

Lough Sheelin Trout Anglers FLEKSI Survey

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Iascach Intíre Éireann
Inland Fisheries Ireland

Lough Sheelin Trout Anglers FLEKSI Survey 2022

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Introduction

Situated on the borders between the counties Cavan, Meath and Westmeath, Lough Sheelin is a lake in the Shannon River catchment, measuring just over 18 km² in wetted area and about 7.5 km in length along its longest northeast–southwest axis from near Mountnugent, Co. Cavan, to the outflow of the River Inny near Finnea, Co. Westmeath. Lough Sheelin is relatively shallow, with around 55% of the lake less than 4.5 metres deep. Furthermore, the underlying geology of the catchment is predominately Carboniferous limestone, and the lake has a high alkalinity, supporting the growth of extensive areas of submerged weed beds. Consequently, Lough Sheelin is a highly productive lake, with great potential for supporting an excellent stock of wild brown trout.

Lough Sheelin is one of Ireland’s premier wild brown trout fisheries, but this status came under threat throughout the 1970s and 1980s as the lake became eutrophic due to nutrient enrichment, including with phosphorous, which promoted the growth of algae (Kerins *et al.*, 2007). Eutrophication also favoured population growth of roach, a non-native invasive cyprinid introduced into Lough Sheelin in the 1970s, which altered predator–prey relationships and population dynamics among pike, roach and trout in the lake (Shephard *et al.*, 2019). Since they arrived in Lough Sheelin in the early 2000s (Millane *et al.*, 2008), zebra mussels are thought to have increased water clarity by filter feeding algal plankton. Although phosphorous loading declined between the late 1980s to mid-2000s (Kerins *et al.*, 2007), but it has fluctuated in the lake since then and remains at a moderate level (Catchments.ie Data. Waterbody: Sheelin, 2023).

Over the years, Inland Fisheries Ireland (IFI) have worked with local anglers and the Lough Sheelin Trout Protection Association (LSTPA) to conserve trout stocks, to protect their habitat and to develop the Lough Sheelin angling resource. Mitigation measures have included water quality monitoring, habitat enhancement in spawning streams, stocking with hatchery-reared trout, promoting catch-and-release angling and pike management. A long-term programme of annual springtime netting surveys has monitored trout stocks in Lough Sheelin from the 1970s until 2015, and Water Framework Directive (WFD) surveys have monitored fish ecological status since 2008 (Delanty *et al.*, 2022). Wild trout stocks declined in the 1980s and 1990s as the lake became eutrophic (O’Grady & Delanty, 2000), but stock surveys and angling reports indicate that trout stocks in Lough Sheelin have returned to a healthier status in recent years (Delanty *et al.*, 2022), despite the environmental pressures and ecological changes in the lake ecosystem.

These dramatic changes in Lough Sheelin over the decades have directly impacted anglers’ experience of this fishery. To empower anglers to share their observations about fishery ecosystems and their knowledge about environmental impacts they have witnessed, IFI have developed the Fishers’ Local Ecological Knowledge Surveillance Indicators (FLEKSI) method. Local Ecological Knowledge (LEK) can be defined as a deep understanding of surrounding ecology developed through long-term interactions with the natural environment. Anglers develop LEK organically as they enjoy their sport and interact with their local environment. LEK is based on the accumulation of observations over time, much like scientific knowledge; however, it lacks structured records and may consequently be considered a “dataless” source of information that may nonetheless inform fisheries management (Johannes, 1998). The LEK of fisheries stakeholders such as anglers therefore represents a potentially valuable source of information to complement scientific research (Berkström *et al.*, 2019; Shephard *et al.*, 2007).

IFI first implemented FLEKSI surveys for the “Fishing Then and Now” survey as part of Irish Marine Recreational Angling (IMREC) programme, which detected declines in cod, pollack, whiting and sea bass stocks that had been recorded in marine fisheries stock assessments (Shephard *et al.*, 2021). In the current survey, the FLEKSI method will similarly aims to quantify the LEK of trout anglers on Lough Sheelin into an indicator of fishery status over time.



Figure 1: View of Lough Sheelin from the IFI boat slip at Kilnahard.

Methodology

Identifying questions of interest is a very important initial step when designing FLEKSI surveys. Questions were designed to collect relevant data of interest and to investigate whether anglers have observed changes in the lake ecosystem. During the survey design, the questions were reviewed by a panel of IFI research and angling development staff, as well as regional staff based locally at Lough Sheelin. In addition, input from trout anglers was provided by representatives from the LSTPA.

The Lough Sheelin Trout Anglers Survey 2022 contained two types of questions:

- Questions on angler behaviour & attitudes to gather background information on angling activity for analysis and to provide anglers with an opportunity to express their attitudes towards conservation and management for the fishery.
- FLEKSI statements asking anglers to compare an aspect of the fishery “NOW” with how they remember it “THEN”, i.e., when they FIRST STARTED angling there.

The survey webforms were created, made available and hosted on IFI’s fisheriesireland.ie website during April to September 2022, which allowed for secure collection and data processing for angler information. The survey was sent to the LSTPA to share with its members, and it was also promoted in the weekly Lough Sheelin trout fishing reports on the fishinginireland.info website to reach the target survey participants.

FLEKSI Statements & Likert Scoring

The statements in the FLEKSI survey were positively phrased, e.g., “*I catch more trout than I used to*”; therefore, disagreement with the FLEKSI statement that anglers’ catches are better now can be expected to be greater when trout abundance was high in the past, and vice versa. Respondents’ answers were scored along an ordinal Likert scale of 1 to 5 for “Strongly disagree” to “Strongly agree” for each response, respectively (for more on Likert scales, see Allen & Seaman, 2007; Robbins & Heiberger, 2011; Sullivan & Artino, 2013).

The respondents’ answers for angling career length were assigned to the period in years when they started their angling career for analysis. Using the R statistics package HH (Heiberger, 2020), diverging stacked bar charts of responses to each statement over the respondents’ career lengths were created to provide a time-series of the state of the fishery for over 40 years. These plots, which are recommended for visualising Likert items and scales (Robbins & Heiberger, 2011), show the proportion of respondents within each career-length interval who selected each response. These scores for sets of related statements (*facets*) are summed together into broader categories (*descriptors*) to build a more general picture of different aspects of the fishery (Shephard *et al.*, 2021).

The plots are centred on the neutral response (coloured grey), which corresponds to a score of 3. Plots with predominately “Agree” or “Strongly agree” scores (coloured blue) indicate that the fishery is better/improving, whereas plots with predominately “Disagree” or “Strongly disagree” scores (coloured pink) indicate that the fishery is worse/declining (Figure 2).

How many years have you been fishing on Lough Sheelin?	Period
up to 3 years	2019 - 2022
4 to 6 years	2016 - 2018
7 to 9 years	2013 - 2015
10 to 12 years	2010 - 2012
13 to 15 years	2007 - 2009
16 to 18 years	2004 - 2006
19 to 21 years	2001 - 2003
22 to 24 years	1998 - 2000
25 to 27 years	1995 - 1997
28 to 30 years	1992 - 1994
31 to 33 years	1989 - 1991
34 to 36 years	1986 - 1988
37 to 39 years	1983 - 1985
over 40 years	before 1983



Response to statement	Score
Strongly agree	5
Agree	4
Neither agree nor disagree	3
Disagree	2
Strongly disagree	1

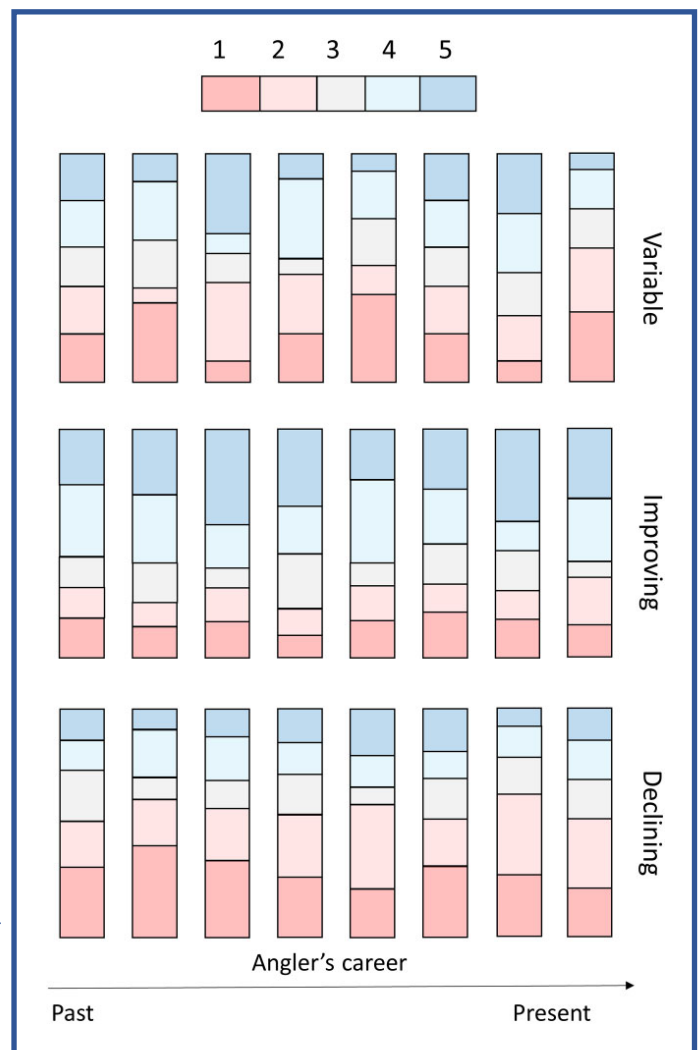


Figure 2: Responses to FLEKSI statements are scored and plotted on diverging stacked barcharts over a time-series based on angling career length. Examples of potential trends in FLEKSI time-series taken from Shephard *et al.* (2021): <https://doi.org/10.1093/icesjms/fsab234>

Results

Respondents' Experience & Angling Preferences

The overall number of valid responses was 132 (Figure 3); there were respondents for all career-length intervals, with the largest cohort in the over-40-year interval (24.2%). The median career length was 25-to-27 years, and 52.3% of respondents indicated that they have been angling on Lough Sheelin for over 25 years.

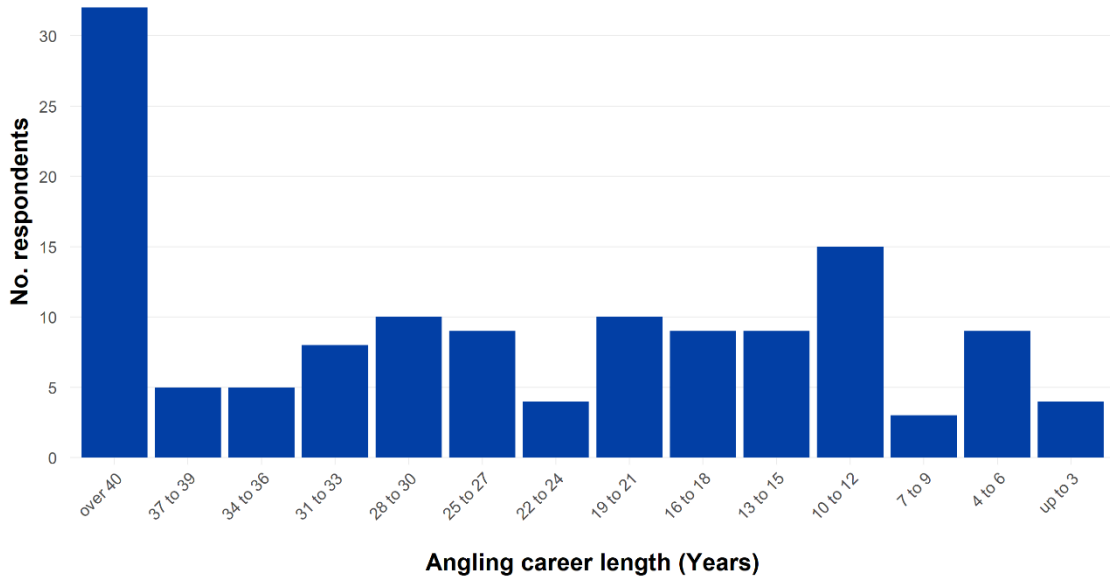


Figure 3: How many years have you been fishing on Lough Sheelin?

Most of the respondents (73%) considered themselves to be experienced and avid anglers on Lough Sheelin (Figure 4). Most respondents (83%) indicated that they fish for trout only (Figure 5), but some respondents also fish for pike (11%), coarse fish (2%) or both pike and coarse fish (5%).

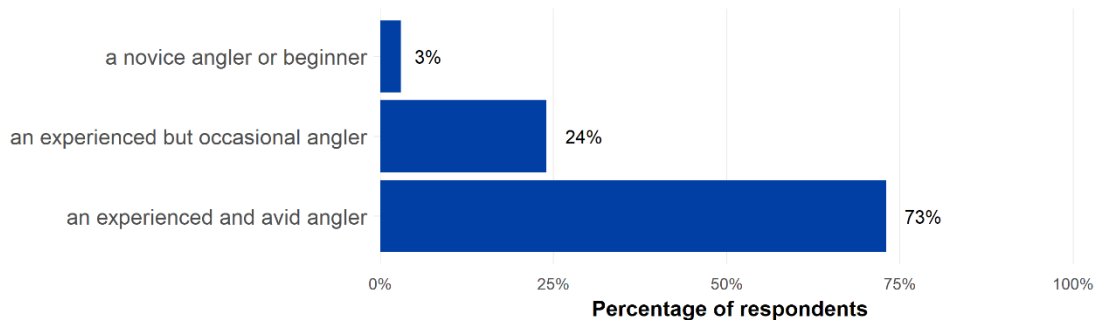


Figure 4: Angler experience: Would you consider yourself to be... ?

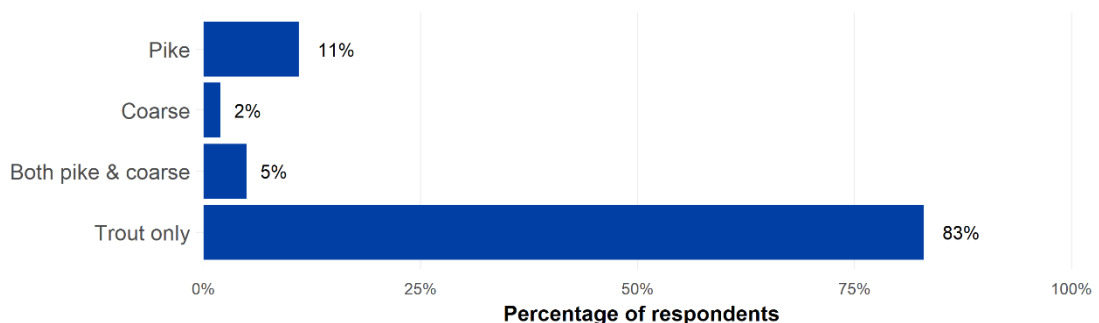


Figure 5: Do you fish for any other species on Lough Sheelin?

Respondents' Trip Frequency & Angling Methods

Trip frequency is lowest but still substantial in March (Figure 6), with 62.9% of respondents visiting Lough Sheelin when the fishery opens in March. Fishing peaks in April–May, when 96.2% of respondents fish on the lake, then falls but remains relatively constant from June to October. The responses indicate that the typical frequency of fishing trips to Lough Sheelin 1–5 trips from month to month over the angling season.

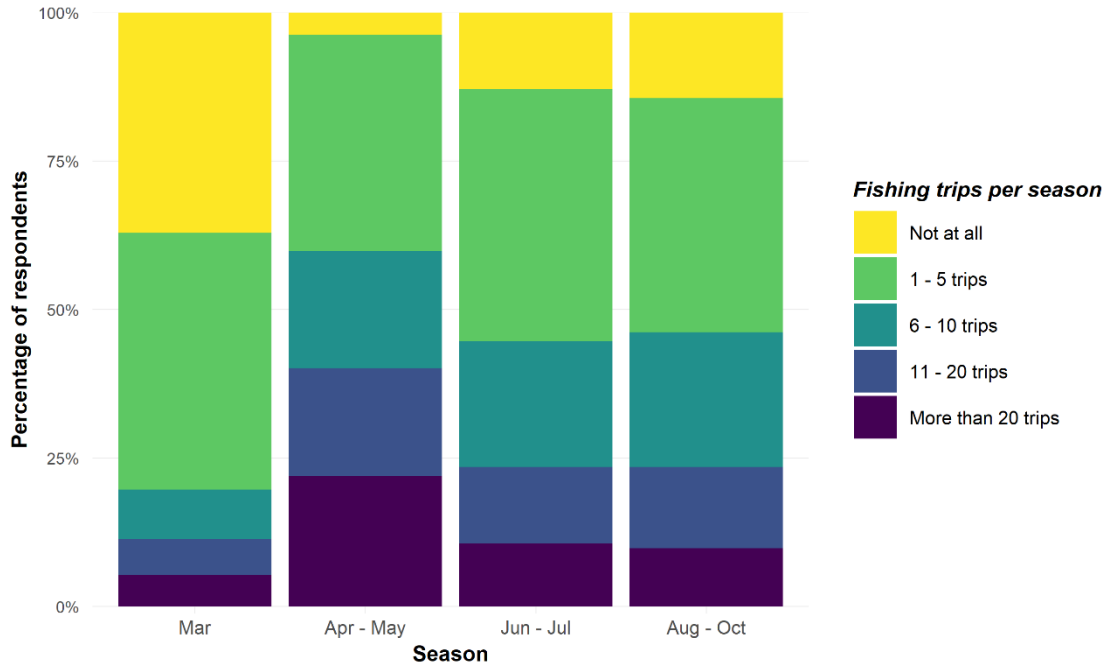


Figure 6: How often do you fish on Lough Sheelin during the following seasons?

When the trout fishery opens in March, wet flies are the most popular method angling method among respondents (Figure 7), but dry flies are the most used method during the late spring and summer months (Apr–May and Jun–Jul, respectively). In the late summer to autumn months (Aug–Oct), wet flies once again become the method most favoured among respondents.

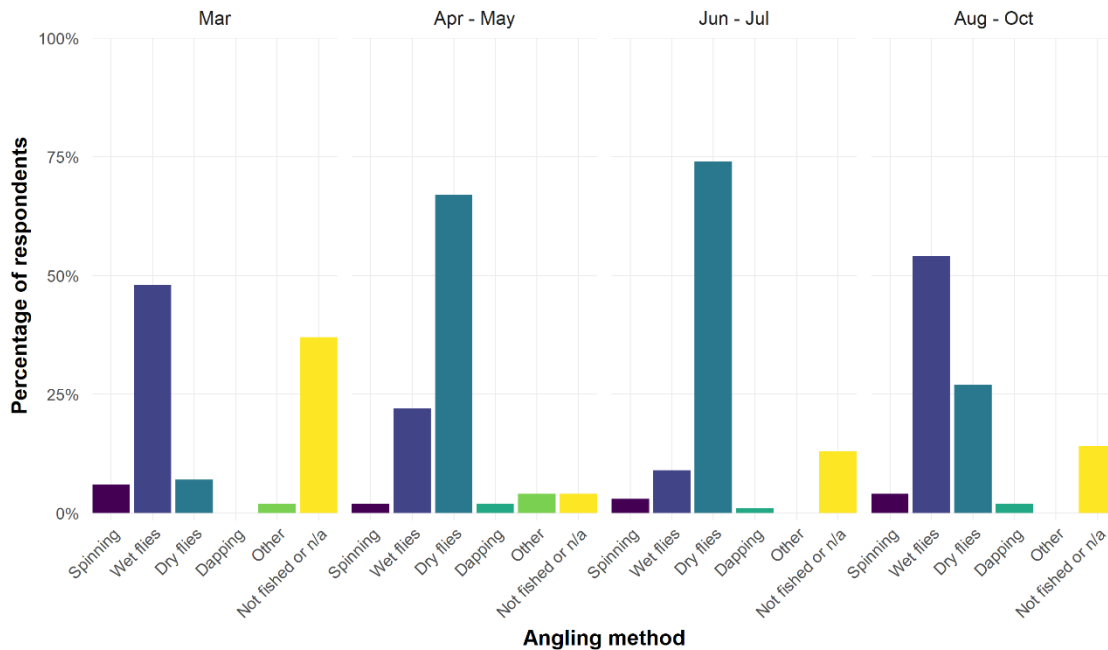


Figure 7: Which method do you use most often during the following seasons?

The data on trip frequency and most used angling method from each respondent were combined to provide insight into seasonal patterns in angling activity (Figure 8). A trip frequency index was created by scoring respondents' trip frequency over the angling season with the minimum number of trips, e.g., "1–5 trips" scored 1, "6–10 trips" scored as 6, etc. The trip frequency scores per method for each period over the season were summed and made proportional to the score for peak angling activity (Apr-May) to calculate respondents' relative angling effort with the method they use most often in each period. Wet flies account for the most angling effort in March, but use of dry flies dominates the late spring and summer months. In the late summer to autumn months (Aug–Oct), the relative amount of angling effort is similar for wet flies and dry flies, even though roughly twice as many respondents answered that they prefer using wet flies during these months (Figure 7).

It must be noted that the diagram below is based only on respondents' answers for their most used angling method and their minimum number of trips, and it must be regarded as an estimate indicating the *relative* amount of effort by anglers with the method *used most often*, not the *absolute* amount of effort using *all* methods.

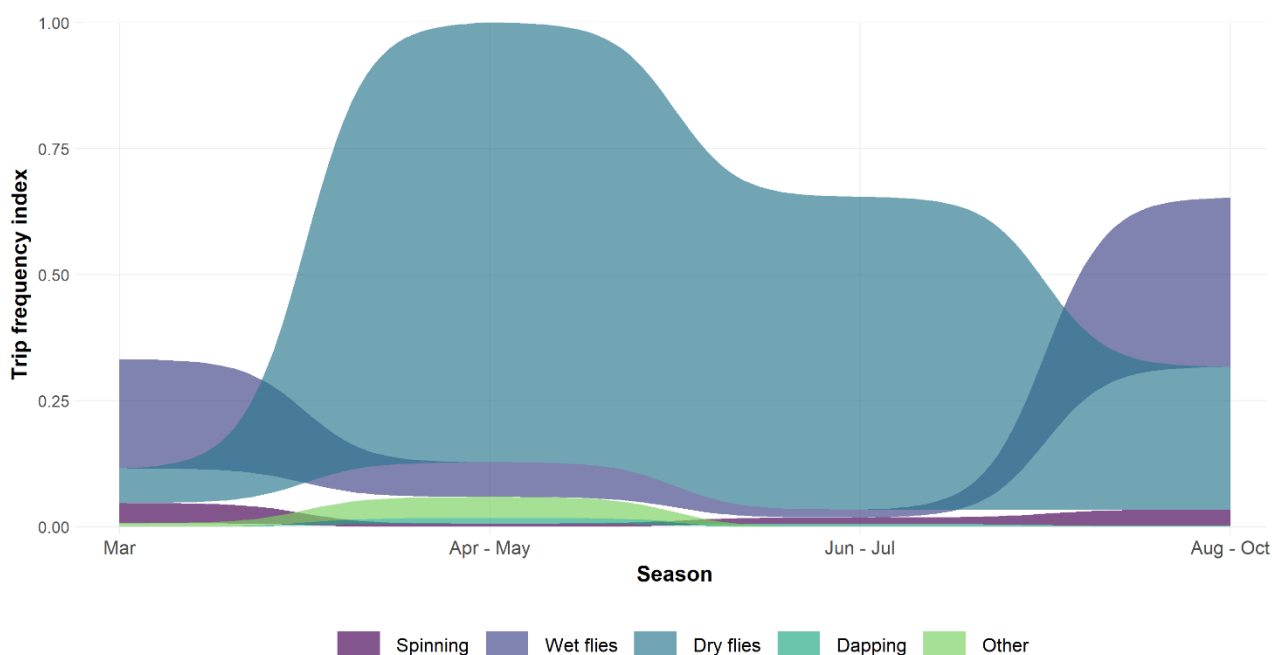


Figure 8: Flow diagram illustrating relative trip frequency and method used most often by respondents from month to month over the angling season.

Respondents' Observations about Trout Stocks & the Ecosystem in Lough Sheelin

An optional text field was used by 47% of respondents to provide their observations about trout stocks and the ecosystem in Lough Sheelin. The word cloud below scales words from the comments to illustrate the frequency of keywords and to give a general impression of the contents (Figure 9).

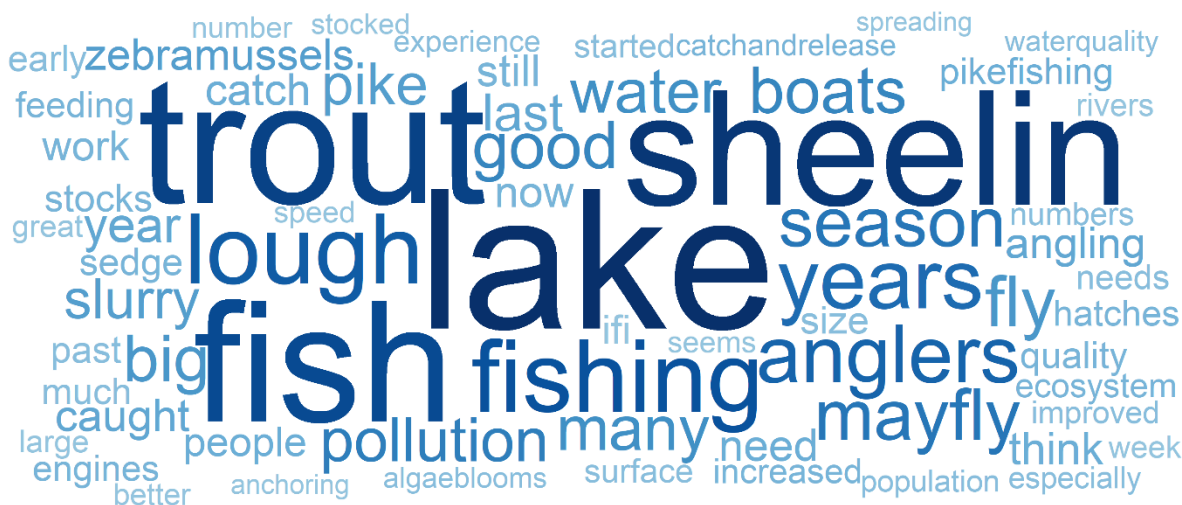


Figure 9: Word cloud: Do you have any further observations about trout stocks and the ecosystem in Lough Sheelin?

The comments were analysed to identify topics of concern to each respondent, and each comment was indexed with one or more categories that best described the comment (Figure 10). Changes in trout abundance and stock was the most discussed topic, followed by changes in prey and trout feeding. Top areas of concern for anglers included agricultural pollution; issues concerning boating & angler etiquette; and pressure from angling activity.

On balance, there was more positivity expressed about fishing quality in Lough Sheelin: 17.7% of respondents expressed an opinion that the lake is currently fishing well, compared with 3.2% of respondents who expressed an opinion that the lake was fishing poorly. Similarly, 12.9% of respondents expressed an opinion that the health of the ecosystem is good/improving, compared with 4.8% who expressed an opinion that the health of the ecosystem was poor/deteriorating.

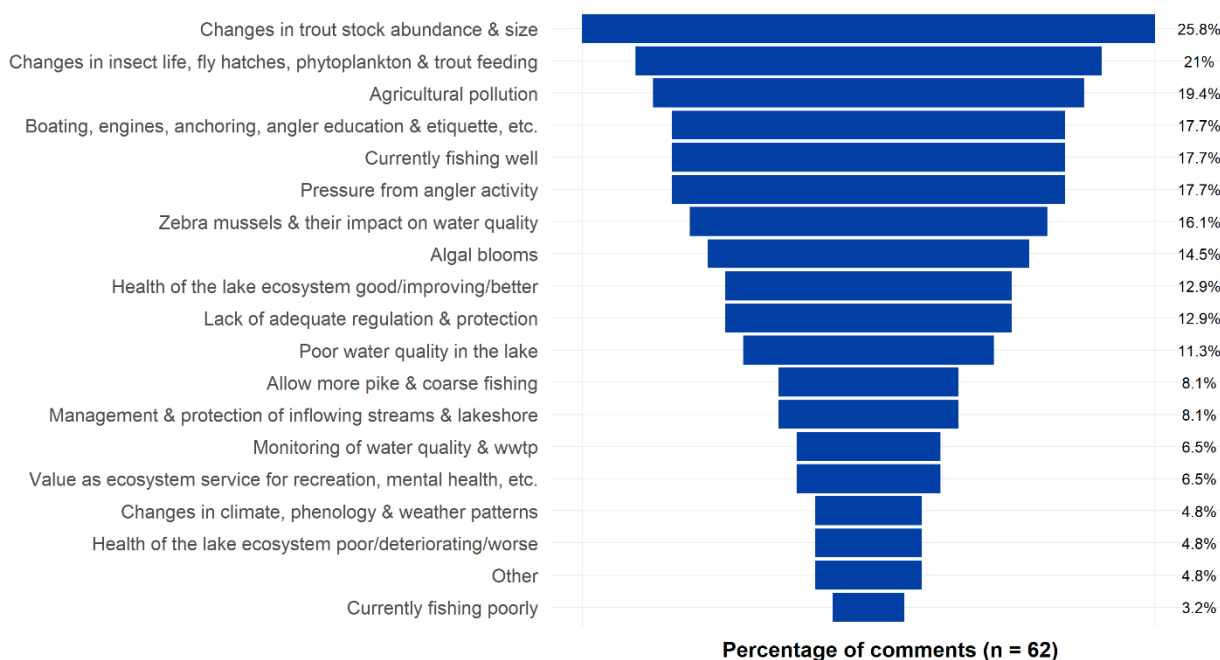


Figure 10: Funnel chart of comments assigned to topics discussed by respondents.

Respondents' Attitudes Towards Conservation & Angler Behaviour

Respondents were asked questions on their awareness about conservation and the actions they take to help conserve fish stocks and protect the environment (Figure 11). Overall, agreement levels with the statements about conservation were very high, peaking with 94% of respondents agreeing or strongly agreeing that they release more fish nowadays. An encouraging sign is that 87% of respondents believe that they now take more action to protect the ecosystem on Lough Sheelin. Nevertheless, 15% of respondents disagreed or strongly disagreed that they feel more positive about environmental protection, which may indicate a degree of ambivalence or pessimism about environmental protection among some of the respondents.

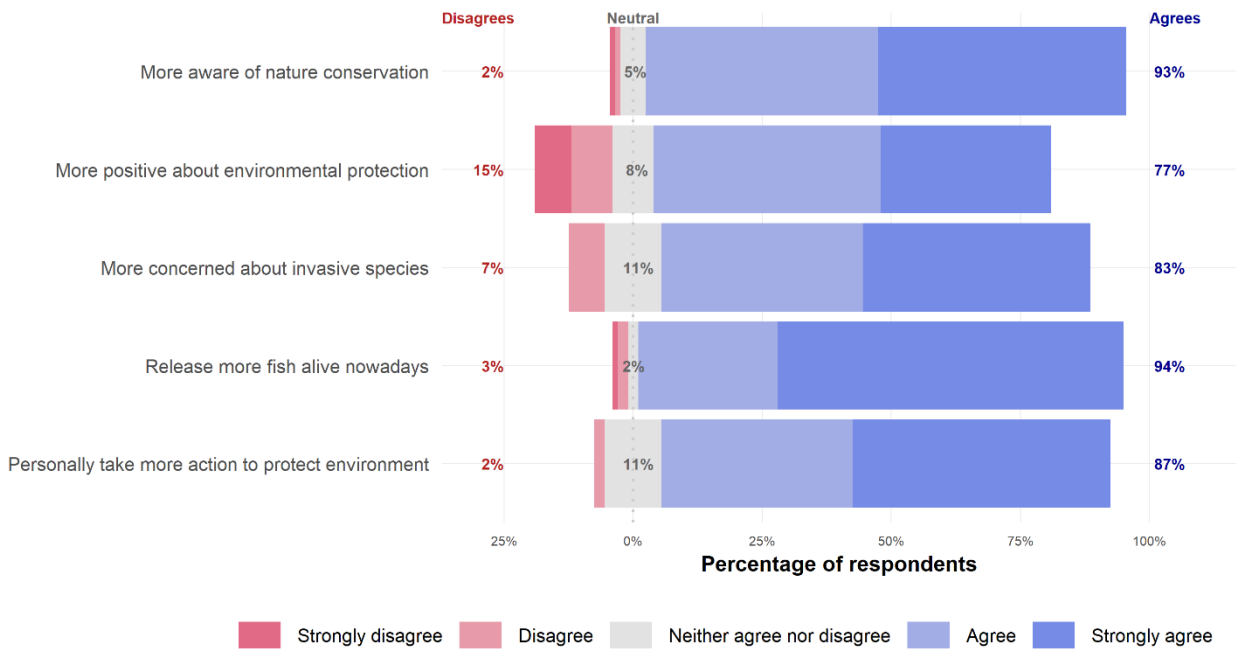


Figure 11: Respondents' conservation awareness & actions. "Disagrees" total in red shows sum of "Strongly disagree" and "Disagree" responses; "Agrees" total in blue shows sum of "Strongly agree" and "Agree" responses.

The survey indicated that boating and angling etiquette are key issues of concern for trout anglers on Lough Sheelin (Figure 12). Fifty-four percent of respondents disagreed or strongly disagreed that wash from boats motoring too fast is not a problem. Angling behaviour is also an area of concern for respondents, with 32% of respondents disagreeing or strongly disagreeing that most anglers still seem to know how to behave considerately on the lake. These questionnaire results are expressed in greater depth by 11.8% respondents in the comments (see Figure 10 in the previous section).

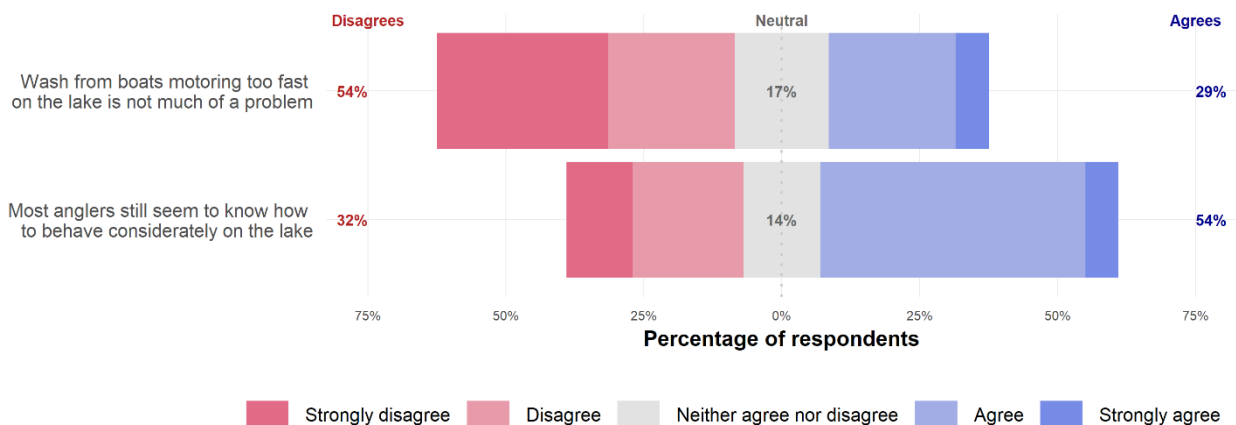


Figure 12: Respondents' opinions on boating & angling behaviour. "Disagrees" total in red shows sum of Strongly disagree and Disagree responses, "Agrees" total in blue shows sum of Strongly agree and Agree responses.

FLEKSI Trout Questions

Overall, the trend in agreement among respondents is variable but mostly positive over the time series, indicating that respondents believe that the abundance and size of trout in the lake is improved compared with when they started fishing (Figure 13). The level of disagreement is greatest among respondents who started fishing in 1998–2000 (22–24 years ago) and 2013–2015 (7–9 years ago).

Descriptor	FLEKSI Survey Statements
Trout	I see more trout pitching, rising and feeding in the lake now
	Big trout have become more common in the lake

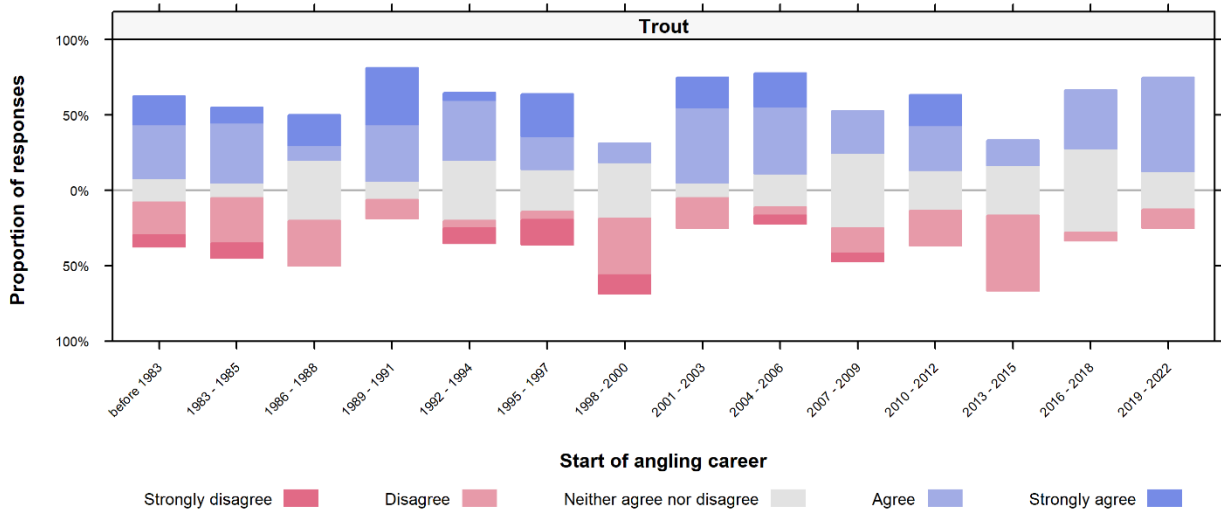


Figure 13: Diverging stacked bar charts of total combined scores for Trout descriptor.

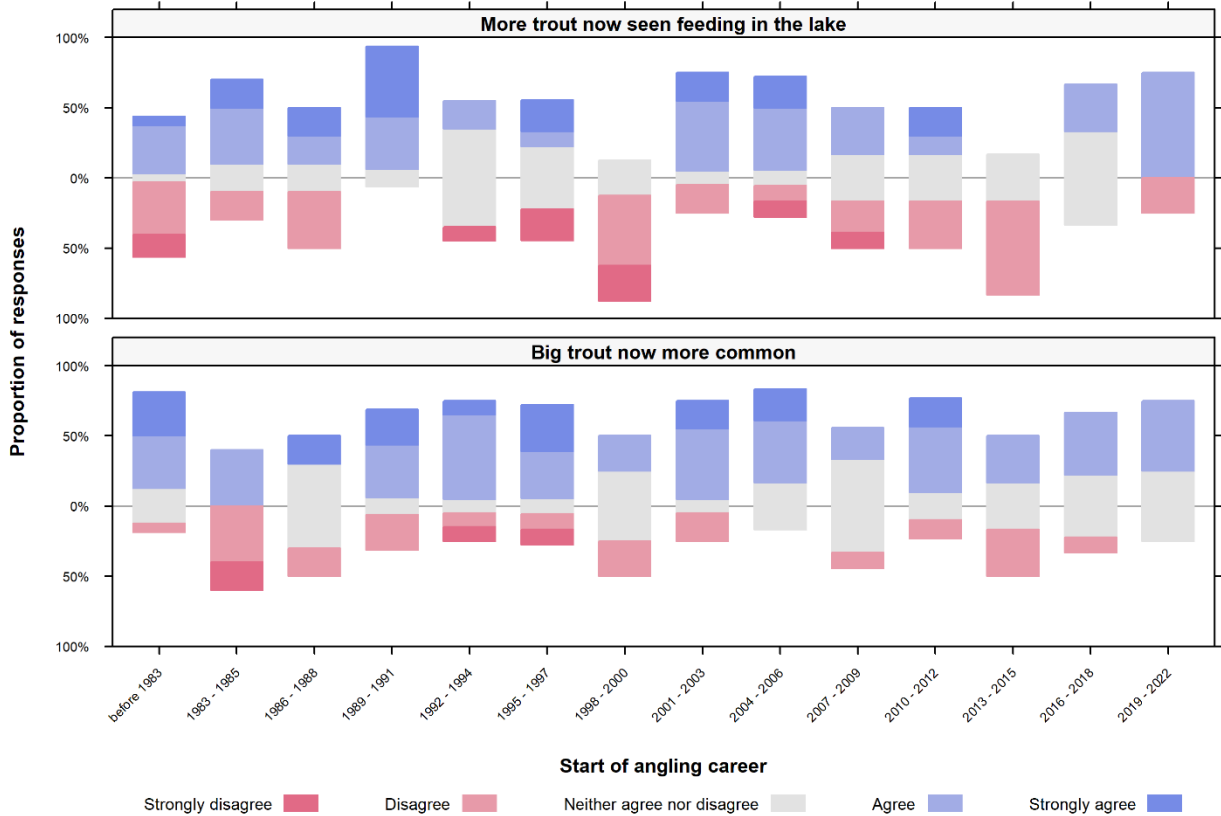


Figure 14: Diverging stacked bar charts of individual facet scores for the Trout descriptor.

FLEKSI Ecosystem Questions

Overall, the trend in agreement among respondents is positive, indicating they believe that the health of the lake ecosystem is now improved (Figure 15). This trend is stronger among respondents that started their angling careers in periods prior to 1998–2000 (22–24 years ago) when comparing water clarity, charophyte cover and ecosystem health now with the 1980s and 1990s (Figure 16). Among anglers who started fishing in 1998–2000 (19–21 years ago) and in 2001–2003 (22–24 years ago), there is an increase in disagreement that water is clearer now, that there are fewer algal blooms now or that the lake ecosystem now seems healthier (Figure 16).

Descriptor	FLEKSI Survey Statements
Ecosystem	The water is clearer than it used to be
	I see fewer algal blooms in the lake now
	There are more charophyte beds and areas of weedy cover nowadays
	The ecosystem in the lake seems to be getting healthier

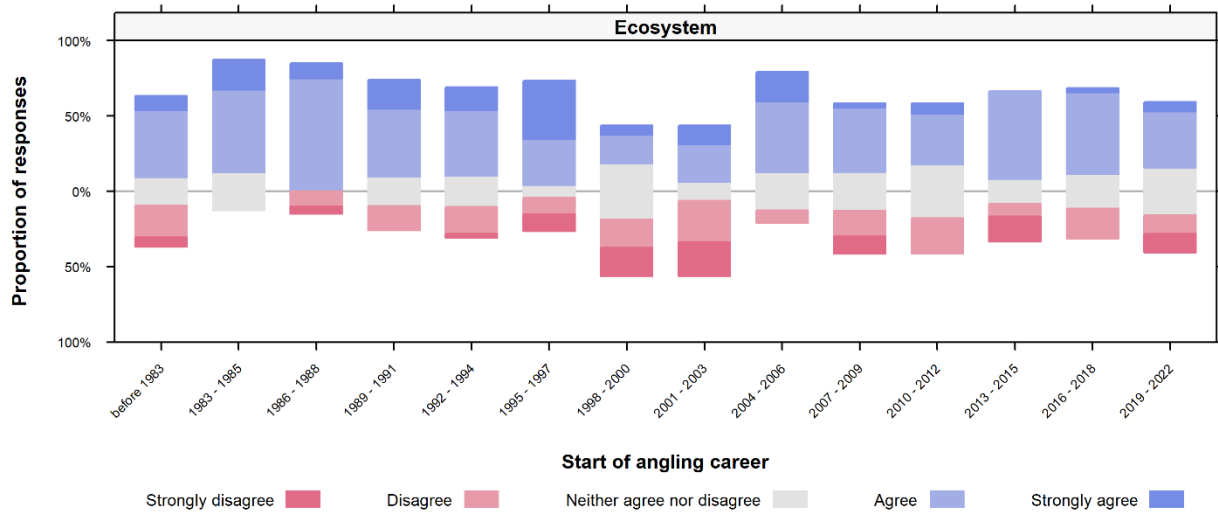


Figure 15: Diverging stacked bar charts of total combined scores for the Ecosystem descriptor.

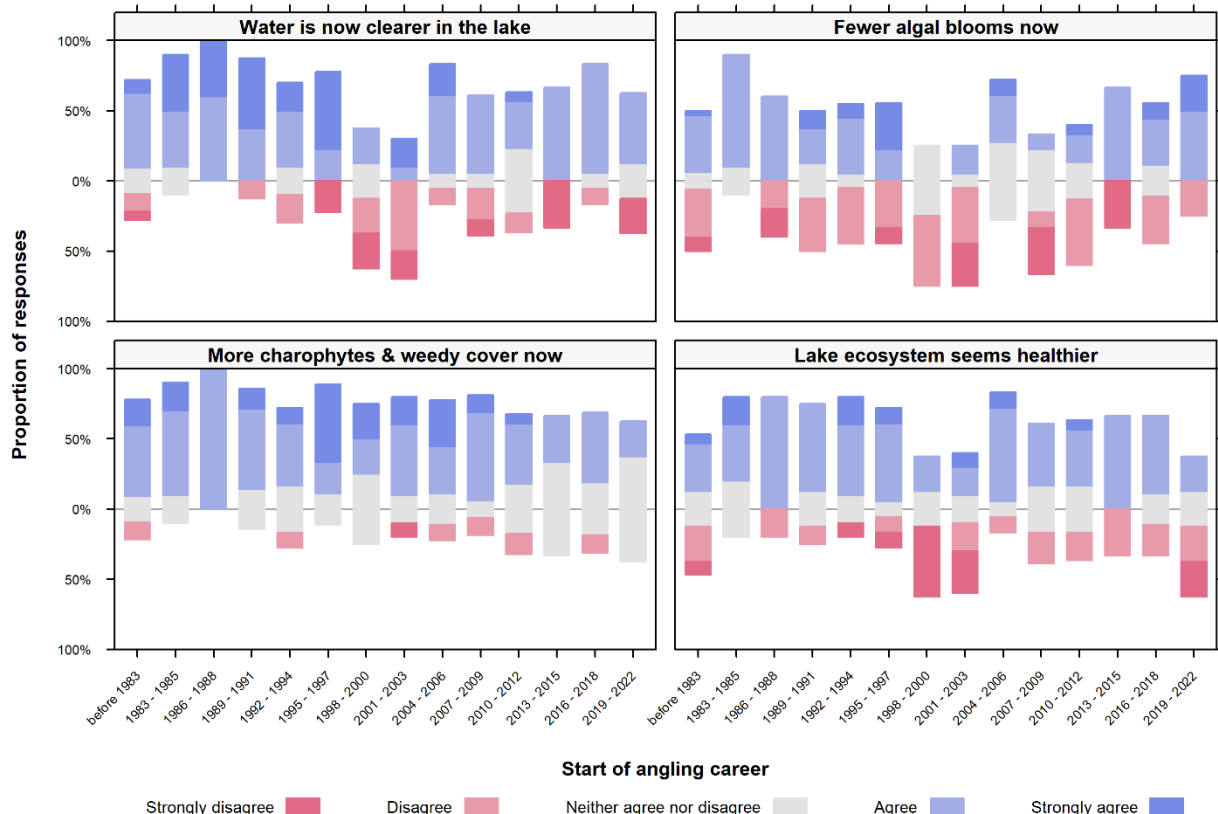


Figure 16: Diverging stacked bar charts of individual facet scores for the Ecosystem descriptor.

FLEKSI Changes in the Lake Questions

Overall, the trend in agreement is positive, indicating that respondents have observed changes in the lake ecosystem over time; these trends are strongest for water quality and seasonal patterns in catch. There is a steady increase in disagreement or neutral response among respondents who started fishing in the lake from 2001–2003 (19–21 years ago) onwards, and it would be expected that anglers who started fishing in the lake more recently might not have witnessed as many ecosystem changes. An exception to this overall pattern is a trend in recent periods that more respondents agree that changes in weather are making it harder to catch trout.

Descriptor	FLEKSI Survey Statements
Changes in the Lake	Water quality in the lake has fluctuated from year to year since I started fishing here
	Seasonal patterns in catch have changed from year to year since I started fishing here
	The best seasons for catching trout are changing
	I now catch trout in drifts out in the middle of the lake more so than nearer the shore
	Changes in weather patterns have made it harder to catch trout

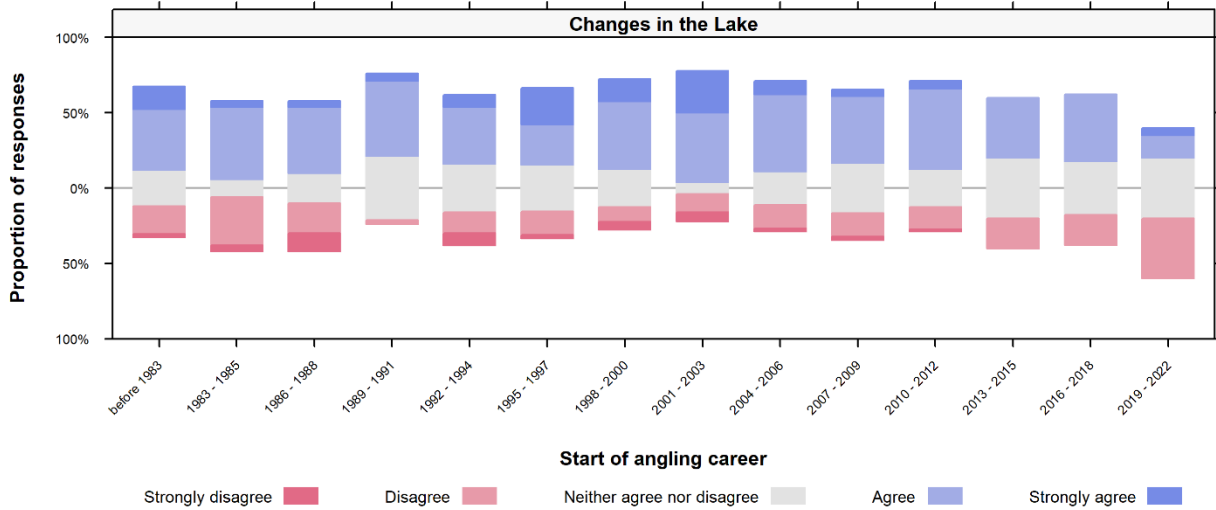


Figure 17: Diverging stacked bar charts of total combined scores for the Changes in the Lake descriptor.

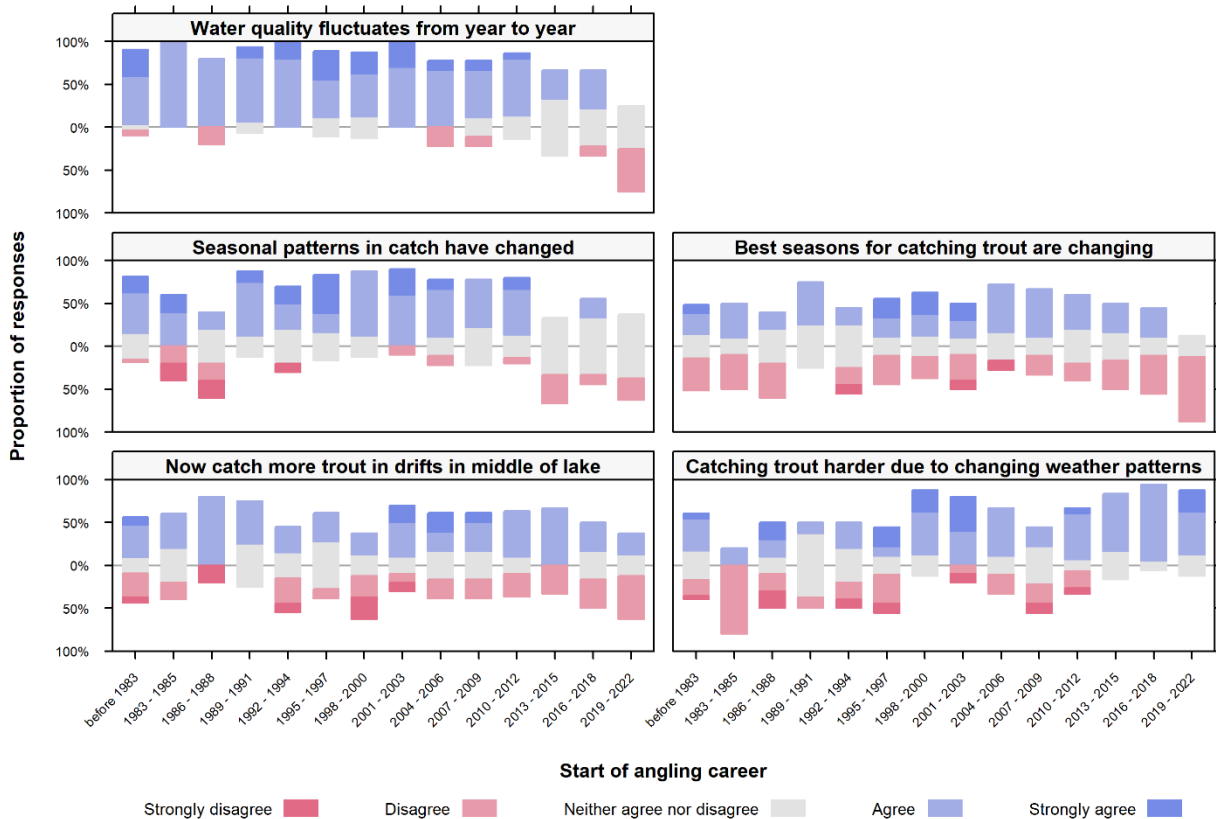


Figure 18: Diverging stacked bar charts of individual facet scores for the Changes in the Lake descriptor.

FLEKSI Feeding Questions

The survey questions on feeding ecology and insect prey included “Don’t know” as an option for response. “Don’t know” responses were assigned a score of zero and so are omitted from the plots.

No trends were evident for the trout Feeding descriptor overall, with a fairly even but variable pattern across all periods (Figure 19). Among the individual facets (Figure 20), there is a steady trend in agreement among respondents that fish fry are more important in trout diet now. There are positive trends in agreement among respondents that mayfly hatches and olive hatches are greater now, although these trends are quite variable.

Among the sedges, the trends over time on whether Murrough hatches are greater now are variable, but there is evidence of disagreement for some periods, such as prior to 1986–1988 and between 1995–1997 and 2013–2015, which may indicate a declining trend for Murrough hatches now compared with these periods. Similar patterns are seen in the responses for the Green Peter sedge, although they do not appear to be as strong. The pattern for hatches of other sedges is variable.

There appears to be a variable but increasing trend in agreement from 1995–1997 (25–27 years ago) that hatches of early midges & duckfly are greater now, and there is a mostly positive increasing trend in agreement that hatches of other midges are greater now. There is a positive trend that respondents mostly agree that bloodworm are more important now, apart from the periods between 1995 and 2000.

Descriptor	FLEKSI Survey Statements
Feeding	Hatches of mayfly are greater now
	Hatches of olives are greater now
	Hatches of the Murrough sedge (Great Red Sedge) are greater now
	Hatches of the Green Peter sedge are greater now
	Hatches of other sedges & caddis (Welshman’s Button, Longhorn, etc.) are greater now
	Hatches of early summer chironomids (duckfly) are greater now
	Hatches of other chironomids (green midges, Campto, etc.) are greater now
	Trout in the lake are now feeding more on bloodworm than they used to
	Trout in the lake are now feeding more on fish fry (pinheads) than they used to

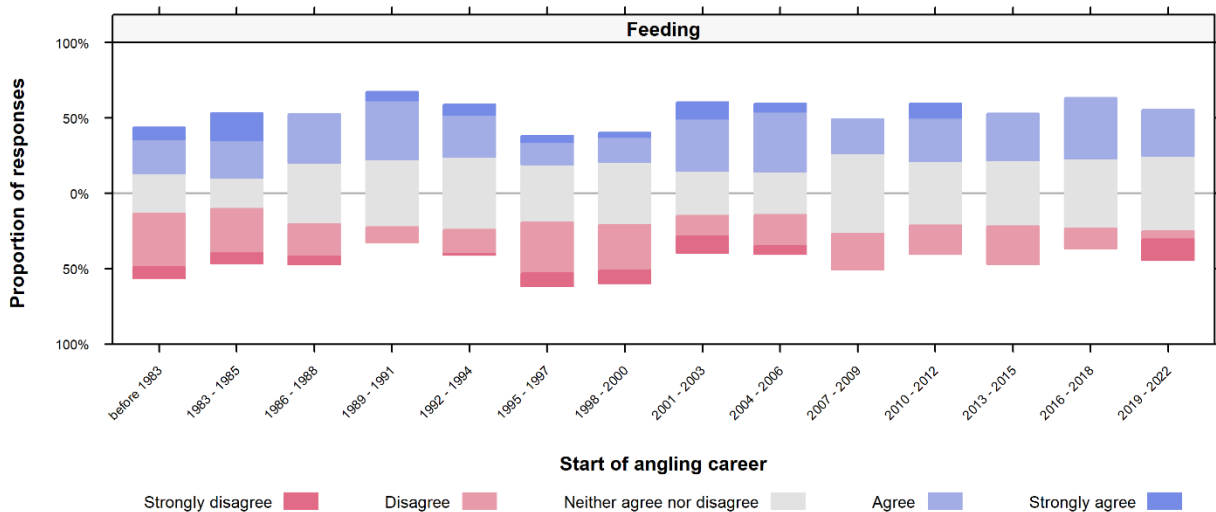


Figure 19: Diverging stacked bar charts of total combined scores for the Feeding descriptor.

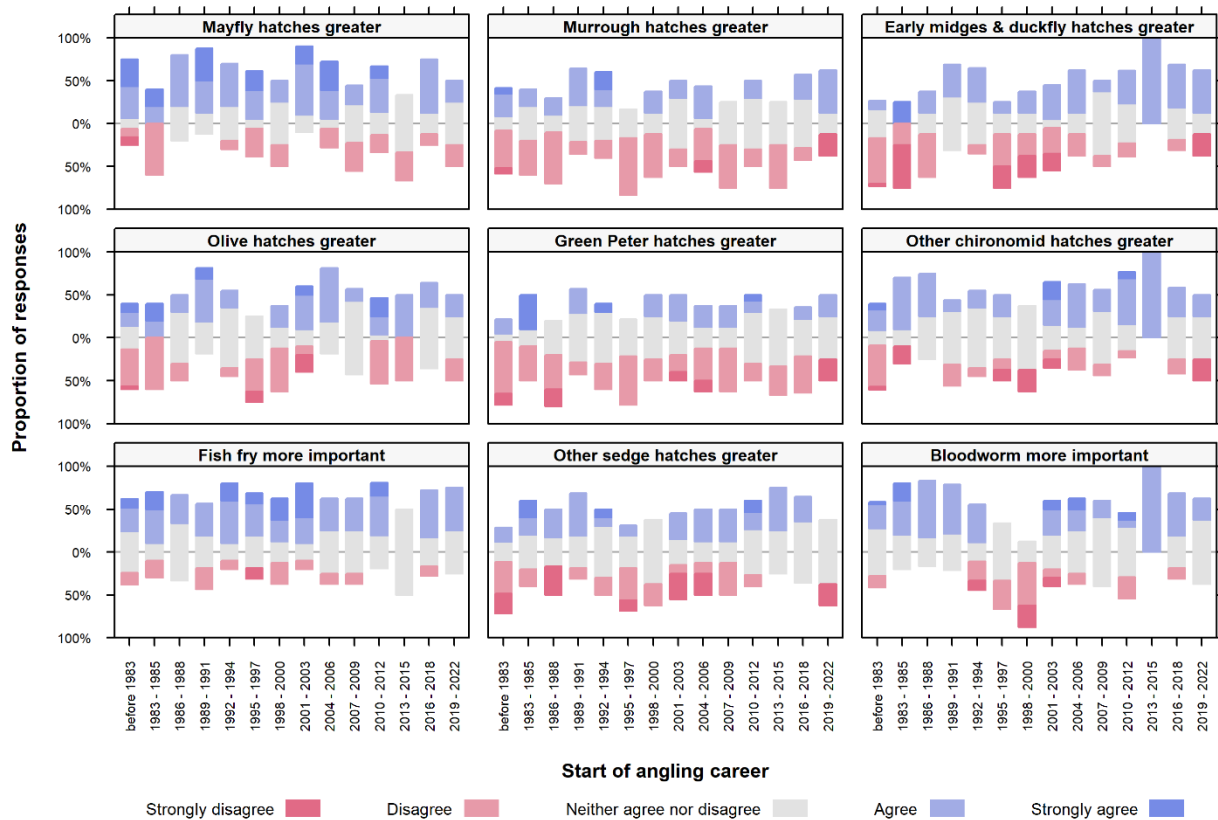


Figure 20: Diverging stacked bar charts of individual facet scores for the Feeding descriptor.

FLEKSI Catch Questions

Overall, the trend in agreement among respondents is variable over the time. The strongest agreement is seen among anglers who started fishing the lake between the periods 1989–1991 to 1995–1997, which may indicate that respondents believe that the mid-1980s to early 1990s were a low point for trout catches. Encouragingly, there is mostly positive agreement among respondents that they catch more big trout now and that they are not worried about changes in catches.

Descriptor	FLEKSI Survey Statements
Catch	I catch more trout than I used to
	I catch more big trout nowadays
	I have very good fishing days more often nowadays
	My favourite drifts have got better
	Catches haven't changed enough to worry me

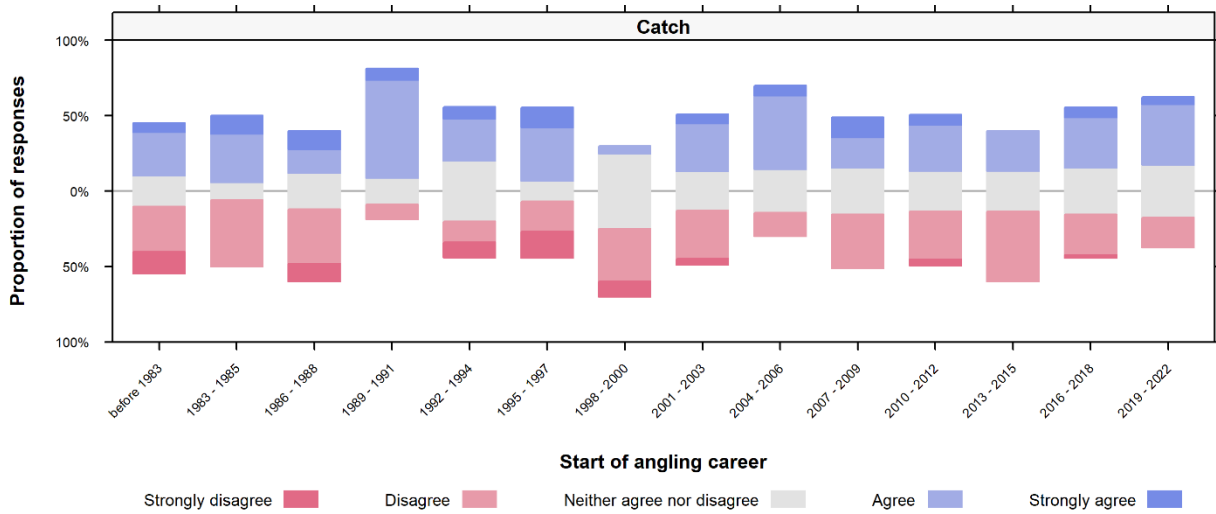


Figure 21: Diverging stacked bar charts of total combined scores for the Catch descriptor.



Figure 22: Diverging stacked bar charts of individual facet scores for the Catch descriptor.

FLEKSI Effort Questions

Overall, there is a variable trend over the time series for the Effort descriptor (Figure 23). There is a positive trend in agreement from respondents that they usually fish the same places that they used to across most periods (Figure 24). There is a trend of increasing agreement over time from 1989–1991 (31–36 years ago) among respondents that they still mostly use the same files and techniques. Respondents for all periods prior to 2010–2012 mostly disagree that the number of anglers has not increased much, which may indicate a steady trend of increasing angling activity from the mid-1980s to the 2000s.

Descriptor	FLEKSI Survey Statements
Effort	I usually fish the same places that I used to
	The number of anglers on the lake has not increased much
	I still use mostly the same flies and techniques

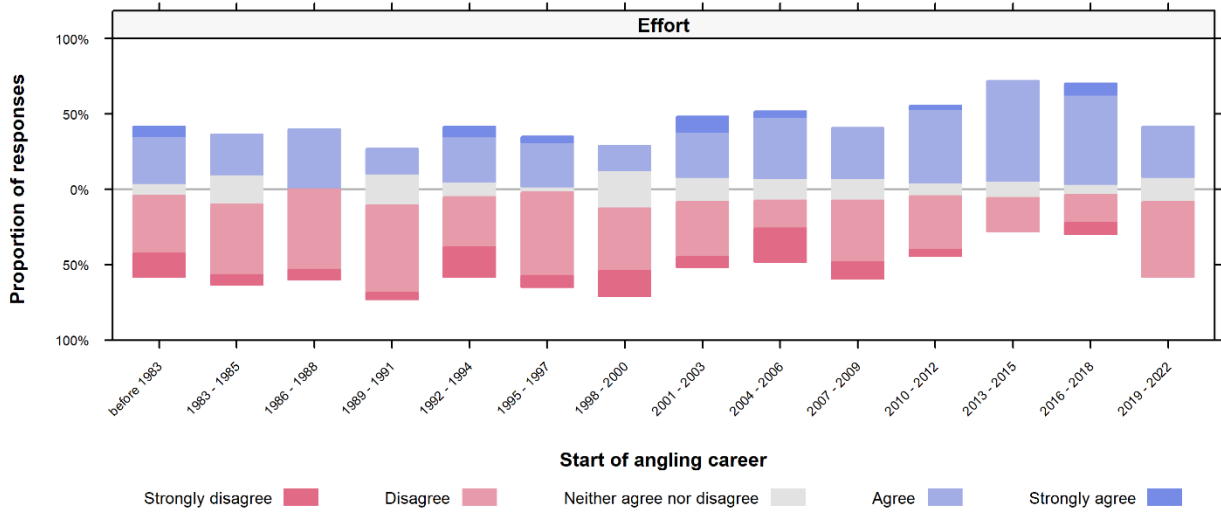


Figure 23: Diverging stacked bar charts of total combined scores for the Effort descriptor.

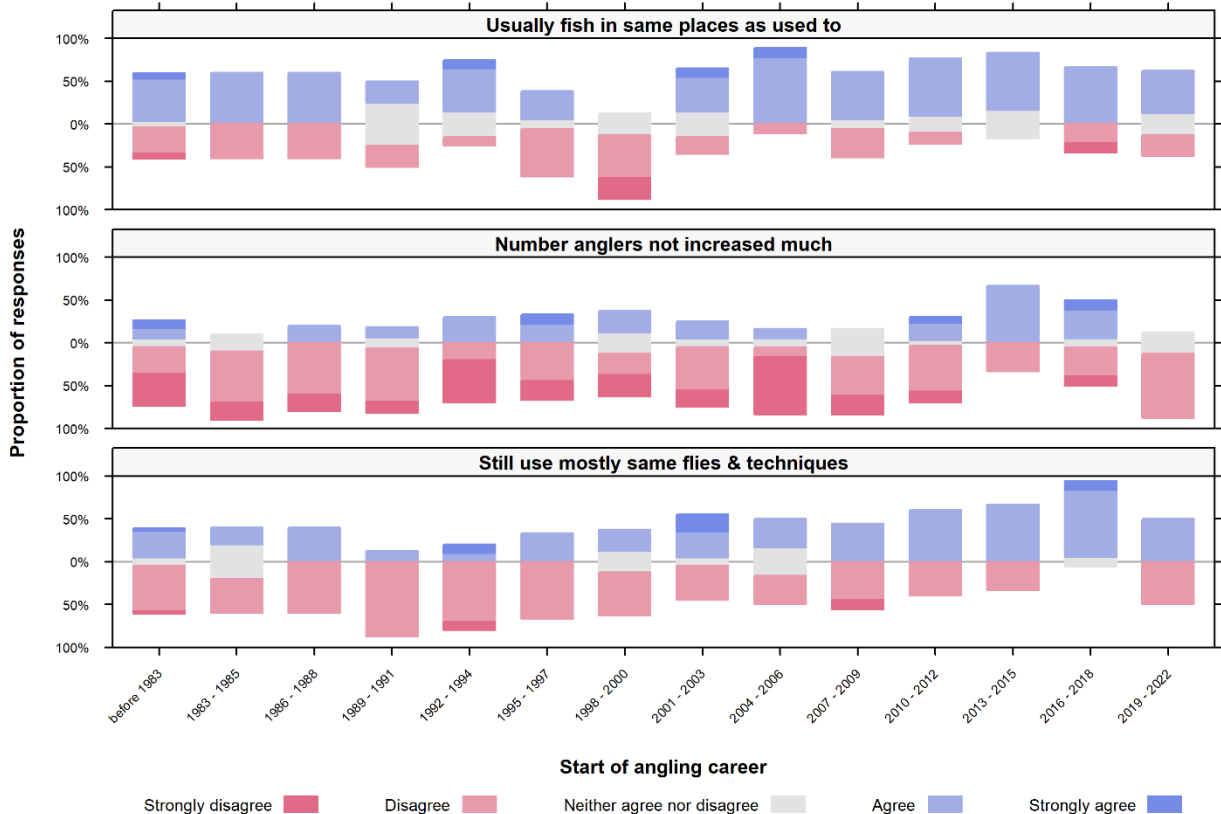


Figure 24: Diverging stacked bar charts of individual facet scores for the Effort descriptor.

Comparison of FLEKSI Results with Historical Scientific Survey Data

Since the 1970s, IFI has conducted fish stock surveys to monitor trout abundance on Lough Sheelin and gathered data on water quality in the lake. These time-series of data were compared with relevant questions from the FLEKSI survey to ground-truth how the FLEKSI respondents' answers compare with contemporaneous scientific data.

The FLEKSI survey statements were positively phrased, e.g., "*I catch more trout than I used to*" and "*The water is clearer than it used to be*"; therefore, disagreement with these FLEKSI statements can be expected to be greater when trout abundance and water clarity was recorded as high in the past, and vice versa. The scores for "Disagree" or "Strongly disagree" for responses on trout catch and water clarity were summed and standardised (see Appendix: Data Standardisation). The scientific measurements corresponding to time periods matching the FLEKSI survey were also averaged and standardised. Standardising the scientific data and FLEKSI results to scores that are spread over the same scale allows direct comparison of their trends over time.

Fish stock surveys typically report relative density as catch per unit effort (CPUE), in which total fish captured is divided by netting effort, i.e., the total number of nets set. There are broadly similar trends apparent when trout CPUE from the springtime stock surveys on Lough Sheelin are compared with response to the FLEKSI statement "*I catch more trout than I used to*", i.e. sharing similar trajectories of rising or falling from period to period (Figure 25). This indicates that the respondents have reported a reliable impression of changes in trout stocks over time for periods prior to the late 1990s and since 2010. The FLEKSI results for respondents' catch diverge from the trout CPUE data in some periods, especially 1998–2000 and 2007–2009, wherein there are fewer respondents and so are less likely to provide a representative sample of the LEK of all anglers. Moreover, it would not be expected that survey CPUE and angler catch are directly comparable because the stock surveys took place in springtime only, whereas respondents' reporting of catch would depend on whichever part of the season they fished.

Water clarity can be measured with Secchi discs, which are weighted black-and-white discs that are lowered into the water to record the depth at which they are no longer visible. In general, respondents' agreement with the FLEKSI statement "*The water is clearer than it used to be*" shows a degree of divergence with the measurements for water clarity from period to period over the time-series (Figure 26).

Chlorophyll is an algal pigment that indicates the amount of algal growth in a waterbody; elevated levels may indicate nutrient enrichment with phosphorous and a risk of algal blooms. For the FLEKSI statement "*I see fewer algal blooms in the lake now*", agreement can be expected to be greater when chlorophyll levels were recorded as high in the past, and vice versa. Similarly to trout catch, there are broadly similar trends in chlorophyll measurements and respondents' observations of algal blooms in the lake from period to period over the time-series, with a degree of divergence in some periods. These trends indicate that in general, the respondents reported a reliable impression of trends in algal blooms in Lough Sheelin over time from the mid-1980s to the late 2010s.

Direct comparison of trends in respondents' agreement with FLEKSI statements with scientific measurements must be interpreted with caution. The overall sample size of 132 respondents divided into 14 periods on a time-series of over 40 years is relatively small. Moreover, 24.2% of respondents are in a single period (over 40 years), and most of the rest of the periods had ten or fewer respondents, which means that the FLEKSI results for some periods are less robust and may be vulnerable to skew by a small number of answers. Another factor to consider is that imprecision of recall by respondents and inaccurate reporting of length of angling career might also introduce an unknown amount of error into the FLEKSI results. Nevertheless, there is some general agreement between scientific data and respondents' opinion for trout catch and for algal blooms. It may be the case that algal blooms on Lough Sheelin in the 1980s and 1990s were a visually striking phenomenon that are relatively easy for respondents to recall, providing more robust agreement on this aspect of changes in the lake ecosystem.

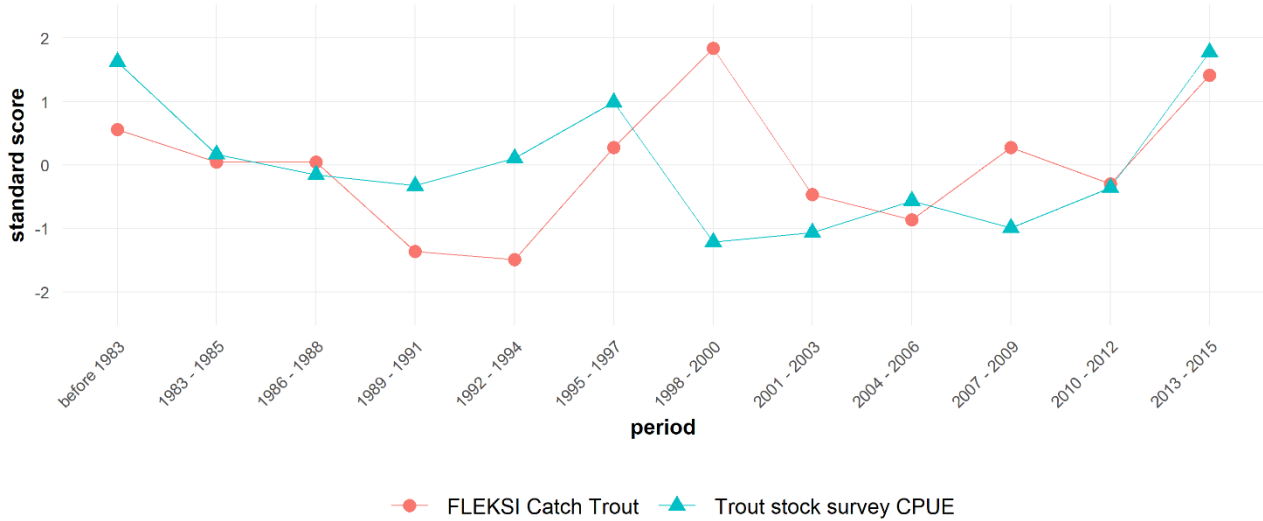


Figure 25: Time-series comparing respondents selecting "Disagree" or "Strongly disagree" for FLEKSI statement "I catch more trout than I used to" versus trout catch per unit effort (CPUE) from fish stock surveys of Lough Sheelin.

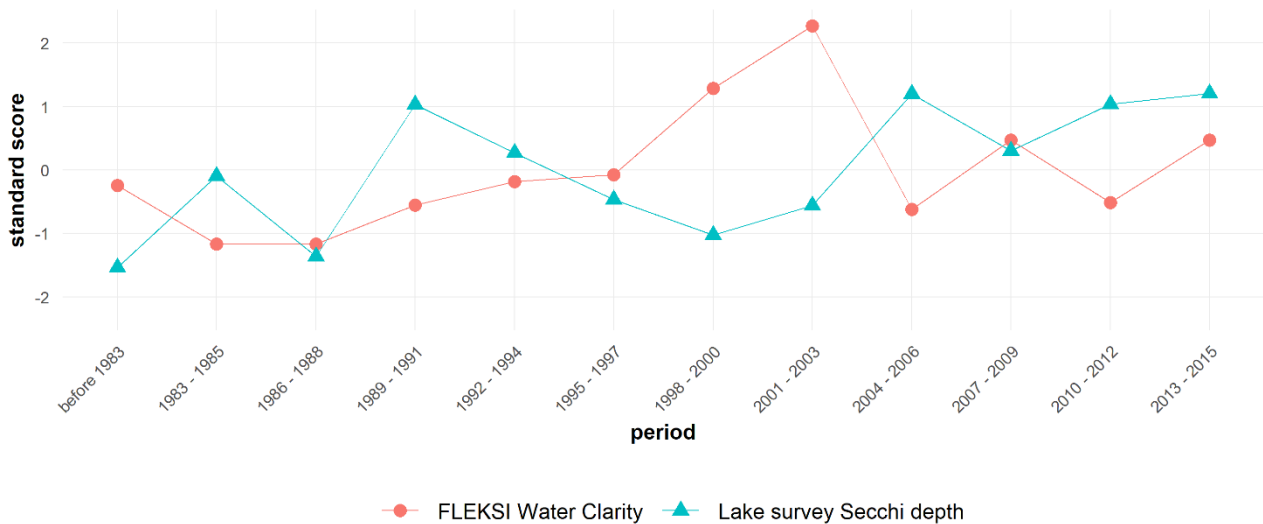


Figure 26: Time-series comparing respondents selecting "Disagree" or "Strongly disagree" for the FLEKSI statement "The water is clearer than it used to be" versus Secchi disc results for water clarity in Lough Sheelin.

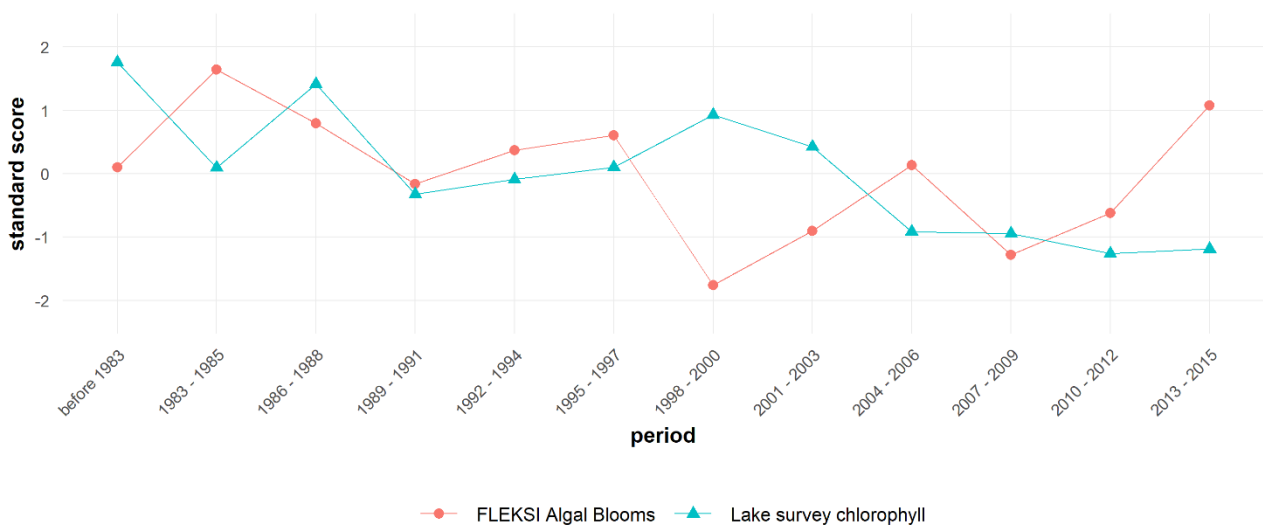


Figure 27: Time-series comparing respondents selecting "Agree" or "Strongly agree" for the FLEKSI statement "I see fewer algal blooms in the lake now" versus chlorophyll levels (indicative of algal activity) in Lough Sheelin.

Summary

The Lough Sheelin Trout Anglers FLEKSI Survey 2022 was conducted to investigate trends in the Lough Sheelin brown trout fishery and ecosystem over the course of anglers' careers. The survey was designed to allow anglers to share their accumulated ecological knowledge about Lough Sheelin, which can be used to identify trends in the fishery over time. In this way, anglers can contribute information that can inform conservation and management policy for this important fishery.

The Lough Sheelin Trout Anglers Survey 2022 contained two types of questions:

- Questions on angler behaviour & attitudes to gather background information on angling activity for analysis and to provide anglers with an opportunity to express their attitudes towards conservation and management for the fishery.
- FLEKSI (Fishers' Local Ecological Knowledge as Surveillance Indicators) statements. This method asks anglers to compare an aspect of the fishery "NOW" with how they remember it "THEN", i.e., when they FIRST STARTED angling there. This provides a time-series of information that can be analysed for trends.

There were 132 respondents to the survey, with 52.3% indicating that they have experience of over 25 years trout angling on Lough Sheelin. Most respondents (83%) indicated that they fish for trout only, but some anglers also fish for pike (11%), coarse fish (2%) or both pike and coarse fish (5%). Attitudes towards conservation were very positive among respondents, with 94% agreeing or strongly agreeing that they release more fish alive nowadays. Boating and angling etiquette are key issues of concern, however, with concerns expressed by 54% of respondents that wash from boats is a problem and by 32% about angling behaviour. Among the 62 anglers who gave a detailed comment, 11.8% of respondents expressed an opinion that Lough Sheelin is currently fishing well, compared with 2.2% who believe the lake is fishing poorly. Threats to trout stocks and the lake ecosystem identified by respondents include agricultural pollution, pressure from angling activity, lack of adequate protection and poor water quality.

In the FLEKSI survey results, the overall trend in agreement among respondents is variable but mostly positive over the time series as regards the abundance and size of trout in the lake and the health of the lake ecosystem. Encouragingly, there is mostly positive agreement among respondents that they are not worried about changes in trout catches. The FLEKSI respondents identified changes in the state of the fishery ecosystem that, for some periods at least, were also detected by contemporaneous scientific surveys; however, the results must be interpreted with caution, especially for those periods where there are relatively few respondents and where the trends reported by the anglers can be skewed by a small number of responses.

The lake ecosystem in Lough Sheelin has featured a web of dynamic interactions between nutrient input, water quality, algal growth, biological invasions and changes in the abundance and ecology of fish communities over the last several decades. The fluctuations observed in the Sheelin brown trout fishery are difficult to capture in the FLEKSI framework compared with a fishery that features trajectories in stock abundance that remain relatively steady over time, such as the decline in catch observed in the marine recreational fishery study (Shephard *et al.*, 2021), especially for periods with few respondents. Nevertheless, FLEKSI does show promise in capturing strong fishery and environmental trends where sufficient survey respondents contribute to LEK across all time periods. Moreover, the FLEKSI methodology gives anglers an opportunity as citizen scientists to record the environmental impacts they have witnessed and provides a framework to formalise anecdotal information into data for analysis.

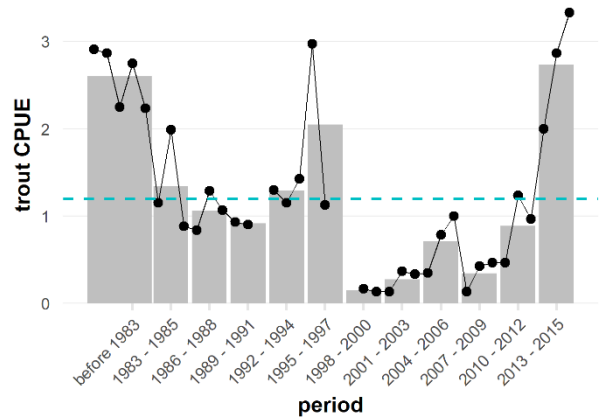
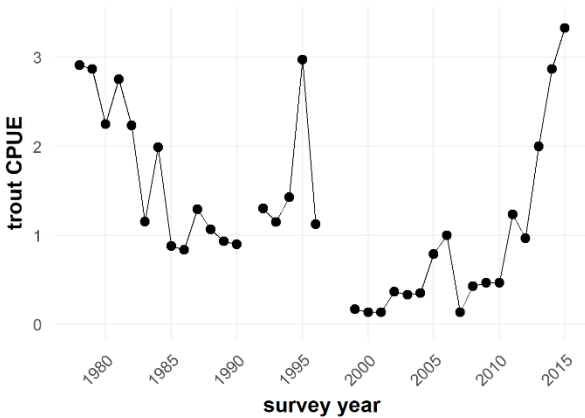
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Appendix: Data Standardisation

Standardisation is a simple statistical calculation that stretches out or compresses the scale that a set of values is plotted on using their average value (also called *mean*) and variation (measured by *standard deviation*). The mean is subtracted from each value, and the result is divided by the standard deviation. The new set of results is centred on a mean of zero, with values greater than the mean receiving a positive standard score, and values less than the mean receiving a negative standard score; however, the patterns or trends in the data remain unchanged (Figure 28).

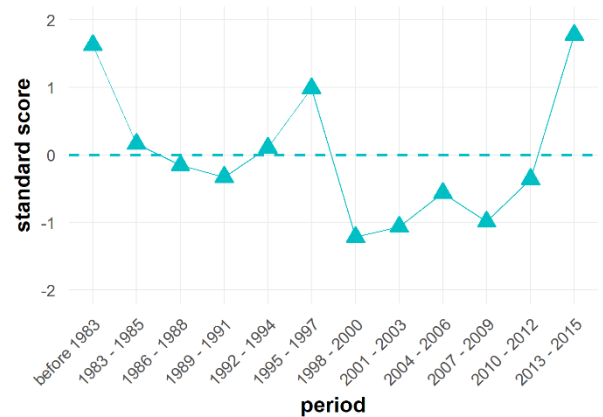
Standardising different sets of data to a mean of zero transforms the range and variation of each set to standard scores spread over the same scale. This is useful for plotting different sets of data side-by-side in the same diagram to compare their trends.



1. Trout CPUE data from annual IFI surveys.

2. Calculate mean trout CPUE in the periods for start of angling career among FLEKSI respondents (grey columns, dashed green line is mean value across all periods = 1.198).

period	mean trout CPUE for each period <i>x</i>	standard score $(x - \text{mean}) \div \text{standard deviation}$
before 1983	2.602	1.628
1983 - 1985	1.341	0.166
1986 - 1988	1.066	-0.152
1989 - 1991	0.916	-0.326
1992 - 1994	1.292	0.110
1995 - 1997	2.050	0.988
1998 - 2000	0.150	-1.214
2001 - 2003	0.278	-1.066
2004 - 2006	0.712	-0.563
2007 - 2009	0.343	-0.991
2010 - 2012	0.888	-0.359
2013 - 2015	2.732	1.779
mean	1.198	
standard deviation	0.863	



3. Calculate standard scores using mean and standard deviation.

4. Plot of trout CPUE transformed to standard scores. Note that dashed green line for mean is now centred on zero but the pattern of green data points remains the same as the height of the grey columns in the panel above.

Figure 28: Diagram of standardisation using trout CPUE as an example.

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