environment SOUTHLAND

Te Taiao Tonga

Fish Surveys in Non-wadeable Systems

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Abstract

Council fish monitoring has usually been limited to wadeable streams, and specifically the clear, shallow and non-weedy streams that can be electro-fished. These habitats provide critical habitat for a range of native and valued species, but the community often interact with larger rivers or lake systems. These larger rivers and lakes are at the downstream end of catchments, where the impacts of increasing nutrient and sediment loads are often experienced. As such, the state and trends of fish communities in larger water bodies are important aspects for the Council to consider when managing the environment. We do not currently collect fishery information from these larger water bodies due to methodological constraints.

This report describes the results from fish surveys in five coastal lakes that were undertaken as part of an assessment into the ecological integrity of those systems. It demonstrates that fyke nets and G-minnow traps can be used to capture a representative range of the fish community. In this case, the methods adopted from Drake et al (2011) produced a dataset that:

1. allowed an exploration of whether the eel community was dominated by shortfin or longfin;
2. indicated that perch may be suppressing common bully numbers; and
3. suggested that large longfin eels were absent from lakes subjected to regular commercial harvesting.

If this kind of information was collected annually at a subset of our state of the environment (SOE) water quality sites, we could compare trends in the abundance and diversity of fish in larger waterways with water quality at those sites. Additionally, the condition of fish can be estimated in a variety of ways, by using length and weight information, and by measuring fat content using our handheld meter. Trends in the condition of fish at our SOE sites may be more responsive to changes in water quality or flow characteristics (e.g. minimum flow conditions) than trends in diversity or abundance metrics. Techniques for monitoring the condition of fish communities in non-wadeable streams should be investigated further.

Fish condition in non-wadeable systems

Introduction

The fish communities in Southland streams are of both cultural interest and ecological significance. People enjoy catching fish, whether it be an introduced brown trout caught with the aid of a carefully tied fly, a large tuna (*Anguilla spp.*) hauled out of the murky depths, or half an ice-cream container full of whitebait (native *Galaxias spp.)* netted out of the Big Bend amidst hundreds of other rival whitebaiters. In all cases, future fishing success depends on the successful reproduction and growth of another cohort of numerous and healthy individuals.

From an ecological perspective, fish are often the top predator in freshwater systems, and so are critical components to monitor from an ecological health perspective. Importantly, most freshwater fish species in New Zealand require migrations either to and from the ocean, or between different freshwater habitats (McDowall 1998). This means the diversity of fish acts as an indicator of how well connected our waterways are. Trout, whitebait, tuna and a variety of other native fish utilise small streams at different stages of their life cycle.

Protecting these small streams and ensuring fish populations are healthy is one of the Council's roles, and we are currently able to monitor small streams using new national protocols (Joy et al 2013). Monitoring data helps assess the condition of those small streams, as well as keeping track of regional fish populations. Our ability to monitor populations in deeper water, however, is limited by a lack of suitable methods. The cultural and recreational activities previously mentioned often take place in larger and deeper waterways, rather than the smaller streams we currently monitor. We thus need to develop suitable methods for monitoring the condition of fish communities in these larger, non-wadeable waterways.

We currently estimate the abundance of fish in smaller, wadeable streams by selecting a 150 m reach and systematically fishing as much of the area as possible (Joy et al 2013). This would be extremely difficult in larger waterways because depth and potentially fast moving water makes most of the waterway inaccessible. Rather than trying to count the fish in these larger systems, another option would be to look at the condition of fish. In other words, are fish healthier in some rivers than in others? Is fish condition improving or deteriorating over time? This approach can be seen as an analogy of the Council's water quantity and water quality programmes. At the moment, we are able to monitor the ***quantity*** of fish in our smaller waterways, and we are now thinking of ways to investigate the ***quality*** of fish in our waterways. We should be able to collect information on the quality of fish from both smaller and larger waterways, because we only need a representative sample of fish from the waterway rather than trying to sample fish from all areas. This avoids the accessibility problems we would encounter trying to estimate the quantity of fish in larger waterways, and means we could start collecting some information on those fish communities that Southlanders are more likely to interact with.

There are numerous methods and metrics that have been used to assess fish condition (e.g. Jenkins 2004), which are primarily aimed at assessing the energetic status of individuals (Stevenson and Woods 2006). Two of the more commonly used indices are *Fulton's condition factor* and the *relative weight*, which use the relationship between fish length and mass and can be seen as a similar concept to the Body Mass Index (BMI) used to assess human health. *Fulton's condition factor* (K) is calculated simply as body mass divided by length cubed for all species, and assumes isometric growth in weight with an increase in length (Nash et al 2006). The *relative weight* (W_r) uses data specific to the species of interest, and develops a predictive equation for the "average" fish of a given length (Wege and Anderson 1978). The actual weight of an individual is then divided by its theoretical weight and multiplied by 100, with values over 100% indicating superior condition, and values less than 100% indicating inferior condition. Both of these metrics are attractive because of the relative ease with which the information can be collected (length and weight), although *relative weight* benefits from developing a species-specific relationship for length to weight and so does not make an assumption of equality for fish shape (an eel versus a trout, for example).

The weight of a fish can be heavily influenced by its reproductive state and recent feeding habits. After reproducing, for example, brown trout (especially females) are much lighter than they were before spawning. This would make it unreasonable to compare the condition of trout in one stream before spawning with the condition of trout in another stream after spawning, because the post-spawning stream would appear to produce inferior fish. This potential problem can be reduced by sampling different systems within a narrow timeframe, and by sampling the same stream over time during the same seasonal window (e.g. always sample in February-March).

The potential effect of recent diet on weight is more difficult to overcome. Fish that have fed heavily before sampling, for example, would score higher on the condition index, even though this may not be reflective of their long-term weight and condition. The author has dissected a flathead (*Platycephalus fuscus*) whose stomach contained a squid longer than the flathead itself. In this example, the weight of the flathead before and after eating the squid would have been very different. Fish can also feed on "heavy" but not necessarily energetic prey such as molluscs or crustaceans which have low-energy content shells, or fish may also ingest gravel along with their prey. This can result in a stomach full of heavy contents such as bones and bivalve shells (Jenkins 2004). The weight of the fish is being used a proxy for their energetic content, and so anything that increases weight without comprising or contributing to energy reserves is misleading.

Fat content is a more direct measure of energetic status. The wet weights used to calculate the aforementioned condition indices do not always have a clear relationship with fat content (Sutton et. al. 2000). Although it may be possible to detect abrupt differences in the condition of fish using weight as a proxy for energetic status, more subtle changes that may occur in Southland rivers over time are less likely to be detectable (Sutton et al 2000). Historically, measuring fat content directly required fish to be sacrificed, but a relatively new and non-lethal method is now available using a portable handheld fish fat meter (Distell 2007). This technique uses a microwave sensor to measure the water content in the sample, which is then converted into an estimate of fat content. The relationship between water weight and fat weight is usually very strong (Sutton et al 2000, Distell 2007,) but needs to be established for each species of interest. This technique is commonly employed by the aquaculture industry to grade fish, and has also been successfully used by Whiterod (2010) for assessing the condition of Murray cod (*Maccullochella peelii*). In the latter case, 83.7% of the variation in energy density was explained using results from the fish fat meter, which indicates the fish fat meter could be a reliable method for assessing fish condition based on fat content.

The purpose of this investigation was twofold. Firstly, we wanted to assess whether rapid and non-lethal techniques could be used to assess the condition of fish in Southland waterways. Secondly, despite the accessibility issues in larger waterways, we wanted to trial the use of fyke nets and G-minnow traps in systems outside the scope of our current fish monitoring protocols (Joy et al 2013). For the sake of efficiency, this data was collected while surveying five coastal Southland Lakes that required fisheries information to be collected as part of a separate programme. For fish condition, we focused on two commonly used indices that use wet weight and length (K and W_r), as well estimating fat content using the Distell fish fat meter.

Study Sites and Methods

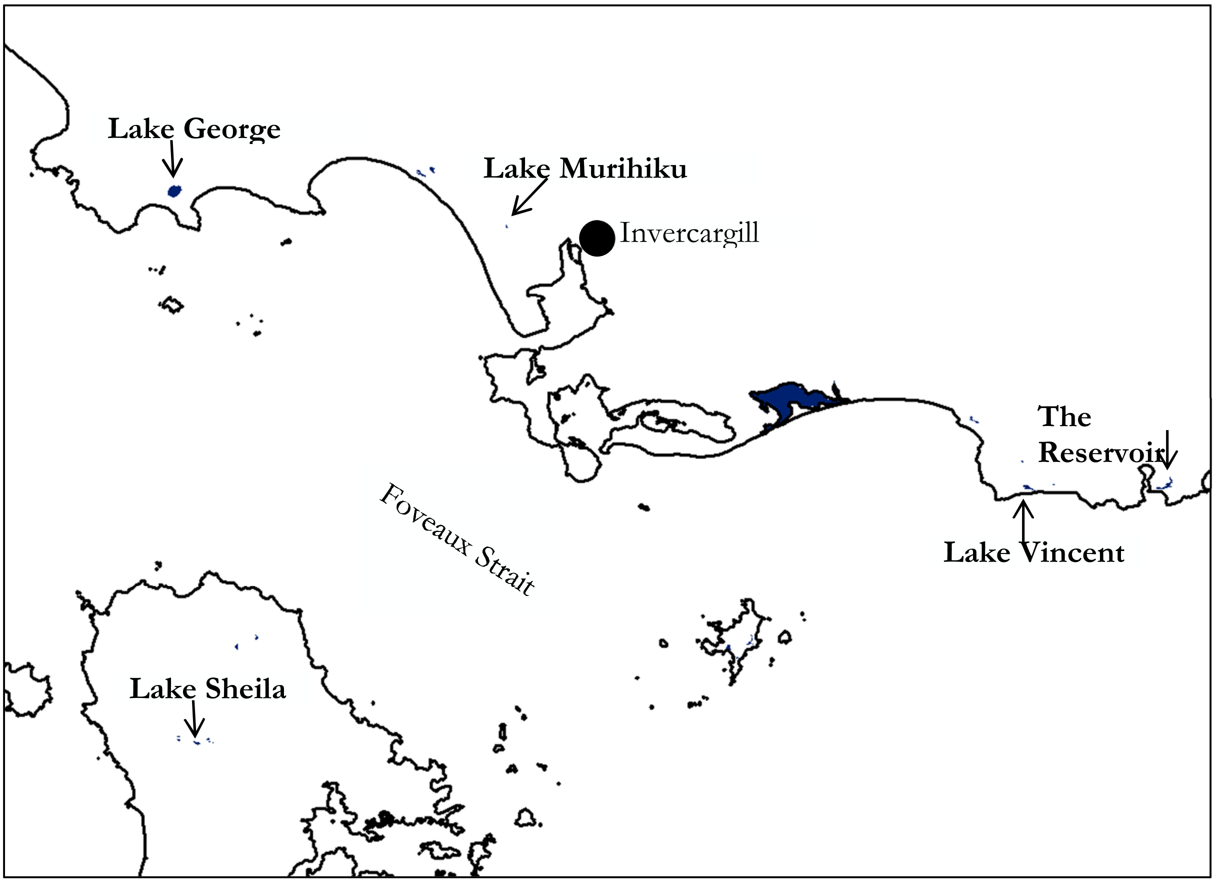

Figure 1: The locations of coastal lakes where fish condition was investigated

Five lakes in Southland were surveyed as part of an investigation into the ecological integrity of our coastal lakes. The locations of these lakes are indicated in Figure 1. More information on these lakes can be found in Schallenberg and Kelly (2012). In brief, all five lakes are shallow, namely less than 5 m deep. The catchments of Lake Murihiku, Lake Vincent and The Reservoir are dominated by farmland, whereas the catchment of Lake George has large areas of native forest. The catchment of Lake Sheila is entirely indigenous vegetation due to its location within Rakiura National Park. Because fisheries information needed to be collected as a component of exploring the ecological integrity of these lakes, we decided to focus our preliminary fish condition investigation in these same lakes for the sake of logistic efficiencies.

In each lake, nine unbaited fyke nets and 60 G-minnow traps baited with marmite and bread were set overnight to capture fish. The traps and nets were distributed among three sites, with three fyke nets and two lines of 10 G-minnow traps at each site. This followed the protocols used by Drake et al (2011). The 3-funnel fyke nets had a 3.2 metre body with a single 6 m long wing fixed to the centre of the D-shaped hoop, with the dimensions of the first hoop being a height of 70 cm and width of 90 cm. Stretched mesh size was 32 mm for the main body and wings, and 20 mm for the innermost chamber. Fyke nets were set with the wing fixed to the shoreline, and body running perpendicular to the shore into deeper water. The gee-minnow traps were an even mix of 3 mm and 6 mm mesh-size varieties, spaced evenly along 50 m trap lines. In some instances, the shoreline was either too shallow or too muddy for this arrangement to work, in which case the fyke nets and minnow traps were deployed in the same orientation as close to shore as practicable.

A variety of species were caught in the different lakes, including longfin eel (*Anguilla dieffenbachia)*, shortfin eel (*Anguilla australis*), giant kokopu (*Galaxias argenteus*), redfin perch (*Perca fluviatilis*), brown trout (*Salmo trutta*), inanga (*Galaxias maculatus*) and common bully (*Gobiomorphus cotidianus*). (see Appendix 1). We only had fish fat calibration settings for the two eel species and brown trout, which meant we could only calculate fat content for these three species. Only one brown trout was caught from the lakes (Lake George) which meant we could not explore trout condition. So our investigation of fish condition among lakes was limited to shortfin and longfin eel.

All fish were identified, counted and measured to the nearest mm. When the catch of common bullies was high, only the first 50 individuals were measured. For the purpose of condition measurements, eels were anaesthetised using AQUI-S® and weighed using a mesh bag and UWE hanging scales, model HS-7500 (7.5 kg max weight, 5 gram resolution). Eight fat meter readings were taken from each fish, four on each side as depicted in Figure 2, as per the methodology detailed in the calibration card for "EEL-2" (Distell undated).

Figure 2: Four fat meter readings were taken along each side of the eels (8 measurements total). Image taken from Distell calibration card, "EEL-2"

To compare the condition of eels among lakes, One-way Analyses of Variance (ANOVA) and T-tests were performed on the three different condition indices (K, W_r and fat content), using the excel data analyses tool pack.

Results

Longfin versus shortfin

There was an even ratio of longfin to shortfin in Lake Murihiku (see Table 1), but there were four and 12 times as many shortfin eels in Lake George and Lake Vincent, respectively. Conversely, there were three times as many longfin in The Reservoir. No shortfin were found in Lake Sheila, compared with 20 longfin. So in terms of the eel community, Lake George and Lake Vincent appeared to be shortfin dominated, whereas The Reservoir and Lake Sheila were longfin dominated.

Table 1: Numbers of longfin versus shortfin eels in the different lakes

Lake	Shortfin	Longfin
Lake Murihiku	3	3
Lake George	29	8
The Reservoir	13	40
Lake Vincent	12	1
Lake Sheila	0	20

Perch and small native fish

The presence of perch was negatively correlated with the abundance of common bully in the lakes surveyed. Almost 4,000 common bullies were caught in The Reservoir, compared with just two caught in the nearby Lake Vincent. Large numbers of common bully were also caught in the perch-free Lake Sheila, which was the only lake to support large numbers of inanga.

Table 2: Relationship between perch and abundance of small native fish *(perch-free lakes in grey)*

Lake	Perch/Trout caught?	Common bully	Inanga
Lake Murihiku	Yes/No	0	0
Lake George	Yes/Yes	1	3
The Reservoir	No/No	3905	0
Lake Vincent	Yes/No	2	0
Lake Sheila	No/No	259	360

Harvest pressure and eel size classes

The dominant size class of eels caught in fyke nets for both species from both lakes fell within the harvestable size range of 220 g to 4 kg (Figure 3). Large longfin eels were absent from lakes subjected to commercial harvesting pressure (Figure 3B – no longfin above 2 kg in fished lakes), but commercially harvested lakes did contain shortfins large enough to be sexually mature females (Figure 3A).

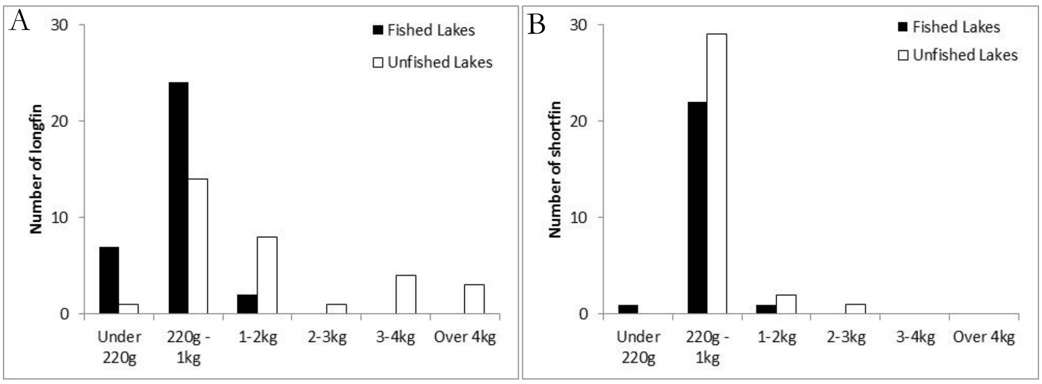

Figure 3: Size class of eel populations in commercially harvested versus non-commercially harvested lakes. The harvestable size range for commercial fishing is 220 g to 4 kg.

Fish condition indices

The Fulton condition index of longfin eels among lakes was significantly different ($F_{4,57}$=4.09, p<0.01), with a higher condition in Lake Sheila than in The Reservoir (T_{49}=-2.76, p<0.01). But there was no significant difference in the relative weight of longfin from the different lakes ($F_{4,57}$=1.87, p=0.13). There were no significant differences for either Fulton condition ($F_{3,30}$=1.82, p=0.17) or relative weight ($F_{3,30}$=2.73, p=0.06) among the shortfin populations. The relative weight was only marginally non-significant (0.06), however, and Lake Murihiku shortfin appeared to score more highly on this index than shortfin in the other lakes.

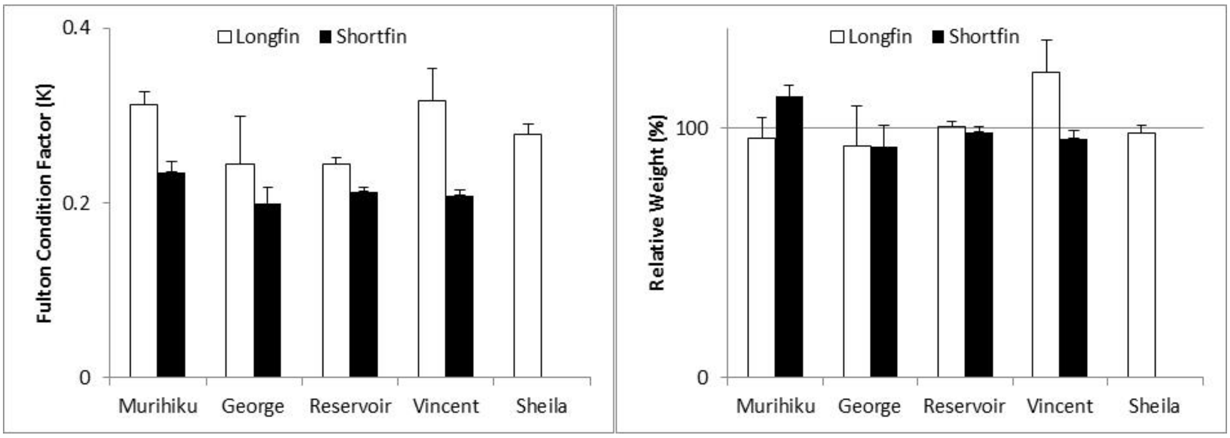

Figure 4: The Fulton condition and relative weight indices of shortfin and longfin eels captured in the different lakes. Relative weights above 100% are considered to be in superior condition (heavier than predicted). The Fulton Index is relative within, but not between, species (i.e. longfin not necessarily in better condition than shortfin). ***(Error bars are standard error)***

The average fat contents of longfin in two lakes within Department of Conservation estate (George and Sheila) were less than the fat contents of longfin in lakes on private land ($F_{4,57}$=10.52, p<0.001). But this pattern did not extend to shortfin, which exhibited the same average fat content among all four lakes they were found in ($F_{3,30}$=0.70, p=0.56). Fat content could only be measured in two longfin from Lake George, so these results can only be indicative. The sample sizes from The Reservoir and Lake Sheila were 31 and 20 respectively, and provided strong evidence that longfin in Lake Sheila had less fat than longfin in The Reservoir (T_{49}=4.86, p<0.001).

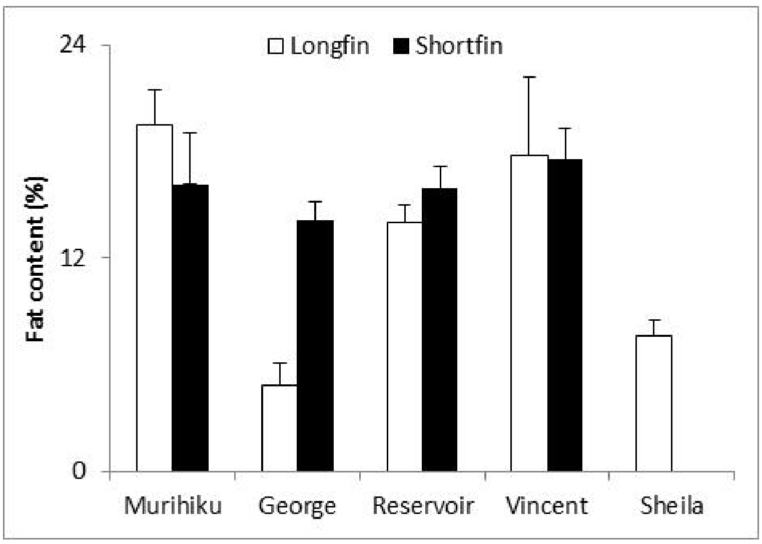

Figure 5. Fat content of eels as measured with the fat meter. ***(Error bars are standard errors)***

Discussion

Fish communities in non-wadeable systems

Shortfin are commonly associated with estuaries, lagoons, lowland lakes, swamps and rivers, whereas longfin are considered more generalised and often penetrate much further inland (Glova et al 1998). It was therefore somewhat surprising that the eel communities in the Reservoir and Lake Sheila were dominated by longfin rather than shortfin, because all of these systems were coastal lakes. Shortfin eel only appear to occur infrequently on Stewart Island (Leathwick et al 2010), which may explain why shortfin were not caught in Lake Sheila. And The Reservoir, as its name suggests, is an artificial lake that was formed by damming a small coastal creek, which may influence its nature as a lentic habitat and affect its attractiveness to shortfin. In this particular case, the specific results are not so important, but serve to demonstrate that indices can be generated by using relative measures of abundance within a non-wadeable site (ratios) when more quantitative estimates on population size cannot be determined.

There was a striking difference between the numbers of common bully in lakes with and without the introduced redfin perch. Perch are voracious predators and can prey heavily upon fish when they are larger than 200mm (Morgan et al 2002). A negative effect of the introduced brown trout on native *Galaxias* species has been well documented in New Zealand for some time (e.g. Townsend 1996, McDowall 2006). A suppressive effect of redfin perch on the abundance of small fish in lakes has been documented overseas (e.g. Morgan et al 2002), and was apparent in a large scale survey of New Zealand Lakes (Kelly and Schallenberg, *unpublished data*), but the ecological impacts of this species has received little attention in New Zealand. The reduced abundance of common bullies in Southland lakes where perch were present indicates that more work should be directed into determining whether this species poses a risk to the diversity of native fish in Southland and New Zealand.

Large longfin eels were absent from the two lakes subjected to regular commercial harvest (Lake Vincent and The Reservoir). There is considerable discussion around longfin populations in New Zealand, which are listed as "At Risk: Declining" (Allibone et al 2009). After reviewing available information, the Parliamentary Commissioner for the Environment has recently called for a suspension of the commercial longfin fishery (PCE 2013). The long-lived nature of longfin eels, delayed sexual maturity and fact that they only spawn once, coupled with the highly efficient capture rate of baited fyke nets, means that longfin populations in harvested areas are unlikely to produce sexually mature females (Hoyle and Jellyman 2002). The hypothesis that fishing removes longfin before they have time to reach sexual maturity was supported by the size class distribution in the coastal lakes surveyed, with several large longfin (greater than 2 kg) being captured in Lake Murihiku, Lake George and Lake Sheila, but no similar sized individuals from Lake Vincent or The Reservoir.

Although this study was limited in scope, it does provide support for collecting fisheries information from non-wadeable systems even if more rigorous and quantitative approaches are currently unavailable (e.g. Joy et al 2013). In this case, the methods adopted from Drake et al (2011) produced a dataset that:

1. allowed an exploration of whether the eel community was dominated by shortfin or longfin;
2. indicated that perch may be suppressing common bully numbers; and

3. suggested that large longfin eels were absent from lakes subjected to regular commercial harvesting.

Because meaningful information has been generated from fish surveys in non-wadeable systems, and although methods will need refinement, we feel there is good justification for incorporating a trapping style approach of non-wadeable systems into the Council's fisheries monitoring programme.

Fish condition

The limited spatial extent of this study and low numbers of fish caught in some systems prevented thorough analyses of the different fish condition indices. The preliminary results and overseas studies, however, do indicate a condition-based approach to fisheries assessment shows promise for assessing the state of Southland waterways. Even with the limited dataset, significant differences among longfin populations were identified. Most strikingly, the longfin in Lake Sheila had significantly less fat than longfin in The Reservoir. The pattern of fatter eels in lakes outside of conservation estate could be related to increased nutrient inputs and greater productivity and food resources for eels in lakes with more farming runoff. Interestingly, the Fulton Condition Index suggested the opposite pattern, with longfin in Lake Sheila scoring significantly higher than longfin in The Reservoir. This may reflect Lake Sheila eels being heavier, but less fatty, than The Reservoir eels, which is a pattern that could be driven by a number of factors. For example, Lake Sheila fish could be more muscular rather than fatty, eat heavier dietary items such as mussels, or ingest more gravel while feeding etc. Determining what condition index is most relevant to the state of the fisheries, or whether a particular condition index is better linked with water quality, will need to be investigated further as a suitable fish condition indices are developed for the Southland region.

Recommendations

1. Extend the current fisheries monitoring to include fyke netting at a subset of the non-wadeable, SOE water quality monitoring sites. This will enable fish condition indices to be measured at these sites, alongside water quality, macro-invertebrate and periphyton information.

2. Use the multi-chambered, fine-mesh fyke nets recommended in Joy et al 2013.

3. Test the methodology to use including bait choice, number of nets to deploy per site, and sampling window with respect to season and river conditions.

4. Explore how different condition indices correlate with fishery health (recruitment, abundance) versus nutrient loading (WQ quality variables).

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Schallenberg and Kelly (2012, 2013), Kelly et. al. (2013) and Wriggle (2013a, 2013b, 2013c, 2013d)

Appendix 1: Details of species caught from the different lakes

Lake	Shortfin	Longfin	Perch	Common Bully	Giant Kokopu	Brown Trout	Inanga	Redfin Bully
Lake Murihiku	3	3	12	0	0	0	0	0
Lake George	29	8	7	1	0	1	3	0
The Resevoir	13	40	0	3,905	1	0	0	0
Lake Vincent	12	1	18	2	15	0	0	0
Lake Sheila	0	20	0	259	9	0	360	1