

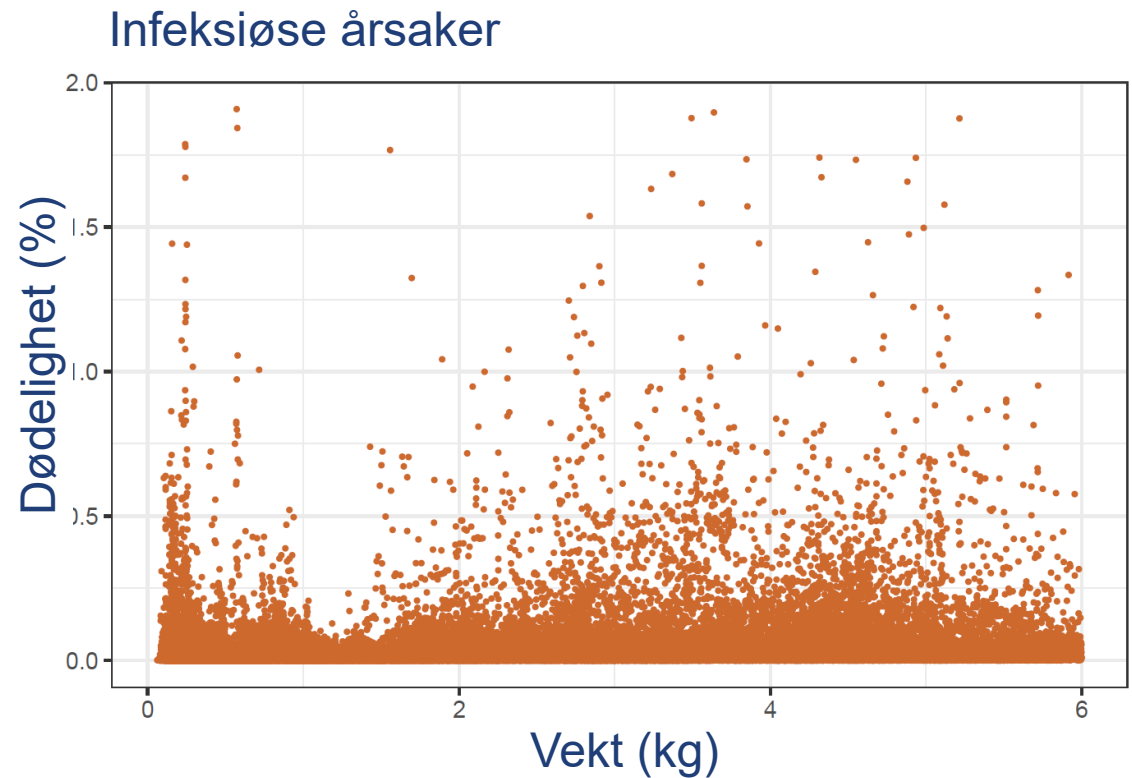
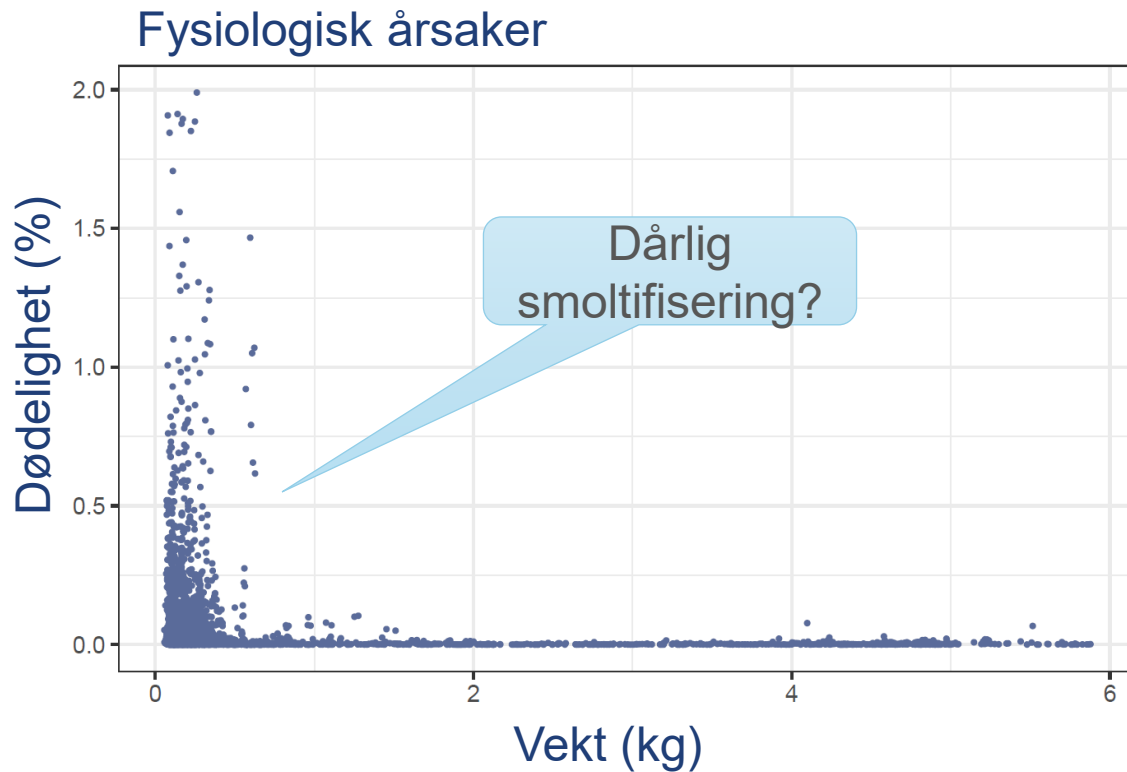


Smoltifisering – hva må man kunne for å produsere robust smolt?

Trygve Sigholt, Senior Scientist

MORFISH, Risiko i landbaserte anlegg, 6. november 2023

Dødelighet i løpet av produksjonssyklus



Victor Henrique Silva de Oliveira, Veterinærinstituttet
Havbruk 2022

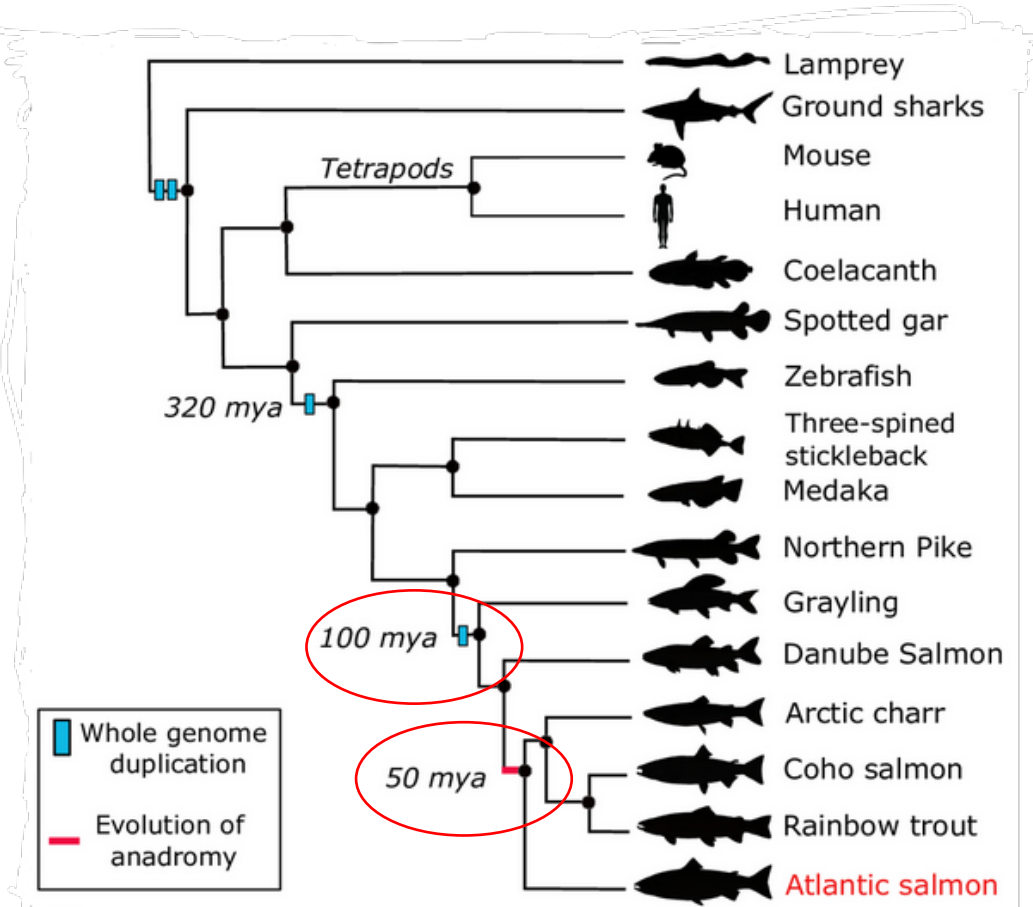


Hva er en smolt?

En **smolt** er en ung laks som kan

- **Overleve og**
- **Vokse normalt i sjøvann**

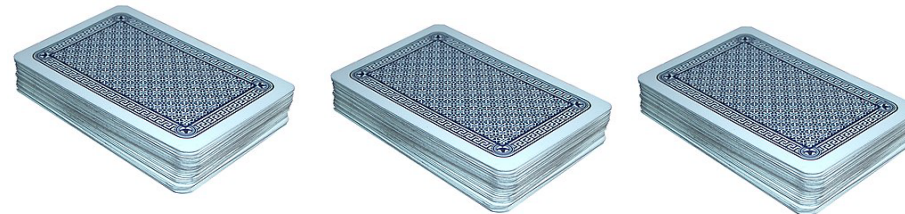
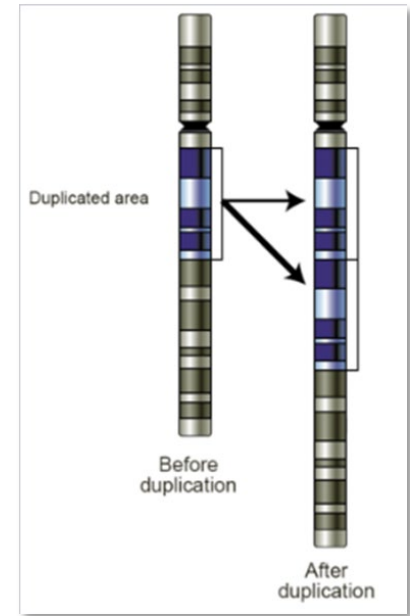
Helgenomduplikering og anadromi



Hel-genom-duplikering

Ekstra kopi av gener

Stor tilpasningsevne til miljø



Typer av sjøvannstoleranse hos laksefisk



- Utvikling som yngel (pukkellaks: *O. gorbuscha*)



- Gradvis utvikling med økende størrelse (bekkerøye: *Salvelinus fontinalis*)

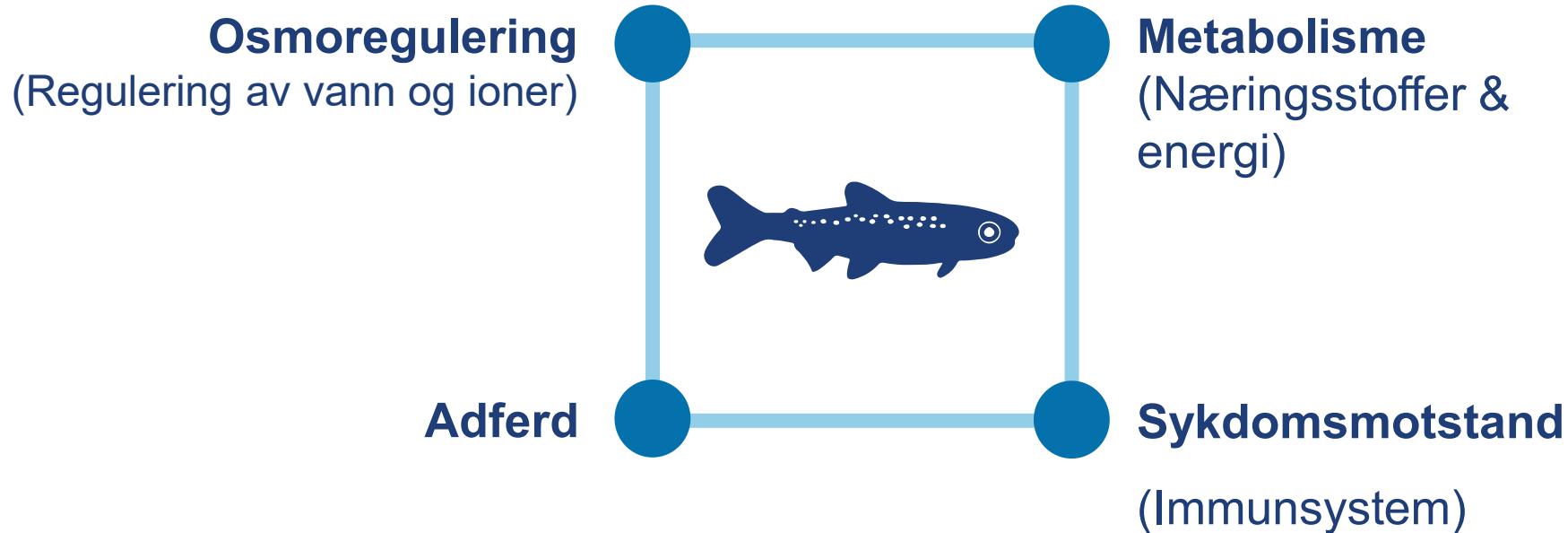


- Miljøstyrt pre-adaptasjon til sjøvann (Atlantisk laks: *Salmo salar*)



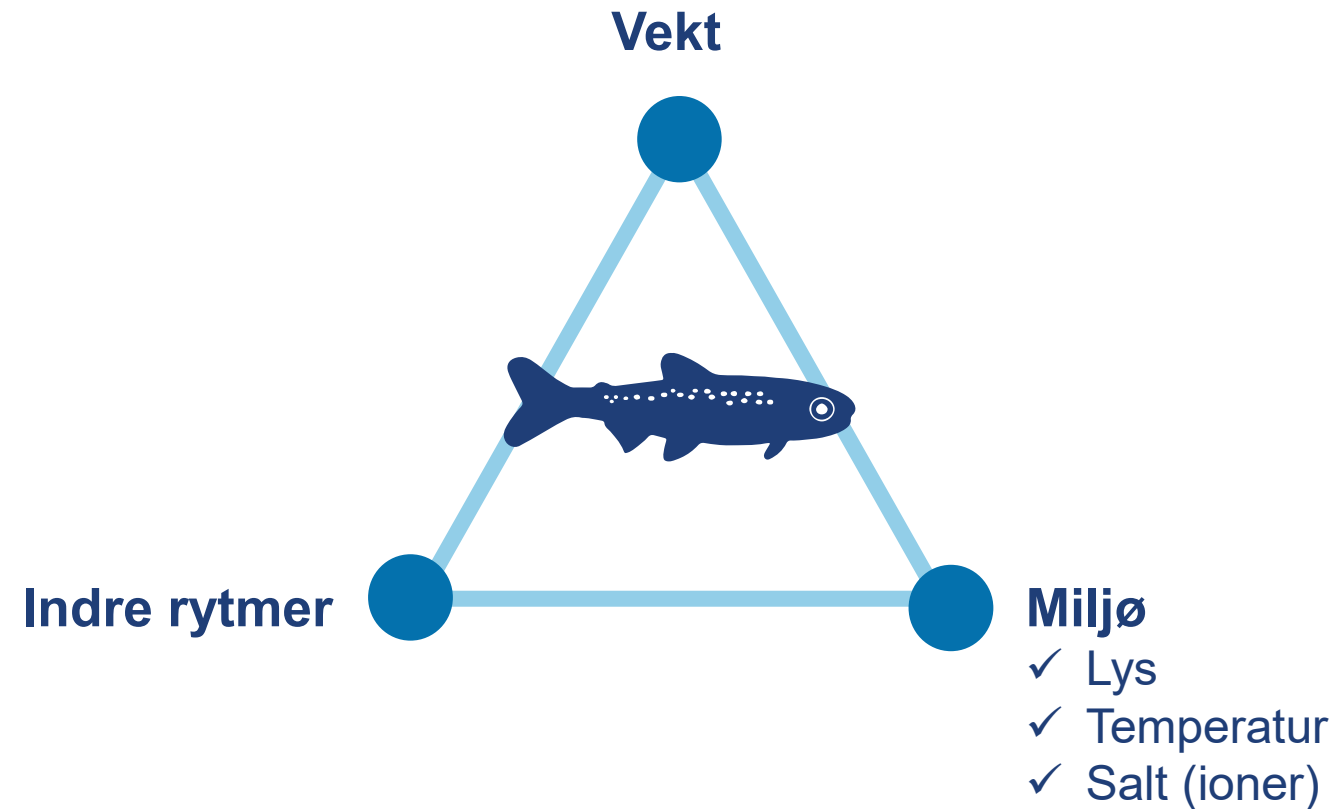
Smolt-endringer

“Smolt-firkanten”

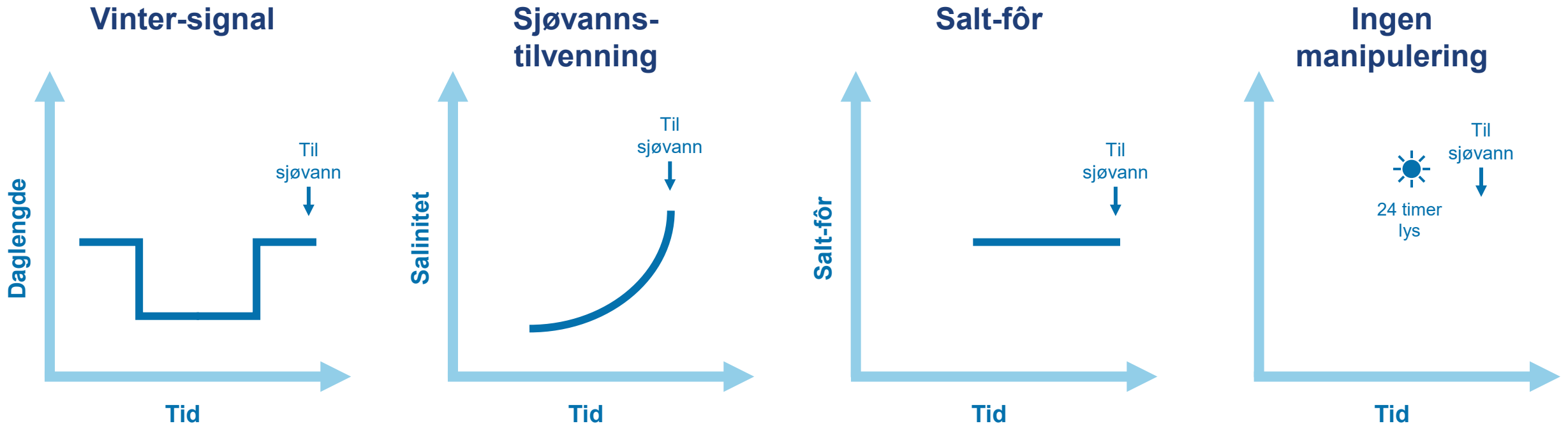


Hva regulerer smoltifisering?

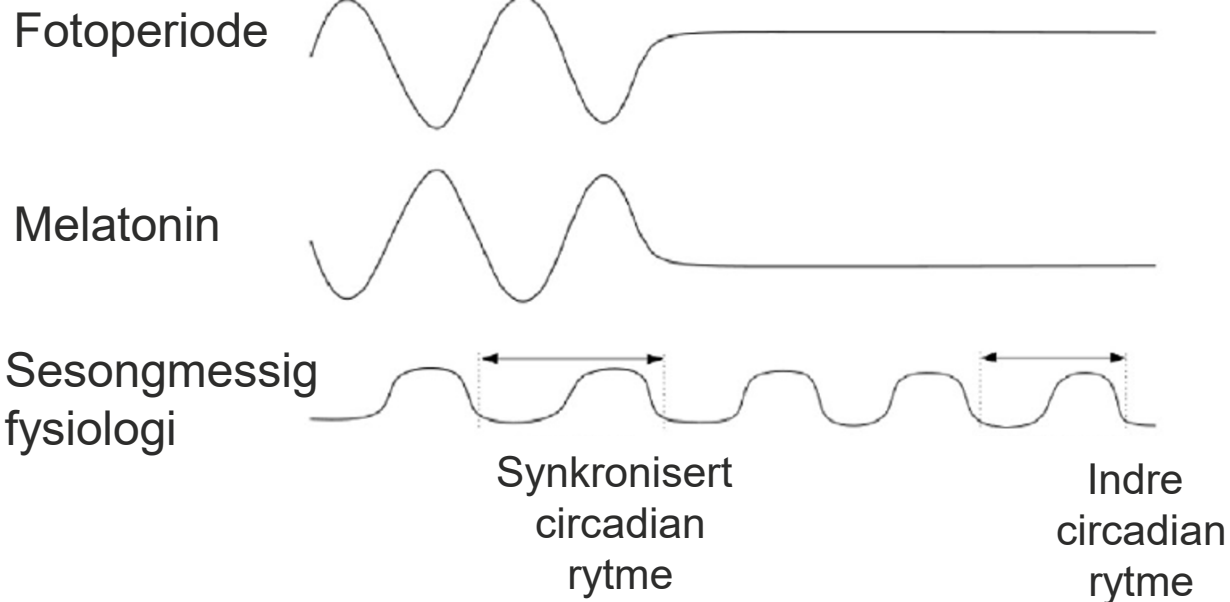
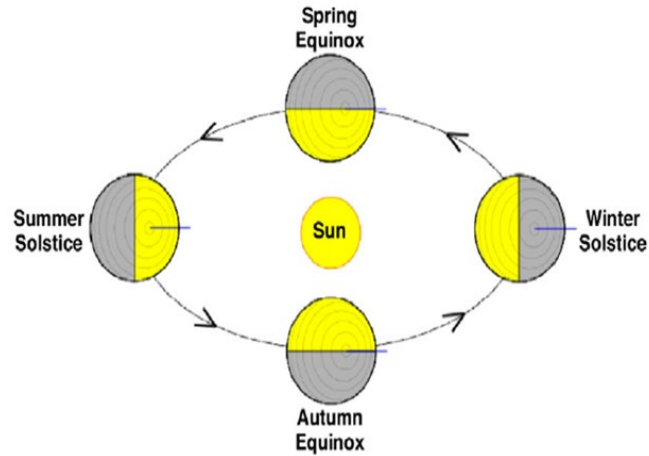
“Smolt-trianglet”



Smoltifiserings - strategier



Circadiane- og circannual-rytmer



Jordrotasjon

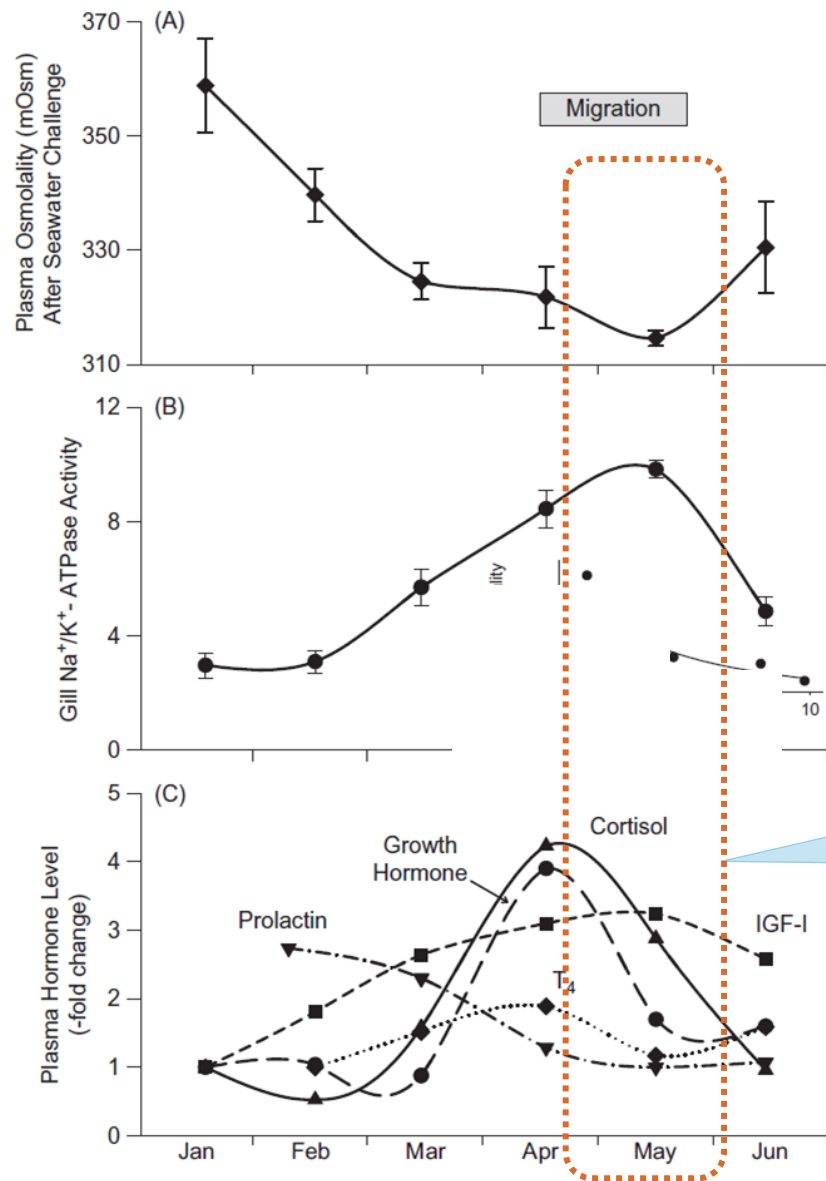
Rotasjon rundt sola

Circadiansk klokke
~24 timer

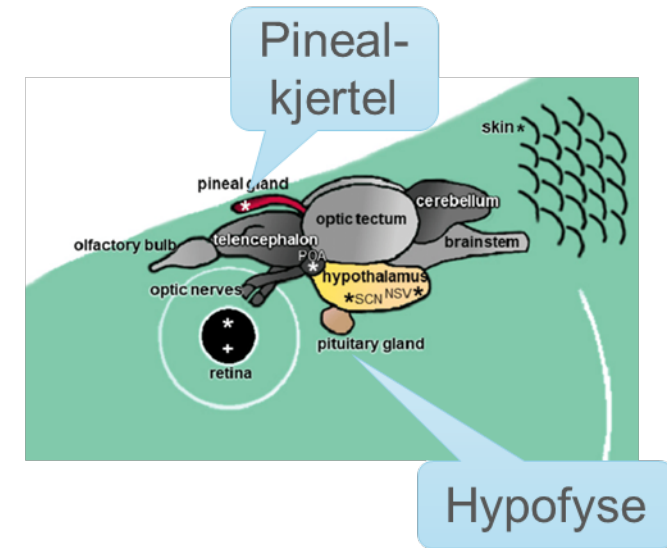
Circannual klokke
~12 måneder

Fotoperiodisme

Sesongbasert fysiologi

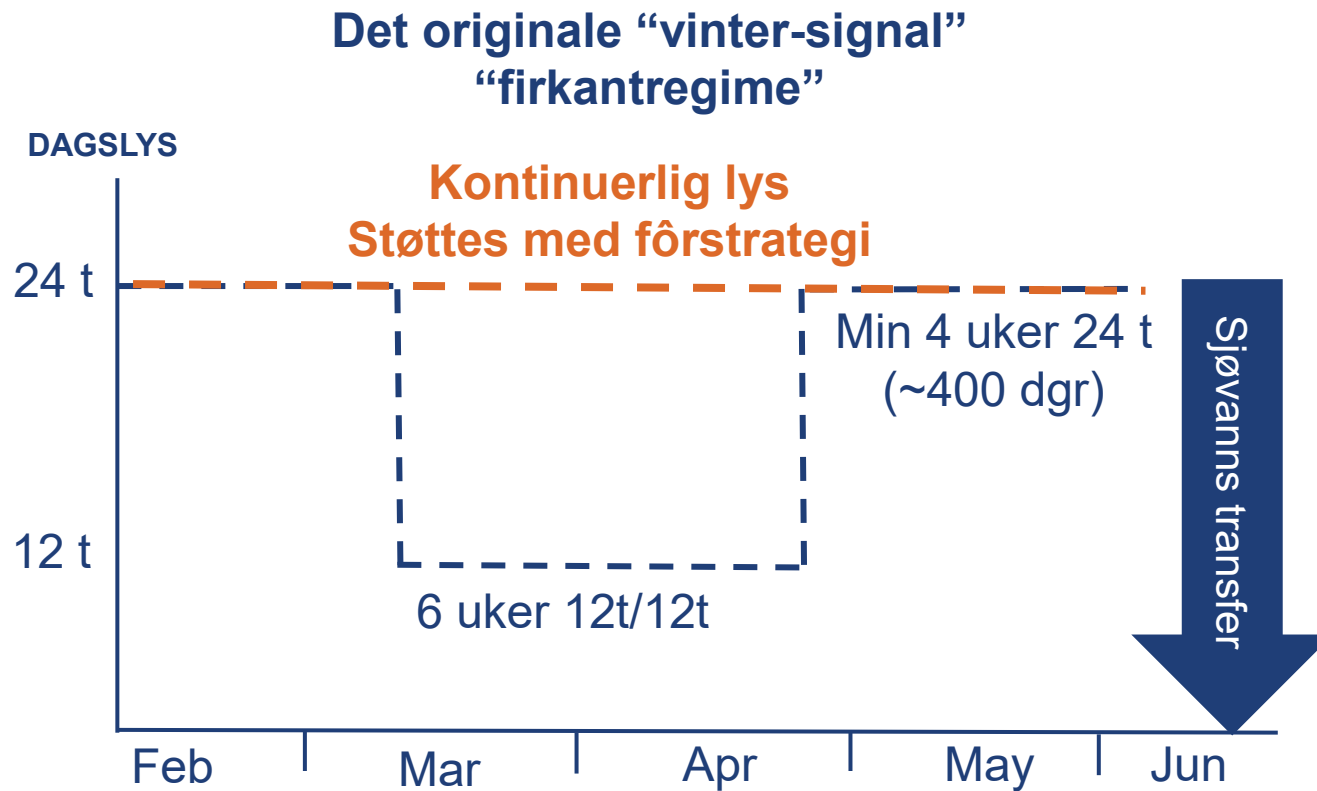


Smolt-
vindu



Franziska Kupprat (2022) Effects of skyglow on the physiology of the Eurasian perch, *Perca fluviatilis*. PhD Thesis

Lysets kraft

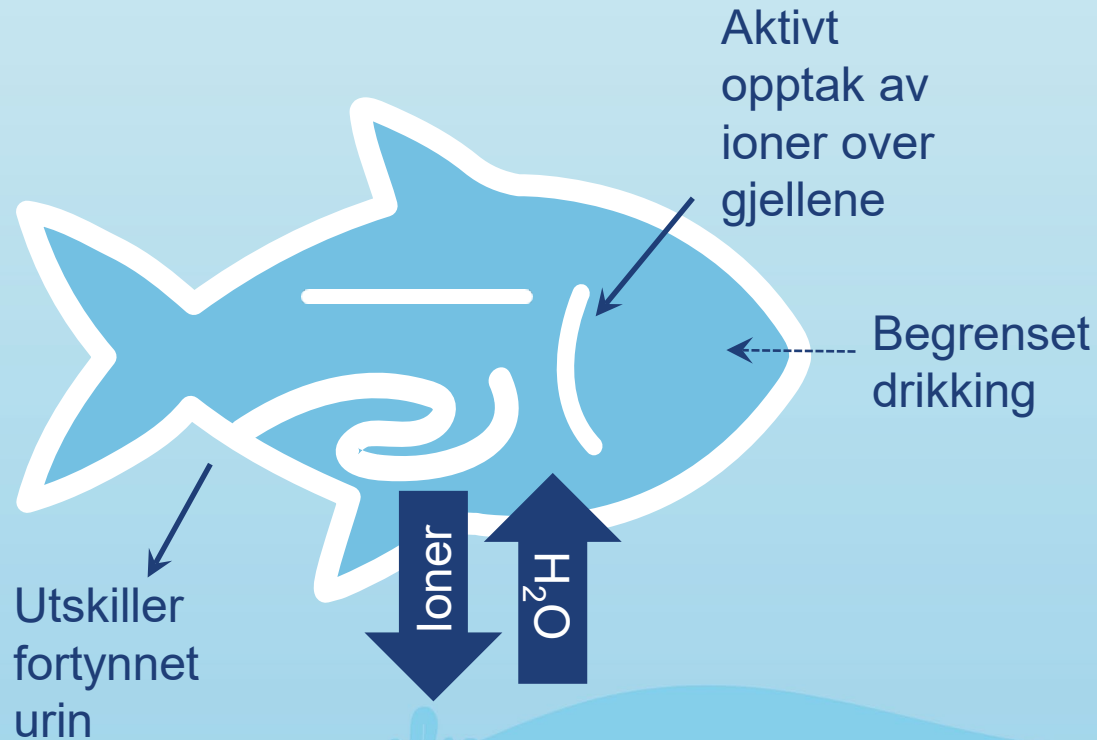


- Vinter-signal, firkantregime (Zeitgeber)
- Simulerer korte vinterdager
- Synkroniserer
 - ✓ de endogene rytmene i den enkelte fisk
 - ✓ hele populasjonen skal bli smolt samtidig

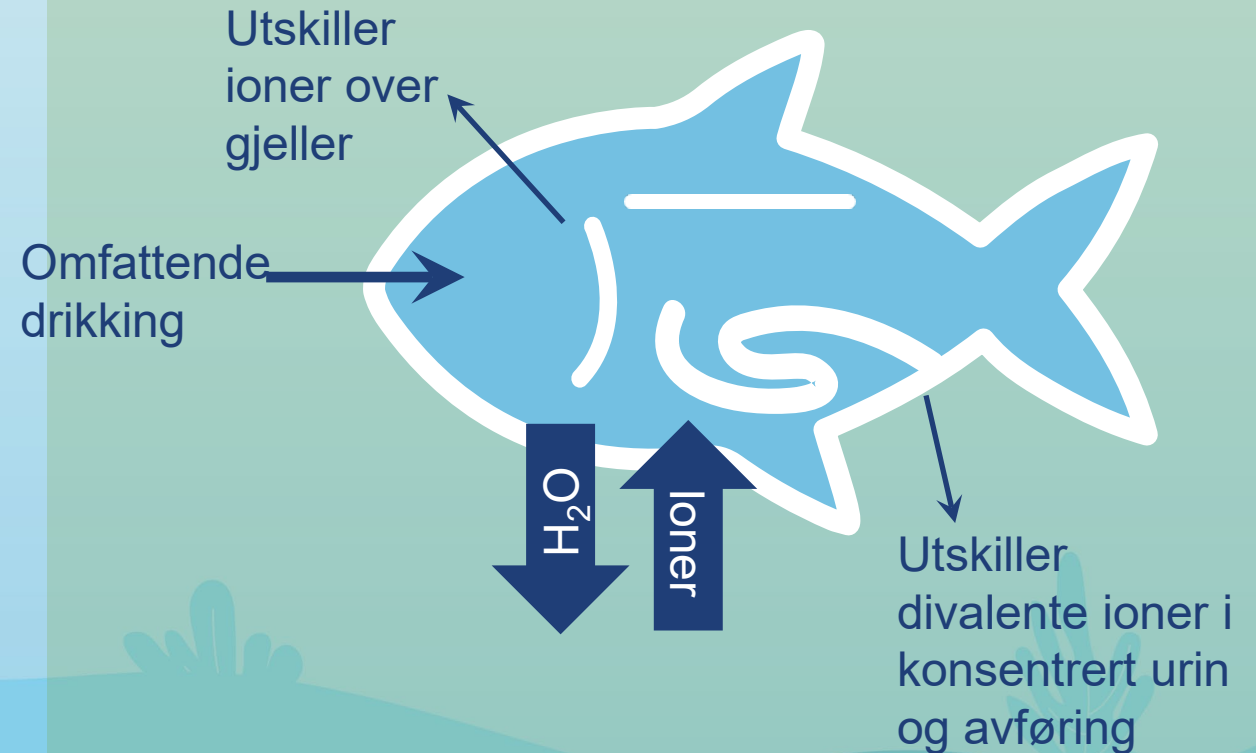
Skifte miljø fra **FERSKVANN** til **SJØVANN** opprettholder indre ione- og vannbalanse



Ferskvann

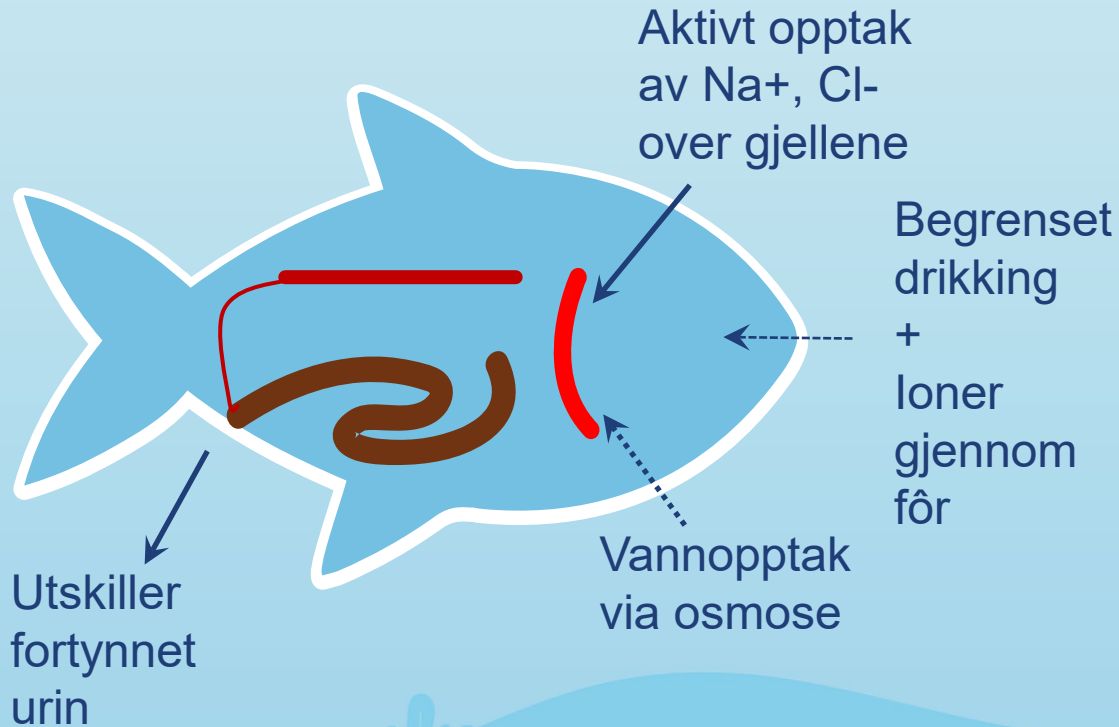


Sjøvann



Smoltifisering innebærer en synkronisert endring i **GJELLER**, **TARM** og **NYRE** for å oppretthold ione- og vannbalanse i sjøvann

Ferskvann



Sjøvann



Tre osmoregulatoriske organer må jobbe synkront sammen i en robust smolt

Indikatorer for sjøvannsklar smolt

HVA DU SER

Morfologi

- ✓ Sølvfarging
- ✓ Ingen parrmerker
- ✓ Mørke finnekanter
- ✓ Lav kondisjonsfaktor

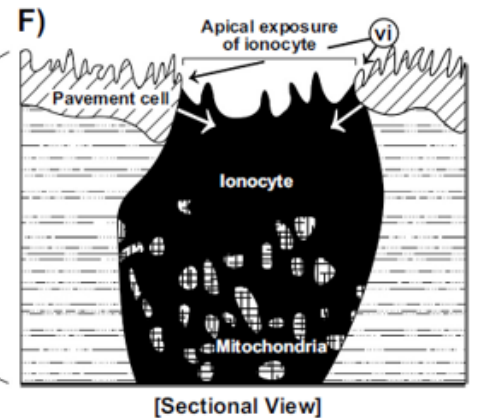
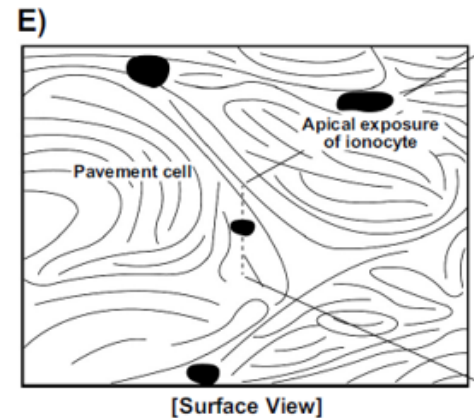
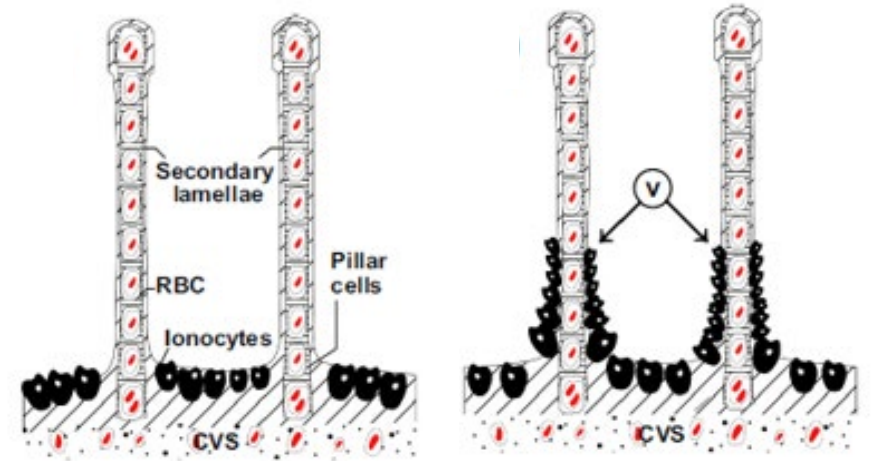
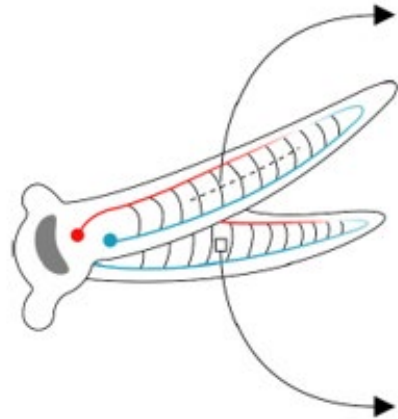
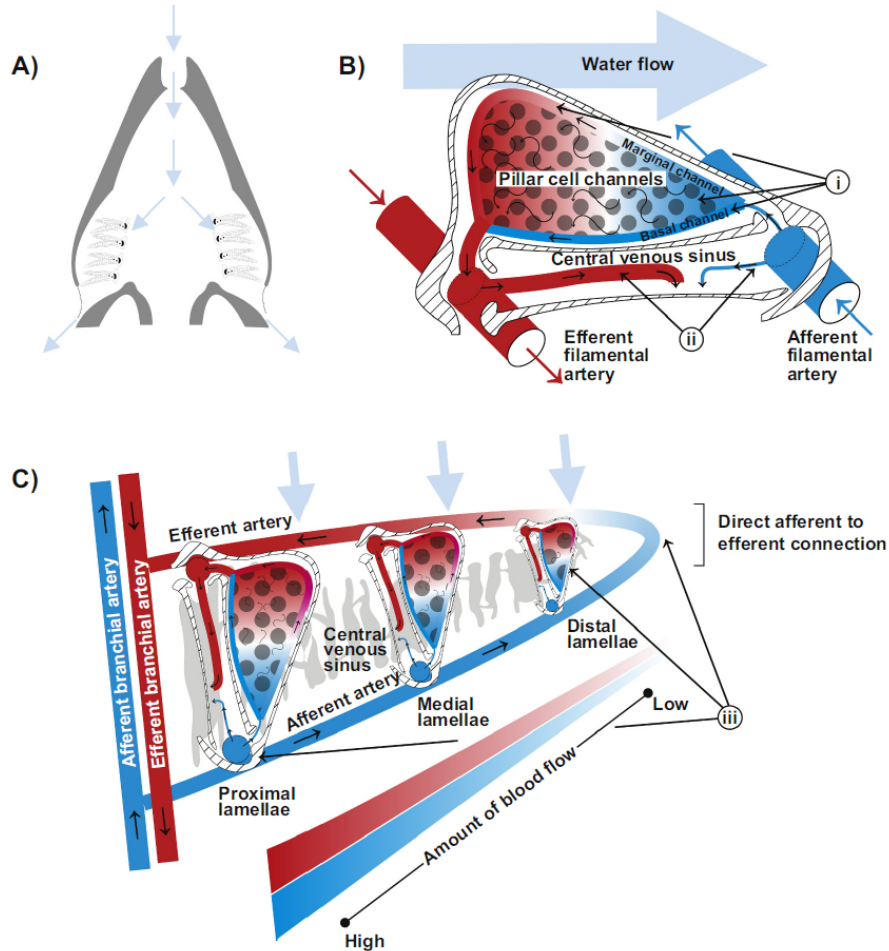
Atferd

- ✓ Stimatferd
- ✓ Svømming medstrøms

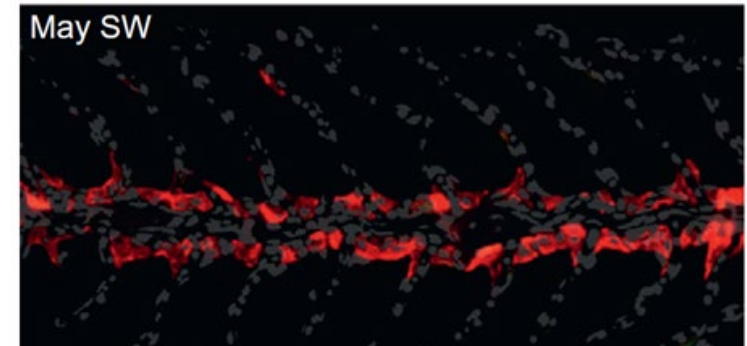
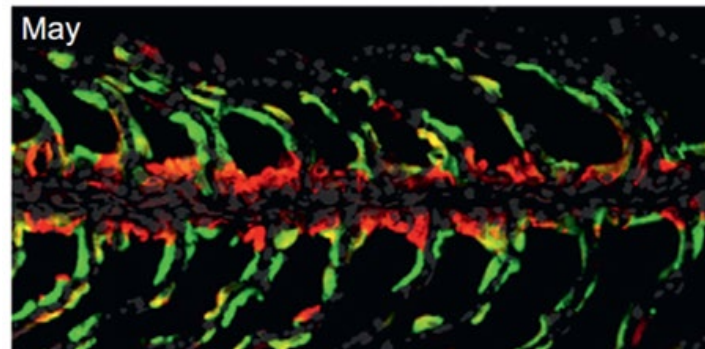
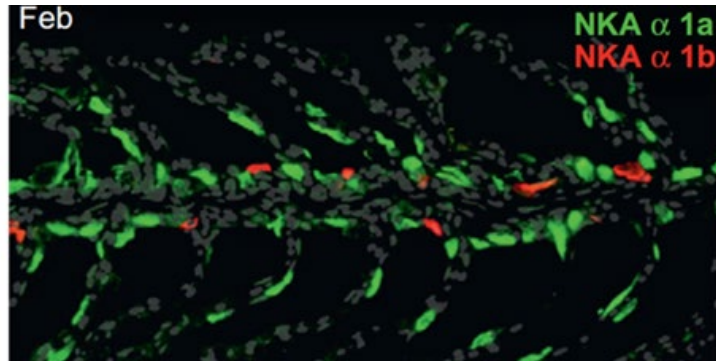
HVA DU MÅLER

Ioneregulering

- ✓ Ioner i blod (Na^+ , Cl^- , osmolalitet)
- ✓ Enzymer og gener som regulerer "pumpene" (NKA α 1a, NKA α 1b, NKCC, CFTR)



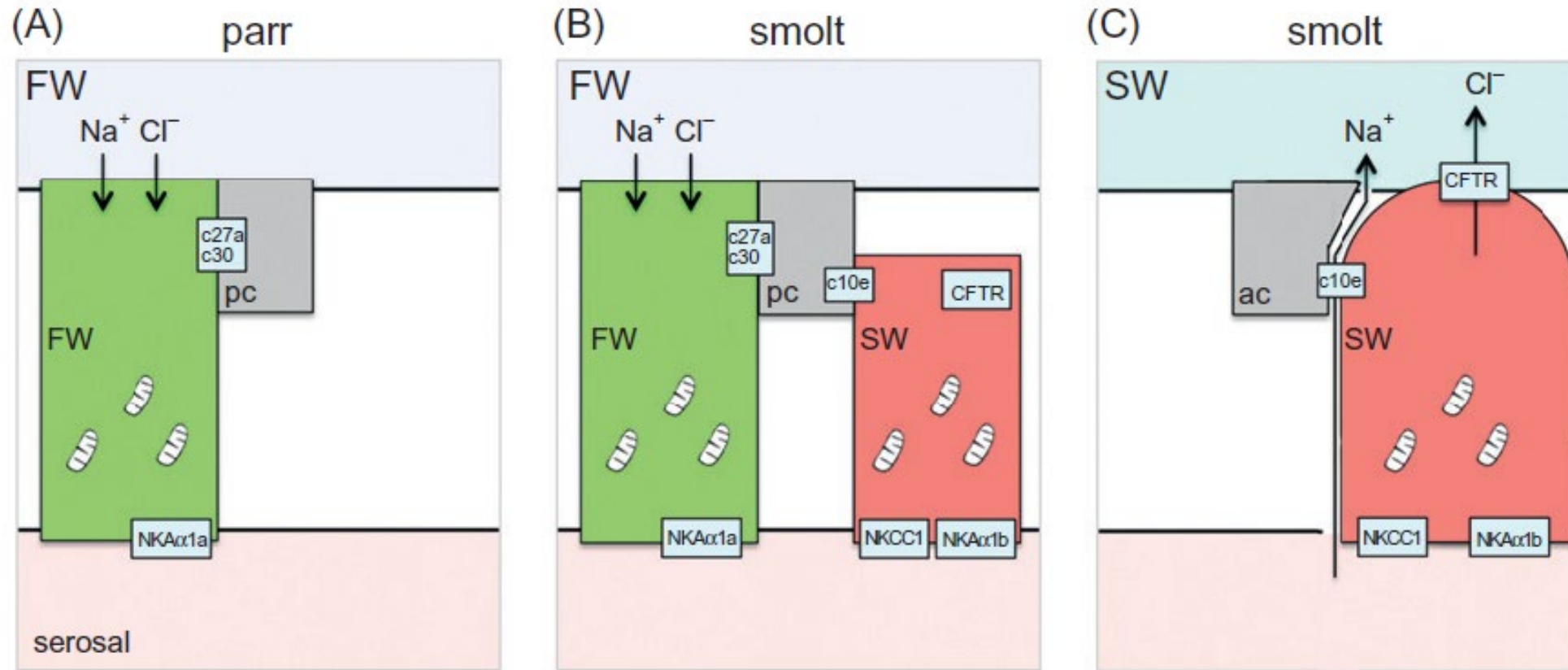
Gjeller spiller en sentral rolle i salttransport



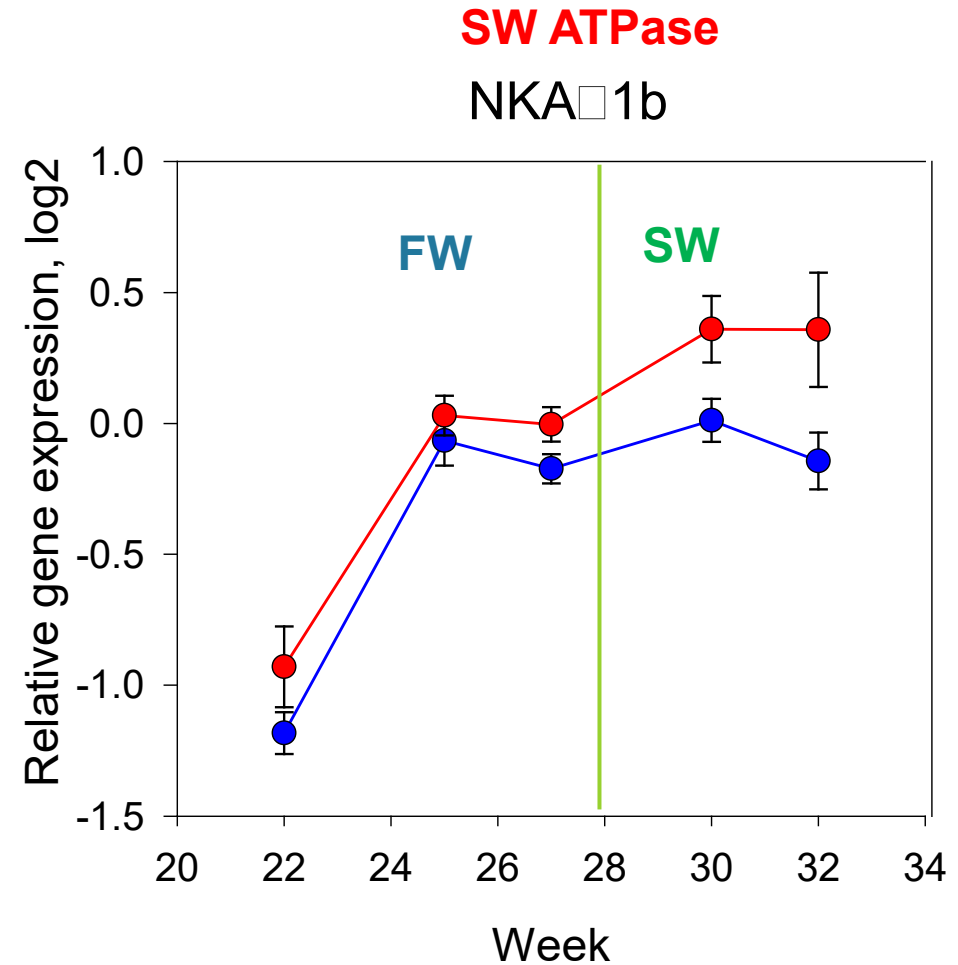
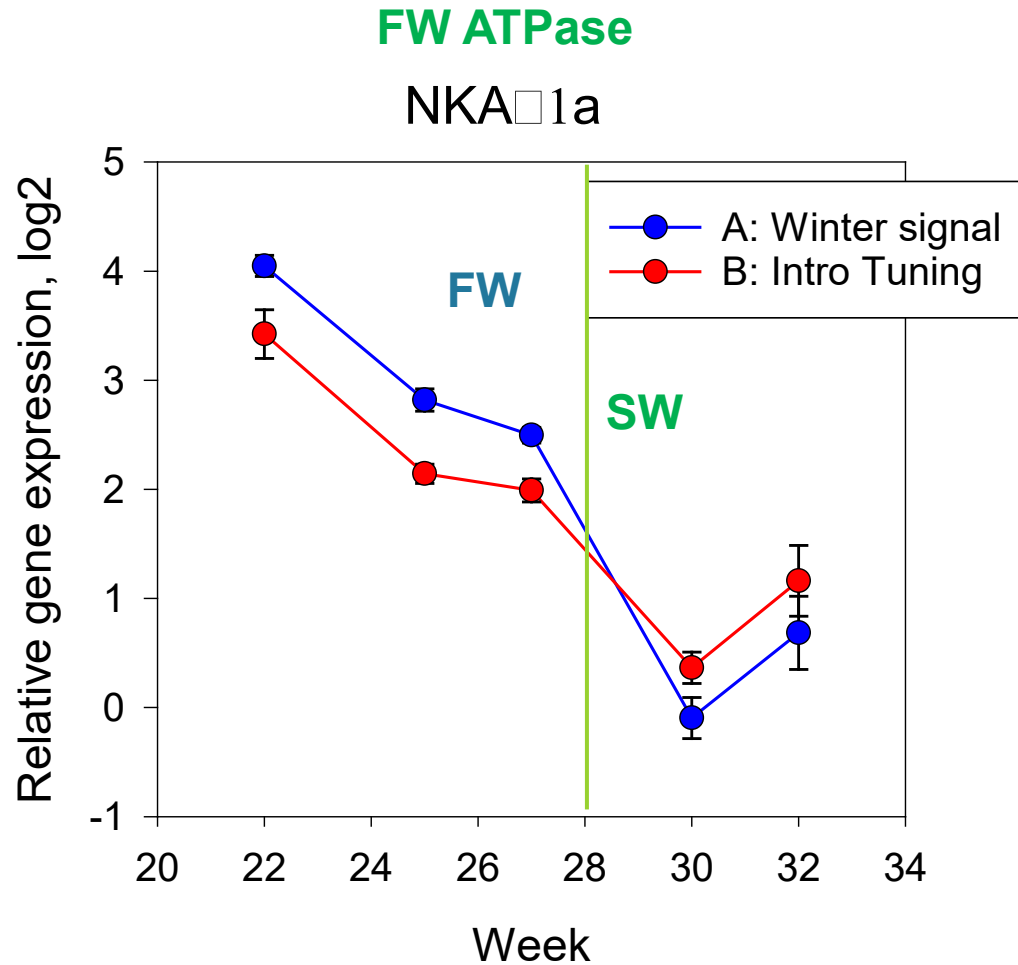
Celler som regulerer ione-
balansen i **FERSKVANN**

Celler som regulerer ione-
balansen i **SJØVANN**



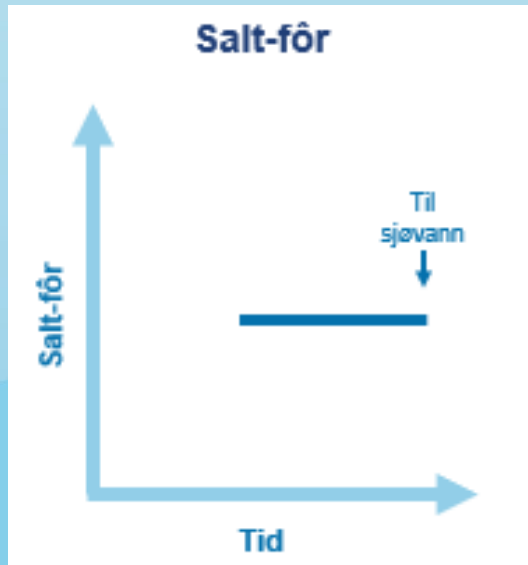
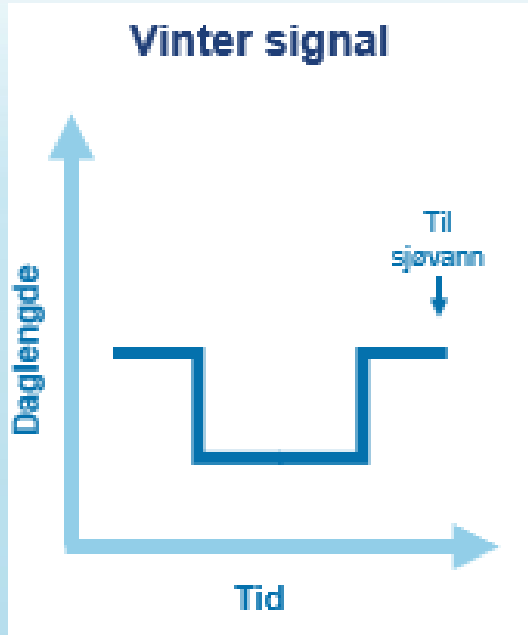


Smoltifiseringsdieter støtter sjøvannstilpasningen



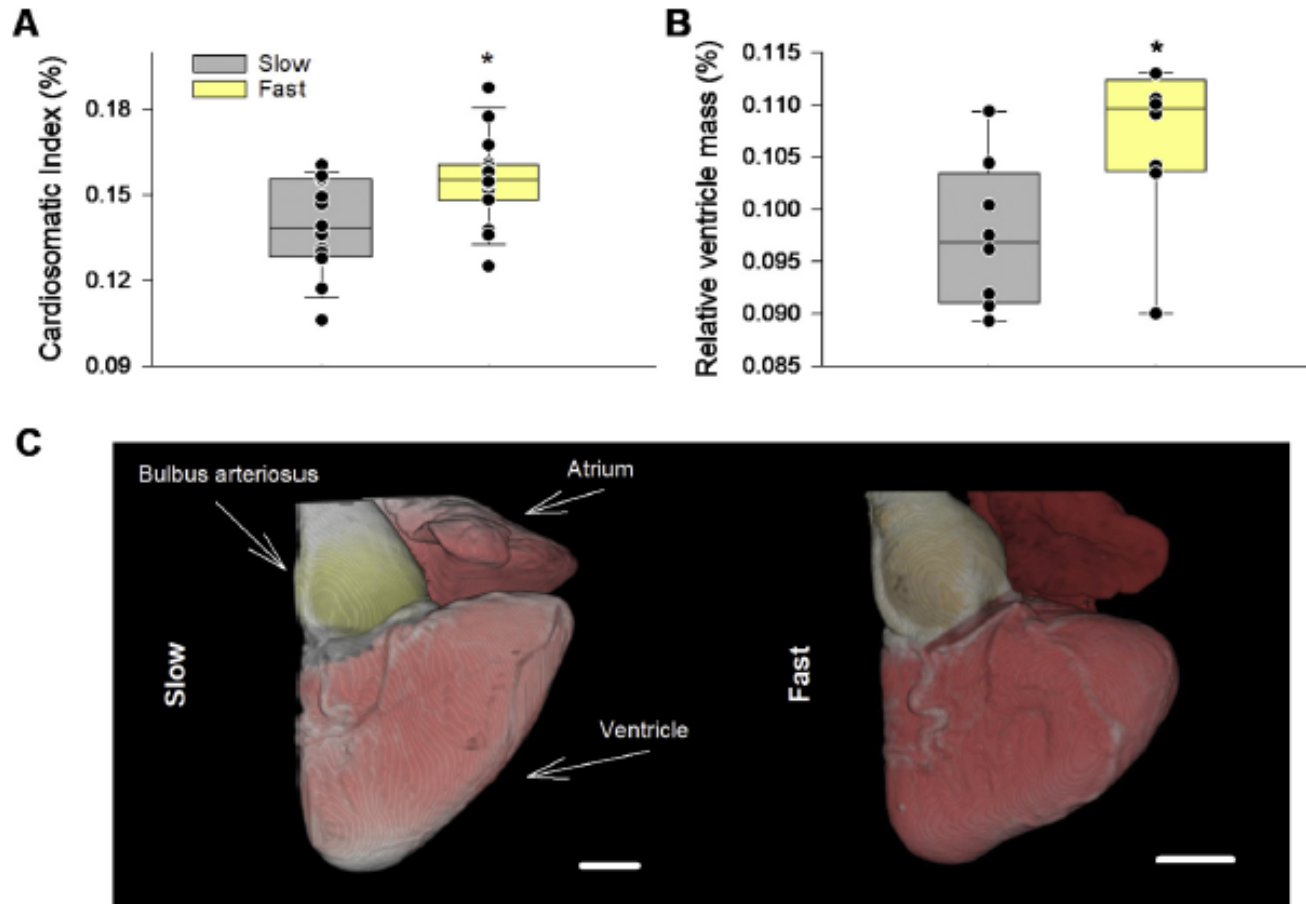
“Best of two worlds?”

Kombinere lysmanipulering med en salt-diett



- ✓ Synkronisering av populasjonen (enda mer aktuelt for stor smoltproduksjon)
- ✓ Forlenge "smoltvinduet"
- ✓ Forbedre kontroll med smoltifisering
- ✓ Støtter hjerteutvikling og robusthet i sjøvann

Rask vekst er ikke best for hjerte i sjø



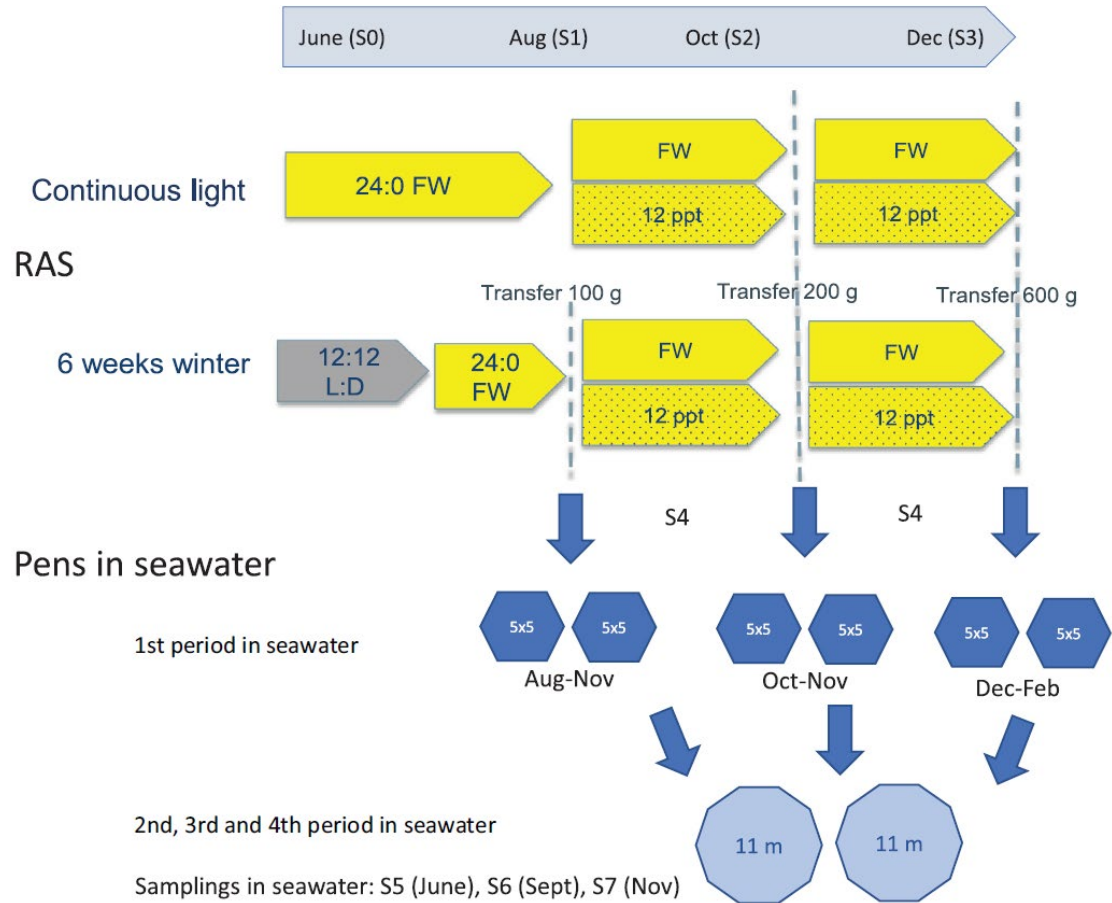
Rask (fast) smolt: 11 måneder ved 13 °C
Langsom (slow) smolt: 18 måneder ved 8 °C

- Rask smoltproduksjon:
- Større kardio-somatisk indeks (CSI: (Hjertevekt/kroppsvekt) *100)
- Rundere hjerte
- Bulbus feiljustering
- Tykkere compactum

Avvikende hjerteform:
✓ Raskere aldring
✓ Hjertesvikt

Frisk et al. 2020. Aquaculture 529: 735615. FHF-project 901586

Er storsmolt best?



Light	Salt	Freshwater	Brackish
6 uker 12 hour vinter-periode	FW + ☾	100 g 200 g 600 g	12 ppt + ☾ 200 g 600 g
		24 hour	FW + ☀ 200 g 600 g



Rapport 38/2018 • Utgitt desember 2018

Hva betyr fremtidens produksjonsstrategier for ytelse, helse og velferd i sjøfasen (BENCHMARK)

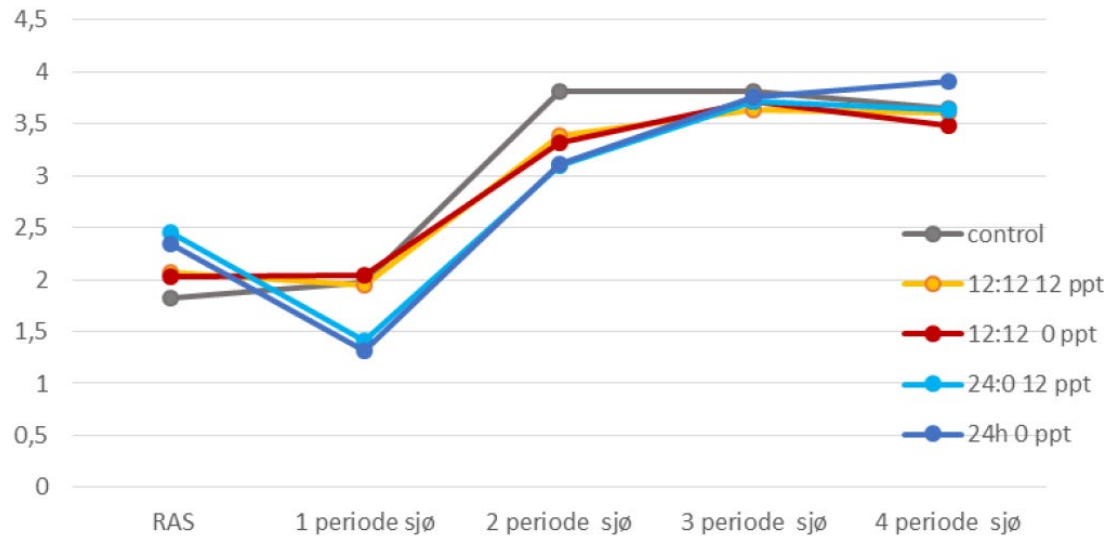
Faglig sluttrapport

Trine Ytrestøl, Grete Bæverfjord, Jelena Kolarevic, Mari Solheim, Elise Hjelte, Turid Mørkøre og Per Brunsvik

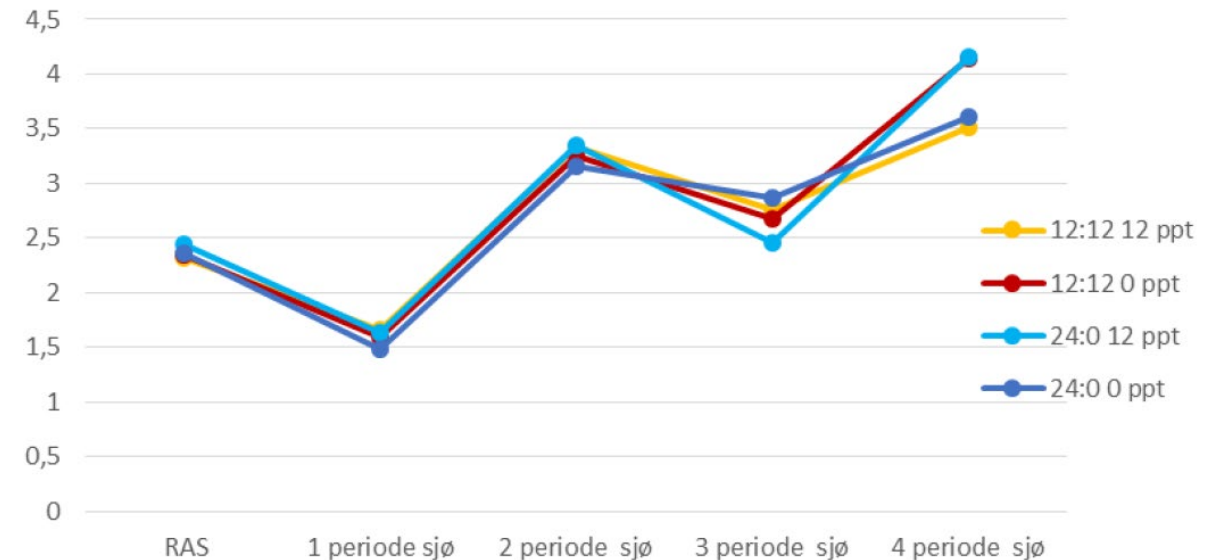
Vekst (TGC) i RAS og sjø



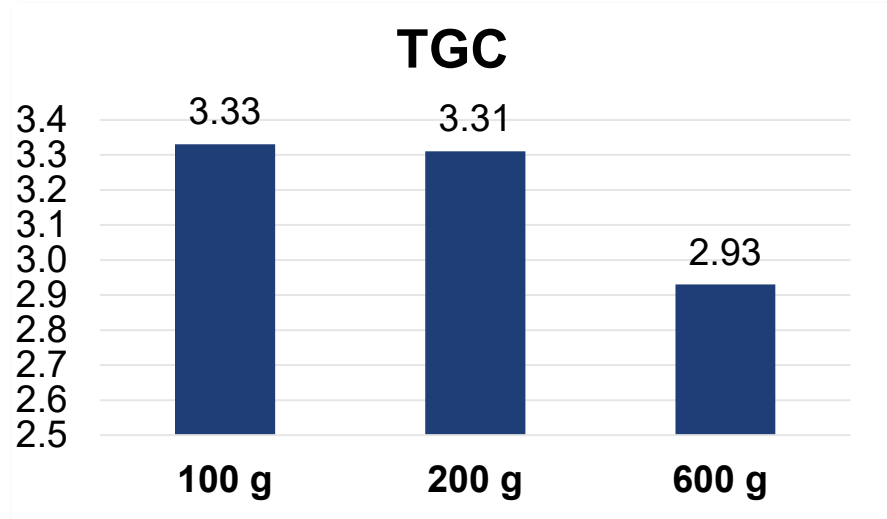
TGC kontroll og 200 g



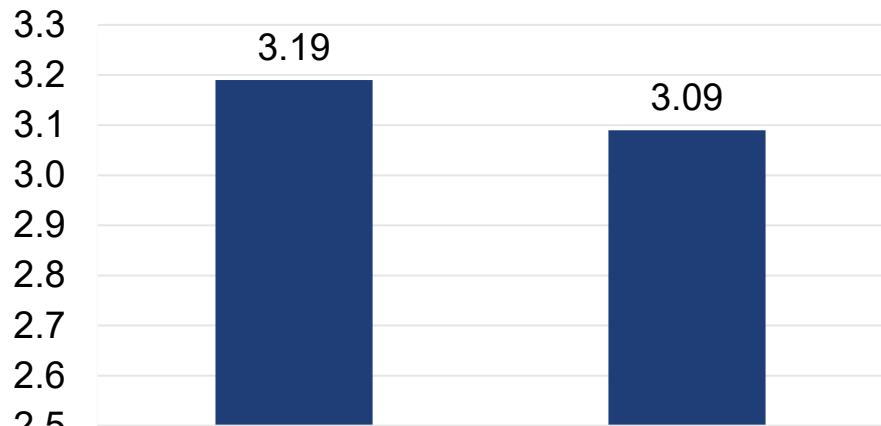
TGC 600 g



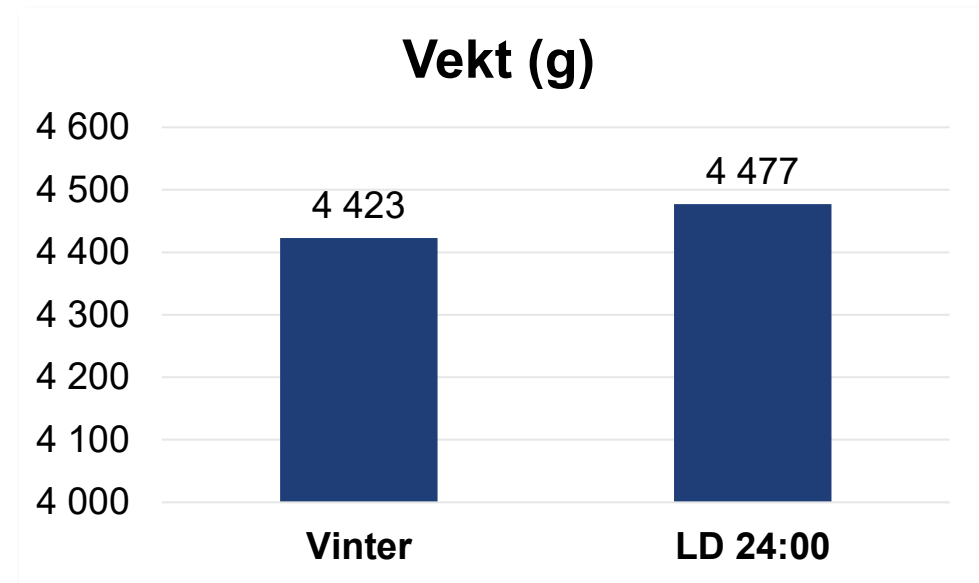
Vekst i hele sjøfasen



$P < 0.0001$

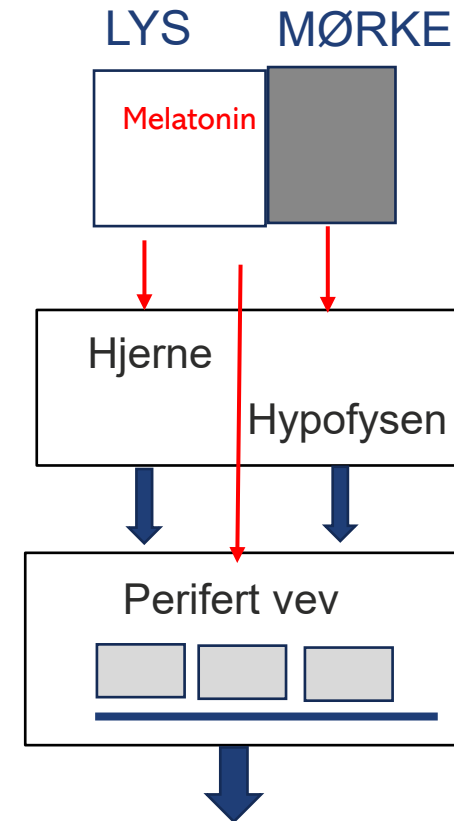


$P < 0.001$



$P < 0.05$

Desynkronisering av osmoregulatoriske organer?



Osmoregulering – Metabolisme – Immunologi - Atferd

“Take home message”

- Smoltifisering styres av en indre rytme i laksen
- Smoltifisering er en naturlig prosess som (delvis) kan styres ved lysmanipulering og diett
- Invester i smoltproduksjonen
 - ✓ Mer robust fisk
 - ✓ God ytelse i sjøen



**Powered by Partnership
Driven by Innovation**