Vandring til smolt i elv og fjord - og litt om nye metodar for observasjon av sjøåtferd og vandring hjå vill postsmolt

Henning Urke[1], Helge Bjerck[1,4], Thrond Haugen[2], Torstein Kristensen [4], Jo Arve Alfredsen[3], Nikolai Lauvås[3]

[1] AquaLife R&D
[2] NMBU
[3] NTNU, Institutt for teknisk kybernetikk
[4] Nord universitet

NTNU | Norwegian University of Science and Technology

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Stjørdalselva 1998-2000- smoltutvikling og utvandring – startfôret og vill

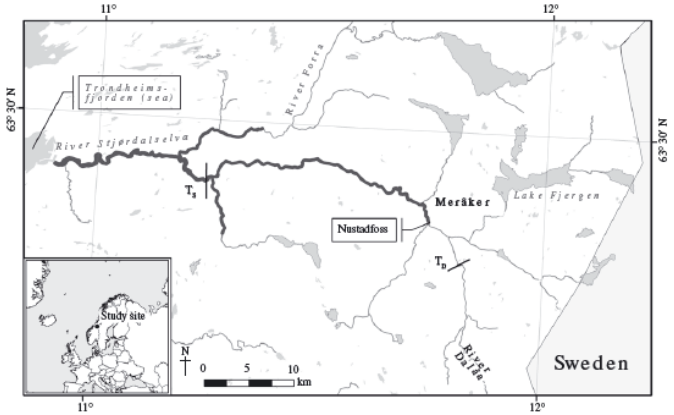


FIG. 1. The River Stjørdalselva in central Norway with location of the smolt traps in the tributary River Dalåa (T_D) and in the River Stjørdalselva (T_S). The natural distribution of wild anadromous *Salmo salar* is indicated with a broad line.

Journal of FISH BIOLOGY fsbi

Journal of Fish Biology (2014) **84**, 178–192
doi:10.1111/jfb.12276, available online at wileyonlinelibrary.com

Development of seawater tolerance and subsequent downstream migration in wild and stocked young-of-the-year derived Atlantic salmon *Salmo salar* smolts

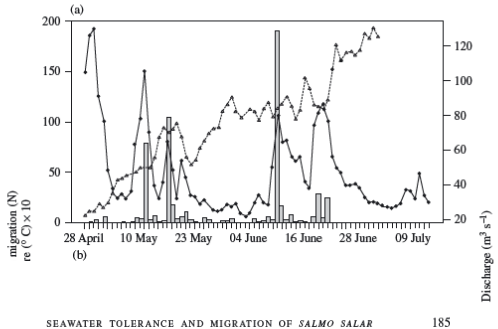
H. A. URKE*†, J. V. ARNEKLEIV‡, T. O. NILSEN§‖ AND K. J. NILSSEN¶

Journal of FISH BIOLOGY fsbi

Journal of Fish Biology (2014)
doi:10.1111/jfb.12508, available online at wileyonlinelibrary.com

Long-term hypo-osmoregulatory capacity in downstream migrating Atlantic salmon *Salmo salar* L. smolts

H. A. URKE*†, J. V. ARNEKLEIV‡, T. O. NILSEN§‖, K. J. NILSSEN¶, L. RØNNING‡, J. B. ULVUND* AND T. KRISTENSEN*



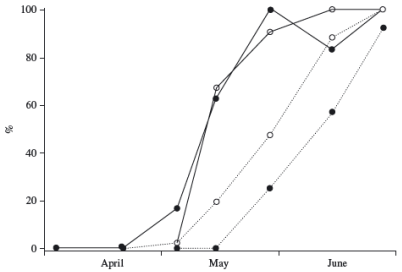


FIG. 4. Cumulative frequencies of downstream migration (...) and relative proportion of *Salmo salar* with seawater (SW) tolerance (—) for wild *S. salar* smolts (○) in the River Stjørdalselva and *S. salar* smolts previously stocked as young-of-the year parr (●) in the tributary River Dalåa in 1998. SW tolerance is expressed here as per cent of *S. salar* within each test having a blood plasma osmolality <350 mOsm kg^{-1} after 24 h SW exposure. SW exposure tests were conducted on 3 April, 20 April, 4 May, 14 May, 28 May, 13 June and 26 June.

alar smolt
(–▲–) and
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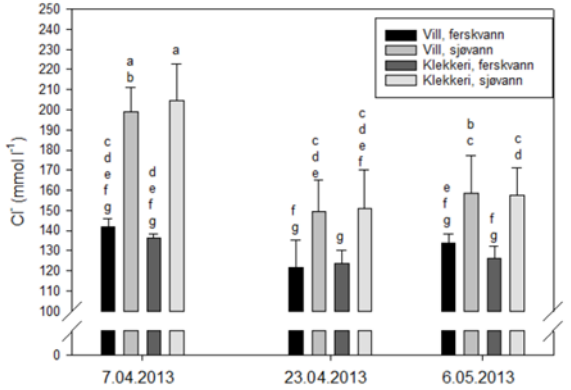
Aqua Life R&D

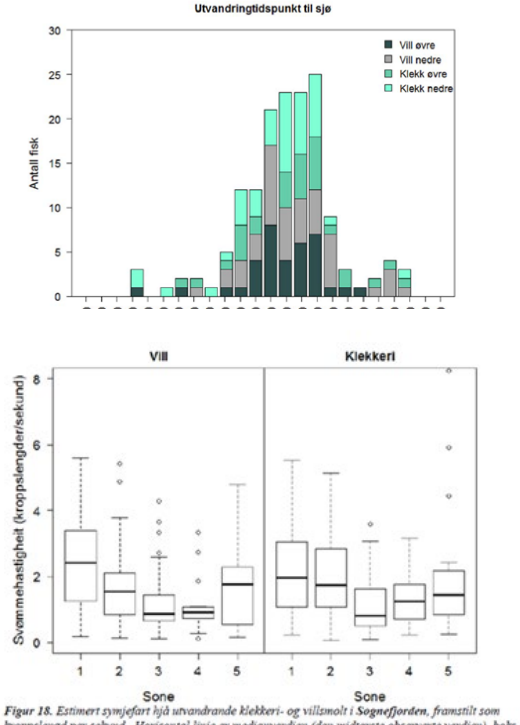
Ljøsne klekkeri 2009-2014- dokumentasjon smoltutvikling og utsettsstrategier



Figur 7. Plasma klorid i kontrollgrupper i ferskvann og etter 24 timars sjøvavasstoleransetest hos vill –og klekkeriprodusert smolt. Søyler som ikkje er forbunde med felles bokstav er signifikant ulike ($p<0,05$). Statistisk analyse basert på Tukey-Kramer HSD test etter fullfaktoriell Least square fit analyse (tidspunkt, klekkeri/villfisk og ferkvatn/sjøvatn som parametrar) på log transformerte data).

Tabell 4. Oversikt over fisk merket dei forskjellige periodane samt utvandring prosentar.

Periode	Opphav	Satt ut	Tal merket	Tal observert i sjø	% utvandra til sjø
1	Vill	6.4.2013	40	27	67,5
1	Klekkeri	6.4.2013	40	27	67,5
2	Vill	24.4.2013	40	24	60,0
2	Klekkeri	24.4.2013	40	27	67,5
3	Vill	6.5.2013	40	38	95,0
3	Klekkeri	6.5.2013	39	29	74,4
Totalt			**239**	**172**	**72,0**



*Figur 18. Estimert symjefart hjå utvandrande klekkeri- og villsmolt i **Sognefjorden**, framstilt som kroppslengd per sekund. Horisontal linje er medianverdien (den midtarste observerte verdien), boks er 25-75 percentilen (50% av observasjonane ligg innanfor dette intervallet), vertikal linje er 5-95 percentilen (90% av observasjonane ligg innafor dette intervallet), og runde punkt er enkeltobservasjonar utanfor dette området. Klekkerismolt og villsmolt er statistisk testa for skilnader (t-test) og det vart ikkje detektert statistisk signifikant skilnad på gruppene (t= -0.24, p=0.98.).*

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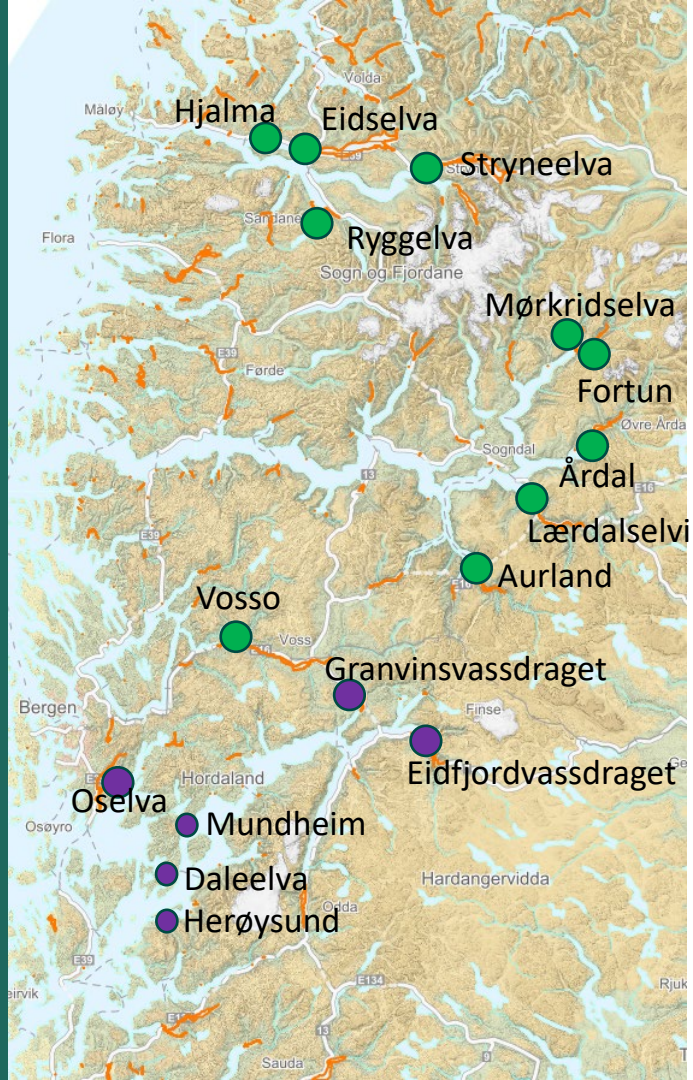

AT Aktivitet i PO3 & PO4

Fjordsystem	Vassdrag	År
Hardangerfjorden-	Eidfjordvassdraget	2018-2025
Bjørnafjorden	Granvinsvassdraget	2018-2025
	Oselva	2018-2025
	Mundheim	2021
	Daleelva	2021
	Herøysund	2021
Osterfjorden	Vossovassdraget	2015, 2016
Sognefjorden	Lærdalselvi	2009- 2017
	Aurlandselva	2012-2015
	Årdalselva	2013-2015
	Fortunselva	2013-2015
	Mørkridselva	2015
Nordfjord	Stryneelva	2017-2025
	Eidselva	2018-2025
	Ryggelva	2023
	Hjalma	2023

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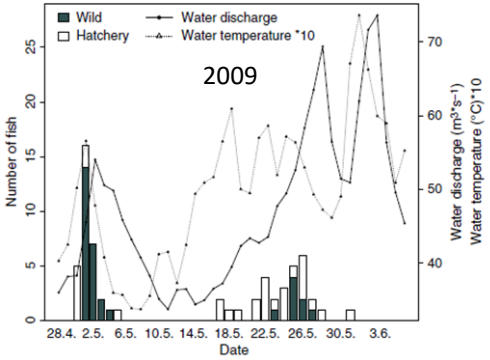
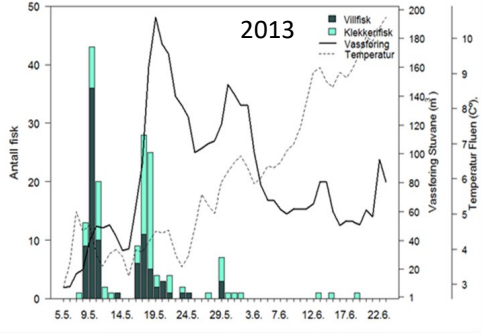
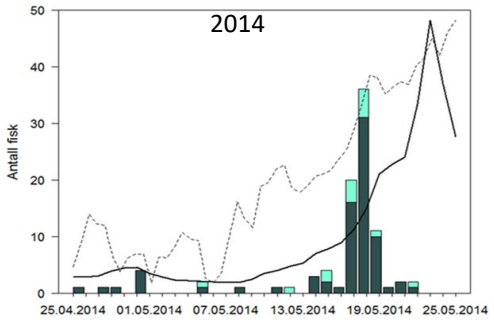
Laksesmolt Lærdalselvi 2009, 2013 og 2014 smoltutvikling og AT







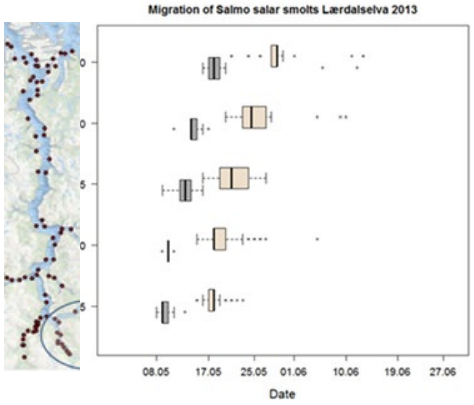
Fisheries Management and Ecology

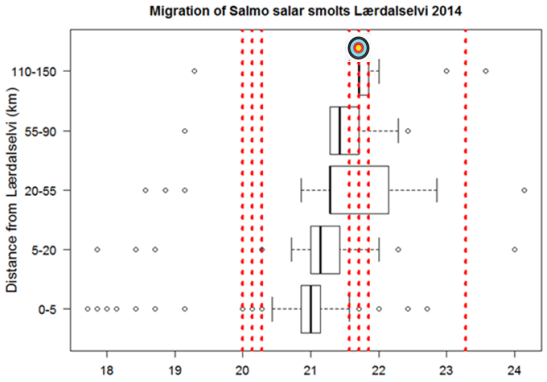
Fisheries Management and Ecology, 2013

Riverine and fjord migration of wild and hatchery-reared Atlantic salmon smolts

H. A. URKE, T. KRISTENSEN & J. B. ULVUND
Norwegian Institute of Water Research, Trondheim, Norway

J. A. ALFREDSEN
Norwegian University of Science and Technology, Trondheim, Norway





Fiskedata			Prev (%)	Infeksjonsmål		% >10 lus
Lokalitet	Uke	N total		Intensitet (snitt ± SD)	max	
Sognefjord	20	8	0		0	0
	21	60	3	1 ±	1	0
	23	4	75	1 ±	1	0

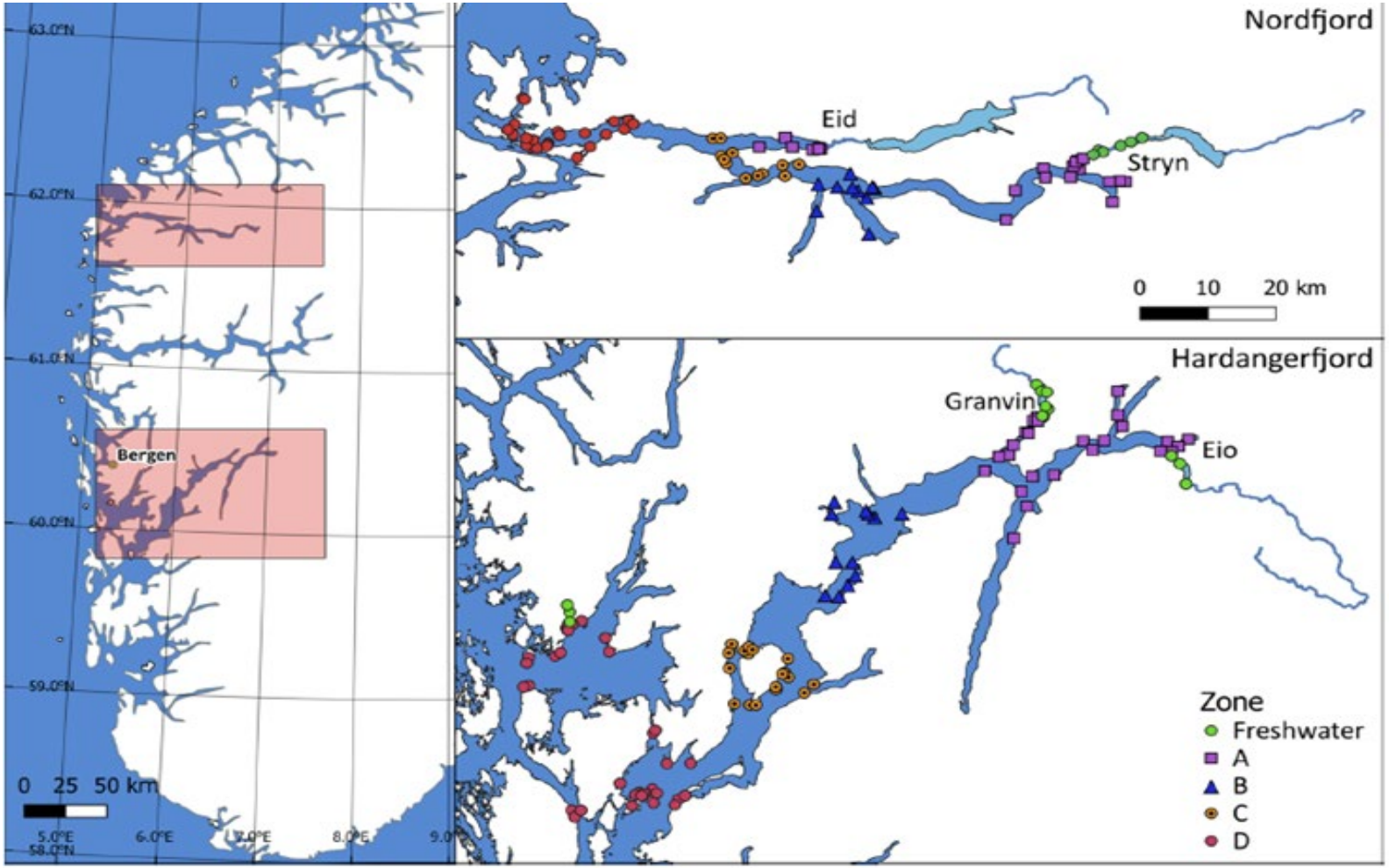
Aqua Life R&D

Utvandring og sjøoverleving til klekkerismolt (laks) fra Lærdalselvi – LEvaSogn 2019-2026

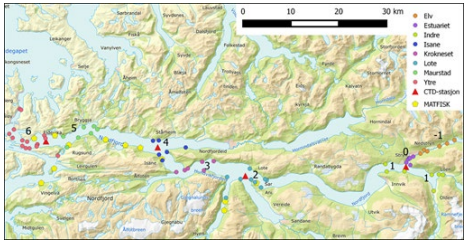
- PIT baserte studiar
- Mål
  - Dokumentere klekkerismolten sitt bidrag til gytebestanden
  - Evaluere klekkerismolt som kompenserende tiltak for tapt ungfiskproduksjon etter vassdragsregulering

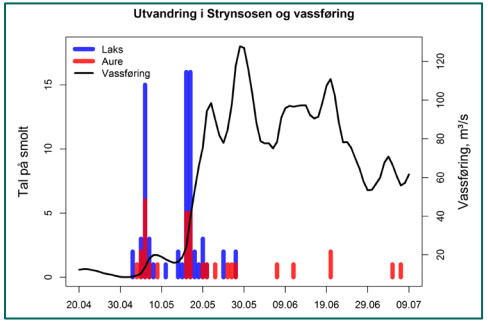
AquaLife R&D

AT vassdrag og nettverk av passive akustiske mottakere



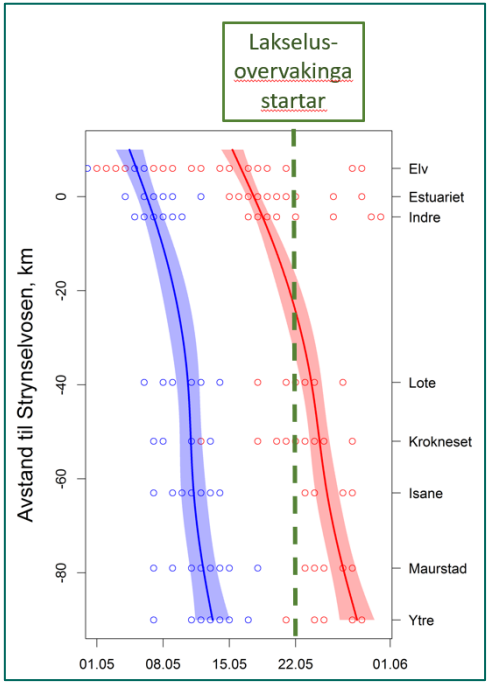
Stryneelva 2017 laksesmolt





- Vassføringsauke sett i gong utvandringa – det går to grupper
- Fyrstegruppa hadde gått ut då luseovervakinga var sett i gong
- Dei fyrste merka laksesmoltane kjem til ytre del av fjorden den 7. mai.
- Vandringa frå elveos til dei forlet ytre fjord tok i snitt 8,3 dagar.
- **Vi kan predikere ankomsttid til ytre fjord med 74 % presisjon.**

	Opphaldstid (dagar)		Ankomsttid (dag på året)		
Sone	[10%;50%;90%]	snitt±SD	[10%;50%;90%]	snitt±SD	n
–1	[0.1;1.1;9.5]	9.4±29.3	[120.8;127.7;138.1]	129.8±7.3	79
0	[0.1;1.1;11.1]	6.7±18.0	[125.0;135.7;234.0]	146.5±38.9	80
1	[0.3;2.9;6.0]	5.4±15.9	[126.0;136.2;140.1]	134.5±6.0	50
2	[0.1;1.5;6.5]	5.0±14.5	[127.0;139.2;142.0]	135.1±6.7	37
3	[0.1;1.0;8.6]	9.0±28.8	[129.6;139.6;145.4]	138.1±7.7	34
4	[0.3;0.7;2.7]	1.2±1.2	[128.4;141.2;146.3]	138.8±10.5	23
5	[0.1;0.4;8.3]	9.2±31.0	[128.8;134.7;145.9]	137.8±9.7	18
6	[0.1;0.9;7.6]	7.3±28.3	[129.9;139.9;146.7]	139.0±8.9	25



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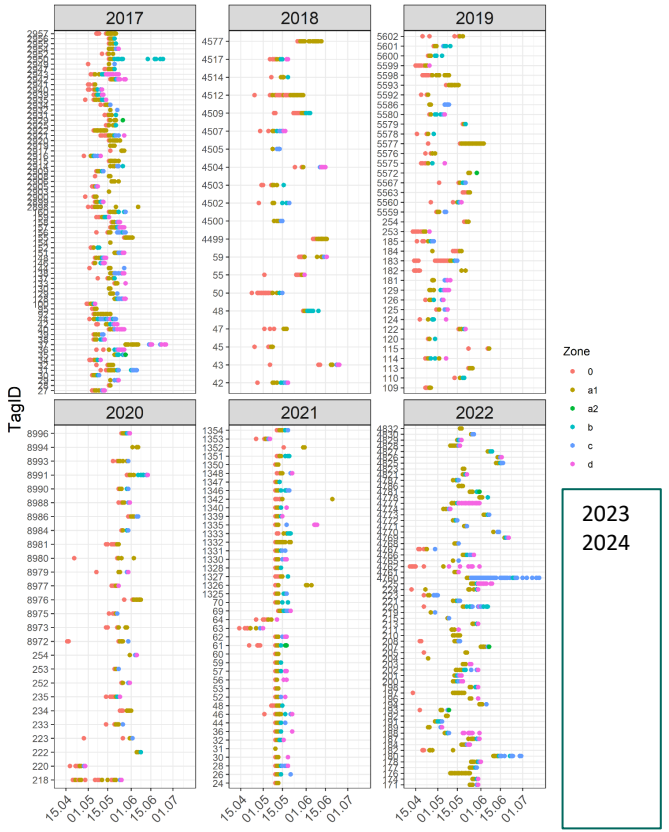
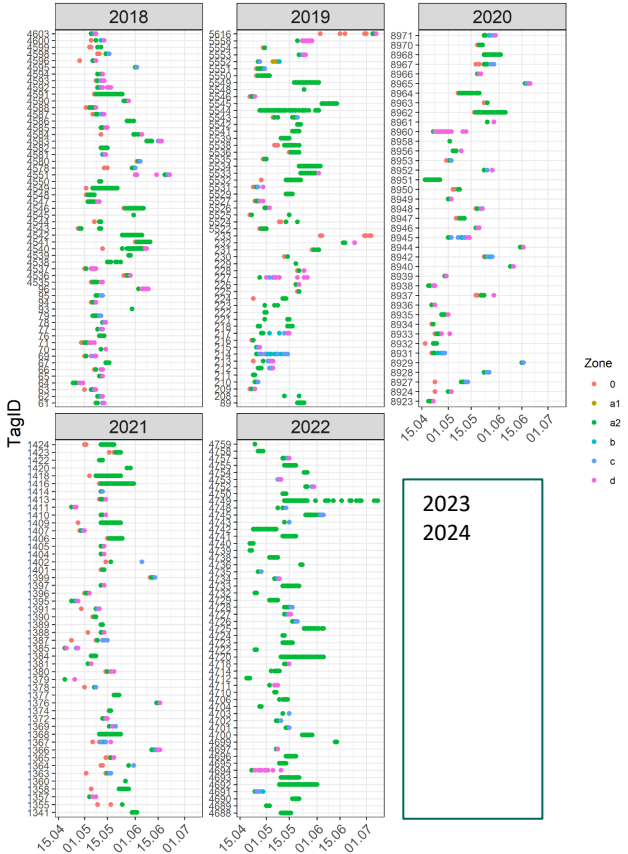
Rådata laksesmolt telemetri 2017-2022

Stryneelva



2023
2024

Eidselva



2023
2024

2023
Hjalma

2023
Ryggelva

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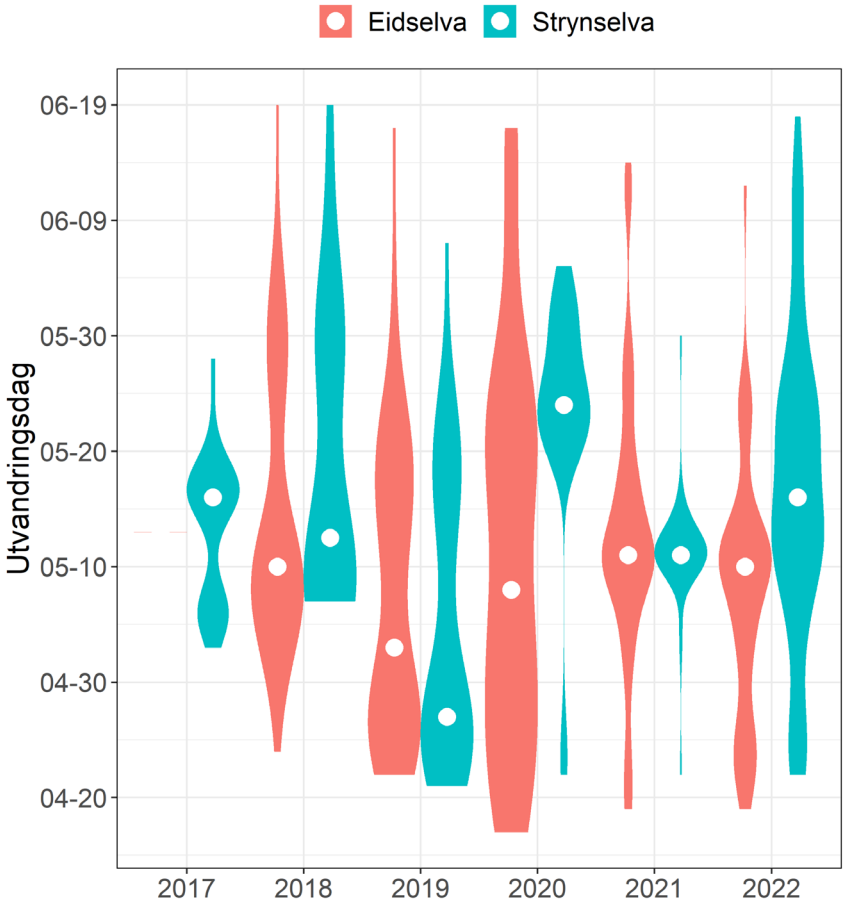
Utvandringstidspunkt

- Større år-til-år-variasjon i utvandringstidspunkt hos Eidselvsmolten enn Strynesmolten
- Mykje variasjon mellom individ innan år hjå båe populasjonane



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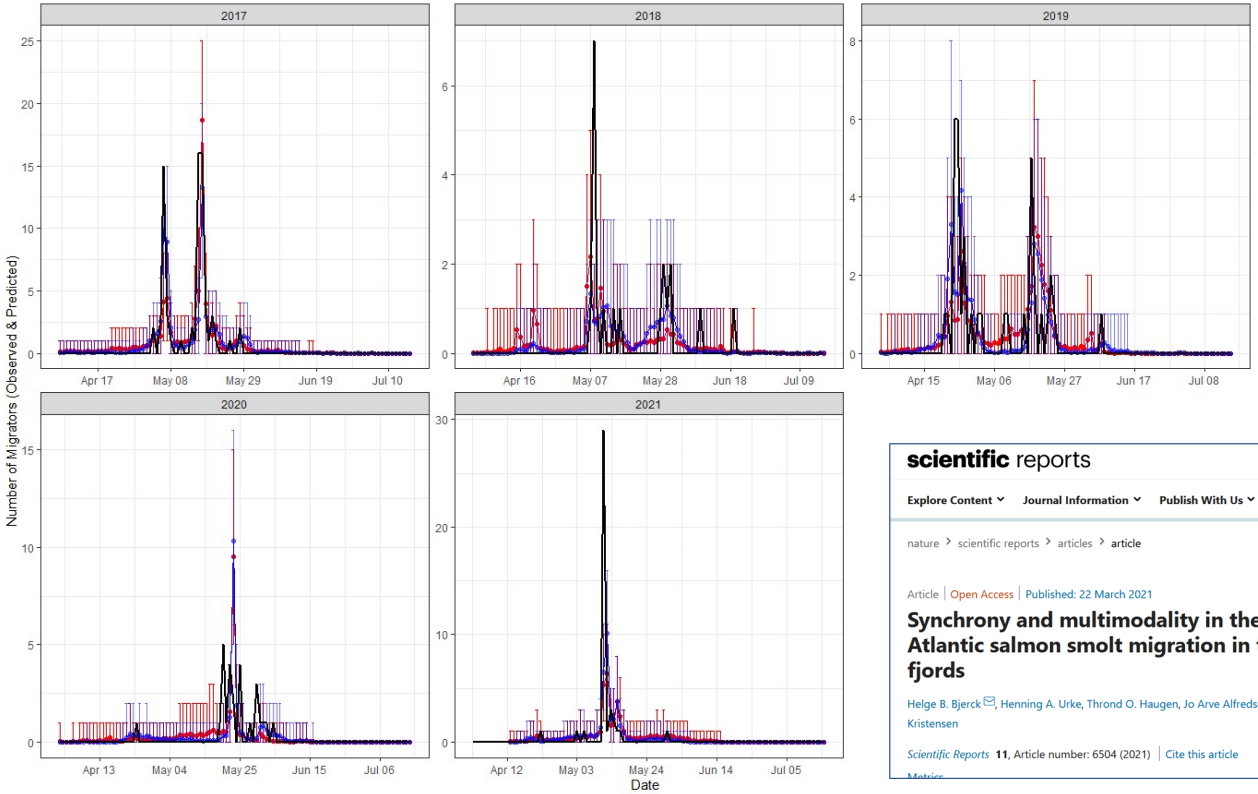
Utvandringsmodeller (Bjerck et al in prep)



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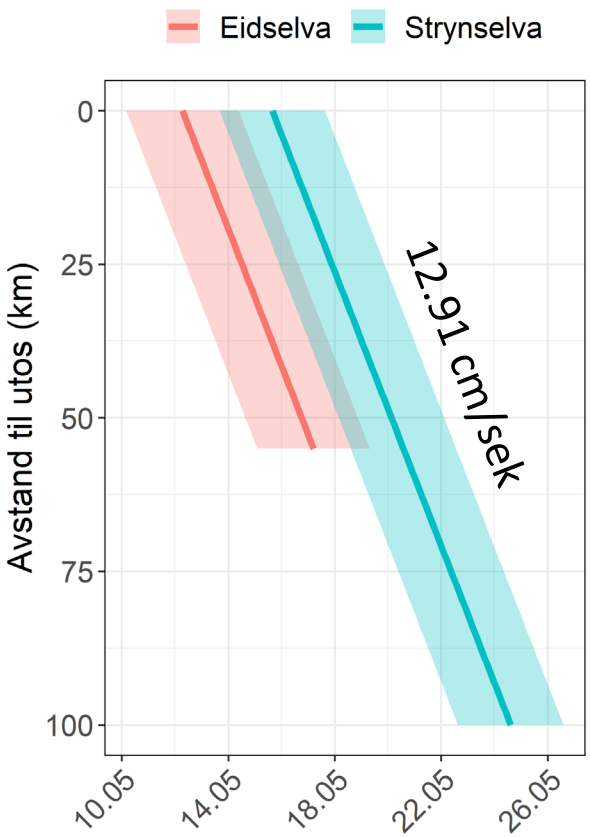
Synchrony and multimodality in the timing of Atlantic salmon smolt migration in two Norwegian fjords

Helge B. Bjerck, Henning A. Urke, Throndo O. Haugen, Jo Arve Alfredsen, John Birger Ulvund & Torstein Kristensen

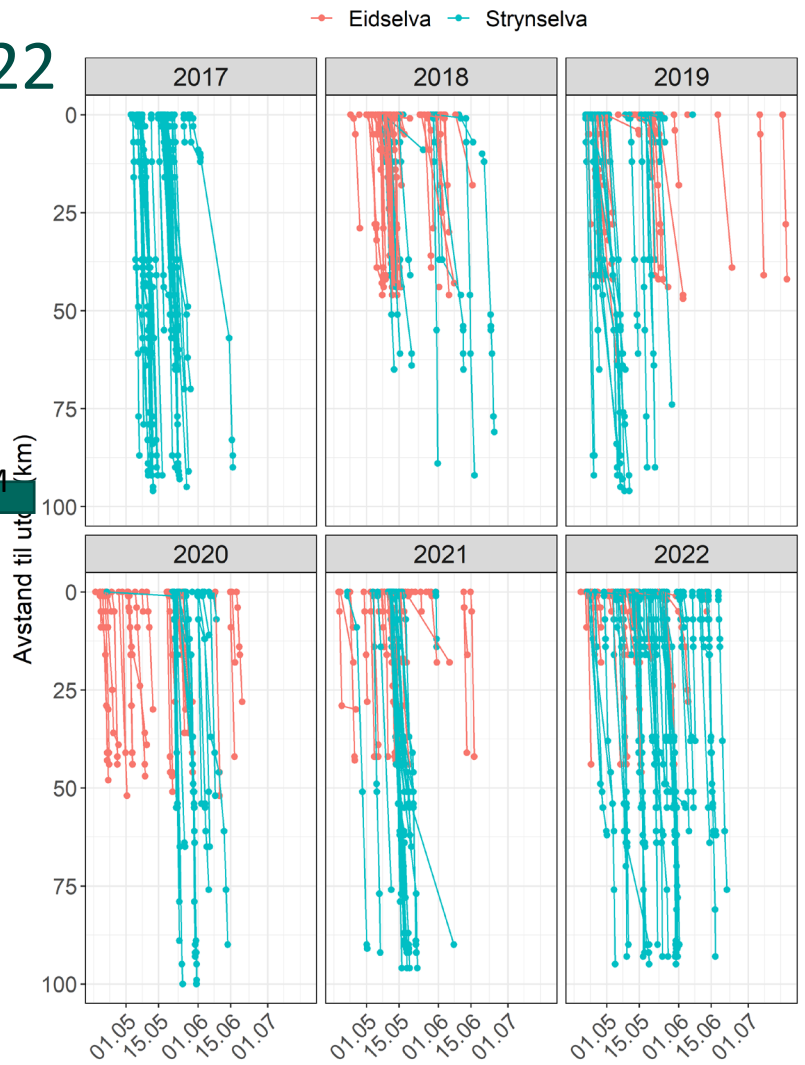
Scientific Reports **11**, Article number: 6504 (2021) | Cite this article

Metrics

Framdrift i fjorden 2017-2022



LMM



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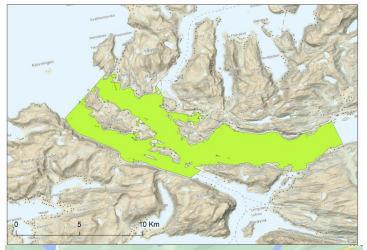
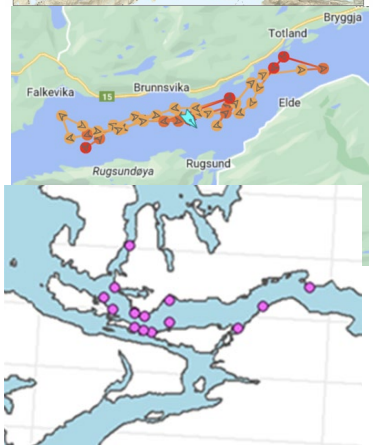
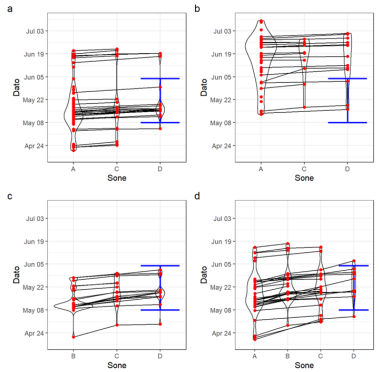
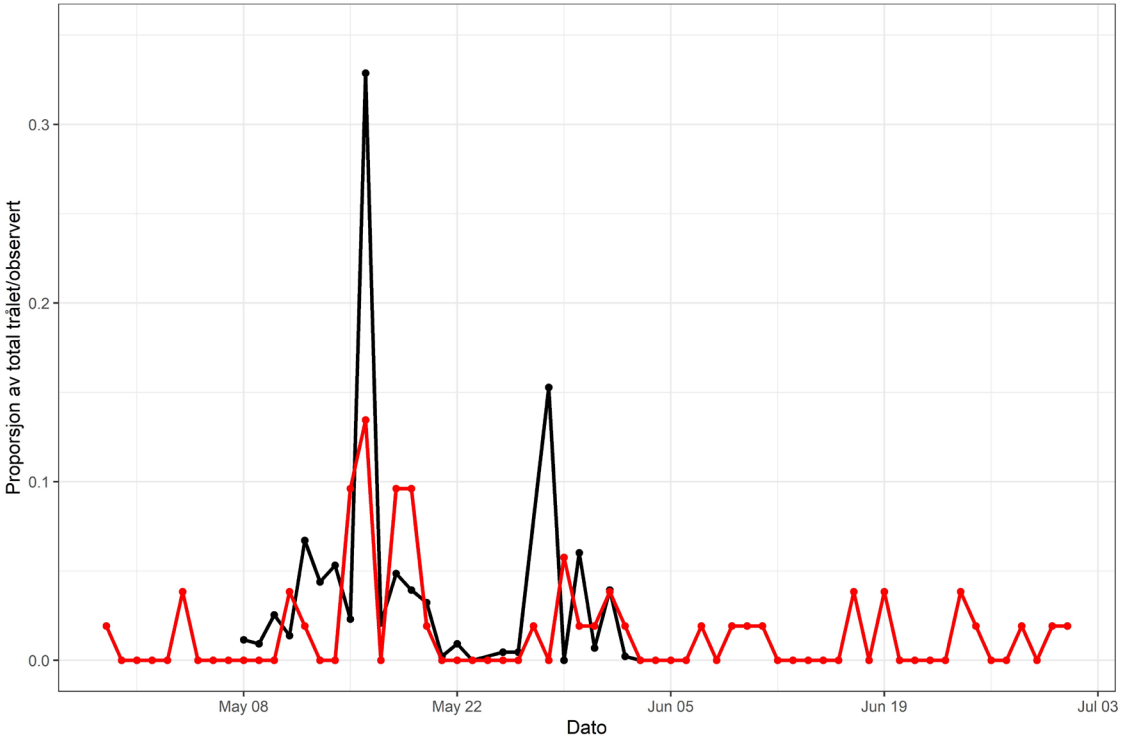
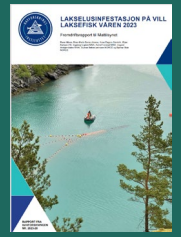
Samsvar mellom fangst (NALO, tråling smolt) og registrering AT fisk i ytre Nordfjord 2023





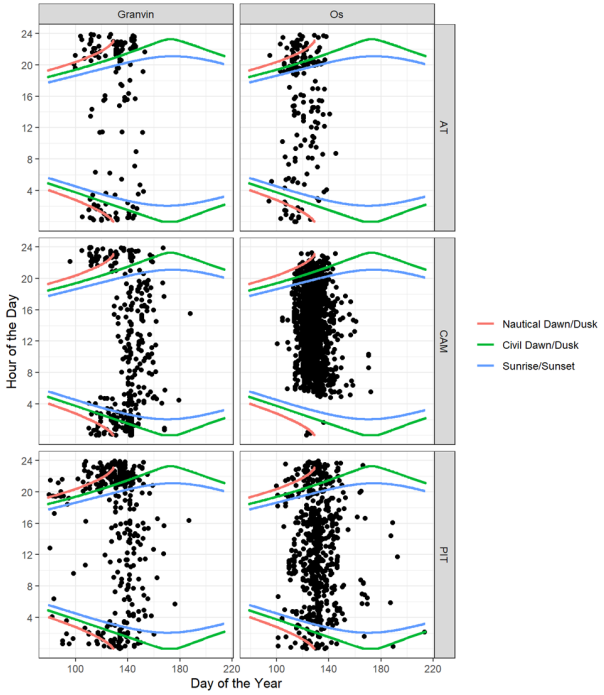


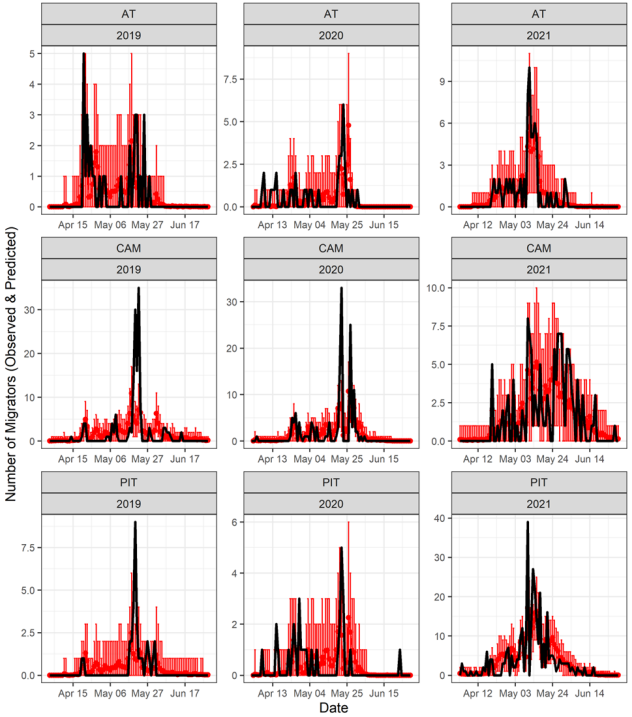




Aqua Life R&D

Tre ulike metodar forregistreing utvandring – AT, PIT og kamera i samme to vassdrag over fleire år (Bjerck et al in prep)





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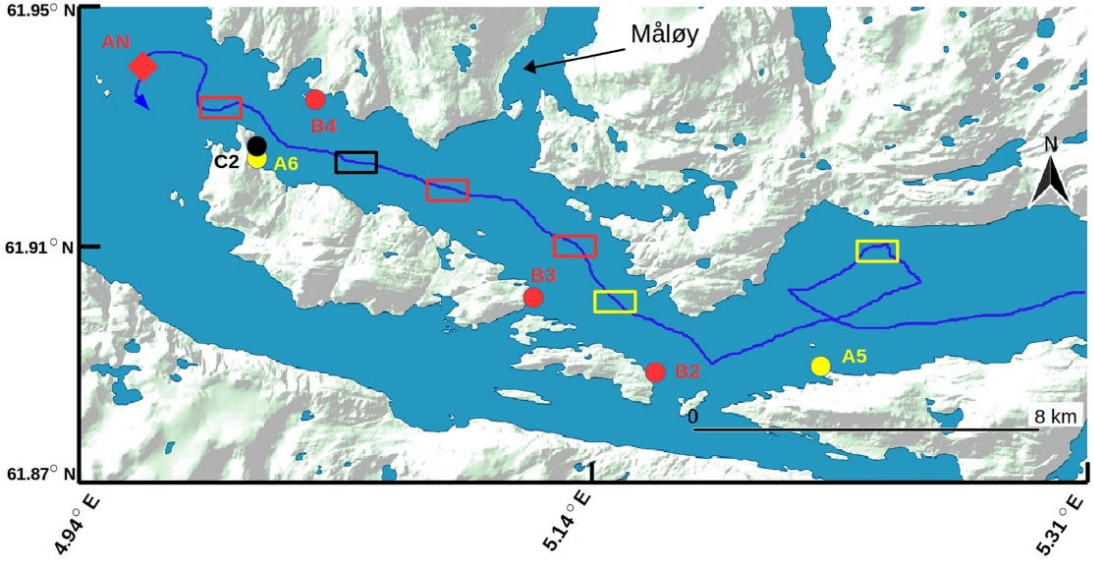
USV «AutoNaut»
Autonom bølgje- og soldriven farkost

Lokalisering av postsmolt på kysten sørvest av Vågsøy, 100 km og 5 dagar etter han forlot Stryneelva.



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A Persistent Sea-Going Platform for Robotic Fish Telemetry Using a Wave-Propelled USV: Technical Solution and Proof-of-Concept

Alberto Dallolio[1], Helge B. Bjerck[2], Henning A. Urke[3] and Jo A. Alfredsen[1]*

[1] Center for Autonomous Marine Operations and Systems, Department of Engineering Cybernetics, Norwegian University of Science and Technology, Trondheim, Norway, [2] Faculty of Biosciences and Aquaculture, Nord University, Bodø, Norway, [3] INAQ AS, Trondheim, Norway

USV «FishOtter»
Autonom batteridriven katamaran

Fig. 1. The FishOtter ASV.

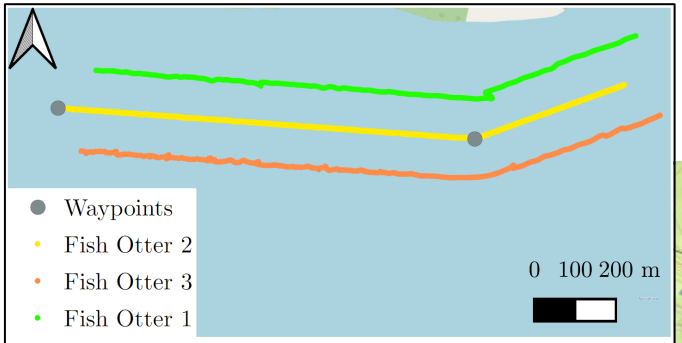
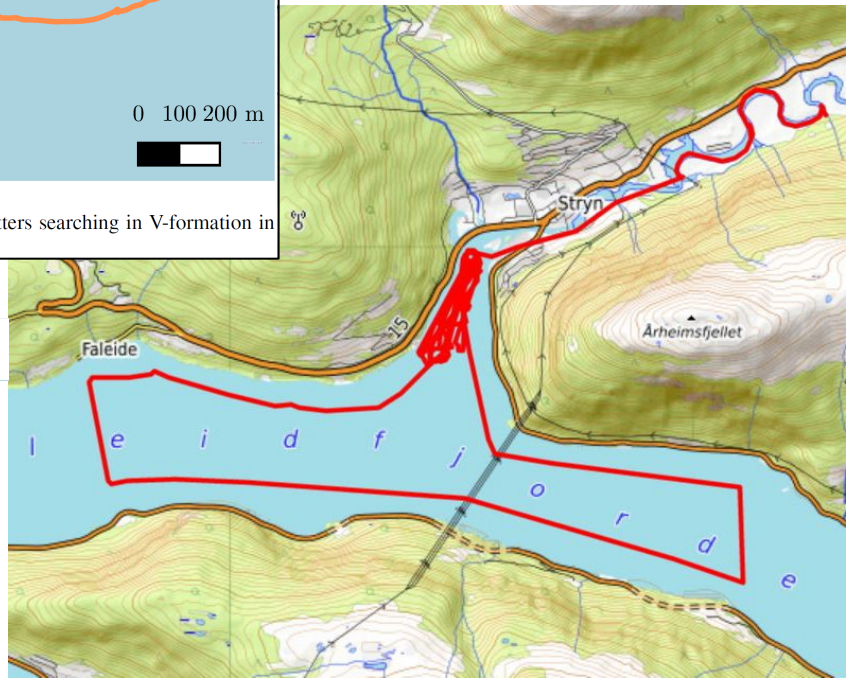


Fig. 12. Observed paths navigated by FishOtters searching in V-formation in a Norwegian fjord.



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Design and validation of a system of autonomous fish tracking vehicles

Nikolai Lauvås
Norwegian University of Science and Technology
Department of Engineering Cybernetics
Trondheim, Norway
nikolai.lauvas@ntnu.no

Henning Andre Urke
Aquaflife R&D AS
Trondheim, Norway
henning.urke@aquaflife-rd.no

Jo Arve Alfredsen
Norwegian University of Science and Technology
Department of Engineering Cybernetics
Trondheim, Norway
jo.arve.alfredsen@ntnu.no

***Abstract*—This paper presents the technical design and validation of an autonomous surface vehicle (ASV) system capable of robotic search, localization and autonomous tracking of free-ranging fish carrying acoustic transmitter tags. The system consists of three identical differential-thrust catamaran vehicles equipped with time-synchronized acoustic telemetry receivers capable of accurate timestamping and decoding of signals received from individually coded tags. Multi-vehicle signal receptions allow time-difference of arrival (TDoA) measurements and are used in position estimates to enable collaborative fine-scale tracking and mapping of the movements of individual fish.**

The performance of the system was validated through several sea trials culminating in a deployment over several days in a Norwegian fjord where migrating wild Atlantic salmon smolts and sea-run brown trout had previously been tagged using acoustic transmitters in a nearby river. The three vehicles were

I. Introduction

Acoustic telemetry is a well-established scientific tool for spatial ecological studies of the movement and migration patterns of fish and other aquatic animals [1] and is usually subdivided into passive and active approaches. While passive acoustic telemetry relies on deploying extensive arrays of moored archival receiver units to detect and log the presence of acoustically tagged animals for retrospective analysis, active acoustic telemetry typically involves manual real-time tracking of tagged animals using a directional receiver from a tracking vessel. Active tracking can potentially provide movement data of high spatial and temporal resolution, but is generally regarded as exceedingly labor intensive and is subject to

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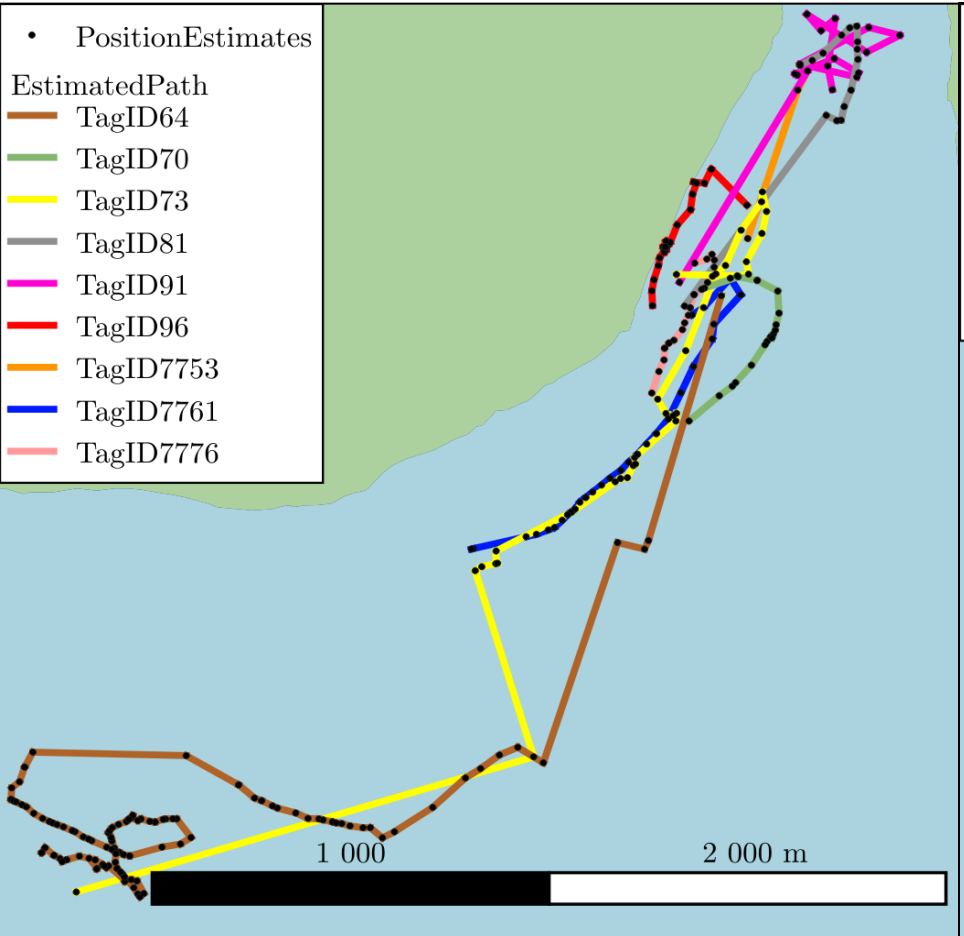
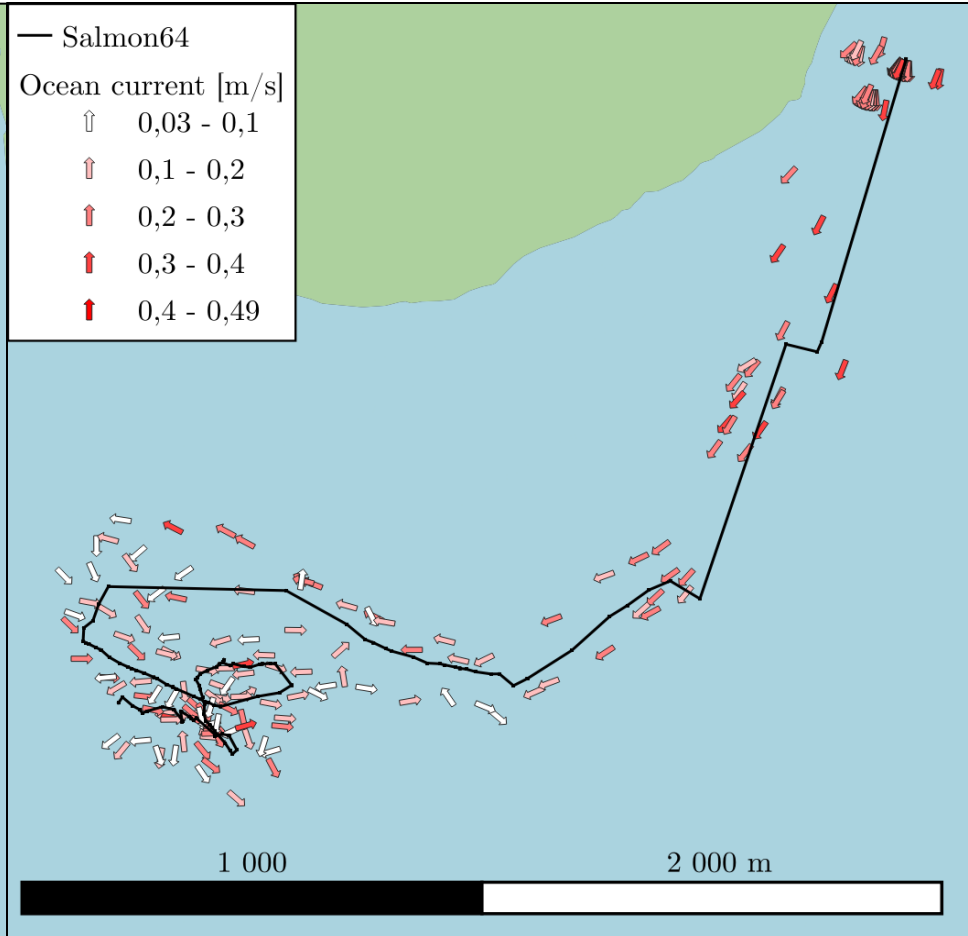
Autonom sporing av totalt 9 postsmolt av laks og sjøaure i Faleidefjorden mai 2023



Sporing av postsmolt med samtidig måling av overflatestraum i Faleidefjorden utanfor Stryneelva



Konklusjon

- Hva har AT-studiene lært/gitt oss:

  Utvandringsmodeller for smolt av laks

  - Hva igangsetter utvandringa
  - Flere utvandringsgrupper pr elv

  Liten variasjon mellom utvandringsgruppene og vassdrag når det gjelder framdriftshastighet i fjordmiljøet

  - 0,8-1,5 kroppslengder i sekundet;
    - 12 cm smolt: 8,3-15,5 km/døgn; 15 cm smolt: 10,4-19,4 km/døgn

  Vi kan med god presisjon forutsi når smolten er ved oppdrettsområdene ut fra vassføringsregimet i de studerte elvene

  - Dette har ført til økt presisjon med tiltak og overvåking (tidsperioden er kjent pensum)

- Konseptet med autonom sporing av postsmolt er demonstrert for første gang i Nordfjord, der nye og mer robuste sporingsalgoritmer er under utvikling for FishOtter-systemet.

Aqua Life R&D

henning.urke@aqualife-rd.no

+47 95 81 84 88

Takk til

- Stryn Elveeigarlag, Hornindalsvassdraget Forvaltningslag, Eid Elveeigarlag, Lærdal Elveeigarlag
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