



# Good ecological status?

## Workshop on salmon and sea trout and their habitats

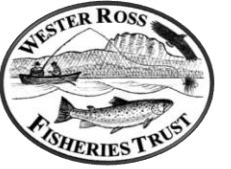
Loch Torridon  
Community Centre  
23<sup>rd</sup> April 2024

<https://www.facebook.com/WRFT22>

[www.wrft.org.uk](http://www.wrft.org.uk)



# Programme



- 10.20 Welcome and introduction.** Dr Michael Aitchison (Chair, WRFT); Dr Sue Ward (Administrator, WRFT)
- 10.30 Malnourished nursery streams?** Are surplus salmon eggs a vital food source for pre-smolt parr in some rivers in Wester Ross?  
Peter Cunningham (Biologist, WRFT)
- 10:50 Short introductions from local groups and researchers**
- 11.10 Break
- 11.30 Rediscovery of a herring spawning ground near Gairloch.** Dr Michelle Frost (West of Scotland Herring Hunt)
- 11.50 Still too many sea lice in coastal waters? Future prospects.** Peter Cunningham (WRFT Biologist)
- 12.10 Inshore Fisheries Management group update.** Alastair Hamilton (North West Coast Regional Inshore Fisheries Group)
- 12.30 **Short introductions from local groups and researchers**
- 12.40 Lunch
- 13:30 Introduction to discussion groups: how heathy are our waters for wild salmon and sea trout populations? What can be done to improve them?**
- 13:40 Discussion groups (A) freshwater habitats, (B) coastal marine habitats . . .**
- 14:30 Report back and sum up**
- 14:40 end of workshop**
- 15:00 WRFT AGM (please see other notice)**



## Malnourished nursery streams?

Are (were) surplus salmon eggs a vital food source for pre-smolt parr in some rivers in Wester Ross?



Peter Cunningham  
(Biologist, WRFT)

[info@wrft.org.uk](mailto:info@wrft.org.uk)



Nic Butler and Dr Shraveena Venkatesh by  
the Little Gruinard River, 22<sup>nd</sup> August 2023

SEA

# Returning adult salmon

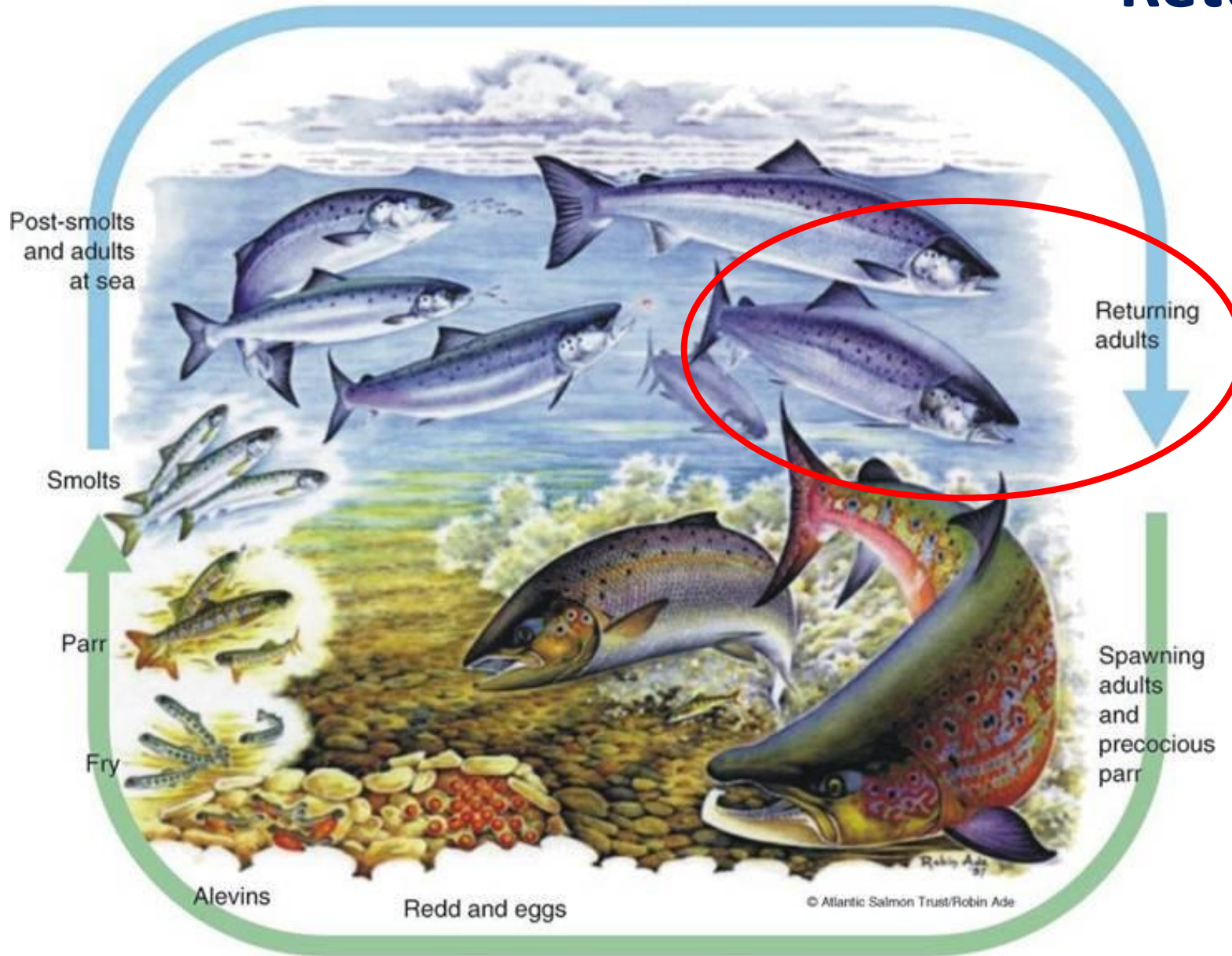


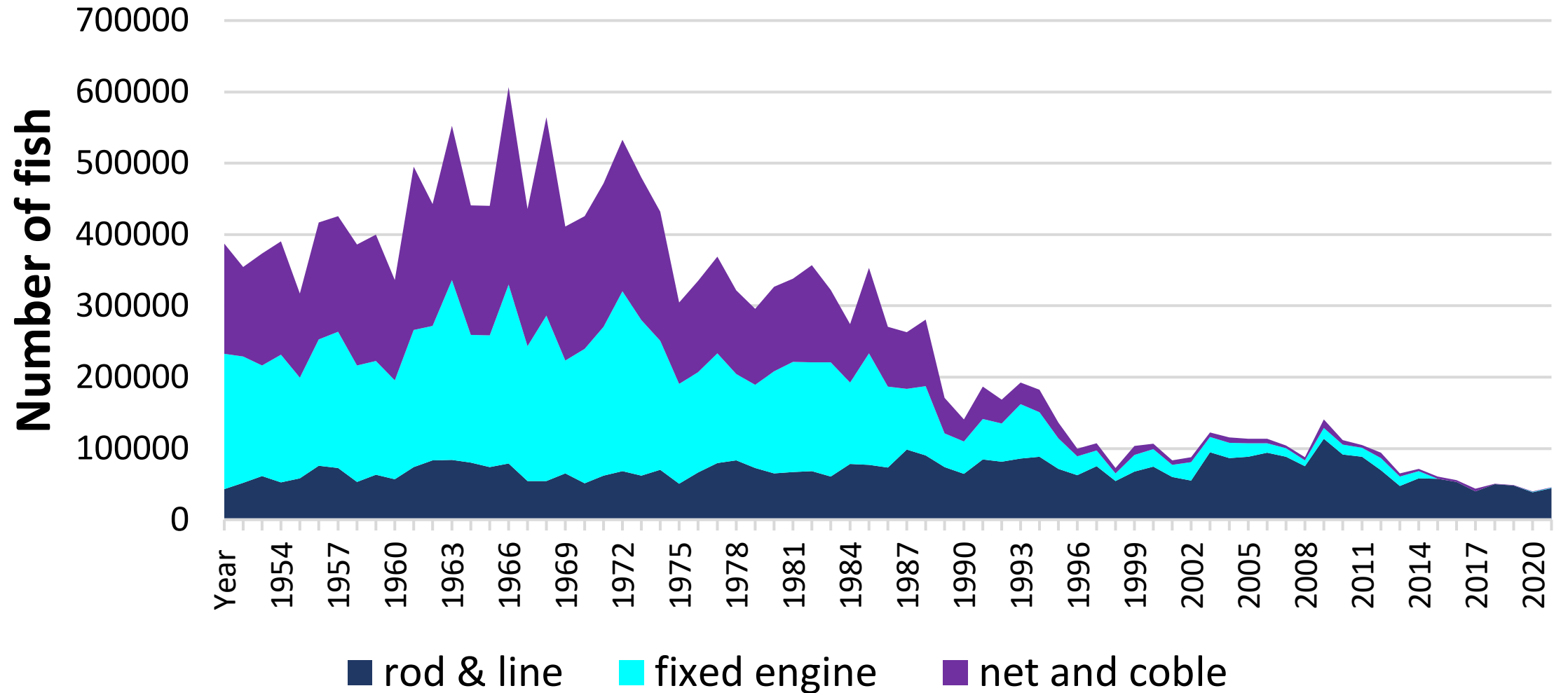
photo by Connaire Cann

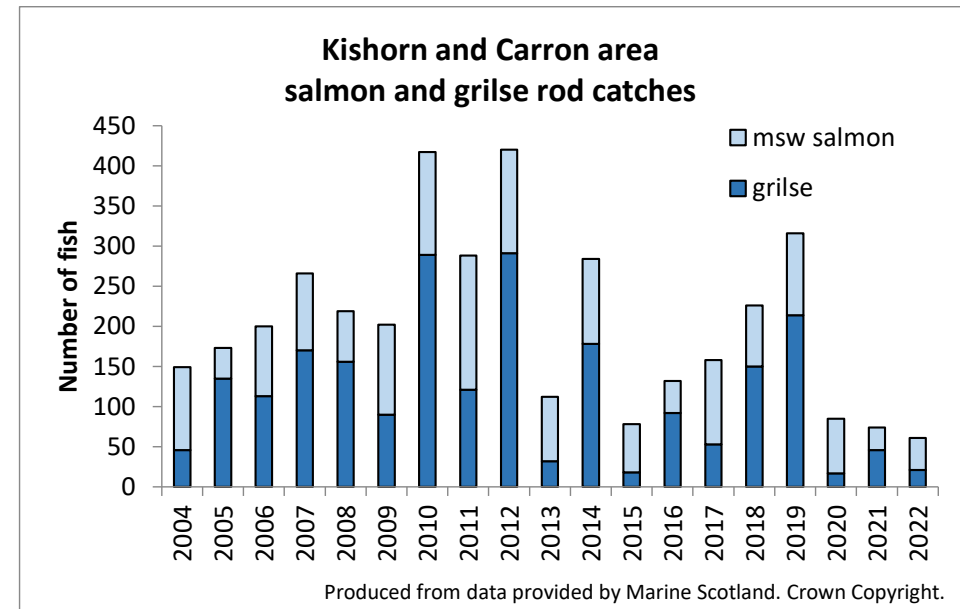
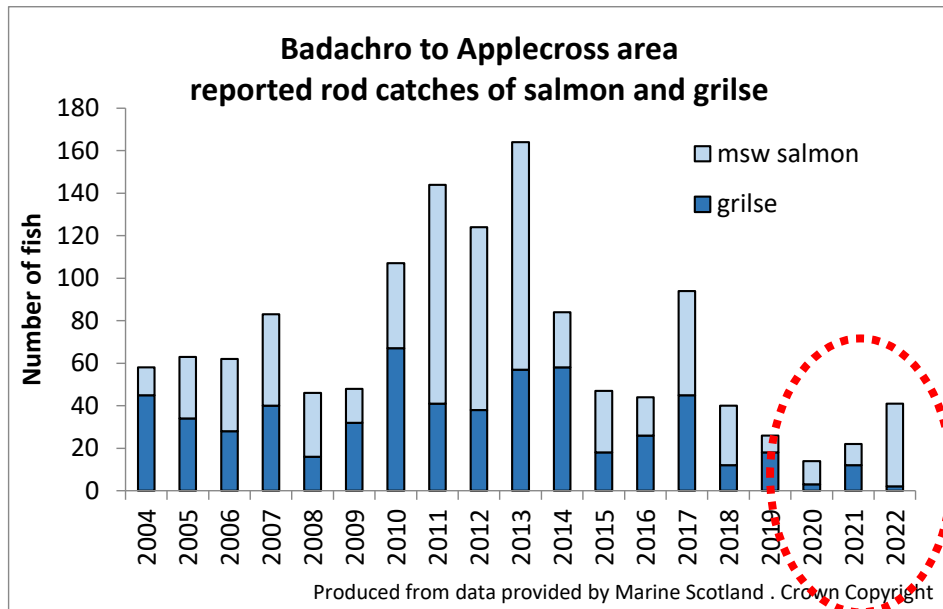
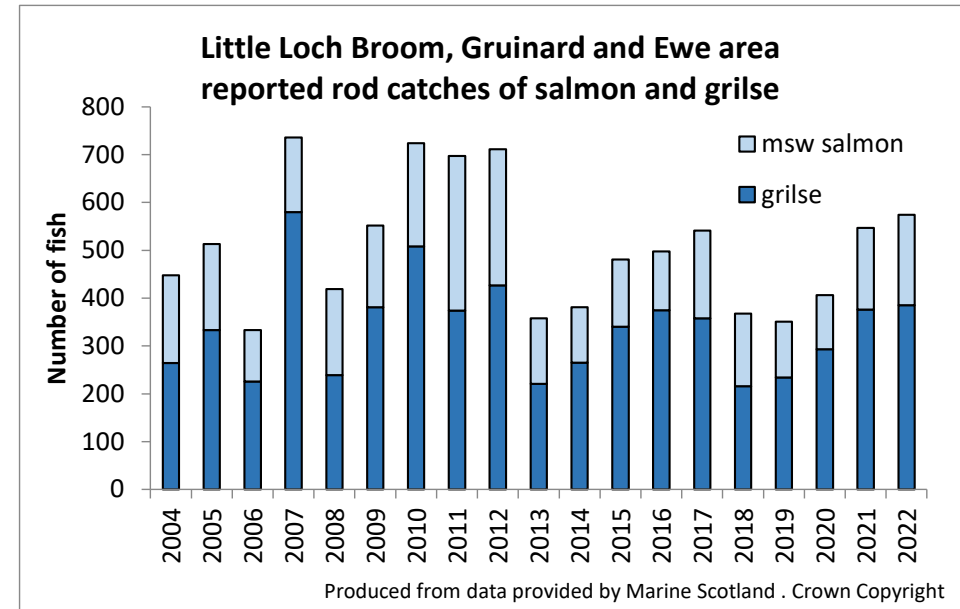
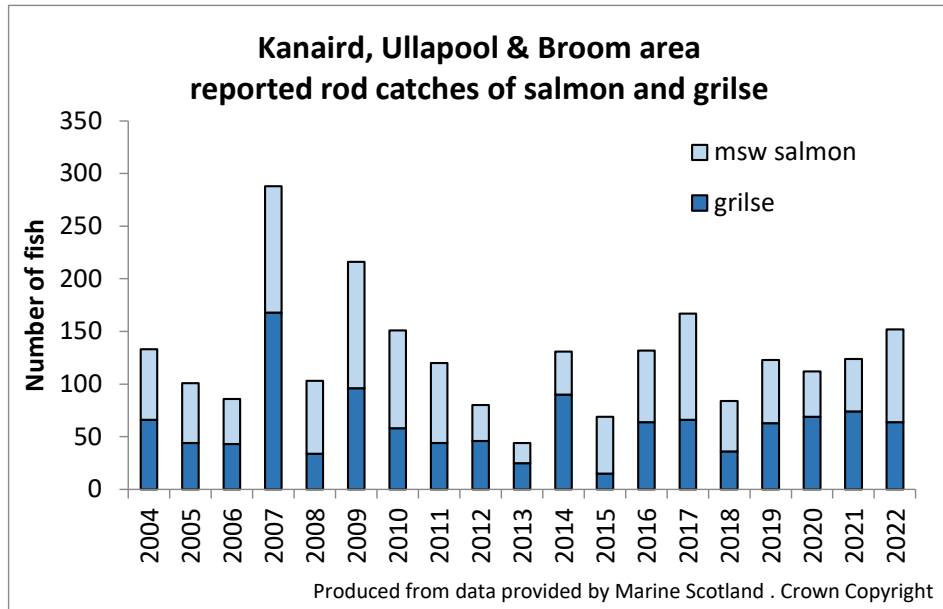
Releasing an adult salmon,  
September 2022

***How many adult salmon return from the sea to freshwater?***

# Reported combined net and rod catches of wild salmon in Scotland, 1952 to 2022

(source, Scottish Government catch statistics)





# Major salmon rivers in the Wester Ross Fisheries Trust area

↓ viable populations?

↓ native salmon endangered

Canaird ↓

Ullapool ↓

Broom ↓

Dundonnell ↓

Gruinard ↓

Little Gruinard ↓

Ewe ↓

Torrison ↓

Kerry ↓

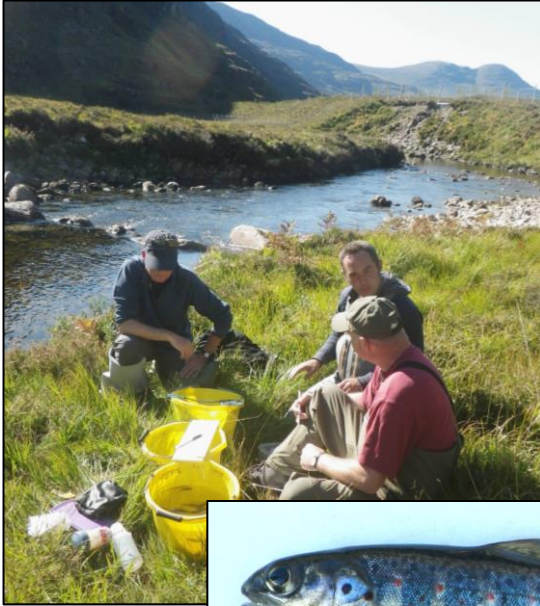
Balgy ↓

Badachro ↓

Applecross ↓

*Wester Ross Marine Protected Area*

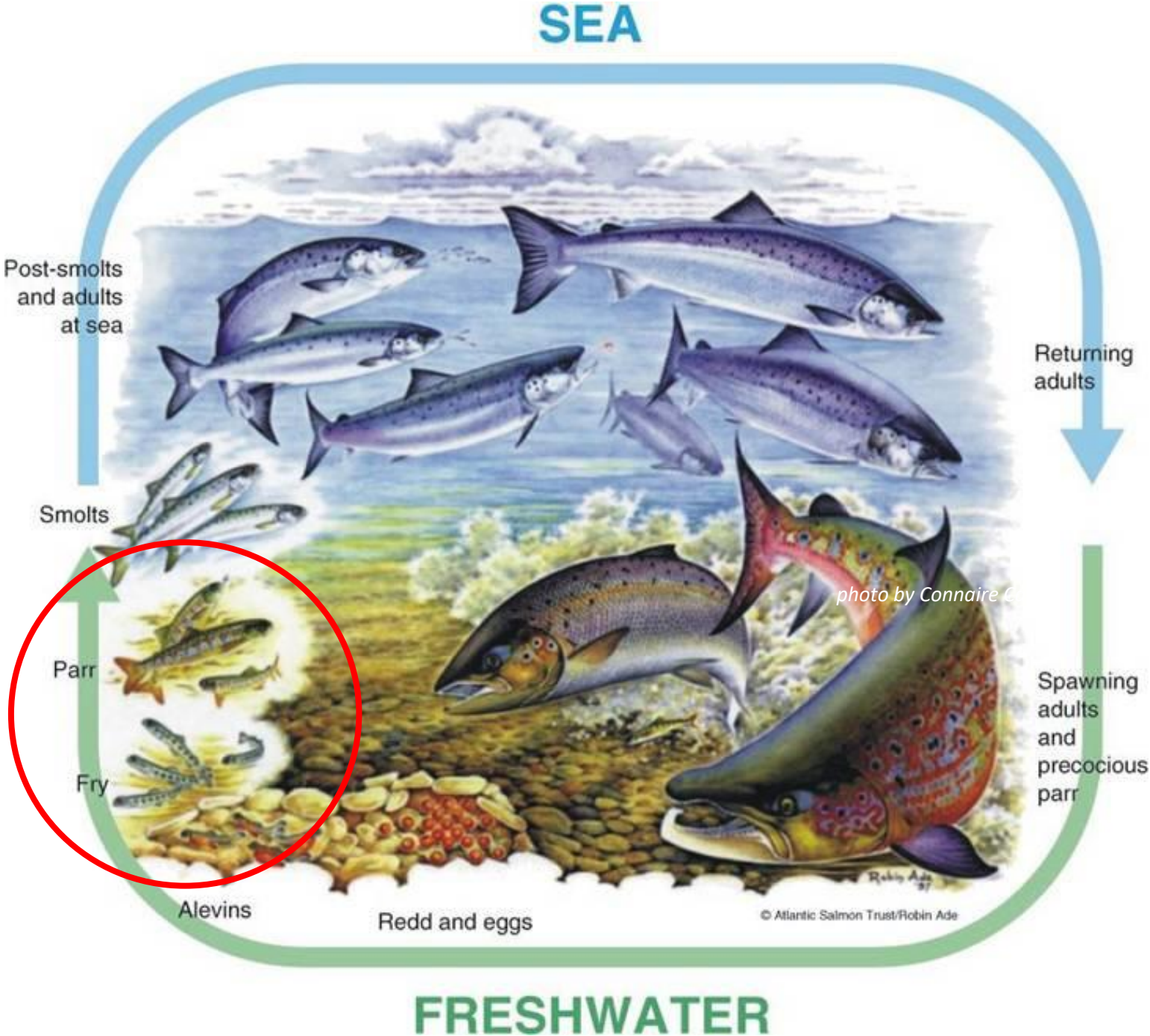
# Juvenile salmon



Juvenile fish survey team by Torridon River, 20<sup>th</sup> September 2019.



**How many juvenile salmon in our rivers?**





# WRFT Juvenile fish surveys 2023



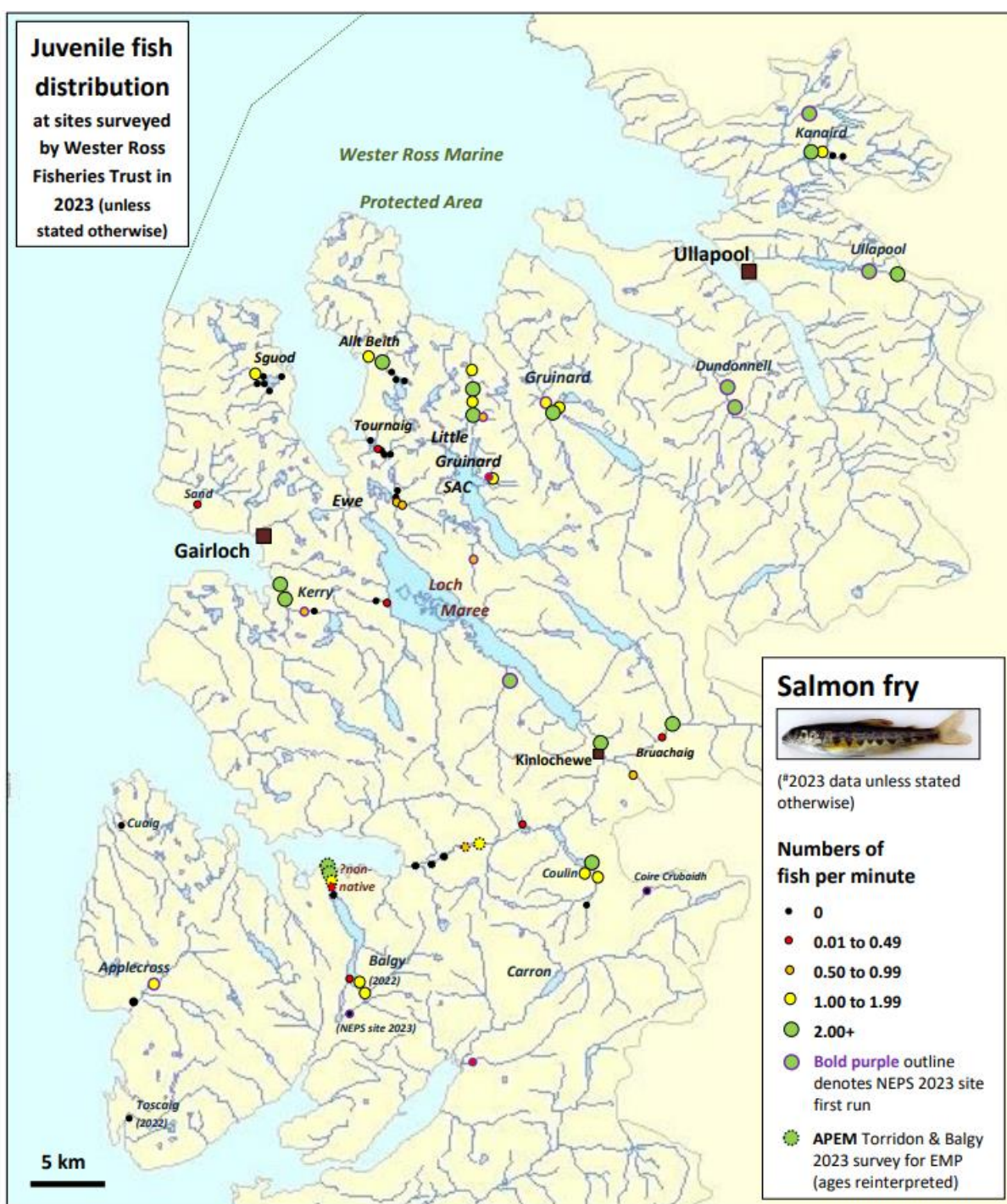
Nic Butler and Dr Shraveena Venkatesh en route to NEPS e-fish site in Little Gruinard River SAC headwaters, 10<sup>th</sup> August 2023

# WRFT Juvenile fish surveys 2023

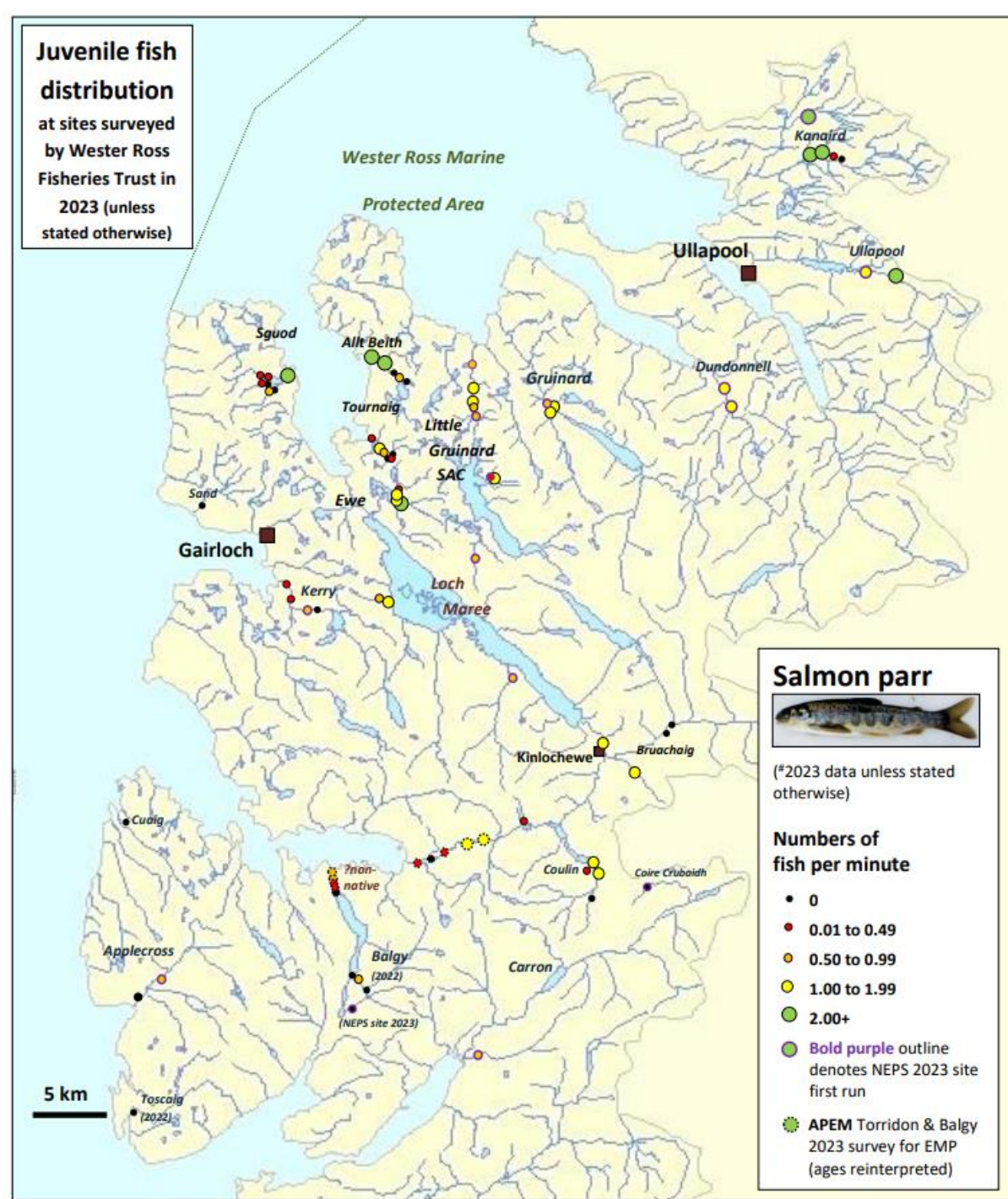


WRFT juvenile  
fish survey,  
River Kanaird,  
24<sup>th</sup> August  
2023

**Juvenile fish distribution**  
at sites surveyed by Wester Ross Fisheries Trust in 2023 (unless stated otherwise)



**Juvenile fish distribution**  
at sites surveyed by Wester Ross Fisheries Trust in 2023 (unless stated otherwise)

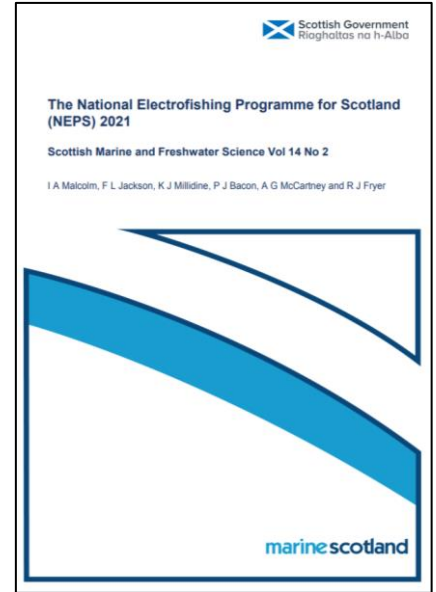


# National Electrofishing Programme of Scotland [NEPS]

reporting has focussed on **estimated numbers** of fry and parr / m<sup>2</sup>

The screenshot shows the NEPS website with the following elements:

- Navigation menu: Welcome, Site-wise Fish Data Description, Site-wise Fish Data Maps (selected), Regional Fish Data Description, Regional Fish Data Maps, Genetic Data Description, Genetic Introgression Maps, Site-wise Water Quality Data Description, Site-wise Water Quality Data Maps, References and Acknowledgements.
- Filters on the left:
  - Survey-spatial scale: NEPS-Catchment
  - Sampling year: 2021
  - Location: Gruinard River
  - Species: Salmon
  - Lifestage: parr
  - Metric: Estimated Density
- Main map: Gruinard River Salmon parr 2021: Estimated Density. The map shows a river network with a color scale for density in n m<sup>-2</sup> (0.02 to 2.00).
- Footer: Marine Scotland Science Crown Copyright 2022. OPR licensed from CSIR, NERAC. Crown copyright and database right 2022. All rights reserved. OPR Licence number 00024625. Maps are plotted on British National Grid (meters). Dark grey lines are catchments that come under Conservation Regulations.



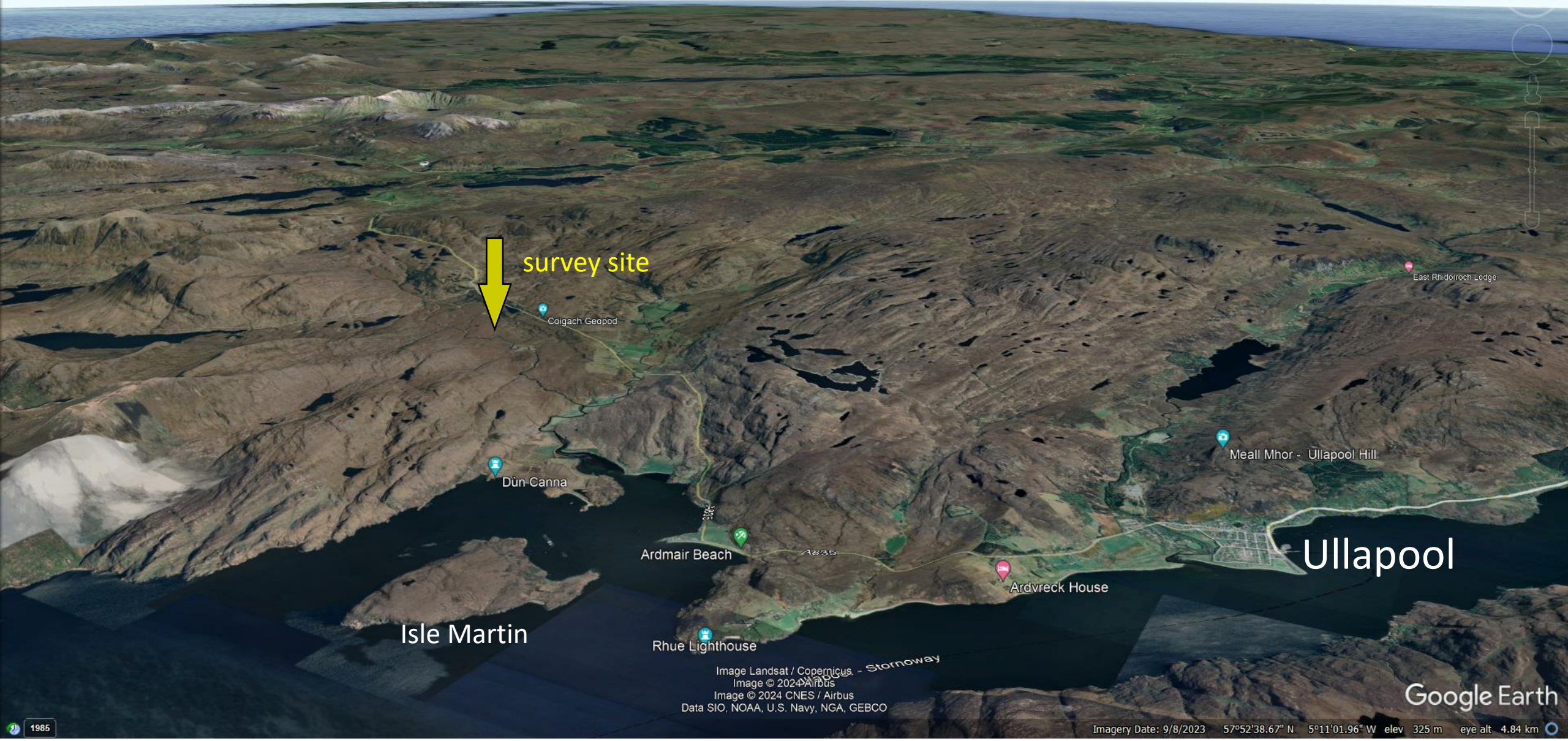
However **growth and biomass** of fry and parr / m<sup>2</sup> are important for assessing health and estimated smolt production and smolt size

Big fat smolts have higher rates of marine survival than small skinny ones (c. Armstrong, et al 2018)





# River Runie, tributary of the River Canaird, 24<sup>th</sup> August 2023



survey site

Coigach Geopod

Dùn Canna

Ardmail Beach

Rhue Lighthouse

Ardreck House

Meall Mhor - Ullapool Hill

East Rhiadorrach Lodge

Ullapool

Isle Martin

Image Landsat / Copernicus - Stornoway  
Image © 2024 Airbus  
Image © 2024 CNES / Airbus  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

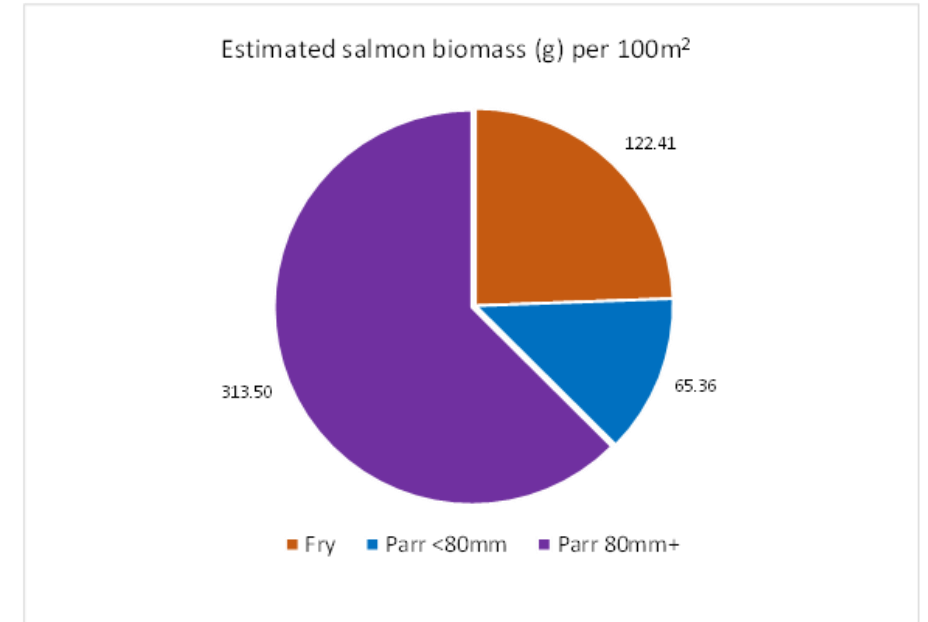
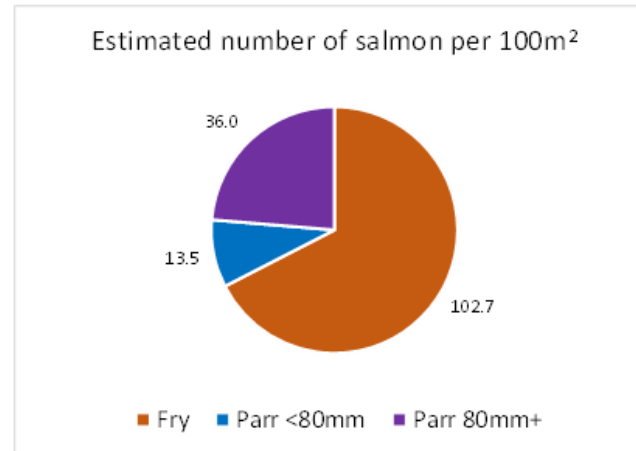
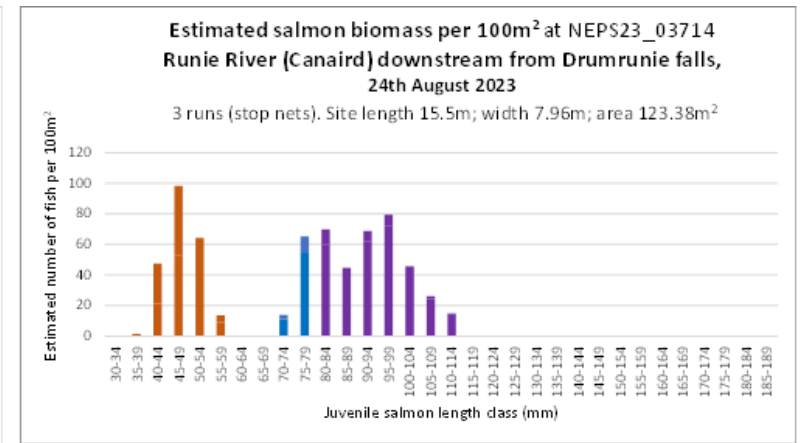
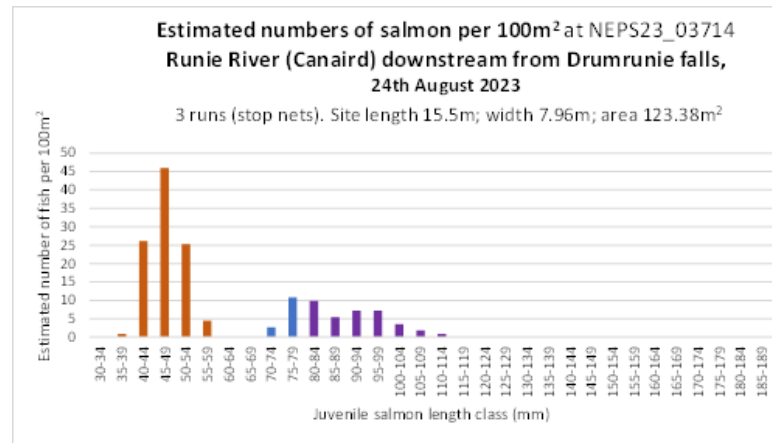
Google Earth

# River Runie (Canaird) 24<sup>th</sup> August 2023

- 3-run NEPS site



- **estimated production of >25 smolts per 100m<sup>2</sup>**



The minimum density of juvenile salmon was **152.2 juvenile salmon / 100m<sup>2</sup>**, and **total biomass: 501.27grams / 100m<sup>2</sup>**.

These figures are much higher than for some sites in other rivers in Wester Ross, including sites in the Gruinard and Little Gruinard River reported below.



# Gruinard River



survey site



The Fisherfields Round, Fisherfield Forest

Camhinnis Bathy

Garloch Beach (East)

Inverewe Viewpoint

Arctic Convoy Museum

Rocklea Self-catering Cottage  
Gruinard Beach

Gruinard Bay View Point

Ocean view

Gruinard Bay Caravan Park & Camping

Image © 2024 Maxar Technologies  
Image Landsat / Copernicus  
Image © 2024 CNES / Airbus  
Image © 2024 Airbus

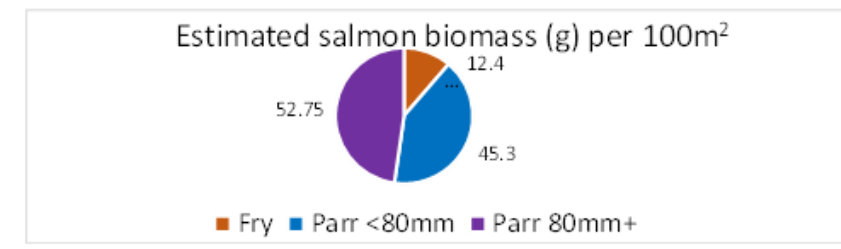
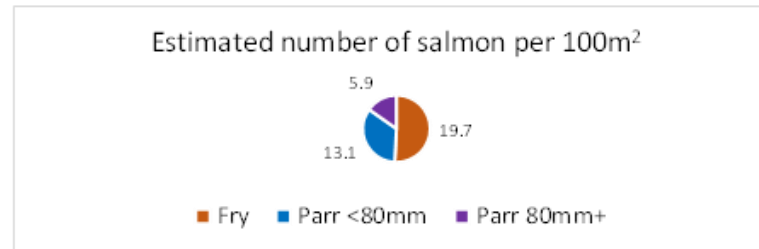
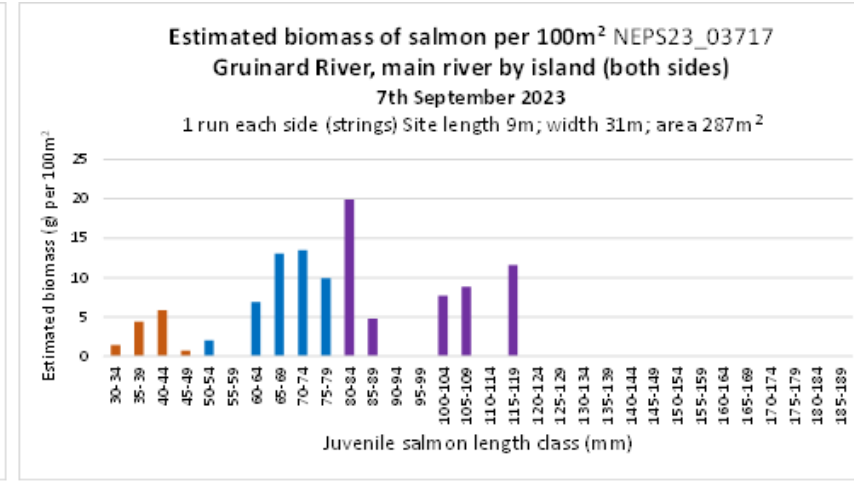
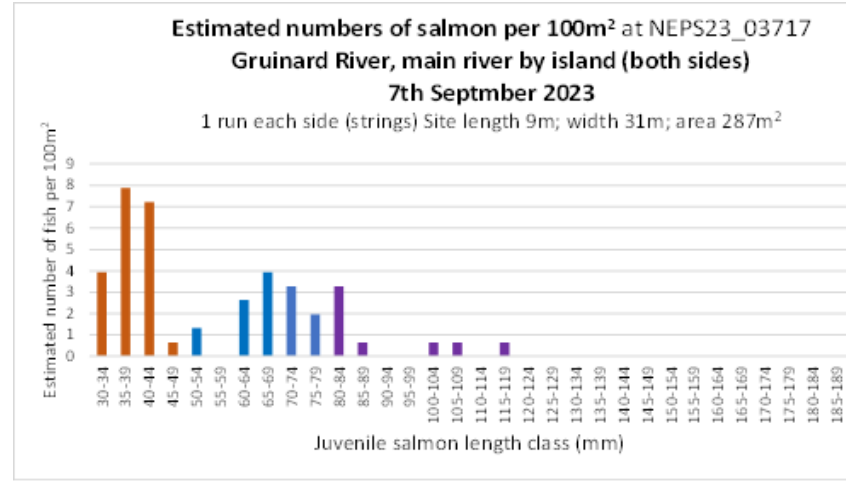
# Gruinard River

## 7th September 2023

- 1-run NEPS site



- estimated production of <5 smolts per 100m<sup>2</sup>
- malnourished parr?

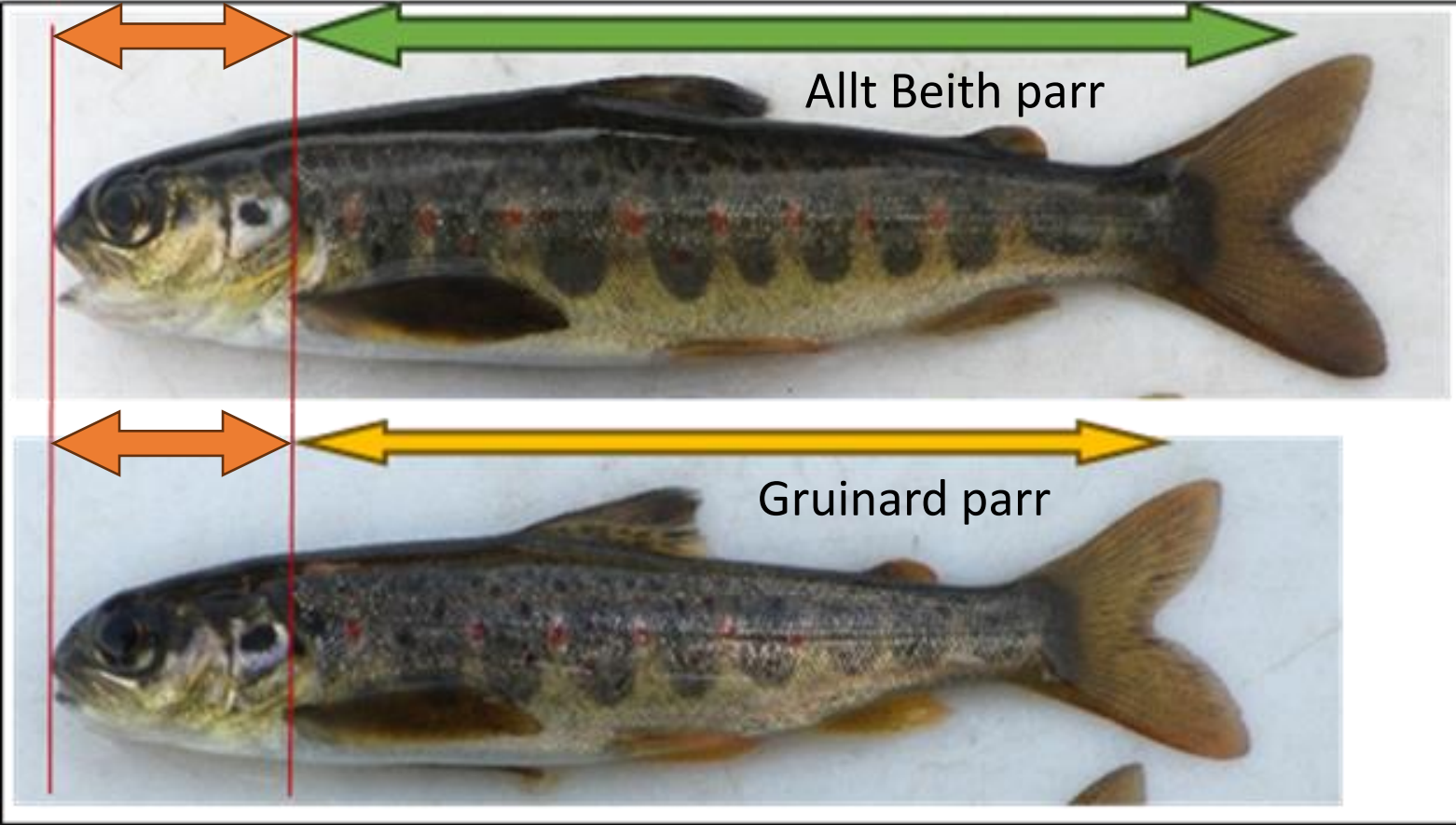


The total estimated minimum density of juvenile salmon was just **39 juvenile salmon / 100m<sup>2</sup>**, and **total estimated biomass 110 grams of juvenile salmon / 100m<sup>2</sup>**.

In addition to juvenile salmon, two juvenile trout and two eels were recorded.



# Big differences in Wester Ross between size and condition of juvenile salmon in different rivers



Huusko et al (2011) found that **juvenile salmon may shrink** when subject to harsh living conditions, with shortening of the spine.



# Little Gruinard River, 22<sup>nd</sup> August 2023

North

survey site

The Fisherfields Round, Fisherfield Forest

Camhinnis Bally

Camhinnis Bally (East)

Inverewe Viewpoint

Arctic Convoy Museum

Rocklea Self-catering Cottage  
Gruinard Beach  
Gruinard Bay View Point

Ocean view

Gruinard Bay Caravan Park & Camping

Image © 2024 Maxar Technologies  
Image Landsat / Copernicus  
Image © 2024 CNES / Airbus  
Image © 2024 Airbus

Google Earth

Imagery Date: 3/22/2022 57°51'39.24" N 5°34'51.71" W elev 75 m eye alt 4.57 km

1985

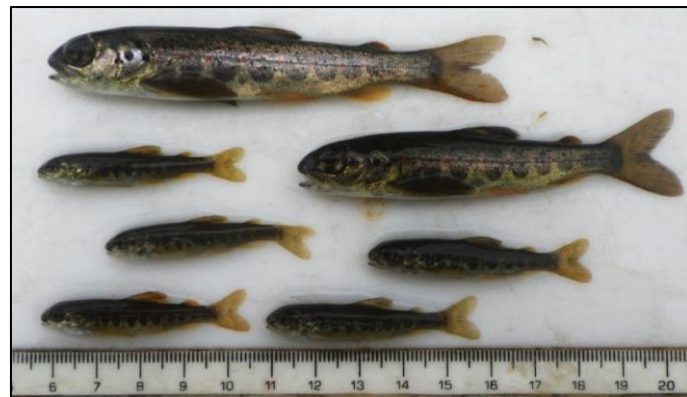
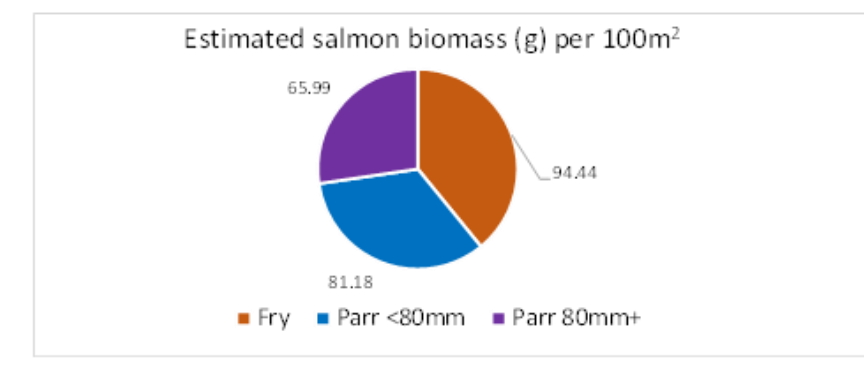
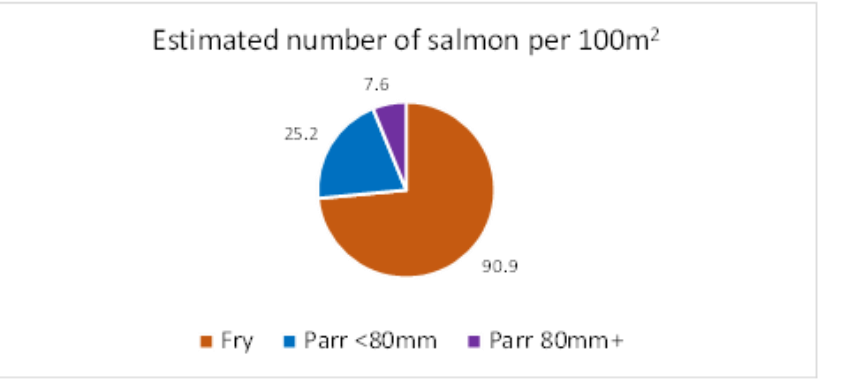
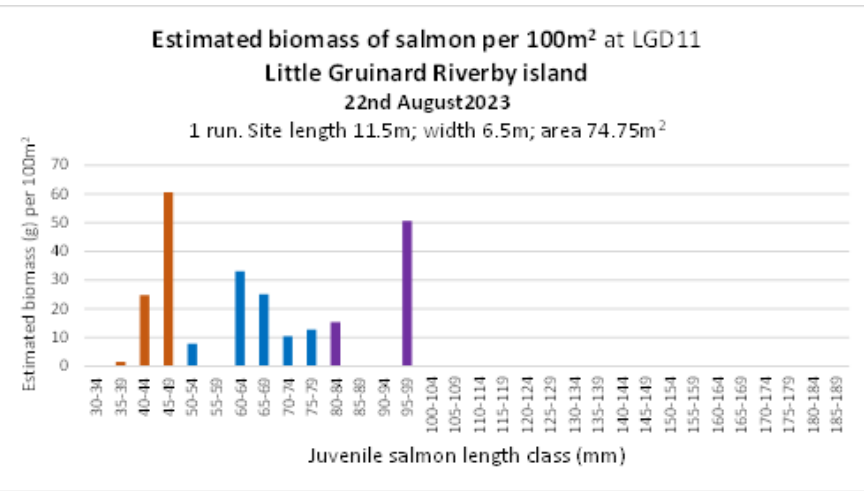
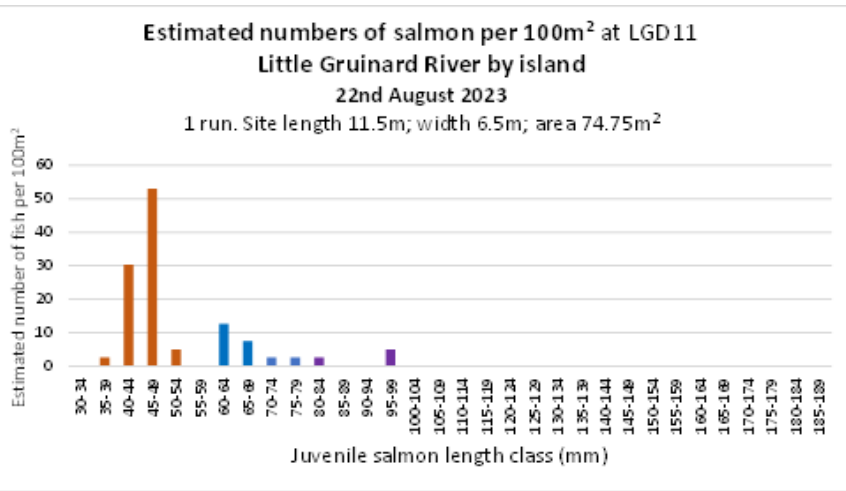
# Little Gruinard River

## 22<sup>nd</sup> Aug 2023

- 1-run WRASFB site



- estimated production of ~6 smolts per 100m<sup>2</sup> malnourished parr?

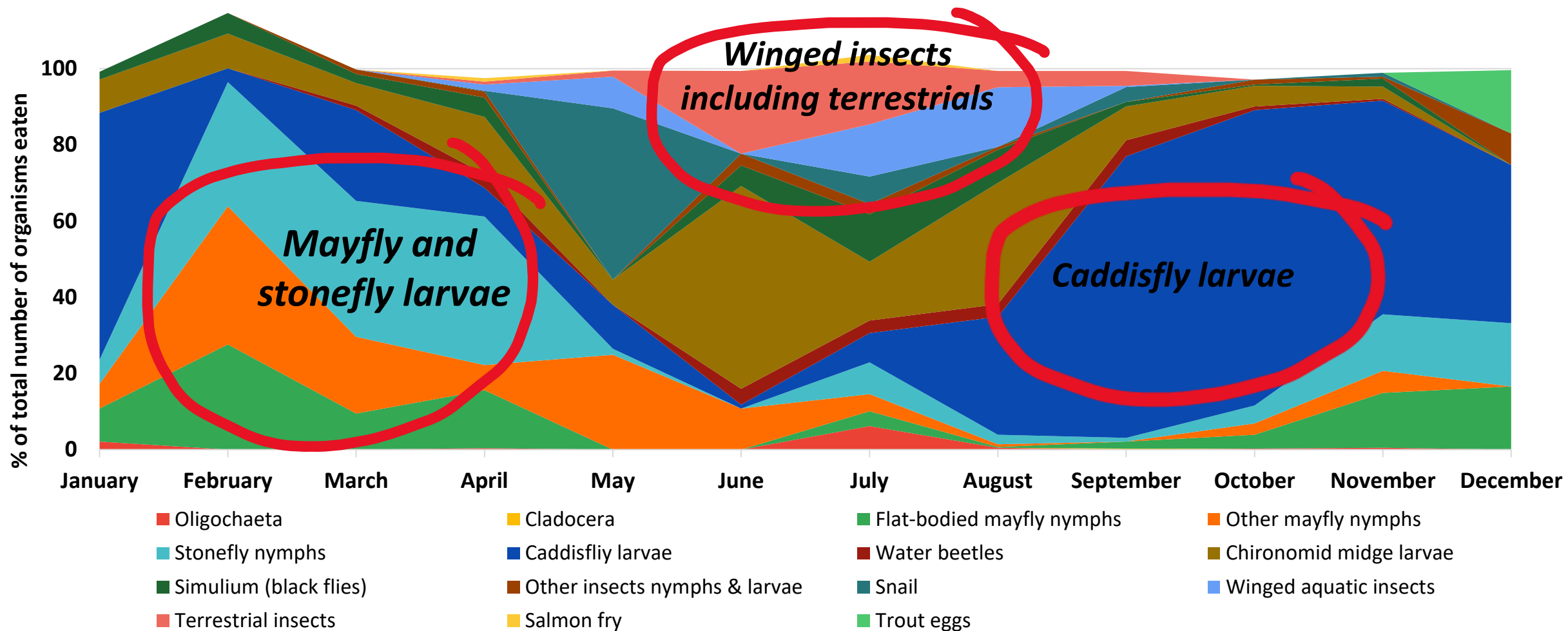


The minimum density of juvenile salmon was **124 juvenile salmon / 100m<sup>2</sup>**, with a total estimated biomass of **241 grams of juvenile salmon / 100m<sup>2</sup>**.

The fish were mostly small salmon fry, with just a minor proportion of parr big enough to become smolts in 2024.

# What do salmon parr eat at different times of year (if they can find it . . . )?

**Food of salmon parr (stocked as eggs), River Bran and tributaries (River Conon system)**  
 Number of food organisms expressed as % of the total organisms eaten by parr; from Mills (1964)



Source of data: Mills, D. H. (1964). The ecology of the young stages of the Atlantic salmon in the River Bran, Ross-shire. *Sci. Invest. Freshw. Fish. Scot.* 32, 1-58

## Juvenile salmon food



In Wester Ross, numbers of aquatic insects are usually higher where rivers have some additional nutrient sources

# Little Gruidie River, 22<sup>nd</sup> August 2023



Banks of sediment where salmon have spawned ('ancestral redds') may be hundreds of years old?

survey site

Feedback

50 ft 10 m

© 2024 TomTom, © OpenStreetMap, © Voxel Imaging

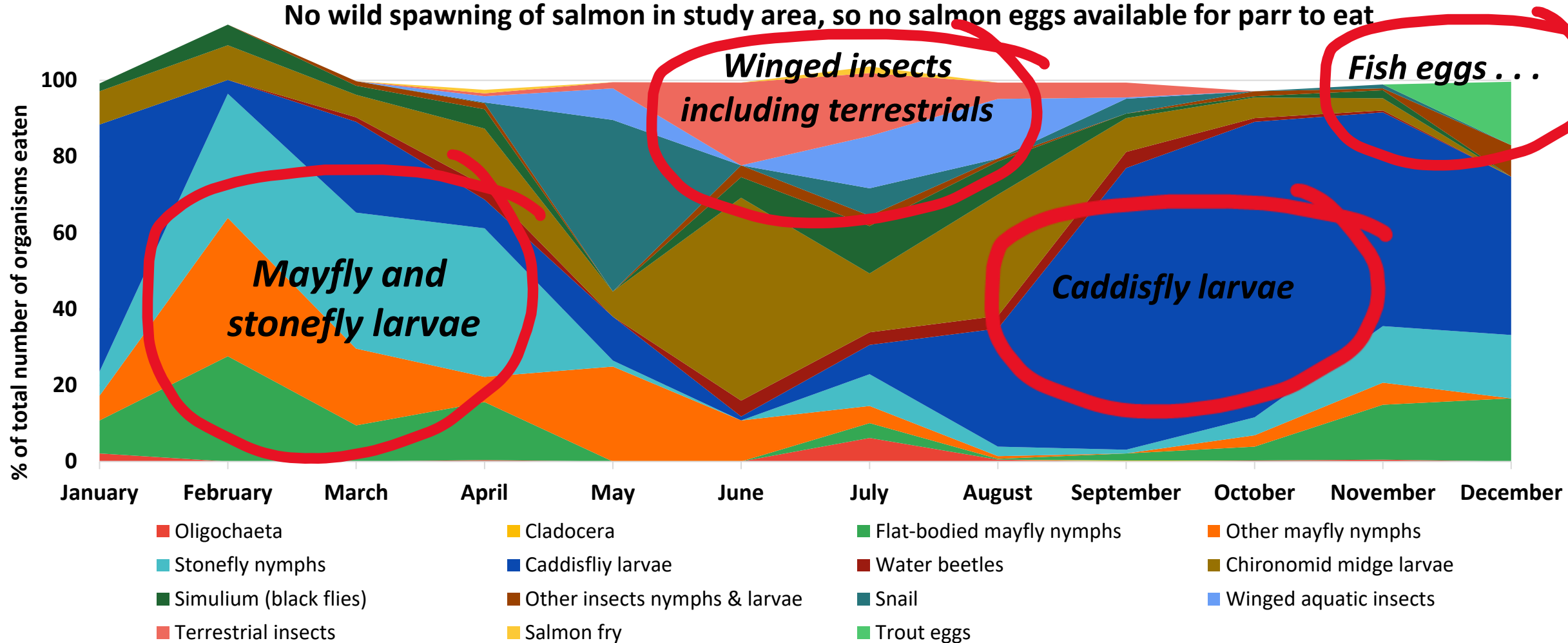
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# What do salmon parr eat at different times of year (if they can find it . . . )?

Food of salmon parr (stocked as eggs), River Bran and tributaries (River Conon system)

Number of food organisms expressed as % of the total organisms eaten by parr; from Mills (1964)

No wild spawning of salmon in study area, so no salmon eggs available for parr to eat



# In autumn and early winter, salmon parr can eat many salmon eggs

What is the importance of salmon eggs as a food for pre-smolt salmon parr in oligotrophic streams?

The Lives of

S  
An  
Life

**From:** Alan Youngson [mailto:alan.youngson@btinternet.com]

**Sent:** 19 November 2018 16:47

**To:** Peter Cunningham

**Subject:** Re: salmon eggs and salmon parr

Hi Peter,

I hope you are well.

The egg-eating question is an interesting one. As you know lots of the parr (and trout) contain eggs at spawning time. You don't have to open them up to see this because the eggs are so packed into the fish that the mass in the stomach bulges characteristically on the fishes' underside. A parr of 120mm can hold 12 to 15 eggs if offered them and parr down to 70mm can (somehow) get them down. As far as I can discover, eggs are the only thing that captive wild parr will eat.

This little trout had 11 salmon eggs in its stomach. Possibly its best meal of the year!

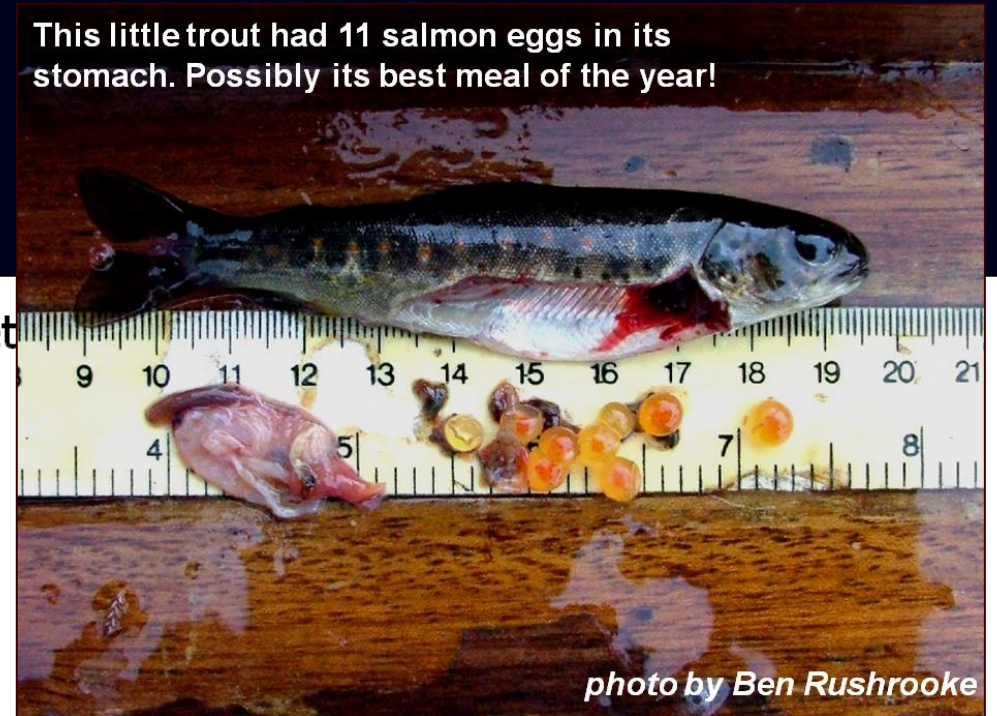


photo by Ben Rushrooke



Juvenile salmon food can include salmon eggs and alevins



# Girnock Burn, Aberdeenshire Dee, Scotland

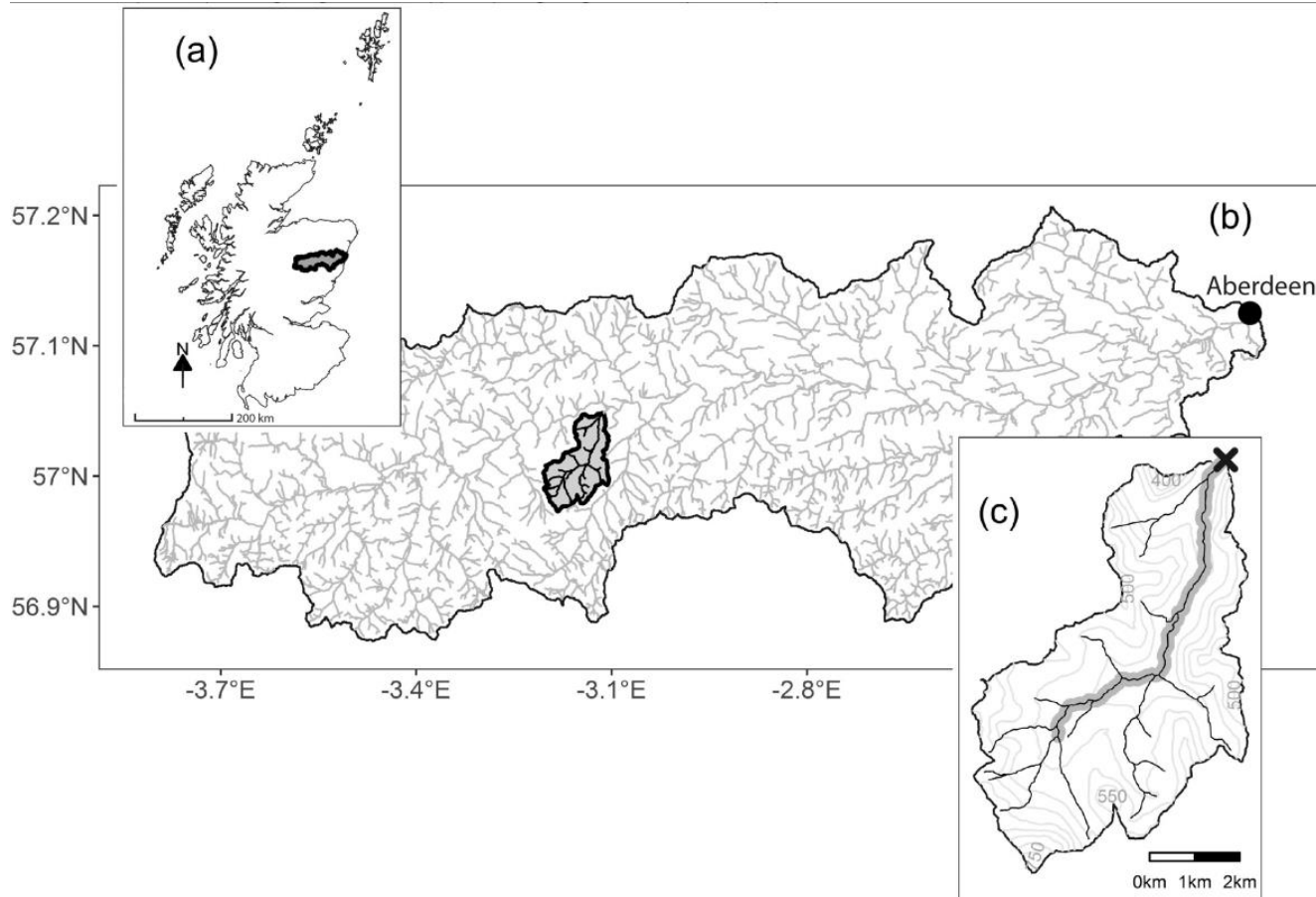
where Alan Youngson and colleagues monitored wild salmon

Upstream-downstream fish traps to record adult salmon moving into the burn (upstream) and juvenile salmon moving out of the burn (downstream)



Image © 2024 CNES / Airbus  
Image © 2024 Maxar Technologies  
Image Landsat / Copernicus

# Girnock Burn review paper, just published!



Received: 21 November 2023 | Revised: 2 February 2024 | Accepted: 6 February 2024  
DOI: 10.1002/hyp.15105

Check for updates

WILEY

**INVITED REVIEW**

## Six decades of ecohydrological research connecting landscapes and riverscapes in the Girnock Burn, Scotland: Atlantic salmon population and habitat dynamics in a changing world

C. Soulsby<sup>1,2</sup> | I. A. Malcolm<sup>1,3</sup> | D. Tetzlaff<sup>1,2,4</sup>

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<sup>2</sup>Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany  
<sup>3</sup>Marine Directorate, Scottish Government, Edinburgh, UK  
<sup>4</sup>Department of Geography, Humboldt University, Berlin, Germany

**Correspondence**  
C. Soulsby, School of Geosciences, University of Aberdeen, Aberdeen AB24 3UF, Scotland.  
Email: [c.soulsby@abdn.ac.uk](mailto:c.soulsby@abdn.ac.uk)

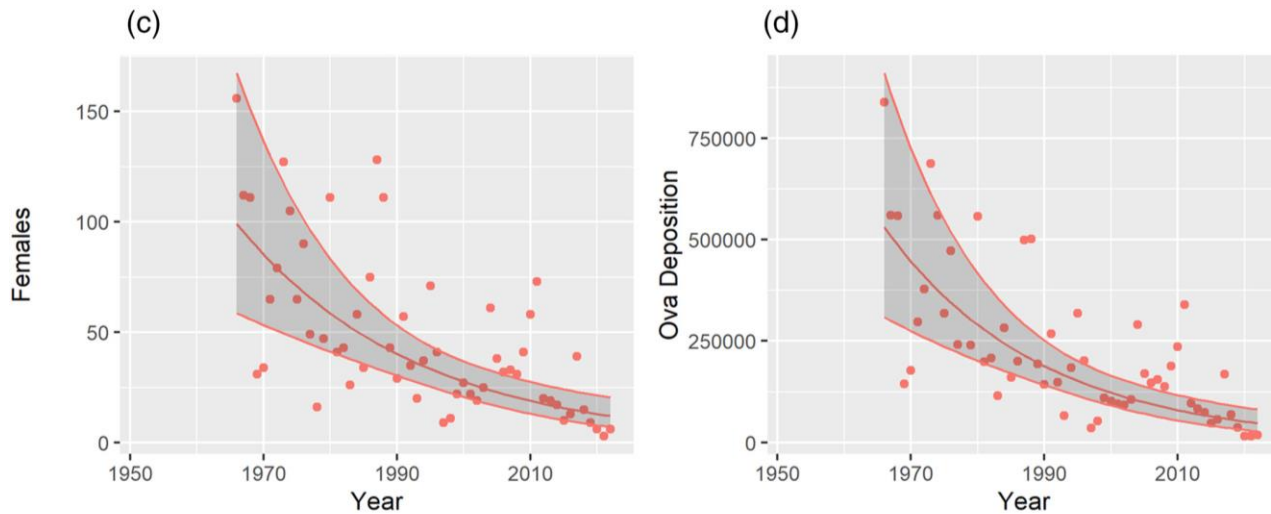
**Funding information**  
Leverhulme Trust

**Abstract**  
Long-term data are crucial for understanding ecological responses to climate and land use change; they are also vital evidence for informing management. As a migratory fish, Atlantic salmon are sentinels of both global and local environmental change. This paper reviews the main insights from six decades of research in an upland Scottish stream (Girnock Burn) inhabited by a spring Atlantic salmon population dominated by multi-sea-winter fish. Research began in the 1960s providing a census of returning adults, juvenile emigrants and in-stream production of Atlantic salmon. Early research pioneered new monitoring techniques providing new insights into salmon ecology and pop-

Soulsby, Chris & Tetzlaff, Doerthe & Malcolm, I.A.. (2023). Six decades of ecohydrological research connecting landscapes and riverscapes in the Girnock Burn, Scotland: Atlantic salmon population and habitat dynamics in a changing world.. 10.22541/au.170067435.59383187/v2.

<https://onlinelibrary.wiley.com/doi/10.1002/hyp.15105>

From: [Six decades of ecohydrological research connecting landscapes and riverscapes in the Girnock Burn, Scotland: Atlantic salmon population & habitat dynamics in a changing world](#)



**In 1970, 100 female salmon returned to spawn depositing 500,000+ eggs, producing 100,000 fry by day 240 of year; with potentially 200,000+ surplus eggs, food for 4,000 pre-smolt parr.**

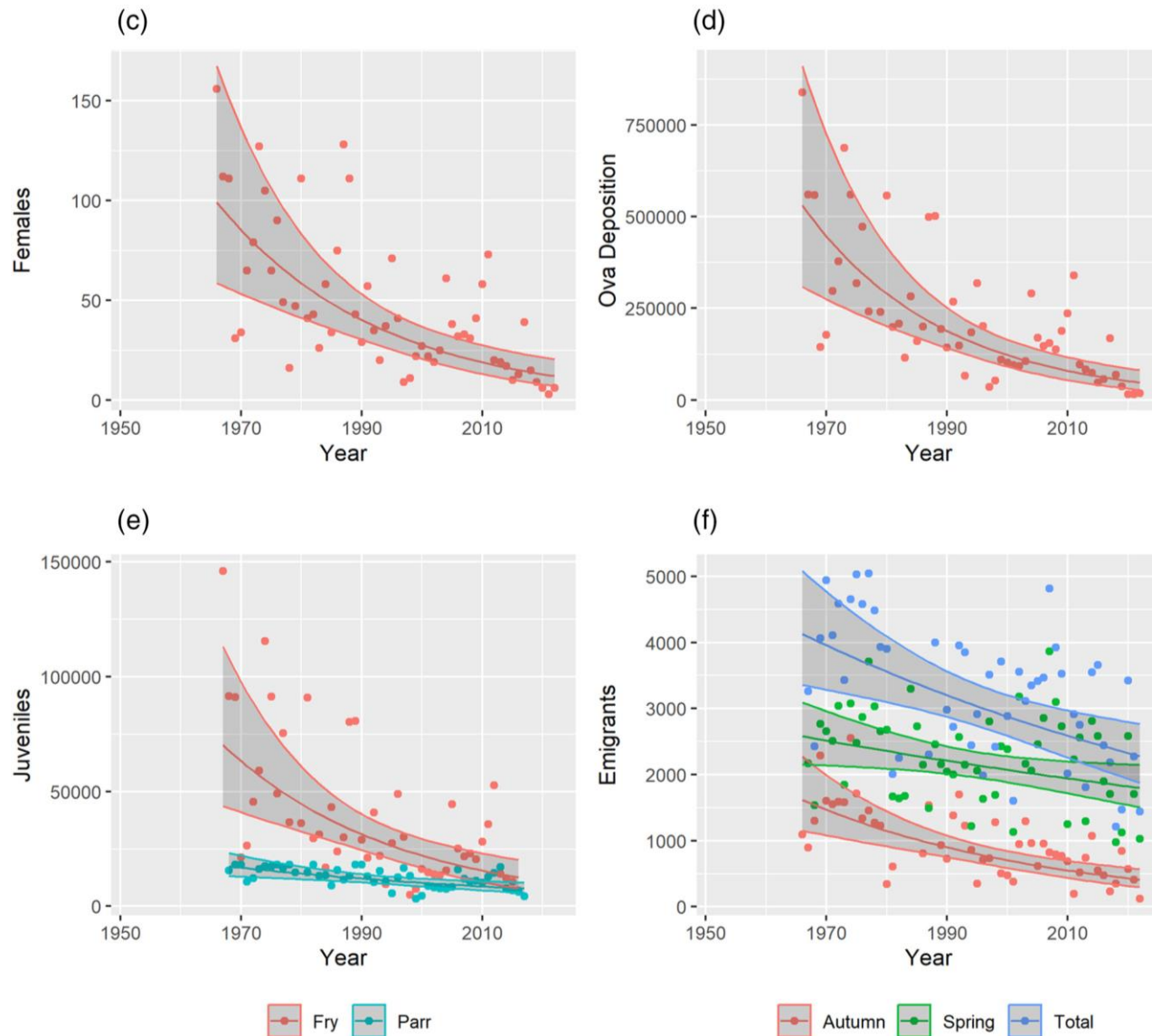
**In 2022, less than 20 adult female returned, depositing less than 50,000 eggs; with virtually no surplus eggs (not enough eggs to sustain juvenile production).**

*(left) Figure 4 Girnock burn female numbers (Glover & Malcolm, 2015b) (c), Ova deposition (d), Fry (0+) and Parr (>0+) production*

Hydrological Processes, Volume: 38, Issue: 3, First published: 17 March 2024, DOI: (10.1002/hyp.15105)

<https://onlinelibrary.wiley.com/doi/10.1002/hyp.15105>

# From: [Six decades of ecohydrological research connecting landscapes and riverscapes in the Girnock Burn, Scotland: Atlantic salmon population & habitat dynamics in a changing world](#)



**In 1970, over 4000 juvenile salmon (including smolts) emigrated from the Girnock Burn**

**By 2018, only around 2000 juvenile salmon (including smolts) emigrated from the Girnock burn**

*(left) Figure 4 Girnock burn female numbers (Glover & Malcolm, 2015b) (c), Ova deposition (d), Fry (0+) and Parr (>0+) production (e), and production of emigrants (Glover & Malcolm, 2015c) (f). Fry and Parr production estimates are for day of the year 240, following Glover et al., 2018.*

**Hydrological Processes, Volume: 38, Issue: 3, First published: 17 March 2024, DOI: (10.1002/hyp.15105)**

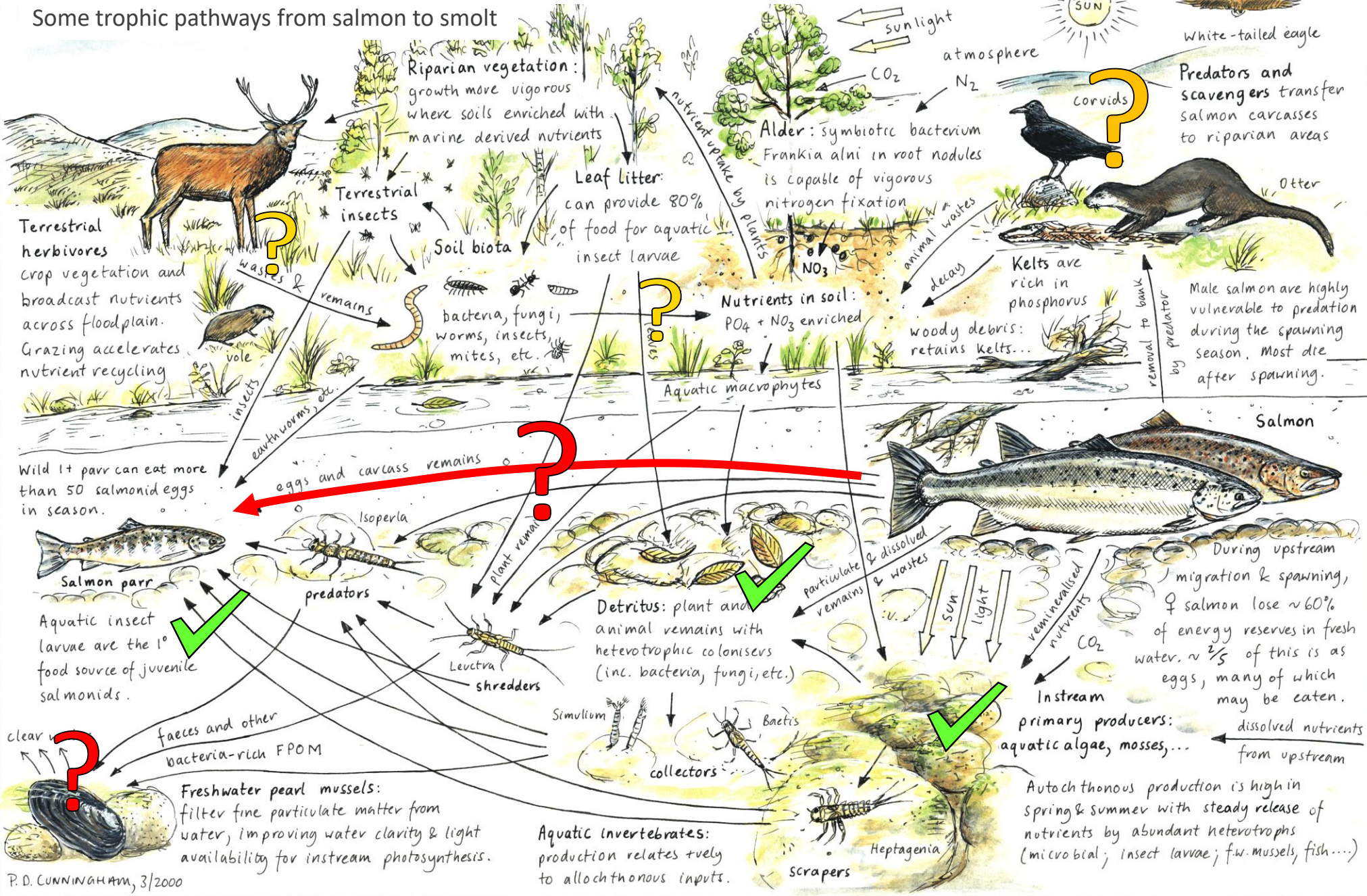
<https://onlinelibrary.wiley.com/doi/10.1002/hyp.15105>

# How important were (are) surplus salmon eggs as food for salmon parr?

Research over past 20 years has focussed on instream indirect trophic pathways via streambed flora and fauna.

For some rivers in Wester Ross surplus 'washed out' eggs may have provided many vital meals for pre-smolts.

## Adult salmon provide marine nutrients for other wildlife . . .



P. D. CUNNINGHAM, 3/2000

Most Atlantic salmon return to freshwater only once to spawn . . .



*Little Gruinard River*

*"...what if I told you that the trees are here, in part, because of salmon? That the trees that shelter and feed the fish, that help build the fish, are themselves built by the fish?"*

*-- Carl Safina, essayist for **Salmon in the Trees***



*photos by Amy Gulick*







In the past, many more salmon returned to Scottish rivers from the sea each year.

**How much marine nutrient was transferred to terrestrial ecosystems in Scotland in the past?**

**How many surplus eggs were there for salmon parr?**

**How important was this for pre-smolts?**



# Gruinard River salmon eggs as food for parr model

North

Ruler

Line Path Polygon Circle 3D path 3D polygon

Measure the distance between two points on the ground

Map Length:	8,005.83	Meters
Ground Length:	8,008.36	
Heading:	142.45	degrees

Mouse Navigation

Length ~8000m

Wet width <10m to >25m

For purposes of model – assume **100,000m<sup>2</sup>** of nursery habitat for juvenile salmon



# Salmon eggs as winter nutrition model for the Gruinard River how many surplus eggs are needed for pre-smolt salmon?

1. Assume river length 8,000m and wet width 12.5m, so river wetted area of 100,000m<sup>2</sup>. At smolt production of 10 smolts per year per 100m<sup>2</sup> of river area, annual smolt production of 10,000 smolts.
2. At **high marine survival rate** of 10% (of 10,000 smolts), return of 1000 adult salmon. If sex ratio of adult salmon is 50%:50% males to females, then 500 adult female salmon (assume all 500 survive and spawn).
3. If each female salmon is of average mass 2.5kg, then total mass of 1,250 kg of female salmon. If 1,200 eggs per kg, then total transfer of eggs to river is 1,500,000 eggs. To produce average fry density at swim up of 1 fry per m<sup>2</sup> of stream habitat, just 100,000 eggs are needed. So over 1,400,000 surplus eggs.

If just 50% of surplus eggs are eaten by salmon parr before they smolt in late autumn early winter, then each pre-smolt has (700,000 eggs / 10,000 pre-smolt salmon).

4. That is an average of 70 eggs (or alevins) per pre-smolt salmon. Potentially the most important winter food source for pre-smolt salmon parr in the Gruinard River? Salmon parr are known to be able to eat from 12 – 15 eggs in a meal (Youngson, 2014); then they take many days to digest the eggs.





**DRAFT** About sustaining wild salmon populations in Wester Ross:  
smolt production and smolt size varies between rivers



Peter Cunningham [info@wrft.org.uk](mailto:info@wrft.org.uk)  
January 2024

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## Low marine survival rate scenario

5. However, if the marine survival is only 2% (of 10,000 smolts) then return of only 200 adult salmon; or 100 female salmon. At 2.5kg per female salmon, 250kg of female salmon. If 1,200 eggs per kg, then total transfer of eggs to river is only 300,000 eggs.

6. To produce average fry density of 1 fry per m<sup>2</sup> of stream habitat need just 100,000 eggs. So only 200,000 surplus eggs.

7. If 50% of surplus eggs are eaten by large salmon parr before they smolt in late autumn early winter, then each pre-smolt has (100,000 eggs / 10,000 pre-smolt salmon), so just 10 eggs per pre-smolt salmon.





**DRAFT** About sustaining wild salmon populations in Wester Ross:  
smolt production and smolt size varies between rivers



Peter Cunningham [info@wrft.org.uk](mailto:info@wrft.org.uk)  
January 2024

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## What is the energy value of a salmon egg to a salmon parr?

8. A salmon egg (wet mass) weighs from 0.05g to 0.14g (variation in egg size), with an energy content of 0.4kJ to 1.0kJ, mostly as protein and lipid (Berg et al, 2001).

9. A fasting salmon needs 30kJ – 80kJ of energy per kg of salmon per day (Kaushik & Medale, 1994), so 0.03kJ to 0.08kJ per g of salmon per day.

10. Therefore, a 10g parr (of length ~100mm) would need 0.3kJ to 0.8kJ per day; a 20g (~120mm) parr would need 0.6kJ to 1.6kJ per day, and so on (energy requirements also vary according to water temperature).

**11. Therefore, during winter months, one salmon egg would provide approximately the energy requirements of a salmon parr of 100mm – 120mm for a day.**





**DRAFT** About sustaining wild salmon populations in Wester Ross:  
smolt production and smolt size varies between rivers



Peter Cunningham [info@wft.org.uk](mailto:info@wft.org.uk)  
January 2024

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## Conclusions from this model

- Until the 1970s, surplus salmon eggs may have been able to provide pre-smolt salmon with their minimum energy requirements for about 70 days during the early winter . . .
- However in recent years, surplus salmon eggs may have been able to provide food requirements for pre-smolt salmon of only 10 days or less

Are (were) surplus salmon eggs a vital food source for pre-smolt parr in some rivers in Wester Ross?



**Malnourished nursery streams?**



**DRAFT** About sustaining wild salmon populations in Wester Ross:  
smolt production and smolt size varies between rivers



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## Wester Ross juvenile salmon production report for 2023

- To sustain salmon populations, what matters most is how many smolts are produced per unit wetted area and how big and strong the smolts are. **We need to focus on this.**
- **What can be done to enhance food supply for juvenile salmon in Wester Ross?**



Big salmon  
smolts from  
Badachro River,  
21<sup>st</sup> April 2021

# Thank you to:



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and to estates, members, other supporters,  
and many volunteers for lots of in-kind help  
in 2023