



Partnership working at Loch Leven to understand ecosystem service benefits from freshwaters

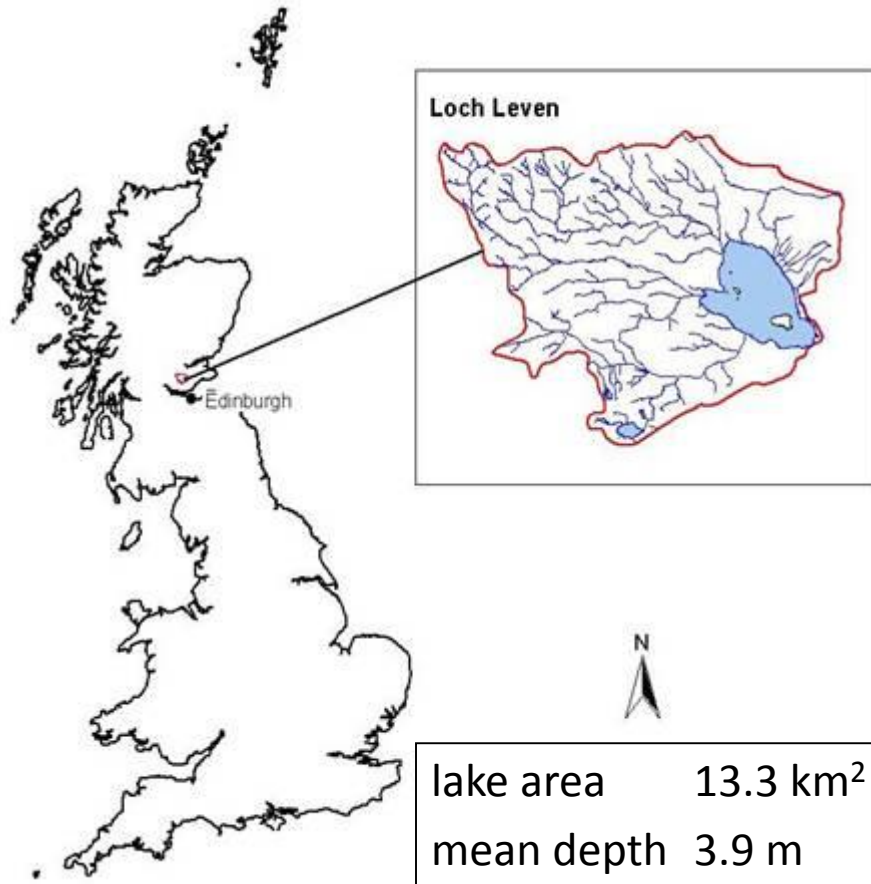
Laurence Carvalho, Helen Woods, Ian Winfield, Linda May (**CEH**)
Jamie Montgomery, Michael Wilson & Willie Wilson (**Loch Leven Fishery**)
Neil Mitchell, Jeremy Squire & Karen Mitchell (**SNH**)
Judith Moore & Shona McConnell (**SEPA**)

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Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Loch Leven, Scotland



- World famous brown trout fishery
- High bird conservation value
- Historical importance – tourism value
- Recreation hotspot
- Scientific value (monitored for 50 yrs)
- Agricultural catchment
- Water purification service
- Water supply to downstream industry

Long-term records collected by CEH

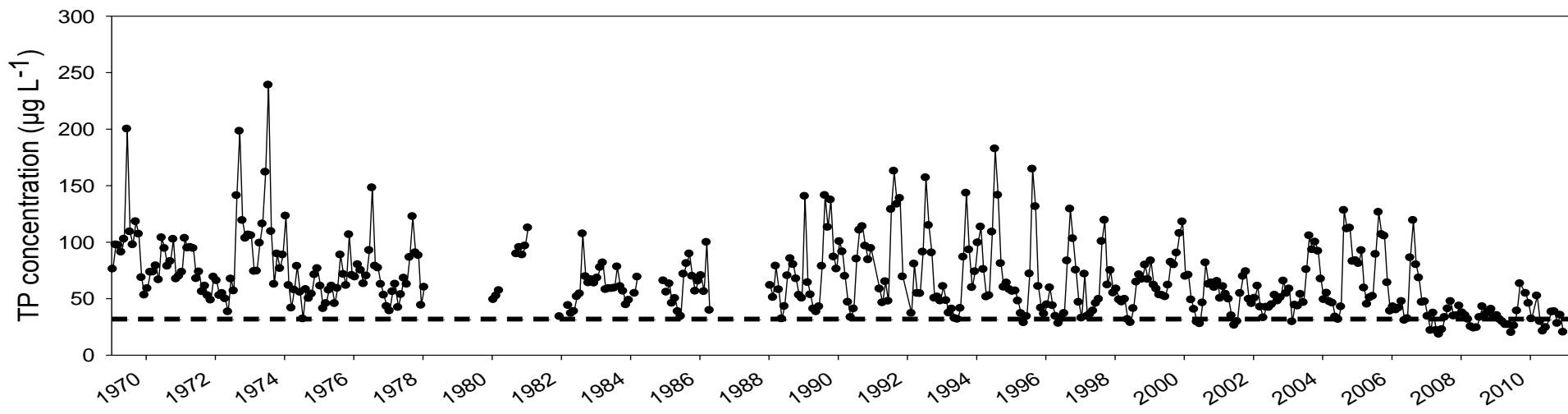
Length of dataset: 50 years (1968 onwards)

Sampling frequency: fortnightly

Measurements covering...

- Physics (water temperature, water clarity)
- Chemistry (N, P, Si, etc.)
- Biology (phytoplankton, zooplankton, macrophytes, benthic invertebrates, fish)

Nutrient loading data: 1985, 1995, 2005, 2015

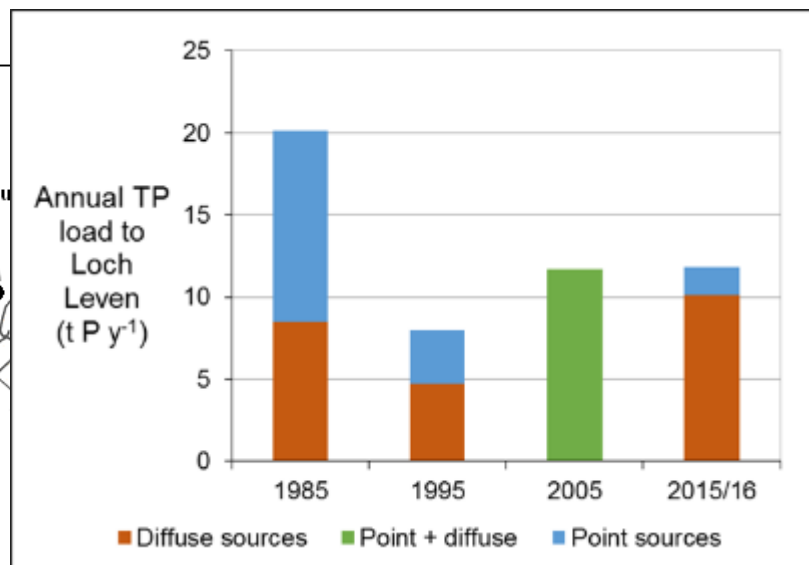
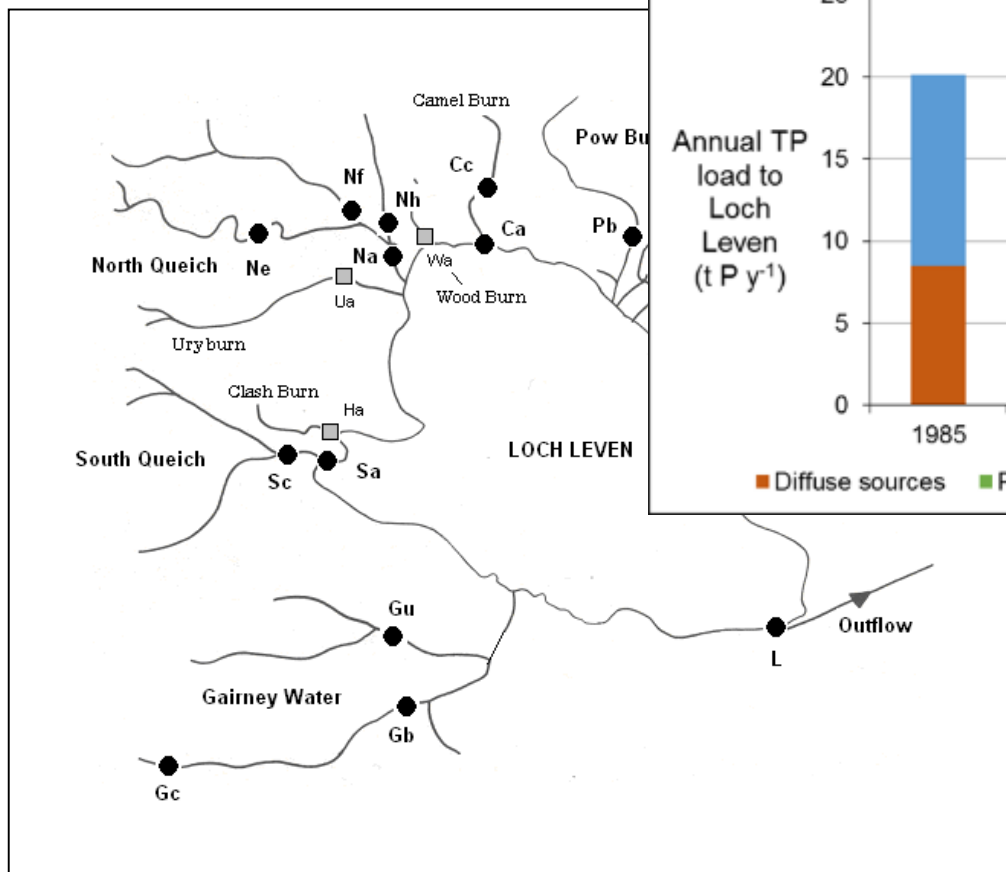


Datasets Collected by Partners

- Weather **since 1968** (Willie Wilson)
- Outflow discharge **2011 -** (SEPA)
- Macrophytes **1821 - 1999** (Various incl. Univ. Glasgow)
- Fish catches **daily since 1900** (Kinross Estates Company)
- Bird counts **monthly since 1967** (SNH)
- Satellite images & optical properties **2002-** (Univ. Stirling)
- Paleo-datasets: diatoms & macrofossils **1750 - 2005** (UCL)
- Angler numbers **daily since 1900** (Kinross Estates)
- Water supply **daily since 1850** (Tullis Russell)
- Tourist visitor numbers **daily since 2004** (Castle Island & RSPB Reserve)
- Recreational users (Heritage Trail) - **monthly since 2008**



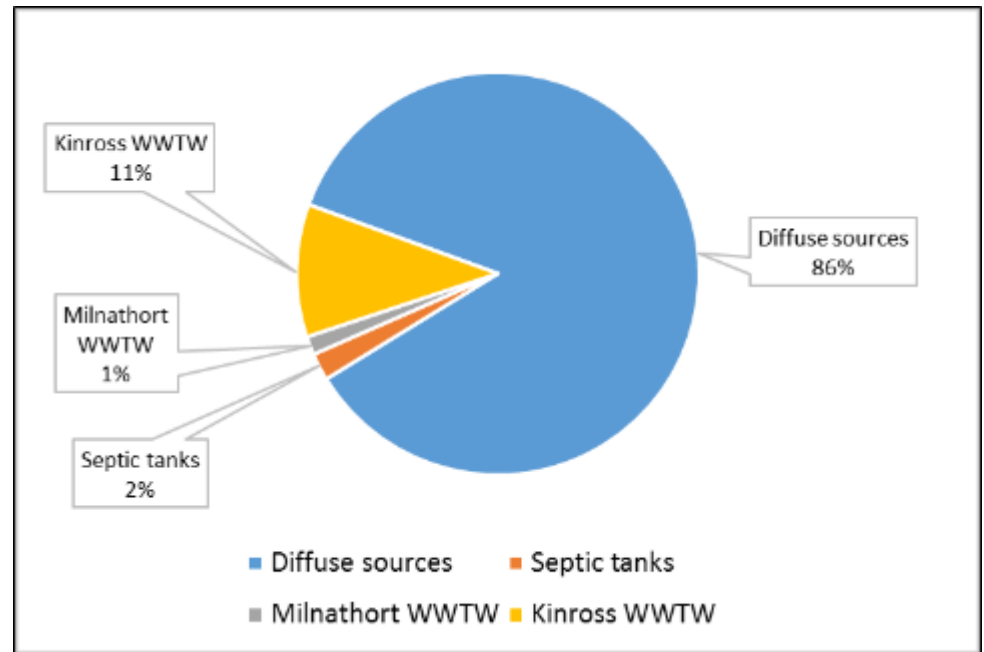
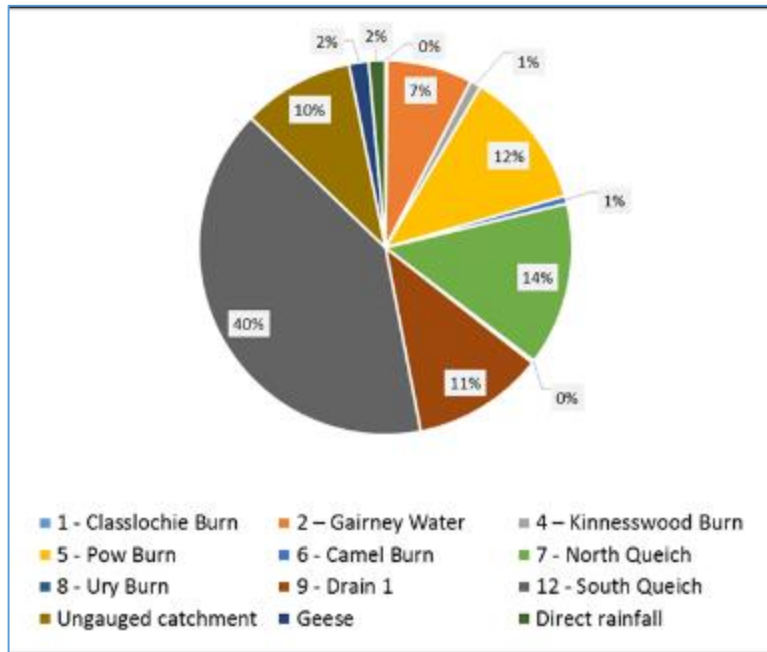
Loch Leven Decadal Loading Survey



P input measured every 7-8 days during 1985, 1995, 2005 & 2015/16

Bailey-Watts & Kirika, 1987, 1999; Defew 2008; May et al. 2017

2015/16 Source apportionment of P input



May et al., 2017

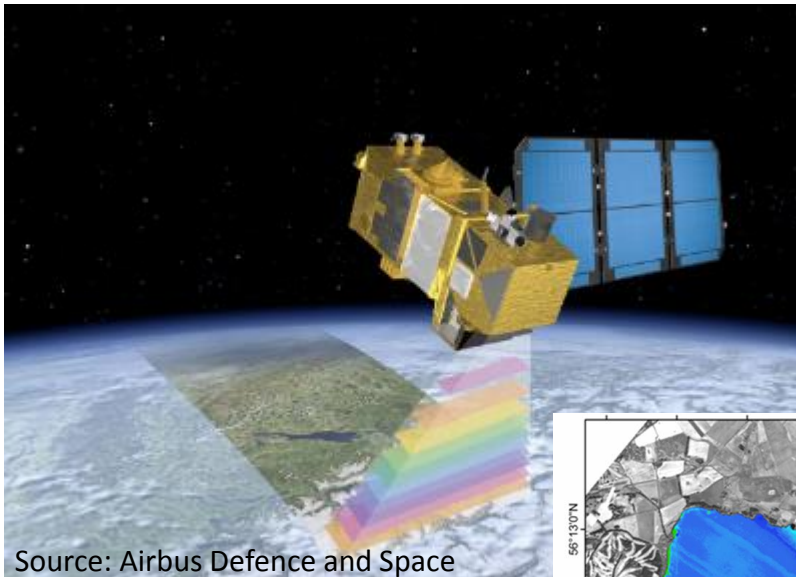
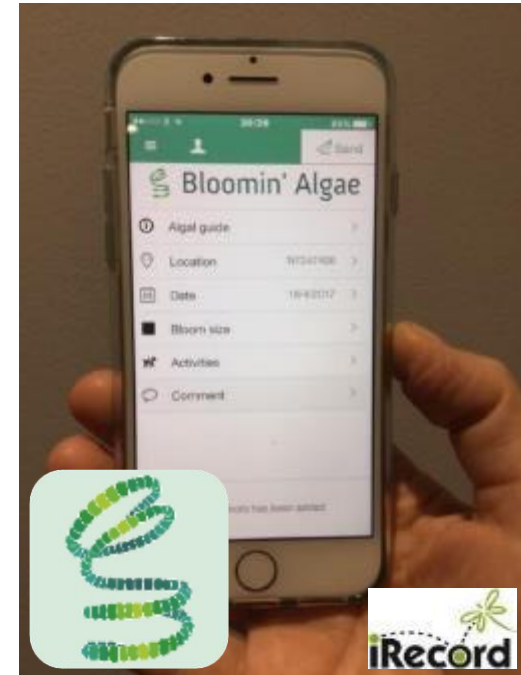
- Storm wastewater inputs unknown
- Diffuse sources dominate
- Sub-catchments behave differently

Monitoring Algal Blooms

Peter Hunter, Andrew Tyler & Evangelos Spyarakos



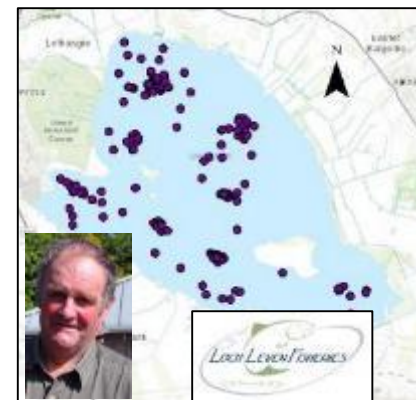
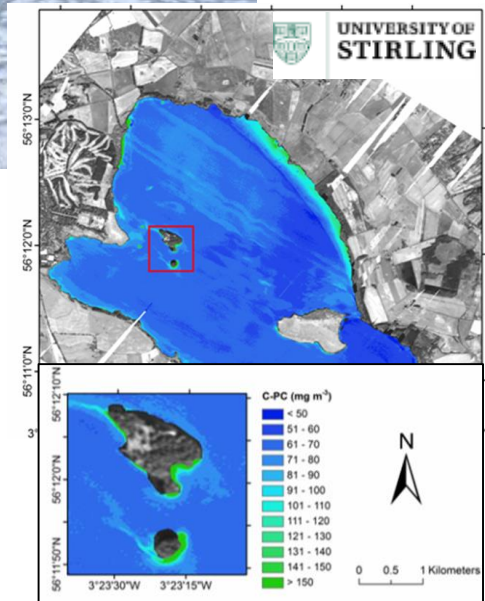
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Source: Airbus Defence and Space

Loch Leven

ESA test site for
Sentinel 2 & 3
Water Quality
Monitoring



Citizen validation data using Cyanotorch

EU OpenNESS Project



Centre for Ecology & Hydrology

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External Partners

Grazia Zulian (European Commission JRC)

Anders Madsen (HUGIN Ltd.)

Graciela Rusch (NINA)

Advisory Board

- Julia Martin-Ortega, JHI / Univ. Leeds
- Jamie Montgomery, Kinross Estates Company
- Michael Wilson, Loch Leven Fisheries
- Willie Wilson, Loch Leven Fisheries
- Fiona Kantzidis, Historic Environment Scotland
- Keith Miller, River Leven Trustees
- Karen Mitchell, SNH
- Judith Moore, SEPA
- Uwe Stoneman, RSPB
- George Lawrie, TRACKS

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WFD Status vs Services



WFD Ecological
Status



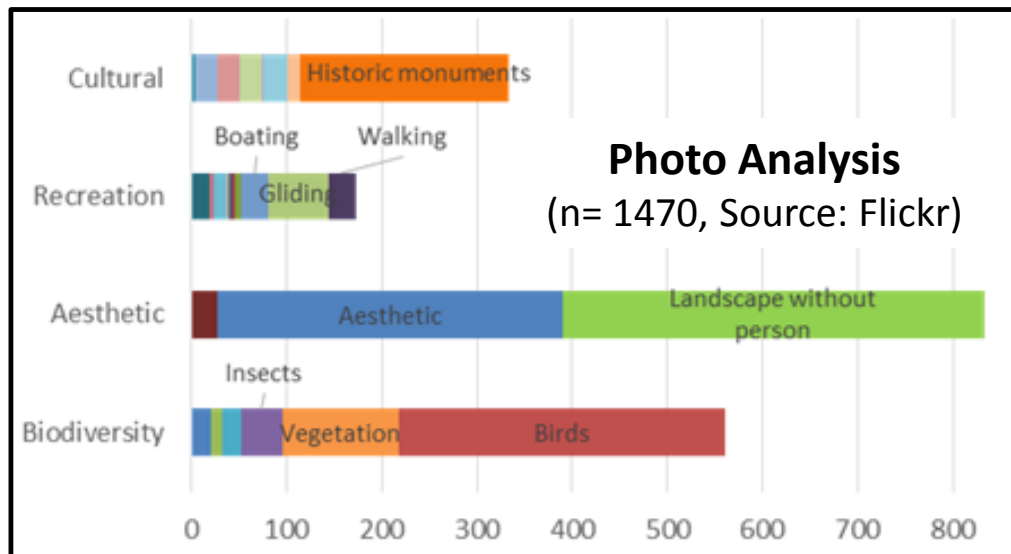
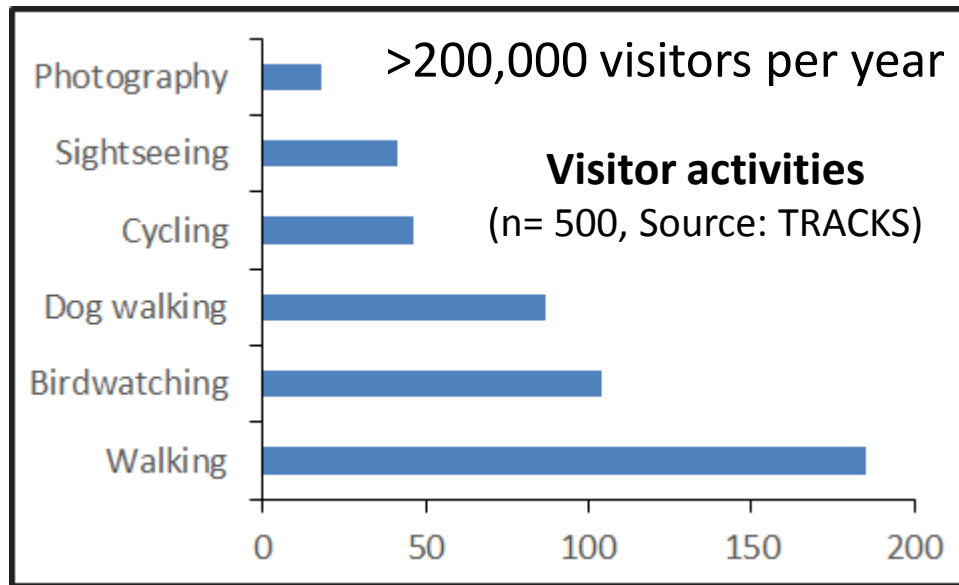
Does improved WFD status
deliver enhanced benefits?



Tourism & recreation



Why do people visit?



Visitors attracted by:

1. Landscape aesthetics
2. Birds
3. Historic monuments

Bad WFD status does impact use

WARNING

TOXIC ALGAE PRESENT

Lake unsafe for people and pets

Until further notice:

- **Do not swim or water ski.**
No nade o practique el esquí acuático.
- **Do not drink lake water.**
No tome el agua del lago.
- **Keep pets and livestock away.**
Mantenga alejados las mascotas y el ganado.
- **Clean fish well and discard guts.**
Limpie bien el pescado y deseche las tripas.
- **Avoid areas of scum when boating.**
Evite las áreas con espuma o verdín cuando ande en lancha.

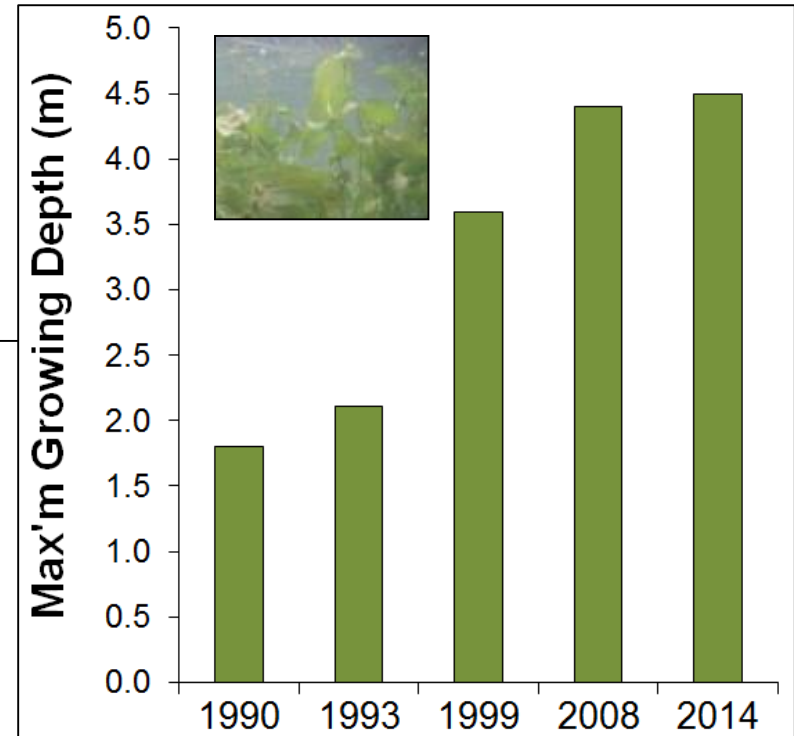
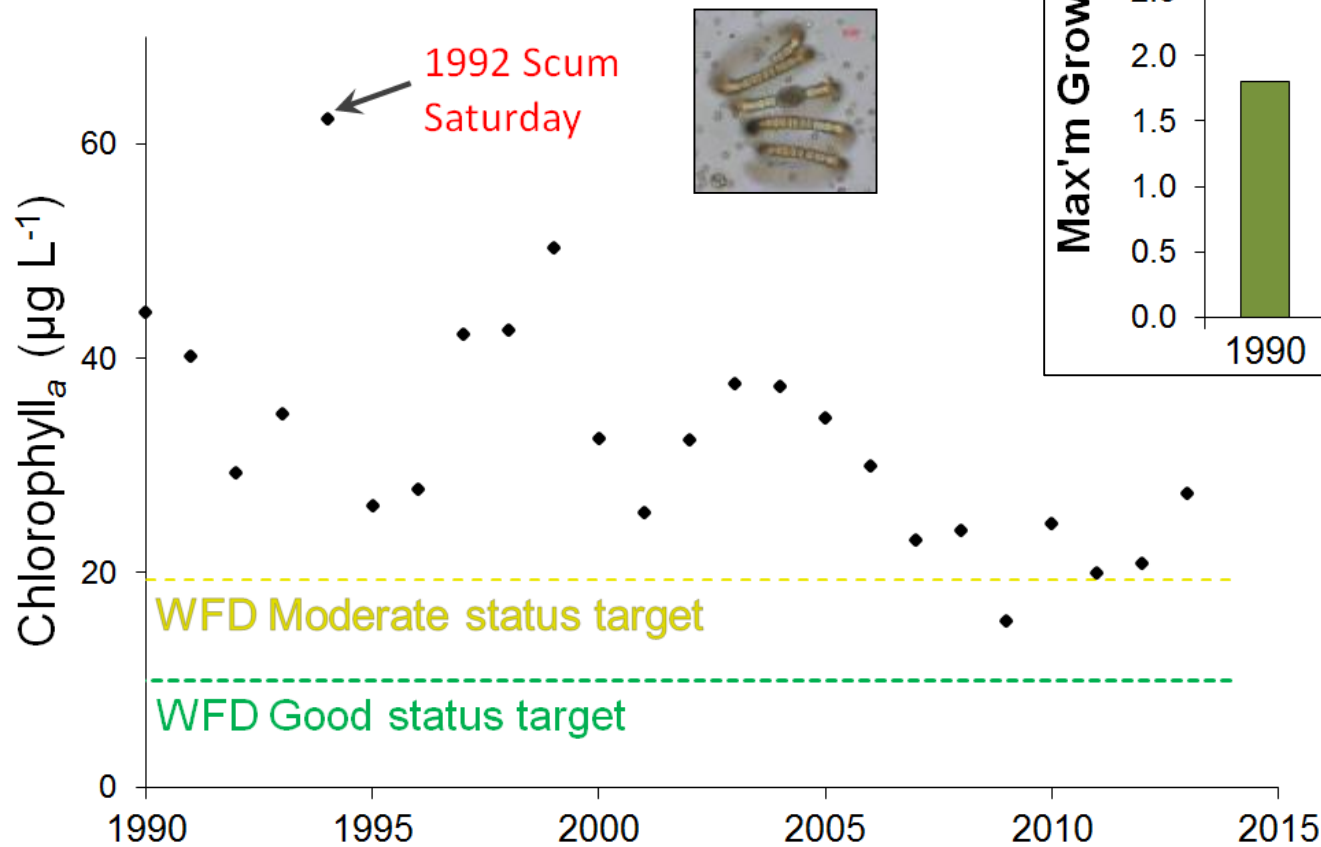
Call your doctor or veterinarian if you or your animals have sudden or unexplained sickness or signs of poisoning.

Report new algae blooms to Department of Ecology:	Call your local health department:
360-407-6000	

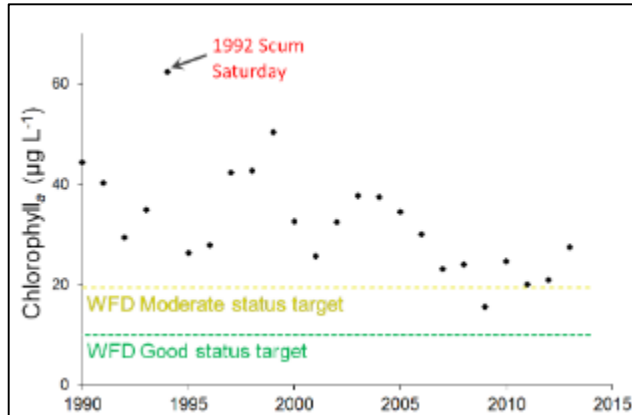


Loch Leven Status 1990 to 2015

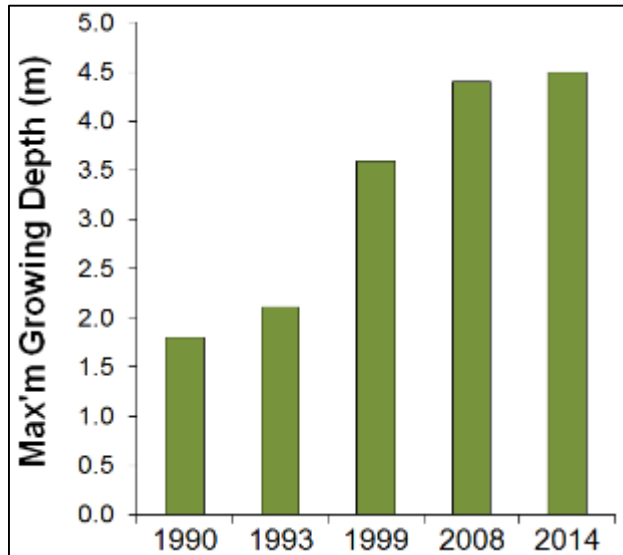
*1992 'Scum Saturday' cost
local community ~ €1 million*



WFD Indicators & Recreational Quality



Algal Bloom Indicator



Plant Cover Indicator



But visitor data only available since 2007, after WQ improvement, so relationship demonstrated qualitatively only

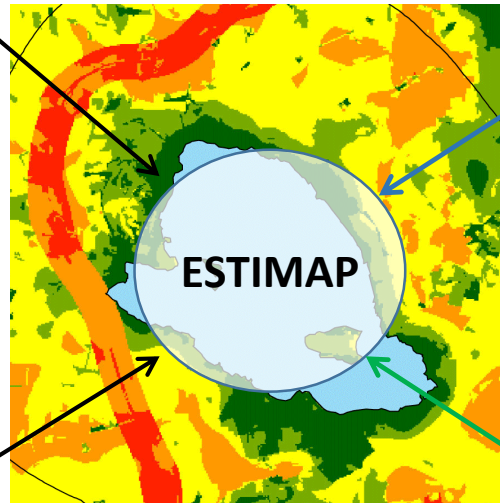
Mapping Recreational Potential



Tourism facilities

GPS coordinates of:

- Hotels
- Cafés
- Historic monuments
- Viewpoints
- Bird hides
- Listed buildings
- Gardens/parks
- Educational sites



Water quality Indicator

Land-water boundary emphasis

Natural features/land use data

- UK Land cover map 2007
- Ancient Woodland Inventory
- Lakes and rivers
- Elevation and slope
- National Nature Reserves
- Bird reserves (RSPB)

Infrastructure data

- Roads
- Paths/trails
- Car parks
- Picnic areas

Ecology is just a component
of ecosystem services

Fishing & Ecological Status: It's Complex

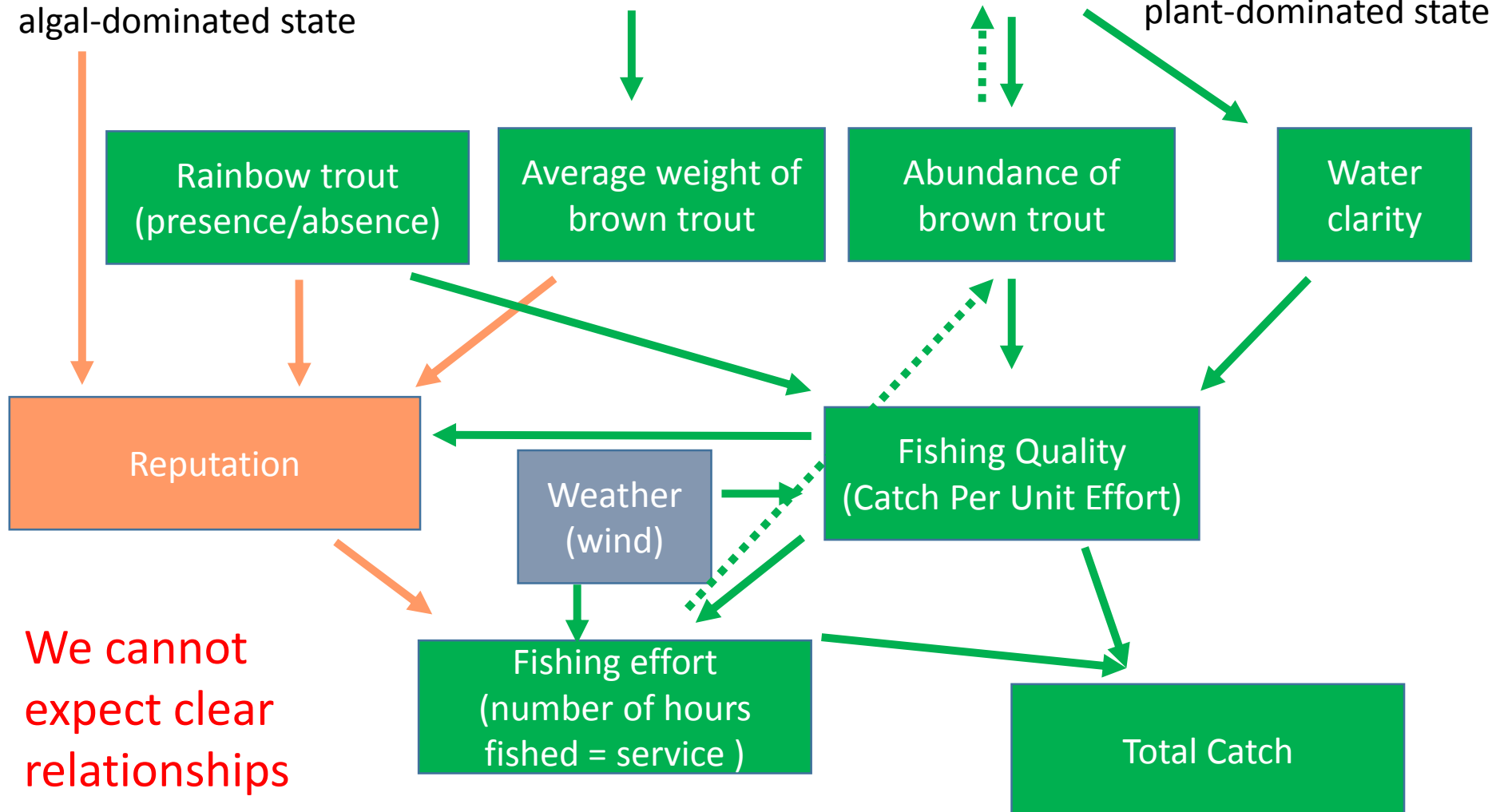


algal-dominated state

Ecological Status
(algae, plants)
Bad – Poor - Moderate – Good - High



plant-dominated state



WFD Status vs Fishing: a simplified model



Bad
(algae-dominated state)

Ecological Status
(algae, plants, invertebrates)
Bad – Poor - Moderate – Good - High



Good
(plant-dominated state)



Abundance of
brown trout

Fishing Quality
(Catch Per Unit Effort)

Number of fishermen
(Service)

Fishery log book scheme

- In close cooperation with Kinross Estate Company (Loch Leven Fishery)
- Cards given out through fishing seasons of 2013 to 2016
- Captures data on fishing trip, effort and catch (fish length and weight)
- Thanks to Jamie Montgomery for digitising returns for 2016



Loch Leven
2013 Catch Survey
No: 0296

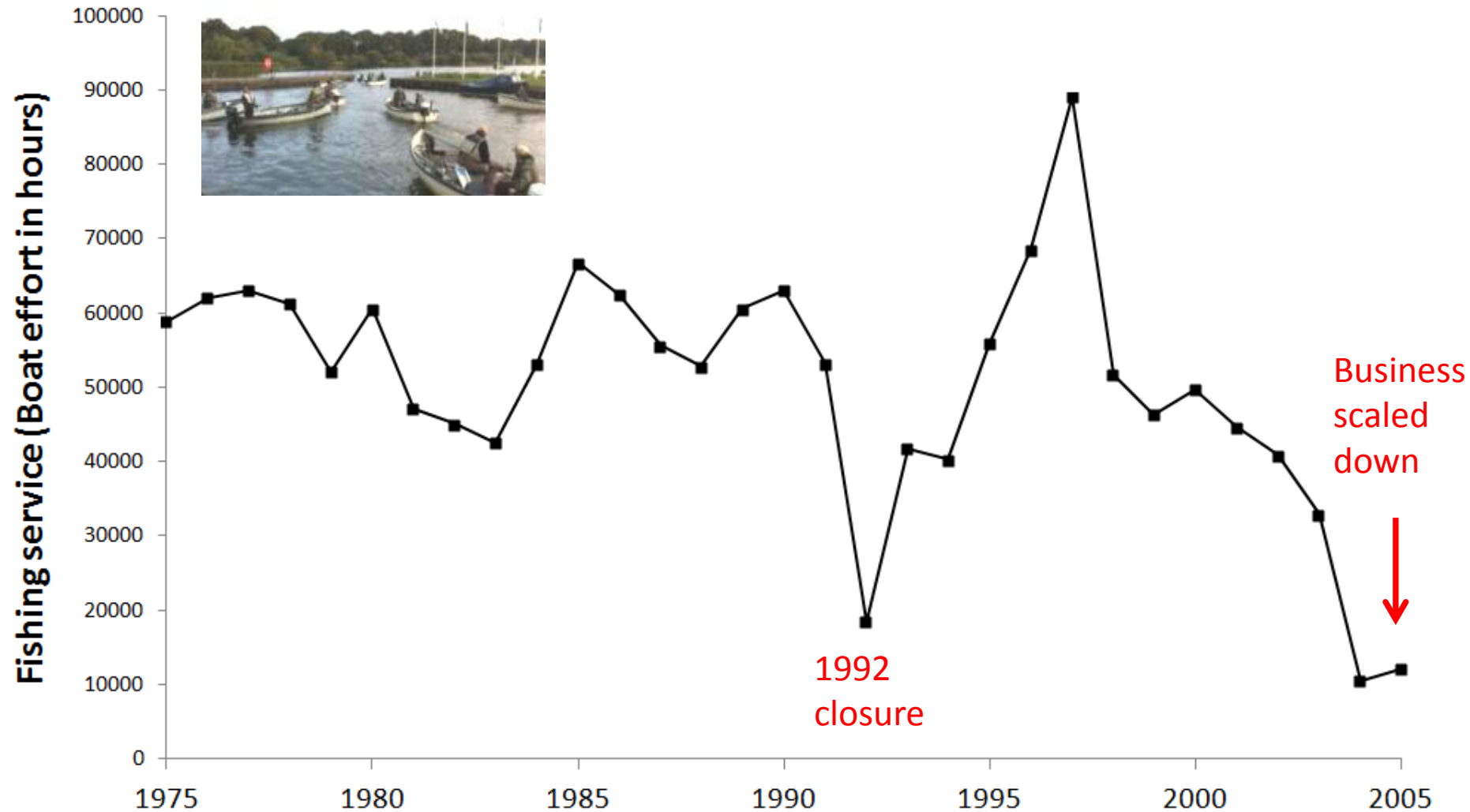
Date _____ No of Rods in Boat: 1 2 3

Session _____ Hours Fished _____

Fish No	Length	Weight*	✓Kept	Area of Loch
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

* Weight records optional (just if you have them)
or Please register NIL return days - not just those with catches.

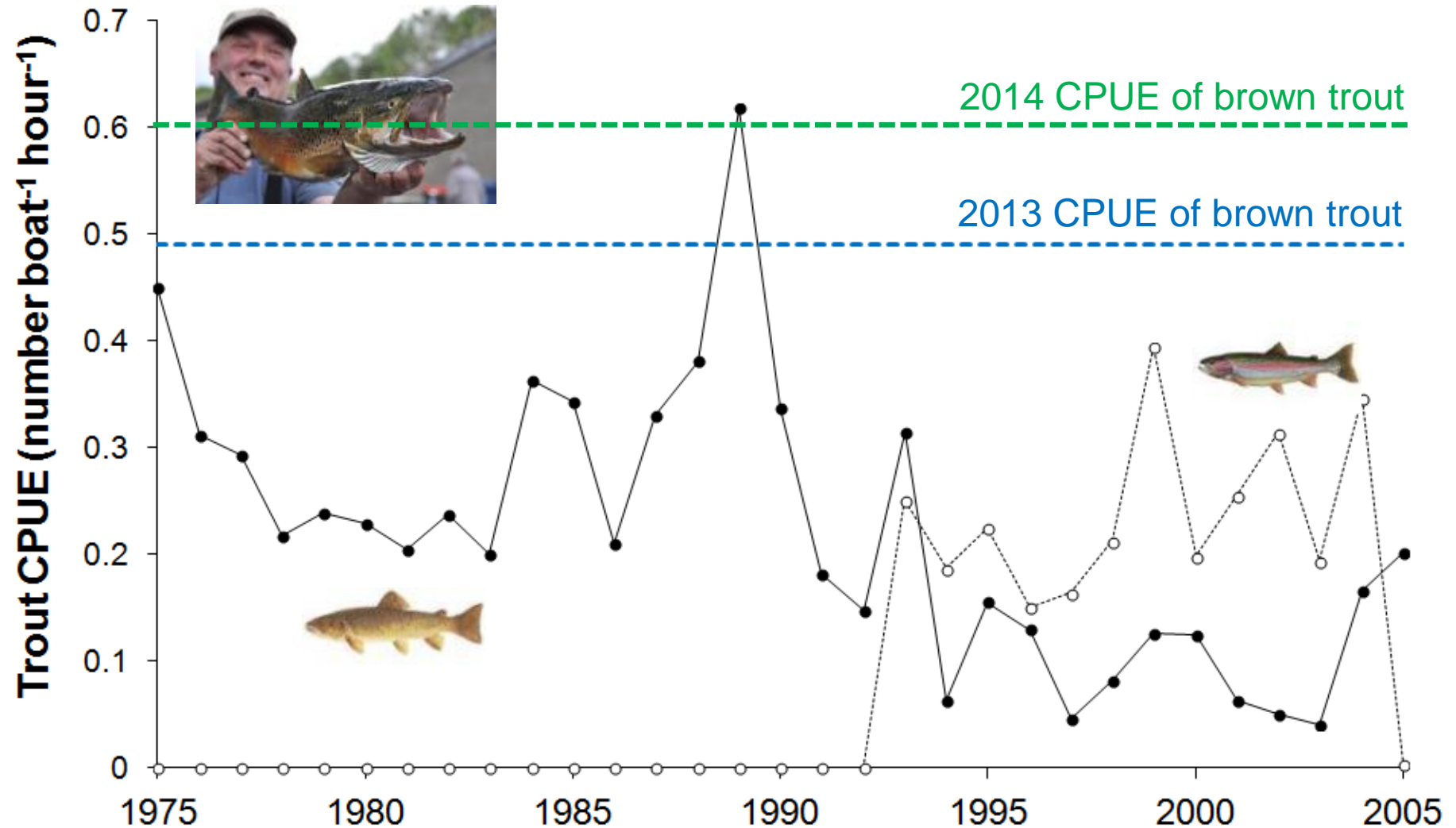
Fishing Service



Service: number of anglers or boat hours - not fish caught

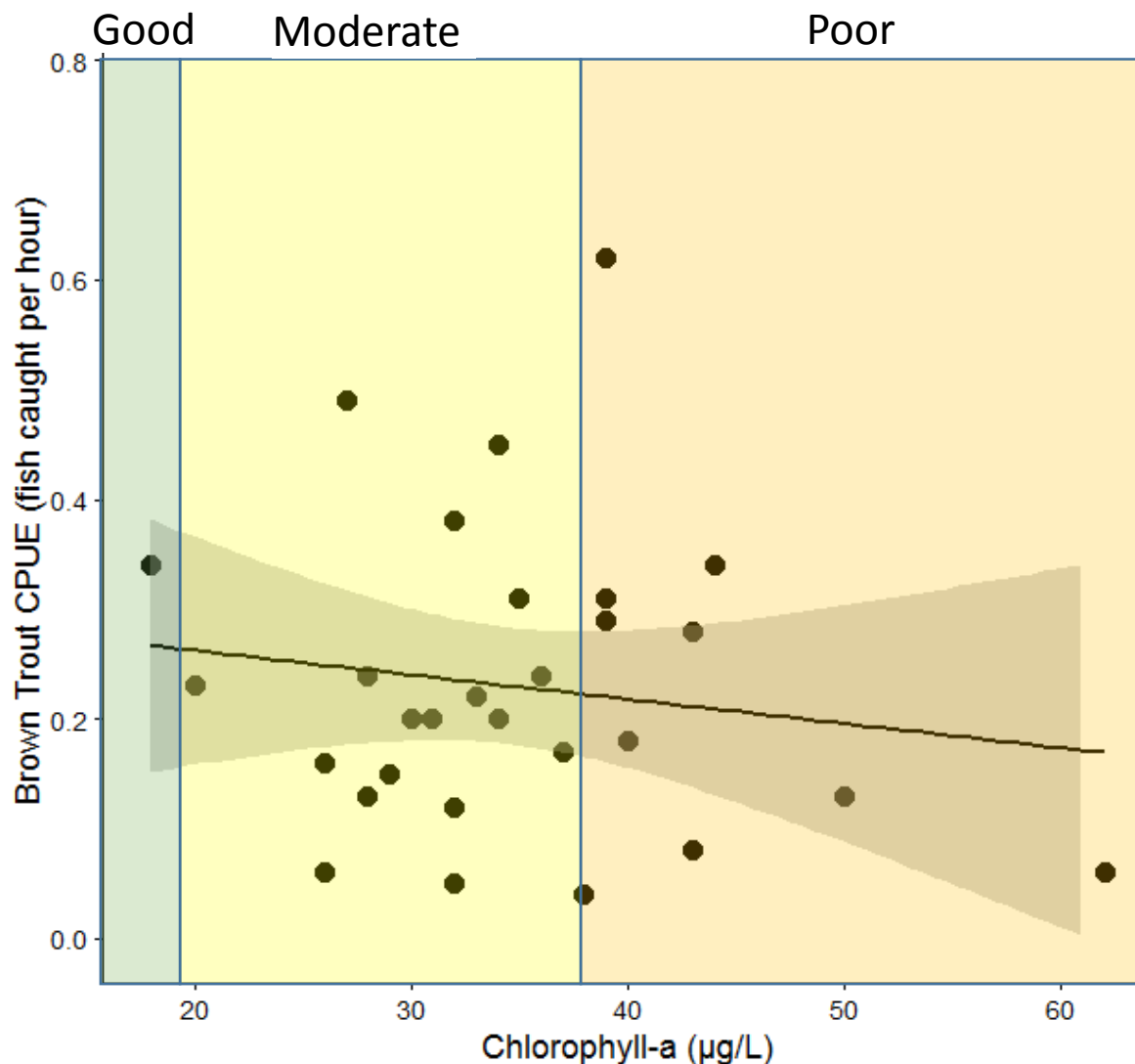
Status (algal blooms) – can affect service directly e.g. 1992

Fishing Quality



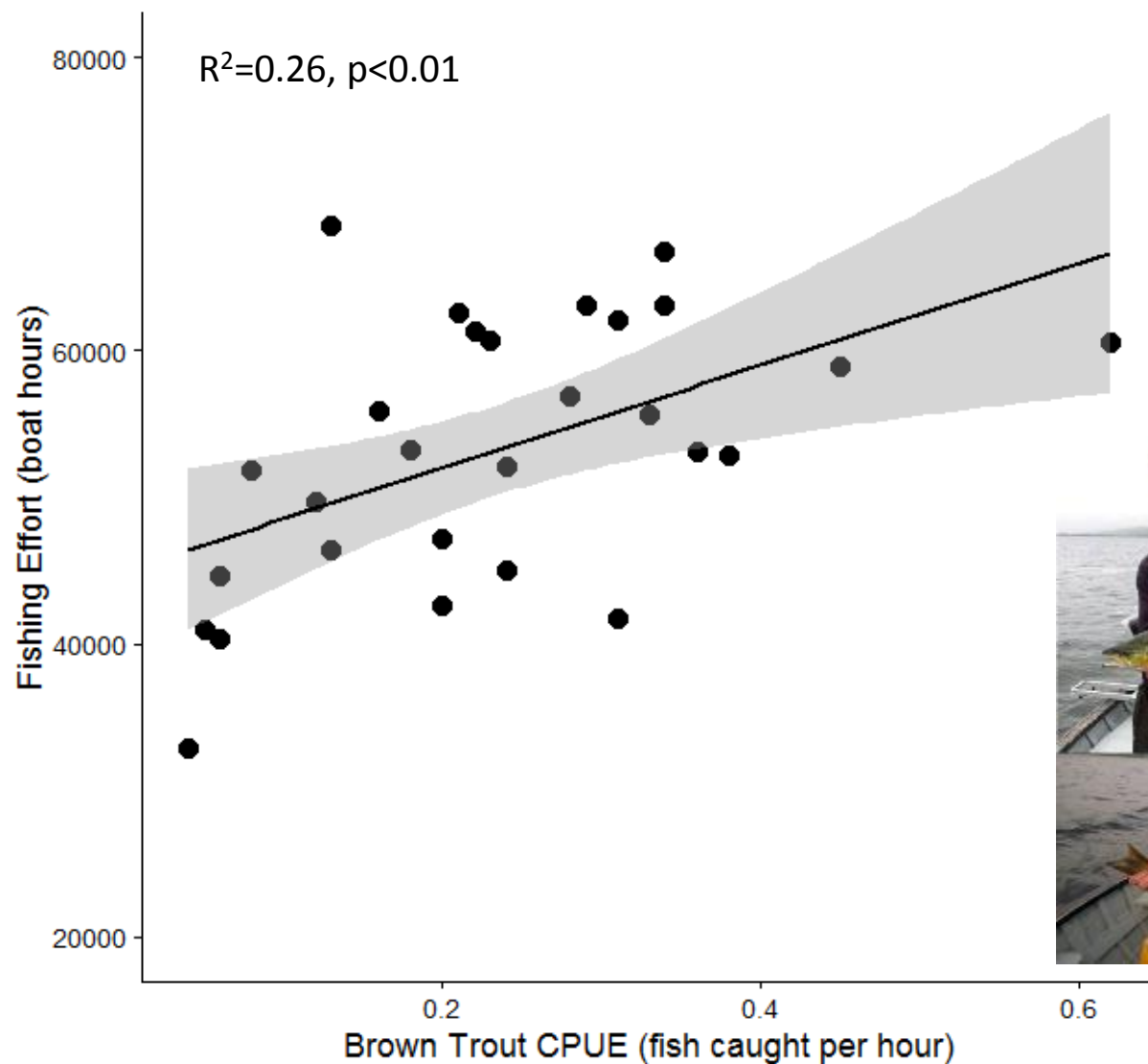
Catch Per Unit Effort – good indicator of fishing quality and the sustainability of the fishery – 2013 & 2014 very healthy & larger fish caught

Habitat Quality vs Fishing Quality



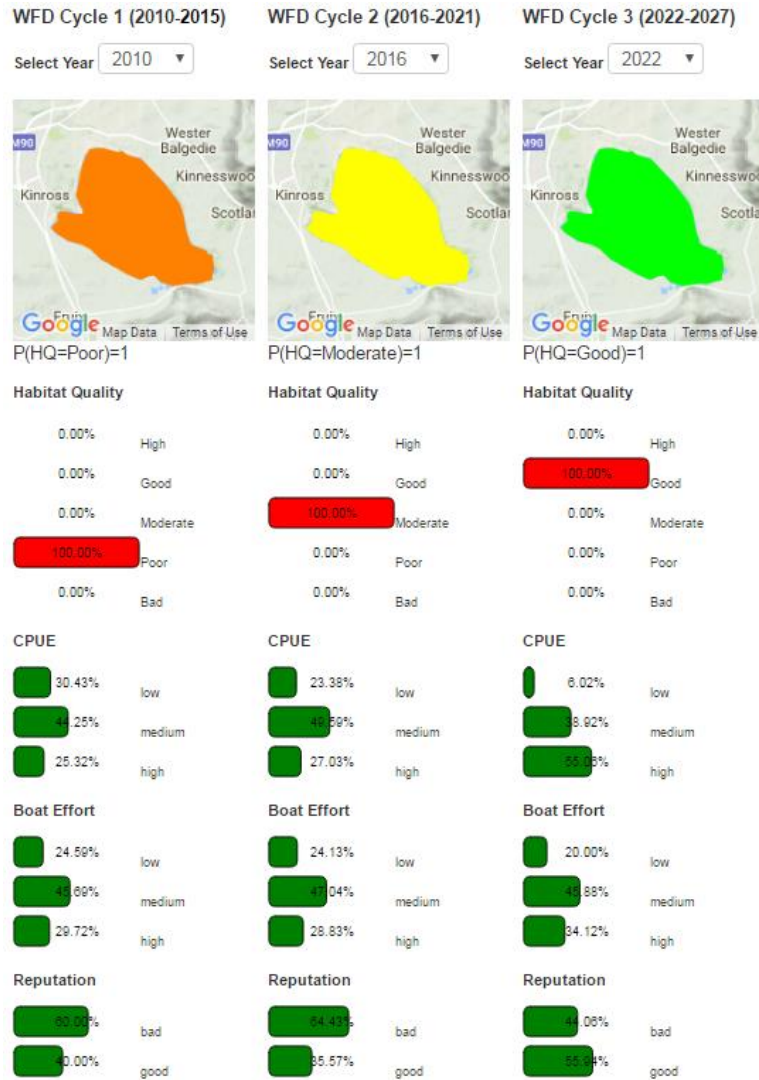
Improving status has no significant effect on CPUE
(although it generally goes in right direction)

Fishing Quality vs Fishing Service



CPUE has a significant effect on fishing effort.
Very low CPUE results in reduced fishing effort

Tool for predicting future fishing services



Loch Leven Fishing BBN

Select year and change probabilities:

1. Change habitat quality to see effect of WFD status on fishing quality
2. Change reputation to see the effect on fishing service (boat effort).

- What is the future sustainability of the fishery?
- Will there be an increased demand for fishing boats?

HUGINEXPERT
The leading decision support tool

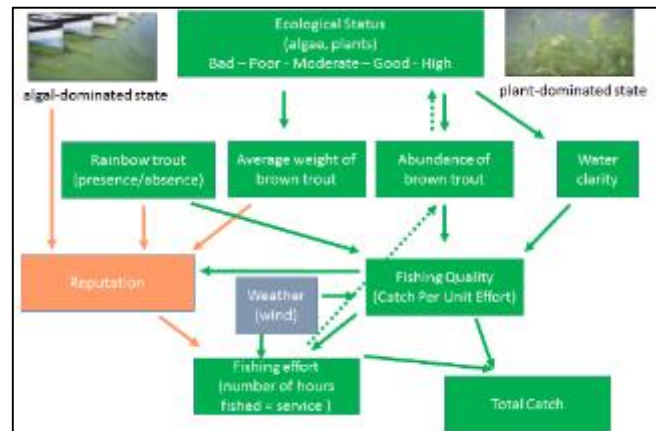
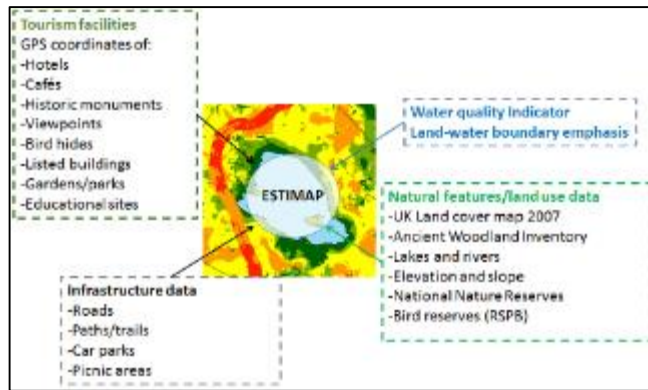


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http://openness.hugin.com/caseStudies/LochLeven_Habitat

Status vs Services: A Summary



- Poor/Bad ecological status can have severe impacts on services
- Good status generally has a positive effect on cultural services
- WFD data can be used to indicate services
- Relationships are complex, indirect and non-linear
- Service data limited so difficult to demonstrate link between env. quality & services

Need for partnership approach to understand all relationships and collate necessary data to develop understanding

Loch Leven: Catchment Research Platform



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