

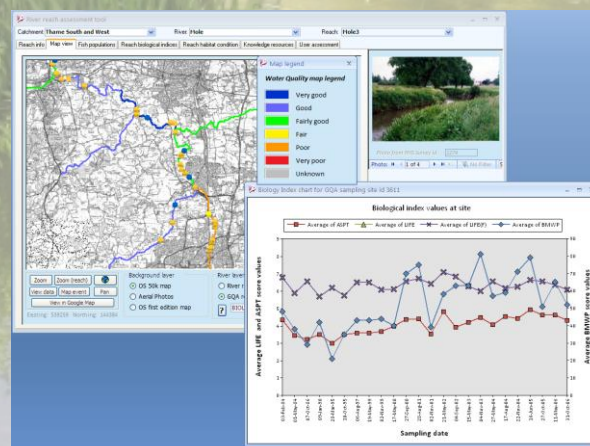
ToolHab

Decision Support System

Tools for Managing Habitats



May 2014



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ENVIRONMENT
AGENCY

UNIVERSITY OF
Southampton
School of Geography

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Welcome to the ToolHab Decision Support System.

ToolHab is a Decision Support System developed for the Environment Agency England and Wales to help assess and prioritise river reaches for habitat enhancement work.

ToolHab is one of the outcomes of a wider five-year research project sponsored by the Environment Agency and hosted by the University of Southampton (School of Geography) on decision support and river management. The aim of the research was to investigate the factors affecting the uptake of science and scientific products such as computer tools and models within a conservation organisation.

Through its servers, intranet and internet connections, Environment Agency staff have access to a wide range of data and knowledge of potential benefit to their many duties (e.g. the national fisheries database (NFPD), the RHS database, BioSys, GIS data, aerial photographs, satellite images, species databases etc). One major issue is to make these sources of information available to staff in a format that is relevant to their work and adapted to their skills and work practice.

Decision Support Systems are computer programs that help users in their day-to-day decision-making processes by providing them with information relevant to their jobs. Decision Support Systems combine databases and predictive models into simple user interfaces.

This particular project was initiated by the Environment Agency fisheries science team and Thames region Fisheries, Recreation and Biology team to investigate the potential use of existing data and computer software for managing fish and their habitats.

The aim of this project is to develop a prototype Decision Support System using existing knowledge, data and software to help with the management of fish population and the implementation of the Water Framework Directive. The prototype DSS will be tested by Environment Agency staff from fisheries and other department.

The Decision Support System contains data for a total of 15 rivers of which 10 are located in Thames region, 3 in North West region and 2 in North East region. Only information for the main stems of the rivers were included in ToolHab. A range of datasets on fisheries, river habitats, water quality, biology and man-made structures are available through a built-in GIS interface and a series of simple forms and graphs. ToolHab also contains simple conceptual models of habitat suitability for nine species of fish and three life stages designed by fisheries experts from the Environment Agency.

Altogether, ToolHab provides simple and easy access to existing data and knowledge on rivers and fish thus facilitating the assessment of habitat quality, the identification of pressures and impacts, and the identification of measures for restoring/improving habitats.

The project record is available in the shape of a PhD thesis document downloadable from the University of Southampton and on the Environment Agency portal (project SC060093).

Getting started with ToolHab.



To start the application after installation, double-click on the ToolHab icon

This will open the application and a first screen will be displayed for a few seconds



The next screen to appear will be the user login window

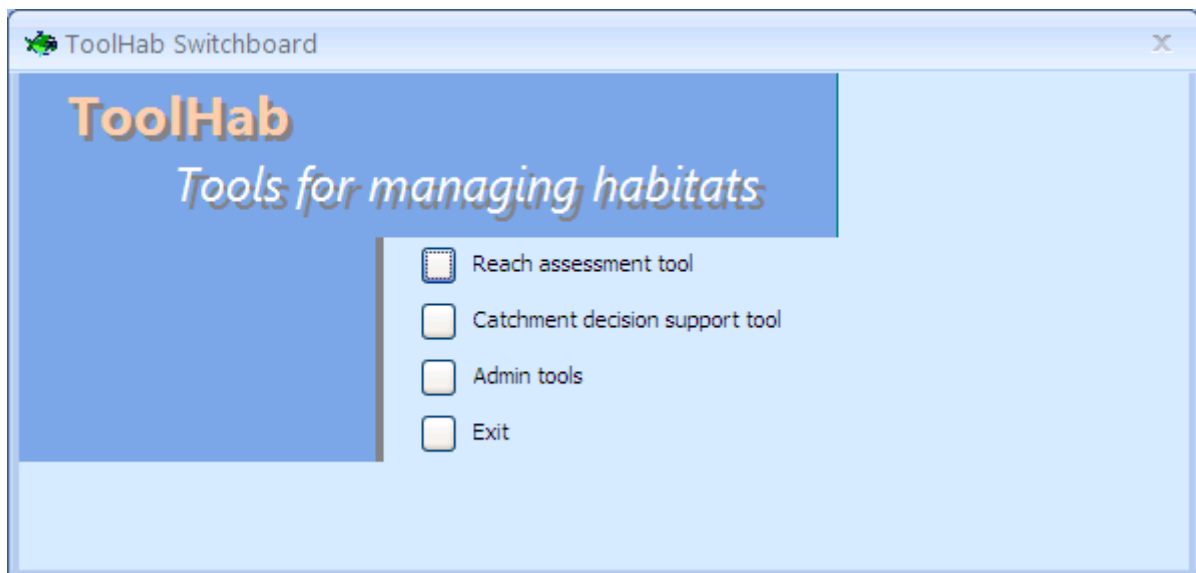
If you are already a registered user, select your user id and click ok.

If you are not registered yet, click on the 'Add new' button and the following screen will appear
Enter your details and press 'Close'

Switchboard options

The ToolHab switchboard has four options:

- The reach assessment tool option will open a tool for assessing individual river reaches. The tool gives users access to fisheries, biological, river habitat and water quality data along with maps and aerial photography. The data can be viewed for individual sampling sites but also at the scale of river reaches. Each river has been split into a series of discrete units representing homogeneous habitat sections. The tool also enables users to input their local knowledge using a simple interface. Historic information about river sections or individual events can be recorded and showed on map. The reach assessment tool was designed for Catchment Officers to help them identify pressures and impacts and suggest management actions. The tool is fully functional
- The catchment decision support tool summarises the information collected using the reach assessment tool at the scale of rivers (from source to mouth) or catchments. This decision support tool was developed for Technical Specialists within Environment Agency fisheries units to identify pressures and impacts at catchment scale and design strategies and programmes of measures. At the moment, this tool is not fully functional and is for demonstration purposes only. It will display information and enable to query GIS data but it will not enable a full assessment at catchment scale.
- The admin tools menu can be used to change the paths to aerial photo, maps and RHS photo directories and to perform an update of the database and help file.



River reach Decision Support tool

The river reach Decision Support tool was designed to help with the assessment of habitat quality for 23 species of fish, the identification of pressures and impacts and the design of restoration/habitat improvement measures.

[illegible]

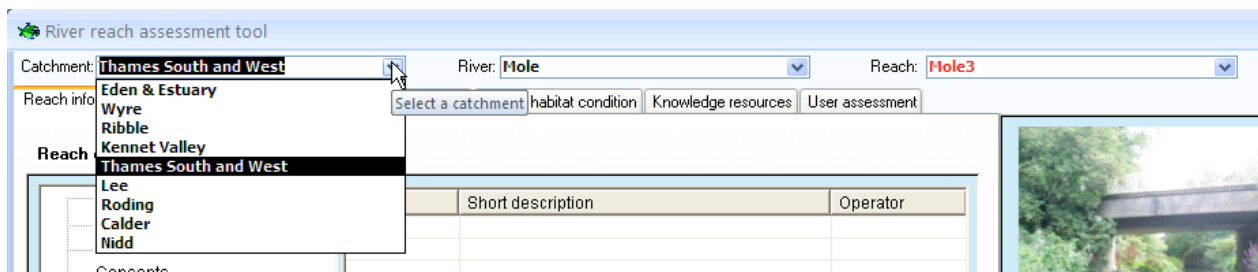
River reaches were defined using 4 indices representing habitat dimensions (i.e. substrate type, flow type, channel vegetation structure and activity) that were mapped along the river network using predictive models and GIS data. Each reach represents a homogeneous morphological unit with regards to the four dimensions mentioned above as observed now and at reference condition. Each reach should therefore contain only one habitat type (for example a reach dominated by riffles and runs over cobbles/gravel-pebbles substrate mix with no marginal vegetation and high levels of erosion and deposition) that is different in one or more of its components from river reaches upstream and downstream. It is important to note that river reaches will be homogeneous in terms of the observed habitat on the day of survey and habitats as they would be if the reach was unimpacted by human activity. To learn more about the technique used to derive river reaches, go to [appendix 3](#)

Using this technique, the river reaches for 15 rivers selected to be part of the Decision Support System were defined and given a unique name and identification number based on their position in the catchment. Existing fisheries, biological, RHS and barriers data points were then associated with their respective river reaches using GIS and summary statistics were produced. The river reach decision support tool displays summary data for all river reaches (the view below shows the data associated with the default river reach on the river Mole).

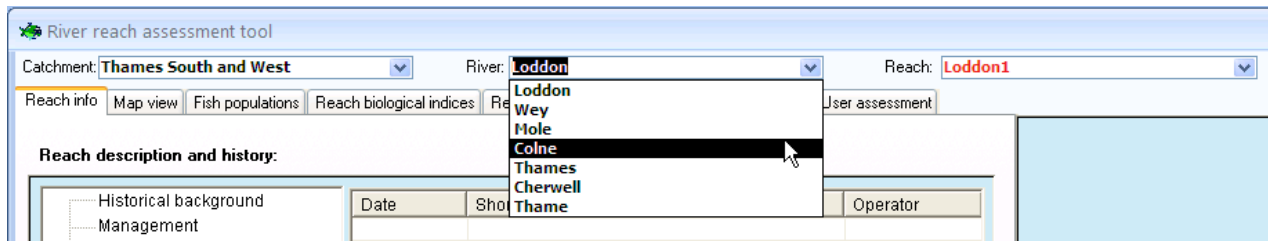
The reach assessment tool contains seven tabs.

At the top of the window are three drop-down boxes with information about the selected reach.

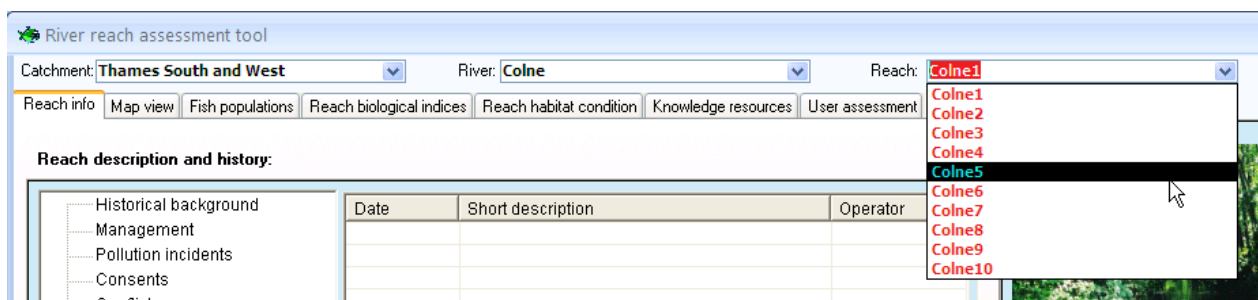
To select a river reach, start by selecting the relevant catchment using the 'Catchment' drop-down box.



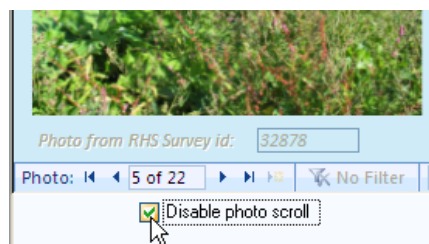
Then, use the 'River' drop-down box to select your river of choice.



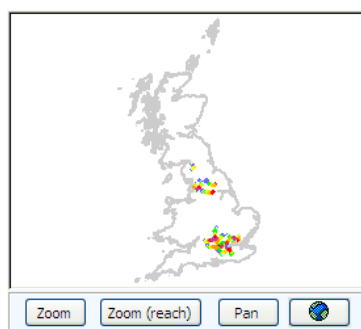
Then use the 'Reach' drop-down box to select a reach. For each river, river reaches have been numbered in ascending order from source to mouth. River reach ids containing a '0' (e.g. Mole03) generally are on tributaries or on adjacent arms of the river.



Photographs of River Habitat Survey (RHS) sites associated with the selected river reach are displayed on the right-hand side in a slide show. To stop the slide show and view the photos individually, check the 'Disable photo scroll' box and then click on the navigation buttons to flick through the photographs.



In the bottom right-hand corner, is a small map displaying all 15 rivers. You can zoom in and out of the map using the zoom button (left click to zoom in and right click to zoom out). You can also click on the 'zoom (reach)' button to display the selected reach.



Before we start the assessment of the reach, we will first look at the end of the process which is the 'User assessment' form.

Learning about the river history:the reach info tab

Most knowledge is in people's minds and memories. The Environment Agency for example, hosts on its servers vast amounts of data on water quality, biological quality and river habitats but there is no repository for local knowledge accumulated by generations of staff on the river history and associated events and anecdotes. As part of the research carried out for the project, local staff identified that a module for capturing and storing local knowledge on river reaches would bring tremendous added value to the Decision Support System.

Using the reach info tab, information about historical events can be captured, dated and geographically located. The general history of the river can also be recorded.

Reach History

In the left-hand panel, there are seven categories of events that can be recorded or viewed. If you click on any category title, a list of associated events will appear in the left and right panels. To view an event, simply double-click on the corresponding line in the list.

Tip: instructions as to what to do will appear if you hover with the mouse specific parts of the screen

[illegible]

Double-click on the 'Sewage Outflow' to view the event.

Detailed information about the event is now visible. To learn more about the person who reported these particular pollution incidents, double click on his name.

Reach description and history:

<ul style="list-style-type: none"> Historical background Management Pollution incidents <ul style="list-style-type: none"> 2010: Sewage outflow Consents Conflicts Others Comments 	Event Sewage outflow Operator Mike Clark Date 23-Mar-04 Description Pollution due to storm and sewage overflow. Numerous fish killed.
	Location Easting: 526621 Northing: 144538
	Attachment:
	Links

[Add new event](#)
[Delete event](#)
[Locate on map](#)

When event coordinates are indicated, you can click on the 'locate on map' button and it will take you to the 'Map view' tab and locate the event using a yellow circle.

Reach info **Map view** Fish populations Reach biological indices Reach habitat condition Knowledge resources User assessment

Zoom Zoom (reach) View data Map event Pan View in Google Map

Background layer
☒ OS 50k map
☐ Aerial Photos
☐ OS first edition map

River layer
☒ River reaches
☐ GQA reaches
 BIOL_GRD06

☒ Fisheries Surveys
☒ River Habitat Surveys
☒ Biology Surveys
☒ Barriers

Easting: 532921 Northing: 136693

Local knowledge: adding events

Now we will quickly demonstrate how you can add events using the 'reach info' tab or the 'map view' tab.

Adding an event using the 'Reach info' tab

Click the **Add new event** button. The following form will appear:

Event for the reach Mole3

Reach Name: Mole3

Category: [dropdown arrow]

Event

Operator Marc Naura

Event date

Description

Location

Links

Attachments

Close Cancel

Please note that the reach ID and your name are automatically added.

First choose a category for the event using the drop-down box:

Category: [dropdown arrow]

Event

Operator

Date

Historical background

Management

Pollution incidents

Consents

now enter a short title for the event in the 'event' field, a date and a description.

If you want to, you can add:

- The location of the event using six-figure Easting and Northing in the 'Location' field;
- Links to several websites or network folders/documents in the 'Links' list box;
- Several documents related to this particular event in the 'Attachments' list box.

once you have finished adding information, click **Close**

Adding an event using the 'Map view' tab

It can be sometimes difficult to figure out the exact coordinates of events. It is possible to create events directly using the map. Go to the 'Map view' tab and click on **Zoom (reach)** to focus on the selected reach, then use the **Zoom** and **Pan** buttons to zoom to the right location. Finally, click the **Map event** button and then click on the map at the exact location where the event occurred. The same form as before will appear but this time, the Easting and Northing will have been automatically added. Proceed as before and click the **Close** button to save the event.

Now go back to the 'Reach info' tab and check that your event has been recorded.

Reach info **Map view** Fish populations Reach biological indices Reach habitat condition Knowledge resources User assessment

Event for the reach Mole3

Reach Name: Mole3

Category: Event

Operator: Marc Naura

Date: 31-Mar-10

Description:

Location: Easting: 527404 Northing: 142898

Links:

Attachments:

Close Cancel

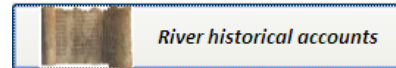
Zoom Zoom (reach) View data Map event Pan View in Google Map

Background layer

- ☒ OS 50k map
- ☐ Aerial Photos
- ☐ OS first edition map

Local knowledge: river historical accounts

To get an overview of the river historical background, click on



This will open a window with a series of records on the general history of the river, its management, the land use etc.

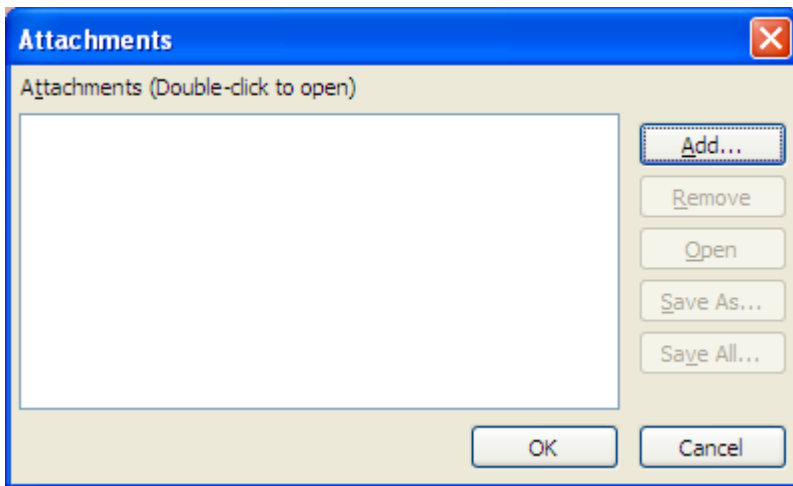
A screenshot of a web application window titled "River Mole historical account". The window has a red sidebar on the left with labels: "River", "Title", "Operator", "Date", "History", "Links", and "Attachments". The main content area is white. Under "River", the text "Mole" is displayed. Under "Title", it says "A short history of the river Mole". Under "Operator", it says "Guest". Under "Date", it says "01-Apr-10". Under "History", it says "In the 18th century..." followed by a paragraph of text: "Please note that there are 2 historical accounts here. Go to the next one by clicking the right blue arrow head below .", "Enter some text and add some extra font, features such as colours, bold, italics, highlights or even", a bulleted list with "bullet points", and "1. numbered...". Below this, it says "You can also add hyperlinks in the text: www.riverhabitat.org". Under "Links", there are two URLs: "http://en.wikipedia.org/wiki/index.html?curid=174514" and "http://www.visitdorking.com/sh_the_river_mole.asp". Under "Attachments", there is an empty box. At the bottom of the window, there are "Close" and "Cancel" buttons, a "Categ" dropdown menu, and a navigation bar with "Historical account", "1 of 2", "No Filter", and a "Search" button.

Please note that there may be more than one record for a single river. To create your own account of the river history, add a new record by clicking on the button in the navigation panel.

You can add links to websites or documents by copying and pasting the URL or path to the document.

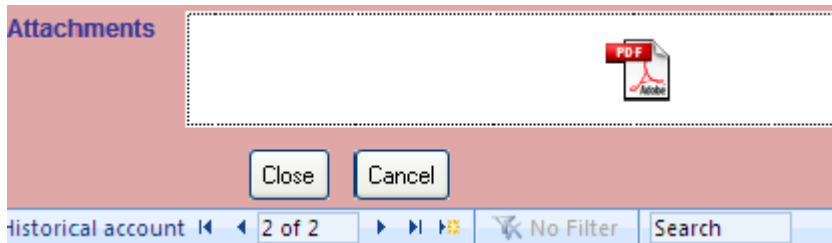
You can also import within ToolHab entire documents as attachments. The difference between a link and attachment is that attachments are included within ToolHab (they stay and 'travel' with it). 'Links' simply link to an existing file on the web. If the file disappears, moves or the website changes name, the link will be lost. Beware that attachments increase the size of the application.

To add an attachment, double-click on the attachment box and the following window will appear.

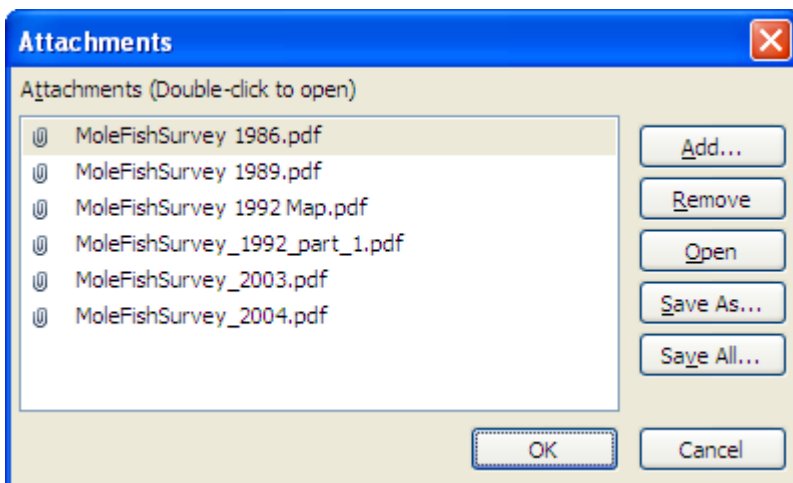


Click add to locate the file you want to attach. You can attach more than one file.

To view an attachment, double-click on the attachment icon (here a pdf file).



The attachments window will open and display all available files for this particular record. To view an attachment, select it in the list and click open.



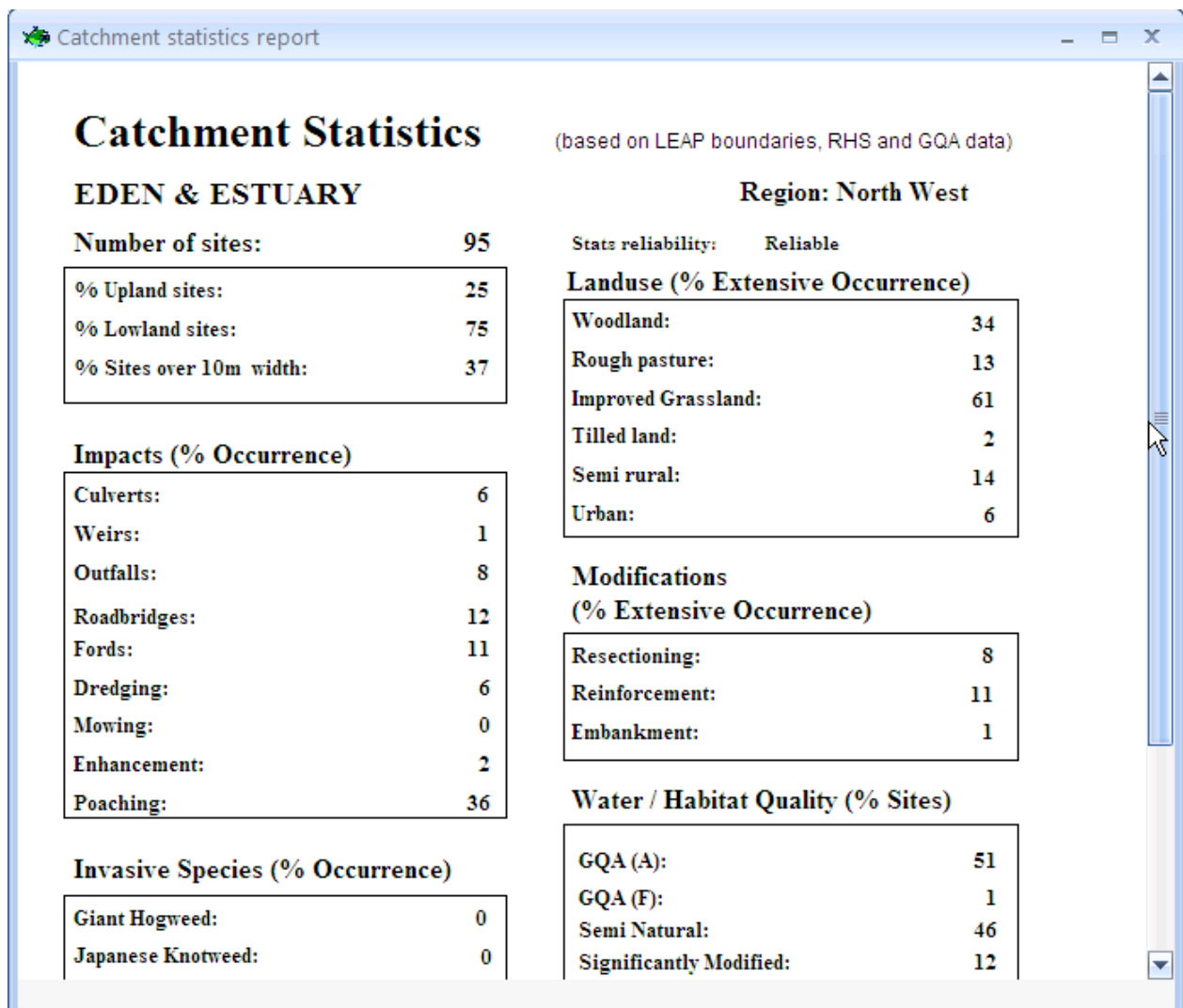
Local knowledge: Summary catchment report

To get an overview of the catchment summary report, click on



This will open a window with a series of records on the general history of the river, its management, the land use etc.

The example below show a catchment report summary for the Eden and estuary catchment. The summary includes statistics for randomly selected River Habitat Survey sites on the catchment. In this case, there are 95 sites that were used to produce the statistics. It shows that the catchment is dominated by improved grassland and woodland land uses, and that 46% of the sites are semi-natural. Poaching occurs at 36% of all sites showing potential impacts from hill farming and cattle on river habitats. A majority of the sites had good water quality and few were impacted by pollution or physical modifications.

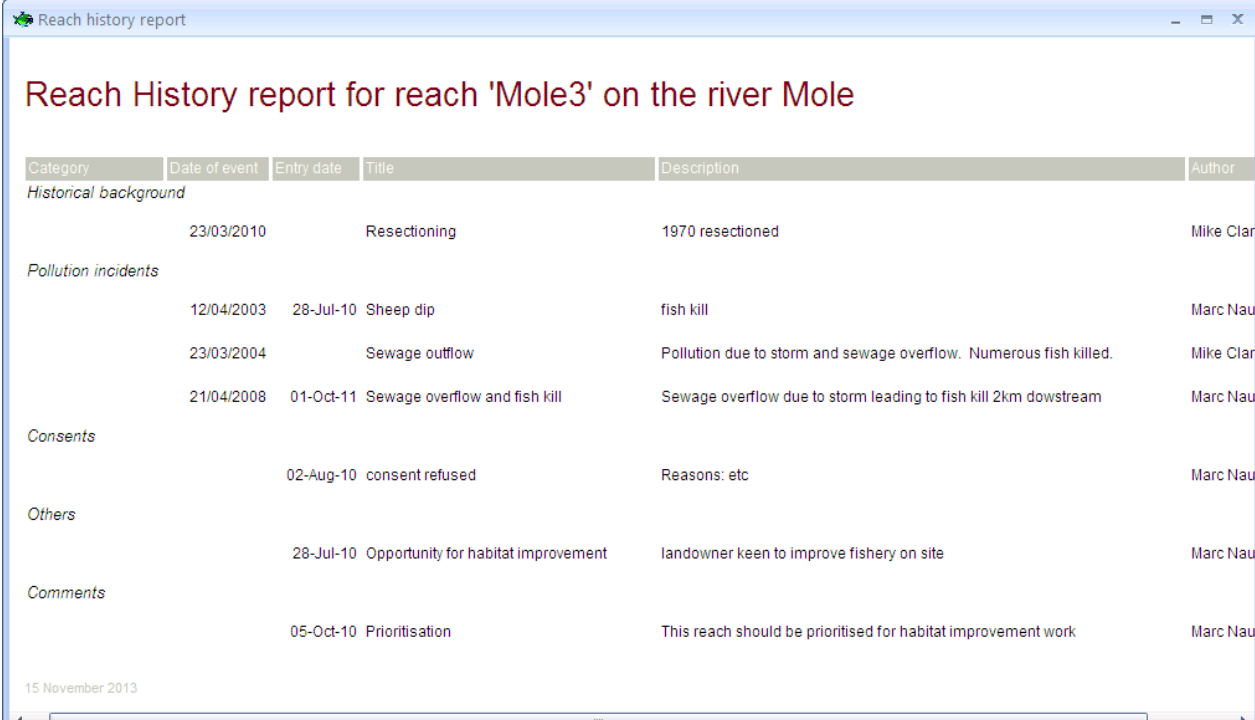


Local knowledge: Summary catchment report

A report detailing all reach historical accounts can be produced by clicking on the

[View all events on river](#)

button. The report can be printed or exported to a word processing document.



Category	Date of event	Entry date	Title	Description	Author
<i>Historical background</i>					
	23/03/2010		Resectioning	1970 resectioned	Mike Clar
<i>Pollution incidents</i>					
	12/04/2003	28-Jul-10	Sheep dip	fish kill	Marc Nau
	23/03/2004		Sewage outflow	Pollution due to storm and sewage overflow. Numerous fish killed.	Mike Clar
	21/04/2008	01-Oct-11	Sewage overflow and fish kill	Sewage overflow due to storm leading to fish kill 2km downstream	Marc Nau
<i>Consents</i>					
		02-Aug-10	consent refused	Reasons: etc	Marc Nau
<i>Others</i>					
		28-Jul-10	Opportunity for habitat improvement	landowner keen to improve fishery on site	Marc Nau
<i>Comments</i>					
		05-Oct-10	Prioritisation	This reach should be prioritised for habitat improvement work	Marc Nau

15 November 2013

Local knowledge: Summary catchment report

A report detailing all river historical accounts can be produced by clicking on the

[View all events on river](#)

button. The report can be printed or exported to a word processing document.

River History Report

River History report for the river Mole

Entry date	Title	Description	Author
	A short history of fish in the river Mole	<p>Double-click on the attachment box to view the 6 attachments on fisheries surveys from 1986 to 2004.</p> <p>Please note that you can create links to files instead of adding an attachment. The link below will open the same file as the first attachment. The difference between a link and attachment is that attachments are included within ToolHab (they stay and 'travel' with it). Links simply link to an existing file or webfile. If the file disappears, moves or the website changes name, the link will be lost.</p>	Guest
	A short history of the river Mole	<p>In the 18th century...</p> <p>Please note that there are 2 historical accounts here. Go to the next one by clicking the right blue arrow head below .</p> <p>Enter some text and add some extra font, features such as colours, bold, <i>italics</i>, highlights or even</p> <ul style="list-style-type: none">• bullet points <p>1. numbered...</p> <p>You can also add hyperlinks in the text: www.riverhabitat.org</p>	Guest


10 September 2010

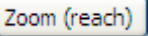
Page 1 of 1


The map view


You can use the map view to display various data layers available in ToolHab. Three background layers are available: a black and white version of the 50,000 scale OS map, Environment Agency aerial photographs and the 1900s first edition OS maps. Not all first edition maps and aerial photographs have been loaded on the Decision Support System because of issues of speed and data storage.

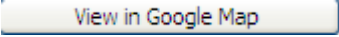
There are series of buttons and function to help view and navigate through the map layers.

Use the  button to zoom in and out using a left click for zooming in and a right click for zooming out. You can also use the wheel of your mouse to perform both functions.

Use the  button to automatically zoom to the selected reach (e.g. Mole3 reach).

Use the  button to automatically zoom to the map full extent.

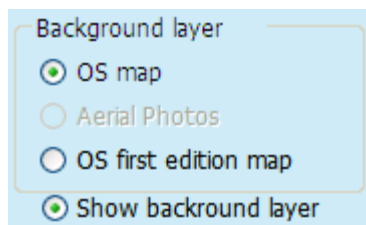
Use the  button to navigate through the map by click-holding an area of the map and dragging it in one of the cardinal directions.

Use the  button and click on any point of the map to open google map and display an aerial photographs of the selected area.

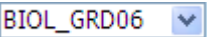

Several background layers can be displayed: OS maps, aerial photos and OS first edition maps. The OS map resolution will vary according to zoom levels. At very large scale, no map will be displayed. As you zoom in further, different resolution maps will gradually appear (1:250k; 1:50k). The maximum resolution is the OS 1:50,000 scale map.

The aerial photograph and OS first edition map layers will only be displayed at low scale. At large scale, the 2 option will be greyed out and unavailable. You will first need to zoom in to enable the option and display the maps.

You can turn the background layer on and off by clicking the 'Show background layer' button.



Two river layers are available: the river reaches defined as part of this research project and the General Quality Assessment (GQA) reaches. The GQA reach layer contains various water quality and biological quality index values that can be displayed as a thematic map using the following drop-down box

. If you want to learn more about GQA, go to [Appendix 1](#). To see the legend of the map, click on the  button.

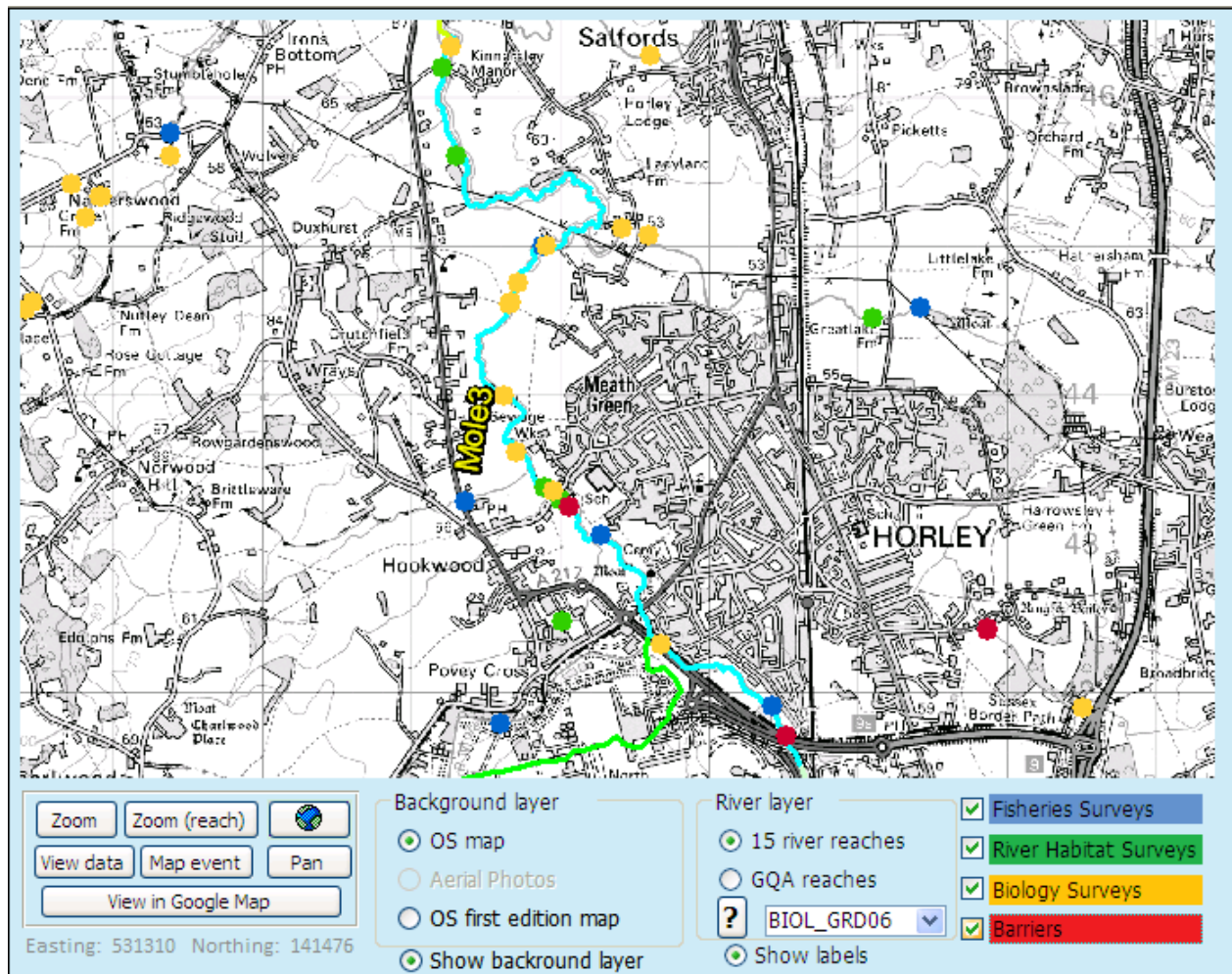
Labels for the river layers will be displayed dynamically according to scale. They will disappear at small and large scales. To turn the labels on and off, press on the 'Show labels' radio button.



You can also view four point layers corresponding to major surveys carried out by the Environment Agency (Fisheries, Biology and RHS) and also to the location of physical barriers to migration (weirs and dams). Data for the whole country river network have been added to the database however, at large scale, only data points related to the 15 rivers for which river reaches have been derived will be displayed. To view the remaining points, you will need to zoom in further and they will appear (see below extra sampling points and tributaries of the river Mole).

- ☒ Fisheries Surveys
- ☒ River Habitat Surveys
- ☒ Biology Surveys
- ☒ Barriers

Click on any of the check boxes associated with the river surveys to display them on the map.

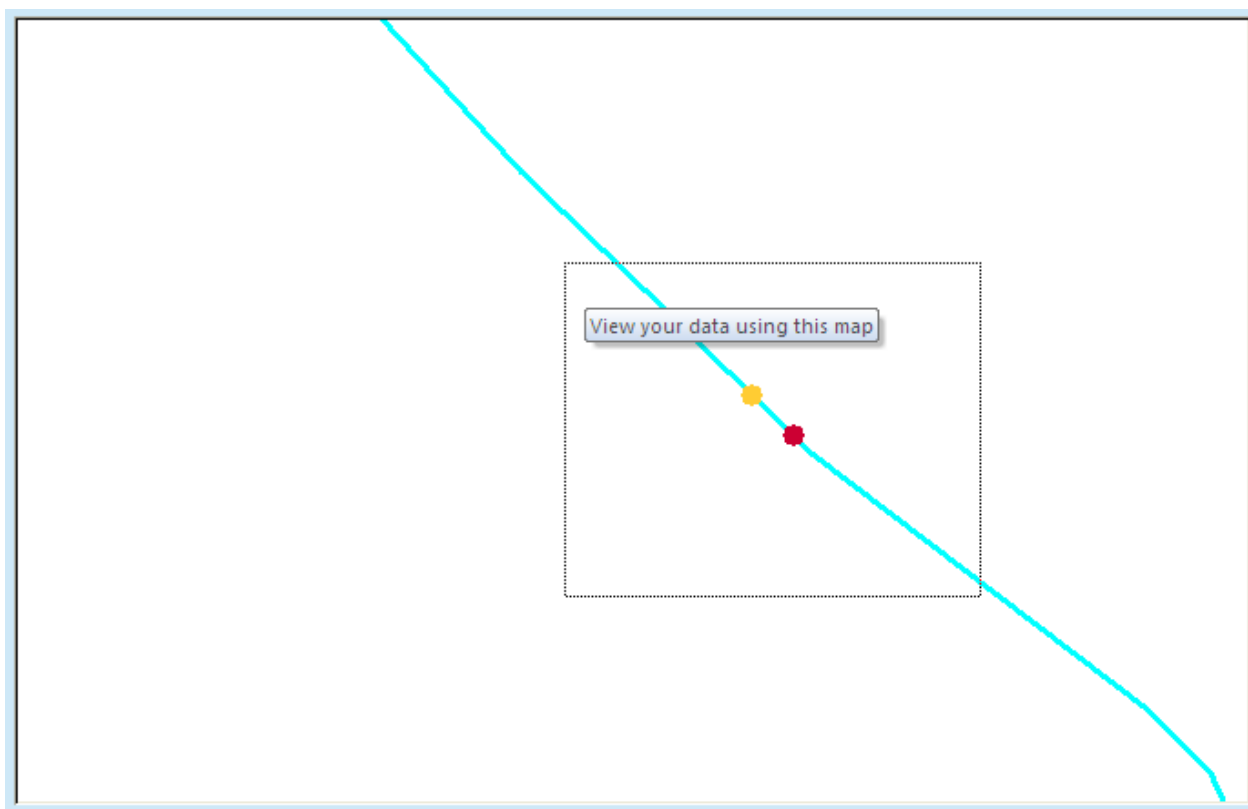


Beware that when you are using the map view, you may be moving from one reach to another on the map but the data displayed on the reach info will not change and will display information for the reach highlighted in the reach drop-down box at the top right hand side of the window (the default is the Mole3 reach).

Viewing survey data

Using the map view, you can also view the data associated with individual sampling points. First, use the [Zoom](#) button to zoom to the area of interest.

Check all four sampling points check boxes, then click on the [View data](#) button and select the sampling points you would like to view by left clicking, holding and dragging a square on the map.



Depending on the points you have selected, different forms will open and display the relevant data.

In the next section, we will have a closer look at the fisheries and River Habitat Survey data forms.

Viewing survey data: the fisheries data form

First, use the **Zoom** button to zoom to the sites of interest. Then select one or more of fisheries sites using the **View data** tool. The following form will open (see below). The number of sites selected and displayed is indicated at the bottom left of the form. The fisheries form has four tabs. The first tab displays general information about the fisheries sampling site.

NFPD site info
Fish density graph
Fish density per survey
Fisheries classification

Sub-catchment name:
Mole (Surrey) (C039032B)

Closest RHS site number:
6332

Distance to RHS site (in m):
447

Closest fisheries site number:
7109

Distance to fisheries site (in m):
2,876

Qmed in cumecs (1 in 2 year max flow):
15.4

Base flow index:
0.5

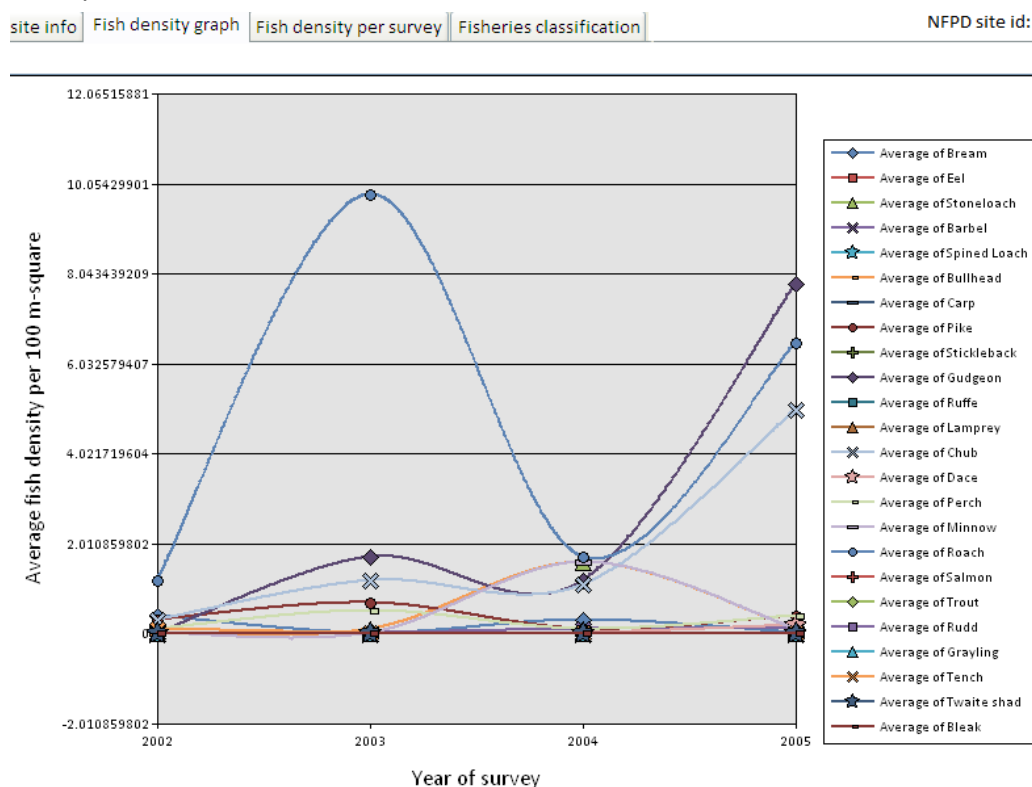
Distance to source (in m):
16,837

Distance to mouth (in m):
73,756

Stream order (Strahler):
5

Fish density graph

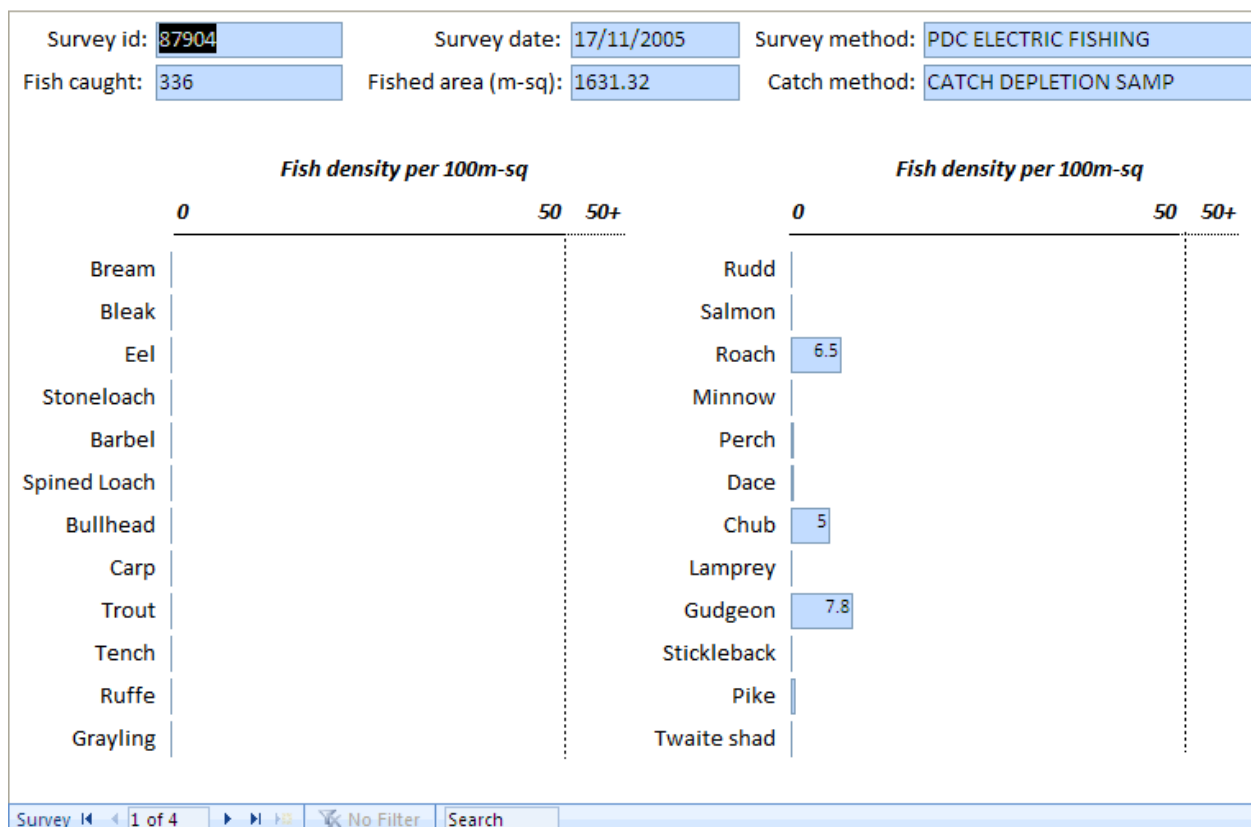
The second tab displays a graph of fish density change along time. Each of the 23 species recorded during survey displayed using symbols joined by a line. To identify specific points lines, just hover with the mouse over the point/line.



Fish density per survey

The third tab contains the same information as the second tab displayed as individual bar charts for each survey year. Click on the navigation buttons at the bottom of the chart to move from one year of survey to the next.

[site info](#)
[Fish density graph](#)
[Fish density per survey](#)
[Fisheries classification](#)
NFPD site info



Fisheries classification

The last tab contains information taken from the Fisheries Classification Scheme (FCS2). FCS2 predicts, for most fisheries survey sites 3 indices:

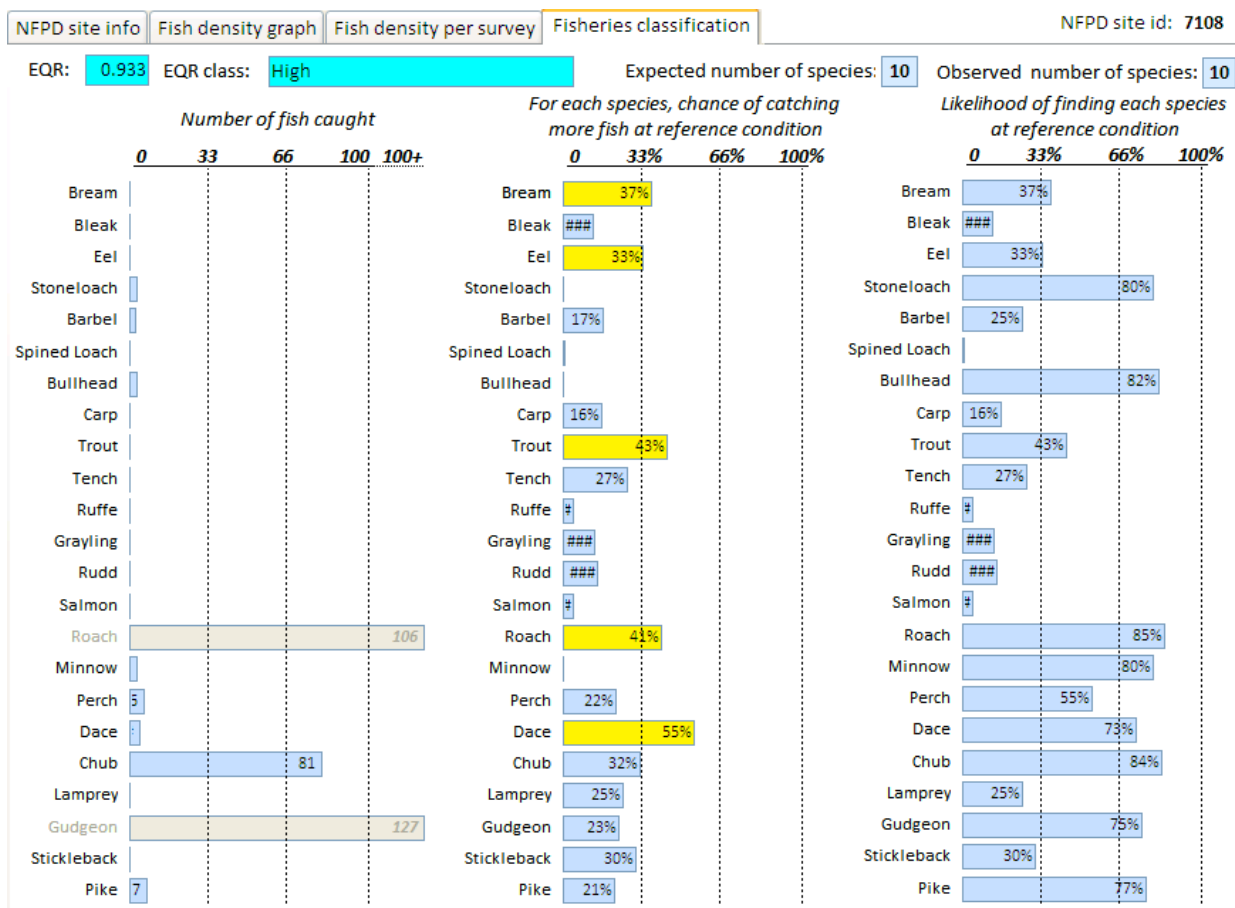
- an overall Environmental Quality Ratio (EQR) score for the site. Values close to 1 indicate closeness to reference condition;
- an EQR class from high to poor;
- the expected number of species caught at reference condition;
- the likelihood of catching each species at reference condition;
- the likelihood of catching more fish than at the surveyed site at reference condition.

The predictions and the actual number of fish caught are displayed as bar charts. The bars on the two charts displaying FCS2 probabilities will change colour according to the probability levels from blue (0-33%) to yellow (33% to 66%) and red (66%-100%).

In the example below, the expected number of fish caught at reference condition exactly matches the number of species caught at the last survey. The overall EQR is very close to one and the EQR class is 'High' indicating High quality status.

All fish species that have a high probability of being caught at reference conditions (see red bars on the right-hand chart) were caught during electro-fishing (left-hand side chart) most of the time in numbers greater than predicted by FCS2 (middle chart). For example, roach were found in high numbers (106 individuals) and according to FCS2 predictions there is a 85% chance of finding roach at the site at reference conditions and a 41% chance of finding more fish than observed. The number of roach caught is therefore likely to be in line with what can be expected at reference condition.

Fish density per survey



Viewing survey data: the River Habitat Survey data form

First, use the **Zoom** button to zoom to the sites of interest. Then select one or more of RHS sites using the **View data** tool. The following form will open (see below). The number of sites selected and displayed is indicated at the bottom left of the form. The RHS form has got 7 tabs. The first tab displays general information about the RHS site, its location, altitude whilst the other tabs provide information on habitat features, modifications, land use and habitat suitability for trout. RHS data have been summarised into indices or graphs/charts to facilitate viewing and data analysis.

More than one RHS site can be selected and displayed. To navigate between sites, use the navigation panel **RHS site** 1 of 1 at the bottom of the window.

The screenshot shows a web application titled "River Habitat Surveys". It has seven tabs: "RHS site info", "Habitat modification", "Man-made structures", "Land-use", "Habitat Indices", "Natural features", and "Habitat assessment tool". The "RHS site info" tab is active, displaying a list of site details in a table-like format. To the right of the text input fields is a large photograph of a riverbank with a red marker and a sign labeled "7274". At the bottom of the form, there are two navigation panels. The top panel is labeled "Photo:" and shows "1 of 1" with navigation arrows and a "No Filter" button. The bottom panel is labeled "RHS site:" and shows "1 of 1" with navigation arrows, a "Filtered" status indicator, and a "Search" button.

RHS site id:	5342
RHS survey id:	7274
Survey date:	16/05/1996
Survey Format:	1996
Catchment:	Cherwell Valley
Sub-catchment name:	MOLE (SURREY)
River:	Mole
Reach:	Mole03
RHS river name:	MOLE
Grid reference:	TQ2630041300
Altitude (m):	56
Slope (m/km):	1.43
Bankfull width (m):	4.2
Bankfull height (m):	0.5
Water depth (m):	0.45

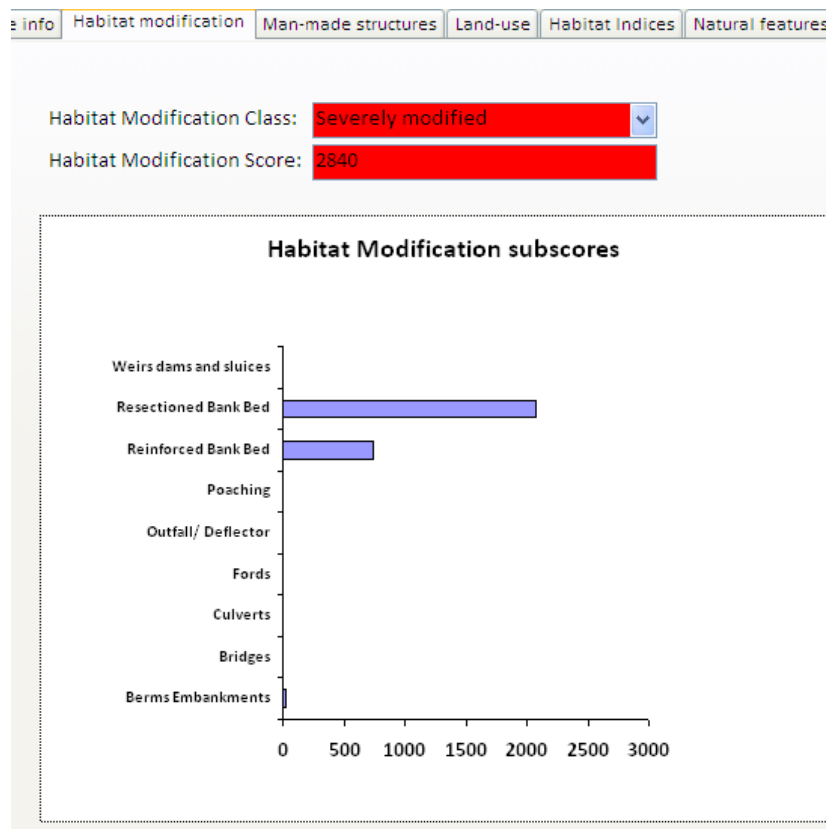
Photo: 1 of 1 No Filter Search

RHS site: 1 of 1 Filtered Search

Habitat modification

The habitat modification tab contains a representation of the Habitat Modification Score (HMS) and its components. The HMS is a scoring system for engineering structures on watercourses. Scores are allocated according to the extent of the structure and its life expectancy.

HMS scores are further classified into 5 classes to provide with a simple modification index from Semi-natural (blue) to Severely modified (red). The total site score and index class are represented in the top 2 boxes. In the graph below, the HMS component subscores are indicated. The graph below shows that the site is severely modified with a score of 2840. The modifications accounting for most of this very high score are resectioning of the banks and bed and the presence of reinforcements. Berms and embankments are also present but account for a much lower part of the total score.

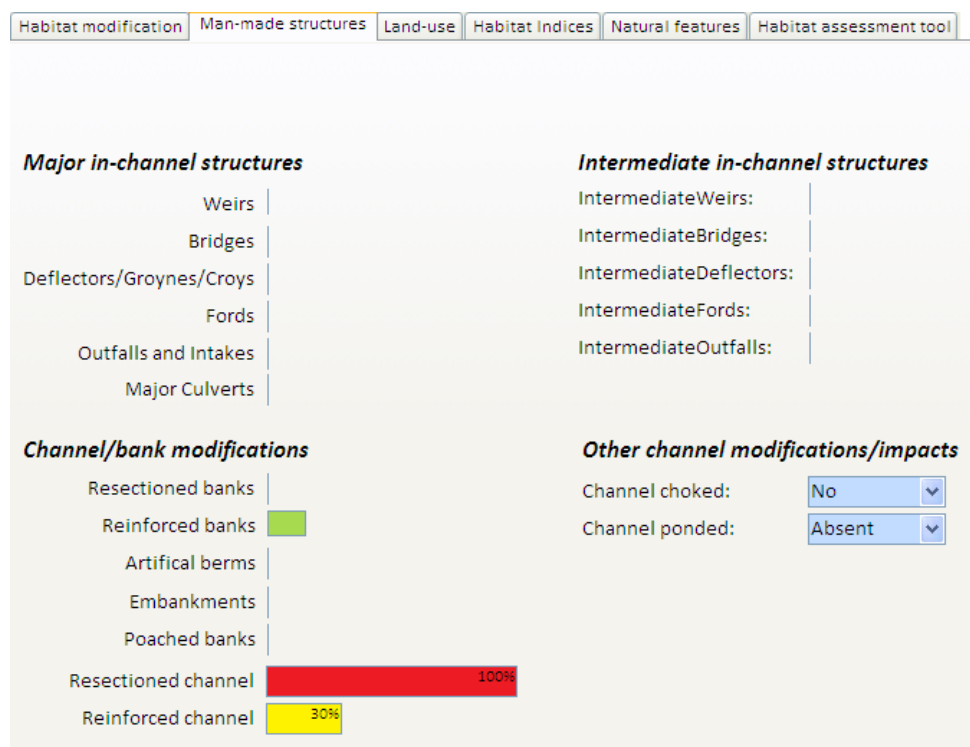


Man-made structures

The third tab contains more detailed information on made-made engineering structures.

The number of in-channel structures, and the extent of bank and channels modifications are shown using colour-coded bar charts (green: extent less than 30%; yellow: between 30% and 60%; red: extent greater than 60%).

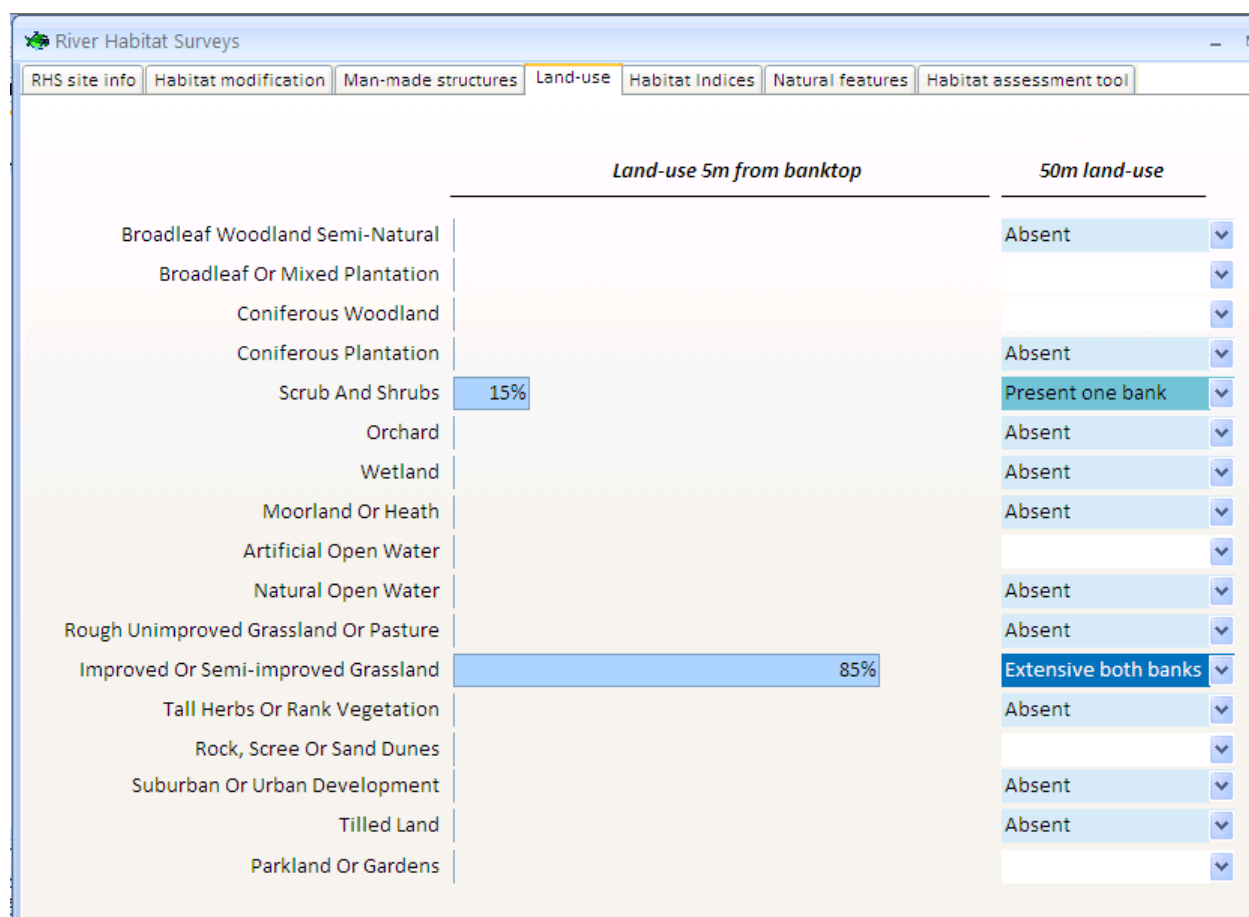
The terms 'major' and 'intermediate' used to qualify in-channel structures refer to the RHS and reflect the size and impact of the structures on channel hydrology and morphology (see RHS manual).



Land-use

At each RHS site, land-use extent is assessed within 5m and 50m of the banktop on both sides. The bar chart below shows the extent of 17 RHS land-use types along the river bank in percentage term for the immediate land-use and using a semi-quantitative scale (Absent, Present and Extensive) for the wider land-use.

The dominant land-use at our site is improved grassland both immediately at the banktop level and beyond.



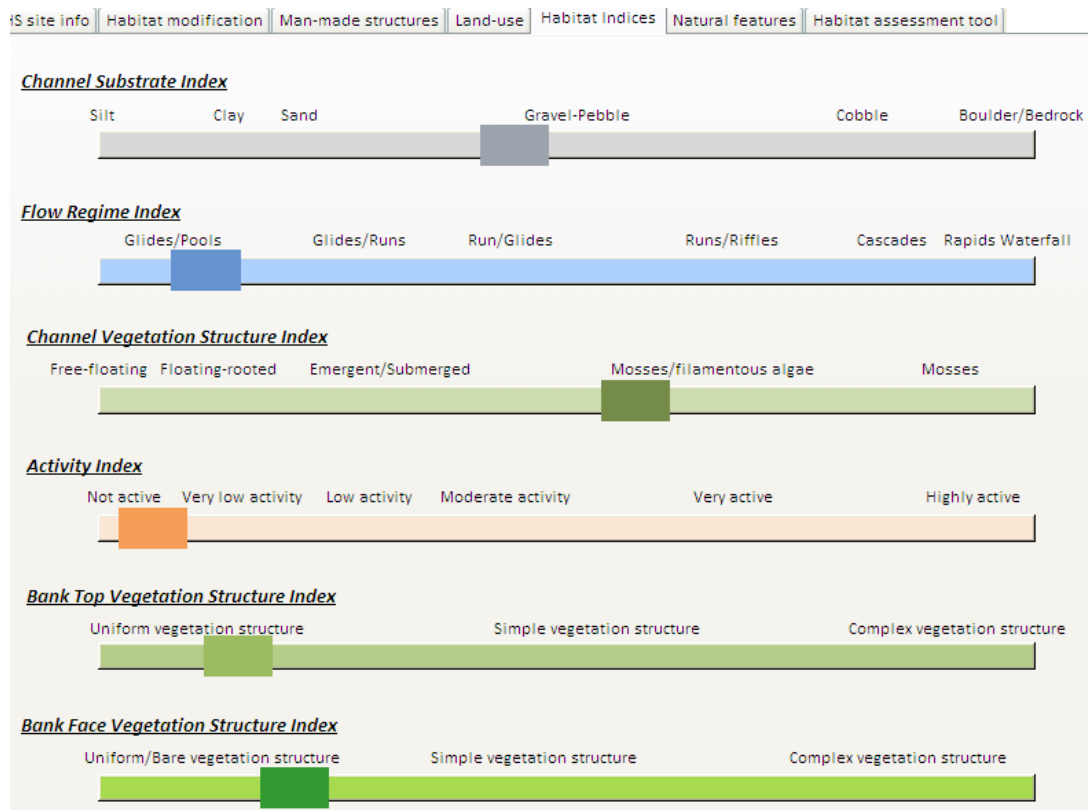
Habitat indices

Information on natural habitat features such as channel substrate, flow regime (e.g. riffles, glides and pools), channel vegetation structure, activity (i.e. erosion and deposition features) and bank vegetation structure (from bare to complex) have been summarised into 6 indices presented on sliding scales representing the main environmental gradients encountered in natural settings (see [River reach definition](#)).

Each scale is labelled according to the feature(s) dominating at key points along its gradient. For example, the Channel Substrate Index represents a gradient between sites dominated by fine substrate on the left of the scale (silt, clay and sand) to sites dominated by coarser substrates (cobbles and boulders). This gradient represents the typical transition between headwater - upland and lowland streams. Similarly, the Flow Regime Index represents a gradient between sites dominated by slow-flowing features (glides and pool) towards sites dominated by faster-flowing habitats such as riffles and rapids.

The 6 scales enable a quick visual assessment of RHS site natural habitat features. For each scale, a marker indicates the location of the RHS site on the scale. In our case we can quickly assess that our site is dominated by gravel substrate but has slow-flowing features, little vegetation in-channel and poor bank vegetation structure. The site displays low levels of activity (erosion or deposition).

Combined with previous data on habitat modification and land use, these indices give us some insights into the potential impacts of the engineering structures and land management in general on river habitats.



Natural features

This sections contains information on natural features recorded in RHS that are not part of the derivation of the 6 indices. Features include the number of riffles, pools and bars and the extent of trees and related features. Channel vegetation extent is also recorded in a broad-brush manner as simple, absent/present/extensive indices. Some features may appear and disappear as you scroll between surveys. This reflects changes in the survey methodology over the years.

River Habitat Surveys

[RHS site info](#) | [Habitat modification](#) | [Man-made structures](#) | [Land-use](#) | [Habitat Indices](#) | [Natural features](#) | [Habitat assessment tool](#)

Riffles, pool and bars

Number of riffles:

Number of pools:

Number of bars:

Channel vegetation

Amphibious:

Emergent broad-leaved:

Emergent reeds:

Filamentous algae:

Floating-leaved:

Free-floating:

Mosses:

Submerged broad-leaved:

Submerged fine/linear leaved:

Trees and associated features

Extent of trees left bank:

Extent of trees right bank:

Shading of channel:

Overhanging boughs:

Exposed bankside roots:

Underwater tree roots:

Fallen trees:

Large Woody Debris:

Debris dams:

Barriers and refuge areas

Natural open water:

Natural waterfalls > 5m High:

Marginal Deadwater:

Habitat assessment tool

The habitat assessment tool is based on combined RHS, water quality and land use data. It uses conceptual models derived by experts (see ['knowledge resources'](#)) and turns them into predictive models using available data.

Expert fisheries officers from the Environment Agency were gathered to build simple conceptual models of fish habitat for 3 life stages (spawning, juveniles and adults). The models were combined and tested on existing fish and habitat data on a total of 2500 sites. The resulting models were then applied to all existing RHS sites and are presented in ToolHab in a graphical way for three species: Trout, Pike and Dace (more species will be added in the future).

The factors affecting each species habitat can be split into 2 broad groups:

- Natural habitat features;
- Pressures and impacts.

On the figure below, all pressures and natural habitat feature have been grouped into 2 columns.

The figure is 'read' from left to right using colour-coded boxes and lines.

The potential impact of each pressure is indicated using the colour of its box. The colour code is as follow:

- Blue: the pressure may not be present or if it is, it has little or no impact on fish density.
- Yellow: the observed pressure level has a **fair** amount of impact on fish density
- Orange: the observed pressure level has **high** impact on fish density
- Red: the observed pressure level has **very high** impact on fish density.

The suitability of each habitat feature is assessed using the colour of its box. The colour code is as follow:

- Blue: very high
- Green: high
- Yellow: fair
- Orange: poor
- Red: very poor or feature absent.

The coloured lined represent the impact of habitat features and pressures on each other and on fish.

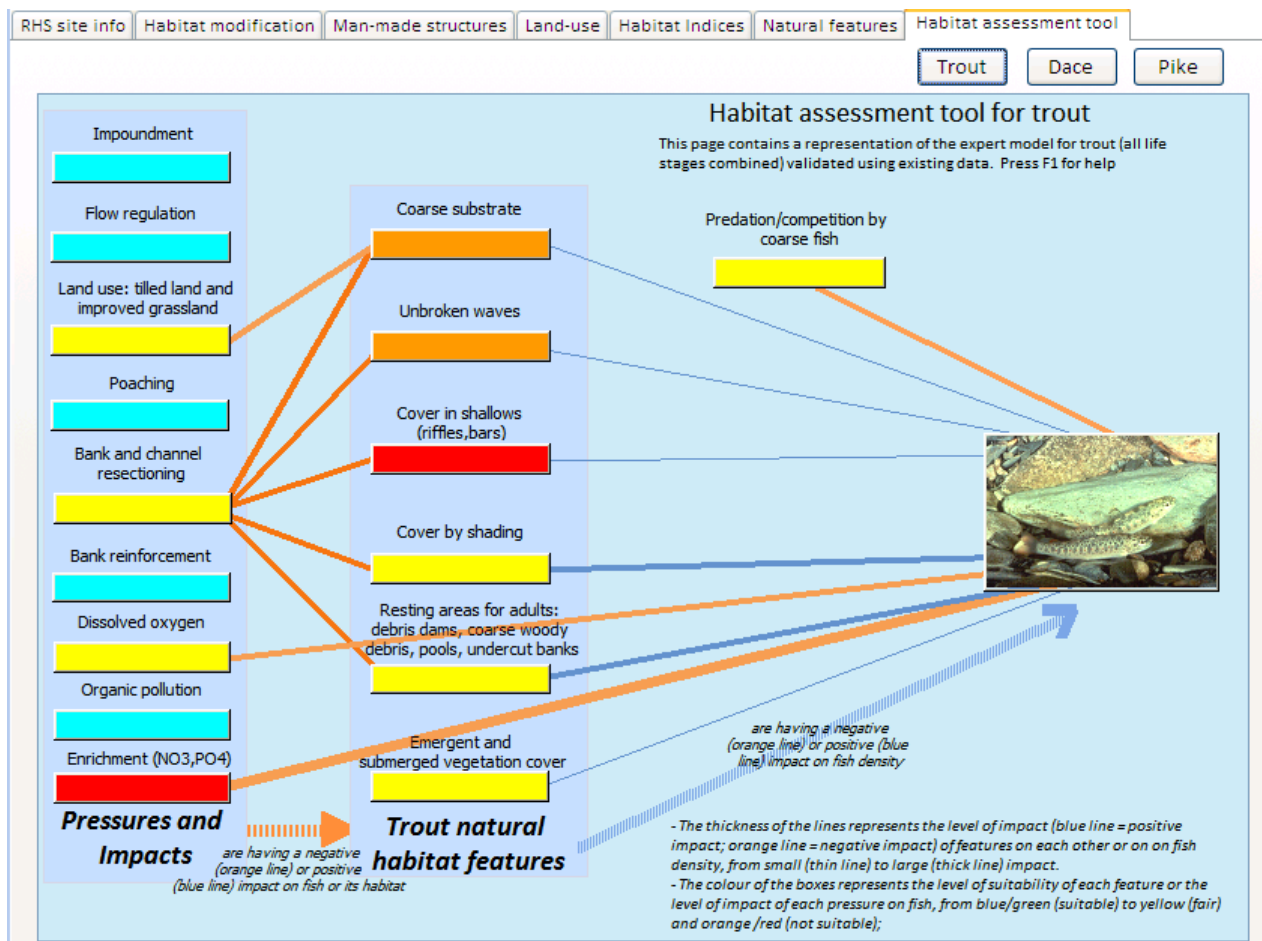
The colour of the lines indicates the nature of the impact:

- blue is for positive impact (e.g. coarse substrate impacts positively on the presence of unbroken waves);
- orange is for negative impact (e.g. tilled land-use will impact negatively on substrate coarseness - by increasing the amount of fine sediment present).

The thickness of the line represents the level of observed impact from low (thin line) to high (thick line)

Sometimes a pressure can be a positive driver to species distribution. For example, high levels of nutrient enrichment may be detrimental to salmonid species but favour the presence of more pollution tolerant species such as roach or pike. When a pressure is positively associated with the occurrence of a species, it will be displayed in shades of grey (according to its overall level of occurrence) in between the 2 columns representing pressures and natural habitats to highlight its ambivalent role.

When a pressure box colour is cyan and there are no arrows linking it to other boxes, it means that the pressure is absent. When a pressure box is greyed out, it indicates missing data.



Example:

Above and below is an example of model outputs for a site that, according to the Fisheries Classification Scheme model predictions and monitoring data available in ToolHab, should have high trout density but is mainly dominated by coarse fish such as pike and dace whose probability of occurrence in a natural state is much lower.

Trout model

The model outputs and RHS data suggest that the site habitats are altogether not favourable to trout. Natural habitat features normally associated with trout are missing or poorly represented (coarse substrate, unbroken standing waves, cover in shallows). Other features such as shading, resting areas for adults and channel vegetation structure are moderately suitable to trout. The site also displayed fairly high levels of bed reinforcement.

The model highlights 3 groups of pressures potentially having an impact on trout habitats and fish density: bank and channel resectioning, land use and water quality (dissolved oxygen and enrichment).

Bank and channel resectioning potentially is the highest source of impact because of its effect on substrate, flow patterns (unbroken waves), the presence of cover in riffles and bars, the presence of shading and resting areas for adults. Bank and channel resectioning requires the use of heavy machinery along with the removal of trees (for access) to create a larger, deeper cross section. This results in slower flows, the deposition of fine sediment in the centre of the channel and on the margins where slow flows also promote the growth of emergent macrophytes. Marginal habitats features such as bars and undercut banks are generally removed and recovery is slow. Tilled land use is also a source of fine sediment that may affect sediment coarseness and the availability of clean gravel for spawning.

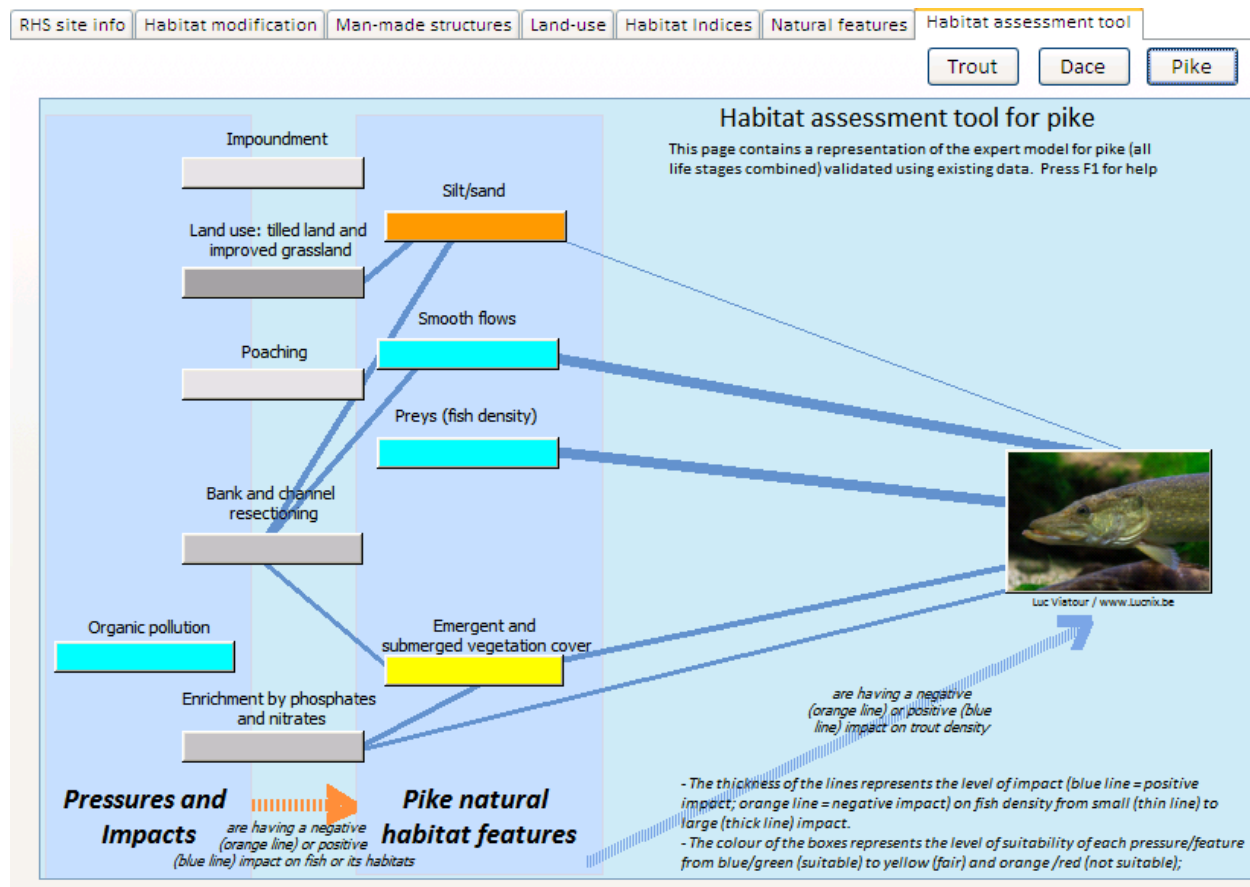
Water quality elements are the second highest potential source of impact on trout density. Dissolved oxygen and BOD levels were fair but enrichment levels were high. Nearby biological and chemical sampling sites and the GQA map showed fair levels of organic pollution but high phosphate inputs potentially having high impact on trout occurrence.

Pike model

The model below suggest that the habitat for pike is altogether suitable. Although it lacks the quantity of

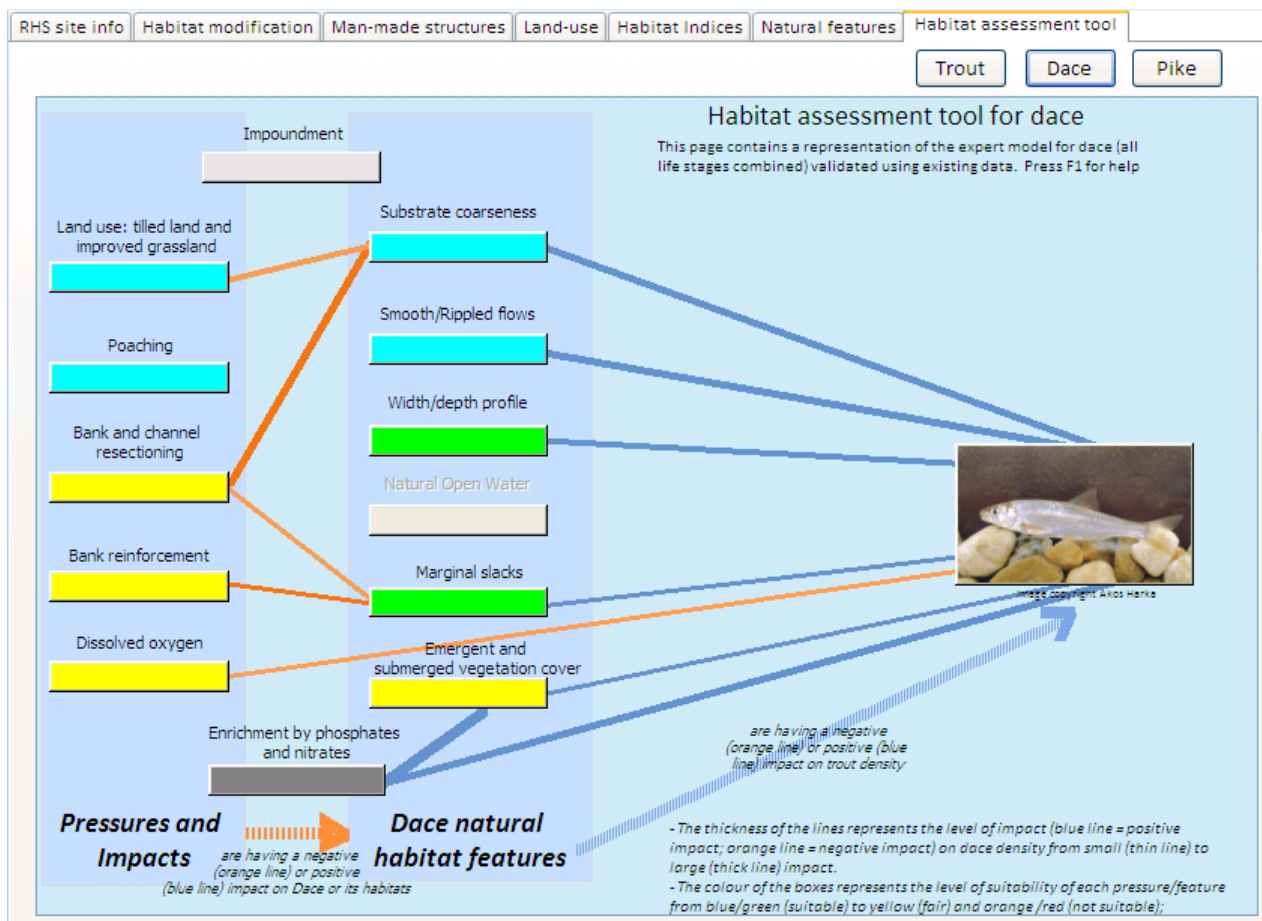
fine substrate pike requires, it displays smooth flows, suitable levels of marginal habitats and plenty of prey (roach, dace, minnows etc.). The model suggest that anthropogenic alterations or 'pressures' such as impoundment, land use and resectioning could be beneficial to pike habitat as they create the slow flowing conditions and marginal habitats that are favourable to pike.

Pike are very resistant to pollution and anthropogenic impacts such as resectioning. In fact, only high levels of organic pollution seem to affect their distribution and they seem to favour rivers with moderate levels of enrichment. Most other types of modifications seem to have potential positive impact on pike habitats. Resectioning, tilled land use and poaching promote the input of fine sediments, smooth flows and marginal vegetation that pike favour.



Dace model

The model for dace indicates that the site displays good levels of habitat suitability for dace. Most natural habitat feature indicators show high levels of suitability and pressures such as bank and channel resectioning and dissolved oxygen are at tolerable ('fair') levels and do not seem to affect negatively dace habitat structure. Dace tend to favour habitat with moderate levels of enrichment. Enrichment on site could have a positive impact on dace occurrence. Bank and channel resectioning does not seem to affect dace as much as trout. This is potentially due to the fact that although dace requires coarse substrate to reproduce, it is more tolerant to fine sediment inputs and it does not require fast flowing features such as trout. On the contrary, dace tends to be associated with sites dominated by deeper mesohabitats such as runs and glides and structures or modifications such as weirs and resectioning increasing depth may be beneficial to them.



In summary, we see here how the fish conceptual and predictive models can be used in combination with fish, chemistry, RHS and other data to diagnose potential pressures and impacts on species habitats.

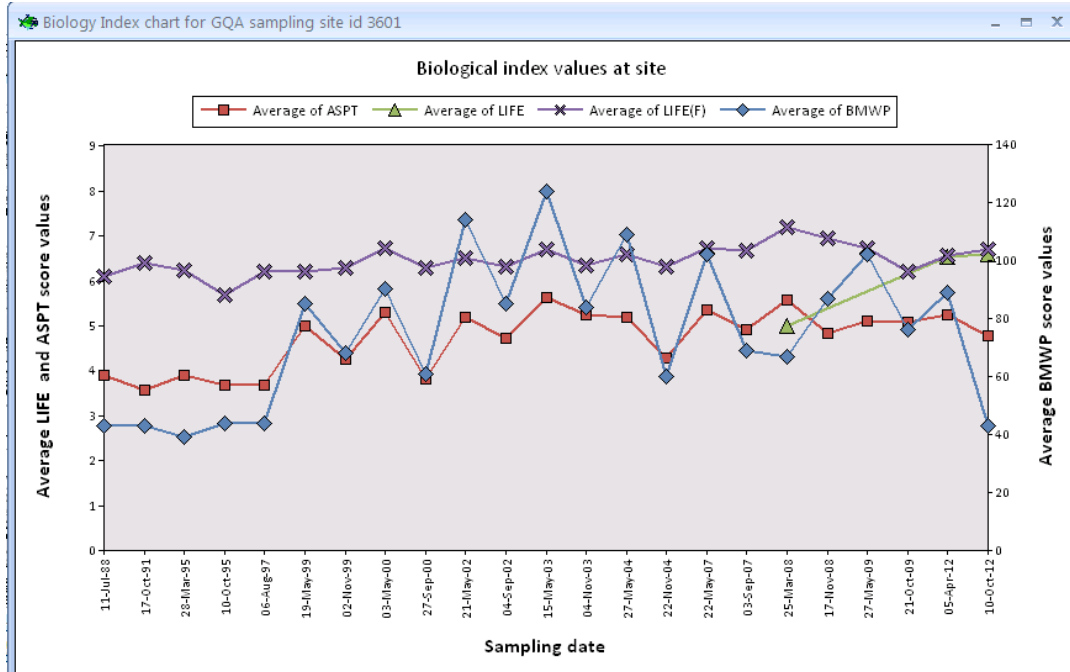
The fisheries predictive models indicated a lack of trout and a potential higher than expected dace and pike population. The conceptual expert models suggested that channel resectioning, land use and water quality may explain the absence of habitat features naturally associated with trout and the occurrence of features associated with pike and dace.

Used in combinations, the models, data and tools enable us to identify potential pressures and impacts and establish a diagnostic before setting management action.

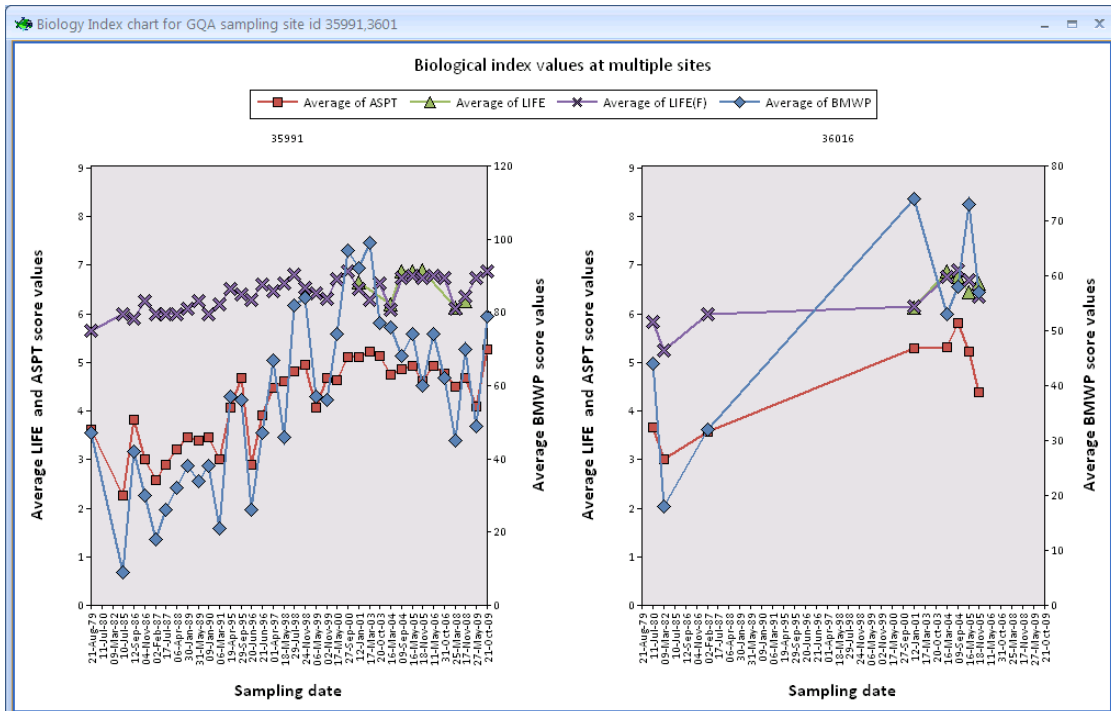
Viewing survey data: the biology data form

First, use the **Zoom** button to zoom to the sites of interest. Then select one or more of biological sampling sites using the **View data** tool. The following form will open (see below). A biology index chart is drawn from all the GQA sampling points selected using the selection tool. The form shows the change in four index values along time: the Average Score Per Taxon, the BMWP, and two LIFE indices.

If you want to learn more about the meaning and significance of biological indices, go to [Appendix 2](#).



You can select up to 4 sites in one go. The data and time series for all selected sites will be displayed into a single panel. An example is given below for data extracted from 2 biological sampling points.

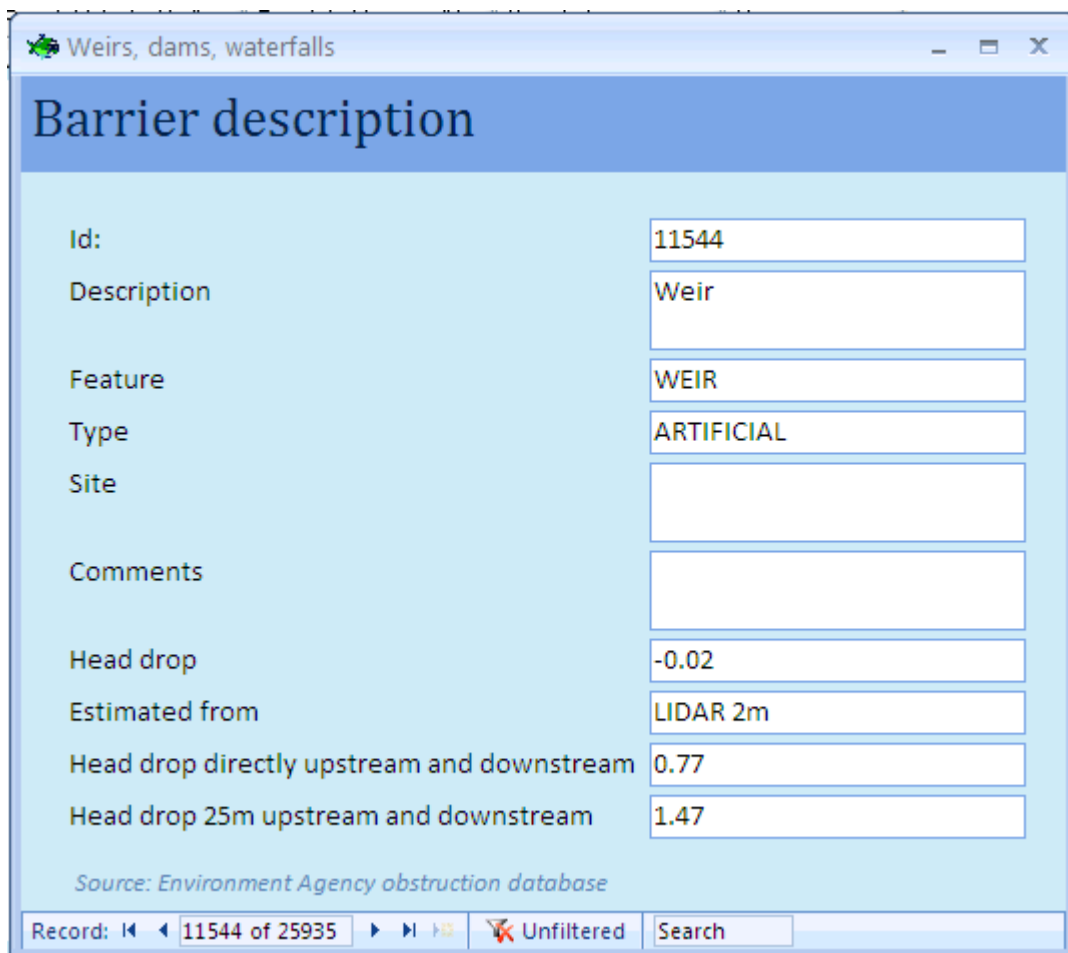


Viewing survey data: the barriers data form

The barrier description form provides detail on the nature of the structure and its potential impact on river connectivity. The difference in altitude before and after the layer have been estimated to be around 77 cm just upstream and downstream of the barrier and 1.47 m when measuring altitude 25 m upstream and downstream of the barrier.

The information is taken from the obstructions database compiled by the Environment Agency. The dataset has limitations and some of the structures listed may not longer exist.

First, use the [Zoom](#) button to zoom to the sites of interest. Then select one or more of barrier sites using the [View data](#) tool. The following form will open (see below). The number of sites selected and displayed is indicated at the bottom left of the form. You can view site data using the navigation buttons at the bottom of the form.



The screenshot shows a web application window titled "Weirs, dams, waterfalls". Inside, there is a form titled "Barrier description". The form contains several input fields with the following data:

Field	Value
Id:	11544
Description	Weir
Feature	WEIR
Type	ARTIFICIAL
Site	
Comments	
Head drop	-0.02
Estimated from	LIDAR 2m
Head drop directly upstream and downstream	0.77
Head drop 25m upstream and downstream	1.47

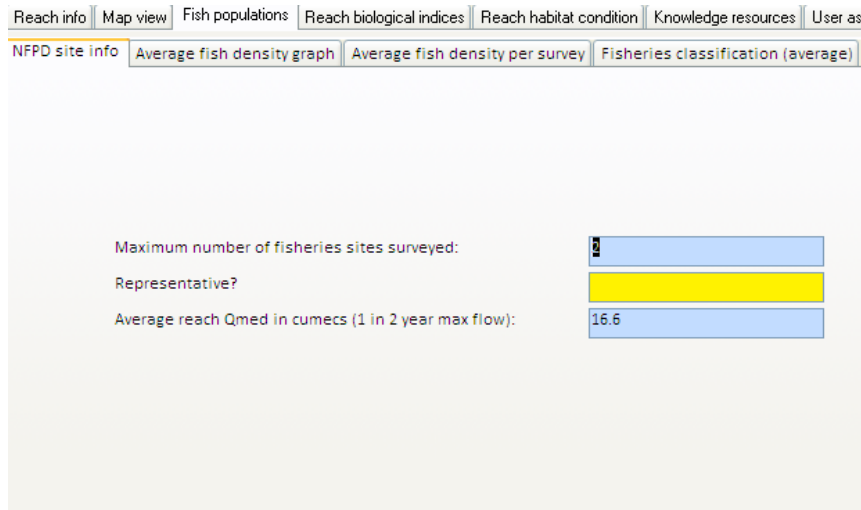
Below the form, it says "Source: Environment Agency obstruction database". At the bottom of the window, there is a navigation bar with the text "Record: 11544 of 25935", a "Unfiltered" status indicator, and a "Search" button.

Reach statistics: Fish Populations

The fish populations tab provide summary statistics for fish density and classification for the selected reach.

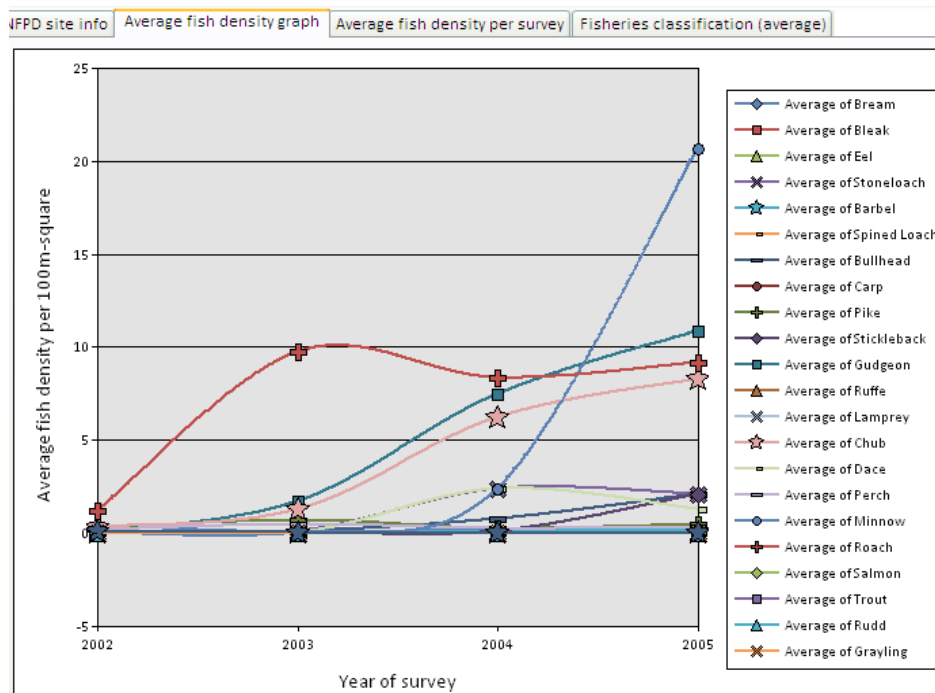
This sections contains 4 sub-sections. The first one gives indications on the number of fisheries sites contained in the reach. It also gives an indication of the representativeness of the statistics produced based on the number of sites within the reach. Reaches with very few sites will provide statistics that are not reliable. As the number of sites surveyed per reach increases, we gain confidence in the statistics produced.

In the case of this particular reach, we have 2 fisheries survey sites present which provides with a moderate level of representativeness.



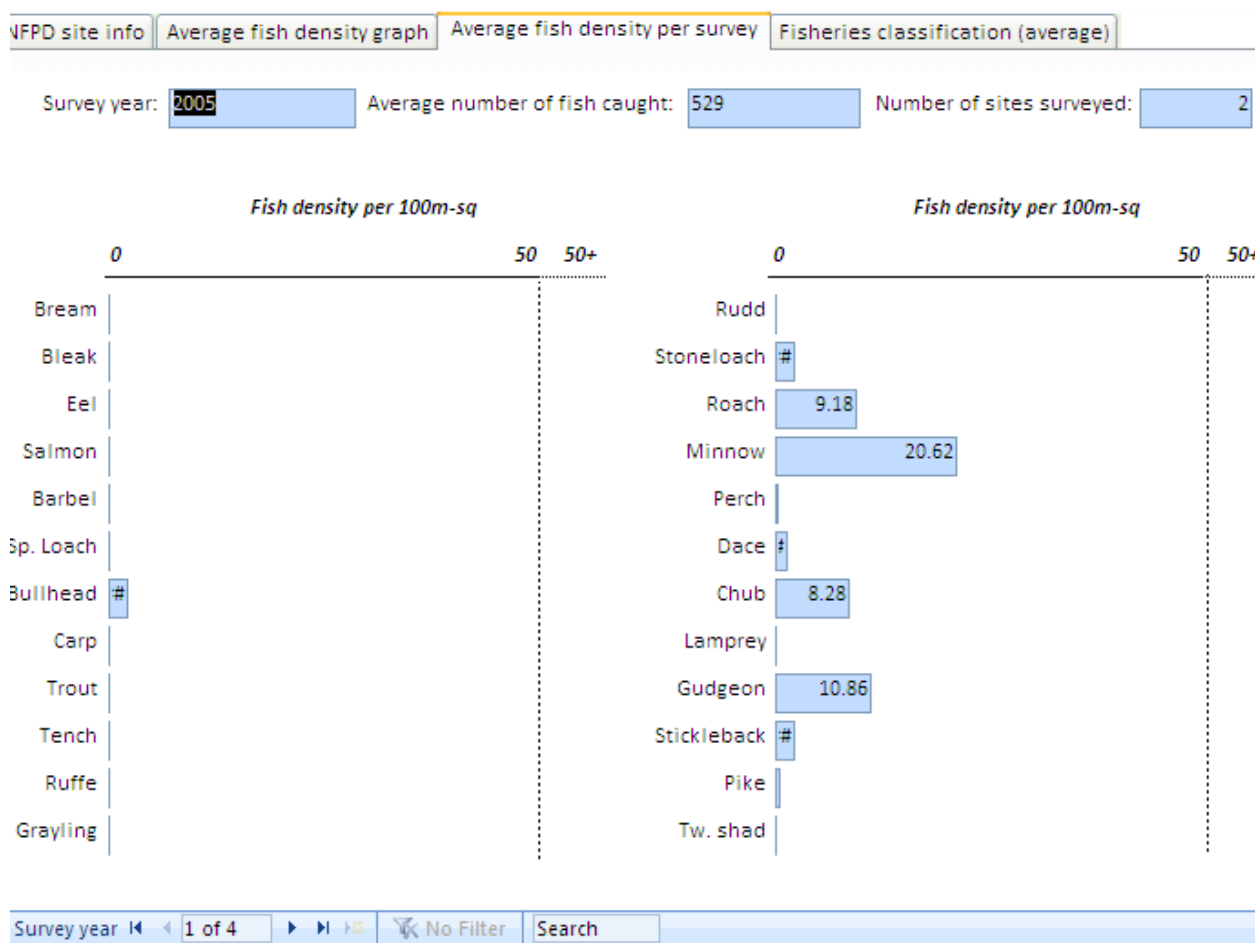
Fish density graph

The second tab displays a graph of average fish density change along time for all the NFPD sites in the reach (2 sites for the Mole3 reach). Each of the 23 species recorded during survey displayed using symbols joined by a line. To identify specific points lines, just hover with the mouse over the point/line.



Fish density per survey

The third tab contains the same information as the second tab displayed as individual bar charts for each survey year. Click on the navigation buttons at the bottom of the chart to move from one year of survey to the next.



Fisheries classification

Finally, the last tab contains information taken from the Fisheries Classification Scheme (FCS2). FCS2 predicts, for most fisheries survey sites 3 indices:

- an overall Environmental Quality Ratio (EQR) score for the reach. Values close to 1 indicate closeness to reference condition;
- an EQR class from high to poor;
- the expected number of species caught at reference condition;
- the likelihood of catching each species at reference condition;
- the likelihood of catching more fish than at the surveyed reach at reference condition;

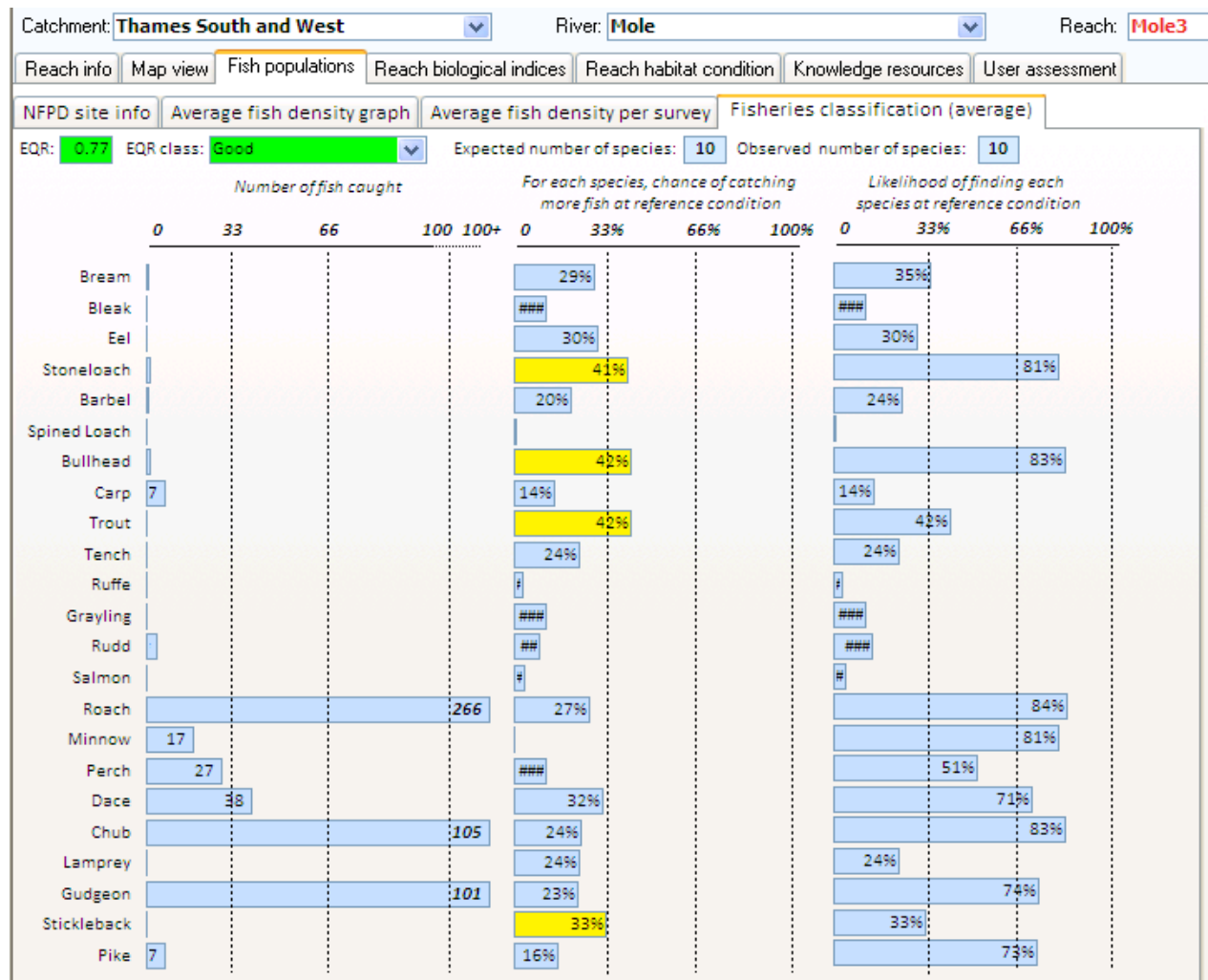
The predictions and the actual number of fish caught are displayed as bar charts. The figures displayed are averages for all NFPD sites on the selected reach.

In the example below, the average expected number of fish caught at reference condition exactly matches the number of species caught at the last survey. The overall EQR is close to one and the EQR class is 'Good'.

All fish species that have a high probability of being caught at reference conditions (see red bars on the right-hand chart) were caught during electro-fishing (left-hand side chart) most of the time in numbers greater than predicted by FCS2 (middle chart). For example, roach were found in high numbers (266 individuals in average) and according to FCS2 predictions, there is a 84% chance of finding roach on the reach at reference conditions and a 27% chance of finding more fish than observed (in average). The

reach has significantly higher densities of roach than can be expected at reference

condition.

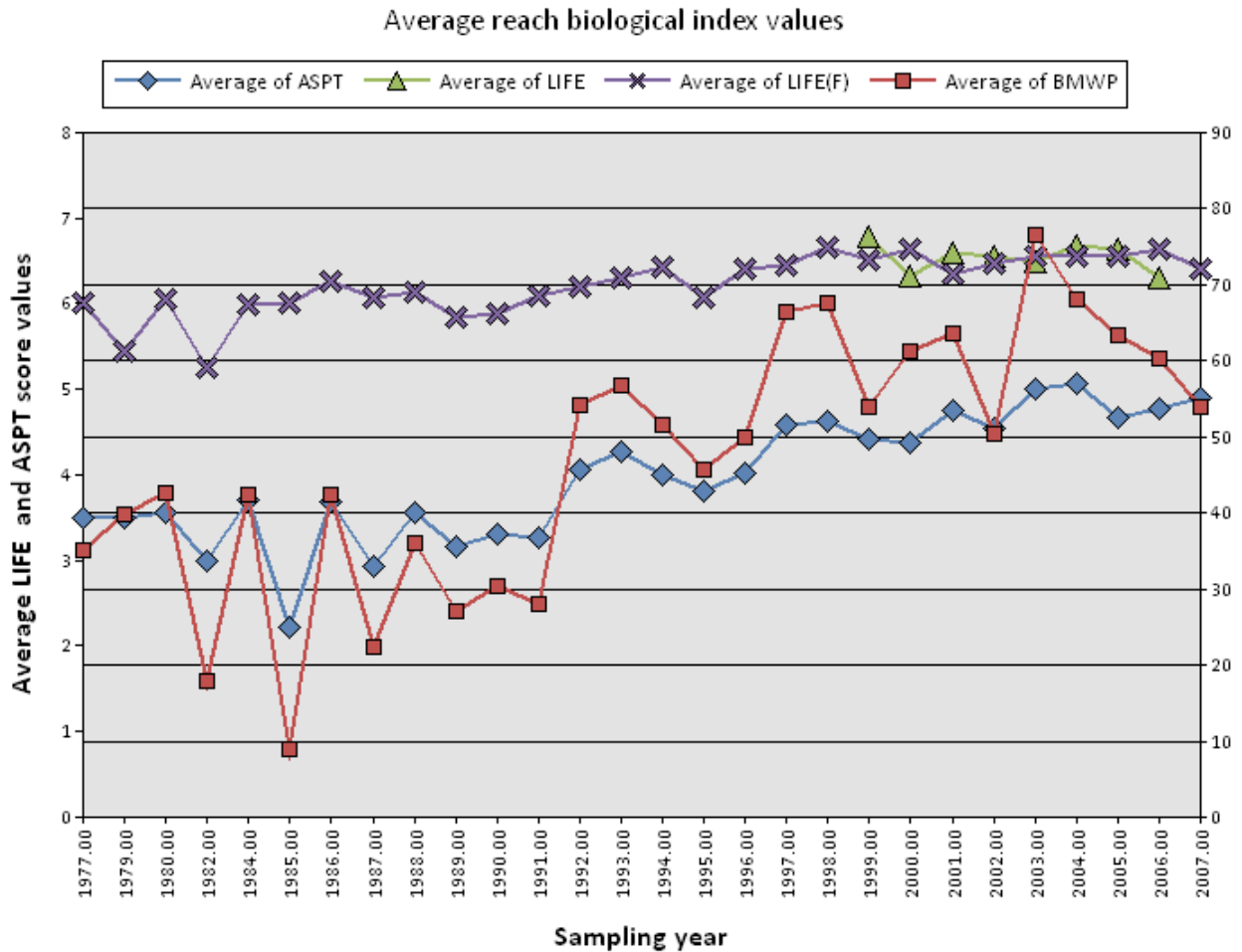


Reach statistics: biological indices

A biology index chart is drawn from all the GQA sampling points within the selected reach. The form shows the change in four index values along time: the Average Score Per Taxon, the BMWP, and two LIFE indices.

If you want to learn more about the meaning and significance of biological indices, go to [Appendix 2](#).

each info Map view Fish populations **Reach biological indices** Reach habitat condition Knowledge resources User assessment



Reach statistics: reach habitat condition

The reach habitat condition tab provide summary statistics for RHS data for the selected reach.

This sections contains 7 sub-sections.


We will show each tab in order and provide an interpretation of results for the reach considered: in our case the river Mole 3rd reach.

Site info

The first section gives indications on the number of RHS sites within the reach. It also gives an indication of the representativeness of the statistics produced based on the number of sites present. Reaches with very few sites will generate statistics that are not reliable. As the number of sites surveyed per reach increases, we gain confidence in the statistics produced.

In the case of this reach (Mole3), we have 4 survey sites present which provides with a good level of representativeness.

The site info section also contains information on site average site altitude, slope, channel width and depth within the reach. Photos of all RHS sites available on the reach are displayed.

Site info	Habitat modification	Man-made structures	Land-use	Habitat indices	Natural features	Habitat assessment
<div>Number of RHS sites: 4</div> <div>Representative? </div> <div>Altitude (m): 51</div> <div>Slope (m/km): 0.9</div> <div>Bankfull width (m): 10.3</div> <div>Bankfull height (m): 2.7</div> <div>Water depth (m): 0.9</div>						
						
Photo: 1 of 7 ⏪ ⏩ No Filter Search						

Habitat modification

The habitat modification tab contains a representation of the average Habitat Modification Score (HMS) and its components. The HMS is a scoring system for engineering structures on watercourses. Scores are allocated according to the extent of structures and their life expectancy.

HMS scores are further classified into 5 classes to provide with a simple modification index from Semi-natural (blue) to Severely modified (red). The total site score and index class are represented in the top 2 boxes.

In the graph below, the HMS component subscores are indicated. The reach is significantly modified with an average score of 1112. The modifications accounting for most of this very high score are resectioning of the banks and bed, the presence of weirs, bridges and reinforcements.

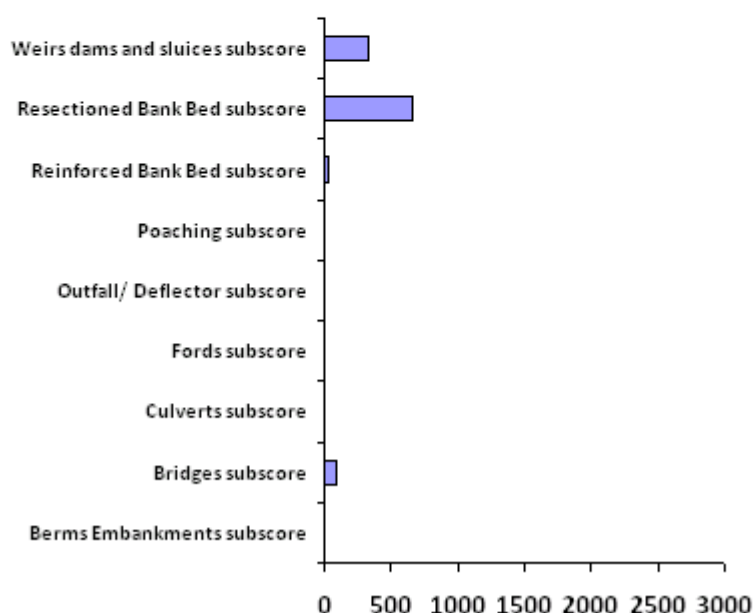
Reach info
Map view
Fish populations
Reach biological indices
Reach habitat condition
Know

Site info
Habitat modification
Man-made structures
Land-use
Habitat Indices
Na

Habitat Modification Class: Significantly modified

Habitat Modification Score: 1112

Habitat Modification subscores



Man-made structures

The third tab contains more detailed information on made-made engineering structures.

The average number of in-channel structures, and the extent of bank and channels modifications are shown using colour-coded bar charts (green: extent less than 20%; yellow: between 20% and 30%; orange: between 30% and 60%; red: extent greater than 60%).

The terms 'major' and 'intermediate' used to qualify in-channel structures refer to the RHS and reflect the size and impact of the structures on channel hydrology and morphology (see RHS Manual).

Site info	Habitat modification	Man-made structures	Land-use	Habitat indices	Natural features	Habitat assessment
<div> <div> Major in-channel structures <div> Weirs: 0 Bridges: Deflectors/Groynes/Croys: Fords: Outfalls and Intakes: Major Culverts: </div> </div> <div> Channel/bank modifications <div> Resectioned banks: Reinforced banks: Artificial berms: Embankments: Poached banks: Resectioned channel: 25% Reinforced channel: </div> </div> <div> Intermediate in-channel structures <div> IntermediateWeirs: IntermediateBridges: IntermediateDeflectors: IntermediateFords: IntermediateOutfalls: </div> </div> <div> Other channel modifications/impacts <div> Channel choked: No Channel ponded: Present Channel realigned: Present Channel overdeepened: Present </div> </div> </div>						

It seems that the major modification found on the reach is channel resectioning (i.e. overdeepening). Little bank resectioning was observed on the reach. This is surprising as bank and channel resectioning are generally associated. Indeed, when resectioning a river, engineers use diggers to overdeepen the channel and reprofile the banks to create a typical trapezoidal channel. If we look at the photographs of one of the sites, site 1274 for which no bank resectioning was observed (see below), we notice that the banks have a fairly uniform 45 degree bankface and trees are lacking or tend to be scattered on the river bank. This suggests that the extent of bank resectioning on site may have been underestimated by the surveyor.

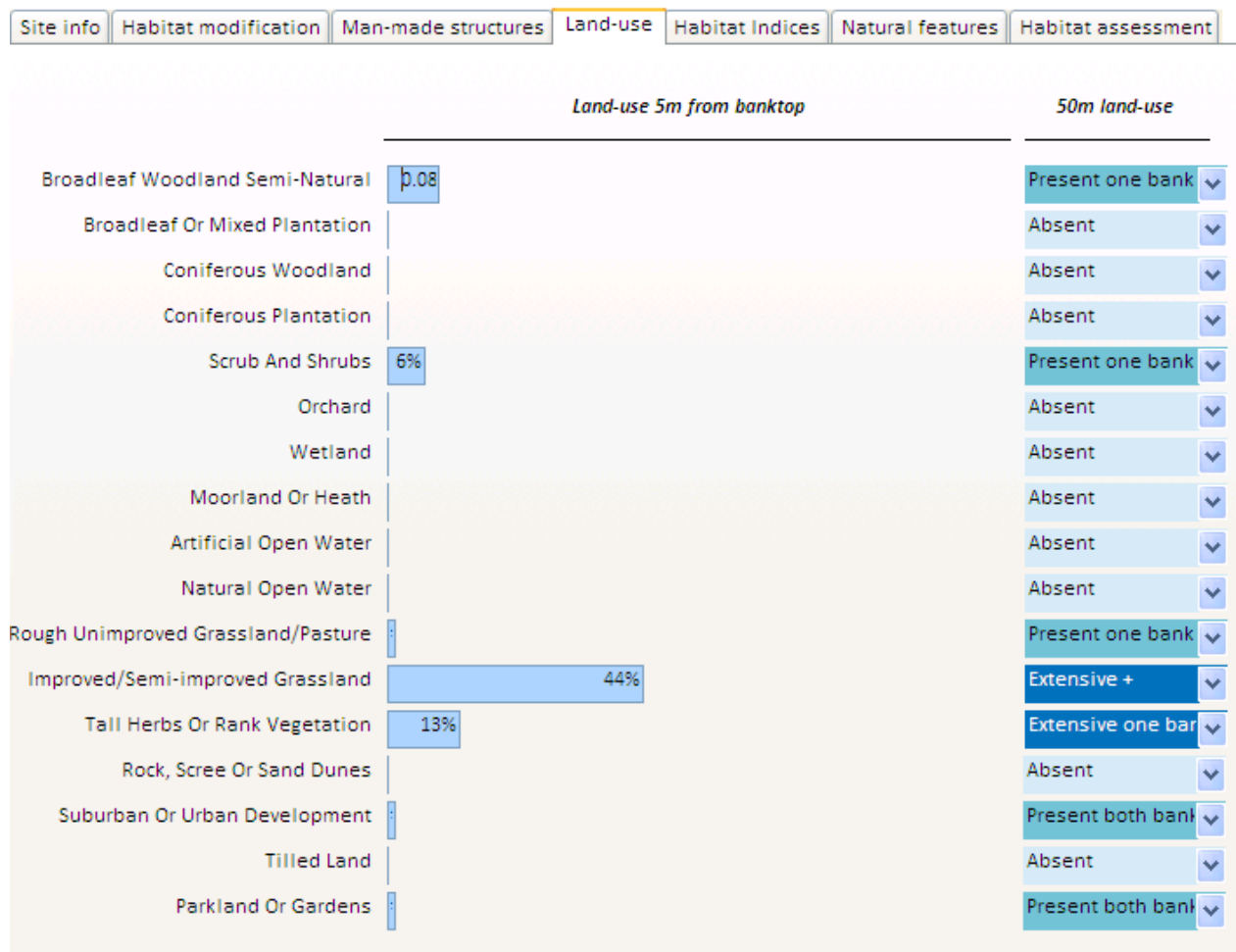
It is important to note that the data and models are not fault proof and some of the features may have been missed out or under recorded by surveyors during surveys. Fortunately, ToolHab provides a whole range of data with adjoining maps, site photographs and aerial photos that enable experienced users to quality control model outputs and produce their own diagnostic based on expertise and the data and models available. In this case, an important sign of modification has been missed out by one of the surveyors but we were able to stop this error and we will be able to take that into account when analysing predictive models outputs and doing our final assessment.



Land-use

At each RHS site, land-use extent is assessed within 5m and 50m of the banktop on both sides. The bar chart below shows the average extent of 17 RHS land-use types along the river bank in percentage term for the immediate land-use and using a semi-quantitative scale (Absent, Present and Extensive) for the wider land-use. Greyed-out land-uses were not recorded. Land-uses marked as 'Extensive +' were extensive on one side and present on the other side.

The dominant land-use at our reach is improved grassland both immediately at the banktop level and beyond.



Habitat indices

Information on natural habitat features such as channel substrate, flow regime (e.g. riffles, glides and pools), channel vegetation structure, activity (i.e. erosion and deposition features) and bank vegetation structure (from bare to complex) have been summarised into 6 indices presented on sliding scales representing the main environmental gradients encountered in natural settings (see [River reach definition](#)).

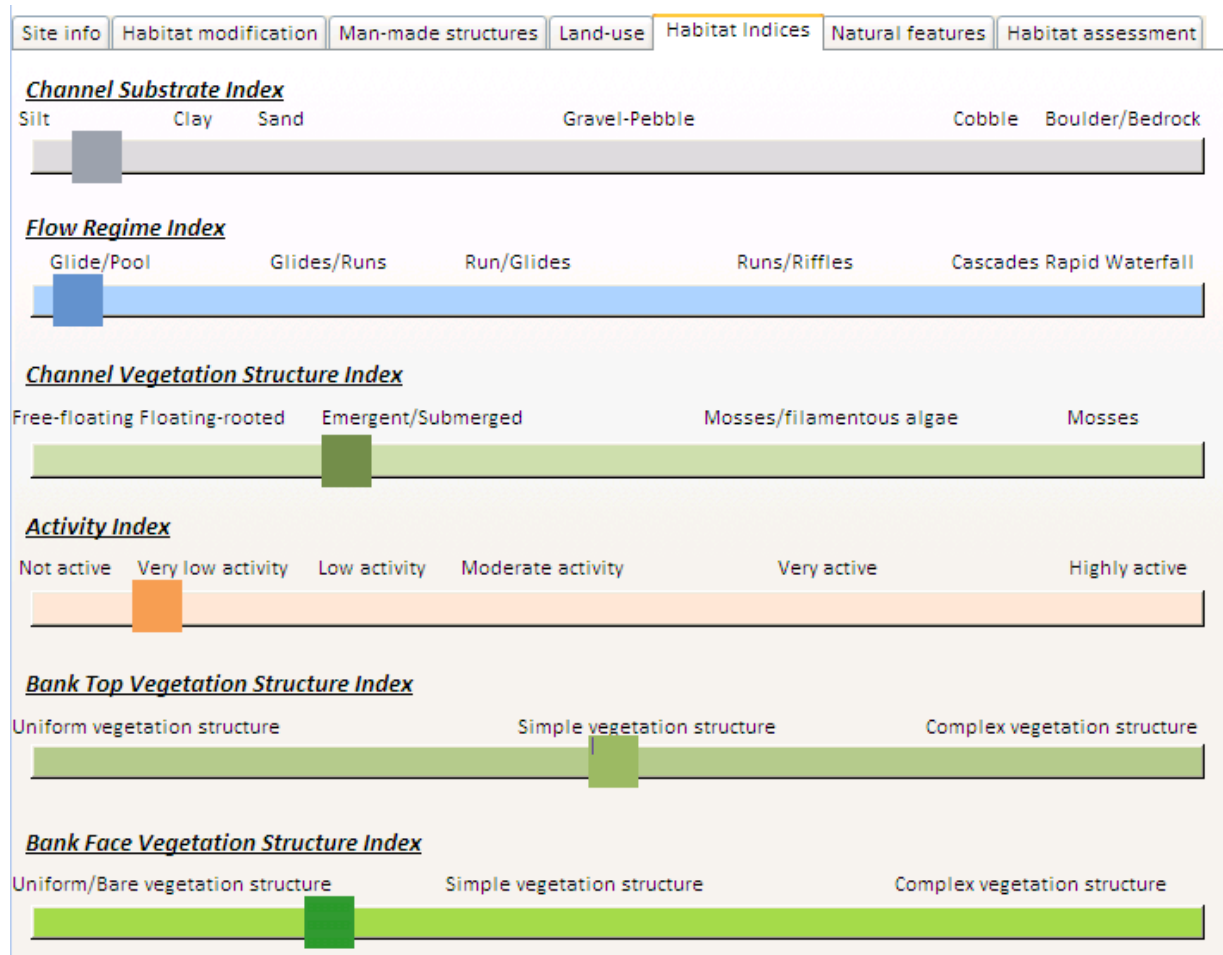
Each scale is labelled according to the feature(s) dominating at key points along its gradient. For example, the Channel Substrate Index represents a gradient between sites dominated by fine substrate on the left of the scale (silt, clay and sand) to sites dominated by coarser substrates (cobbles and boulders). This gradient represents the typical transition between headwater - upland and lowland streams. Similarly, the Flow Regime Index represents a gradient between sites dominated by slow-flowing features (glides and pool) towards sites dominated by faster-flowing habitats such as riffles and rapids.

The 6 scales enable a quick visual assessment of the character of the reach. The values displayed are the average value of the RHS sites on the selected reach.

For each scale, a marker indicates the location of the reach on the scale. In our case we can quickly assess that our reach is dominated by silt substrate and has slow-flowing features, emergent/submerged channel vegetation and uniform/simple bank vegetation structure. The reach displays very low levels of activity (erosion or deposition).

Combined with previous data on habitat modification and land use, these indices give us some insights into the potential impacts of engineering structures and land management on river habitats.

Channel and bank resectioning are generally associated with an increase in channel depth and width resulting in slower flow types and lower levels of activity. Trees are also removed to let machinery access the channel to perform the work. Banks are regularly mowed and trees are cut down to reduce frictions and potential flooding risks. It is possible that the silt and low flow velocities observed are the direct impact of bank and channel resectioning. Channel vegetation and bank vegetation structure could also be affected by the modifications as vegetation is related to flow, and trees and bank vegetation structure will be affected by the management regime (mowing, tree cutting etc). The lack of signs of activity and presence of deposition or erosion features can also potentially be related to channel resectioning as most features would have been removed in the process of regrading the channel.



Natural features

This sections contains information on the average extent of natural features recorded in RHS. Features include the average number of riffles, pools and bars and the extent of trees and related features. Channel vegetation extent is also recorded in a broad-brush manner as simple, absent/present/extensive indices.

The reach considered has in-channel vegetation representative of slow flowing environments that could be the result of overdeepening and over widening as part of channel resectioning. It has few trees on its banks. The absence of trees could be explained by the management regime and the presence of resectioning. There were very few signs of activity and no riffles was observed again suggesting potential impact by management action.

Site info	Habitat modification	Man-made structures	Land-use	Habitat Indices	Natural features	Habitat assessment
-----------	----------------------	---------------------	----------	-----------------	------------------	--------------------

Riffles, pool and bars

Number of riffles:	0
Number of pools:	2
Number of bars:	2

Channel vegetation

Amphibious:	Absent
Emergent broad-leaved:	Absent
Emergent reeds:	Present
Filamentous algae:	Present
Floating-leaved:	Present
Free-floating:	Absent
Mosses:	Absent
Submerged vegetation:	Absent
Submerged broad-leaved:	Present
Submerged fine/linear leaved:	Extensive
Submerged fine-leaved:	Absent
Submerged linear-leaved:	Present

Trees and associated features

Extent of trees left bank:	Occasional clumps
Extent of trees right bank:	Occasional clumps
Shading of channel:	Present
Overhanging boughs:	Present
Exposed bankside roots:	Absent
Underwater tree roots:	Absent
Fallen trees:	Absent
Large Woody Debris:	Absent
Debris dams:	Absent

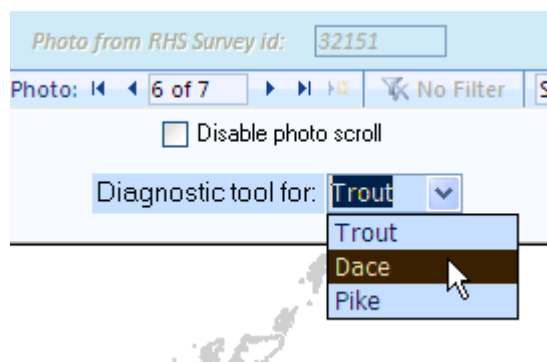
Barriers and refuge areas

Backwaters:	Absent
Natural open water:	Absent
Natural waterfalls < 5m High:	Absent
Natural waterfalls > 5m High:	Absent
Side Channels:	Absent
Marginal Deadwater:	Absent

Habitat assessment tool

The habitat assessment tool is based on combined RHS, water quality and land use data. It uses conceptual models derived by experts (see ['knowledge resources'](#)) and turns them into predictive models using available data.

Expert fisheries officers from the Environment Agency were gathered to build simple conceptual models of fish habitat for 3 life stages (spawning, juveniles and adults). The models were combined and tested on existing fish and habitat data on a total of 2500 sites. The resulting models were then applied to all existing RHS sites and are presented in ToolHab in a graphical way for three species: Trout, Pike and Dace (more species will be added in the future). You can move from one fish model to the other by using the drop down box below the photos (see below).



The factors affecting each species habitat can be split into 2 broad groups:

- Natural habitat features;
- Pressures and impacts.

On the figure below, all pressures and natural habitat feature have been grouped into 2 columns.

The figure is 'read' from left to right using colour-coded boxes and lines.

The potential impact of each pressure is indicated using the colour of its box. The colour code is as follow:

- Blue: the pressure may not be present or if it is, it has little or no impact on fish density.
- Yellow: the observed pressure level has a **fair** amount of impact on fish density
- Orange: the observed pressure level has **high** impact on fish density
- Red: the observed pressure level has **very high** impact on fish density.

The suitability of each habitat feature is assessed using the colour of its box. The colour code is as follow:

- Blue: very high
- Green: high
- Yellow: fair
- Orange: poor
- Red: very poor or feature absent.

The coloured lined represent the impact of habitat features and pressures on each other and on fish.

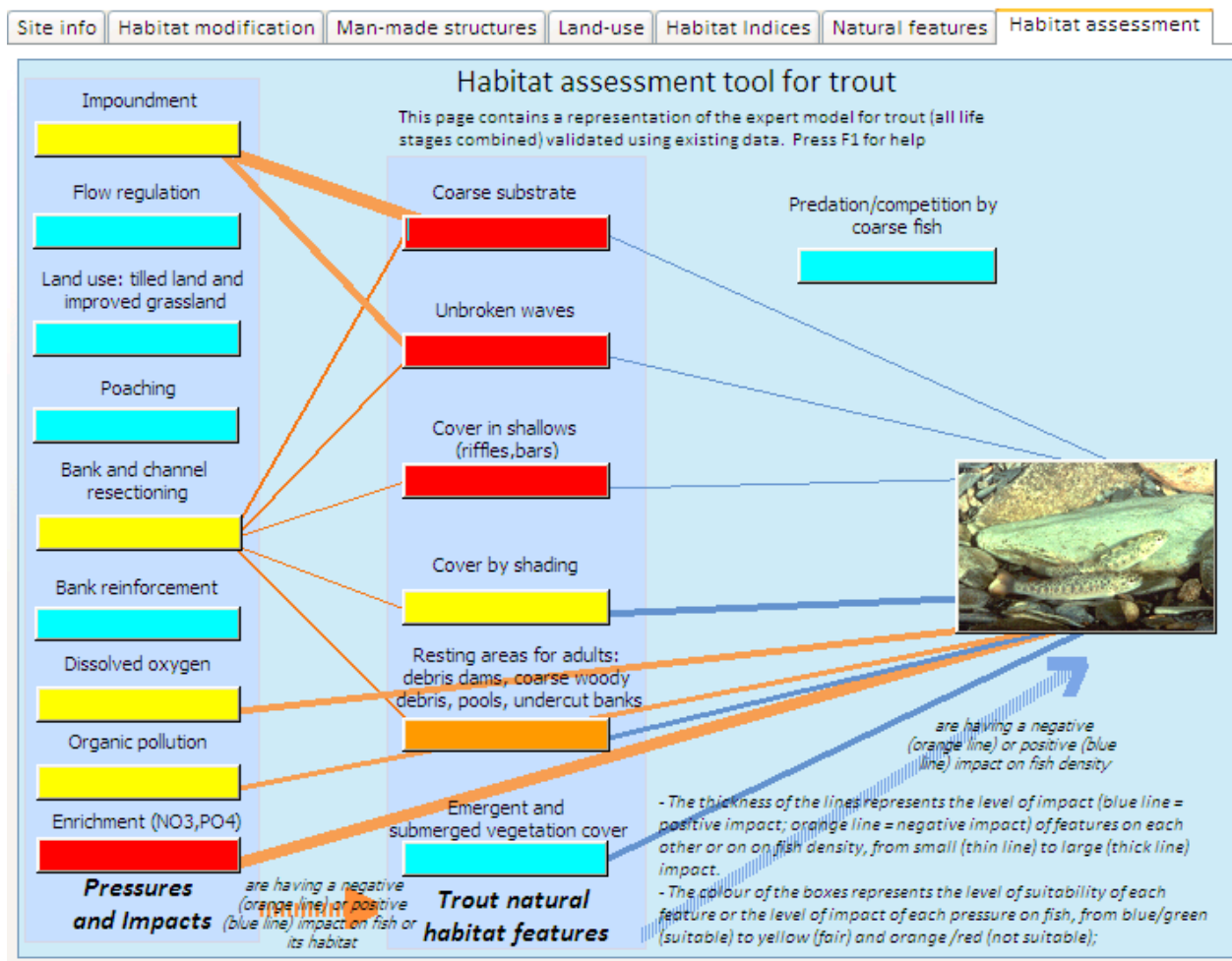
The colour of the lines indicates the nature of the impact:

- blue is for positive impact (e.g. coarse substrate impacts positively on the presence of unbroken waves);
- orange is for negative impact (e.g. tilled land-use will impact negatively on substrate coarseness - by increasing the amount of fine sediment present).

The thickness of the coloured line represents the magnitude of impacts.

Sometimes a pressure can be a positive driver to species distribution. For example, high levels of nutrient enrichment may be detrimental to salmonid species but favour the presence of more pollution tolerant species such as roach or pike. When a pressure is positively associated with the occurrence of a species, it will be displayed in shades of grey (according to its overall level of occurrence) in between the 2 columns representing pressures and natural habitats to highlight its ambivalent role.

When a pressure box colour is cyan and there are no arrows linking it to other boxes, it means that the pressure is absent. When a pressure box is greyed out, it indicates missing data.



Example:

Trout model

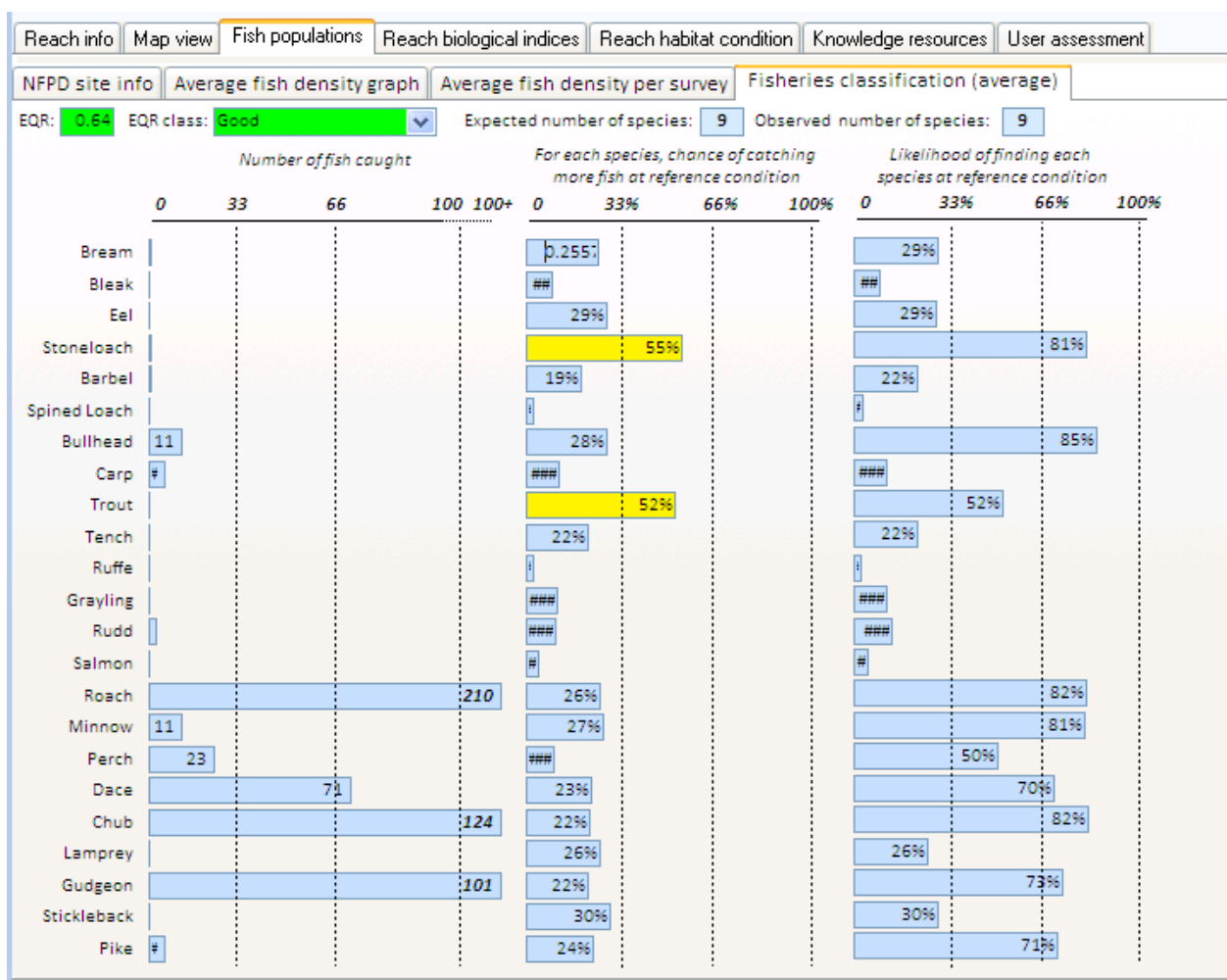
The figure above suggests that the habitats of the river reach are not favourable to trout.

Natural habitat features normally associated with trout are either favourable or fair (cover by shading, channel vegetation) or not favourable (channel substrate, flow type, cover in shallows and resting areas for adults).

The model suggests that the level of pressures on habitats are having an overall moderate to high impact on trout (red and yellow boxes) and a moderate impact on associated natural features. The highest and probably most significant impact according to the model is water quality (enrichment). The levels of phosphates and nitrates are very high and are likely to influence trout populations through their impacts on algal growth and dissolved oxygen. The presence of impoundments is also perceived as having a moderate to high impact. Bank and channel resectioning impact is moderate but it is probably under-estimated. It is likely that bank and channel resectioning are having a significant impact on trout habitats.

This assumes, however, that trout would naturally occur on the reach. The assessment using the fish population and Fisheries Classification Scheme (FCS) tools is that the likelihood of finding trout on such reach at reference condition is 52% but none were caught (see below). The FCS also suggests that, despite the observable modifications and potential impacts on natural habitat features, the fish populations are close to reference condition. The reach is dominated by coarse fish species and especially roach, gudgeon, dace and pike which all have greater than expected densities. Looking at fisheries survey records from the 1980s onward (see [River historical account](#)) and information from the river mole wikipedia page in the river historical module, it seems that the reach was always dominated by coarse fish populations and trout may have been present in tributaries such as Gatwick stream. The FCS predictions for trout for Gatwick stream show high levels of natural occurrence for trout so it is possible that trout may have inhabited the Mole around the confluence with Gatwick stream.

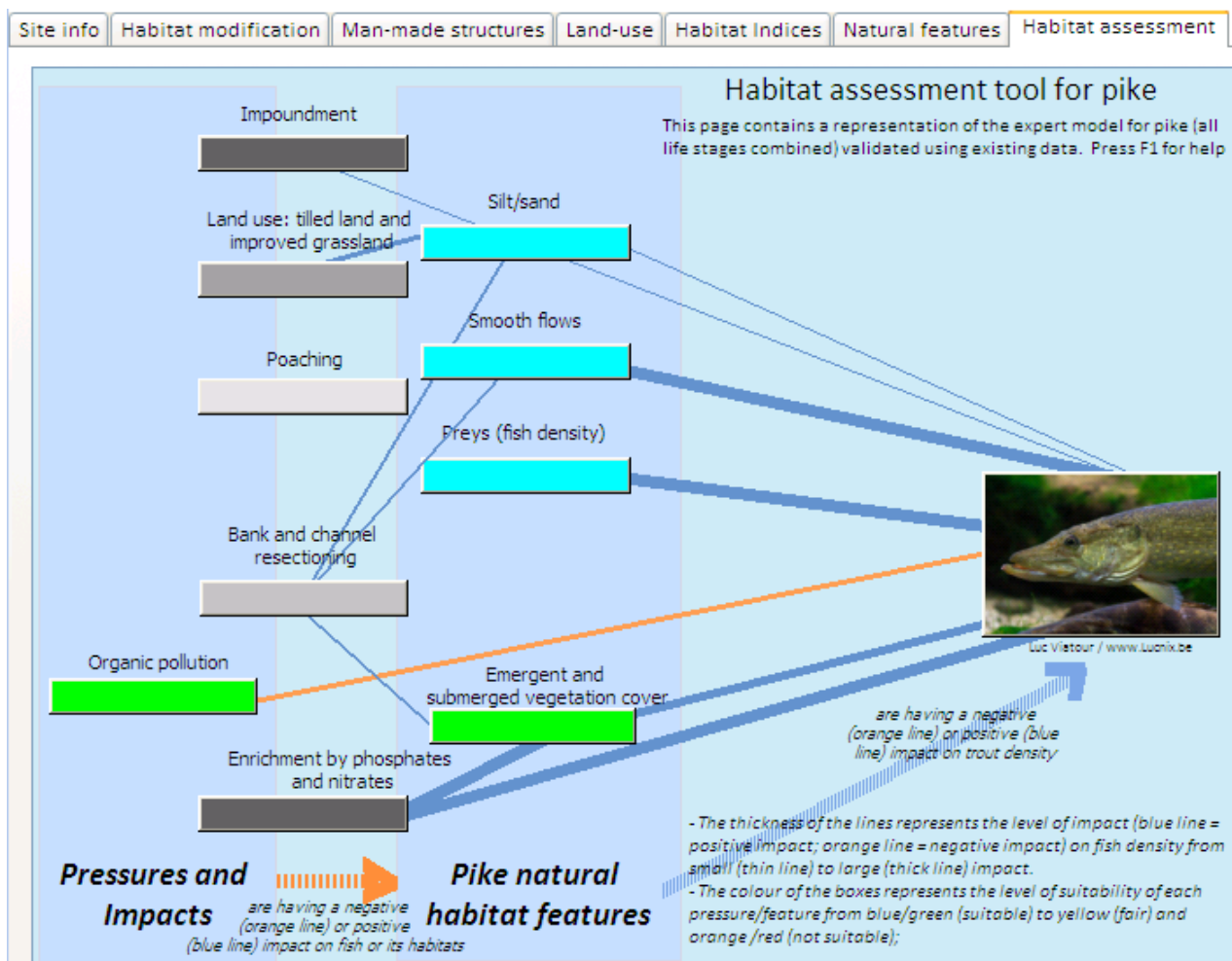
We will now consider the habitat models for pike and dace for the reach.



Pike model

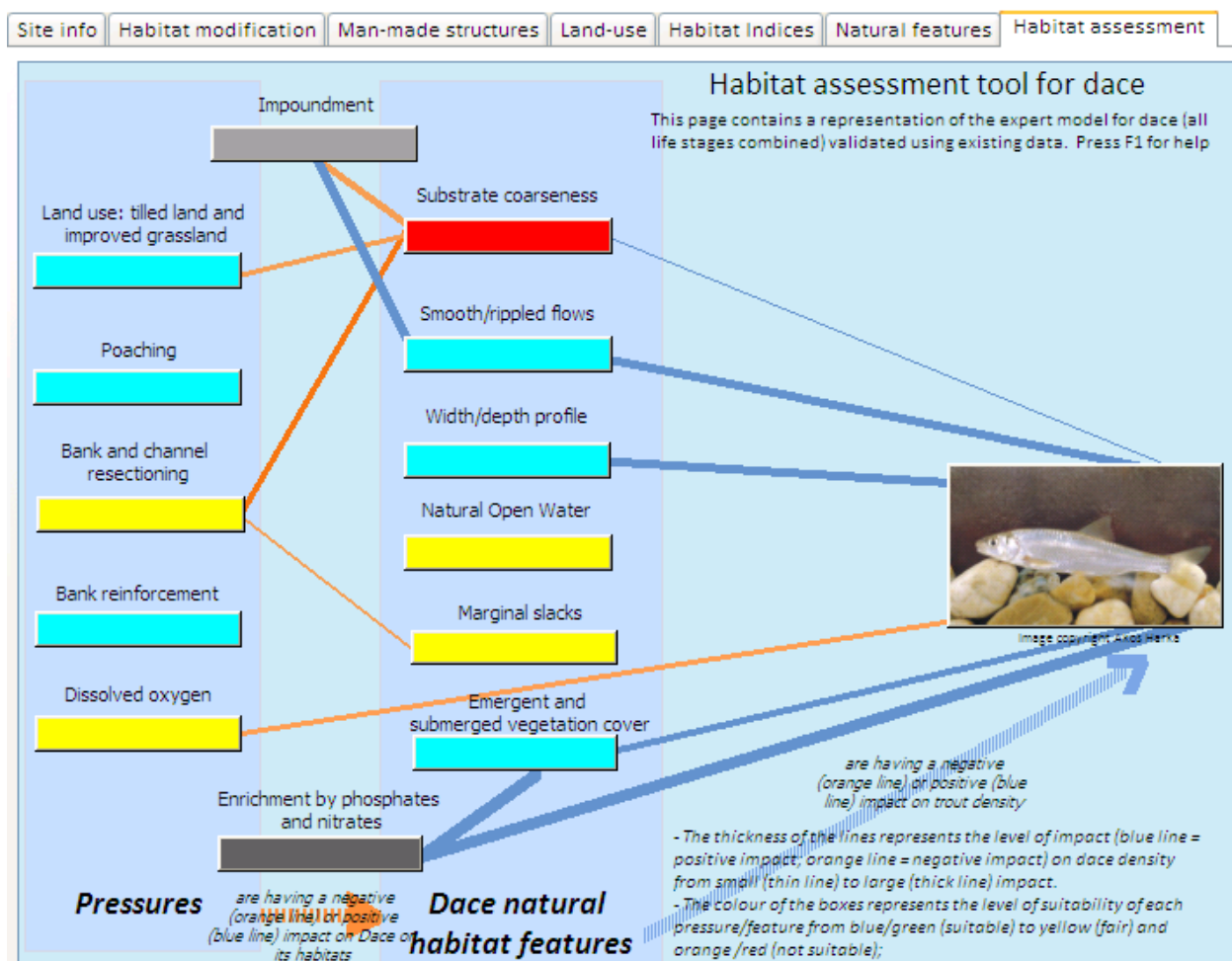
The model below suggest that the habitat for pike is very suitable with adequate levels of fine substrate, smooth flows, suitable levels of marginal habitats and plenty of prey (roach, dace, minnows etc.). The model suggest that existing anthropogenic alterations such as impoundment, land use and resectioning could be beneficial to pike habitat as they create the slow flowing conditions and marginal habitats that are favourable to pike. Enrichment could also be beneficial to fish occurrence due to its impact on potential prey density.

Pike are very resistant to pollution and anthropogenic impacts such as resectioning. In fact, only high levels of organic pollution seem to affect their distribution and they seem to favour rivers with moderate to high levels of enrichment (present on this site). Most other types of modifications seem to have potential positive impact on pike habitats. Resectioning, tilled land use and poaching promote the input of fine sediments, smooth flows and marginal vegetation that pike favour.



Dace model

The model for dace indicates that the site displays good levels of habitat suitability for dace apart from substrate which was altogether too fine. Most natural habitat feature indicators show high levels of suitability and pressures such as bank and channel resectioning and dissolved oxygen are at tolerable ('fair') levels and do not seem to affect negatively dace habitat structure. Dace tend to favour habitat with moderate levels of enrichment. Enrichment on site could have a positive impact on dace occurrence. Bank and channel resectioning does not seem to affect dace as much as trout. This is potentially due to the fact that although dace requires coarse substrate to reproduce, it is more tolerant to fine sediment inputs and it does not require fast flowing features such as trout. On the contrary, dace tends to be associated with sites dominated by deeper mesohabitats such as runs and glides and structures or modifications such as weirs and resectioning increasing depth may be beneficial to them.

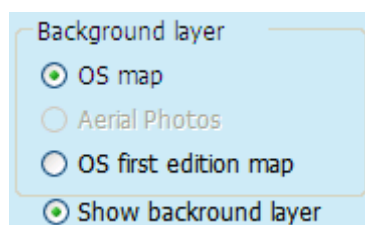


In summary, we see here how the fish conceptual and predictive models can be used in combination with fish, chemistry, RHS and other data to diagnose potential pressures and impacts on species habitats at reach scale.

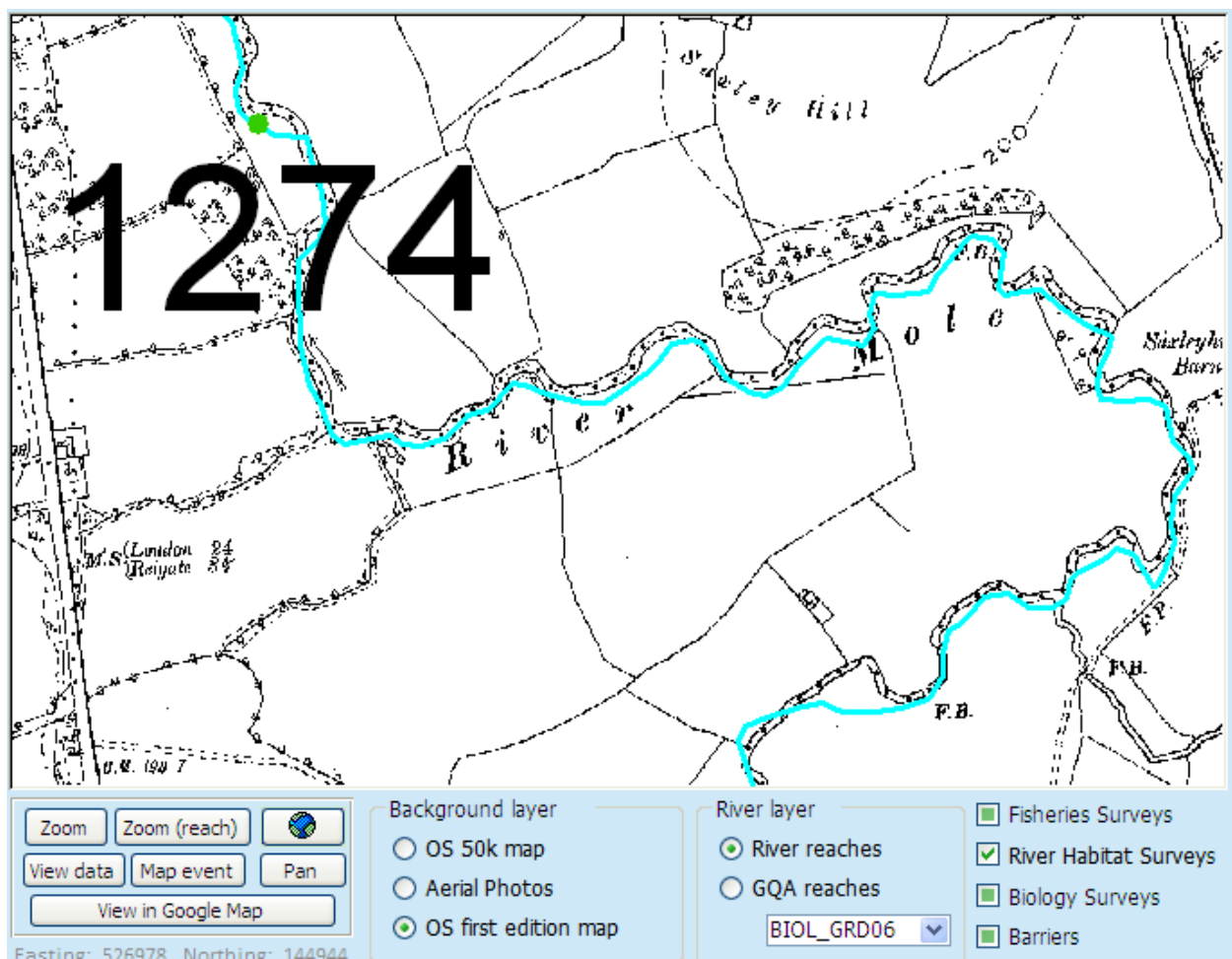
The fisheries predictive models indicated a potential lack of trout and a potential higher than expected dace and pike population. The conceptual expert models suggested that channel resectioning, impoundment, land use and water quality may explain the absence of habitat features naturally associated with trout and the occurrence of features associated with pike and dace.

Further investigations into historical records may be required to ascertain the true nature of original fish populations.

We may want, for example to look at historical maps to see how the river has changed since the 1900s. You can turn the background layer on and off by clicking the 'Show background layer' button.



Below is a snapshot of the 1897 OS maps around RHS site 1274, just downstream of Gatwick airport. As can be seen, the river has not changed its course much since the beginning of the 20th century. This suggests that the modifications observed either pre-date the 20th century or they have been carried out without modifying the planform of the river (i.e. without realigning it).



Knowledge resources

The knowledge resource tab contains links to online resources such as Fishbase and other useful websites. You will need to have access to the internet to access the links. To add links to the list, simply put the cursor in the window and type/copy new links to other useful resources with a short description.

The knowledge resource tab also provides access to the habitat suitability models built by Environment Agency Fisheries experts for 9 fish species and 3 life stages. To view these models, click on the 'Expert habitat suitability models' button.

each info
Map view
Fish populations
Reach biological indices
Reach habitat condition
Knowledge resources
User assessment

Fishbase information on UK fish species

- Trout
- Eel
- Gudgeon
- Roach
- Dace
- Bleak
- Stoneloach
- barbel
- Spined loach
- Bullhead
- Carp
- Pike
- Stickleback
- Perch
- Ruffe
- Lamprey
- Chub
- Minnnow
- Rudd
- Grayling
- Twaite shad

Websites and other useful links

Habitat management decision support website: this is the project websites. You will find links to useful resources, a description of the analyses carried out as part of this research and a discussion forum. Please post any comment, suggestions and feedback
www.riverhabitat.org

The River Restoration Centre: the RRC website is dedicated to river restoration and habitat enhancement techniques. You can view online and download the RRC manual of restoration techniques.
www.therrc.co.uk
www.therrc.co.uk/rrc_manual_pdf.php

ConservationEvidence.com: this sites offers a platform for practioners to share best practice and compare habitat management techniques. You can view and submit your own case studies online and read more formal review papers.
<http://conservationevidence.com>

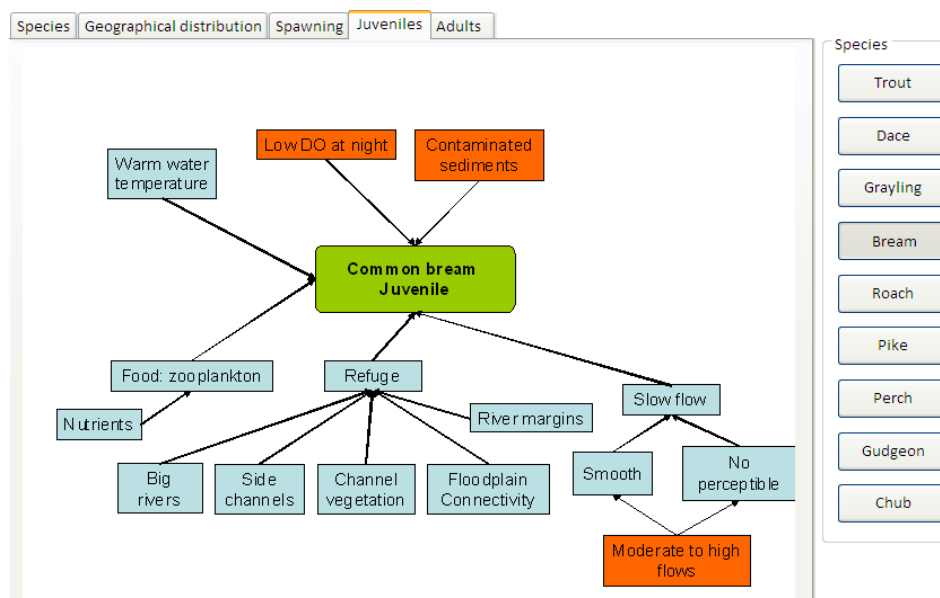
River Habitat Survey: the website contains information on River habitat survey and applications (site in construction).
www.riverhabitatssurvey.org
This link will take you to an application of RHS and water

Habitat models and habitat assessment tools

Habitat Suitability Models were developed for 9 species and 3 life stages by Environment Agency Fisheries experts. The models describe the links between habitat features and species in a simple graphical way.

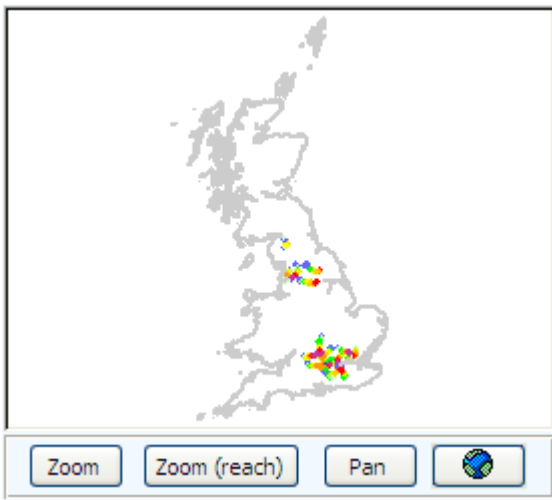
A form with 5 tabs and 9 buttons (one for each species) will open. Using this form, users can view in a graphical way the habitat features (in blue) and the pressures (in orange) that define/affect fish habitats at different stages of their life cycles.

This tool can be used in combination with all the other tools and datasets available in ToolHab to assess the quality of river reaches for fish and the potential pressures and impacts on their habitats. We have tried, as far as possible to include in ToolHab all the data that are needed to carry out this assessment.




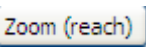
The small map view

You can use the small map view to locate river reaches. The small map view is located at the bottom right-hand corner of the main form. It is designed to help locate individual river reaches. There are no background layers visible to facilitate viewing.




There are series of buttons and function to help view and navigate through the map.

Use the  button to zoom in and out using a left click for zooming in and a right click for zooming out. You can also use the wheel of your mouse to perform both functions.

Use the  button to automatically zoom to the selected reach (e.g. Mole3 reach).

Use the  button to automatically zoom to the map full extent.

Use the  button to navigate through the map by click-holding an area of the map and dragging it in one of the cardinal directions.

User assessment

ToolHab gives users access to a wide range of data and knowledge to enable the assessment of river reaches for 23 species of fish. Reach assessment is done by using the form on the last tab. This form contains all the management information that will be used to build catchment wide habitat improvement strategies. Ideally, this form should be filled in after viewing existing data and model outputs. To help users in their decision-making, ToolHab provides access to a wide range of biological and environmental data as well as models and knowledge.

The aim of the whole assessment process is to assess the suitability of river reach habitats for each species:

- as they are now;
- as they would be at reference conditions and;
- as they would be following improvement work.

Although ToolHab contains predictive models such as the Fisheries Classification Scheme (FCS) that produce similar predictions, their outputs are not automatically included in the user assessment form and it is the user responsibility to assess fish habitats, identify potential pressures and suggest management action. Indeed, models such as the FCS are often based on sample data collected at specific times of the year over a limited time frame and often fail to account for historical trends and events and may not represent the complexity of relationships observed. It was therefore felt that users should be able to review all existing information and data for a reach including local knowledge, historical surveys and anecdotal evidence before making a full assessment and suggesting management action. This way, scientific models and data, as well as local knowledge and expertise can be combined to develop management strategies based on the best evidence and expertise at hand.

Reach info | Map view | Fish populations | Reach biological indices | Reach habitat condition | Knowledge resources | User assessment

Habitat Suitability Date: 13 April 2010 Name: Guest

Species name	Now	At reference condition	After improvement
Bream:	Very low	Very low	Very low
Bleak:	Very low	Very low	Very low
Eel:	Very low	Very low	Very low
Stone loach:	Very low	Very low	Very low
Grayling:	Very low	Very low	Very low
Barbel:	Very low	Very low	Very low
Spined Loach:	Very low	Very low	Very low
Bullhead:	Very low	Very low	Very low
Carp:	Very low	Very low	Very low
Rudd:	Very low	Very low	Very low
Pike:	Very low	Very low	Very low
Stickleback:	Very low	Very low	Very low
Gudgeon:	Very low	Very low	Very low
Ruffe:	Very low	Very low	Very low
Lamprey:	Very low	Very low	Very low
Trout:	Very low	Very low	Very low
Chub:	Very low	Very low	Very low
Dace:	Very low	Very low	Very low
Perch:	Very low	Very low	Very low
Minnow:	Very low	Very low	Very low
Salmon:	Very low	Very low	Very low
Roach:	Very low	Very low	Very low

Overall description:

Pressures and impacts:

Pressure	Impact	Description
* Water Quality	None	

Management restrictions:

Management recommendations:

Expected outcome:
Write here a short description of the intended outcome of suggested recommendations

Estimated cost:

Management opportunity ☐

Opportunity description:

Users can use the drop down boxes to specify the quality of reach habitats for each species using 5 categories and give an assessment of their suspected impacts on reach habitats.

Habitat Suitability

Species name	Now	At reference condition	After improvement
Bream:	Very low	Moderate	Moderate
Bleak:	Very low	Very low	Very low
Eel:	Very low	Very low	Low
Stone loach:	Very low	Very low	Moderate
Grayling:	Very low	Very low	High

The form also give users the opportunity to enter an overall description of the reach, its conditions, pressures and impacts.

The 'Pressures and impact' box can be used to list all pressures,

Very low

Very low

Pressures and impacts:

Pressure	Impact	Description
* Water Quality	None	
PressureName	Description	
Water Quality		Poor water quality due to enrichment by nitrate, phosphates organic matter etc.
Pesticide pollution		Pollution by pesticides, ship dip etc
Agriculture		A land-use pressures including a combination of issues such as diffuse pollution,
Maintenance		Maintenance by dredging, tree cutting, bank mowing etc.
Resectioning		Habitat degradation through resectioning of the bank, bed or realignment of the
Reinforcement		Habitat degradation through reinforcement of the bank and/or bed
Flow regulation		Regulation of flow by weir, sluice, dam or reservoir.
Abstraction		Impact by water abstraction
Discharge		Impact by water discharge
Gravel extraction		Extraction of gravel, pebbles or cobbles
Culverting		The river has been put into a culvert (i.e. pipe)
Litter		Impact by litter, builder's waste etc.
Contamination		Contamination by chemicals leaching from adjacent contaminated land
Road		Pollution and sediment input from nearby major roads (e.g. motoways)
Mining		Pollution or physical disturbance due to mining activity

Very low

Expected outcome:

Pressures and impacts:

Pressure	Impact	Description
Water Quality	Very high	
* Water Quality	None	
	Low	
	Moderate	
	High	
	Very high	

Then users can recommend management actions for the reach and give information on potential restrictions (e.g. gas pipe, road etc) and opportunities (e.g. friendly land owner).

The system requires users to give a description of the expected outcome following improvement along with an estimated cost for the works (optional).

Management restrictions:

Urban area nearby. Gatwick airport upstream.

Management recommendations:

Reduce maintenance

Expected outcome:

higher in channel diversity

Estimated cost:

Management opportunity

☐

Opportunity description:

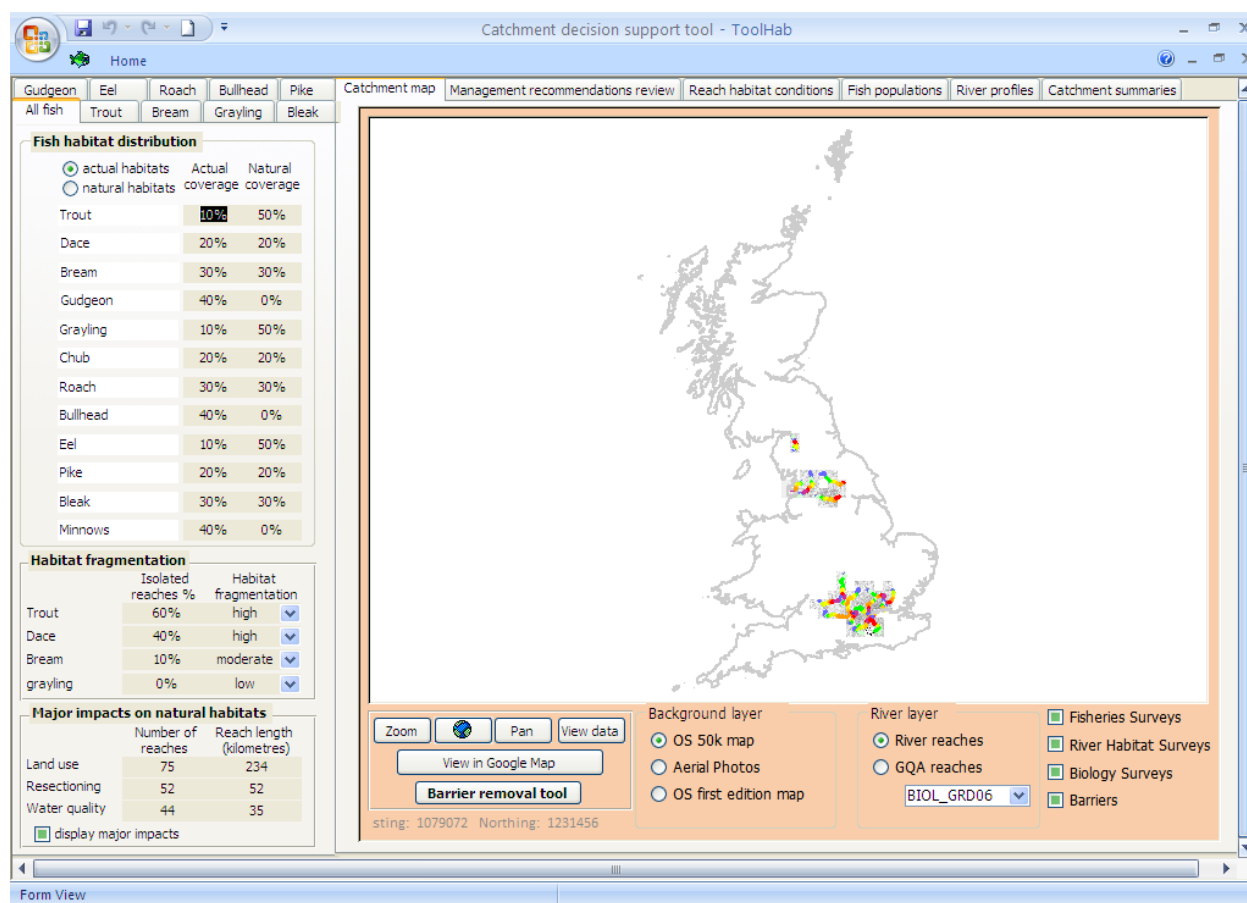
Catchment Decision Support Tool

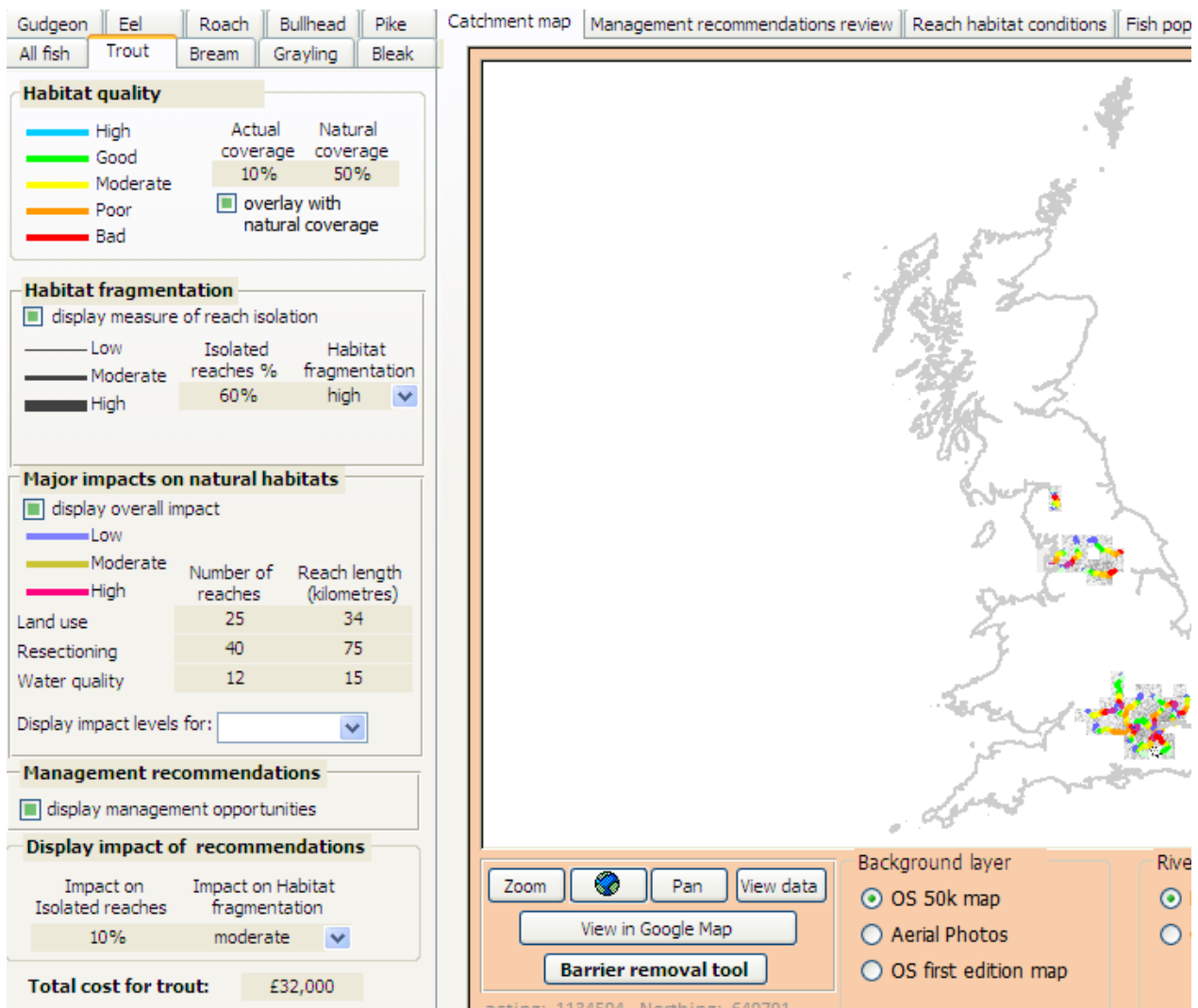
This tool provides an interface to view and summarise the reach habitat assessment information entered by catchment officers using the reach assessment tool.

The aim is to use this tools to develop strategies for improving habitats at catchment scale and prioritise sites/reaches for habitat improvement work.

The interface displays summary statistics on

- habitat suitability for fish as observed and in reference conditions;
- pressures and impacts;
- habitat fragmentation.





Summary statistics can also be viewed using maps and tables for each species by selecting the tabs with species names on the left hand side of the screen (see above example for trout).

Users can also be given access to assessment forms for individual reaches by clicking on the 'Management recommendations review' tab header.

This should help build an overall pictures of habitat quality at river/catchment scale and the pressures affecting those habitats.

For example, we may find that a particular catchment has lost habitats 50% of its habitats for trout potentially due to engineering and land use pressures.

The tool may also tell us how fragmented remaining habitats are and design a strategy for improving habitat quality and connectivity for trout at catchment scale.

To do so, users can access all the information and knowledge inputted by catchment officers and interact with them in the development of the potential strategies. They can also consult existing data and modelling tools (using the 'reach habitat conditions', 'fish populations', 'river profiles' and 'catchment summaries' tab headers and view maps and photos using the map interface.

As ToolHab contains the Environment Agency Fisheries Barriers database, it should be possible to develop a tool to assess the impact of removing barriers on river connectivity. The 'Barrier removal tool' button on the interface is not functional but it illustrate the kind of analyses that could be carried out using the available data.

Altogether, this should facilitate the development of strategies based on existing knowledge (expert, local and scientific) and data.

At present the interface is not functional and is for demonstration purposes only.

Habitat Suitability

Date: 13 April 2010

Name: Guest

Species name

Now

At reference
condition

After
improvement

Bream:	Very low	Moderate	Moderate
Bleak:	Very low	Very low	Very low
Eel:	Very low	Very low	Very low
Stoneloch:	Very low	Very low	Very low
Grayling:	Very low	Very low	Very low
Barbel:	Very low	Very low	Very low
Spined Loach:	Very low	Very low	Very low
Bullhead:	Very low	Very low	Very low
Carp:	Very low	Very low	Very low
Rudd:	Very low	Very low	Very low
Pike:	Very low	Very low	Very low
Stickleback:	Very low	Very low	Very low
Gudgeon:	Very low	Very low	Very low
Ruffe:	Very low	Very low	Very low
Lamprey:	Very low	Very low	Very low
Trout:	Very low	Very low	Very low
Chub:	Very low	Very low	Very low
Dace:	Very low	Very low	Very low
Perch:	Very low	Very low	Very low
Minnow:	Very low	Very low	Very low
Salmon:	Very low	Very low	Very low
Roach:	Very low	Very low	Very low

Overall description:

Resectioned channel with poor water quality

Pressures and impacts:

Pressure	Impact
Water Quality	Very high
Resectioning	High
Maintenance	High
Agriculture	Moderate
* Water Quality	None

Management restrictions:

Urban area nearby. Gatwick airport upstream.

Management recommendations:

Reduce maintenance

Expected outcome:

higher in channel diversity

Estimated cost: £1,000.00

Management opportunity ☐

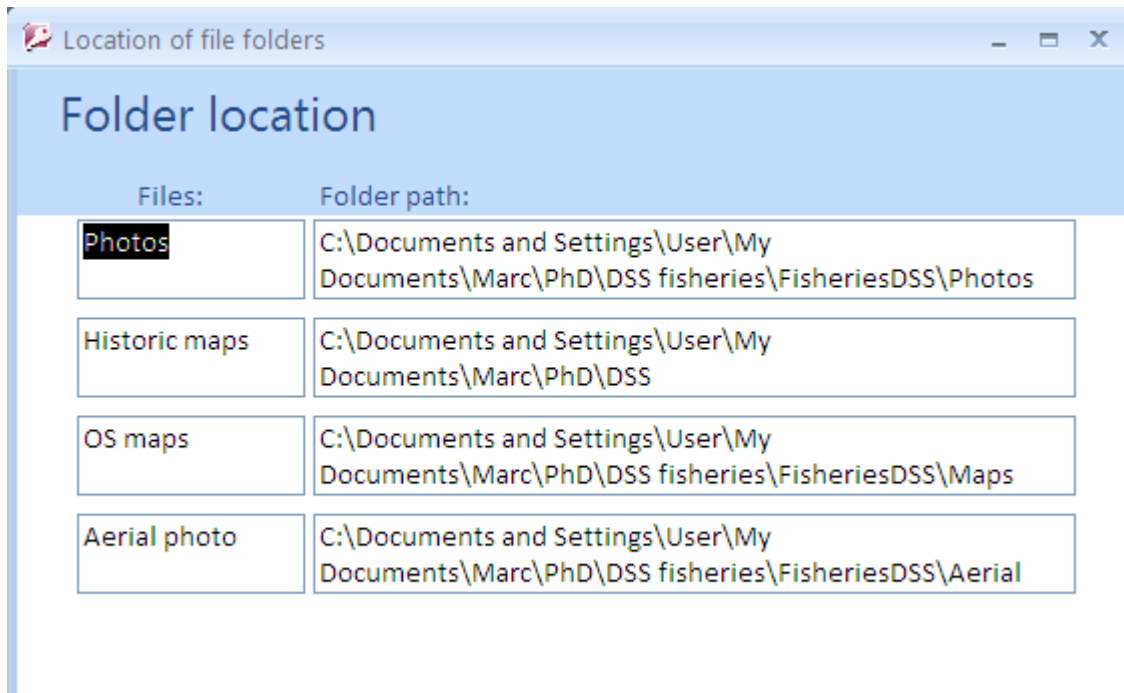
Opportunity description:

Accept

Ignore

File location menu

You can change the path to the folder containing maps and photos. This can be useful if you are using large map/photo files that have to be stored on an external or network drive.

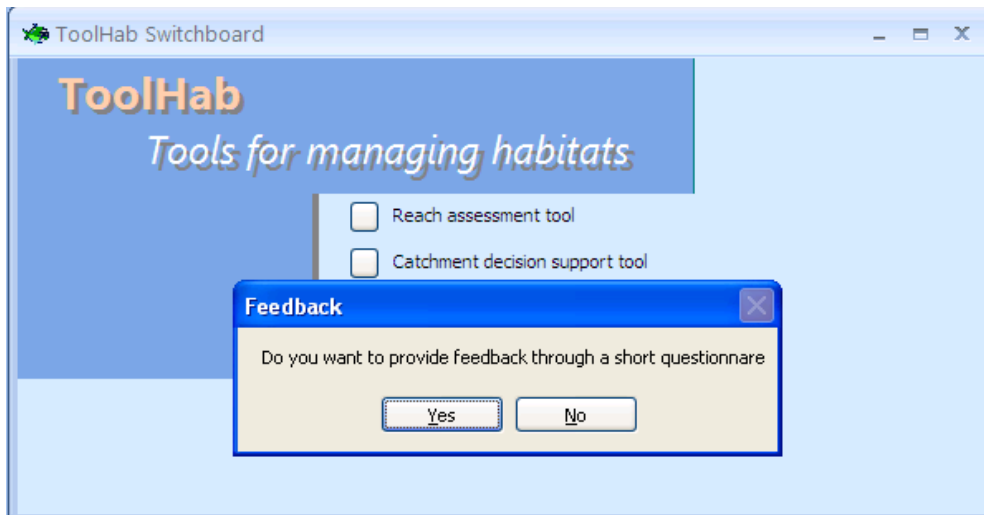


Contact Us

Please contact us for any feedback, comments or bugs at marc.naura@mnaura.freeseerve.co.uk
Alternatively, post your comments on the project website forum page: www.riverhabitatsurvey.org

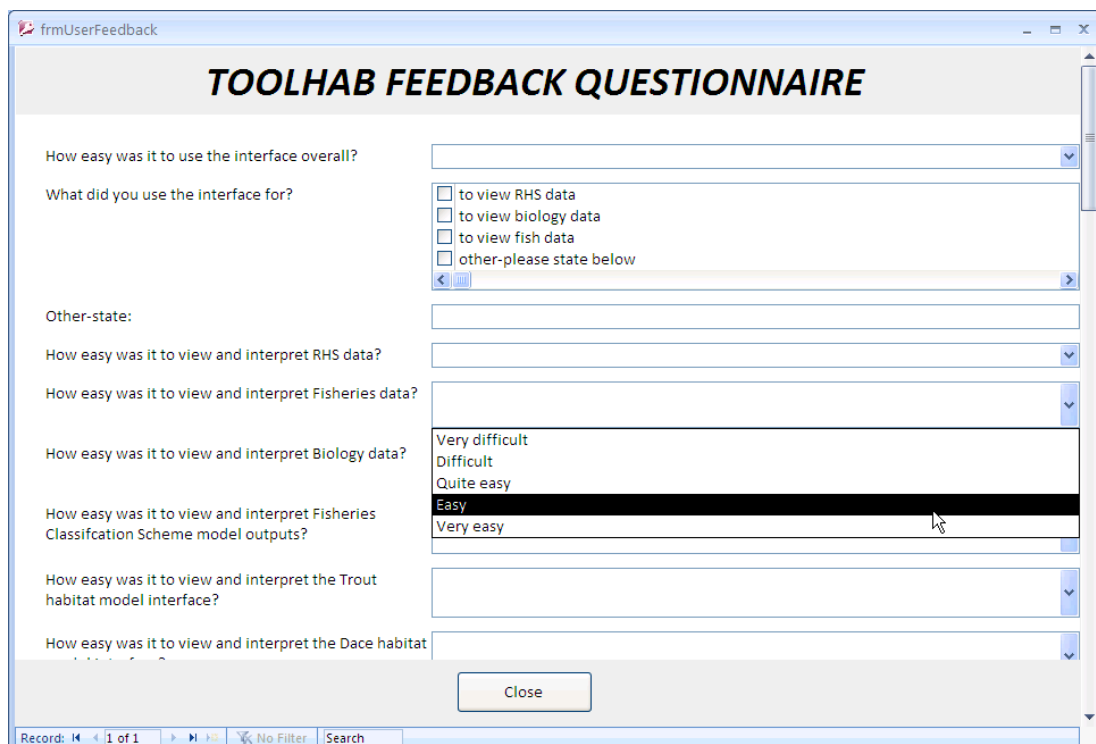
User feedback

On exiting the database, you will be asked to answer a feedback questionnaire.



The questionnaire is designed to help evaluate the usefulness of ToolHab and its potential use within the Environment Agency. Following a trial period, responses from the questionnaire will be analysed and a decision will be made towards developing further the software and applications within it.

Many thanks for your input!

A screenshot of a "frmUserFeedback" window titled "TOOLHAB FEEDBACK QUESTIONNAIRE". The form contains several questions and input fields. The first question is "How easy was it to use the interface overall?" with a dropdown menu. The second question is "What did you use the interface for?" with a list of checkboxes: "to view RHS data", "to view biology data", "to view fish data", and "other-please state below". The third question is "Other-state:" with a text input field. The fourth question is "How easy was it to view and interpret RHS data?" with a dropdown menu. The fifth question is "How easy was it to view and interpret Fisheries data?" with a dropdown menu. The sixth question is "How easy was it to view and interpret Biology data?" with a list of radio buttons: "Very difficult", "Difficult", "Quite easy", "Easy", and "Very easy". The seventh question is "How easy was it to view and interpret Fisheries Classification Scheme model outputs?" with a dropdown menu. The eighth question is "How easy was it to view and interpret the Trout habitat model interface?" with a dropdown menu. The ninth question is "How easy was it to view and interpret the Dace habitat model interface?" with a dropdown menu. At the bottom of the form is a "Close" button. The footer of the window shows "Record: 14 of 1" and "No Filter Search".

Appendices

Appendix 1: Environment Agency General Quality Assessment (GQA) Scheme

Appendix 2: Environment Agency Biological Indices

Appendix 3: River Reach Definition

Appendix 1: Environment Agency General Quality Assessment (GQA) Scheme

The EA has developed a General Quality Assessment scheme (GQA) which provides a consistent method for classifying water quality in rivers and canals across the UK. The scheme provides a way of comparing river quality from one river to another and for looking at changes through time.

The scheme uses four main parameters of measurement which include:

- chemical content;
- biological content;
- nutrient content; and
- aesthetics.

Chemistry

Samples are analysed for three determinands of organic pollution: ammonia, biochemical oxygen demand (BOD), and dissolved oxygen. The results for a site are averaged and percentiles are calculated. These are compared with limits set for each of six grades as shown in the Table 1.1. A grade is assigned to the length of river (which the sampling site represents) according to the lowest grade achieved by any of the three determinands. For example, if a site is grade A for dissolved oxygen and ammonia but only grade B for BOD, then the grade assigned is B.

Table 1.1 Classification: Chemistry

Classification	likely uses and CHARACTERISTICS*
A – Very good	All abstractions Very good salmonid fisheries Cyprinid ¹ fisheries Natural ecosystems
B - Good	All abstractions Salmonid fisheries Cyprinid fisheries Ecosystems at or close to natural
C - Fairly good	Potable supply after advanced treatment Other abstractions Good cyprinid fisheries Natural ecosystems, or those corresponding to good cyprinid fisheries
D - Fair	Potable supply after advanced treatment Other abstractions Fair cyprinid fisheries Impacted ecosystems
E - Poor	Low grade abstraction for industry Fish absent or sporadically present, vulnerable to pollution ** Impoverished ecosystems **
F - Bad	Very polluted rivers which may cause nuisance Severely restricted ecosystems
* Provided other standards are met	
** Where the grade is caused by discharges of organic pollution	

Biology

The macro-invertebrates (small animals that can be seen with the naked eye) found in the kick-samples

taken are identified by the EA. The range of species found is compared with the range that would be expected in the river if it was not polluted or physically damaged. This takes account of natural differences expected due to different types of geology and flow, for example. One of six grades is allocated to each river length, as shown in Table 1.2.

Table 1.2: Classification: Biology

classification	description
A – Very good	Biology similar to that expected for an unpolluted river
B – Good	Biology is a little short of an unpolluted river
C – Fairly good	Biology worse than expected for unpolluted river
D – Fair	A range of pollution tolerant species present
E – Poor	Biology restricted to pollution tolerant species
F – Bad	Biology limited to a small number of species very tolerant of pollution

Nutrients

Samples are analysed for nitrate and phosphate. A grade is assigned for each of these nutrients according to the Table 1.3 and Table 1.4.

Table 1.3 Classification: Nutrients - Phosphates

classification	grade limit (mgP/l)	Description
1	0.02	Very low
2	0.06	Low
3	0.1	Moderate
4	0.2	High
5	1.0	Very high
6	>1.0	Excessively high

Table 1.4 Classification: Nutrients - Nitrates

classification	grade limit (mgno ³ /l)	Description
1	5	Very low
2	10	Low
3	20	Moderately low
4	30	Moderate
5	40	High
6	>40	Very High

Nitrate levels in many English surface waters are increasing. Nitrate pollution is of concern because it has to be removed before water can be supplied to consumers and may result in detrimental environmental impacts. The Nitrates Directive requires all known areas of land draining into nitrate polluted waters to be identified for designation as Nitrate Vulnerable Zones (NVZs). Therefore, if an area of land drains into one or more of the above categories of polluted water, it will be located within a NVZ. Farmers located within these NVZs are required to adhere to an Action Programme of measures to reduce the amount of nitrate lost from their land to the polluted waters

Source: <http://www.environment-agency.gov.uk/>

Appendix 2: Environment Agency Biological Indices

This is based on groups of macro-invertebrates (small animals including mayfly nymphs, snails, shrimps and true worms) that are found on the riverbed.

Macro-invertebrates are used because they:

- do not move far
- have reasonably long life cycles
- respond to the physical and chemical characteristics of the river
- are affected by pollutants which may occur infrequently
- provide a picture of water quality and quantity integrated over time

Samples are collected using a standard method of 3 minutes active sampling with a pond net, plus a 1 minute visual search for animals living on the water surface, or attached to rocks, logs or vegetation. Other features of the sampling area are recorded (substrate type, sampling depth, watercourse width, channel depth, aquatic vegetation, fish, land use, shade, evidence of weed management, pollution, turbidity, etc). In the laboratory, the macro-invertebrates are identified to family level, as a minimum requirement, and to species level (where possible) and their relative abundances estimated, according to the following scheme:

Abundance category	Interpretation
A	1 to 9 specimens in sample
B	10 to 99 specimens in sample
C	100 to 999 specimens in sample
D	1000 to 9999 specimens in sample
E	>10, 000 specimens in sample

Terms used in routine reporting of biology data.

BMWP – Biological Monitoring Working Party Score

Scores are assigned to invertebrate families depending on their tolerance of organic pollution. The individual family scores are added together to give a sample BMWP score, higher scores indicate cleaner conditions. BMWP scores can vary from 0 (grossly polluted) to 150+ (excellent quality).

TAXA

This is the number of BMWP scoring families found in the sample. There may be additional non-scoring taxa in the sample which are not recorded here.

ASPT – Average Score Per Taxon

This is the total BMWP score divided by the number of BMWP scoring taxa and is therefore independent of sample size. ASPT can vary from 0.00 (grossly polluted) to 6.00+ (excellent quality).

LIFE (Family)/ LIFE (Species) – Lotic-invertebrate Index for Flow Evaluation

A flow score is derived for each species/family using the species/family abundance and ecological association with different flows (see conversion table below). An overall LIFE score is calculated for the sample from the sum of the individual species/family flow scores divided by the number of scoring species/families. LIFE scores less than 6.00 generally indicate sluggish or still water conditions. As current velocity increases, so do LIFE scores. LIFE values greater than 7.5 indicate very fast flows.

	Abundance categories			
Flow group	A (1-9)	B (10-99)	C (100-999)	D/E (1000+)
I Rapid	9	10	11	12
II Moderate/fast	8	9	10	11
III Slow/sluggish	7	7	7	7
IV Flowing/standing	6	5	4	3
V Standing	5	4	3	2
VI Drought resistant	4	3	2	1

Reference

Extence C., Balbi DM. and Chadd RP. 1999. *River flow indexing using British benthic macro-invertebrates: a framework for setting hydro-ecological objectives*. Regulated Rivers Research and Management **15**: 543-574.

For more information on these indices contact the Biology team at the Environment Agency, Spalding.

Appendix 3: River Reach Definition

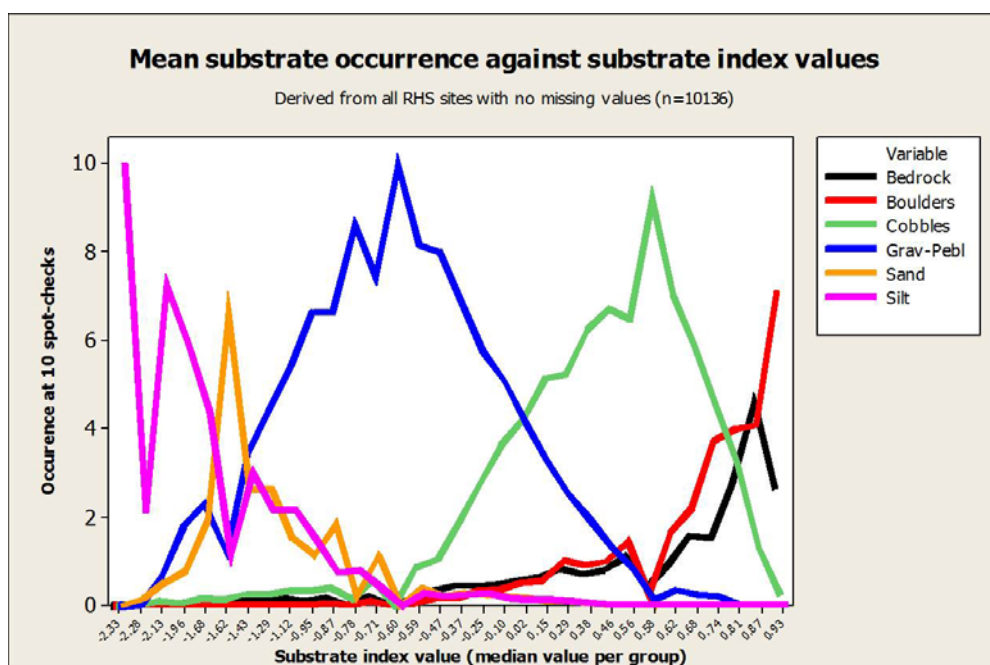
Splitting the river network into homogeneous habitat reaches using river segmentation technique.

Rivers were split into reaches using a segmentation approach based on spatial similarity for a series of indices representing habitat structure. The approach consists of selecting a series of indices or attributes to represent channel morphology that are modelled and predicted using map-derived attributes such as slope, discharge, land use etc. The models are then implemented at regular intervals (e.g. every 500 m) along the river network. The predictions for contiguous river sections are compared and clustered using a statistical spatial clustering algorithm so as to maximise the variance between clusters and minimise the variance within clusters (or reach). Clusters can then be aggregated in the shape of river reaches whose variability can be described and predicted.

For the derivation of river reaches for ToolHab, habitat was defined as a combination of four structural elements: channel substrate, flow regime, erosion and deposition patterns and channel vegetation structure. River reaches were defined as homogeneous stretches of river with regards to the four structural elements as observed and as they would be in natural or near-natural conditions. The four habitats structural elements were derived using field data from the River Habitat Survey (RHS). The RHS is a methodology for recording habitat features that has been applied to more than 25,000 500m river sections in England and Wales since 1994 (Raven *et al.* 1997). The survey is organised in two major sections: 'spot-checks' and 'sweep-up'. The spot-checks are a series of ten 1 m wide transects across the channel at 50 m intervals, where bank and channel physical structure, as well as man-made modifications, land uses and vegetation structure, are recorded in a replicable manner.

Spot-check data on channel substrate, flow types, erosion and deposition features and channel vegetation were collated in four separate tables showing the occurrence of individual features (e.g. for channel substrate, the individual substrate types: bedrock, boulders, cobbles, gravel pebbles, sand, silt, clay, peat and artificial) across 10 spot-checks for existing RHS semi-natural sites. A semi-natural site is defined as a site with little or no signs of man-made modifications to the channel or the banks (Raven *et al.* 1997). The tables were analysed using Correspondence Analysis to extract the most important dimensions that were used as indices for describing the four habitat structural elements.

One of the four indices, the Channel Substrate Index (CSI) is represented in the figure below. The chart was derived for a subset of 1881 semi-natural RHS sites with no obvious signs of modifications and no missing values. The sites were grouped into 31 bins based on their CSI index value and the chart displays, for each bin, the average occurrence of 7 channel substrate types. Finer sediments dominate on the left hand side of the chart (larger negative CSI). The CSI describes a gradient from fine sediment dominated rivers to coarse sediment typical of an upland-lowland shift in substrate size with increasing distance to source and accounted for about 20% of the total variability found in the data. The other indices described similar gradients.



The 4 indices were modelled against a series of GIS attributes using linear regression best subset selection procedure and tested using a jack-knife cross-validation technique. The models were spatially corrected using a series of methods. A simple methodology was to reiterate the existing model and add additional variables representing the index value for the closest RHS on the river network along with the site distance and its location upstream or downstream. Another method was to perform geostatistical analyses on the main model residuals (Bivand *et al.*, 2008). The outputs from all models were compared and the best models were selected.

Two sets of predictive models were derived for the four structural elements indices: one predicting habitat structure as observed during field survey and one predicting habitat structure as it would appear if the sites were semi-natural. The first model set was produced using all existing RHS sites, whether modified or not, and the second set was produced using only semi-natural sites. The R-square values for the best models are presented in the table below.

Amongst the four indices, the Channel Substrate and the Flow indices had the highest level of predictability with R-square at 68% and 56% respectively. The model for channel vegetation and activity in comparison explained 48% and 42% of the variability. Predictions for semi-natural sites showed similar levels of predictability despite the much reduced sample sizes. Spatial corrections brought about slight to moderate increases in predictive ability for the Channel Substrate, the Flow and the Activity Indices and quite significant improvements for the Channel Vegetation Index. Altogether, the predictive ability of the index value models was satisfactory.

	Predictive models produced using all sites		Predictive models produced using semi-natural sites only	
Indices	Main model	Main model with spatial component	Main model	Main model with spatial component
Channel Substrate Index	68% <i>n</i> = 9492	70.4% <i>n</i> = 5857	66% <i>n</i> = 1759	70% <i>n</i> = 604
Flow Index	55.9% <i>n</i> = 12983	61% <i>n</i> = 8282	53.6% <i>n</i> = 1997	67.2% <i>n</i> = 889
Channel Vegetation Index	47.9% <i>n</i> = 11196	58.7% <i>n</i> = 7811	52.2% <i>n</i> = 2036	67.6% <i>n</i> = 853
Activity Index	42.4% <i>n</i> = 12870	47.8% <i>n</i> = 9261	35.3% <i>n</i> = 2140	44.3% <i>n</i> = 986

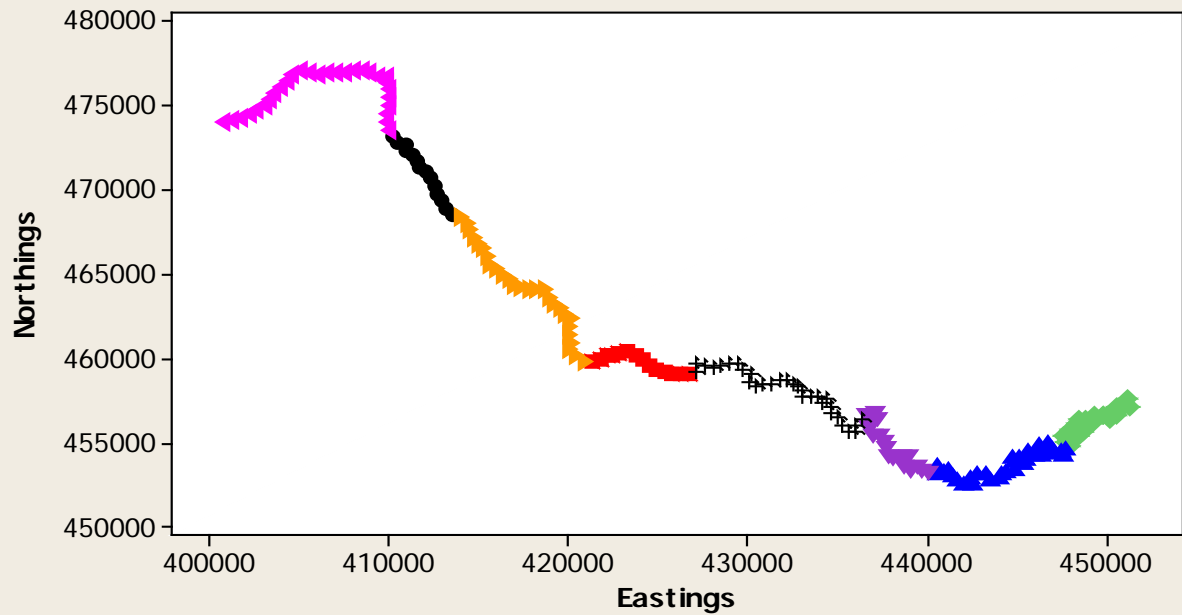
The spatially corrected predictive models were applied to all 500 m sections on the 15 rivers part of the DSS to predict observed and semi-natural values for all four indices. Adjacent 500 m sections were grouped using a spatial clustering freeware called VAST (Brenden *et al.* 2008). VAST was designed for clustering contiguous river segments based on their similarity with regards to attributes or indices and their spatial position within the river network. VAST offers a series of options for clustering river sections. Clustering can be performed starting from the top of the river or the bottom or it can be done randomly or based on similarity levels using various distance measures, linkage methods and affinity threshold values.

Each river was clustered by running the VAST algorithm using various combinations of options. The outputs were assessed using the [Calinski and Harabasz \(1974\)](#) index (CH index), a ratio that compares variance between and within clusters. The four indices were also plotted against the distance to source so as to allow visual checks and the identification of the most optimal solution. Sometimes, clustering was corrected following visual checks when obvious breaks in structural elements index values had been missed out by the clustering algorithm. An example of clustering is shown in the figures below. The first figure shows the best cluster combination found using VAST and the CH index. The second figure shows the distribution of the 4 index values for each 500m point and cluster (in colour) from source to mouth. The sections within each cluster were aggregated into river reaches using GIS ArcView. The resulting maps were circulated to Environment Agency staff for comments as Google Earth kmz files and in pdf format.

Display of river segmentation for the river Nidd

Each dot represents a 500m section

Calinski Harabasz index = 235.7



Index value from source to mouth for the river Nidd

Observed values for 4 indices

(Each dot represents a 500m section; index value on Y scale)

