Review of fish stocks and associated habitat in the River Crana catchment, Co. Donegal

December 2019

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Inland Fisheries Ireland

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Inland Fisheries Ireland Research & Development report

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1 Scope of report

This report reviews the status of salmonid stocks in the River Crana catchment, Co. Donegal with reference to historical and recent fish stock surveys and associated environmental and habitat information. The report was commissioned primarily in response to concerns that fish stocks and associated habitat were negatively impacted after a severe flooding event in August 2017. Scientific advice to support recommended measures to maintain and/or facilitate the improvement of salmonid stock status in the river are presented based on the review.

2 Introduction

In late August 2017 the River Crana catchment was subjected to a severe flooding event, which resulted in bank erosion, the movement of marginal and bed material, and the displacement of materials within the watershed. This '100-year recurrence interval' event greatly impacted on local communities, property and farmland within the catchment area. In the aftermath, additional concerns were raised relating to the potential negative impacts on the resident salmonid stocks and their associated habitat. In response to this, in 2018 Inland Fisheries Ireland (IFI), carried out:

- a rapid catchment-wide assessment of the physical state of the river to adequately support salmonid stocks and identify sections where remediation may be required;
- a catchment-wide assessment of the status of salmonid stocks and comparison with available historical information; and
- a review of the water quality trends in the catchment.

This work was undertaken to inform the development of appropriate fisheries management measures to support salmonid stocks in the Crana catchment.

3 Study area

The River Crana catchment (area 101.3 km^2) located on the Inishowen Peninsula, Co. Donegal, comprises the 16 km River Crana main channel and significant tributaries including the Camowen, Evishbreedy (Owennasop), Glashagh, Meenatomish and Owenboy (Figure 1). Fullerton Dam and associated Reservoir, located in the upper catchment, was completed in 1998 as a municipal water supply for the local region (Roche, 2001; Bridle *et al*. 2002). In the upper catchment, peat moorland, sections of plantation forestry and sheep-grazed rough pasture predominate. Agricultural grassland (rough and well-maintained pasture) is an increasing feature of the landscape in the main channel of the middle catchment and predominates in Owenboy tributary where some small-scale industrial operations are additionally present. The lower portion of the main channel principally flows through agricultural pastureland, followed by low-density urban development and semi-natural parkland in Buncrana town as the river flows to the sea at Lough Swilly (Figure 2). Fish stocks in the River Crana Co. Donegal predominately comprise salmonids (Atlantic salmon, brown /sea trout) and eels.

A compensatory flow regime is in operation at Fullerton Dam to support salmonid stocks as follows:

- a constant *base flow* minimum of 0.025m^3/s;
- twice monthly *freshet* releases from June to December (with hydrograph peaking at 5m^3/s) to simulate natural flood events and supplement river flows to encourage upstream migration to spawning grounds;
- *flushing flows* (with hydrograph peaking at 8m^3/s) to flush fine sediments from spawning gravels which are timed to coincide with natural storm events, with single releases in October or November over a 24-hour period;
- constant release *spawning flows* in the period November to December which supplement natural flow to achieve a maximum of 0.75 m^3/s; and
- *smolt flows* to facilitate migration in the period April to May at a constant rate of 0.3 m^3/s during night-time hours.

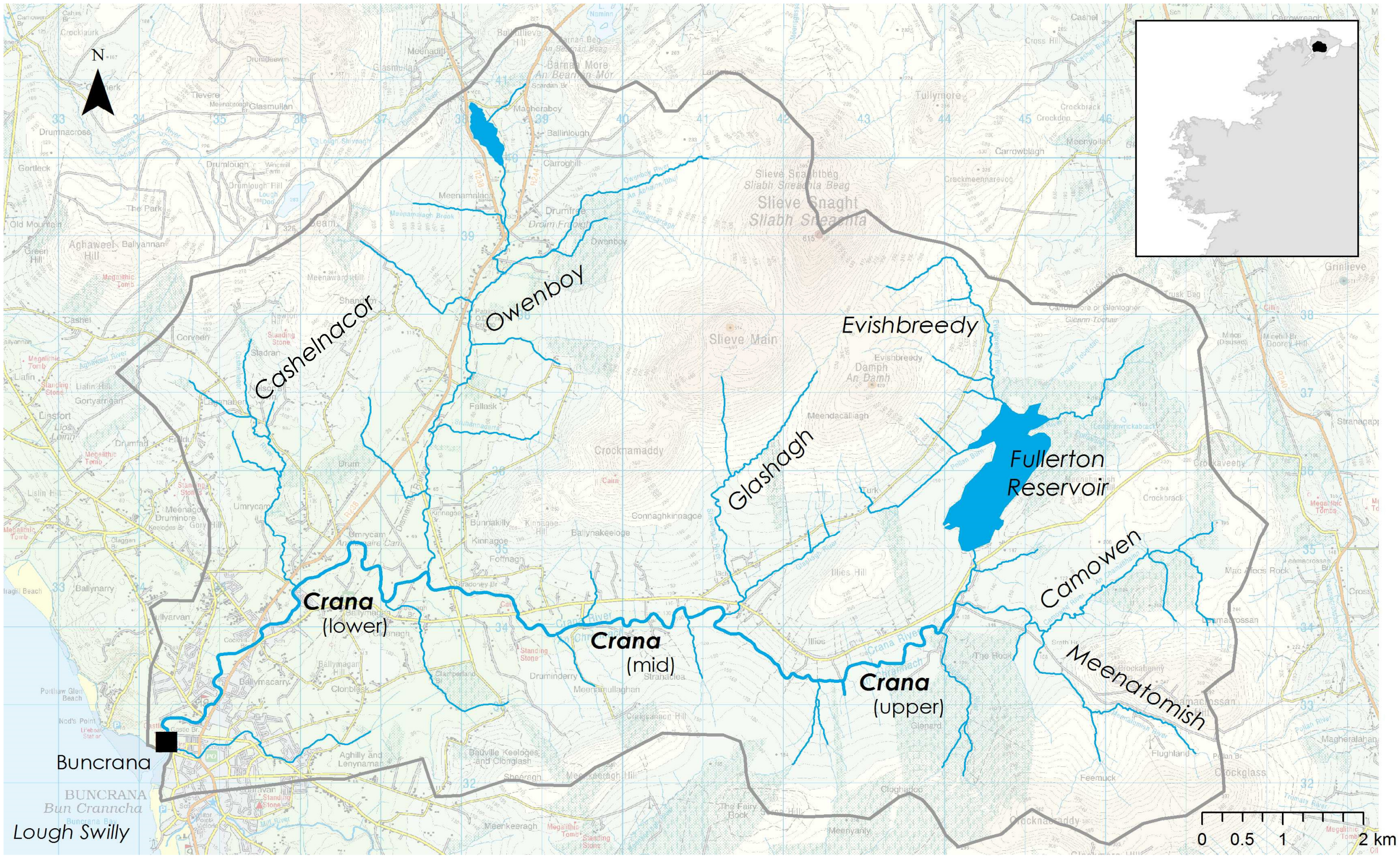

Figure 1 River Crana catchment (bounded in grey colour) highlighting principal constituent waters.

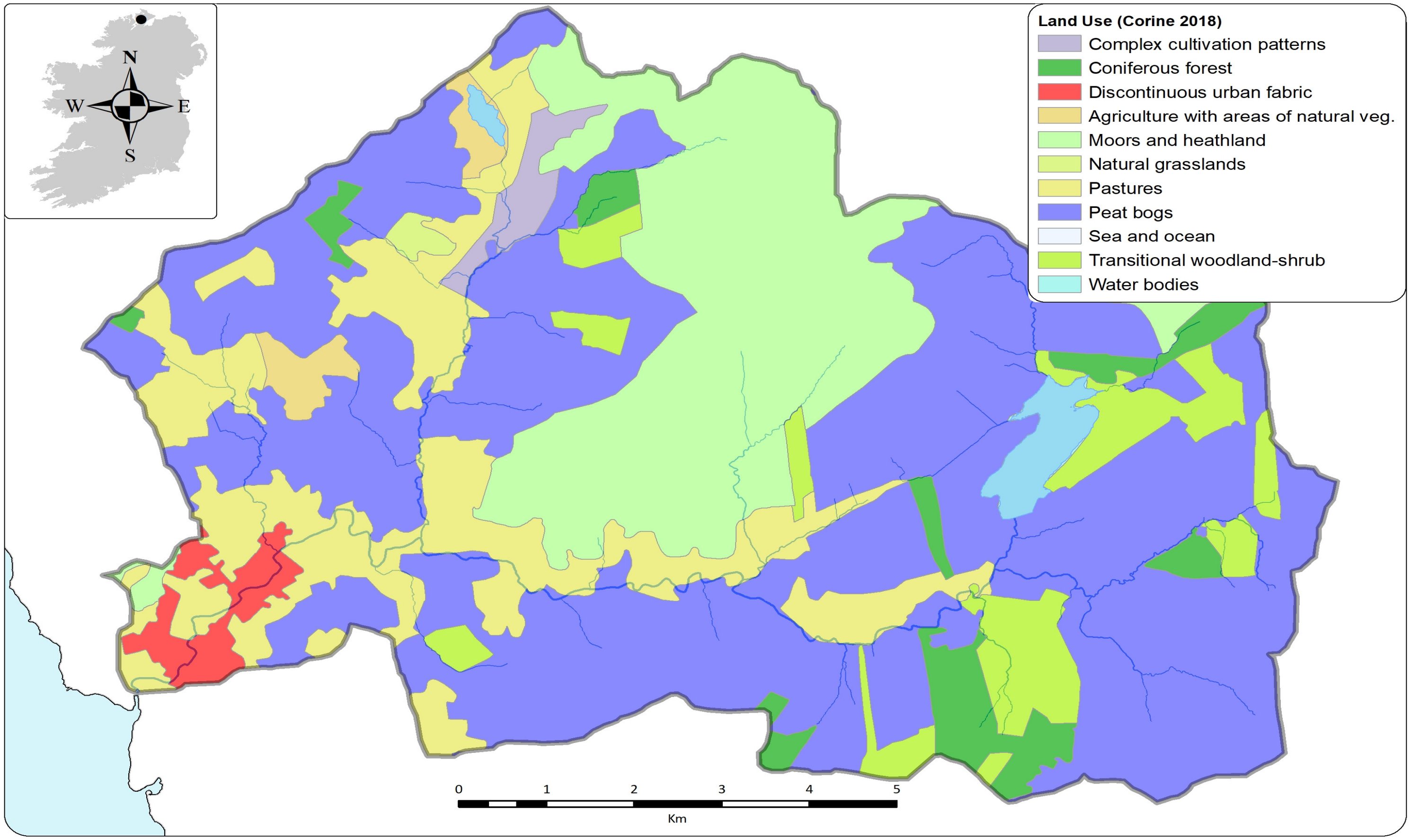

Figure 2 Land use in the River Crana catchment (CORINE land cover data).

4 Methods

4.1 Fish stock assessment

Extensive backpack electrofishing sampling was carried out in August 2018 throughout the River Crana catchment at both main channel and tributary sites to establish the status of resident salmonid stocks. Two methodologies were utilised as follows:

- ***Standard five-minute CWEF approach (salmonid fry index) – $CWEF_5$***

  Catchment-wide electrofishing ($CWEF_5$) is a semi-quantitative technique primarily used to assess salmon fry (0+) distribution and relative abundance in a system. It is used as part of the annual salmon scientific stock assessment which informs the regulation of salmon angling in Ireland (Gargan *et al*. 2009). In general, the survey goal is to sample sites throughout a catchment, in all channels with a stream order ≥ 2, which are accessible to adult salmon in order to map salmon fry distribution and abundance. This approach can also be used to assess juvenile brown trout stocks.

- ***Extended 10-minute CWEF methodology - $CWEF_{10}$***

  This method extends the typical $CWEF_5$ approach above and entails 10-minute timed sampling in representative sites usually comprising a riffle, pool, glide sequence. This type of mixed habitat tends to support 0+ fry and ≥ 1+ salmonid parr and other fish species. Sampling was conducted concurrently with $CWEF_5$. This method is detailed in Matson *et al*. (2018). The values obtained can be raised and converted to be reported as quantitative data (no. fish/m^2).

4.2 Collation of additional information on fish stocks

A $CWEF_5$ stock survey was undertaken in the Crana catchment in 2009 (a 2017 survey was incomplete and therefore, the results are not presented in this report). In addition, prior to the development of Fullerton Dam, fish stock status in the Crana catchment was quantitatively assessed in 1991 and 1999 using the multiple pass $CWEF_{10}$ approach (Gargan and Roche 1991, 1993a, 1993b; Roche 1994). These data have been converted to allow for comparison with the respective $CWEF_5$ and $CWEF_{10}$ surveys undertaken in August 2018. As each $CWEF_{10}$ site was sampled only once in 2018 (i.e. a 'single pass' electrofishing), only the 'first pass' from earlier years, was used to compare fish densities between years.

In addition, the output of the annual scientific stock assessment undertaken by The Expert Group on Salmon (TEGOS) which informs the regulation of salmon and sea trout angling in the Crana catchment is collated and presented. This annual assessment estimates the salmon stock in the river and forecasts returns in the following year, based on angling catches raised by an exploitation rate, with catch data taken from the most recent five-year time series available. If the predicted returns of fish are greater than the conservation limit (CL), this indicates that there is a surplus of fish which can be harvested without affecting the sustainability of the population. In essence, the CL is the minimum number of spawning salmon a river system should have to ensure its population is sustainable. The outcome of the annual assessment is communicated to IFI management who then advise the Minister for Communications, Climate Action and Environment if individual river systems should be open for harvest, open for C&R-only angling or closed, in the following year. A river system exceeding 100% of its CL is recommended to be open to harvest if the surplus is deemed to have a sufficient margin over the CL to minimise the risk of the quota being exceeded. A river meeting between 50% and 99% of its CL is recommended for opening on a catch and release-only (C&R-only) basis. Catchment-wide electrofishing data, if available, can also be used as an index of stock in a river system, whereby if the average salmon fry abundance is greater or equal to 17, TEGOS recommends that a river can be opened for C&R-only fishing. Since 2018, fisheries managers have designated a minimum fry threshold of 15 to permit C&R-only fishing on a salmon river system.

4.3 Ecological quality rating (EQR)

The ecological classification tool for fish in rivers (Fisheries Classification Scheme 2 (FCS2-Ireland)) was developed to assign ecological status to fish in rivers for the Republic of Ireland and Northern Ireland along with a separate version for Scotland (SNIFFER, 2011). The FCS2-Ireland is a geostatistical model based on Bayesian probabilities and works by comparing various fish community metric values within a site (observed) to those predicted (expected) for that site under reference (un-impacted) conditions. THE Ecological Quality Rating (EQR) assessment takes into account site-specific factors such as fish community composition, distance to sea/ from source, geology, gradient and alkalinity. The resulting output is an EQR between 1 and 0 for each site, corresponding to the five different ecological status classes of *High*, *Good*, *Moderate*, *Poor* and *Bad* (Kelly *et al*. 2017). The EQR assessment was conducted on the $CWEF_{10}$ data for 1991, 1999 and 2018.

4.4 Water quality

Water quality information for the Crana catchment was collated from the Environmental Protection Agency (EPA) Q-value assessments (1973, 1977, 1981, 1986, 1987, 1991, 1996, 1998, 2001, 2004, 2007, 2010, 2013 and 2016). A Q-value (1=bad; 2=poor, 3=moderate; 4=good; 5=high) is assigned to a site based primarily on relative proportion of the resident pollution sensitive to tolerant macroinvertebrate community present (Table 1). The scheme mainly represents the effects of organic pollution (i.e. eutrophication and de-oxygenation) but where a toxic effect is apparent or suspected the suffix '0' is added to the biotic index (e.g. 3/0) (EPA 2013).

Table 1 EPA Q-value classification (EPA 2013)

Q-value	WFD status	Pollution status	Condition
Q5, Q4-Q5	High	Unpolluted	Satisfactory
Q4	Good	Unpolluted	Satisfactory
Q3-Q4	Moderate	Slightly polluted	Unsatisfactory
Q3, Q2-Q3	Poor	Moderately polluted	Unsatisfactory
Q2, Q1-Q2	Bad	Seriously polluted	Unsatisfactory

Intermediate values (Q1-2, 2-3, 3-4 etc.) denote transitional conditions

4.5 Habitat assessment

An aerial photographic survey of the River Crana main channel and its significant tributaries was undertaken from the 17–24 July 2018 using a Dji Phantom 4 Professional drone and associated camera (model FC3010). In total, c. 30 km of channel was photographed. River segment images were examined to identify and describe the following:

- geo-hydromorphological character (bank structure, flow profile, channel substrate composition, substrate displacement);
- floodwater impacts (e.g. bank erosion, structural damage to built environment, riparian zone changes);
- land use adjacent to the channel;
- level of instream vegetation cover;
- excess siltation issues;
- flood remedial measures undertaken by landowners; and
- potential fisheries management actions that may be required to restore damaged habitat, maintain fish productivity and/or better protect fish stocks.

The complete results of this survey are presented in the IFI Research & Development preliminary report *Aerial & fish stock survey of the River Crana catchment, Co. Donegal* (Millane *et al*. 2018) which can be accessed at https://www.fisheriesireland.ie/extranet/fisheries-research-1/1551-aerial-fish-stock-survey-of-the-river-crana-catchment-co-donegal/file.html .

5 Results

A complete set of results of the $CWEF_5$ (2009, 2018) and $CWEF_{10}$ (1991, 1999, 2018) surveys undertaken in the Crana are presented in Appendix 1 to Appendix 3. It is important to note that some stocking activities using unfed salmon fry (44,400-121,000 per annum) were undertaken in the catchment between 1996 and 2008 to compensate for the loss of productivity as a result of the installation of the dam (a summary of these activities is provided in Appendix 4; Roche 1994). Therefore, records of salmon fry or parr in such locations in 1999/2009 but not in other sampling occasions are likely a consequence of this. Furthermore, some habitat enhancement measures were undertaken in the mid-Camowen in the 2000s including gravel input, to develop spawning and nursery areas where habitat was previously unsuitable, and works to enable passage over a waterfall barrier.

5.1 Fish stock status – salmon fry

The $CWEF_5$ and $CWEF_{10}$ catchment-wide electrofishing results for 2018 (Figure 3 and Figure 5, respectively) show that salmon fry are predominately distributed in the Crana main channel, and the lower portions of the Owenboy and Glashagh tributaries. Fry abundance is particularly high in the Crana (upper) main channel (mean 40.1 fry/5-min.). Upstream of the Three Sisters Bridge fry were only recorded in the lowermost section of the Camowen and directly downstream of the Fullerton Dam outflow. Fry abundance is variable in the middle and lower sections of the Crana main channel (range 3.6 – 21.9 fry/5-min.).

In general, there is no consistent catchment-wide upward or downward trend in salmon fry abundance between 2018 and 2009 in the $CWEF_5$ sites sampled on both occasions (Figure 3 and Figure 4, respectively). However, there is a notable decrease in fry abundance in 2018 in the uppermost site sampled on the Owenboy where salmon fry were present (site 514; from 49.8 to 3 fry/5-min.). This is further evident at a proximal site ($CWEF_{10}$ site 1027), where salmon fry densities were lower in 2018 (0.1 fry m^{-2}), than both previous sampling periods (1999, 0.28 fry m^{-2} and 1991, 0.53 fry m^{-2}) and reflective of upstream ($CWEF_{10}$ site 1025) where no fry where detected in 2018 (Figure 5), despite being present in moderate densities (0.25 fry m^{-2}) in 1999 (Figure 6). Further to this, in 2018 no salmon fry were recorded at the two sites sampled ($CWEF_5$ sites 519 and 528) in the vicinity of the Camowen-Meenatomish confluence despite being found there (site 519) and nearby (site 521) previously in 2009.

Overall, mean salmon fry density at $CWEF_{10}$ sites fished on all three sampling occasions (1991, 1999 and 2018; Figure 8) was similar in 2018 (0.29 fry m^{-2}) and 1999 (0.3 fry m^{-2}), both of which were higher than the mean fry density in 1991 (0.18 fry m^{-2}).

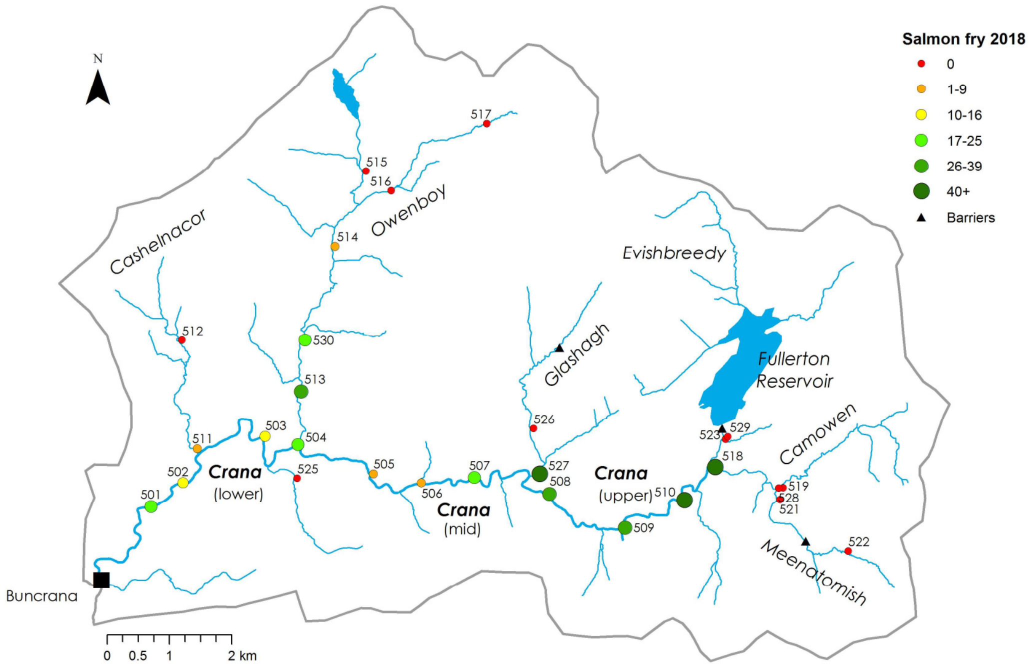

Figure 3 Number of salmon fry recorded at $CWEF_5$ sites the River Crana catchment in August 2018 (no. / 5 min fishing).

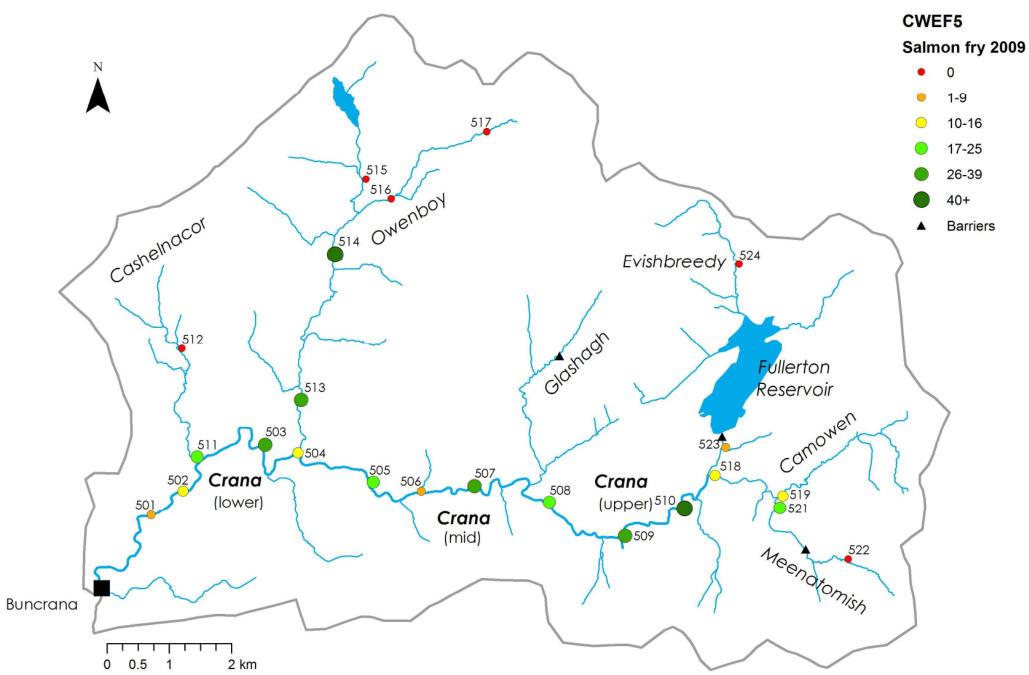

Figure 4 Number of salmon fry recorded at $CWEF_5$ sites in the River Crana Catchment in 2009 (no. / 5 min fishing).

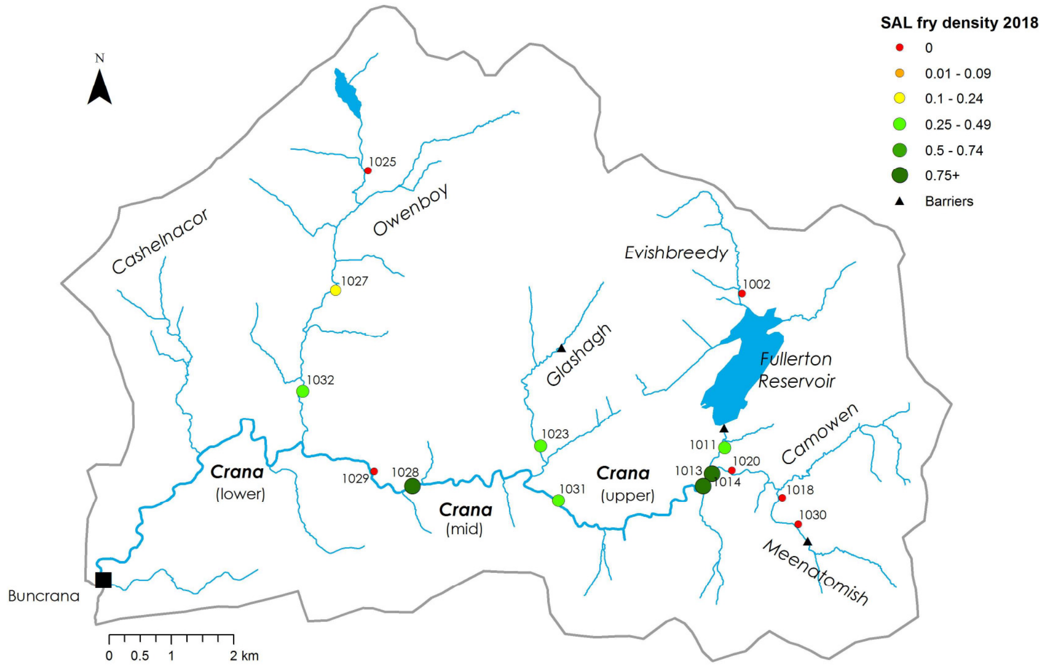

Figure 5 Density of salmon fry (no./m^2) recorded at $CWEF_{10}$ sites sampled in the River Crana catchment in August 2018 ($CWEF_{10}$ 'single pass').

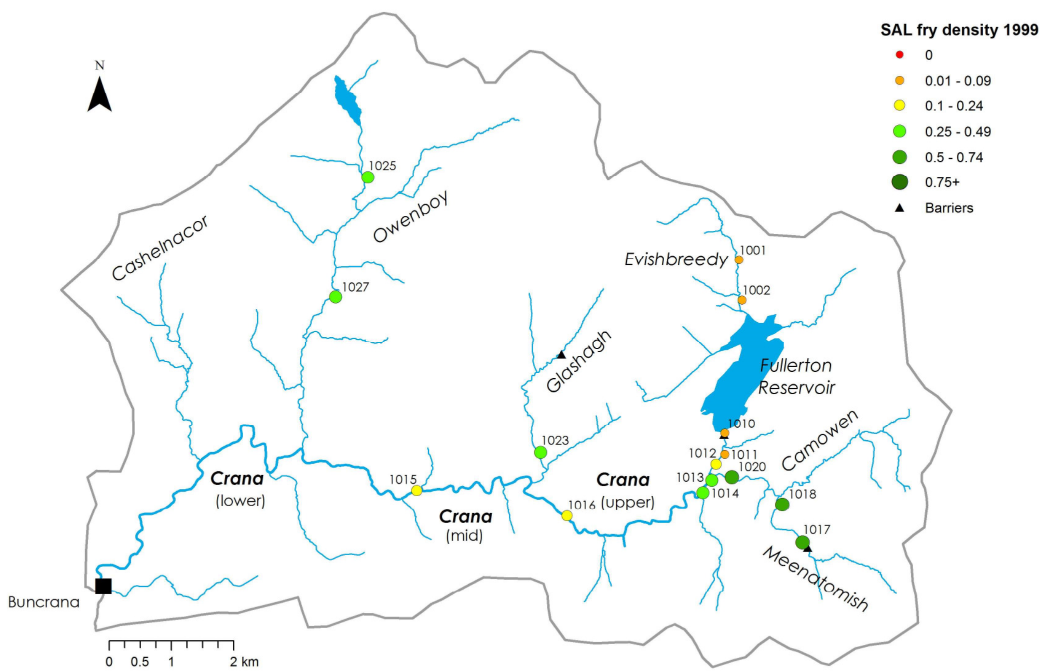

Figure 6 Density of salmon fry (no./m^2) recorded at $CWEF_{10}$ sites sampled in the River Crana catchment in 1999 ('first pass' only).

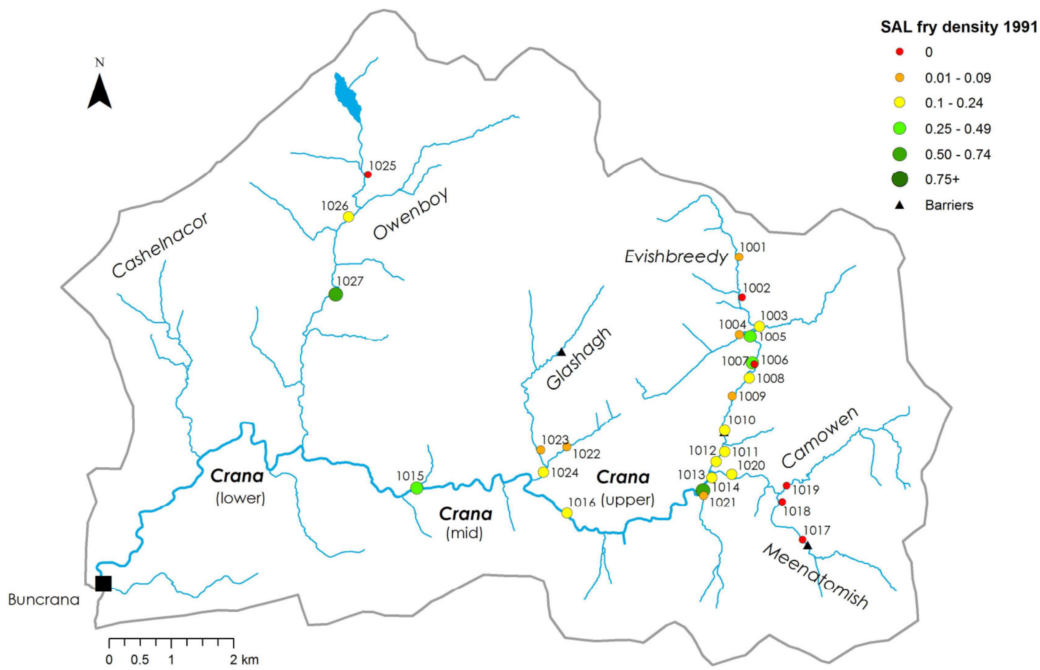

Figure 7 Density of salmon fry (no./m²) recorded at CWEF10 sites sampled in the River Crana catchment in 1991 ('first pass' only).

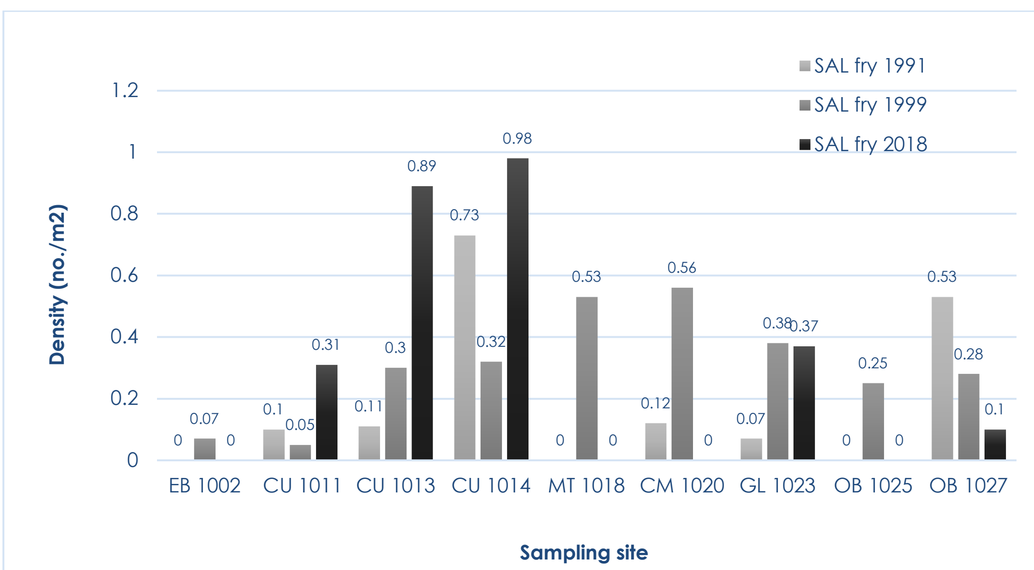

Figure 8 Density of salmon fry at CWEF10 sites fished in all sampling occasions (1991, 1999 and 2018).

5.2 Fish stock status – salmon parr

The $CWEF_{10}$ survey in 2018 shows salmon parr are present in reasonable densities (≥0.2 parr m^{-2}) in the majority of the main Crana channel and lowermost section of the Glashagh. Indeed, the two sites fished in Crana (mid) had the highest recorded parr densities of the 2018 survey (0.48 and 0.64 parr m^{-2}) (Figure 9). Relatively lower densities were recorded at sampling sites in the lower portion of the Owenboy, lower Camowen and Meenatomish tributaries as well as in the Crana (upper) downstream of Fullerton dam (Figure 9). The main Crana channel has relatively higher salmon parr densities at two of the three comparable sites also electrofished in the preceding 1999 $CWEF_{10}$ survey (Figure 12) and are similar to 1991. Densities in the two uppermost sites in the Owenboy ($CWEF_{10}$ sites 1025 and 1027) are relatively lower in 2018 than they were in 1999 (Figure 9 and Figure 10).

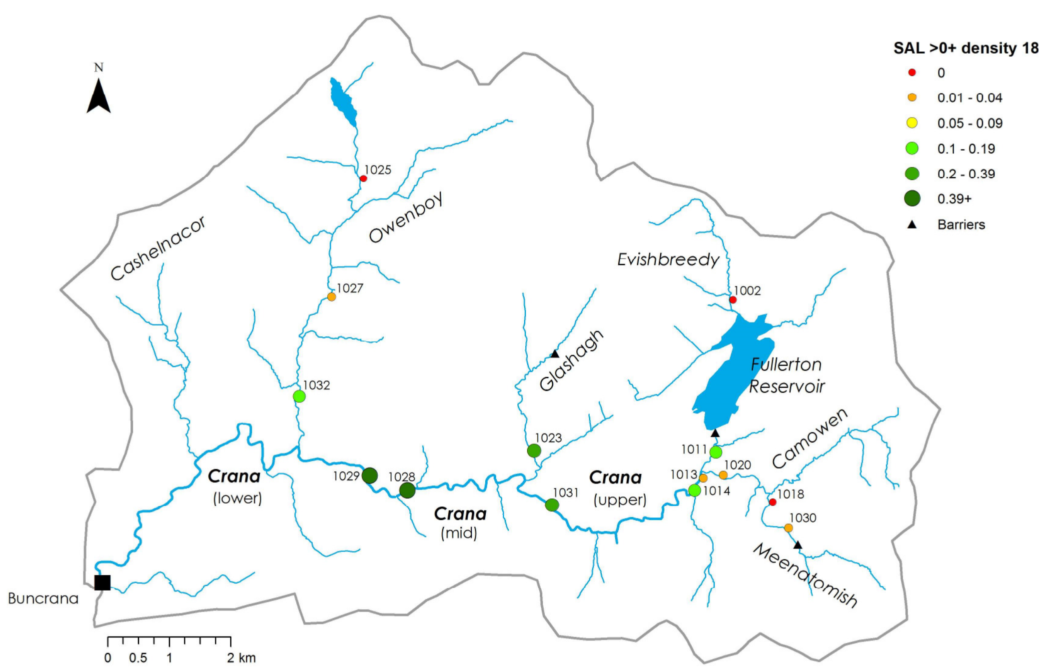

Figure 9 Density of salmon parr recorded at $CWEF_{10}$ sites sampled in the River Crana catchment in August 2018 ('single pass' only).

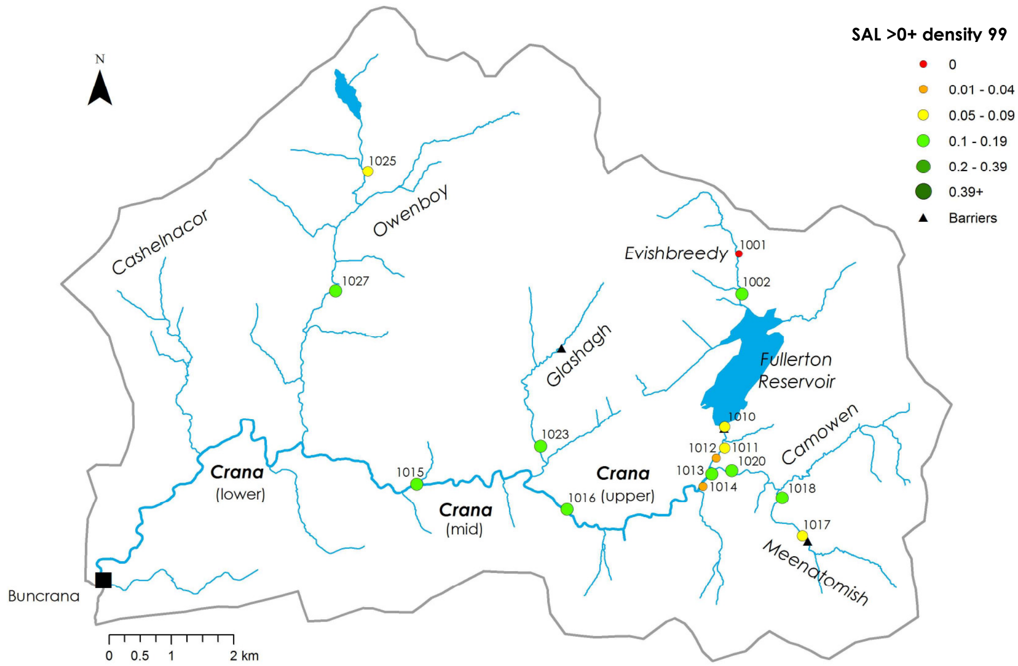

Figure 10 Density of salmon parr recorded at $CWEF_{10}$ sites sampled in the River Crana catchment in 1999 ('first pass' only).

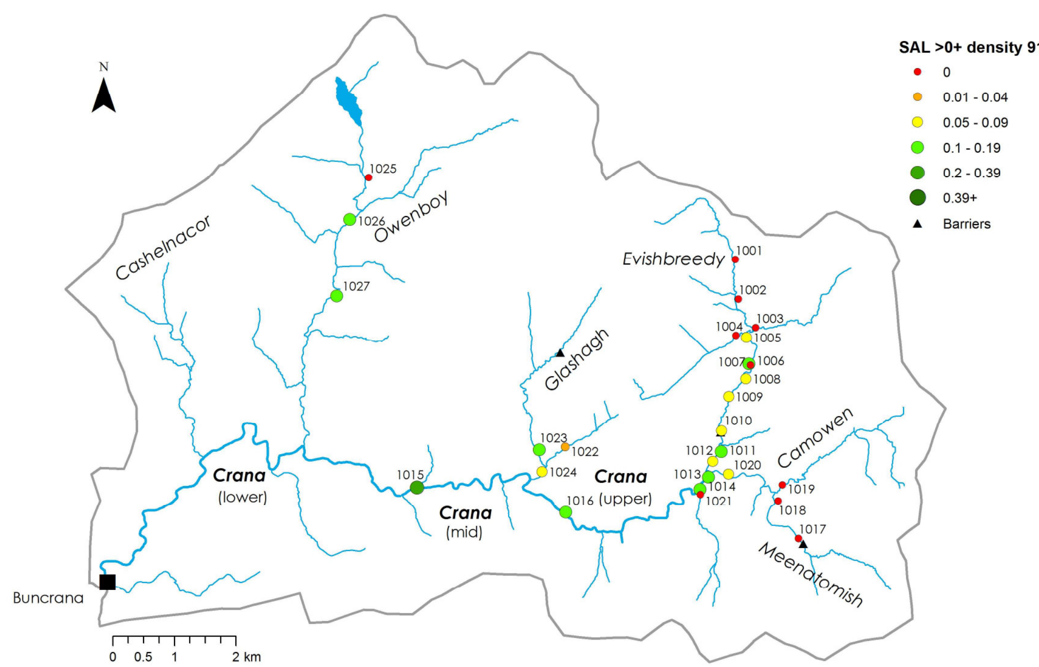

Figure 11 Density of salmon parr recorded at $CWEF_{10}$ sites sampled in the River Crana catchment in 1991 ('first pass' only).

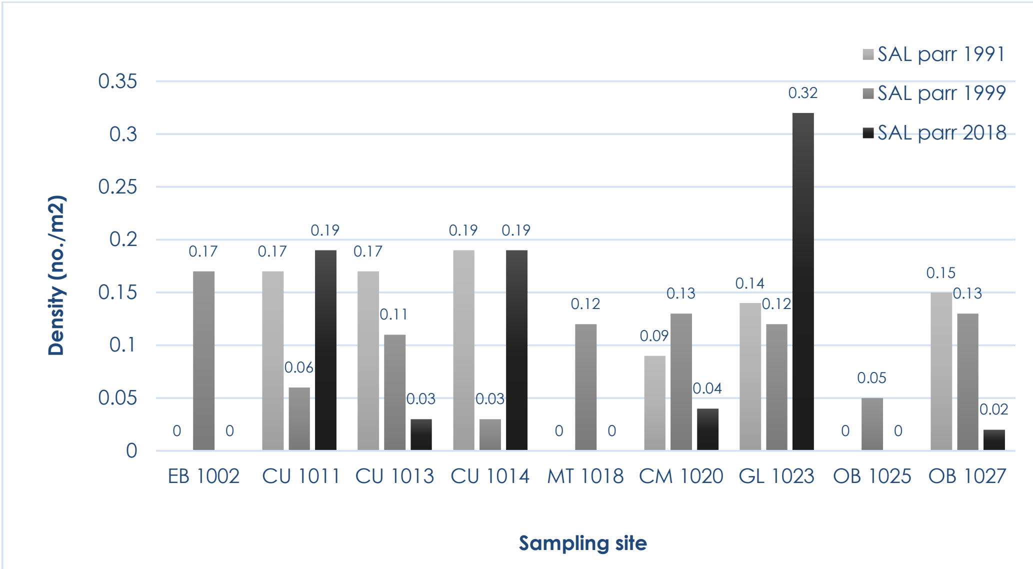

Figure 12 Density of salmon parr at $CWEF_{10}$ sites fished in all sampling occasions (1991, 1999 and 2018).

5.3 Fish stock status – trout fry

Trout fry are widely distributed throughout the Crana Catchment and were recorded at the vast majority of sampling sites on all $CWEF_5$ (2009, 2018) and $CWEF_{10}$ (1991, 1999 and 2018) sampling occasions (Figure 13 – Figure 17). Mean trout fry abundance was marginally higher in 2018 (mean 7.1 fry /5-min.) compared to 2009 (mean 6 fry /5-min.) (Figure 13 and Figure 14). Mean trout fry density in $CWEF_{10}$ sites fished on all three sampling occasions (1991, 1999 and 2018) was higher in 2018 (0.15 fry m^{-2}) than, both 1999 (0.05 fry m^{-2}) and 1991 (0.11 fry m^{-2}) (Figure 18).

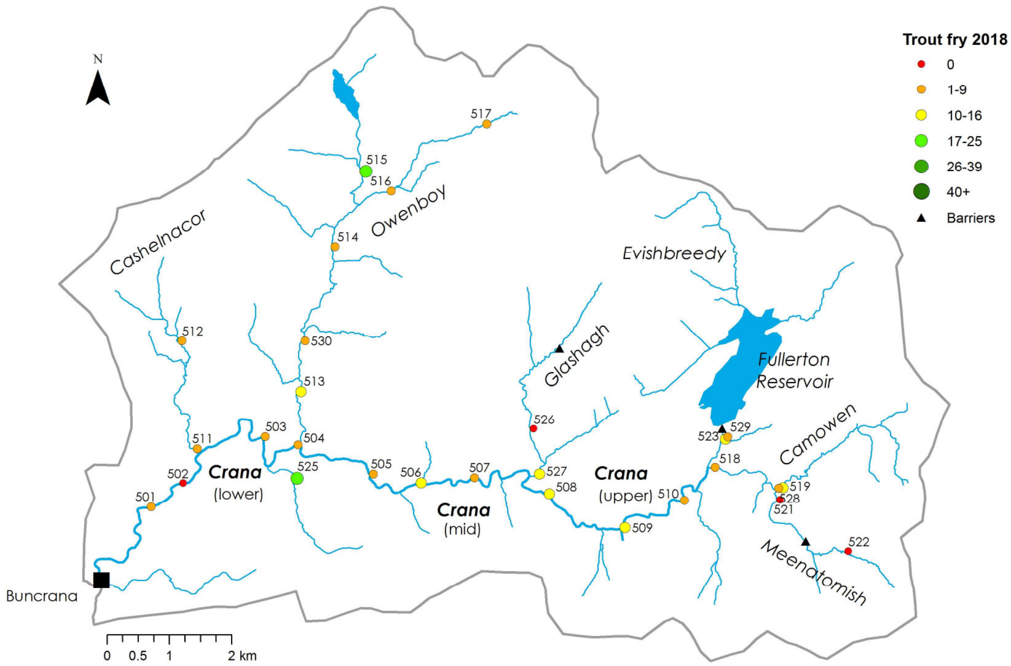

Figure 13 Number of trout fry recorded at CWEF5 sites the River Crana catchment in August 2018 (no. / 5 min fishing).

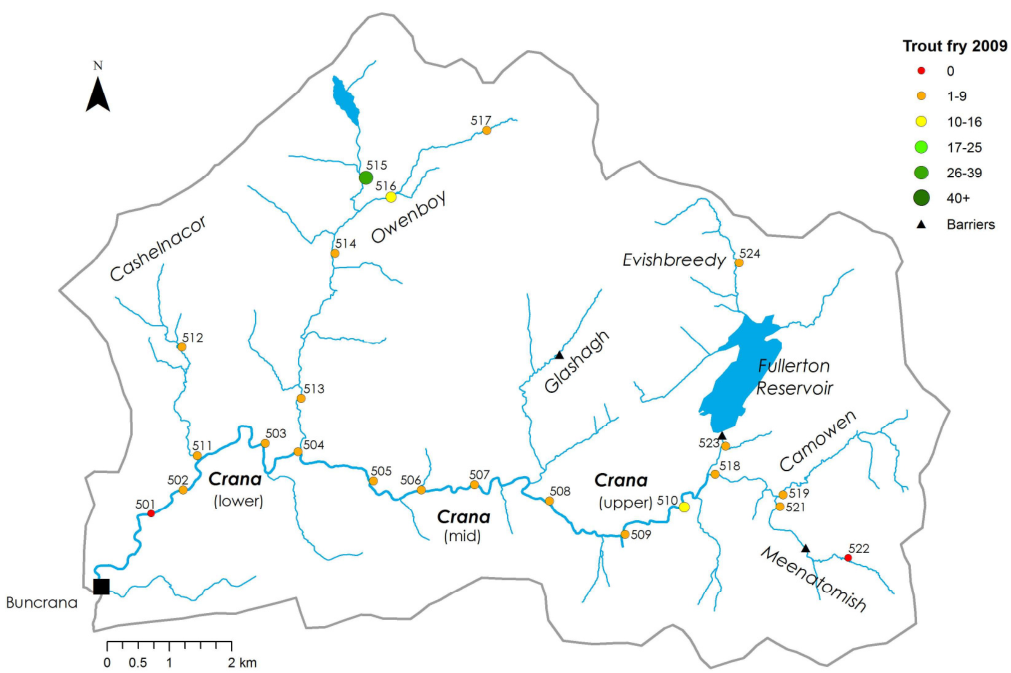

Figure 14 Number of trout fry recorded at CWEF5 sites the River Crana catchment in 2009 (no. / 5 min fishing).

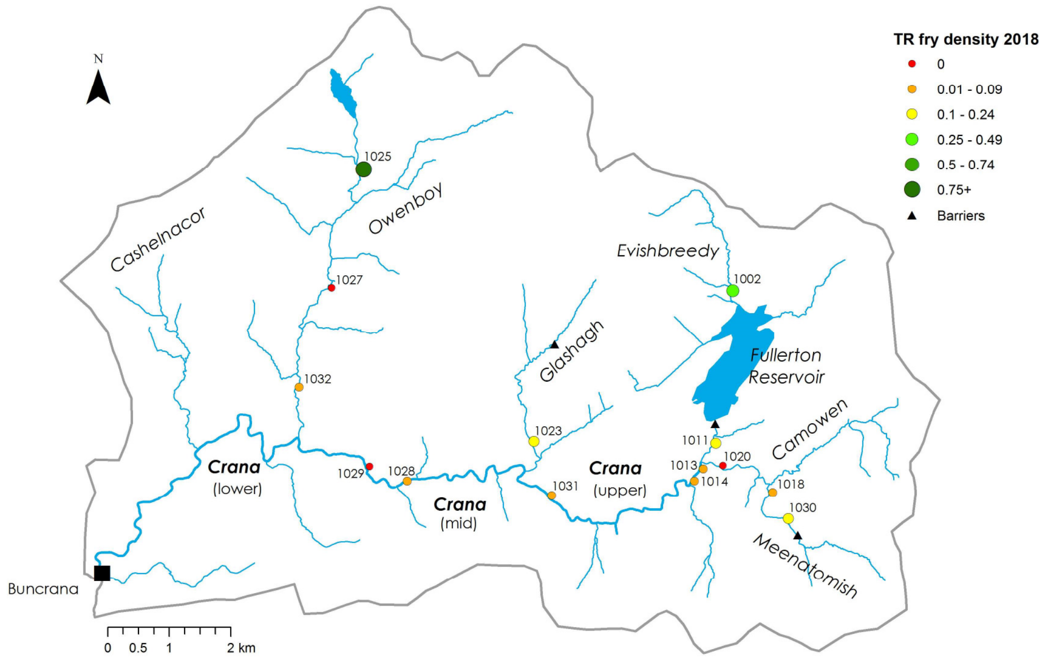

Figure 15 Density of trout fry (no./m²) recorded at CWEF10 sites sampled in the River Crana catchment in August 2018 (CWEF10 'single pass').

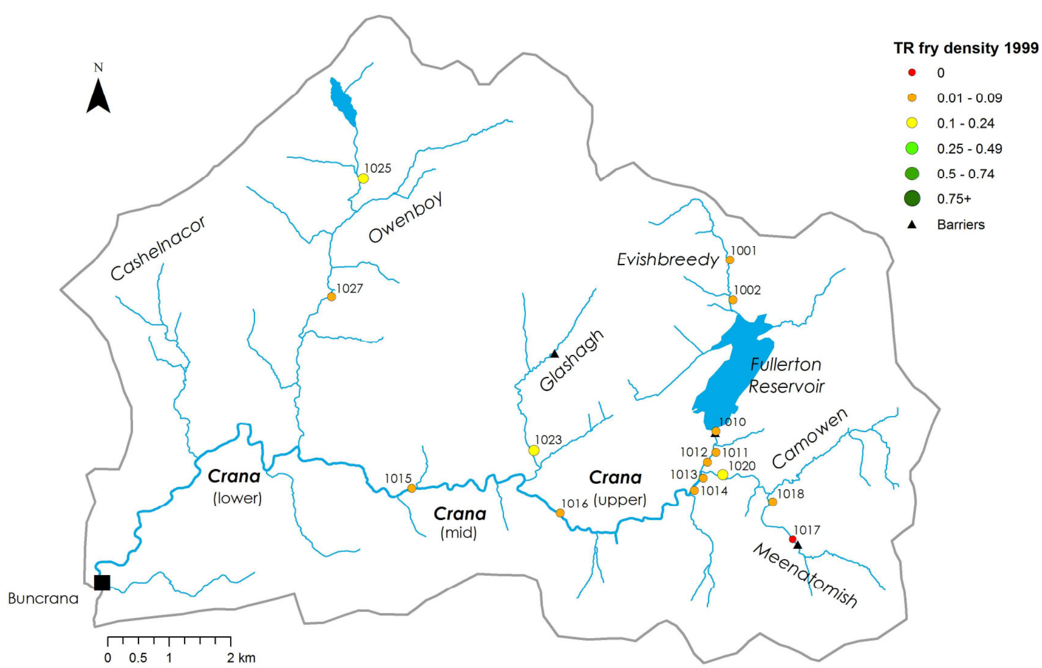

Figure 16 Density of trout fry (no./m²) recorded at CWEF10 sites sampled in the River Crana catchment in 1999 ('first pass' only).

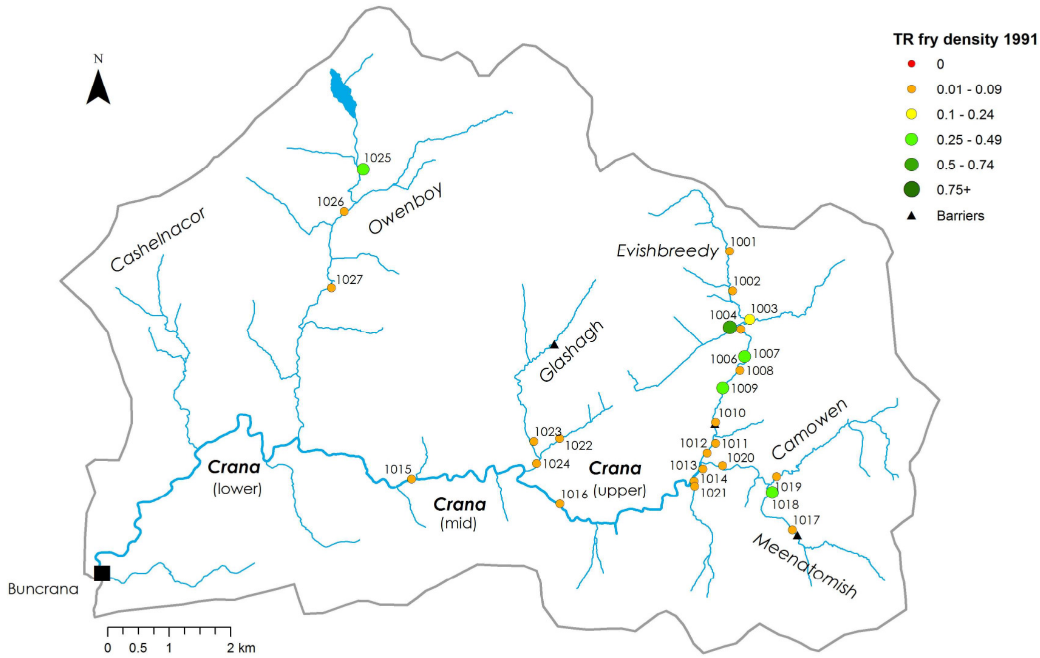

Figure 17 Density of trout fry (no./m²) recorded at CWEF10 sites sampled in the River Crana catchment in 1991 ('first pass' only).

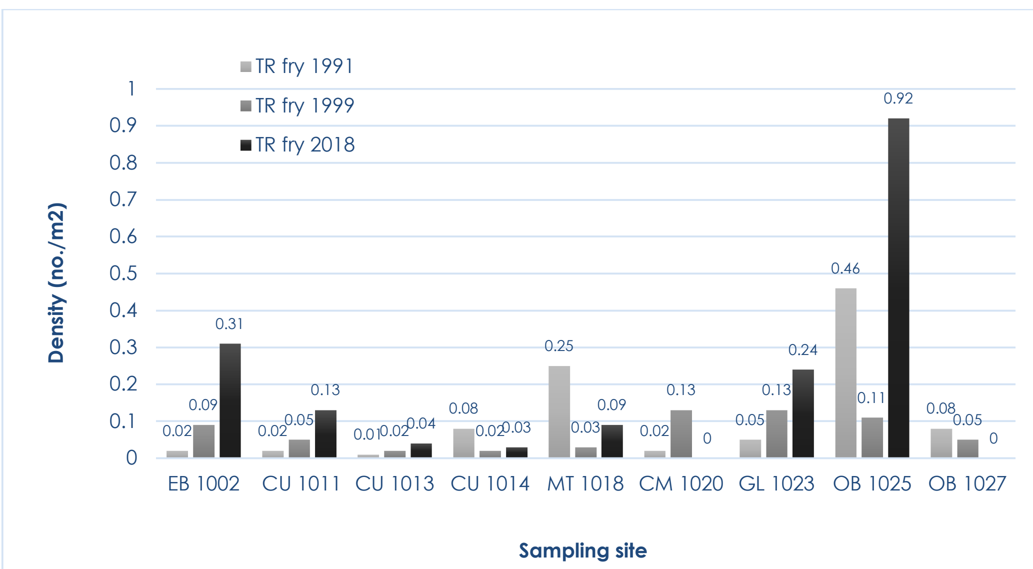

Figure 18 Density of trout fry at CWEF10 sites fished in all sampling occasions (1991, 1999 and 2018).

5.4 Fish stock status – trout parr and adults

Trout >0+ (i.e. parr and adult fish) are widely distributed throughout the Crana Catchment and were recorded at all sampling sites on all $CWEF_{10}$ (1991, 1999 and 2018) sampling occasions (Figure 19–Figure 21). Mean trout >0+ density in $CWEF_{10}$ sites fished on all three sampling occasions (1991, 1999 and 2018) was higher in 2018 (0.13 >0+ m^{-2}) than1999 (0.07 >0+ m^{-2}) and comparable to 1991 (0.11 >0+ m^{-2}) (Figure 22).

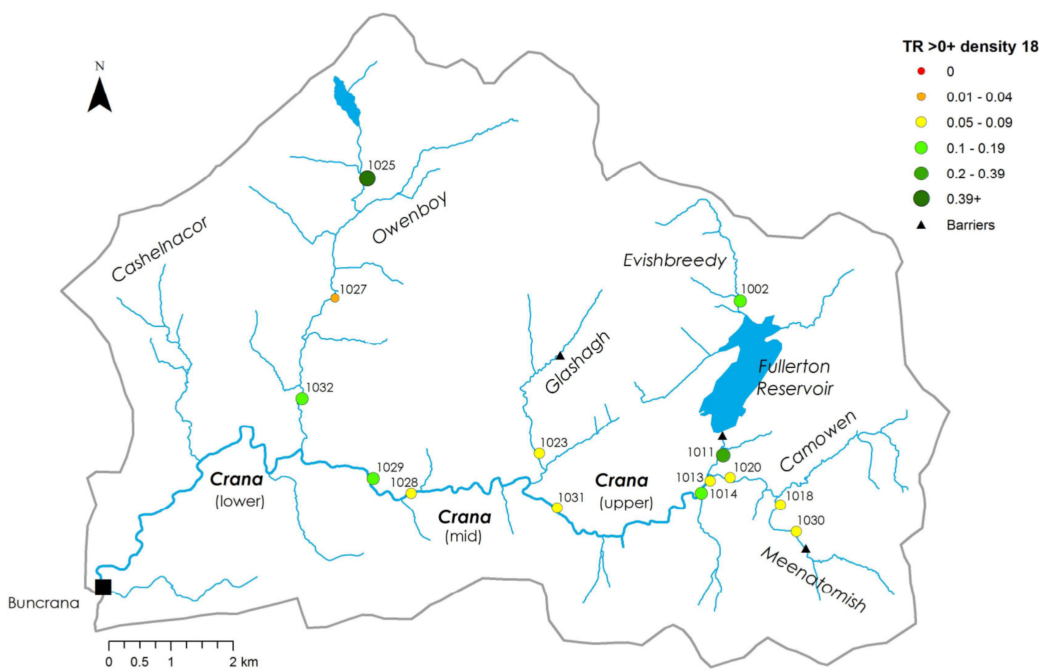

Figure 19 Density of trout parr and adults recorded at $CWEF_{10}$ sites sampled in the River Crana catchment in August 2018 ('single pass' only).

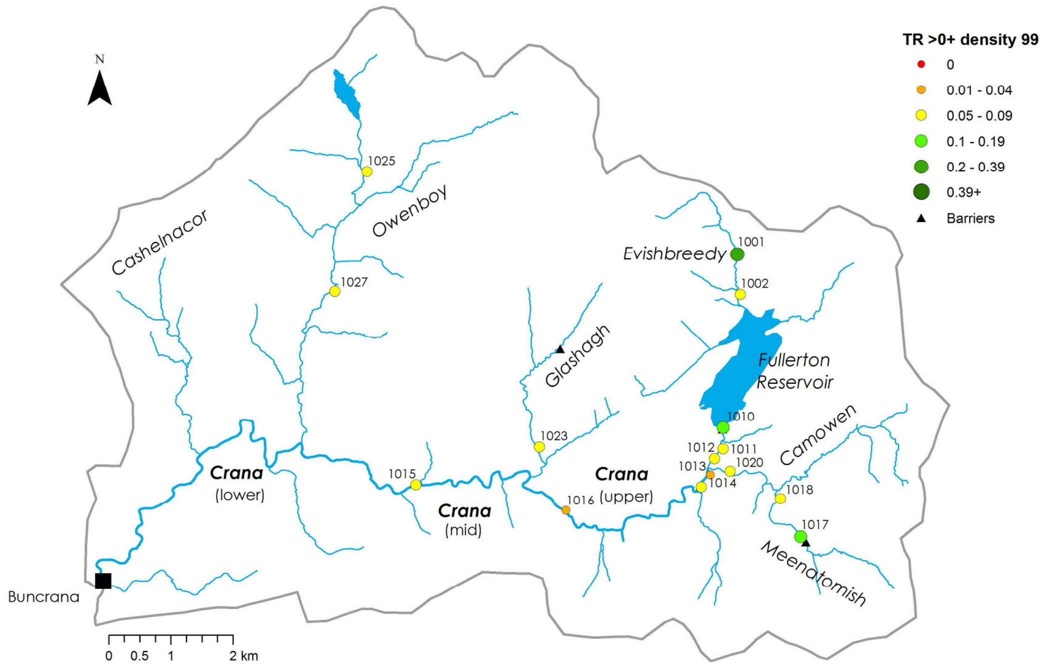

Figure 20 Density of trout parr and adults recorded at CWEF10 sites sampled in the River Crana catchment in 1999 ('first pass' only).

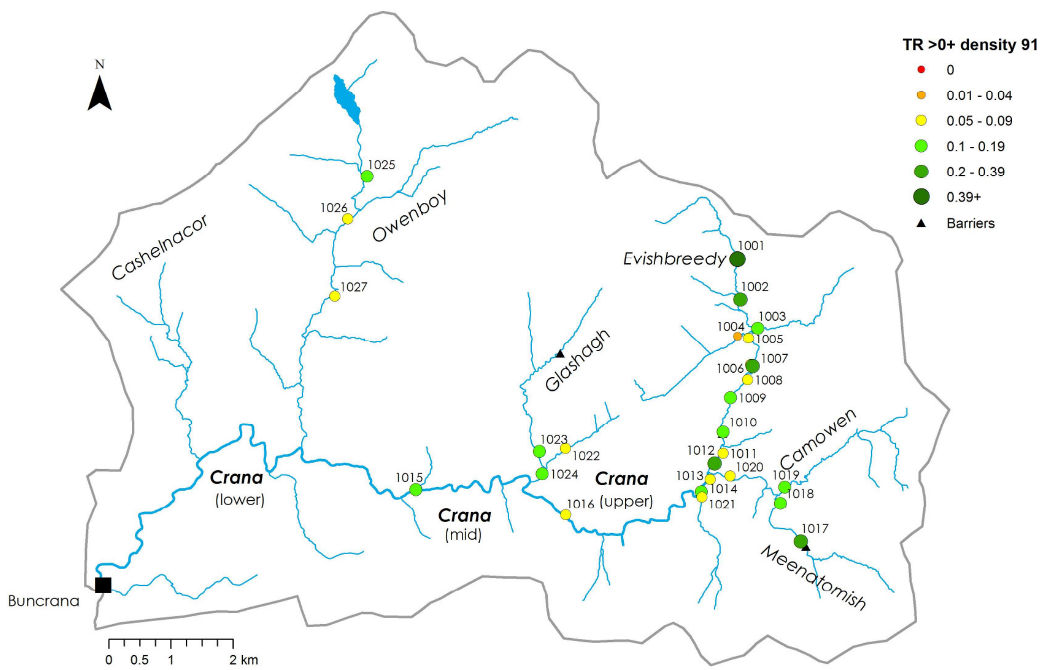

Figure 21 Density of trout parr and adults recorded at CWEF10 sites sampled in the River Crana catchment in 1991 ('first pass' only).

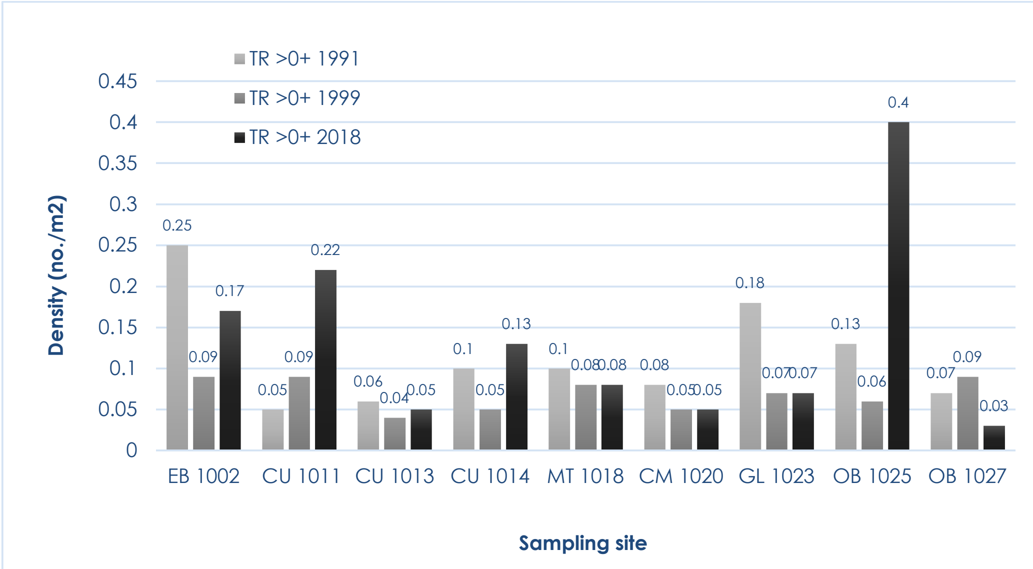

Figure 22 Density of trout >0+ at $CWEF_{10}$ sites fished in all sampling occasions (1991, 1999 and 2018).

5.5 TEGOS scientific stock assessments

Salmon angling in the River Crana catchment has been designated as C&R-only since 2016. Previous to this, the river was open for anglers to harvest fish as the annual scientific stock assessment identified a fish surplus above the conservation limit (CL=1072) which was available for sustainable exploitation. This change in fisheries management status has coincided with the reduction in the rolling mean five-year angling catches used to annually estimate the resident adult salmon stocks and thus ascertain the proportion of conservation limit attained. It should be noted that stock estimates for the Crana are based on the angling catch and an associated exploitation rate. The exploitation rate applied is lower when a river is designated C&R-only to account for the lower fishing pressure on the stock. This has the effect of increasing the stock estimate than otherwise would be the case. For the 2019 salmon fishery, the river was marginally below CL at 0.94 (Table 2).

Draft regulations for the 2020 fishing season have just been published for public consultation (*Wild Salmon and Sea Trout Tagging Scheme Regulations 2019 and Conservation Measures for 2020 Season*). This identifies a surplus of 99 fish for the River Crana and recommends that the fishery operates under brown carcass tags (i.e. one tag issued per angler at a time) to closely monitor the harvest during the fishing season.

Table 2 River Crana system: salmon angling records and associated fisheries status.

Year	Rod harvest	Rod C&R	Total angling catch	Surplus	5-year average	Prop. CL attained	Fisheries status
2019	TBC	TBC	TBC	-65	TBC	0.94	C&R
2018	0	56	56	-467	84	0.57	C&R
2017	0	78	78	-281	103	0.74	C&R
2016	0	100	100	-41	131	0.96	C&R
2015	66	37	103	281	144	1.26	open
2014	52	32	84	160	171	1.15	open
2013	71	77	148	635	186	1.59	open
2012	106	113	219	458	226	1.4	open
2011	109	57	166	664		1.59	open
2010	144	94	238	677		1.6	open
2009	106	52	158	683		1.61	open
2008	251	97	348	611		1.55	open

Angling catches sourced from annual IFI / CFB catch statistics reports; fisheries status sourced from annual SSCS/ TEGOS reports; CL = conservation limit; TBC = official catches yet to be published.

5.6 EQR

In 2018, nine of the 14 (64%) $CWEF_{10}$ sites assessed had an Ecological Quality Rating (EQR) of at least *good* status with seven of these achieving a *high* rating (Figure 23). Sites on the upper portion of the main Crana channel, lower Glashagh, directly downstream of Fullerton Dam and in the uppermost and lowermost sites on the Owenboy achieved a *high* EQR status. Only two sites were deemed to be of *bad* EQR status (mid-site on the Owenboy and a site on the lower Camowen). In 1999, all sites of the 15 assessed with the exception of a single *moderate* EQR status site on the upper Evishbreedy were deemed to be of least *good* EQR status or higher (Figure 24). In 1991, a greater number of sites were sampled in the upper catchment prior to the installation of Fullerton Dam and Reservoir (Figure 25). Variable EQR status is evident here with sites predominately ranging from *moderate* to *high*.

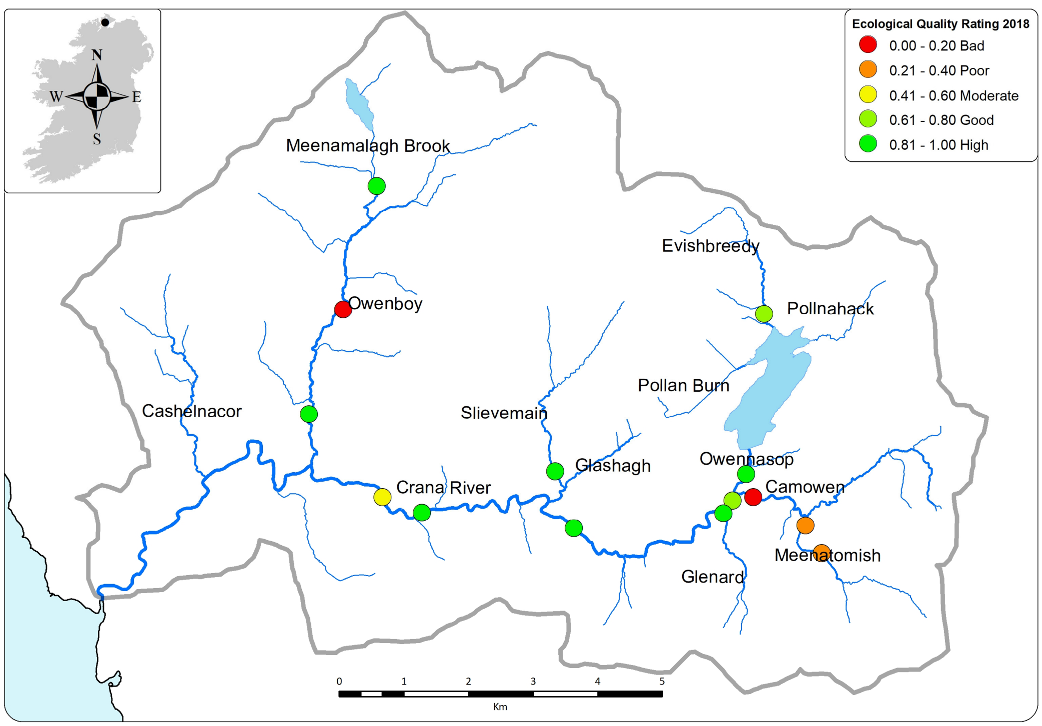

Figure 23 Ecological Quality Rating of fish communities in River Crana Catchment based on 2018 $CWEF_{10}$ site data.

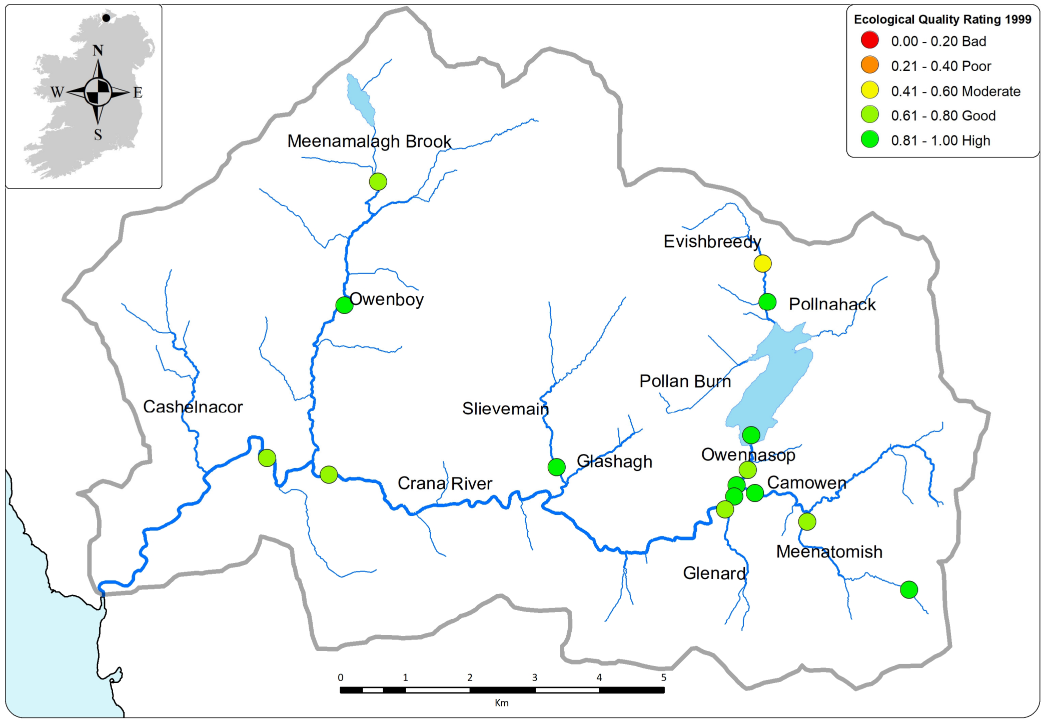

Figure 24 Ecological Quality Rating of fish communities in River Crana Catchment based on 1999 CWEF10 site data.

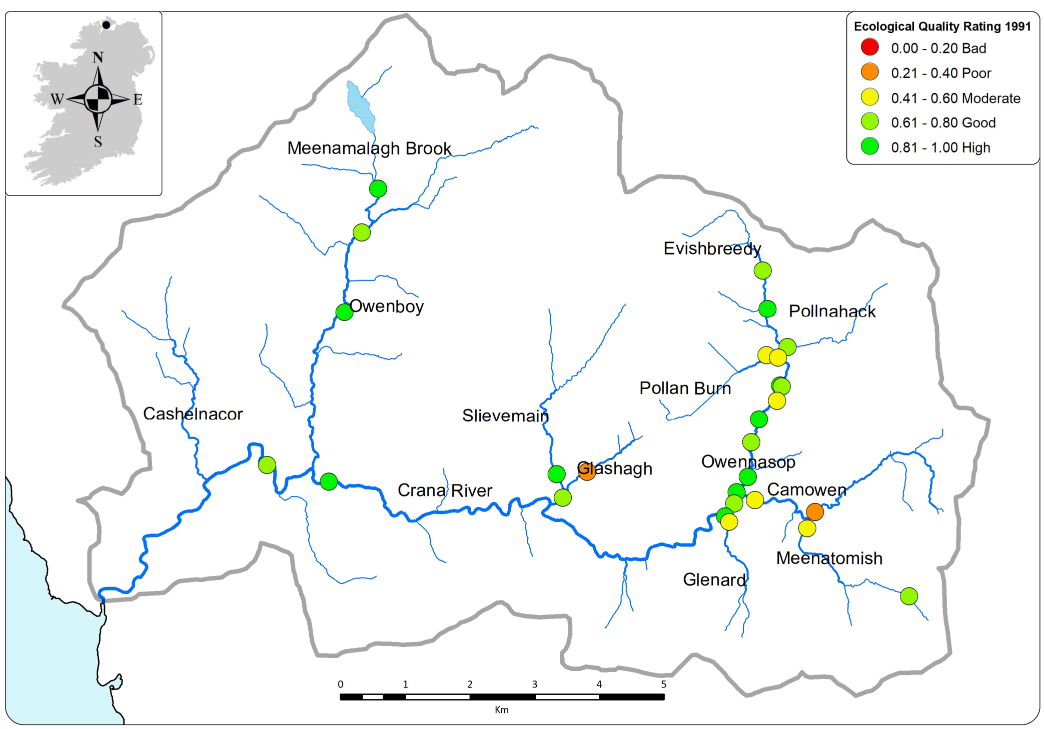

Figure 25 Ecological Quality Rating of fish communities in River Crana Catchment based on 1991 CWEF10 site data.

5.7 Water quality

Based on EPA Q-value site-specific assessments, water quality in the Crana catchment since 2007 is predominately of moderate status. Previous to this, (1973 to 2004), the majority of assessed sites in the system had good or high water quality designations (Figure 26 and Appendix 5). It is notable from the 2016 results that a toxic effect (designated *3/0*) was suspected at four sites in the catchment (at Druminderry Bridge, downstream of the bridge at Cockhill and downstream of Fullerton Dam on the main channel; and in the lower Cashelnacor). The National Characterisation Programme undertaken for the second cycle of the Water Framework Directive river basin management planning assigned water quality status designations to all six river sections that comprise the Crana Catchment based on 2010-2015 data (EPA 2019). It was found that 5 of the 6 river sections had a *poor* ecological status with the Crana (lower) the only river section to achieve a satisfactory *good* status designation. The characterisation identified a range of pressures acting upon the waterbodies within system including:

- cypermethrin toxicity from sheep dipping which is a recurring problem for the Crana (mid)/Glashagh, Camowen/Meenatomish and Evishbreedy (Owennasop);
- siltation issues from diffuse pressures such as peat and forestry within the Crana River;
- pressures such as diffuse agriculture and septic tanks which are notable within the Cashelnacor, Owenboy and Evishbreedy (Owennasop) tributaries;
- illegal dumping in Owenboy; and
- highlighted that hydromorphological issues as a result of Fullerton Dam exist within the Evishbreedy (Owennasop).

No water quality data was available in 2018 when the fish stock assessment was undertaken. However, the relatively low abundance of salmon and trout stocks observed in the vicinity of some sections of the catchment (e.g. Owenboy) found to have impaired water quality status in 2016 was evident.

In addition, Donegal County Council (DCC) has been conducting water quality assessments at multiple sites in the catchment in recent months in 2019. These have identified the need for further investigations on some tributaries notably concerning impacts related to river crossings and animal access, sheep dip and forestry. DCC intends to recommend inclusion of the catchment in the 3rd Water Framework Directive cycle through the upcoming EPA characterisation meeting in spring 2020.

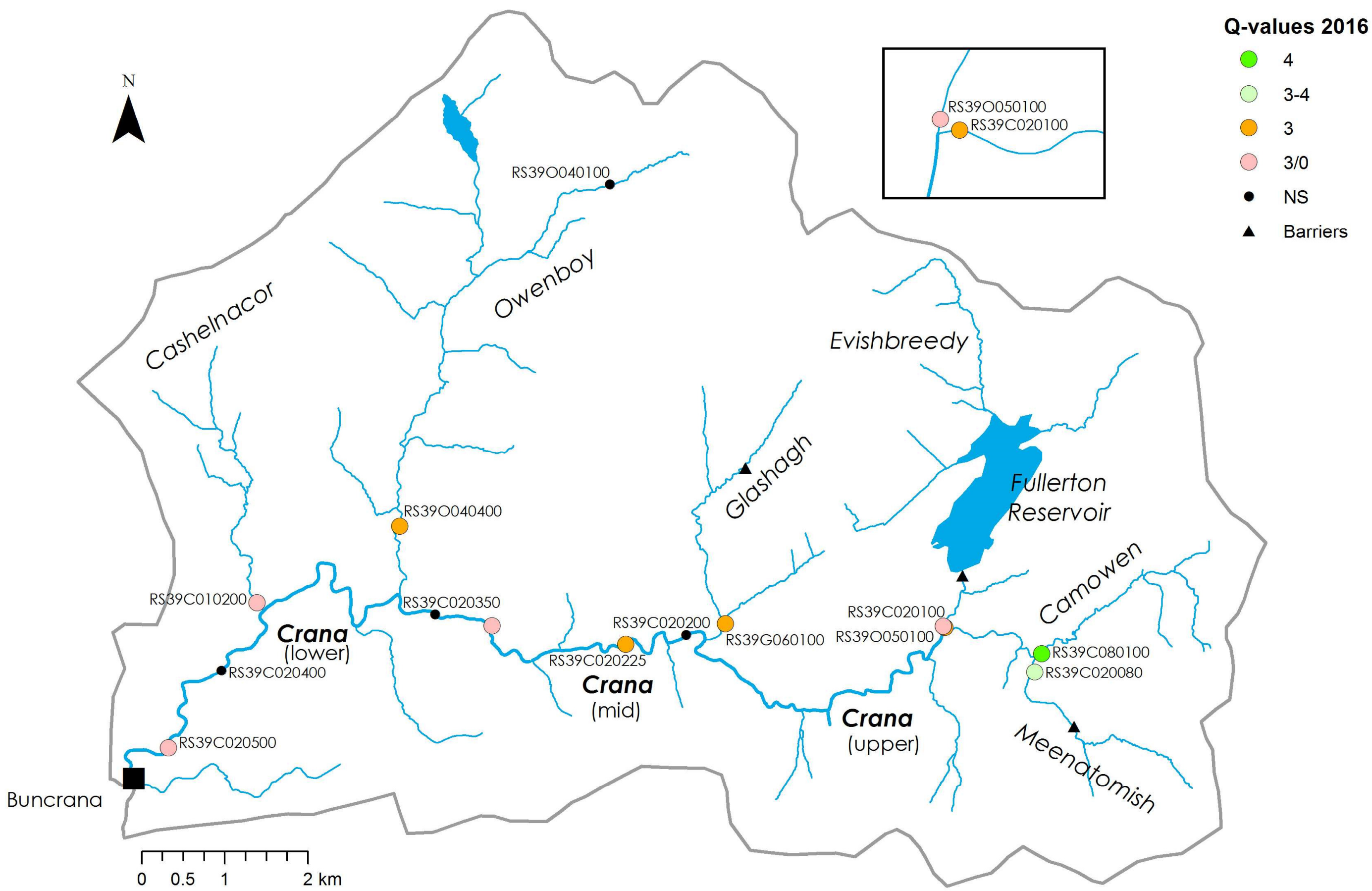

Figure 26 Water quality status in the Crana catchment based on the most recent EPA Q-value assessment in 2016 (NS= not sampled in 2016 but sampled in previous years).

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In general, IFI liaise closely with DCC on such matters and information exchange is normal practice. IFI are also involved with stakeholder meetings including the North West Water Forum which involves statutory and non-statutory agencies with interests in water quality issues.

5.8 Habitat assessment

The complete results of the habitat assessment are presented in the IFI Research & Development preliminary report *Aerial & fish stock survey of the River Crana catchment, Co. Donegal* (Millane *et al*. 2018) which can be accessed at https://tinyurl.com/yyvhqvrw. Overall the aerial survey showed the Crana catchment to be in a relatively good state as regards the geo-hydromorphological character required and expected to support healthy salmonid stocks. Channel substrate throughout the system principally comprises a heterogeneous boulder-cobble mix interspersed with gravels, some sand and occasionally sections dominated by exposed bedrock. Excessive siltation which may be detrimental to juvenile salmonid production was not generally observed. Instream macrophyte cover is generally limited with the exception of the Owenboy tributary. Riffles, runs and pool sequences are a common feature of all the river segments surveyed with glides an increasing feature in the lower gradient, lower portion of the catchment. No overt signs of pollution (e.g. excessive algae) were observed during the survey.

Remedial bank works to repair flood-impacted land and aimed to protect land and property against future such flooding events were locally observed and were not extensive as a proportion of the total catchment wetted area. Such measures principally included the installation of locally-extracted earthen or natural stone levees raising bank height and occasionally the use of artificial concrete block armour or rock armour. At the time of the survey, landowners impacted by the flood had already or were in the final phase of completing remediation works on their land including clearing debris, reseeding fields and refencing riparian zones. As such, the masses of material reportedly displaced in the flooding event onto land adjacent to the channel in some sections of the river were not generally evident. In addition, areas where in-river substrate may have been substantially displaced were not readily identifiable. Some minor potential impediments to upstream fish passage were identified.

6 Discussion

This review aims to establish the current status of salmonid stocks in the River Crana catchment, with reference to historical and recent fish stock surveys and associated environmental and habitat information in order to provide scientific data to identify where appropriate fisheries management actions may be required to better optimise its capacity to support healthy salmonid stocks. In general, variation in stock abundance at the individual river system level can be influenced by a variety of factors, notably, alterations in physical habitat, water quality, environmental factors, predation, and fisheries exploitation pressures. The fish stock and habitat surveys undertaken in 2018 facilitate a determination of whether the salmonid habitat or the salmonid production function was impaired or not after the flooding event in August 2017. In addition, these surveys offer a post-flooding baseline as a basis for ongoing and future catchment-wide assessments of resident salmonid stocks.

Previous fish stock assessments carried out in the 1990s by IFI and presented in this report found that the Crana River was a highly productive salmonid spawning and nursery system which supported a productive salmon fishery. In general, this was additionally supported by the results of the 2018 fish stock surveys which show that there is a reasonable level of juvenile salmonid production in most sections of the Crana system. The presence of fry of both species indicate that adult salmon and trout spawned successfully in the catchment in winter 2017/18. The presence of parr of both species which would have been resident during the flooding event, indicate that they survived and remain extant. In addition, the mean no. of salmon fry (per 5-minute fishing) in 2009 and 2018 was 15.2 and 15.7, respectively, which is marginally above the nationally-applied management threshold of 15 to allow a river to be open for catch & release salmon fishing, and above the national median value of 10.7 based on over 400 such assessments conducted in numerous Irish salmon rivers since 2007. In addition, the catchment-wide mean no. of trout fry (per 5-minute fishing) in both 2009 (6) and 2018 (7.1) was above this national median of 4.6.

Therefore, based on this review, it is considered that the Crana production function has not been severely disrupted and it retains significant fish production capacity. Indeed, the 2018 survey revealed particularly healthy stocks of juvenile salmon in the middle and upper sections of the main Crana channel which clearly highlights their importance as key spawning and nursery habitat for the catchment. Despite this, there are several river sections where some localised degradation in juvenile salmonid stocks are apparent compared to previous survey periods. These include the middle portion of the Owenboy, and the lower Camowen and Meenatomish tributaries. Indeed, the EQR assessment also highlighted that the fish community character in these sections of the catchment was below that expected under non-impacted reference conditions. An artificial barrier in the lower Camowen, as identified in the preliminary report, has the potential to obstruct fish passage into this tributary. The Meenatomish and surrounding land was particularly impacted by a large mud slide during the severe flooding which may have significantly impacted fish stocks there. It is also notable that no salmon were recorded during the 2018 survey at the single site fished above the reservoir which suggests that salmon may be extirpated from this part of the catchment.

The annual TEGOS scientific stock assessment which informs the regulation of salmon and sea trout angling in the Crana catchment indicates that adult salmon stocks were below the conservation limit from 2016 to 2019. However, the most recent assessment for the 2020 fishery shows that the system is now marginally exceeding its CL with an identified surplus of fish available for sustainable harvest. In a wider context, it is important to note that salmon stocks in Irish river systems have experienced periods of declines in both angling catch and abundance over the last three decades (Anon. 2008; SSCS 2016). Indeed, overall, it is estimated that the abundance of Atlantic salmon in Ireland has decreased by 75% in recent decades (Anon. 2008). This is highlighted by the estimated returns of one-sea-winter grilse salmon to Irish rivers, prior to any fishery, which have progressively declined from around 1 million fish per annum in the early to mid-1970s to fewer than 200,000 fish per annum since 2014. This declining trend is also evident in the southern salmon stock complex of North-east Atlantic, as well as for national stocks in its constituent countries which include Ireland (ICES 2017a).

Furthermore, the survival of salmon during the marine phase of its lifecycle (i.e. marine survival) has been identified as the key determinant of trends in population size in natal rivers not only in Ireland, but also throughout the global range of the species, particularly since the declines in stocks have been observed (ICES 2016; ICES 2017a). Known factors which influence marine survival to homewaters include exploitation at sea in commercial fisheries including those at West Greenland and formerly at the Faroe Islands, and interceptory fisheries in coastal waters (ICES 2017a). The impact of salmon aquaculture through increased sea lice-induced mortality on out migrating wild fish at smolt stage and predation pressure have also been identified as regional and local factors in marine survival (Gargan *et al*. 2012; Krkošek *et al*. 2012; Shephard and Gargan 2017). In addition, the influence of climate change and concomitant negative effects on food prey structure and abundance have increasingly been attributed to the declines observed in stocks at sea (Friedland *et al*. 2014; ICES 2017b). Therefore, a combination of factors present in the freshwater, estuaries and marine environment are likely to have regulated the Crana salmon stock in recent decades and currently.

Although the severe flooding in August 2017 impacted local communities, property and farmland as well as Crana river system, the aerial habitat survey showed the river system to be in a relatively good physical state capable of supporting healthy stocks of salmon and trout. The extensive tracts of riparian cover along the river corridor post-flood, as evidenced from the drone survey, comprising mature and semi-mature deciduous trees and shrubbery along the main channel and the Owenboy, serve to stabilise the river banks, limit the potential for excessive erosion and provide cover and shade for fish. The preliminary report identified specific locations in the catchment which would likely benefit from minor interventions to protect riverine habitat such as the installation of riparian fencing and these measures are reiterated in the recommendations section of this report. As part of this, more comprehensive habitat assessments (e.g. RHAT[1]) would be essential to identify any localised habitat issues and degraded river sections (e.g. compacted substrates) that could be addressed through appropriate fisheries management interventions.

In summer 2019, as part of IFI's National Barrier Programme, staff undertook a catchment-wide assessment to identify potential barriers to fish migration in the Crana system. The results of this survey should be available in the first quarter of 2020. From this, specific structures of concern can be further evaluated using a standardised SNIFFER methodology (SNIFFER 2010) to formulate appropriate modification measures to improve connectivity in the system.

This review has highlighted the notable deterioration in water quality status at many sites in the Crana catchment since 2007. This is of particular concern for salmonids which rely on good water quality for stock viability. In this regard, further investigations are considered prudent to identify and develop measures to address the responsible pressures in more detail. More recent information on water quality status would be valuable to review and this is likely to be forthcoming in 2019/20 *via* national monitoring programmes associated with the WFD.

[1] River Hydromorphology Assessment Technique

A favourable hydrological environment is key to supporting healthy salmonid stocks in a natural spate river system such as the Crana. Adequate water flows and levels in spawning and nursery areas are essential for reproductive success and juvenile development as well as for the functioning of the wider ecosystem supporting such stocks. In addition, periodic flood events are vital to facilitate the successful out-migration of salmon and sea trout smolts, their subsequent return as adults to the river and further movements upstream to spawning areas. Ideally, dam discharge volumes should reflect natural spate events in terms of facilitating fish passage. Although a compensatory protocol to mitigate for the regulating effect of Fullerton Dam on salmonid populations is already in operation, a review of the existing regime is considered worthwhile to identify any additional measures that could be beneficial. As climate change is expected to result in an increased frequency of drought periods in summer (Desmond *et al*. 2008), an evaluation of the potential to use additional compensatory discharge (e.g. by the release of artificial freshets) to better protect resident biota during such events also warrants further consideration.

Infestations of wild salmonid smolts with sea lice from marine salmon farms can act as a moderating pressure on river stocks through increased mortality, and for sea trout, influence their premature return to freshwater (Krkošek *et al*. 2012; Gargan *et al*. 2017). Salmon aquaculture has operated in Lough Swilly since the early 1990s and sea lice loads on wild sea trout in the Crana estuary have been assessed in most years since that time (Gargan *et al*. 2017). The results show that sea lice loads are likely to have had a 'high' regulating effect on this wild stock in 12 of the 19 years assessed between 1993 and 2015. This represents an increased mortality risk of greater than 30% for Crana sea trout in these years (Gargan *et al*. 2017). The effects of sea lice on the mortality of the Crana salmon population are more difficult to directly elucidate as salmon smolts migrate away from the Irish coast. However, Irish based research has shown that returns of wild one-sea-winter Atlantic salmon can be over 50% lower where lice levels are high on adjacent salmon farms in the previous year when the smolts are migrating (Shephard and Gargan 2017).

7 Recommendations

In general, conservation measures to promote salmonid stock status in a river system such as the Crana should principally aim to optimise natural productive capacity through the protection, enhancement and restoration of supporting habitat as required and addressing of specific threats and pressures that can be lessened through appropriate fisheries management interventions (i.e. "control the controllables"). The current review has identified some key pressures likely acting on moderating salmonid stocks in the Crana system including those related to water quality, habitat, aquaculture and potential barriers to fish migration, some of which require further investigation. As such the following recommendations are advised:

- In relation to specifications for protection, restoration and enhancement works, it is considered prudent to split this potentially broad scope of activity into two discrete areas: (a) instream/channel works and (b) riparian zone works:

  (a) Instream works

  The fish stock survey suggests that the Crana is currently producing salmon and trout juveniles throughout its extent with some exceptions in the catchment extremities. Distribution and abundance data compare favorably with previous data. The Crana is a high gradient catchment, with good levels of gravel recruitment, and given its relative stability in terms of fish production, no substantive instream works seem to be warranted. Imposing new channel forms without addressing any processes that drive channel form, including system evolution and the wider watershed is inconsistent with basic geomorphological principles (Kondolf 1995). In that regard attempting to 'stabilise' a natural channel by undertaking instream works is not desirable or warranted in this case. On that basis the system should be allowed to repair itself by the natural processes of river evolution. Instream works should be confined to addressing potential fish barrier issues as identified in the preliminary report (Millane *et al*. 2018). SNIFFER or equivalent barrier assessments are recommended prior to undertaking any direct interventions (the results of the IFI barriers assessment will be informative here).

  It is recommended that further annual monitoring of juvenile salmonids in the Crana should be undertaken over the next two years to provide additional confidence that a natural rehabilitation approach is most appropriate to maintain healthy stocks. Comparisons of substrate composition at various sites, particularly spawning areas, with similar data from the 1990s are also likely to be informative.

(b) Riparian zone works –

A programme to stabilise existing repaired banks using natural or assisted recolonisation techniques may be warranted to prevent sloughing of banks or erosion of soils. Planting of willow slips is a recognised stabilisation technique and should be considered. Extensive fencing of all repaired banks will assist the natural recolonisation process. In addition, the installation of fencing where currently absent may reduce the potential for livestock ingress and thus promote better long-term bank stability. It is recommended that potential capital support mechanisms for riparian landowners to fund such fencing works should be identified.

- To provide more detailed reach assessments, to assess the departure of hydromorphological features from 'naturalness' and to allow for the assignment of a morphological classification directly related to WFD status i.e. High, Good, Moderate, Poor or Bad, RHAT surveys (NIEA, 2009) are warranted. The River Hydromorphology Assessment Technique tool is widely used in the UK and also in Ireland in the context of WFD hydromorphological status assignment.
- It is unclear from the aerial survey whether there is a now much lower presence of instream aquatic vegetation since the flooding event. However, if ground surveys show that this is the case, the natural re-establishment of such habitat (e.g. aquatic moss dominated) in suitable river sections may also benefit fish stocks. Transferring moss-covered boulders to sites bereft of such cover may be a useful remedial action and monitoring the success of such an action would be informative.
- The deterioration in water quality status in the Crana catchment is of particular concern for salmonids which rely on good water quality for stock viability. Further investigations are recommended to identify and develop appropriate measures to address the responsible pressures. Ultimately, the identification and implementation of such measures comes under the 2nd cycle of the River Basin District Management Plan 2018-2021 where the Crana system is contained within a revised single administrative area for the North Western and Neagh Bann International River Basin Districts. IFI supports the intention to recommend inclusion of the catchment in the 3rd Water Framework Directive cycle through the upcoming EPA characterisation meeting in spring 2020.

- A review of the potential influence of the water discharge regime at Fullerton Dam on salmonid populations in downstream sections of the Crana and how this could be made more favourable to support resident salmonid stocks is recommended.
- Lice levels on wild sea trout in the Crana estuary should continue to be monitored annually to contribute to the further understanding of the impacts of sea lice and salmon aquaculture on wild salmonid stocks, particularly at the vulnerable smolt stage.
- Although the majority of remedial works have already been undertaken by landowners to address flood damage, awareness of invasive species biosecurity should be promoted amongst such stakeholders to reduce the potential for spread of invasive species. Japanese knotweed and Himalayan balsam are present in localised areas of the Crana catchment. Both would present potentially significant issues for the riparian zone, if they become further established, in terms of competition with native riparian species and consequent impacts arising from such change. Stringent measures to control this potential degradation of riparian habitat need to be put in place.

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10 Appendices

10.1 Appendix 1: $CWEF_5$ (2009 and 2018)

Table 3 Abundance of salmon and trout fry at $CWEF_5$ sites in the River Crana catchment in 2009 and 2018.

Water	Site code	Irish grid	Salmon		Trout	
			2009	**2018**	**2009**	**2018**
Crana (lwr)	501	C 35134 33651	3	21.72	0	1.28
Crana (lwr)	502	C 35649 34035	14.38	12	2.62	0
Crana (lwr)	503	C 36965 34778	26.78	13.85	1.22	4.15
Crana (lwr)	504	C 37490 34645	15.79	20.78	1.21	1.22
Crana (mid)	505	C 38701 34178	20.57	3.6	3.43	2.4
Crana (mid)	506	C 39471 34032	6.67	7.85	1.33	9.15
Crana (mid)	507	C 40325 34119	27.84	21.91	1.16	6.09
Crana (upper)	508	C 41529 33856	24.75	38.25	8.25	12.75
Crana (upper)	509	C 42742 33314	25.04	31.68	5.96	11.32
Crana (upper)	510	C 43692 33754	43.5	50.41	14.5	2.59
Cashelnacor	511	C 35876 34582	16.1	6.88	6.9	4.13
Cashelnacor	512	C 35626 36322	0	0	7	5
Owenboy	513	C 37540 35502	27.5	28.03	5.5	10.97
Owenboy	514	C 38082 37837	49.79	3	2.21	3
Owenboy	515	C 38581 39045	0	0	35	23
Owenboy	516	C 38989 38729	0	0	15	1
Owenboy	517	C 40520 39807	0	0	6	3
Camowen	518	C 44188 34284	14.53	46.03	8.47	6.97
Camowen	519	C 45276 33955	11.77	0	5.23	13
Meenatomish	522	C 46322 32937	0		0	
Meenatomish	521	C 45227 33765	18.75		1.25	
Crana (upper)	523	C 44353 34735	1.4	0	5.6	14
Evishbreedy	524	C 44573 37679	0		4	
Trib. of Crana (lwr)	525	C 37478 34107		0		25
Glashagh	526	C 41273 34908		0		0
Glashagh	527	C 41369 34179		78.68		10.32
Camowen	528	C 45207 33952		0		7
Crana (upper)	529	C 44387 34774		0		4
Owenboy	530	C 37604 36325		24.75		2.25
Camowen	561	Not available	16.88		1.13	

Decimals result from the apportioning by species of fry observed but not captured during survey.

10.2 Appendix 2: CWEF$_{10}$ Salmon (1991, 1999 and 2018)

Table 4 Salmon density (fry and parr) at CWEF$_{10}$ sites fished in the River Crana catchment in 2018, 1999 and 1991 (sites surveyed in all years are highlighted in grey).

Water	Site code	Location	Fry 2018	Fry 1999	Fry 1991	Parr 2018	Parr 1999	Parr 1991
Evishbreedy	1001	C 44535 37720	NS	0.078	0.082	NS	0	0
Evishbreedy	1002	C 44585 37074	0	0.07	0	0	0.17	0
Evishbreedy	1003	C 44866 36607	NS	NS	0.213	NS	NS	0
Evishbreedy	1004	C 44544 36481	NS	NS	0.086	NS	NS	0
Evishbreedy	1005	C 44719 36444	NS	NS	0.25	NS	NS	0.083
Evishbreedy	1006	C 44755 36016	NS	NS	0.385	NS	NS	0.162
Evishbreedy	1007	C 44782 35997	NS	NS	0	NS	NS	0
Evishbreedy	1008	C 44707 35777	NS	NS	0.205	NS	NS	0.051
Evishbreedy	1009	C 44429 35490	NS	NS	0.082	NS	NS	0.054
Crana (upper)	1010	C 44310 34931	NS	0.039	0.124	NS	0.078	0.072
Crana (upper)	1011	C 44309 34590	0.31	0.05	0.1	0.19	0.06	0.17
Crana (upper)	1012	C 44171 34436	NS	0.12	0.114	NS	0.024	0.093
Crana (upper)	1013	C 44101 34178	0.89	0.3	0.11	0.03	0.11	0.17
Crana (upper)	1014	C 43960 33978	0.98	0.32	0.73	0.19	0.03	0.19
Crana (mid)	1015	C 39367 34014	NS	0.16	0.391	NS	0.121	0.222
Crana (Upper)	1016	C 41782 33606	NS	0.118	0.183	NS	0.144	0.149
Meenatomish	1017	C 45560 33181	NS	0.629	0	NS	0.085	0
Meenatomish	1018	C 45231 33794	0	0.53	0	0	0.12	0
Camowen	1019	C 45300 34054	NS	NS	0	NS	NS	0
Camowen	1020	C 44425 34229	0	0.56	0.12	0.04	0.13	0.09
Unnamed trib.	1021	C 43969 33898	NS	NS	0.063	NS	NS	0
Glashagh	1022	C 41773 34669	NS	NS	0.018	NS	NS	0.035
Glashagh	1023	C 41353 34620	0.37	0.38	0.07	0.32	0.12	0.14
Glashagh	1024	C 41399 34267	NS	NS	0.167	NS	NS	0.064
Owenboy	1025	C 38581 39045	0	0.25	0	0	0.05	0
Owenboy	1026	C 38274 38365	NS	NS	0.193	NS	NS	0.133
Owenboy	1027	C 38065 37124	0.1	0.28	0.53	0.02	0.13	0.15
Crana (mid)	1028	C 39291 33979	1.15	NS	NS	0.48	NS	NS
Crana (mid)	1029	C 38680 34215	0	NS	NS	0.64	NS	NS
Meenatomish	1030	C 45488 33363	0	NS	NS	0.01	NS	NS
Crana (mid)	1031	C 4164 333742	0.3	NS	NS	0.23	NS	NS
Owenboy	1032	C 37539 35502	0.28	NS	NS	0.14	NS	NS

NS= not surveyed.

10.3 Appendix 3: CWEF$_{10}$ Trout (1991, 1999 and 2018)

Table 5 Trout density (fry; and >0+) at CWEF$_{10}$ sites fished in the River Crana catchment in 2018, 1999 and 1991 (sites surveyed in all years are highlighted in grey).

Water	Site code	Location	Fry 2018	Fry 1999	Fry 1991	>0+ 2018	>0+ 1999	>0+ 1991
Evishbreedy	1001	C 44535 37720	NS	0.031	0.08	NS	0.313	0.437
Evishbreedy	1002	C 44585 37074	0.31	0.09	0.02	0.17	0.09	0.25
Evishbreedy	1003	C 44866 36607	NS	NS	0.15	NS	NS	0.122
Evishbreedy	1004	C 44544 36481	NS	NS	0.52	NS	NS	0.029
Evishbreedy	1005	C 44719 36444	NS	NS	0.02	NS	NS	0.05
Evishbreedy	1006	C 44755 36016	NS	NS	0.08	NS	NS	0.081
Evishbreedy	1007	C 44782 35997	NS	NS	0.4	NS	NS	0.2
Evishbreedy	1008	C 44707 35777	NS	NS	0.02	NS	NS	0.081
Evishbreedy	1009	C 44429 35490	NS	NS	0.26	NS	NS	0.136
Crana (upper)	1010	C 44310 34931	NS	0.074	0.04	NS	0.177	0.105
Crana (upper)	1011	C 44309 34590	0.13	0.05	0.02	0.22	0.09	0.05
Crana (upper)	1012	C 44171 34436	NS	0.06	0.05	NS	0.078	0.238
Crana (upper)	1013	C 44101 34178	0.04	0.02	0.01	0.05	0.04	0.06
Crana (upper)	1014	C 43960 33978	0.03	0.02	0.08	0.13	0.05	0.1
Crana (mid)	1015	C 39367 34014	NS	0.006	0.03	NS	0.061	0.136
Crana (Upper)	1016	C 41782 33606	NS	0.006	0.02	NS	0.035	0.087
Meenatomish	1017	C 45560 33181	NS	0	0.08	NS	0.187	0.326
Meenatomish	1018	C 45231 33794	0.09	0.03	0.25	0.08	0.08	0.1
Camowen	1019	C 45300 34054	NS	NS	0.04	NS	NS	0.15
Camowen	1020	C 44425 34229	0	0.13	0.02	0.05	0.05	0.08
Unnamed trib.	1021	C 43969 33898	NS	NS	0.08	NS	NS	0.083
Glashagh	1022	C 41773 34669	NS	NS	0.04	NS	NS	0.07
Glashagh	1023	C 41353 34620	0.24	0.13	0.05	0.07	0.07	0.18
Glashagh	1024	C 41399 34267	NS	NS	0.04	NS	NS	0.18
Owenboy	1025	C 38581 39045	0.92	0.11	0.46	0.4	0.06	0.13
Owenboy	1026	C 38274 38365	NS	NS	0.04	NS	NS	0.096
Owenboy	1027	C 38065 37124	0	0.05	0.08	0.03	0.09	0.07
Crana (mid)	1028	C 39291 33979	0.07	NS	NS	0.05	NS	NS
Crana (mid)	1029	C 38680 34215	0	NS	NS	0.13	NS	NS
Meenatomish	1030	C 45488 33363	0.1	NS	NS	0.05	NS	NS
Crana (mid)	1031	C 4164 333742	0.06	NS	NS	0.06	NS	NS
Owenboy	1032	C 37539 35502	0.07	NS	NS	0.12	NS	NS

NS= not surveyed
>0+ = parr and adults

10.4 Appendix 4: Summary of stocking activities in the Crana catchment

Salmon stocking activities using unfed fry commenced in the River Crana catchment in 1996 and ceased in 2008.

Table 6 Salmon stocking activities in the River Crana catchment between 1996 and 2008 (number of unfed fry stocked and location of stocking.

Year	Location	No. of fry	Year	Location	No. of fry	Year	Location	No. of fry
1996	Camowen	40,000	2002	Camowen	15,000	2006	Camowen	20,000
1996	Evishbreedy	10,000	2002	Owenboy	15,000	2006	Owenboy	20,000
1996	Glenard	5,000	2002	Glenard	10,000	2006	Glenard	5,000
1996	Minthags outfall	5,000	2002	Cashnacor	5,000	2006	Evishbreedy	5,000
1996	Owenboy	15,000	2002	Slievemain/ Glashagh	5,000	2006	Slievemain/ Glashagh	5,000
1997	Camowen	40,000	2002	Gleenagall	2,500	2006	Cashnacor	5,000
1997	Evishbreedy	10,000	2002	Evishbreedy	5,000	2008	Camowen	15,000
1997	Glenard	5,000	2002	Fullerton Dam	10,000	2008	Owenboy	15,000
1997	Minthags outfall	5,000	2002	Pollantober/ Pollnahak	2,500	2008	Glenard	3,500
1997	Owenboy	15,000	2003	Camowen	20,000	2008	Evishbreedy	3,500
1998	Camowen	40,000	2003	Owenboy	20,000	2008	Slievemain	3,400
1998	Evishbreedy	10,000	2003	Glenard	15,000	2008	Glashagh	2,000
1998	Fullerton Dam	30,000	2003	Cashnacor	7,000	2008	Cashnacor	2,000
1998	Glenard	5,000	2003	Slievemain	5,000			
1998	Minthags outfall	5,000	2003	Glashagh	5,000			
1998	Owenboy	15,000	2003	Gleenagall	2,500			
1998	Glashagh	15,000	2003	Evishbreedy	10,000			
1999	Camowen	40,000	2003	Fullerton Dam	15,000			
1999	Evishbreedy	10,000	2003	Pollantober/ Pollnahak	500			
1999	Fullerton Dam	30,000	2004	Camowen	15,000			
1999	Glenard	5,000	2004	Owenboy	15,000			
1999	Minthags outfall	5,000	2004	Glenard	10,000			
1999	Owenboy	15,000	2004	Evishbreedy	5,000			
1999	Glashagh	15,000	2004	Slievemain/ Glashagh	5,000			
2000	Camowen	40,000	2004	Pollantober/ Pollnahak	4,000			
2000	Evishbreedy	10,000	2004	Cashnacor	4,000			
2000	Fullerton Dam	25,000	2005	Camowen	20,000			
2000	Glenard	5,000	2005	Owenboy	15,000			
2000	Minthags outfall	5,000	2005	Glenard	5,000			
2000	Owenboy	15,000	2005	Evishbreedy	7,000			
2000	Glashagh	2,000	2005	Slievemain/ Glashagh	10,000			
2000	Sleivemain	10,000	2005	Glasha	3,000			
2000	Cashnacor	2,000	2005	Cashnacor	5,000			
2000	Cleanha	2,000	2005	Fullerton Dam	5,000			
2000	Pollanhack	5,000						

Data collated from information provided to IFI by the Buncrana Anglers Association.

10.5 Appendix 5: Water quality in the Crana catchment

Table 7 Water quality of sites in the Crana catchment (EPA Q-values).

Water	StationID*	easting	northing	StationNam	QV73	QV77	QV81	QV86	QV87	QV91	QV96	QV98	QV01	QV4	QV7	QV10	QV13	QV16
Cashelnacor	C010200	635813	934581	Bridge u/s Crana River confl.					4-5	5	4-5		4	4	4	3	2-3	3/0
Meenatomish	C020080	645170	933746	Srath Br										4		3	3	3-4
Camowen	C020100	644088	934287	Bridge near Stracarragh	5	5	5	4-5	5	4-5	4-5	4	4	3-4	3	3	3	3
Crana (mid)	C020200	640974	934198	E. of Bindoo			5	5	5	4	4	4						
Crana (mid)	C020225	640251	934084	Br N of Stranaclea									4	4	3	3	3	3
Crana (mid)	C020300	638646	934306	Druminderry Bridge	5	5	5	4-5	4-5	5			4-5	4	3	3	3	3/0
Crana (mid)	C020350	637955	934442	Br d/s Druminderry Br							4-5	4						
Crana (lwr)	C020400	635385	933769	Bridge at Cock Hill	5	4-5	4-5	4	5	4								
Crana (lwr)	C020500	634747	932841	First Br d/s Br at Cock Hill	5	5	5	4	5	4-5	4	4	4	4	4	4	4	3/0
Camowen	C080100	645254	933969	0.1km u/s confl. with Crana										3	3		3	4
Glashagh	G060100	641449	934332	Glashagh Bridge							3		3	4		3	3	3
Owenboy	O040100	640059	939608	Carroghill Bridge					4	4								
Owenboy	O040400	637530	935501	Kinnagoe Bridge					5	4-5	4-5	4-5		4	3-4	3	3	3
Crana (upper)	O050100	644068	934298	Bridge at Stracarragh					4-5	4-5	4		3-4	3	3	3	3	3/0

* Station ID prefix is “RS39”; QVXX = Q-value and year of assessment.