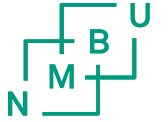


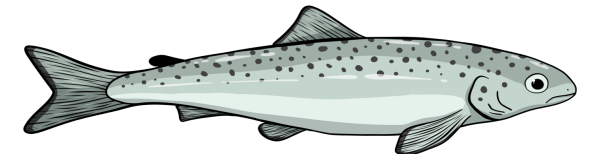
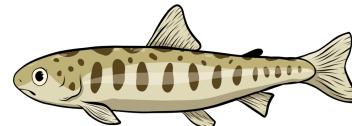
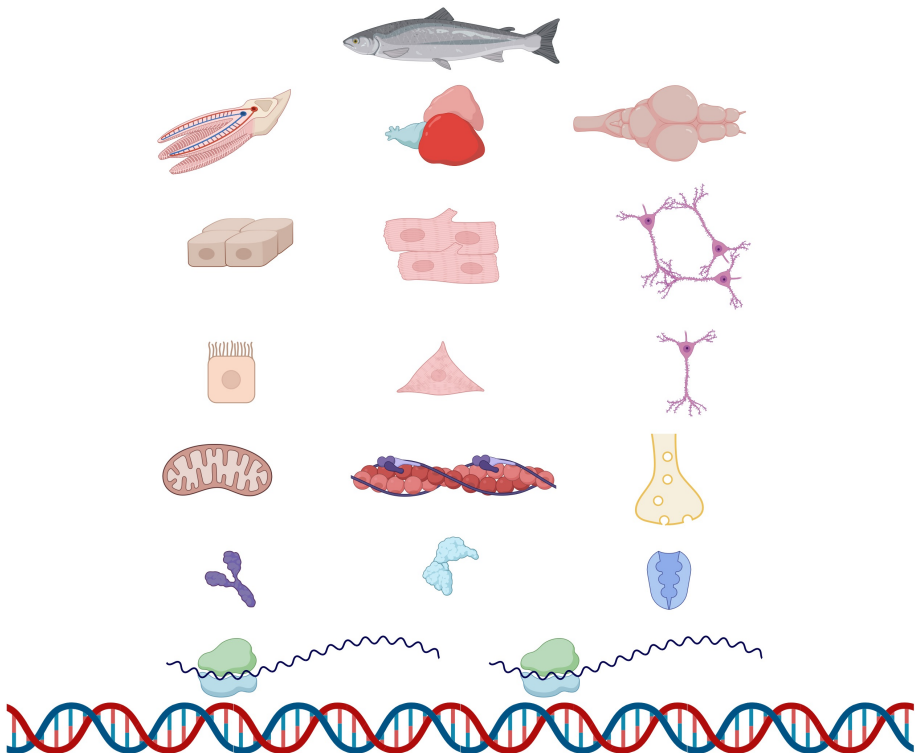
Laksens fysiologi som nøkkel til bærekraftig havbruk – kunnskapsstatus og veien videre



FHF workshop 29.04.2025

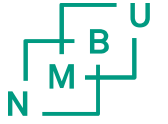


Kjetil Hodne
NMBU



Fysiologi er vitenskapen om livet

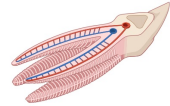
- Beskriver biologien, fysikken og kjemien for hvordan organismen fungerer



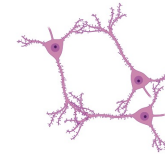
Organisme



Organ



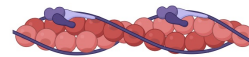
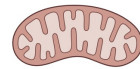
Vev



Celler



Organeller



Protein



mRNA



Gen



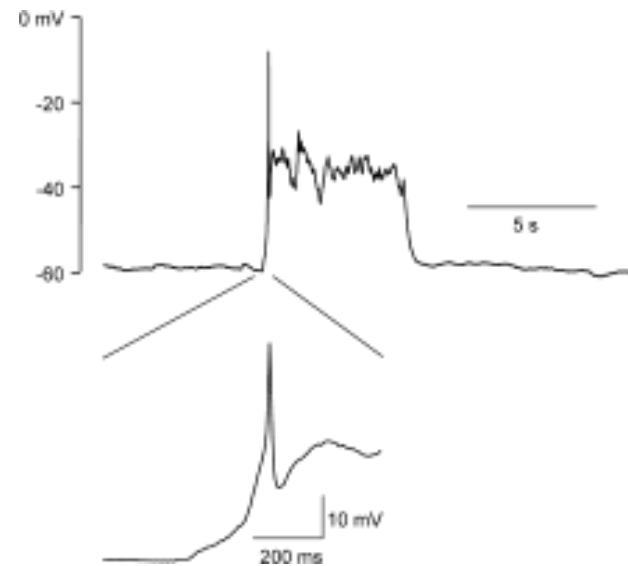
Optimalisert for det naturlige miljøet laksen lever i

Naturlig miljøet $\neq$ Oppdretsmiljø

Electrophysiological Properties of Pituitary Cells in Primary Culture from Atlantic Cod (*Gadus morhua*)

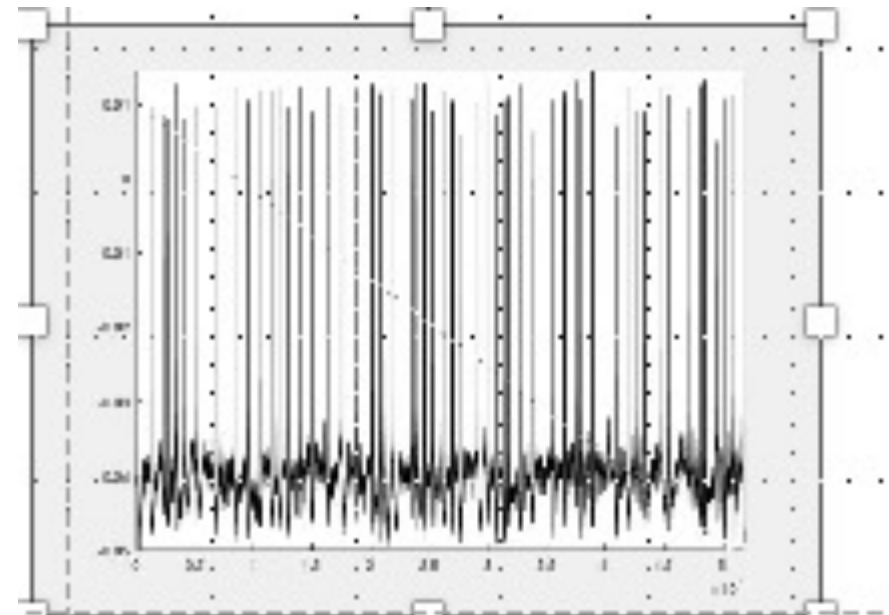
Trude M. Haug Kjetil Hodne Finn-Arne Weltzien Olav Sand

Department of Molecular Biosciences, University of Oslo, Oslo, Norway

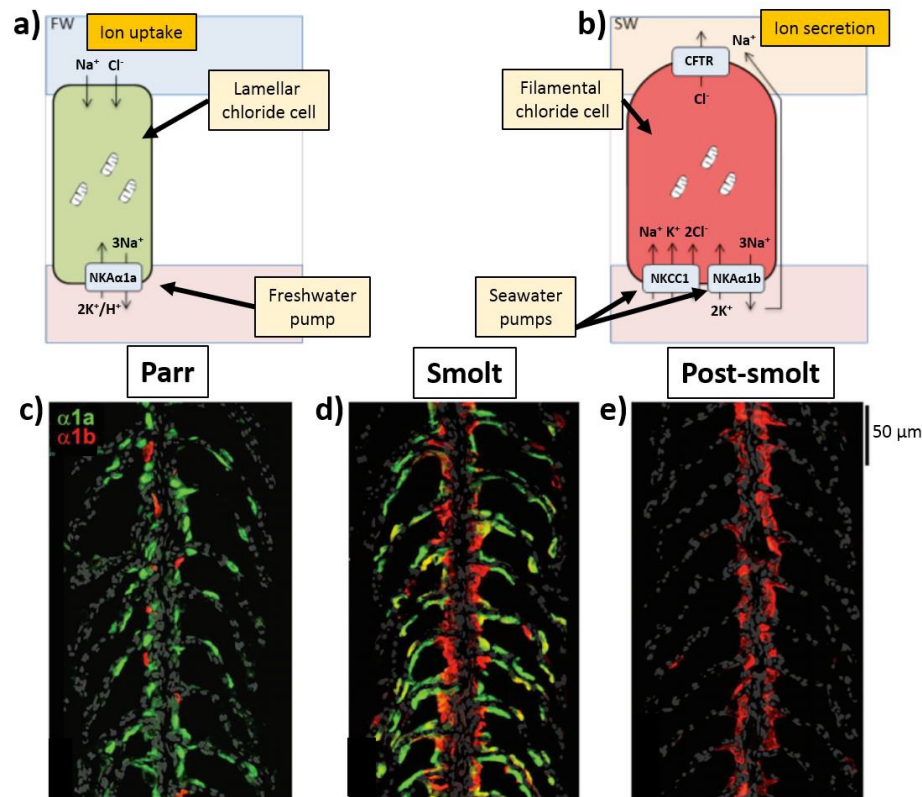
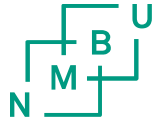


Optimized conditions for primary culture of pituitary cells from the Atlantic cod (*Gadus morhua*). The importance of osmolality, pCO₂, and pH

Kjetil Hodne^a, Kristine von Krogh^a, Finn-Arne Weltzien^{a, b}, Olav Sand^b,
Trude M. Haug^b

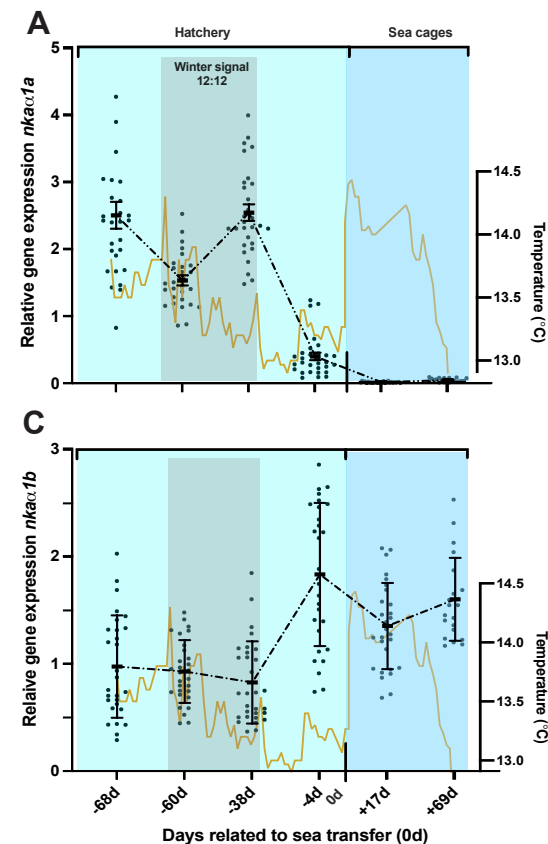


Bakgrunn for bruk av Nka i validering av smoltstaus

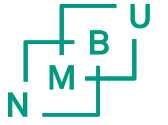


McCormick et al. (2013).

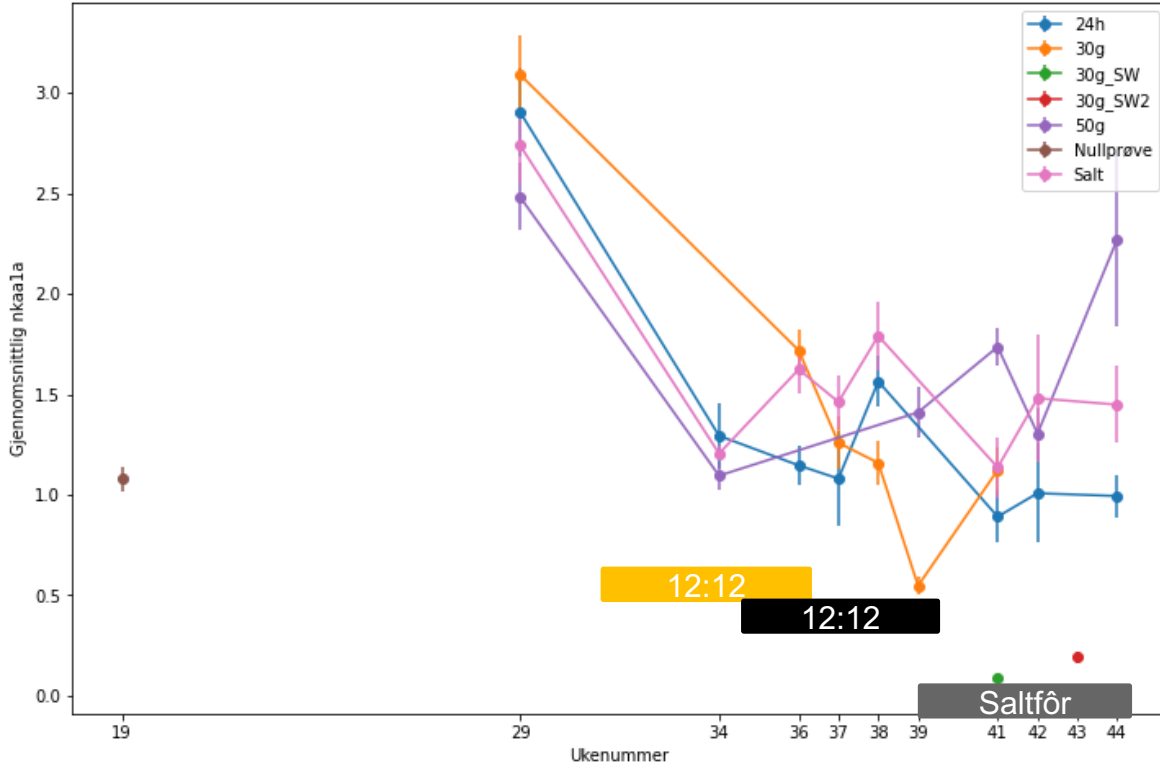
1. *nkaα1a* og *nkaα1b* er lokalisert til bestemte celletyper
2. Gjellenes morfologi endres under smoltifisering
3. Genuttrykk av *nkaα1a* og *nkaα1b* som nøkkelregulator



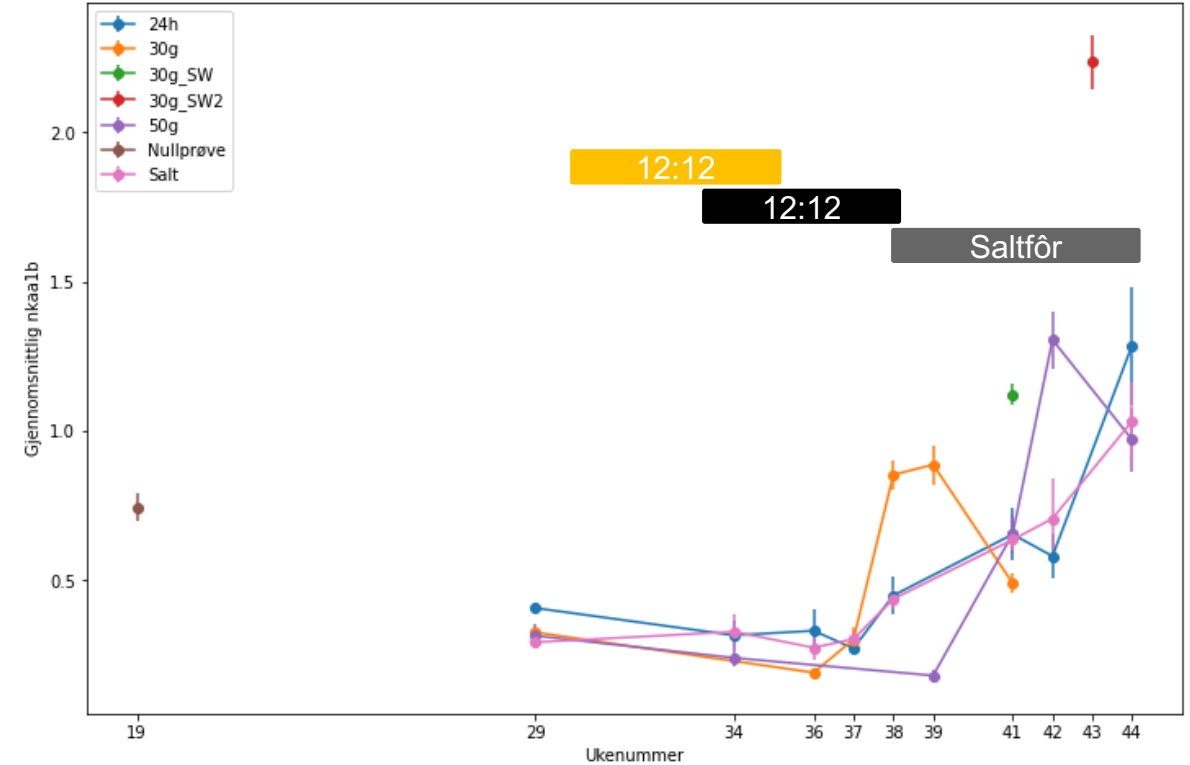
Gir informasjon om genuttrykk et riktig bilde av smoltstatus? - Eksempel fra karforsøk



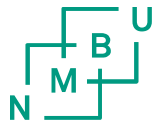
Gjennomsnittlig nkaa1a for alle Grupper med SEM per Ukenummer



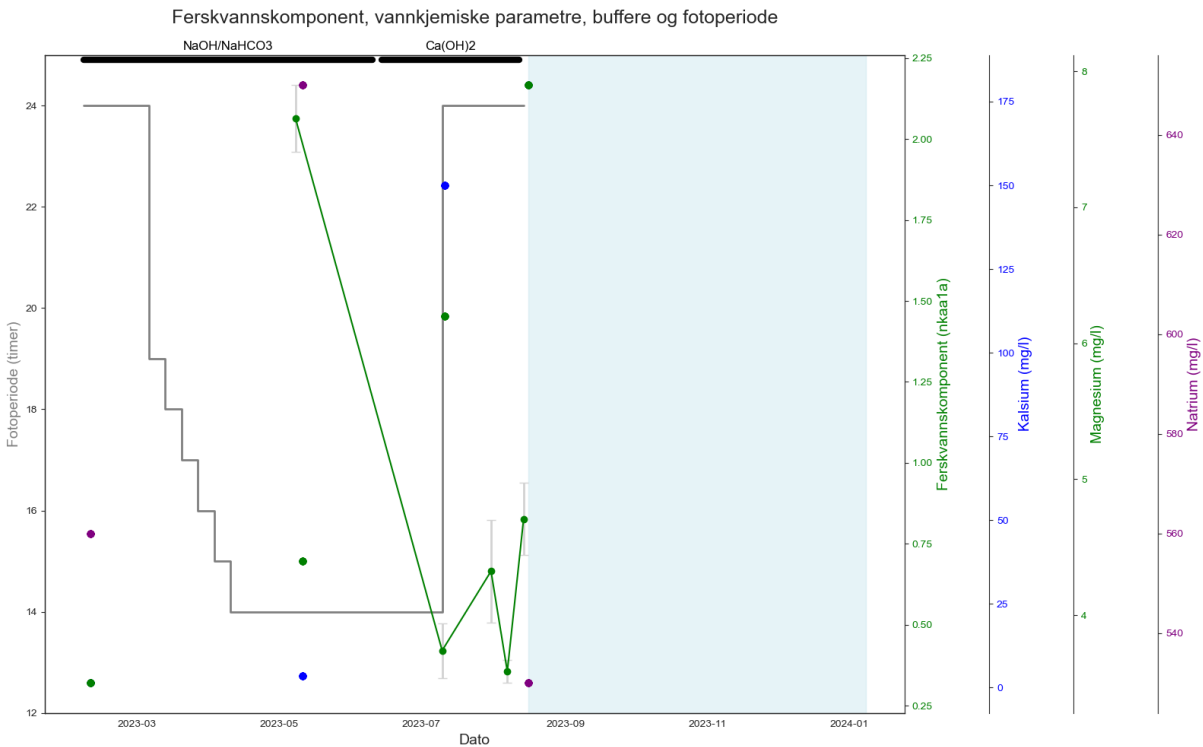
Gjennomsnittlig nkaa1b for alle Grupper med SEM per Ukenummer



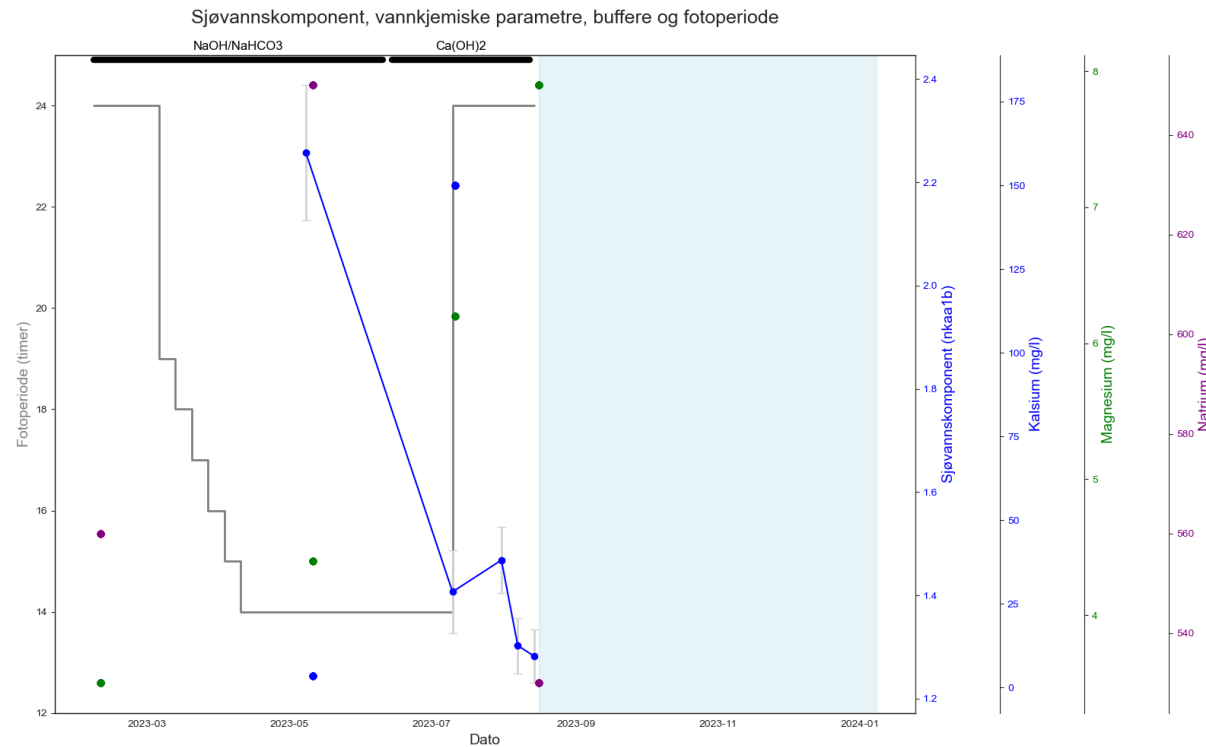
Gir informasjon om gnuttrykk et riktig bilde av smoltstatus? - Eksempel fra fullskala produksjon i RAS



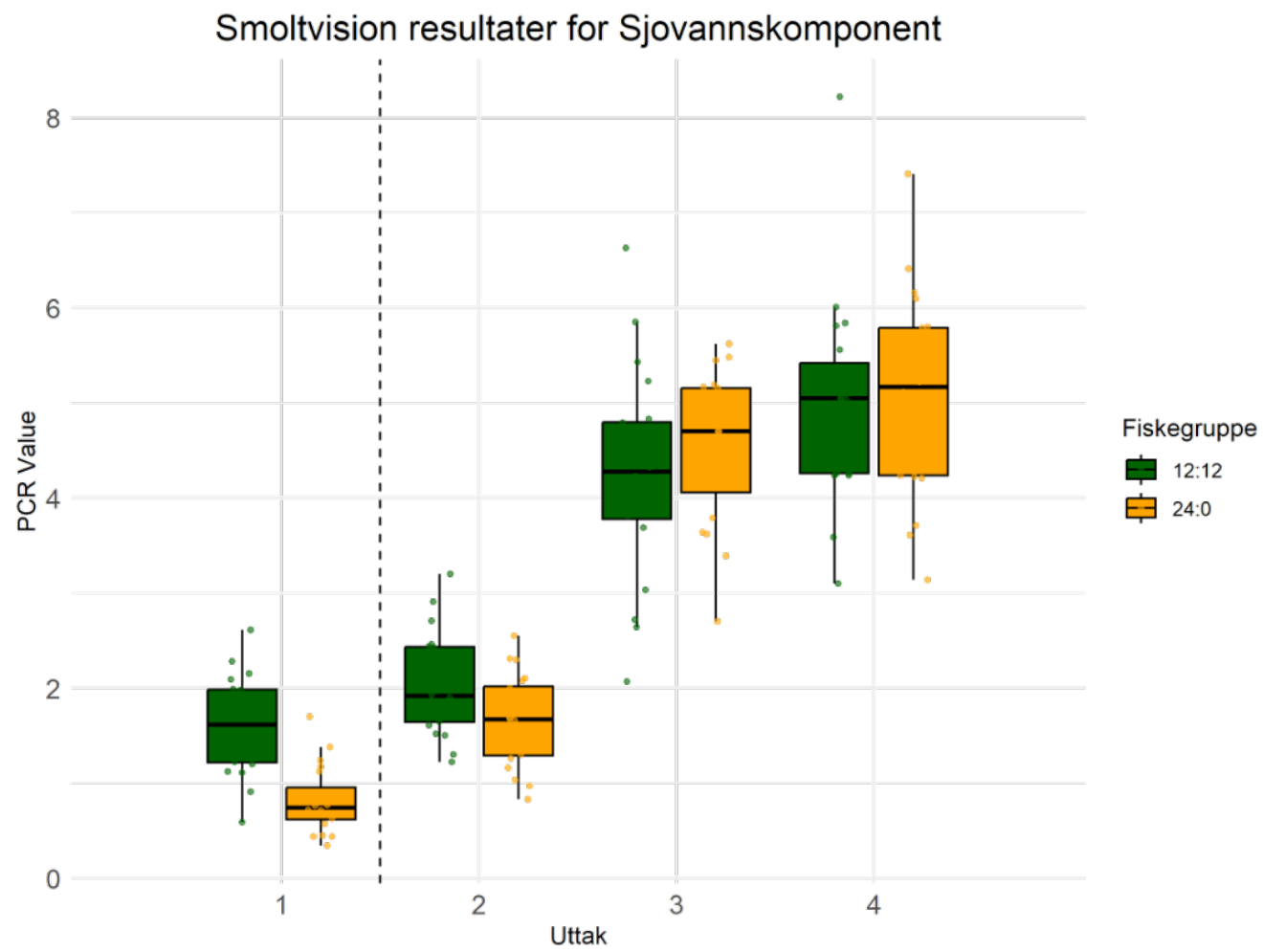
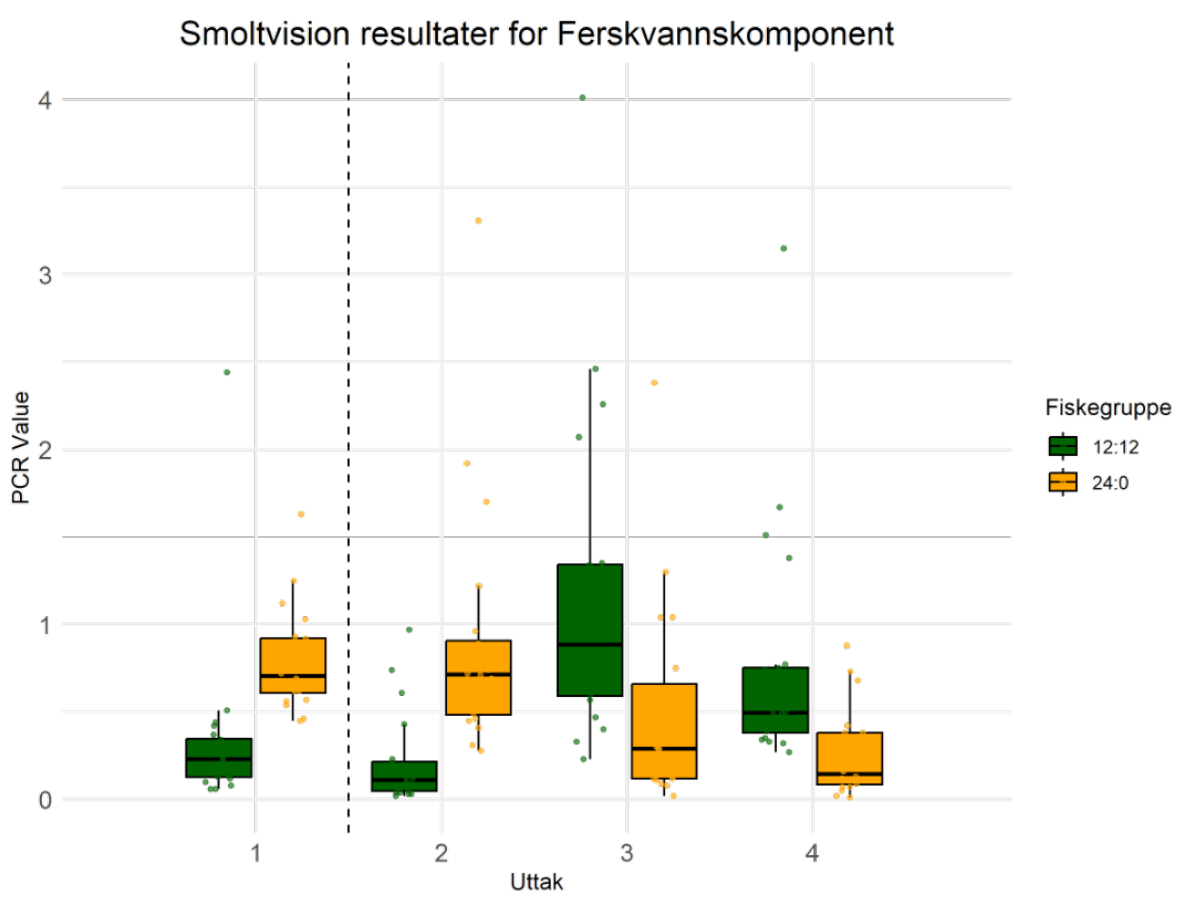
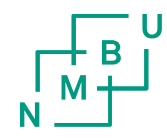
nkaa1a



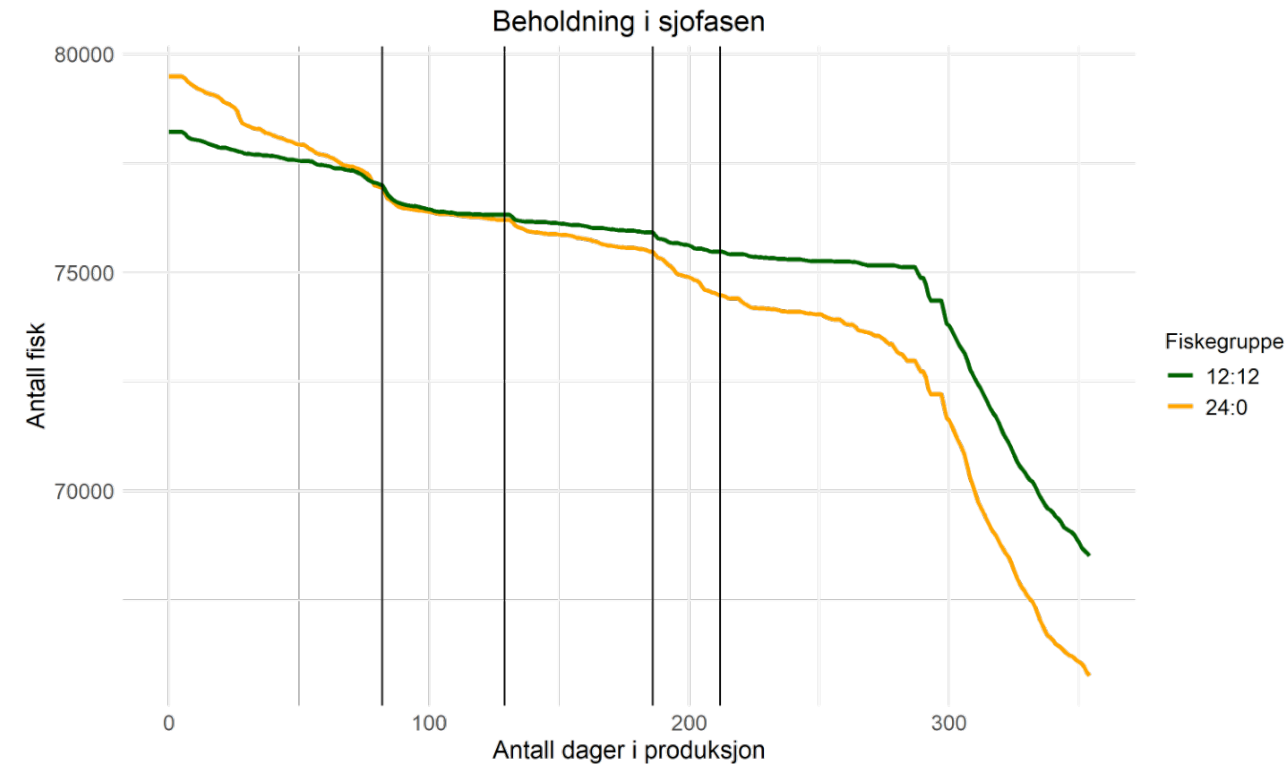
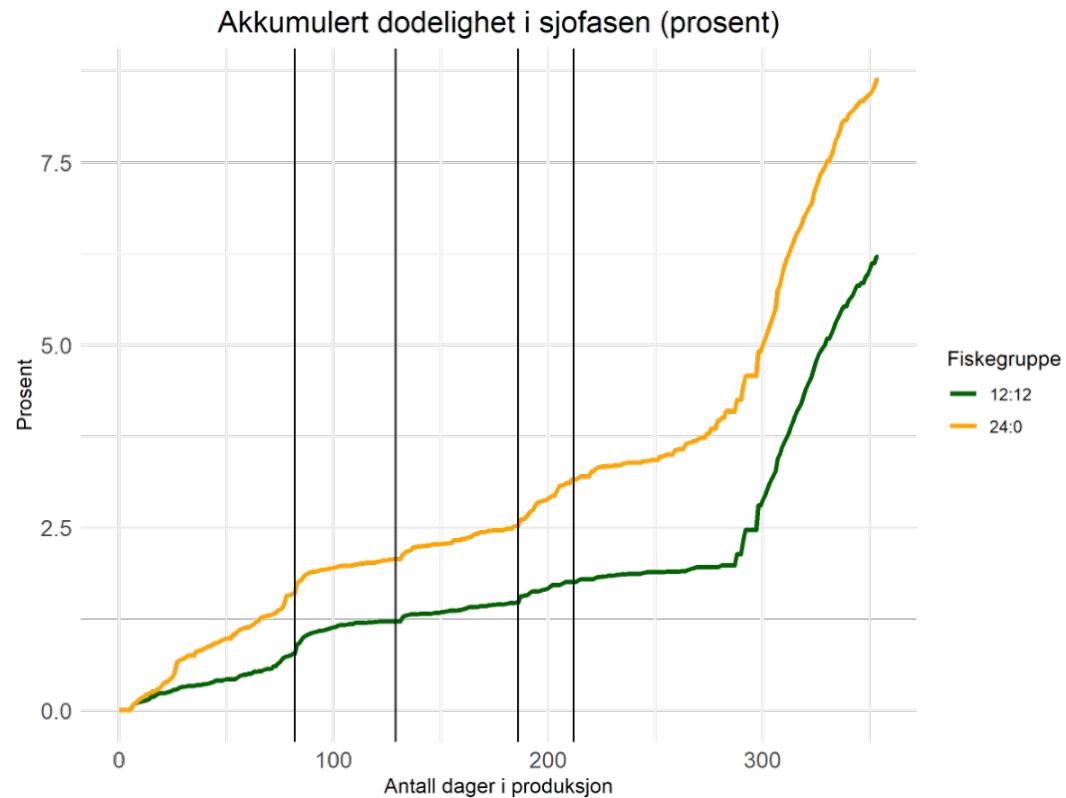
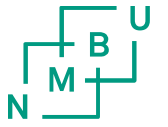
nkaa1b



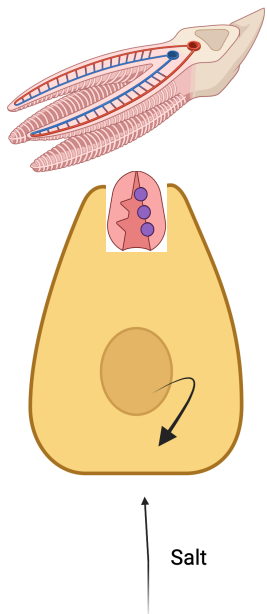
Sammensetning av *nka* subenheter viser ingen forskjeller mellom laks som har fått vintersignal og laks som har kun stått på kontinuerlig lys



Laks produsert i fullskala produksjon viser økt dødelighet uten vintersignal



Miljøtilpasning vs smoltifisering

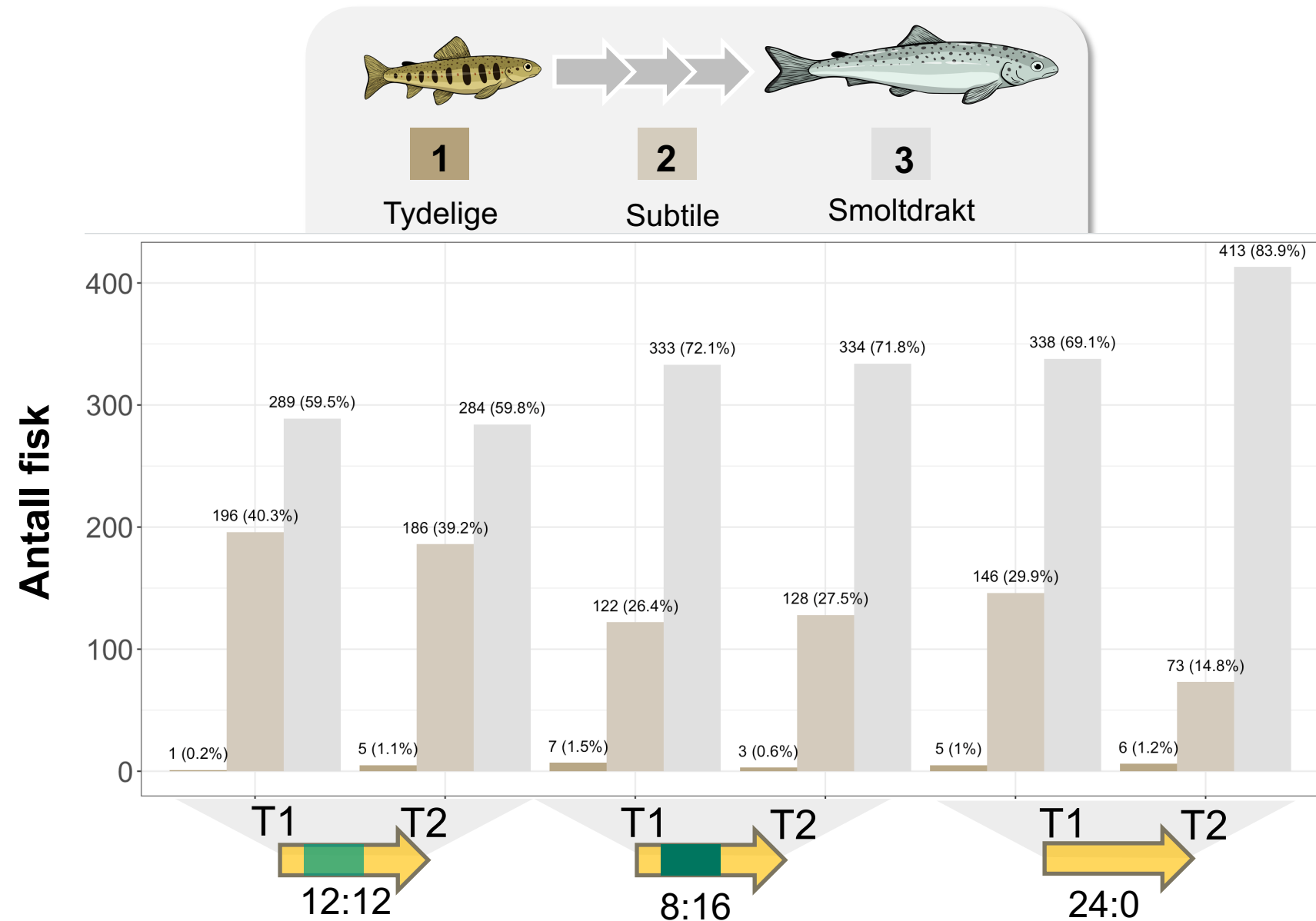
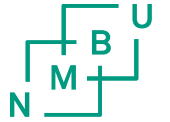


- Litt salt: -Redusert osmotisk trykk -Redusert genuttrykk -Mindre protein
- Mer salt: -Økt osmotisk trykk -Økt genuttrykk -Mer protein
- Men betyr mer salt (mat eller sjøvann) smoltifisering?

Ingen remodellering på celle- eller organ- nivå ?

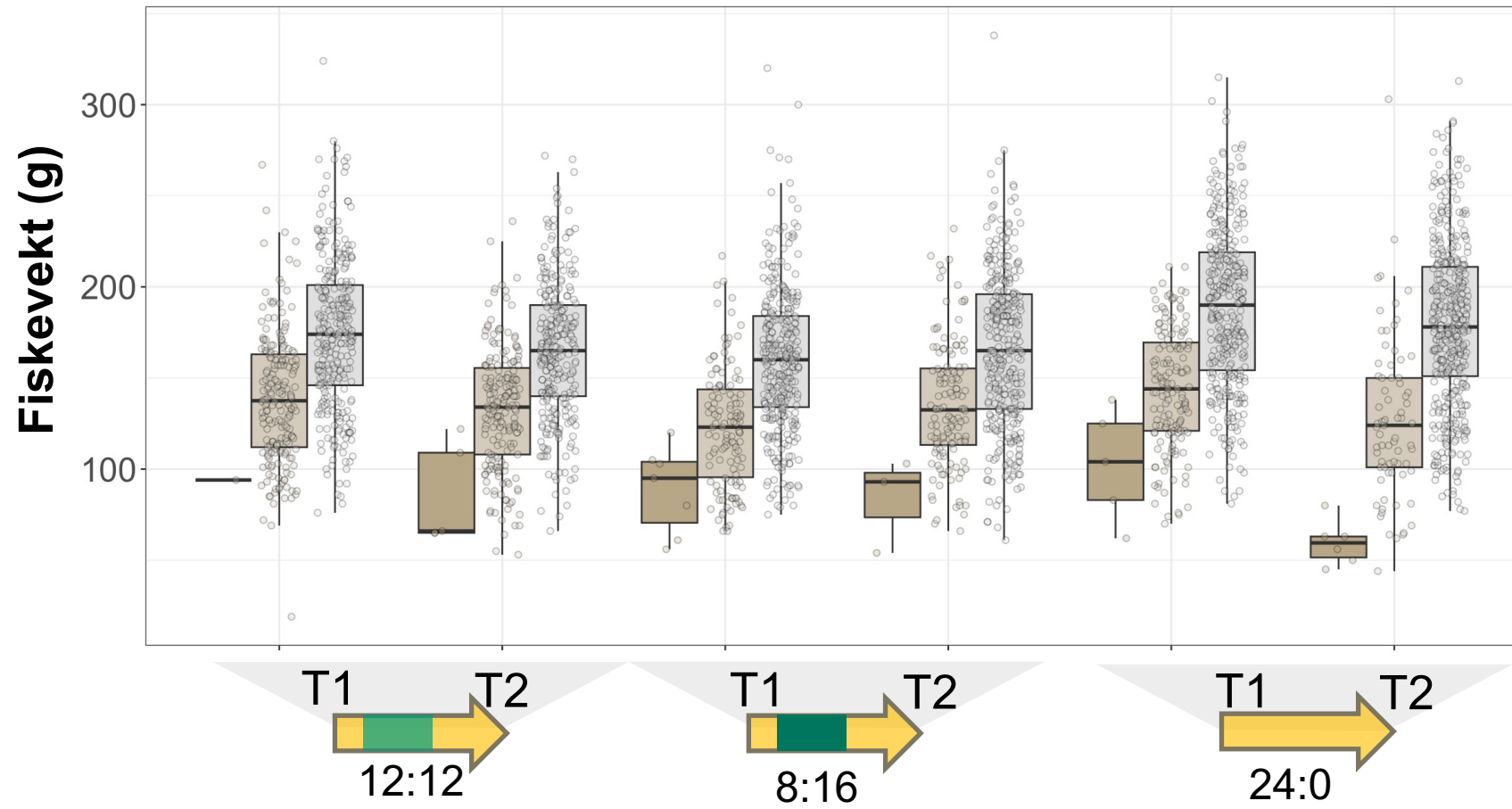
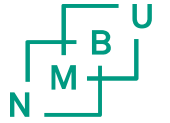
Kun en transient tilpasning til miljøet ?

Validering av smoltstaus basert på smoltdrakt



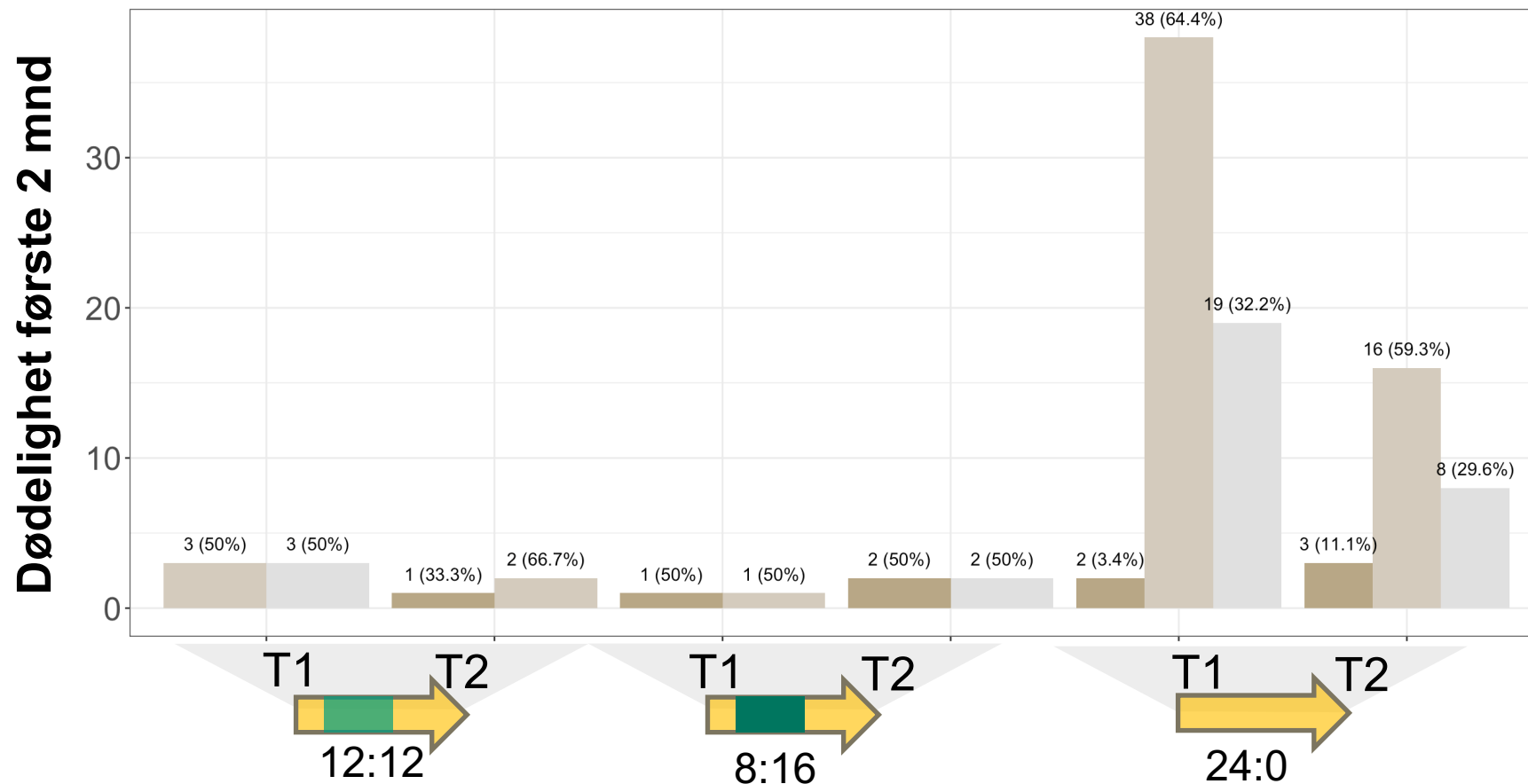
Validering av smoltstaus basert på smoltdrakt

-Økt vekt i 24:0 gruppen



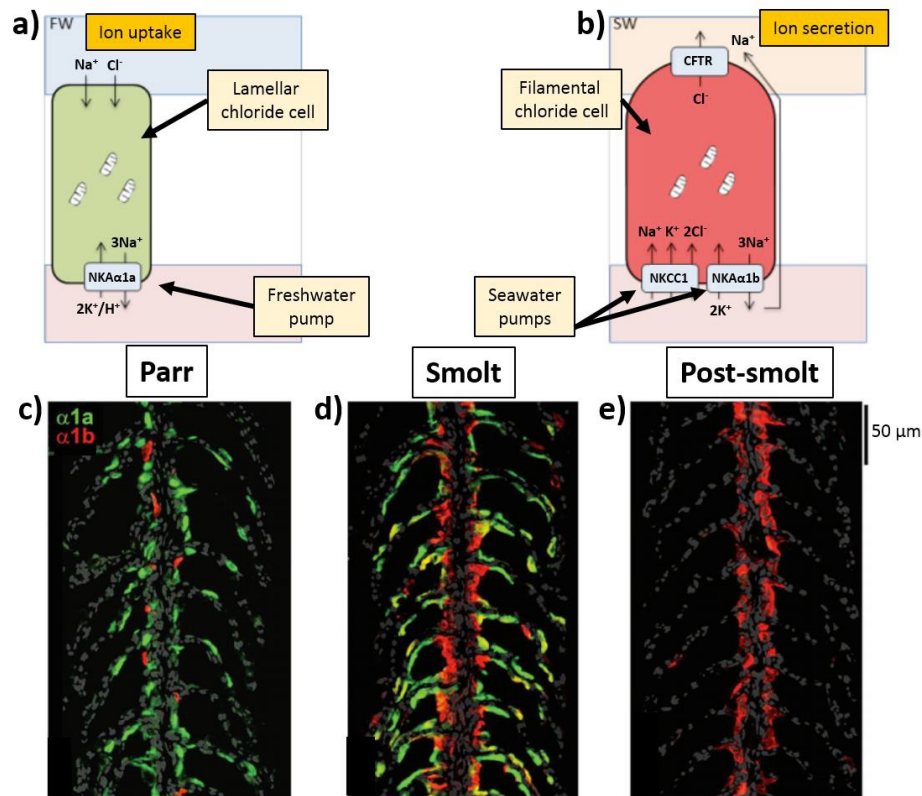
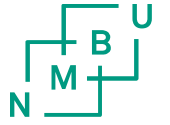
Validering av smoltstaus basert på smoltdrakt

-Økt dødelighet i 24:0 gruppen

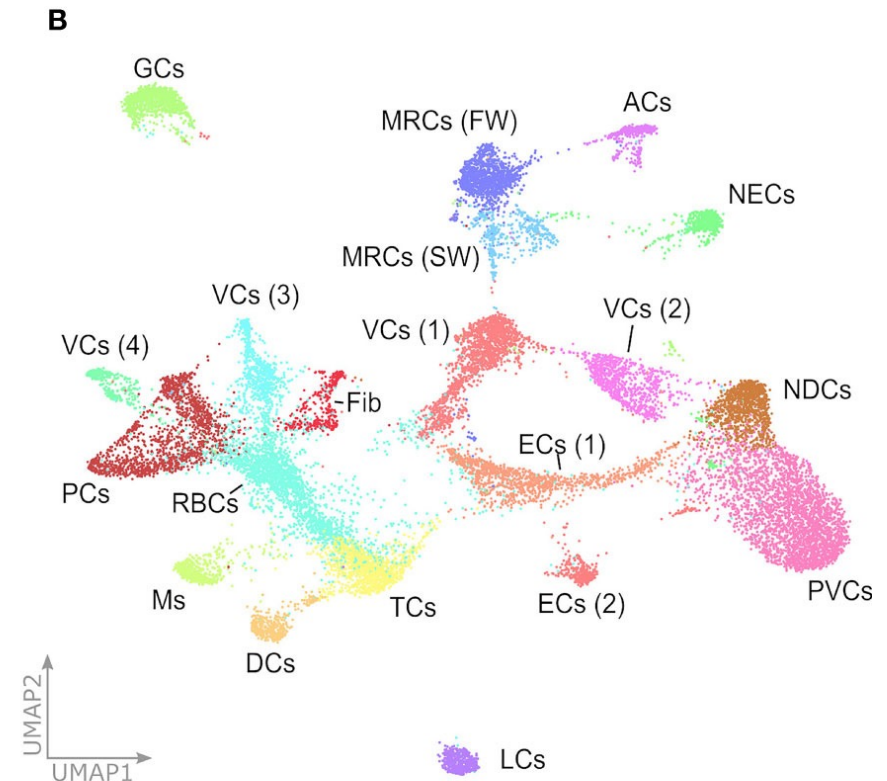


Smoltifisering

– en metamorfose med kompleks remodelering på celle- og organ-nivå



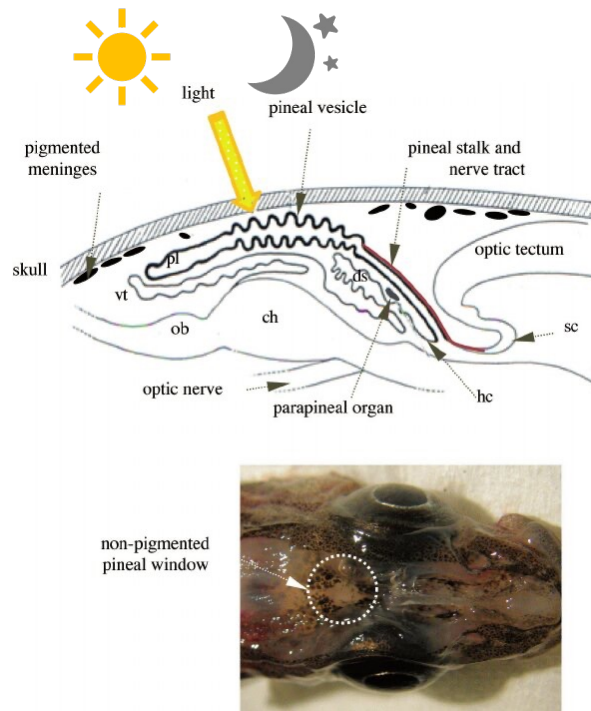
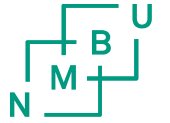
McCormick et al. (2013).



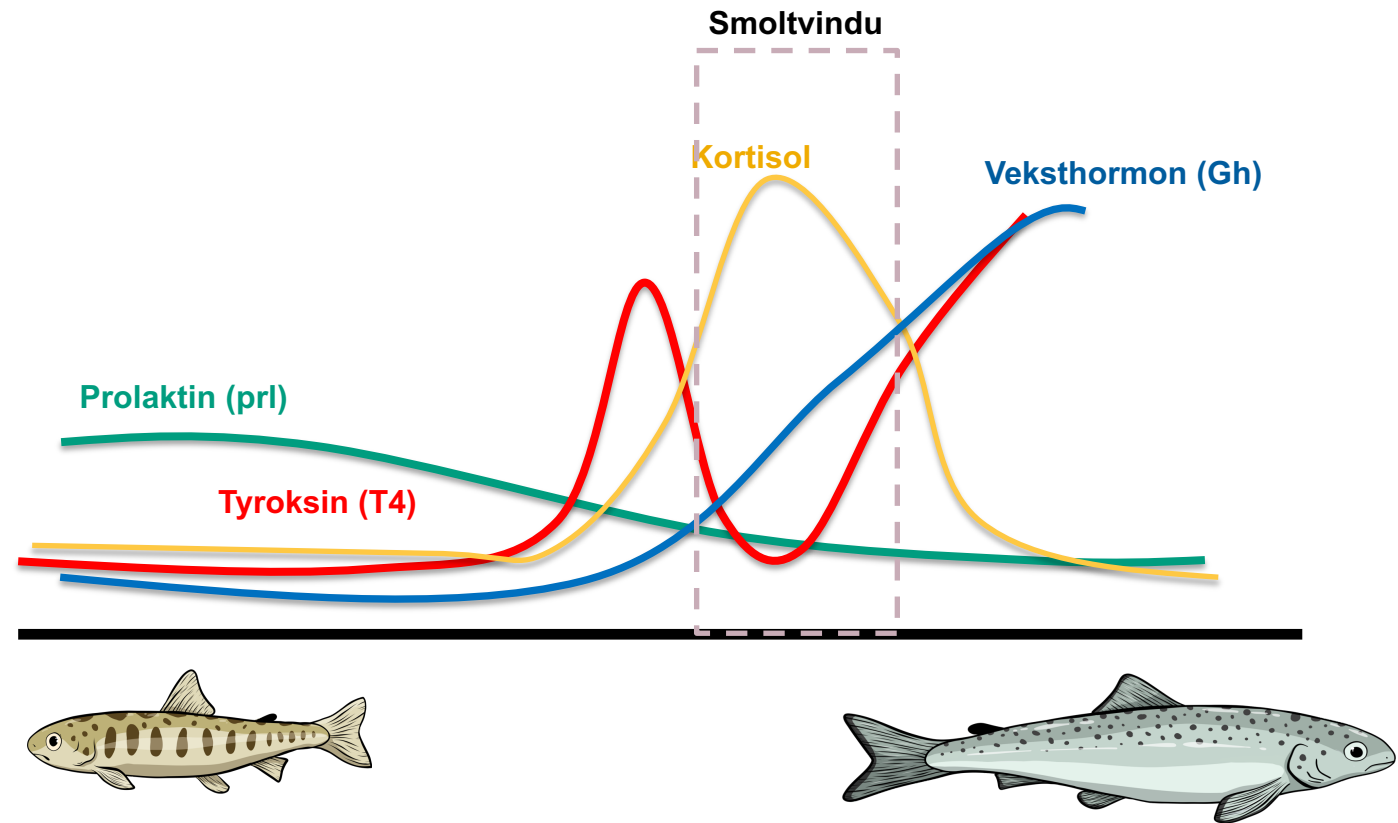
West et al. (2021).

Smoltifisering

– Et samspill mellom miljø og organer

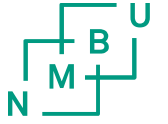


Falcón et al 2011

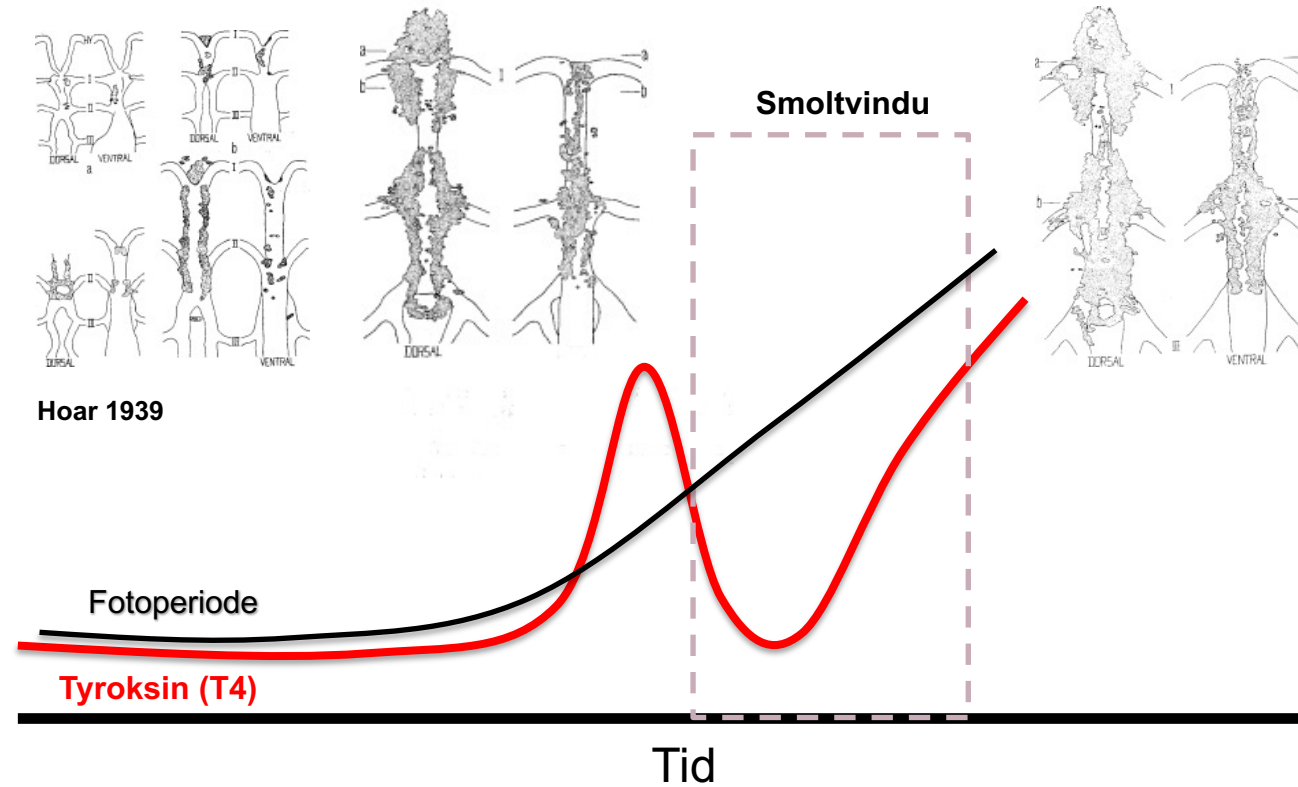


Hormoner under smoltifisering

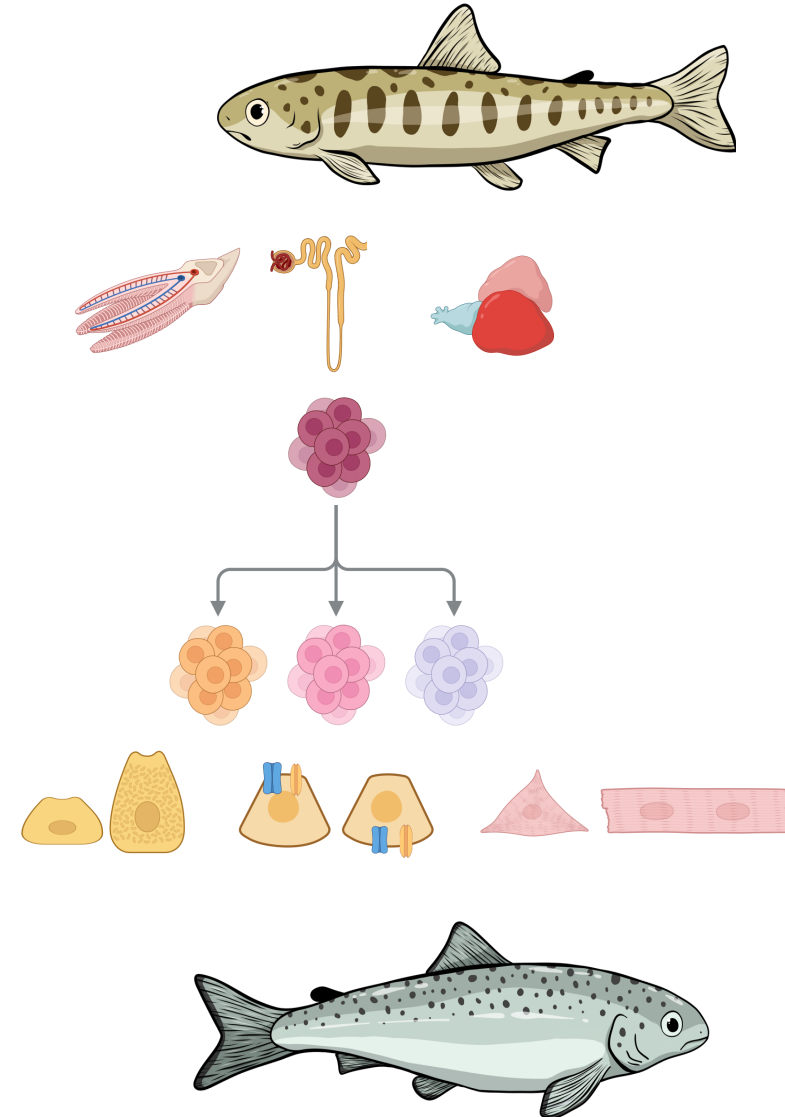
– synkroniserer organer og driver cellulær remodellering



Thyroideaorganet utvikles gjennom smoltifiseringen

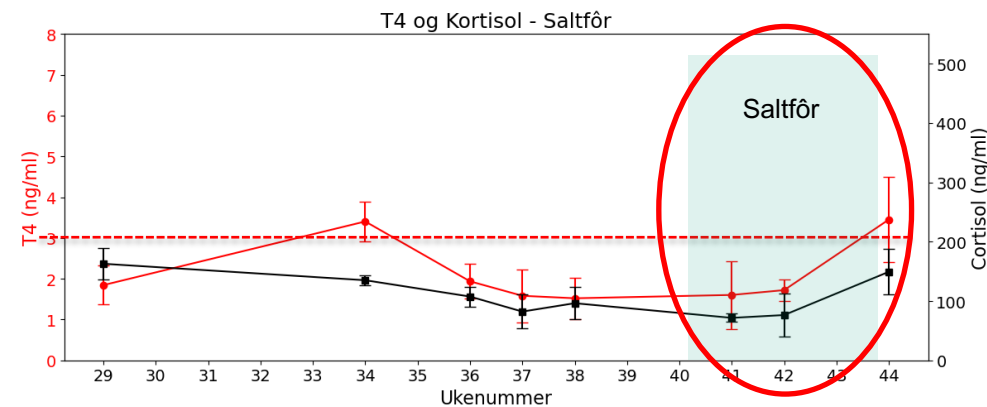
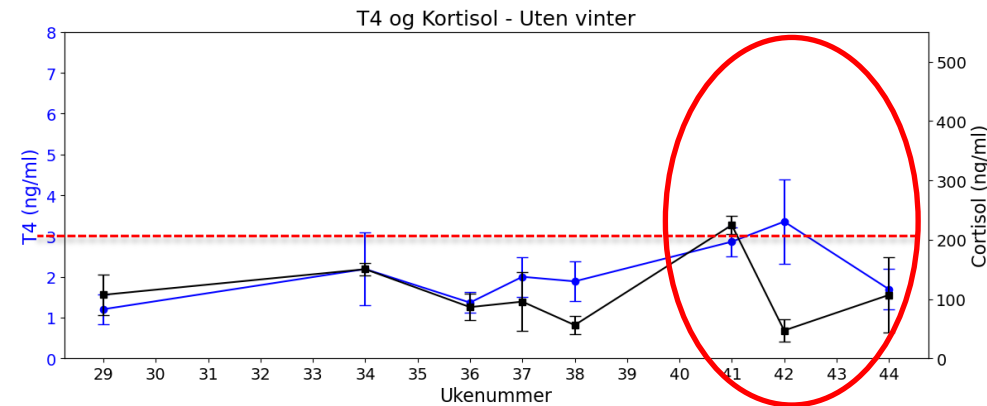
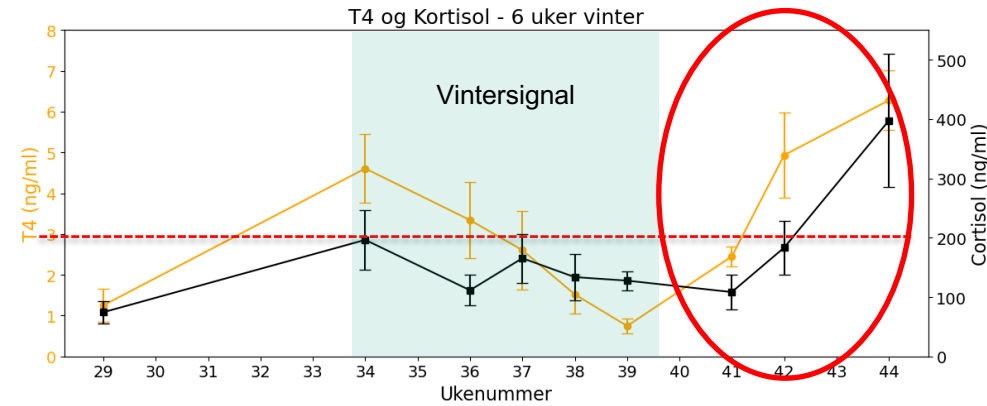
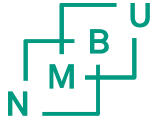


Hoar 1939

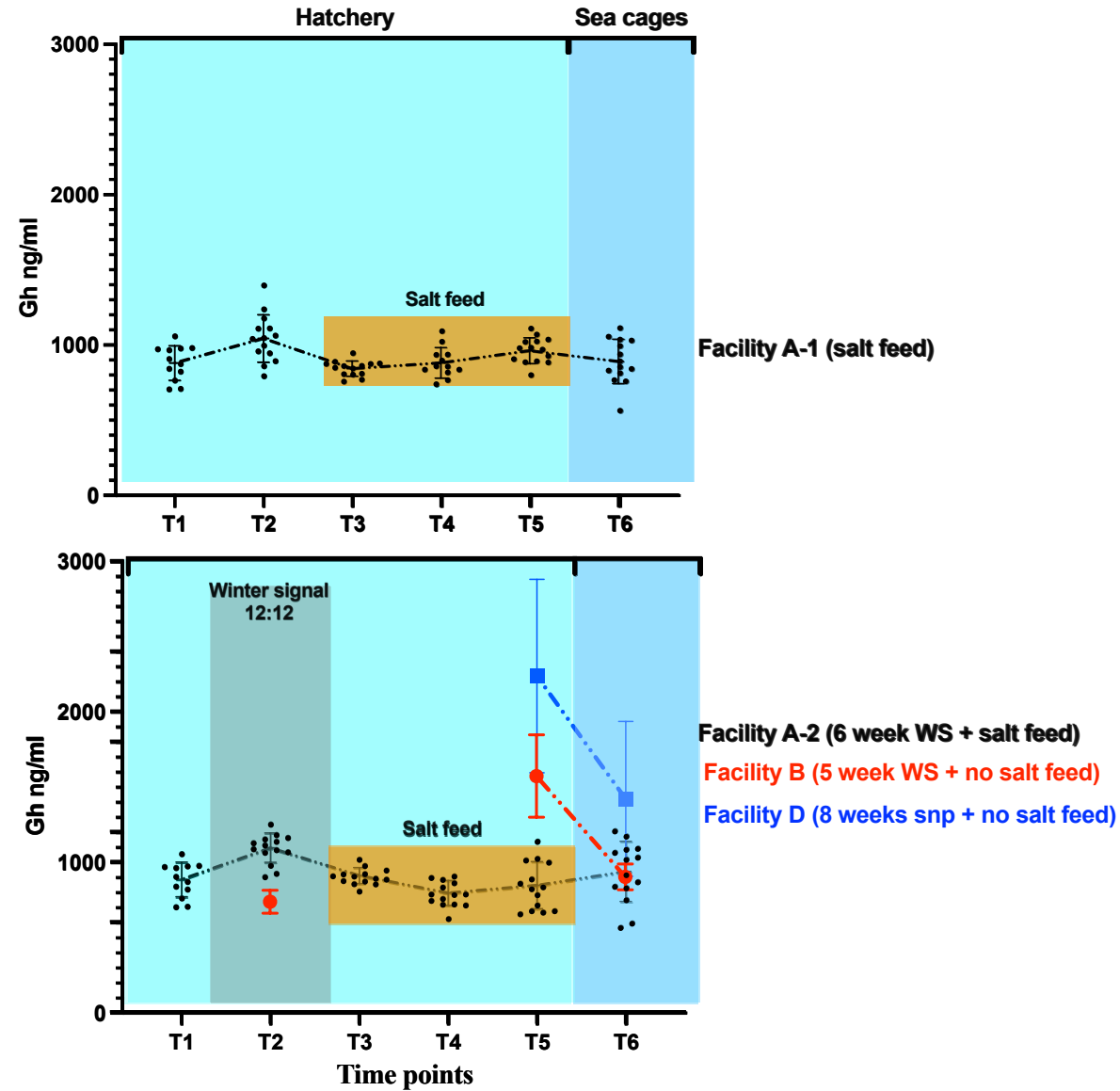
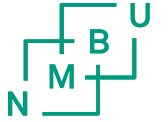


Lys og fotoperiode

- T4 og kortisol responderer kun ved bruk av «vinter»

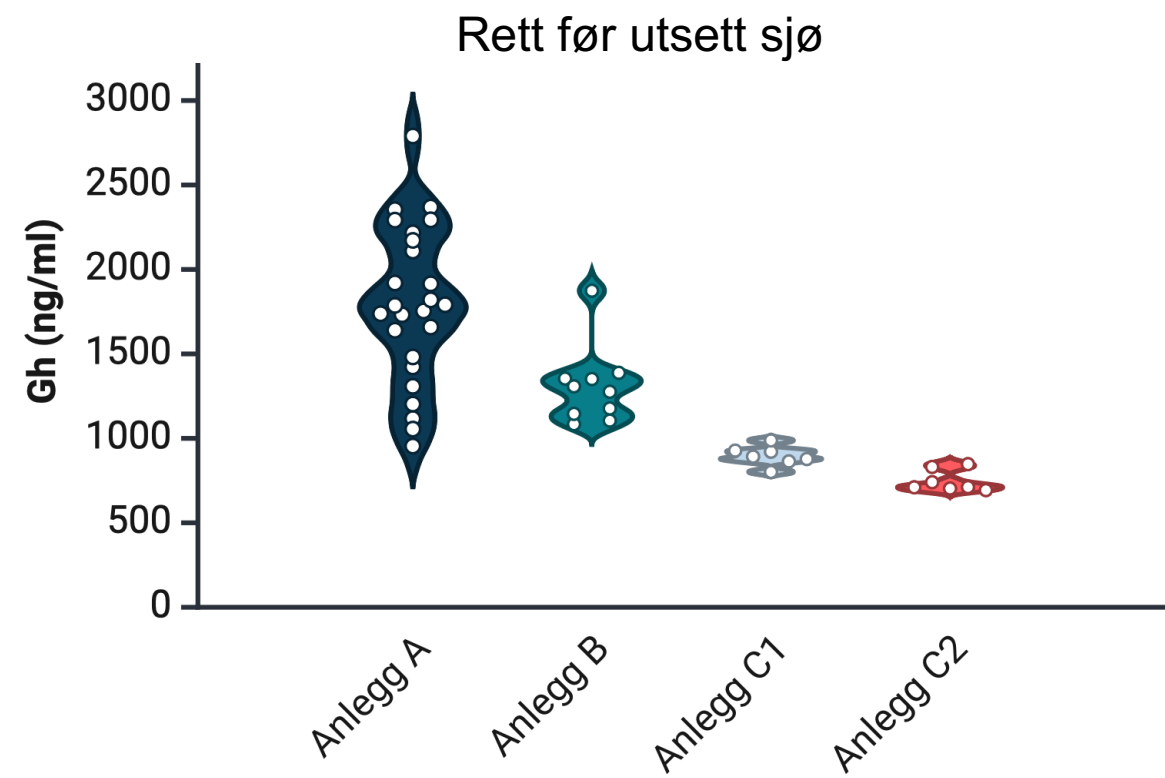
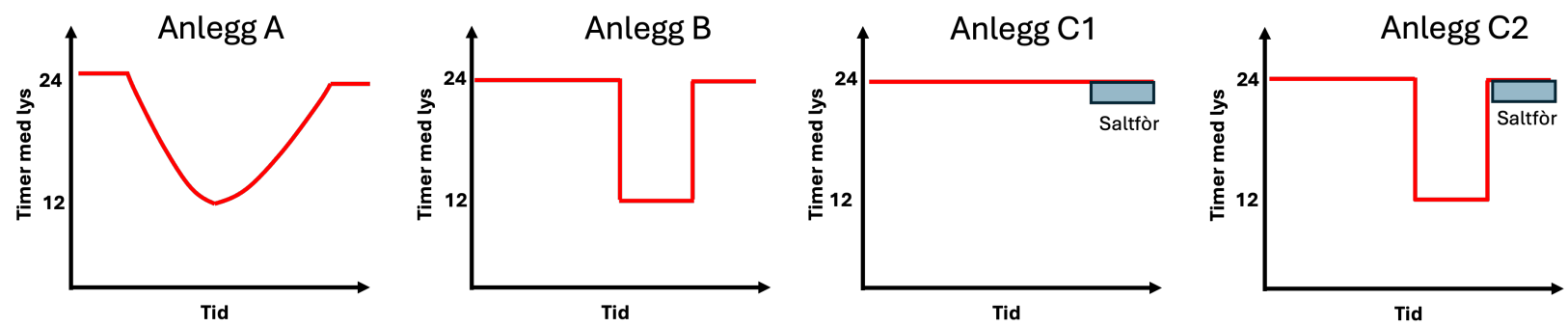
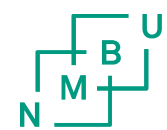


Inhiberer saltfôr frigjøring av veksthormon (Gh)?

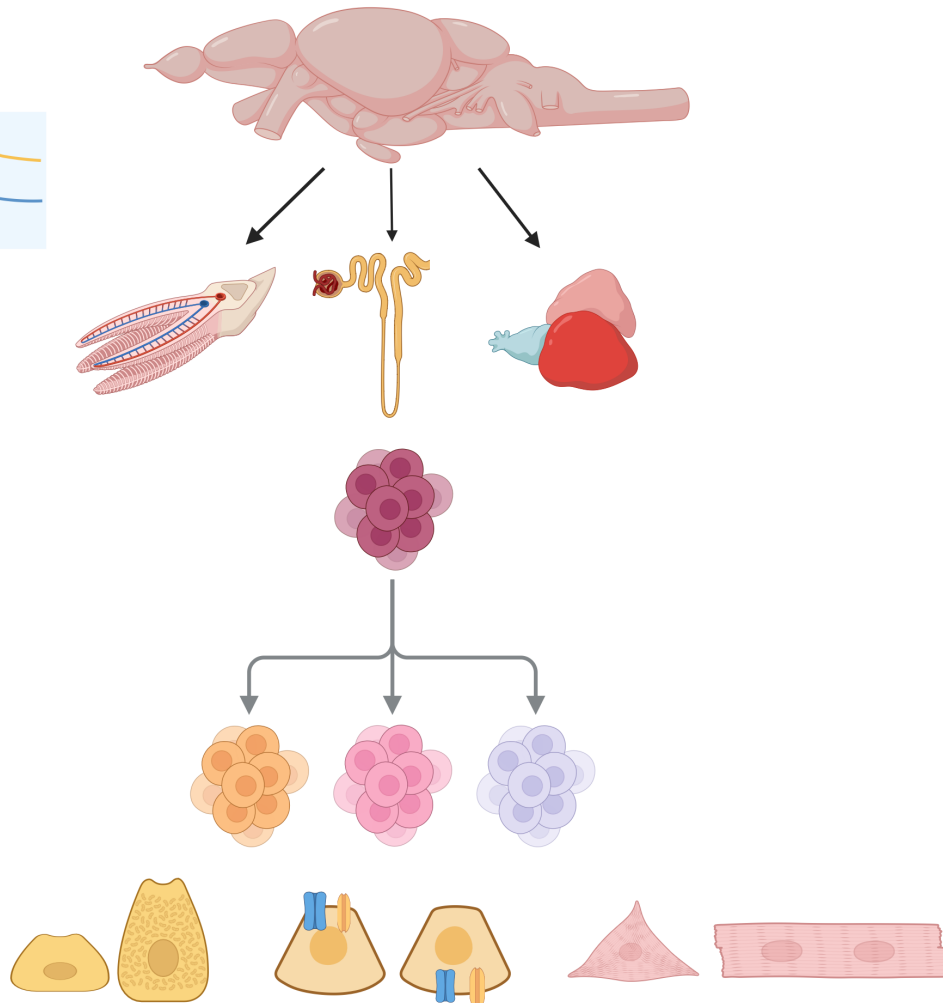
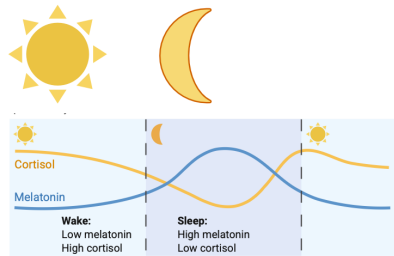
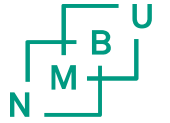


Kan en simulert naturlig fotoperiode føre til øke plasmanivåer av Gh?

– sammenlikning mellom ulike settefiskanlegg

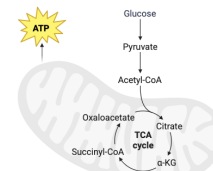
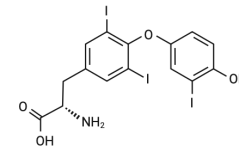


Fortsatt begrenset kunnskap for hvordan hormoner påvirker celler og vev hos laks

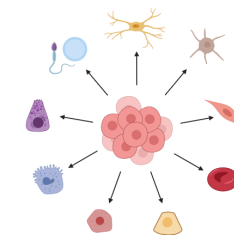
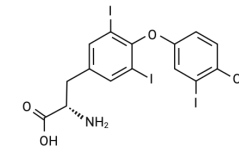


Tyrosin

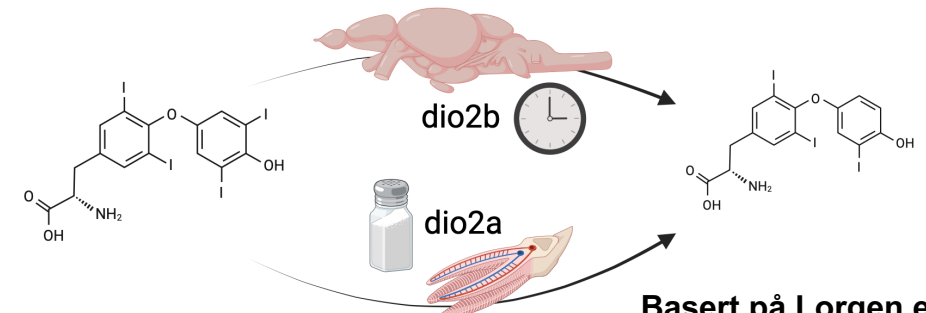
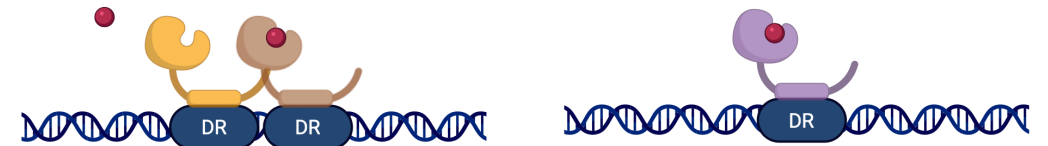
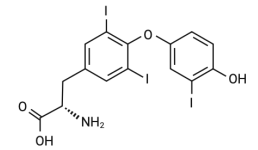
Metabolisme



Differensiering

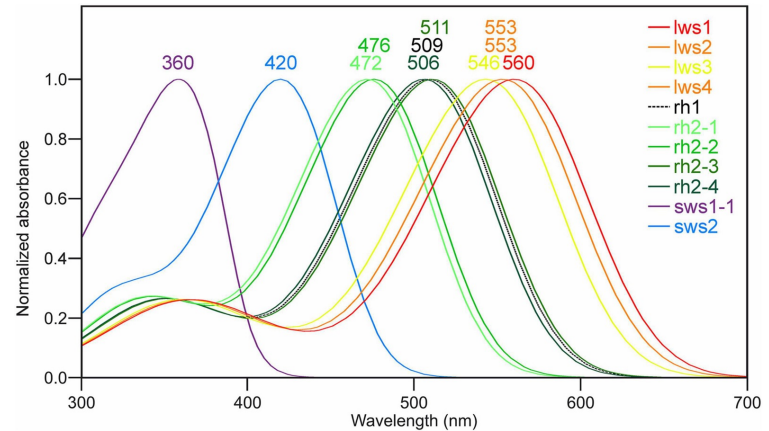
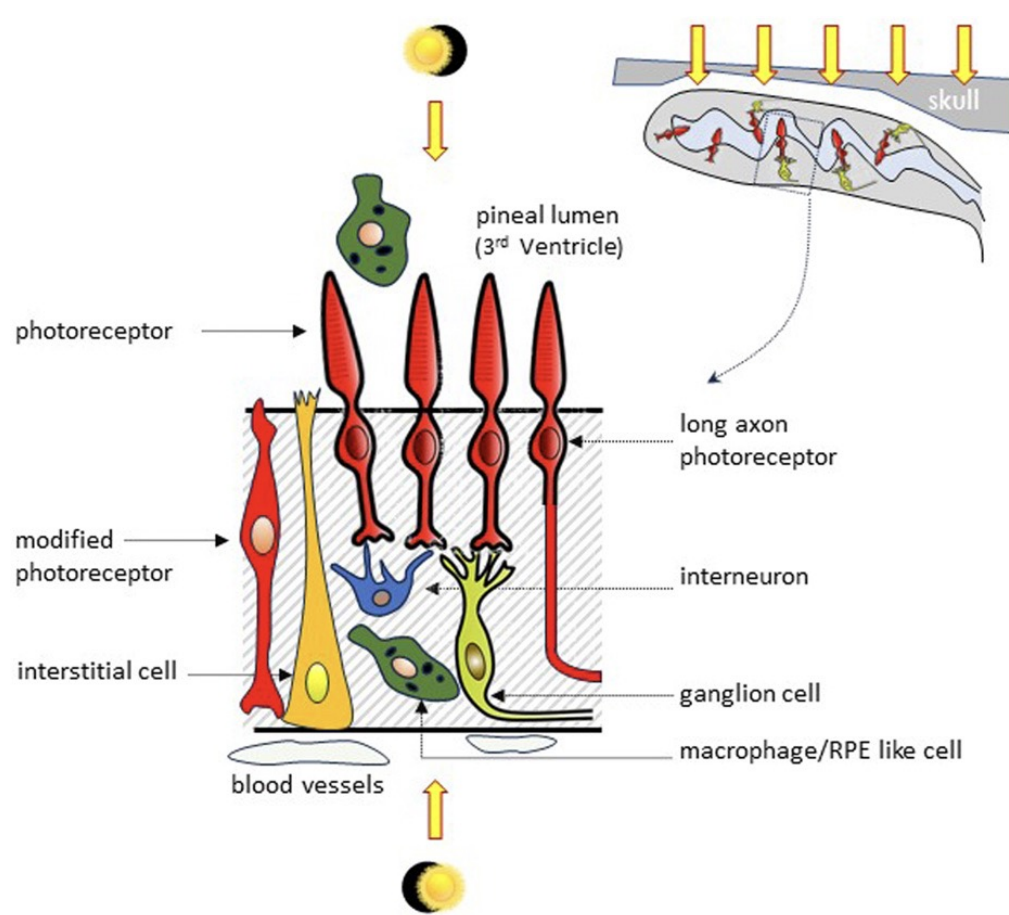
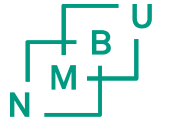


Biologisk rytme

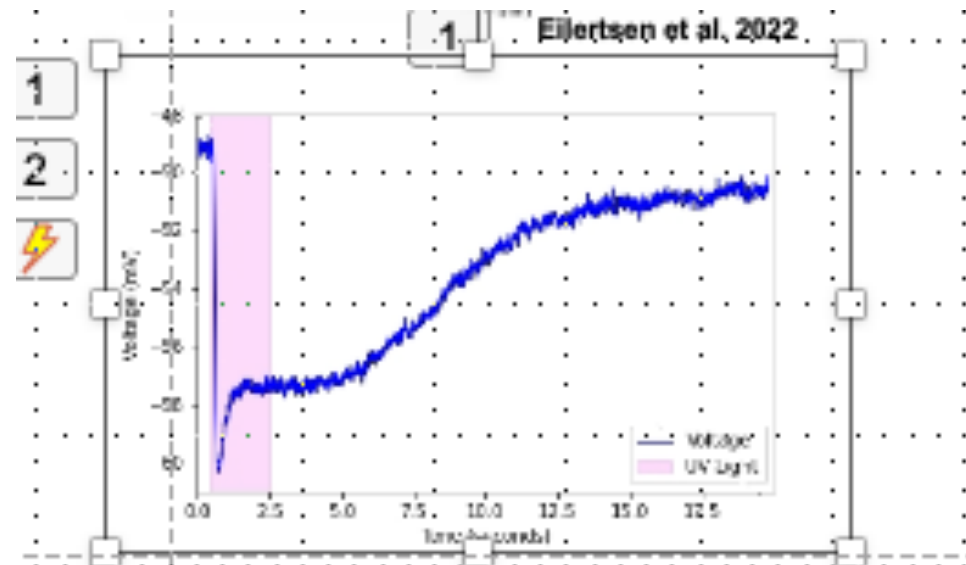


Basert på Lorgen et al 2020

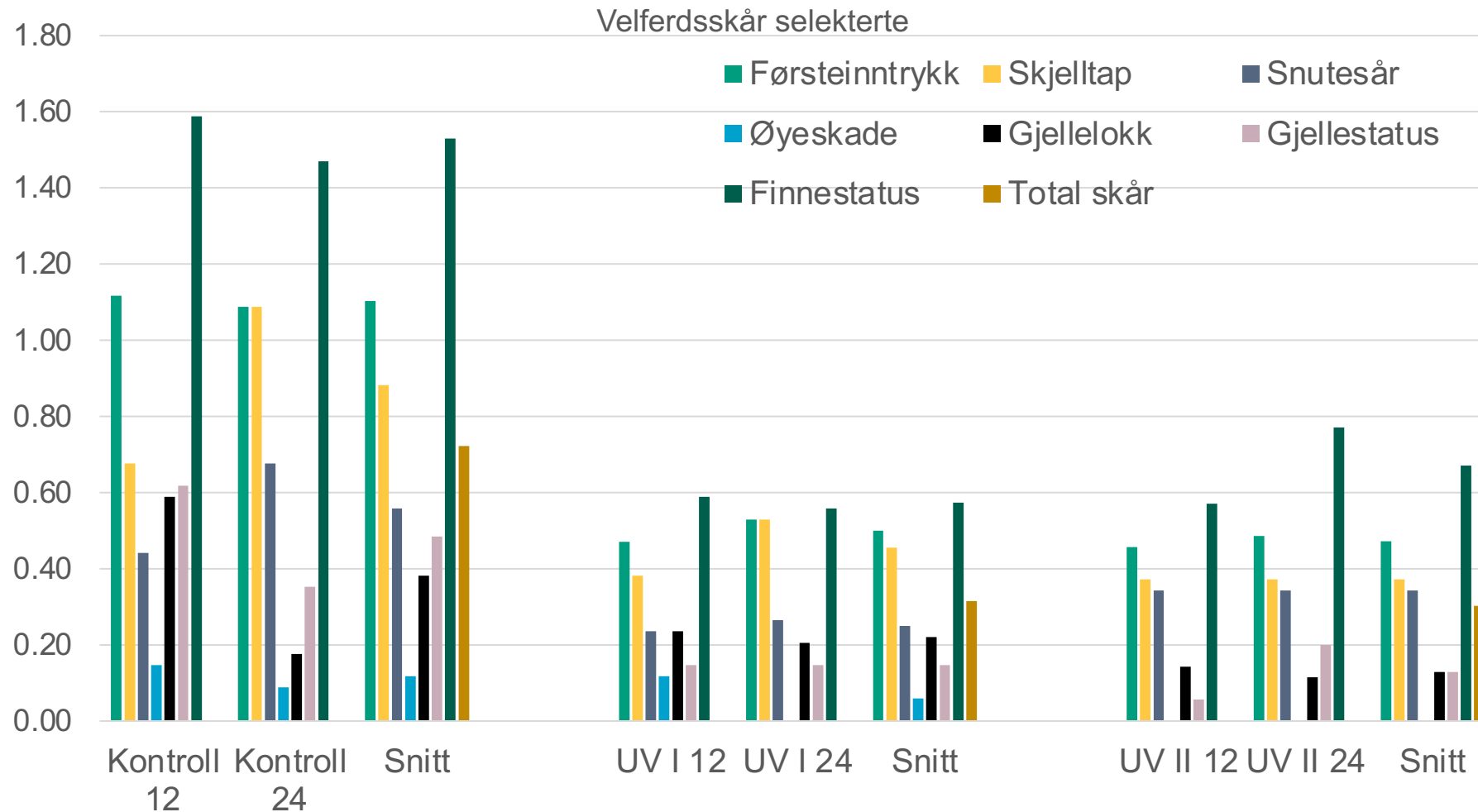
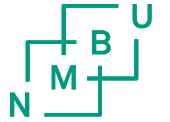
Fortsatt begrenset kunnskap for hvordan miljø påvirker celler og vev hos laks



Eilertsen et al. 2022

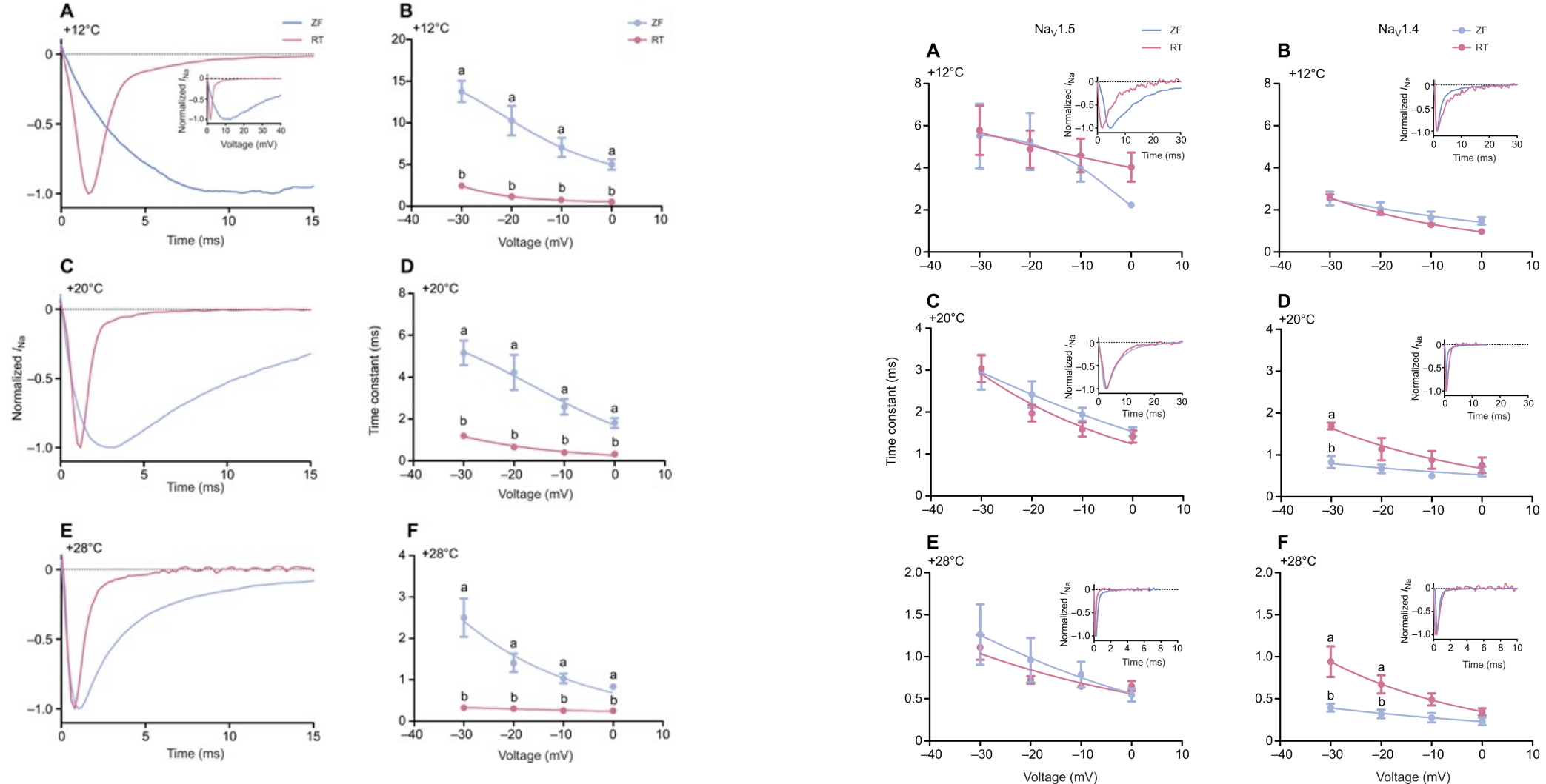
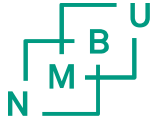


Fortsatt begrenset kunnskap for hvordan miljø påvirker celler og vev hos laks

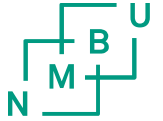


Fisk er ikke altid fisk

Ørret ≠ sebrafisk ≠ cellelinjer (fra pattedyr)



Oppsummering



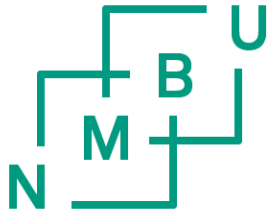
Fysiologisk forståelse – nøkkelen til bærekraftig havbruk

- **Funksjon:** Hvordan celler, organer og hele fisken normalt opererer.
- **Regulering:** Hvordan interne og eksterne signaler (hormoner, miljø) styrer prosessene.
- **Kapasitet:**
 - **Fysiologisk kapasitet:** Tilpasningsevne innenfor normal funksjonsramme.
 - **Patologisk respons:** Når belastning overskrider kapasiteten, oppstår sykdom eller svikt.

Behov for helhetlig tilnærming

- Smoltifisering = **systemisk transformasjon**.
 - Ikke en enkel justering i ett organ eller ett gen.
- Krever integrert forståelse av **hormonell styring, organutvikling og cellulær remodeling**.
- Biomarkører som NKA er nyttige, men **må ses i en større fysiologisk kontekst**.

Tusen takk!



Marit Stormoen
David Persson
Hege Lund
Kjetil Hodne
Ida Hellene Kallevik



Christine Klykken
Torolf Storsul



Elise Hjelle
Svein Alexandersen
Mari Solheim



MOWI ASA
SinkabergHansen AS
AS Sævareid Fiskeanlegg
NRS
Lerøy