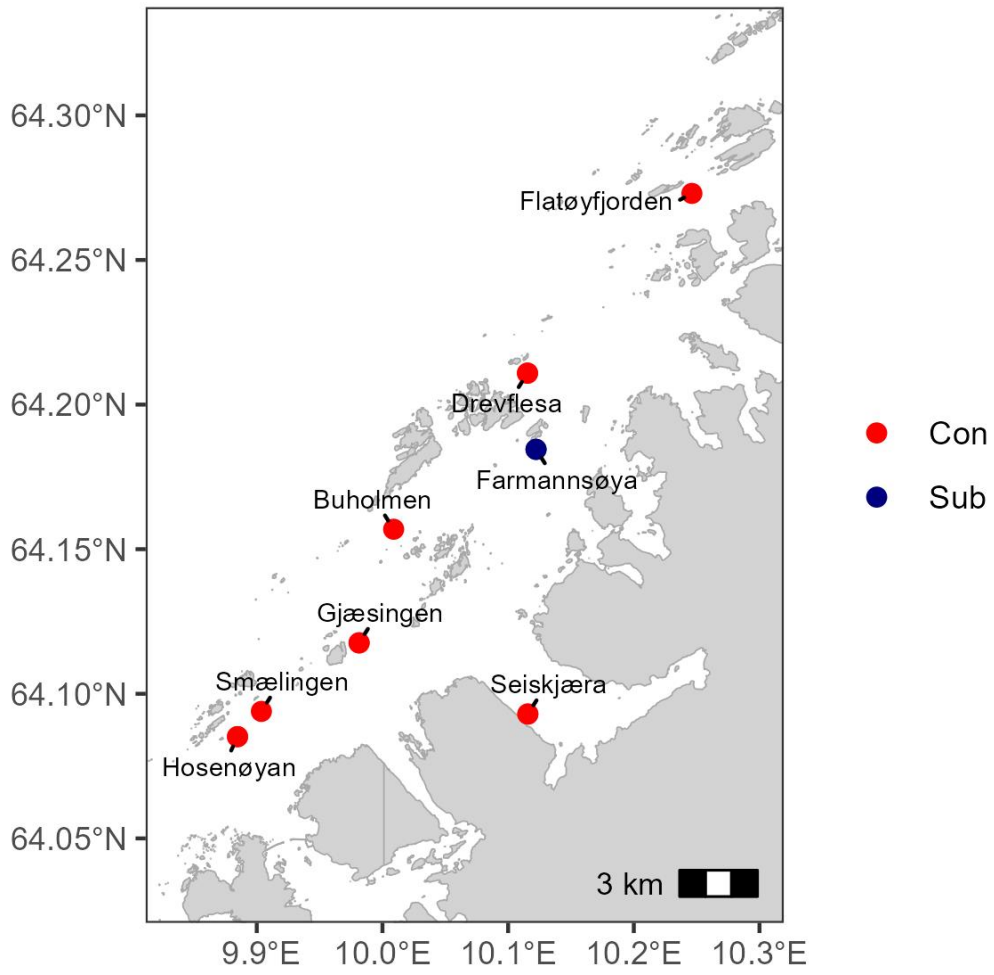
Holus per fisk

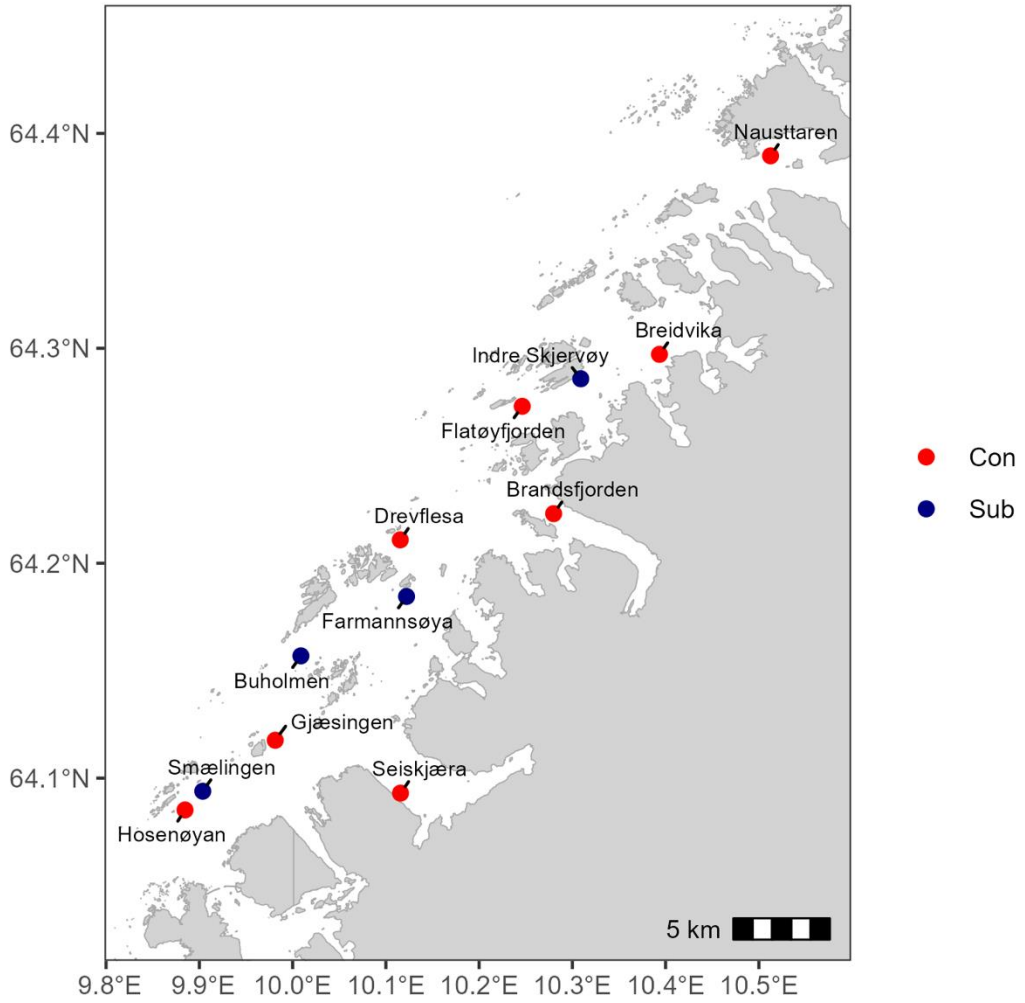
Behandlinger



Oppedal et al., in prep

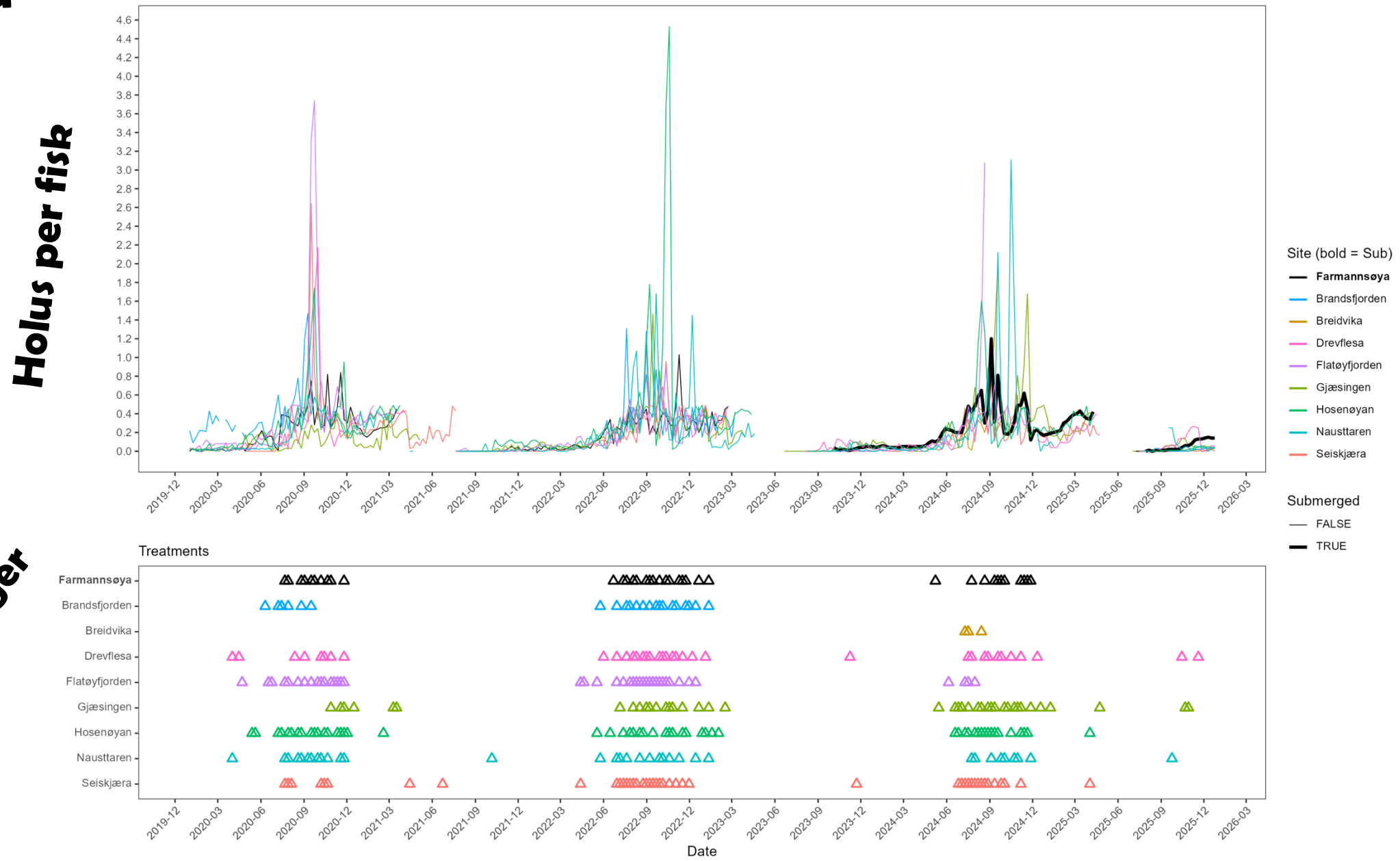
Farmannsøya





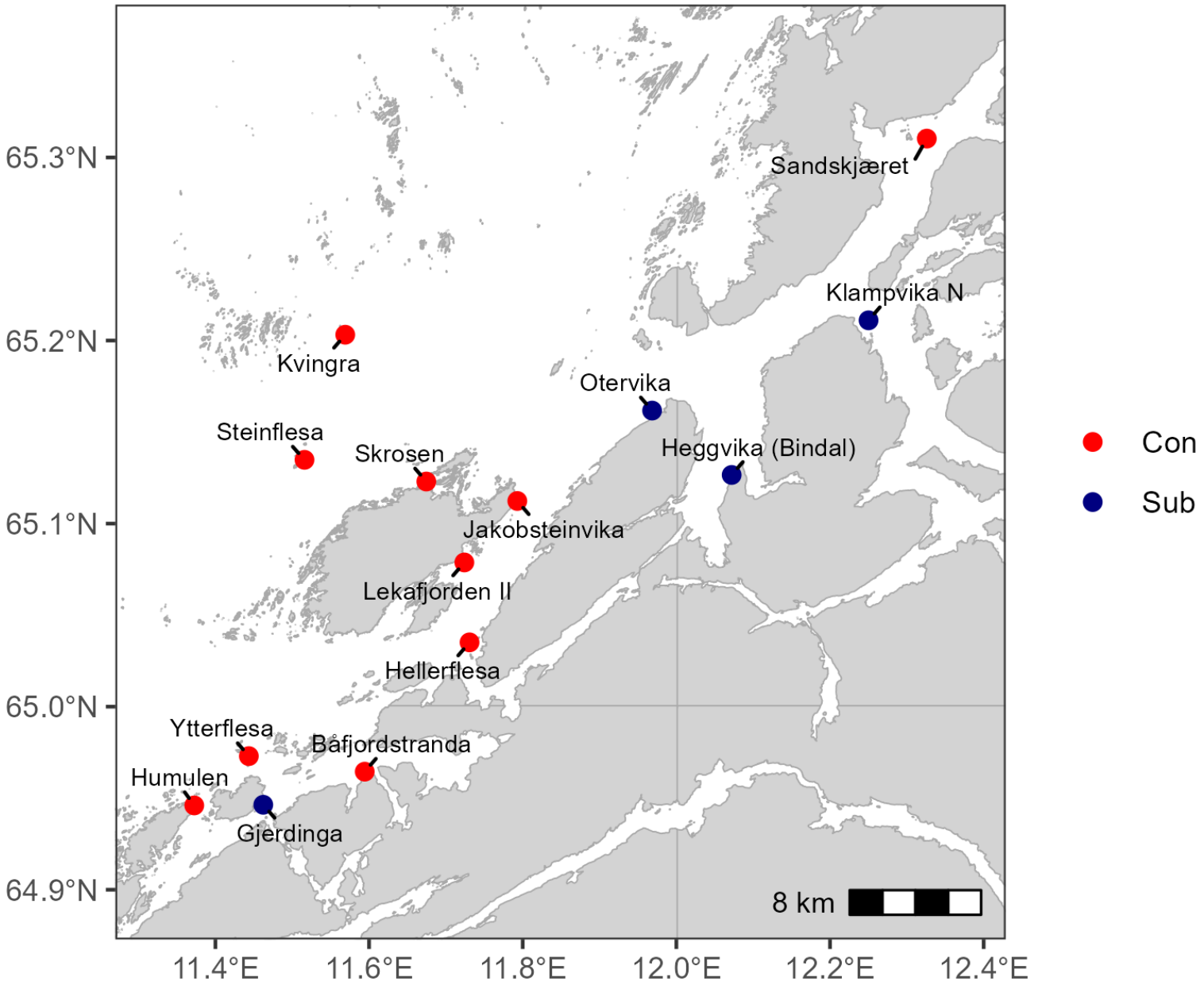
Oppedal et al., in prep

Farmannsøya



Oppedal et al., in prep

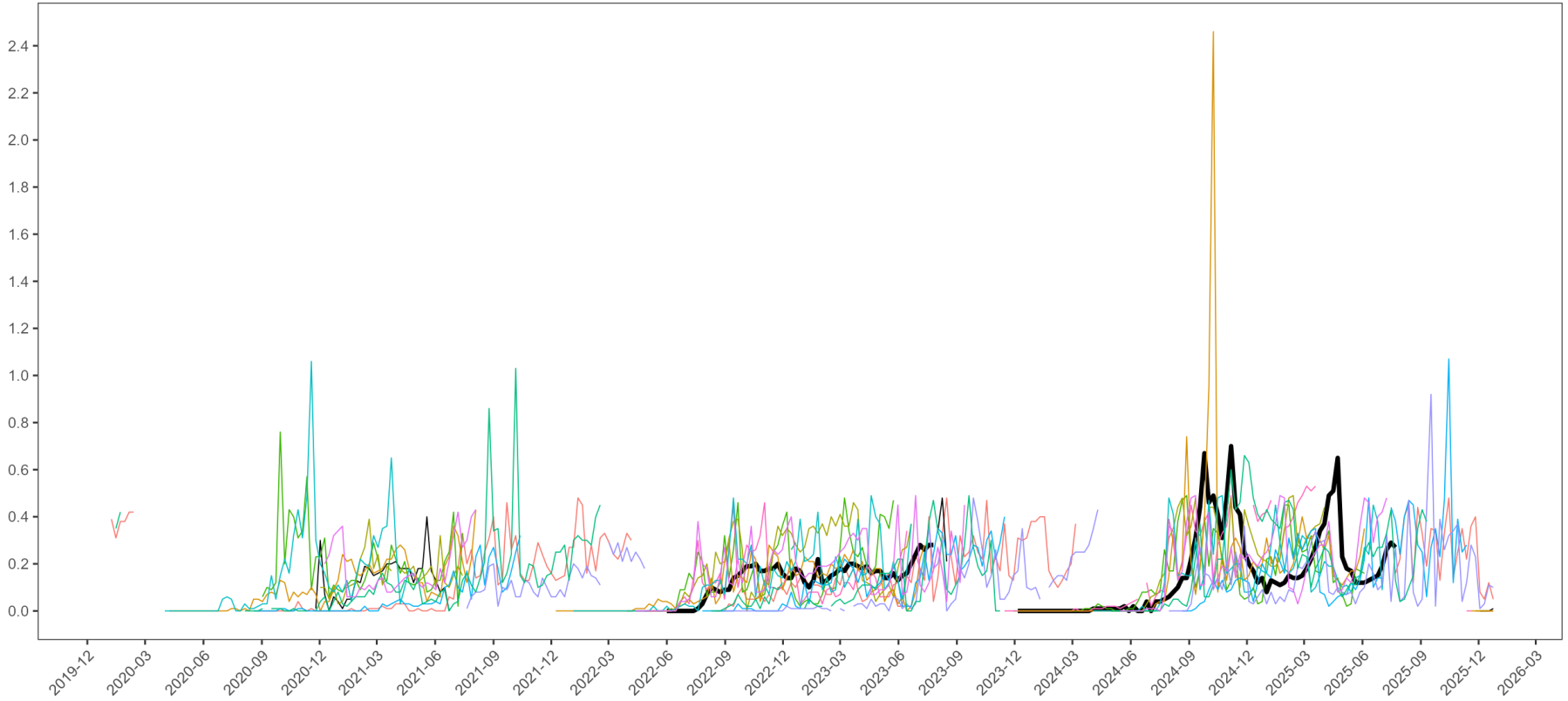
Gjerdinga



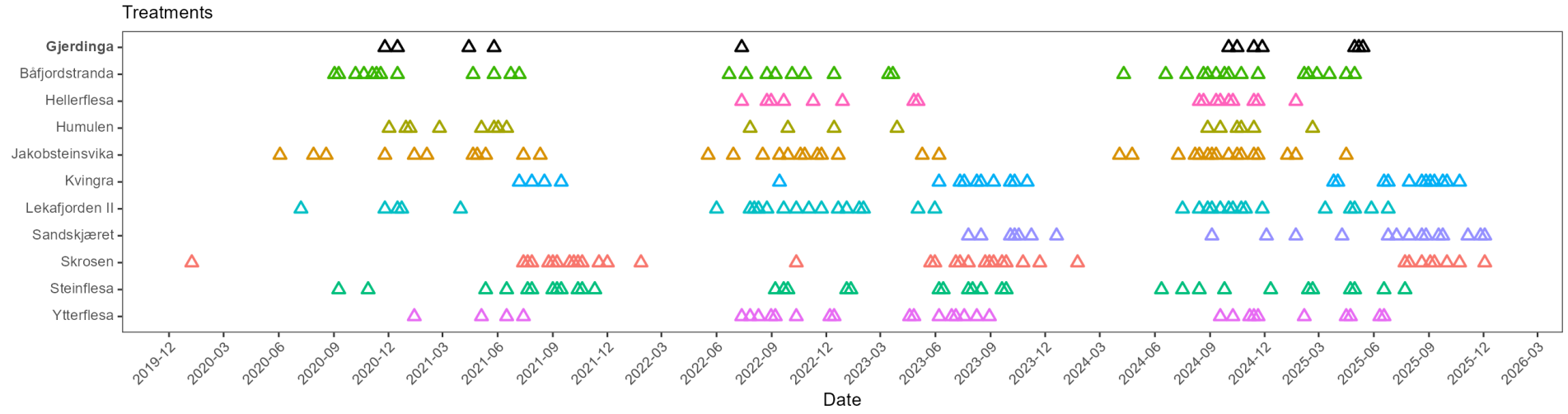
Oppedal et al., in prep

Gjerdinga

Holus per fisk

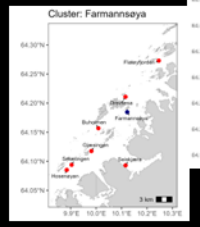


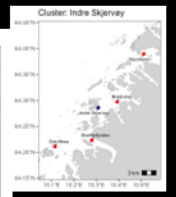
Behandlinger



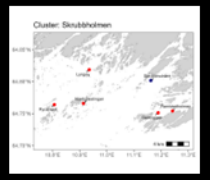
Oppedal et al., in prep


Cluster: Ulværholmen


Cluster: Farmannsøya

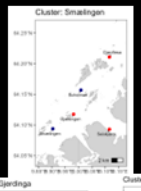

Cluster: Indre Skjervøy

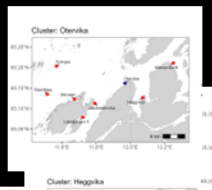

Cluster: Årnes

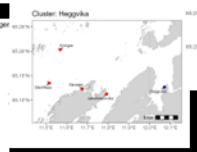

Cluster: Skrubbholmen

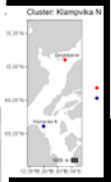

Cluster: Gjerdinga

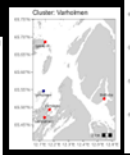

Cluster: Økseringer

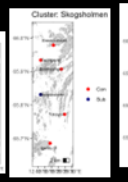

Cluster: Smølingen

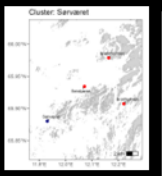

Cluster: Otervika

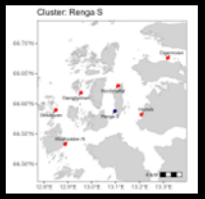

Cluster: Heggvika


Cluster: Klampvika N


Cluster: Varholmen

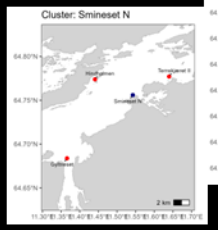

Cluster: Skogsholmen

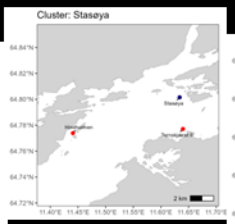

Cluster: Sørværet

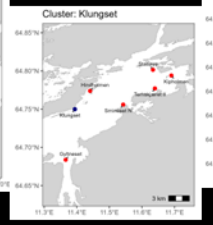

Cluster: Rønga S

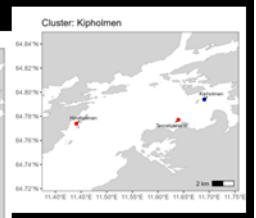

Cluster: Ånderbakk

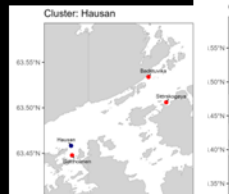

Cluster: Fellesholmen

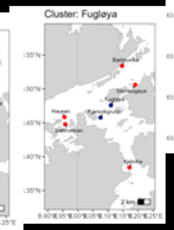

Cluster: Smineset N


Cluster: Stasøya

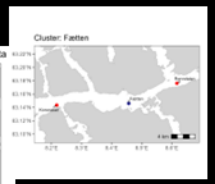

Cluster: Klungset


Cluster: Kipholmen

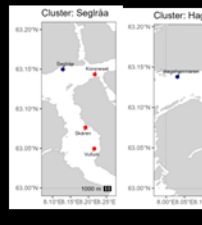

Cluster: Hausan


Cluster: Fugløya


Cluster: Ringholmen


Cluster: Halsbukta

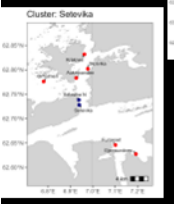
Cluster: Hagahammaren

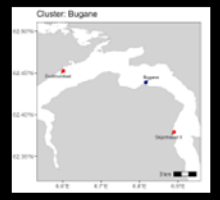

Cluster: Bogen

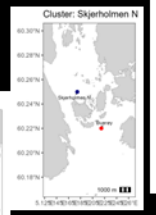
Cluster: Endreset

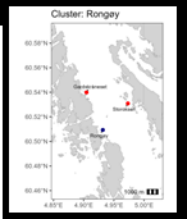
Cluster: Seglråa

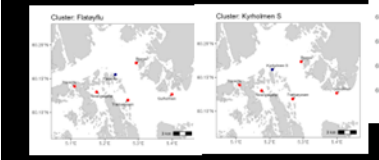
Cluster: Fætten


Cluster: Setevika

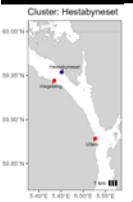

Cluster: Bugane


Cluster: Skjerholmen N

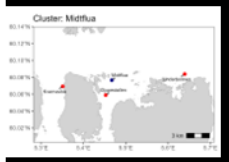

Cluster: Rongøy


Cluster: Flatøyflu

Cluster: Kvitholmen S


Cluster: Hestabyneset


Cluster: Gjengane


Cluster: Midtflua

Analyse

Bevegelige lus som responsvariabel

```
Response: mobile
                                          Chisq Df Pr(>Chisq)
submerged_fac                           235.0576  1  < 2.2e-16 ***
ns(lag_curr95_5m, df = 2)                21.2627  2  2.415e-05 ***
ns(lag_cop, df = 3)                    1466.6481  3  < 2.2e-16 ***
ns(weeks_with_fish, df = 4)            5405.3633  4  < 2.2e-16 ***
lag_temp_5m                             132.1334  1  < 2.2e-16 ***
weeks_since_treatment                     1.7468  1     0.1863
submerged_fac:ns(lag_curr95_5m, df = 2)  72.9694  2  < 2.2e-16 ***
submerged_fac:ns(lag_cop, df = 3)       128.2164  3  < 2.2e-16 ***
submerged_fac:ns(weeks_with_fish, df = 4)  79.1330  4  2.659e-16 ***
```

Behandlinger per uke

Holus som responsvariabel

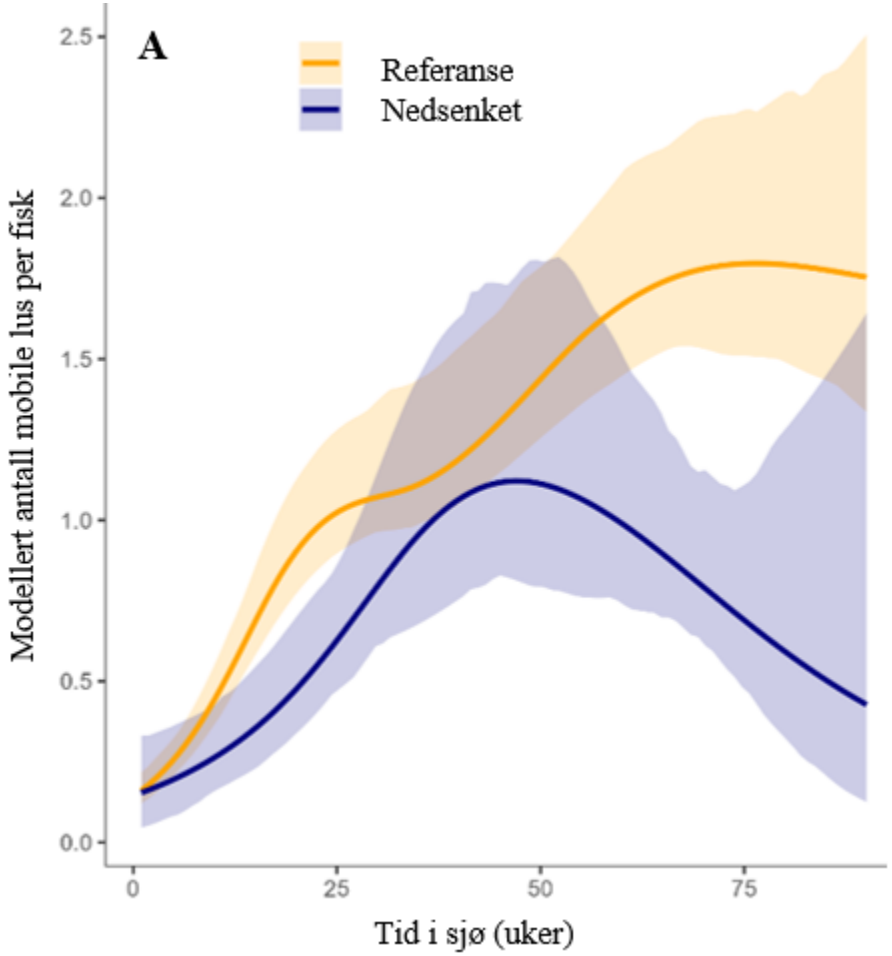
```
Response: af
                                          Chisq Df Pr(>Chisq)
submerged_fac                           54.5902  1  1.485e-13 ***
ns(lag_curr95_5m, df = 2)               16.7622  2  0.0002292 ***
ns(lag_cop, df = 3)                   1268.8326  3  < 2.2e-16 ***
ns(weeks_with_fish, df = 4)           7837.9908  4  < 2.2e-16 ***
lag_temp_5m                              3.9694  1  0.0463340 *
weeks_since_treatment                   84.9882  1  < 2.2e-16 ***
submerged_fac:ns(lag_curr95_5m, df = 2) 39.5037  2  2.642e-09 ***
submerged_fac:ns(lag_cop, df = 3)       19.9787  3  0.0001715 ***
submerged_fac:ns(weeks_with_fish, df = 4)  55.6016  4  2.430e-11 ***
```

Tid til første behandling

```
Response: first_treatment_week
                                          Chisq Df Pr(>Chisq)
any_submerged                           15.1869  1  9.738e-05 ***
mean_lag_temp_5m                        32.4166  1  1.244e-08 ***
mean_lag_cop                             0.4095  1   0.522207
any_submerged:mean_lag_temp_5m           0.0602  1   0.806117
any_submerged:mean_lag_cop               0.0448  1   0.832418
mean_lag_temp_5m:mean_lag_cop            8.9945  1   0.002708 **
any_submerged:mean_lag_temp_5m:mean_lag_cop  0.2842  1   0.593978
```

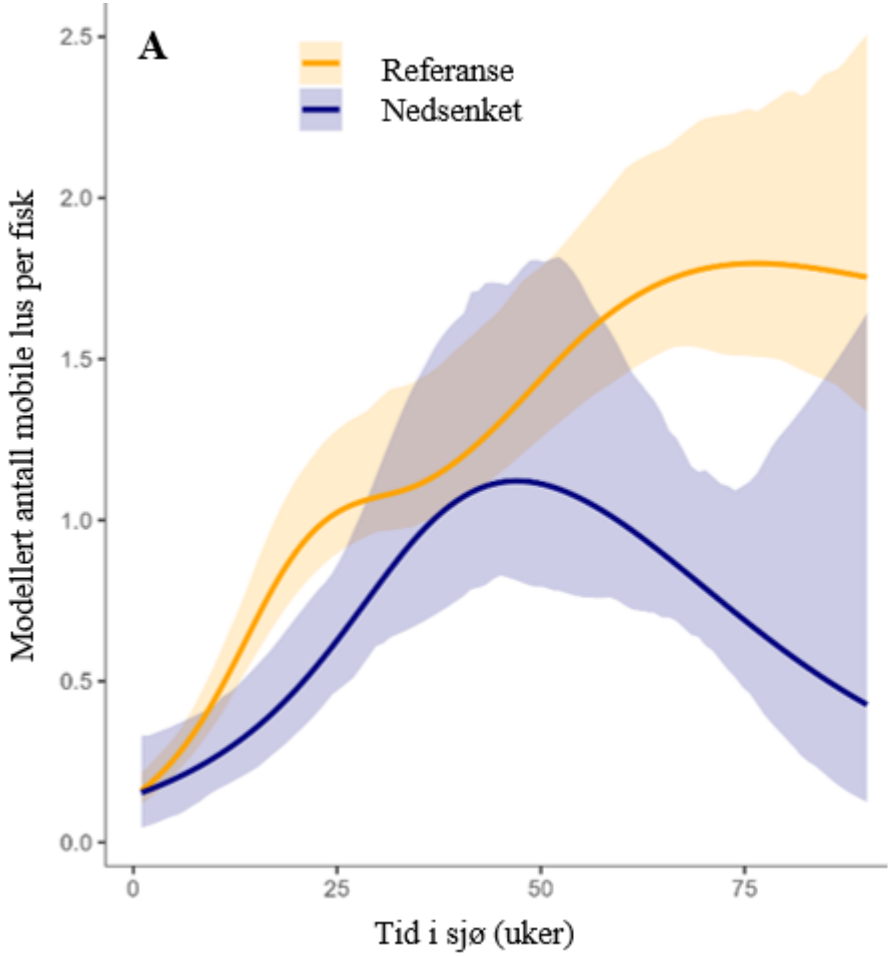
Oppedal et al., in prep

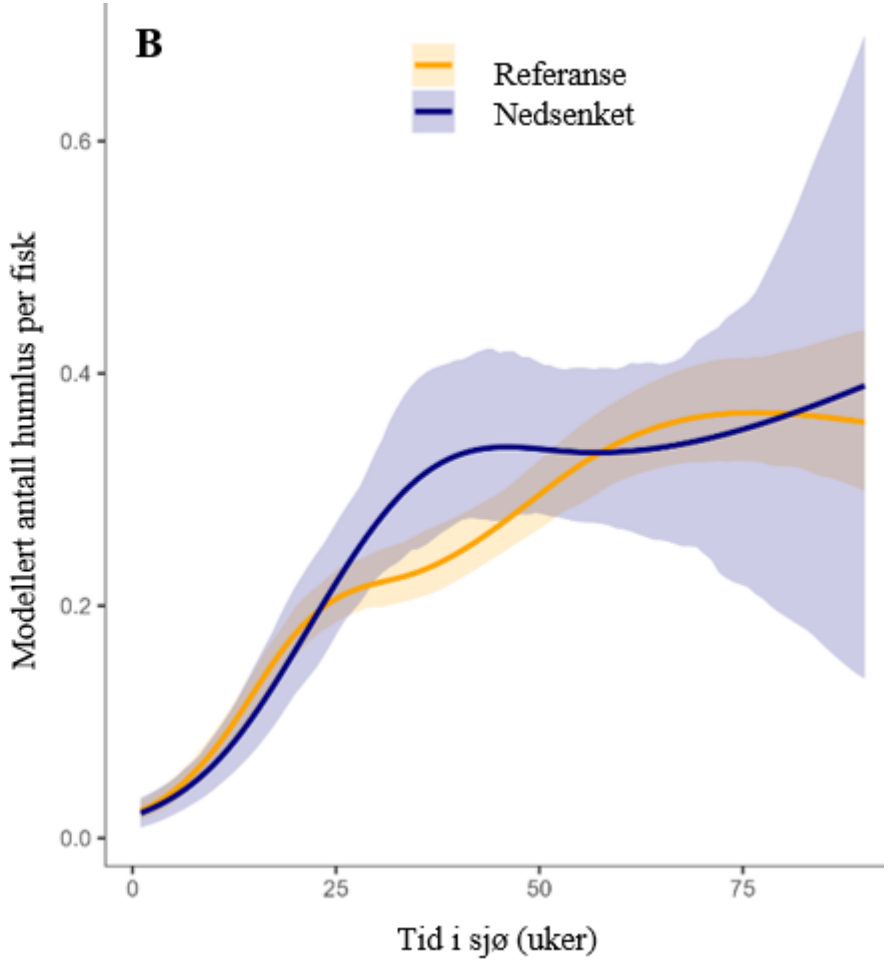
Færre bevegelige lus



Oppedal et al., in prep

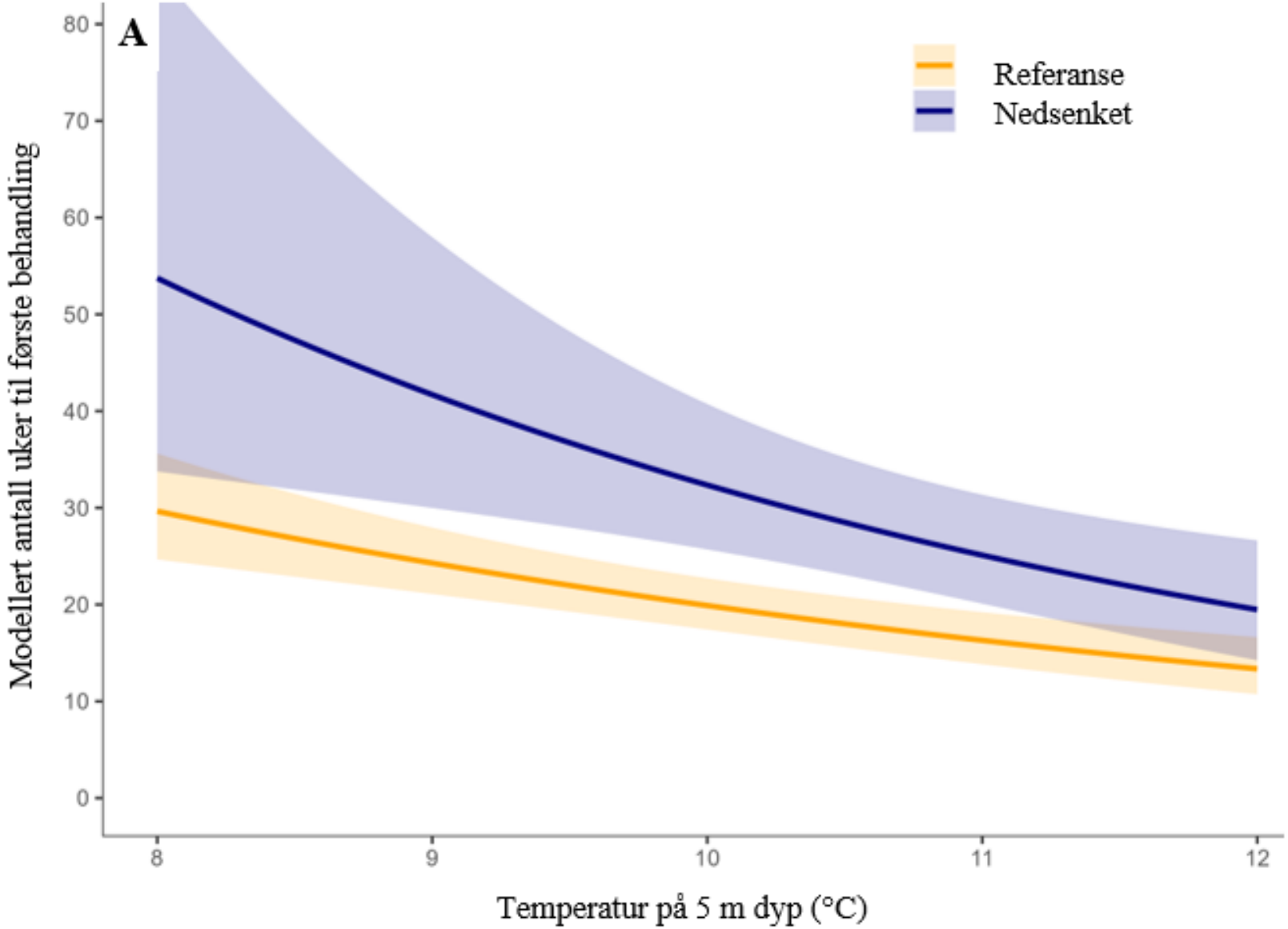
Mindre og mer hunn lus





Oppedal et al., in prep

>40% forsinket <u>første</u> behandling

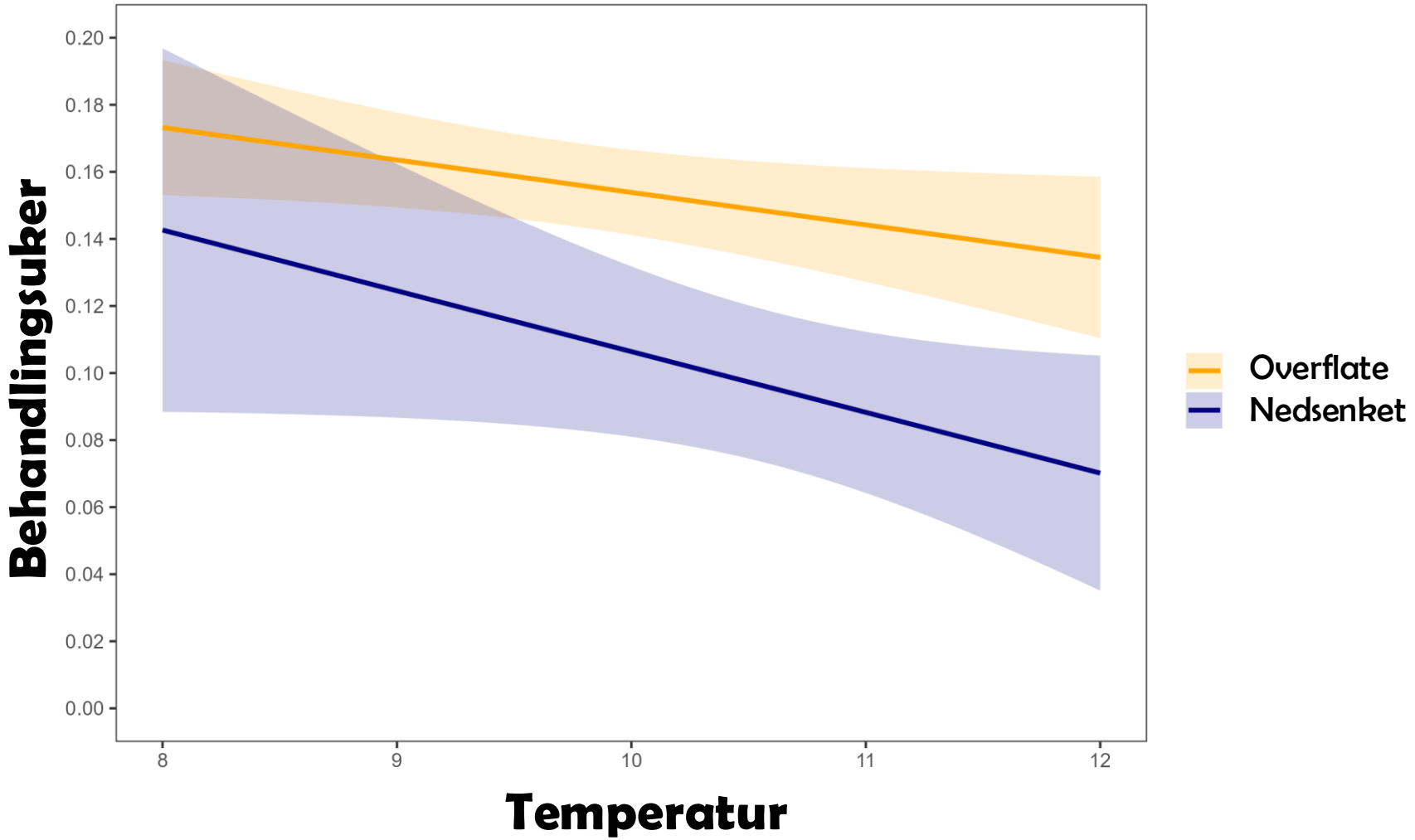


Oppedal et al., in prep

Ca 35% færre behandlingsuker

(70% på merdbasis - industridata)

Noen anlegg unngår helt avlusinger
De fleste får færre avlusinger
Noen anlegg avluser som normalt



Oppedal et al., in prep

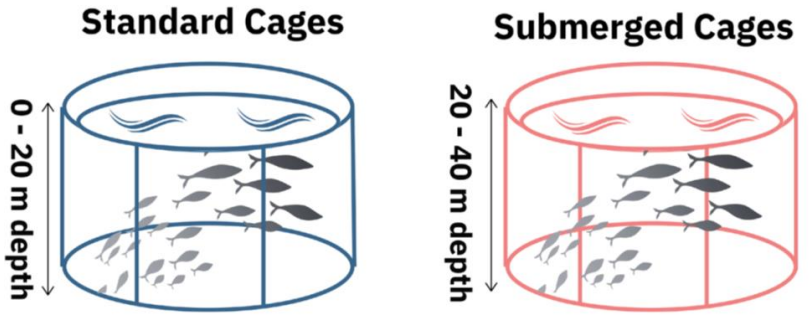
Hvorfor variasjon

- Variasjon skyldes:
  - luselarvetetthet (+)
  - vannstrøm (+/-)
  - vertikal nedblanding (+/-),
  - termo-/ haloklin (ns), …

  - Miljø er viktig, men ikke klar og tydelig i analysen,
  - nedblandingsdyp burde være viktig

Får vi dypere luselarver?

- Lus fra nedsenket eller standard anlegg



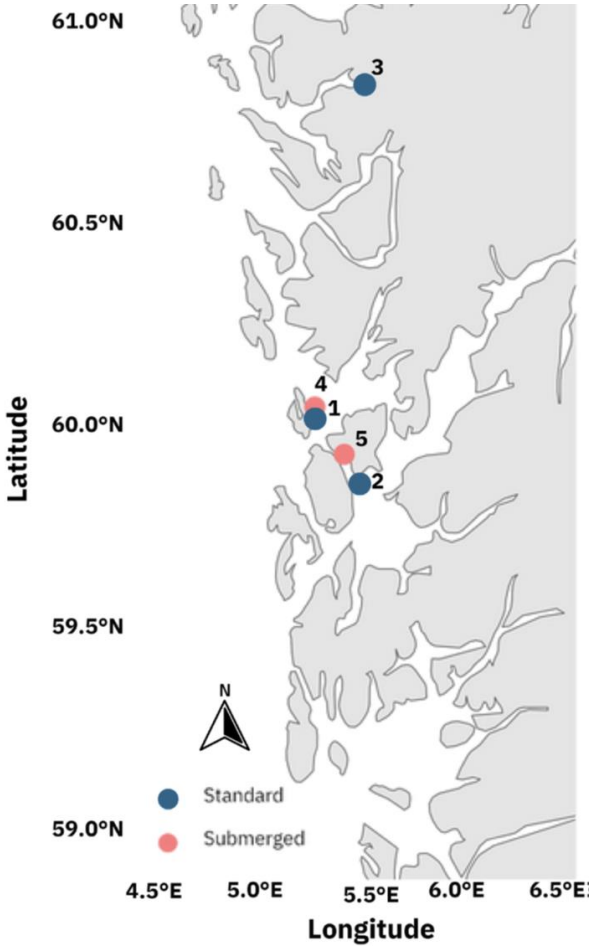
Brattavika 1
Circumference: 160 m
Depth of Cage: 0-20 m
Capacity: 130 000 fish
Size of Fish: 3kg

Uføro 2
Circumference: 160 m
Depth of Cage: 0-20 m
Capacity: 50 000 fish
Size of Fish: 5 - 7 kg

Smørdalen 3
Circumference: 10 - 100 m
Depth of Cage: 0-20 m
Capacity: 10 000 fish
Size of Fish: 2 - 8 kg

Gjengane 4
Circumference: 160 m
Depth of Cage: 20-40 m
Capacity: 120 000 fish
Size of Fish: 1.8 kg

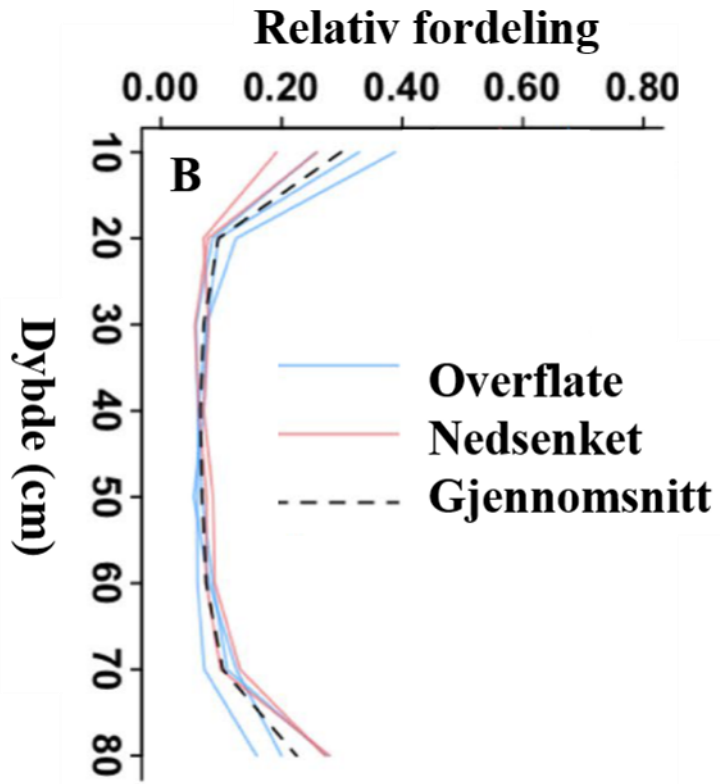
Hestabyneset 5
Circumference: 160 m
Depth of Cage: 20-40 m
Capacity: 120 000 fish
Size of Fish: 1 - 1.5 kg

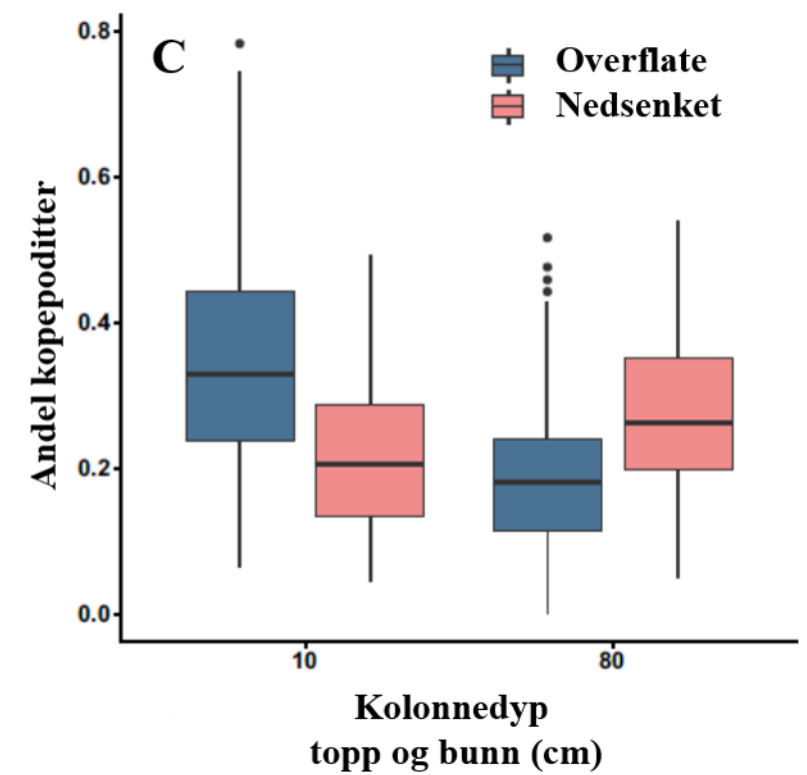


O'Neill et al., 2025

Lus fra nedsenket drift reagerte mindre på trykk

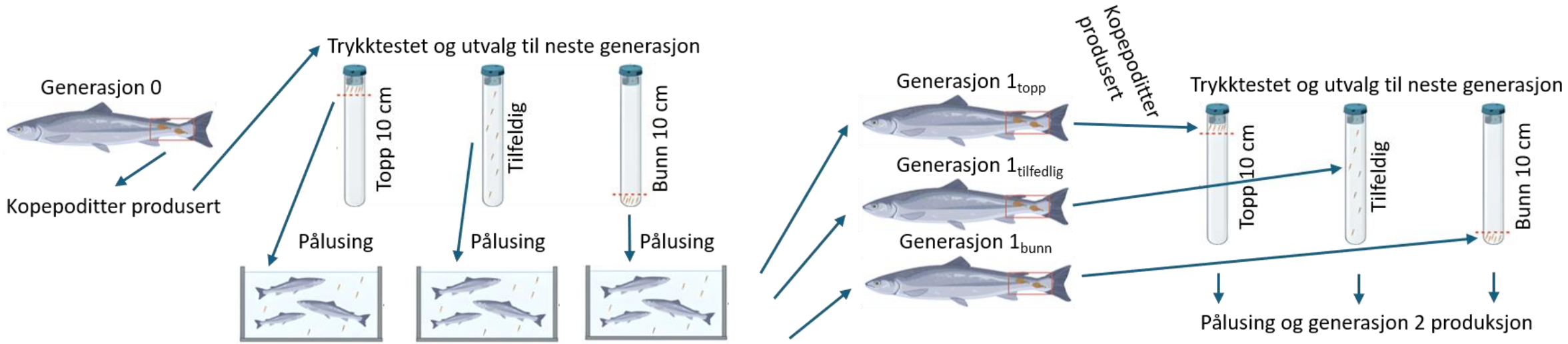






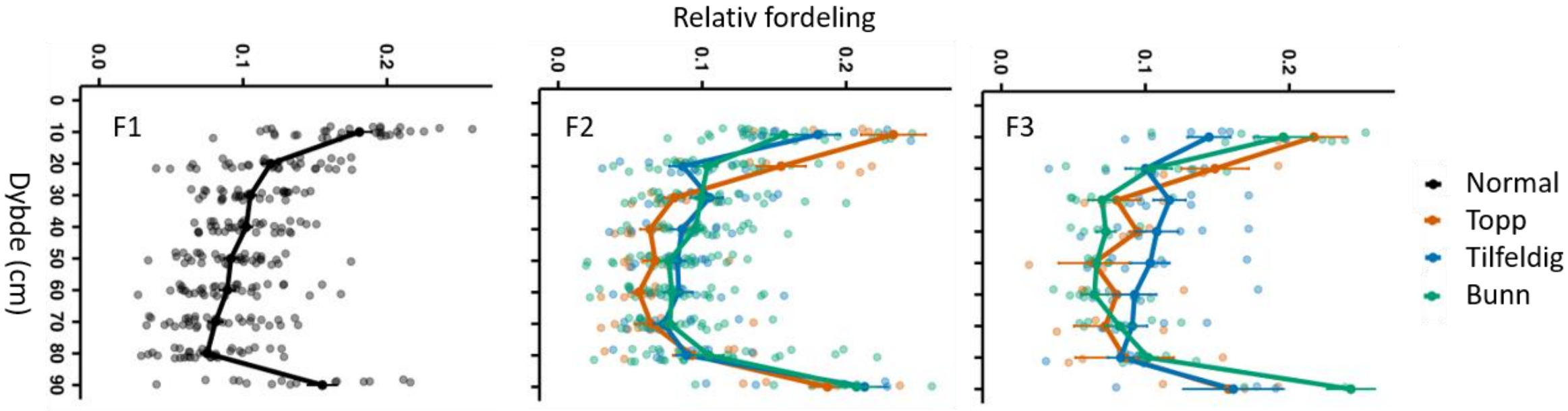
O'Neill et al., 2025

Lus kan bli mer dybdeelskende…



O'Neill et al., in prep

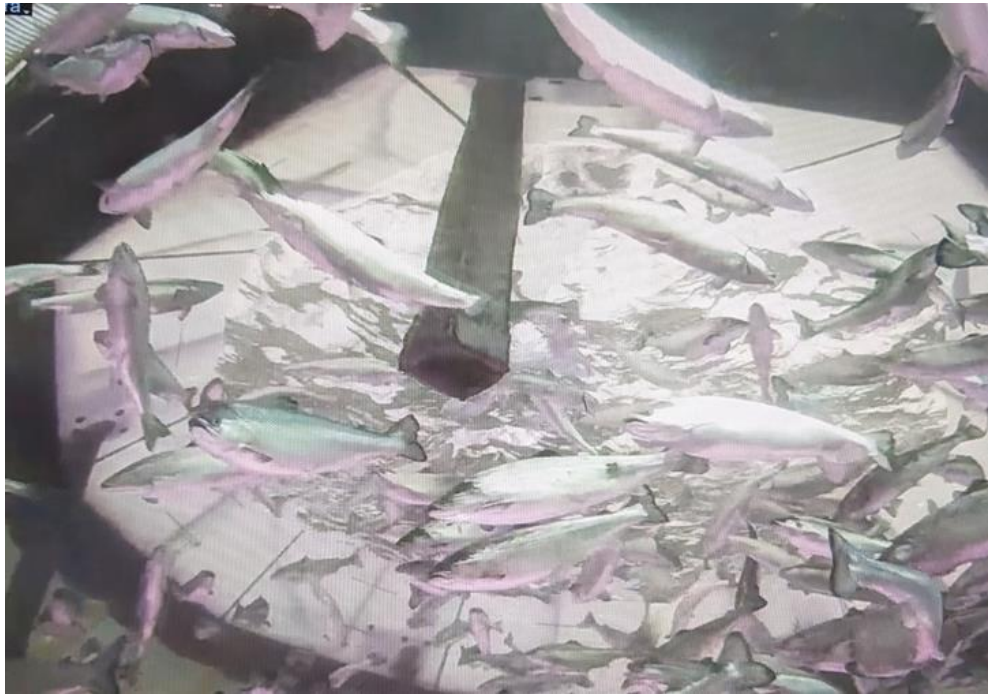
Lus kan bli mer dybdeelskende…



Arveligheten bunn-selektert linje var h^2 = 0,11-0,12,
- dvs moderat additiv arvelig komponent.

O'Neill et al., in prep

Utfordringer ved «start»



Harde ting – skader/ snutesår.

Fôringsrutiner – «tregere spising».

Fôrspredning

Kameraplassering

Kuppel design og luftlomme stabilitet

Reparasjoner, endringer, rengjøre utstyr (glidelåser montert....)

Utfordringer - Fremtidige og nåværende

- Påslagsdynamikk
  - Hvorfor tidvis påslag?
    - Overflatetid?
    - Påslag i dypet
      - miljø, sesong, stratifiering
      - storm og nedstrømming
- Lys
  - på/ av stress
  - modning
  - ingen hvile?

Lys – må det være på?

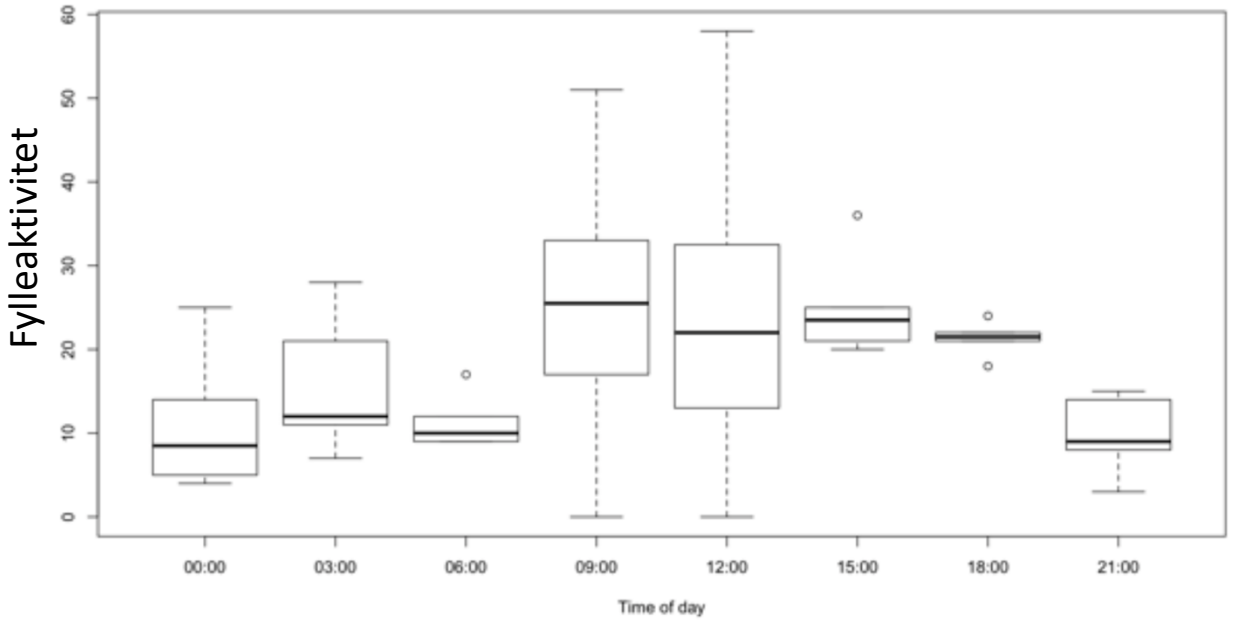
- Mørke fungerer i små skala forsøk (men lys kan avhjelpe?)

- Lys brukes kommersielt
  - Variasjon i mengde lys
    - Bare i kuppel
    - Kuppel + flere dyp
    - Kuppel + flere dyp men med variasjon dag/ natt (nylig)

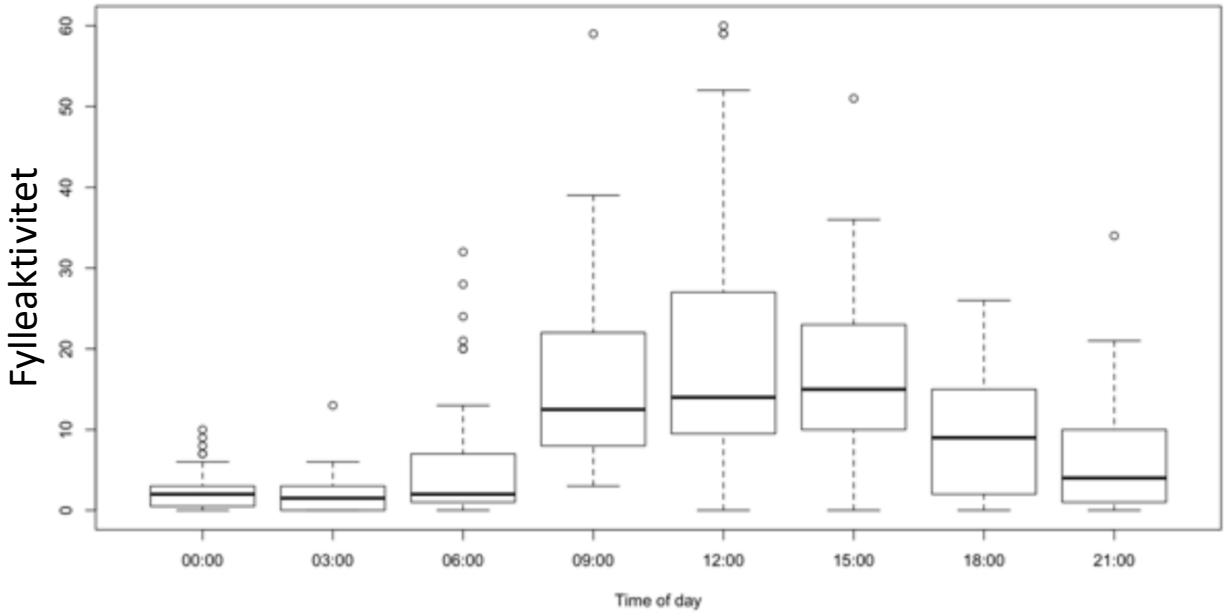
- Tryggere å ha det på fra start ….

Mer svømmeblærefylling på natt med lys

Med lys på



Naturlig med mørk natt



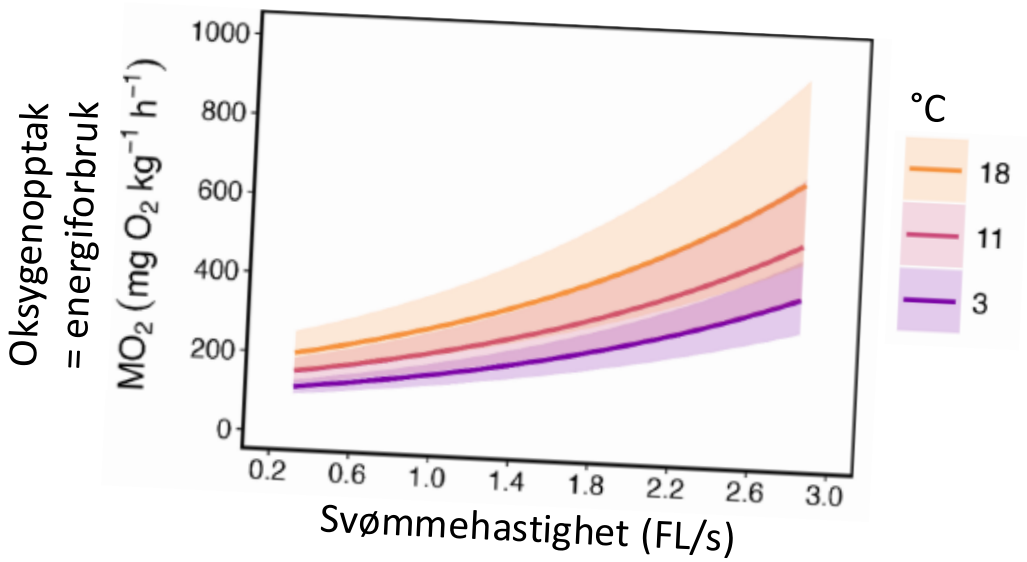
Fannemel

Effekter av lys (LL)

- På/ av stressrespons (spesielt på «svak» fisk)
- LL – økt andel modning/ utenomsesongmodning?
  - Manglende synkende daglengde – modningsrekruttering
    - modningsspurt etterfulgt av stagnasjon
  - «Free-running seasonal cycle» - ute av fase modning
  - LL + høy temperatur gir modning
- LL – ingen normal døgnsyklus/ hvile?
  - Usikkert, forskning mangler
- Kan LL gi dårligere/ stagnasjon i tilvekst
  - ikke lenger sesongsignal som er med på styre tilvekst – lengdevekst
  - økt aktivitet og mer energibruk og dårligere FCR?
- LL_{kuppel} på, men LL_{dypere} av eller dimt (høst eller bare om natten)
  - Ikke testet og dokumentert godt nok

Utfordringer - Fremtidige og nåværende

- Høyere fôrfaktor (ca 10%)
  - Aktivitet?
  - Økt energiforbruk
- Brå temperaturendring med dyp
  - legg inn dybdestopp?
- Forsinket appetitt etter utsett
- AGD observert, ikke normalt for lokalitet



Utfordringer - Fremtidige og nåværende

Heve/ senke dynamikk og «coping» etterpå

Forstå atferd

Dynamisk dyp

Lokalitetsmiljø – temperatur – oksygen - dypere/ grunnere?

Utsett størrelse/ metode/ tid/ tilvenning

Stamme – stress mestring

Manglende elektrisitet

Tap av fôr energi og næringstoff? ....

Fôrfordeling – trengsel med stor fisk – sår?

Vitamin D? – melanin m.m

Vitamin D – mindre i nedsenket

	N	Mean-D3_mg/kg
April		
Muscle		
Submerged15	3	0.027
Submerged25	3	0.020
Surface0	3	0.060
Plasma		
Submerged15	3	0.027
Submerged25	3	0.020
Surface0	3	0.057

June		
Muscle		
Submerged15	3	0.020
Submerged25	3	0.017
Surface0	3	0.067
Plasma		
Submerged15	3	0.010
Submerged25	3	0.007
Surface0	3	0.047

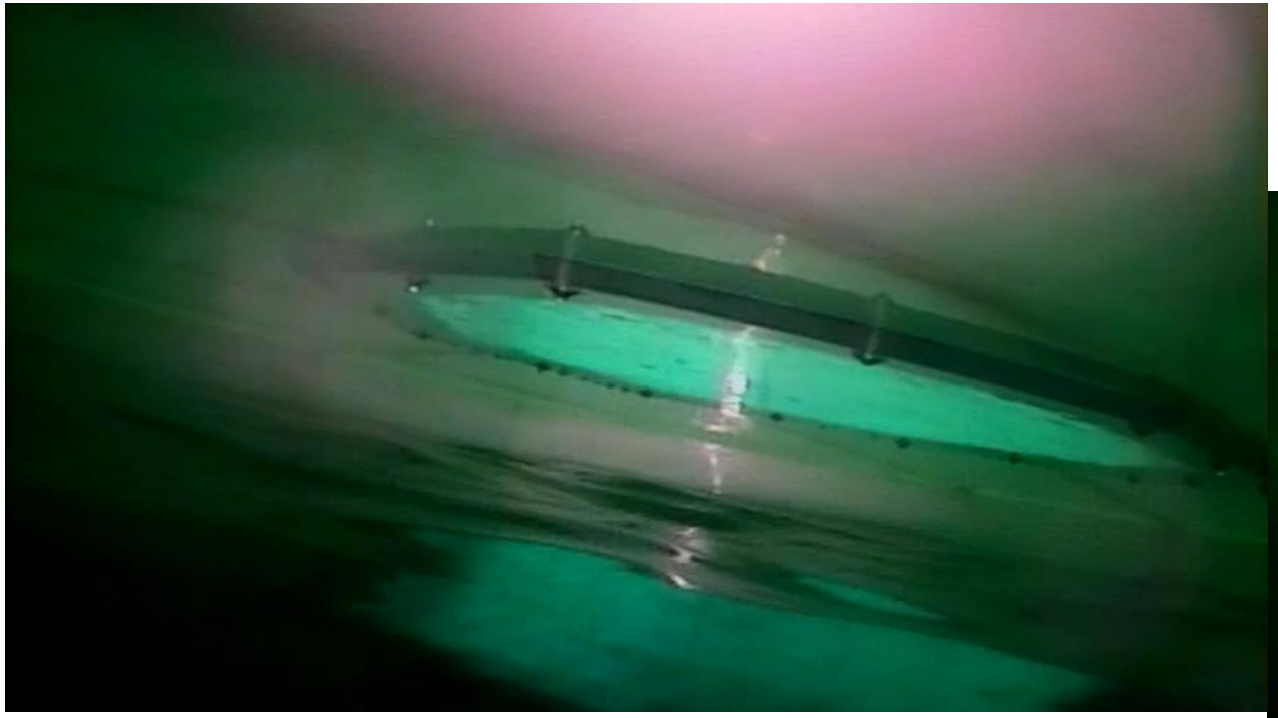
Hendelser



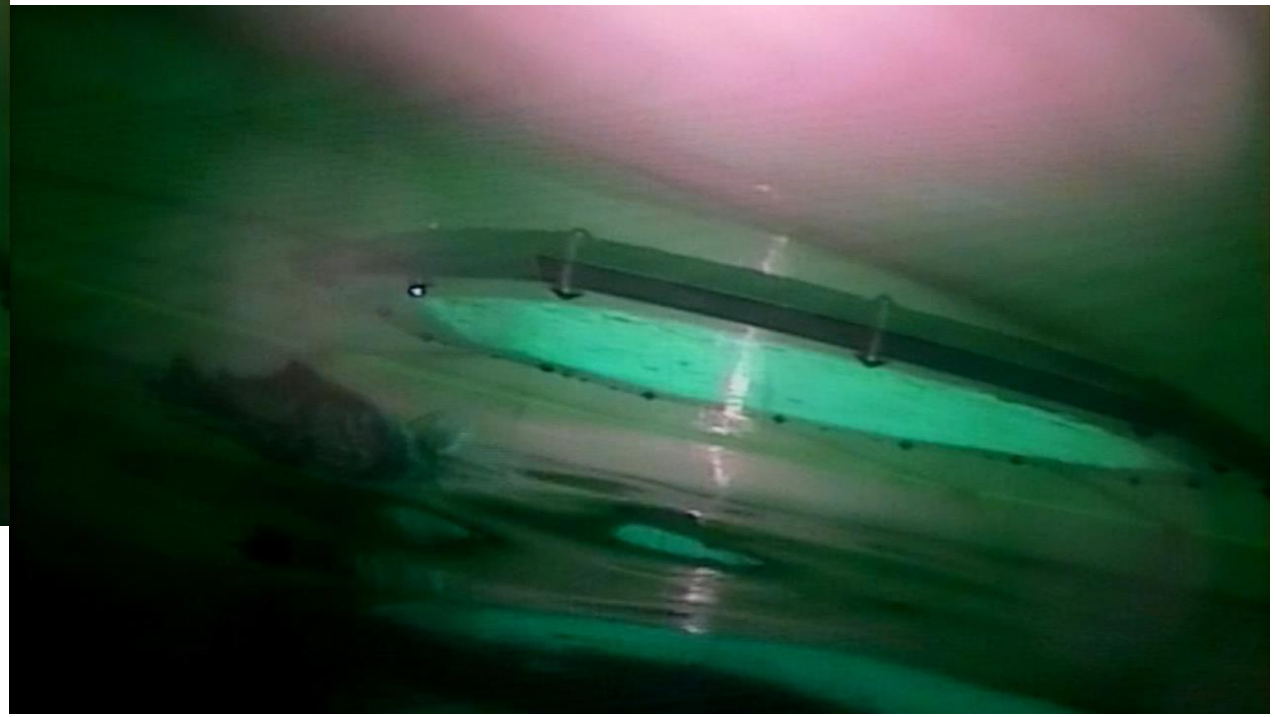
- Uvær
  - Stressrespons
  - Elektrisitet mangler
  - Lys av (og på)
  - Deformert not
  - Bevegelse av not/ merd?
  - Lyd
  - Tom for luft
  - Svak fisk takler utfordringer dårligere
- Tunfisk
- Hull i not
- Dårlig smolt (shit in, shit out)
- «Stresset» fisk inn
  - Transport, avlusing

Svømmeblærefylling
- hva er optimal størrelse og lufthøyde?

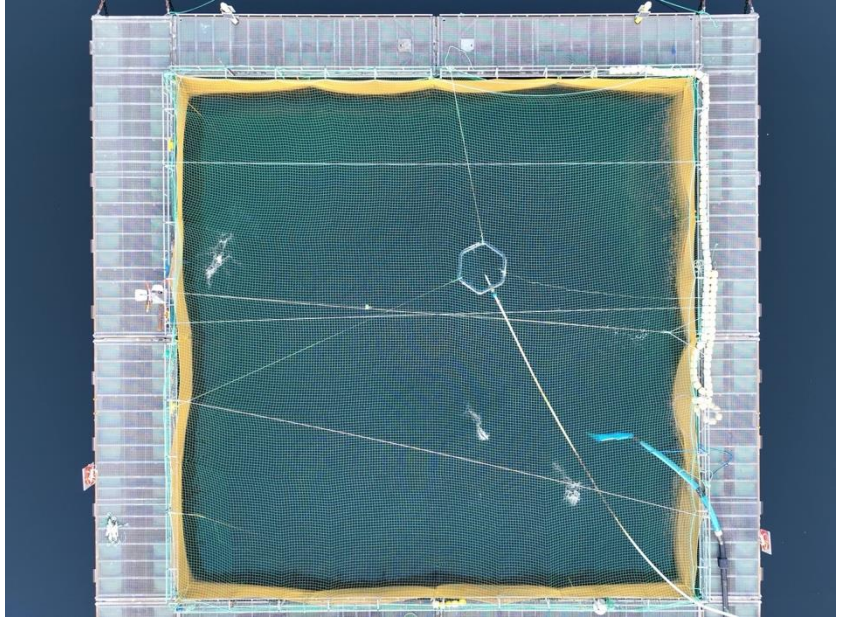
Rulle (vake):



Hoppe:

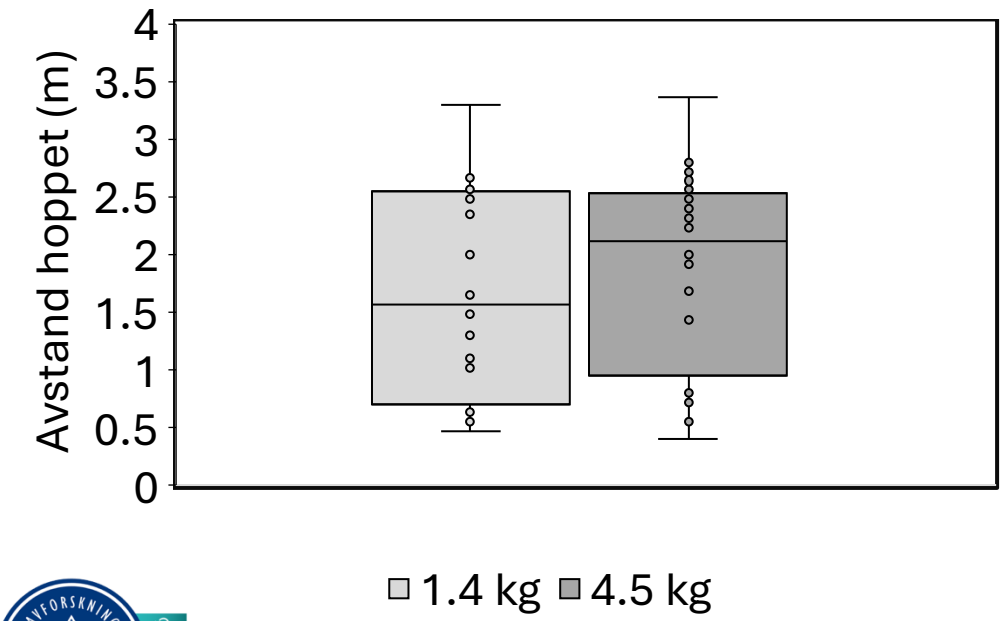


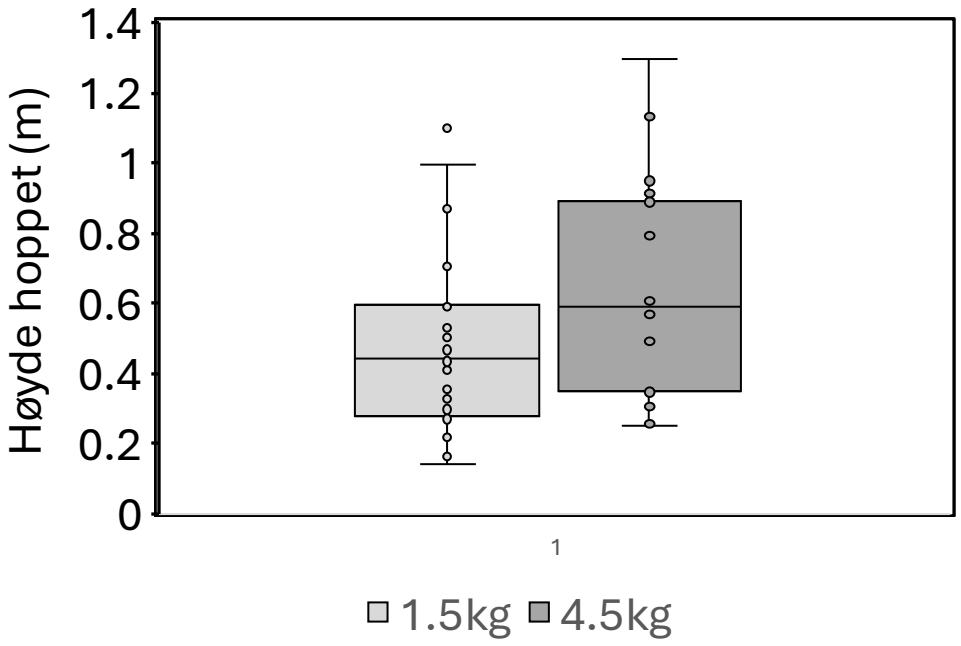
Fannemel, 2020



Hvor langt og høyt hopper laksen?



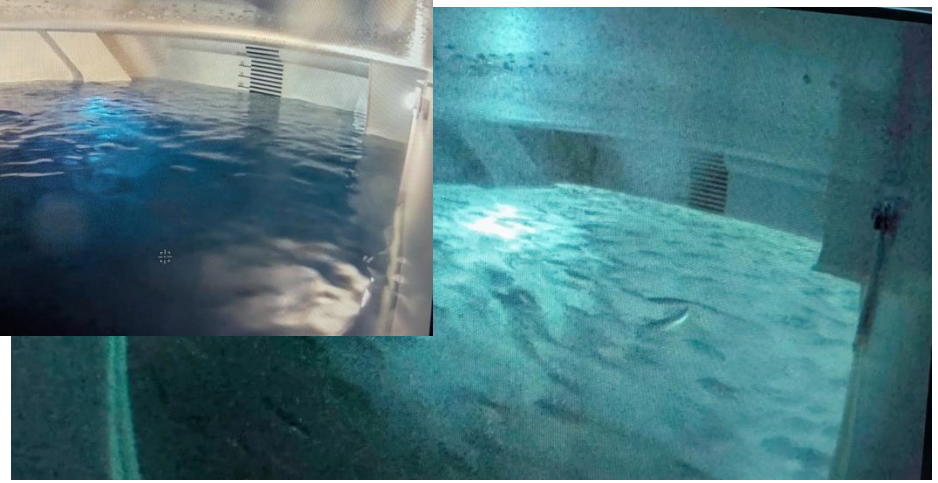




Minimalt med hopp observert kommersielt

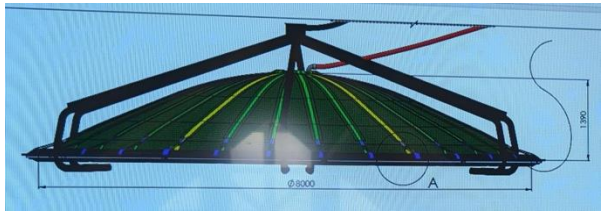
Arctic Offshore Farm

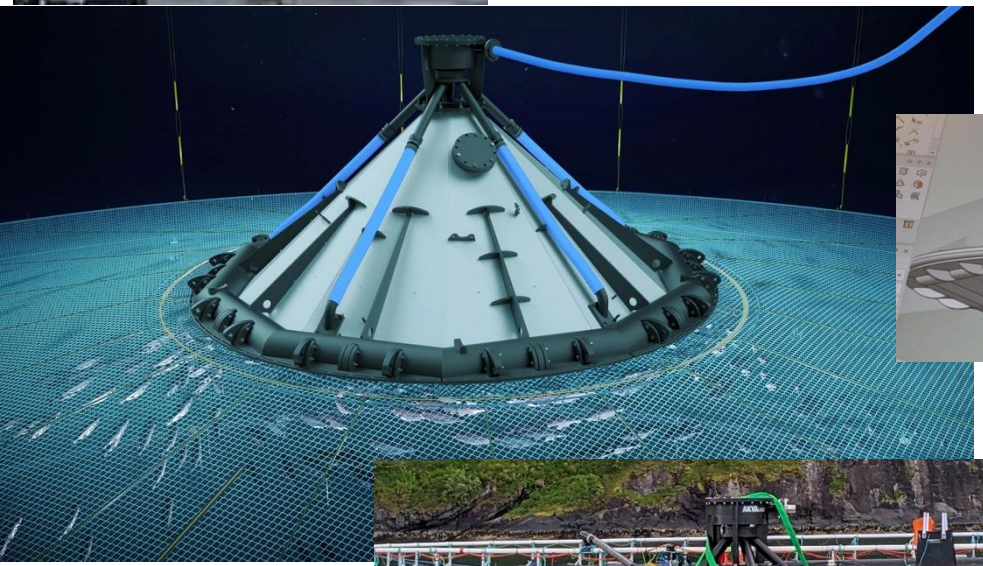






Nautilus

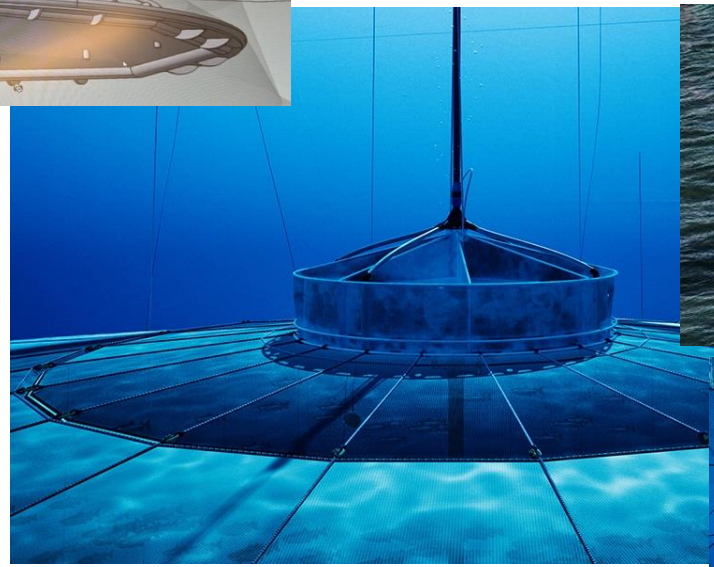




SinkaBerg_Nærøysund

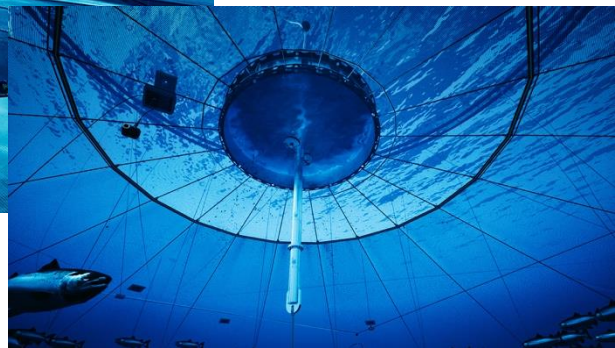


ScaleAQ









Diameter 5 m minus

AOF: 10m*10m

Lufthøyde: 0/0.4-1 m



- Nedsenkete drift gir færre lus og behandlinger
  - Fortsatt variasjon i effektivitet, >440 merder
  - Virker ikke overalt
  - Noen utfordringer …
    - Lys
    - Økt FCR
    - Dynamisk, dybde, stratifiert

Støttet av Forskningsrådet
Finansiert av: FHF

Takk for oppmerksomheten

Foto: Frode Oppedal, HI