Sockeye Spawning Monitoring 2018-2020 and Development of a Sockeye Spawning Run Monitoring Programme
(J Couper – September 2020)

Male sockeye in full spawning colours on it's way up the Twizel River. *Photo: Richard Cosgrove.*

Contents:

Introduction

History and Biology

The sockeye salmon (*Onchorynkus nerka*) of the Waitaki Lakes are the only self-sustaining population of sockeye in the Southern Hemisphere. Sockeye were introduced in 1901 in an effort to create an anadromous sea-run (sea resident, spawning in freshwater) population similar to that of the Northern Hemisphere, however no self-sustaining anadromous sea-run of sockeye was ever confirmed.

Lake resident *O. nerka* are referred to as "kokanee" in their native range. Kokanee are often genetically distinct from their anadromous form, referred to as sockeye. Genetic and phenotypic analysis of fish from New Zealand and British Columbia in 1998 showed that *O. nerka* present in the Waitaki Catchment are sockeye (Quinn, Graynoth, Wood, & Foote, 1998), despite having a kokanee life history pattern. For the purposes of this report New Zealand *O. nerka* will be referred to as "sockeye".

Waitaki lakes sockeye occur as mostly distinct populations partially separated by dams that only allow downstream migration. Like all Pacific salmon, sockeye die shortly after spawning.

Sockeye salmon predominantly filter feed for tiny zooplankton, meaning they are less likely to compete with trout or Chinook salmon for food in the lake environment. Recent gut samples of sockeye contained 99% *Daphnia pulex*, an introduced zooplankton. Historic gut samples of NZ sockeye contained a range of species (Graynoth, Bennett, & Pollard, 1986), suggesting diets may have changed since the mid-eighties. Confirmation of current diet composition would require an elaborate research programme.

Sockeye are now established in lakes Pukaki, Ohau and Benmore and sporadically in the lower Waitaki River (due to spills) and Lakes Ruataniwha, Aviemore and Waitaki. Sockeye spawning occurs in most tributaries of these lakes. Lake edge spawning is believed to be minimal.

This report represents the end of a three-year monitoring programme that aimed to better our understanding of the Waitaki Catchment sockeye spawning run and inform an ongoing monitoring programme. The three-year programme was funded in equal parts by Central South Island Fish & Game Council (CSIFGC) and Meridian Energy.

Value to Anglers

The kokanee fisheries of the Northern Hemisphere are highly valued due to the abundance and superb eating qualities of the fish. The sockeye fishery in the Waitaki Catchment is now developing with anglers and staff learning when, where and how to take advantage of this massive resource. CSIFGC staff have adapted Northern Hemisphere kokanee fishing techniques to use locally available gear and sourced a small amount of genuine kokanee tackle to give to anglers keen on helping to develop our understanding of the resource.

The most common methods used to catch kokanee and NZ sockeye use a boat with a downrigger, leadline or paravane to fish relatively deep. A large metal "dodger" (Figure 1) creates vibrations and light flashes to bring in sockeye from a large area. One theory on the purpose of the dodger is it imitates a sockeye actively feeding. Around a metre behind the dodger a small shiny spinner incites the sockeye to bite. Staff have produced a video on how to target sockeye and plan to keep developing our knowledge of fishing methods.

Figure 1: Lake Benmore- Ahuriri Arm sockeye taken on a northern hemisphere rig. Dodger on the bottom left and "Dick Nite" spinner on the bottom right.

Issues remaining with development of the fishery are, NZ anglers not wanting to take smaller fish and a perception that sockeye are unpalatable. Ongoing management could include sharing methods to cook whole fish to make the most of a smaller fish and informing people of the fantastic eating qualities of sockeye outside of the spawning period.

Sockeye have a further value to anglers as a forage fish for trout and Chinook salmon present in the catchment. Sockeye emerge from their redds and move downstream quickly to reach a lake environment (Foerster, 1968). These small fish are vulnerable to predation and likely to represent a large annual food source in the Waitaki Catchment (Figure 2) although more work is required to prove this. As the sockeye grow they convert food resources from tiny zooplankton that trout struggle to take advantage of into small fish, a preferred food for large trout. Sockeye may also provide an additional bonus with the fact they spend most of their time in the limnetic zone (open water). Sockeye feeding in the limnetic zone are more vulnerable to predation by trout. A limnetic food source for trout is likely to increase their catch rates by anglers, who typically prefer to troll deeper water (Hayes & Hill, 2005). It appears that sockeye fill a similar niche to the smelt in the lake fisheries of the North Island. Lakes without a limnetic food source are production limited by the amount of littoral (shallow edge) habitat (Hayes & Hill, 2005), which is relatively low in the Waitaki Lakes.

One key benefit of sockeye monitoring up to now has been the inclusion of a significant proportion of waterways in the Waitaki Catchment in schedule 17 of the Canterbury Land and Water Regional Plan. Schedule 17 identifies and names specific salmon spawning waters and inclusion in it greatly increases protection of these waterways.

Figure 2: The stomach contents of a Lake Benmore brown trout, containing 26 juvenile sockeye. Photo: Hamish Stevens.

Methods

The first year of the helicopter monitoring consisted of multiple counts of key spawning sites to improve our understanding of the timing and duration of the run. For more details on run timing, please refer to the CSIFGC report on sockeye spawning for 2018 (Couper, 2018), available on request. Total runs were estimated using the Area Under the Curve (AUC) method described in Unwin (1994).

For the second and third year, sockeye were counted either on foot or by helicopter, at or near the peak of the run. Counts were then scaled up to total run estimates using scaling factors from data gathered in the first year.

Counts that were not completed in any particular year were estimated using proportions to nearby runs, based on other year's data.

All estimates in this report use a residence time (the average number of days between stream entry and death) of 15 days to keep consistent with last year's report. Personal communications with NZ sockeye expert, Dr Eric Graynoth, indicated that research based on daily trap counts and periodic stream spawning counts on Larch Stream showed that the residence time is likely to be lower than this, which suggests our estimates are conservative. It's likely that residence time is longer on lengthier streams that are further away from the lake. Updating the residence time by repeating the Larch Stream trapping or extending it to other spawning tributaries would take a significant amount of staff time.

Results

Spawning Run Estimates

Table 1 shows the estimated spawning totals for each identified spawning water and the total for each lake catchment. The 2020 total is likely to be the largest sockeye run ever in New Zealand. Extreme rainfall in the catchment over summer meant that water was spilt over dams throughout the catchment. This facilitated large scale downstream migration and lead to sockeye spawning in almost every place they have been historically recorded including lower Waitaki River tributaries.

Table 1: Estimated sockeye spawning run totals for 2018-2020. The maximum value in each category is highlighted in blue in the rightmost column.

	2018	2019	2020
Lake Benmore	**32,000**	**36,580**	**42,770**
Twizel River	17,440	16,810	19,520
Ahuriri River	0	0	10,750
Lower Ohau River	7,840	7,970	5,710
Maryburn	1,440	3,470	3,360
Tekapo River	10	1,950	720
Fraser Stream	1,670	1,610	660
Shepherds Creek	790	760	560
Omarama Stream	150	190	430
Mint Stream	1,820	1,100	390
Pukaki River	0	560	170
Grays River	290	480	170
Snowy Gorge Creek	0	0	130
Falstone Creek	440	1,580	100
Silver Creek	0	30	80
Fork Stream	90	70	20
Stoney River	0	0	0
Scrubby Creek	20	0	0
Lake Aviemore	**2,150**	**0**	**13,610**
Otematata River	2,000	0	10,340
Clear Stream	0	0	1,950
Deep Stream	150	0	770
Gibson Stream	0	0	510
Loch Laird Camp Stream	0	0	40
Lake Ohau	**110**	**27,800**	**9,120**
Larch Stream	100	15,300	5,620
Unnamed Dobson Tributaries	0	7,080	1,790
Stockyard Stream	10	3,160	1,140
Unnamed Hopkins Tributaries	0	2,260	570
Lake Pukaki	**4,420**	**6,880**	**5,680**
Glentanner Stream	4,420	6,880	5,680
Lake Waitaki	**0**	**0**	**2,510**
Aviemore Spawning Race	0	0	2,510
Lake Ruataniwha	**300**	**0**	**0**
Upper Ohau River	300	0	0
Catchment Total	**38,980**	**71,260**	**73,690**

Lake Benmore

The Lake Benmore spawning run has increased over the last three years and represented almost sixty percent of the Waitaki Catchment spawning total. The 2020 spawning population in some tributaries was lower than in 2018, however this was made up for by a large run in the Ahuriri. Anglers in previous years have reported small pods of sockeye moving up the Ahuriri and staff have seen them in the Ireland Road bridge area. Helicopter spawning counts have showed no sockeye present at peak spawning times until this year. Sockeye in the Ahuriri for the 2020 survey were only present in small stable side streams.

Lake Aviemore

The 2018 estimate is based on angler reports and historical data although staff did see sockeye spawning off the SH8 bridge in late April 2018. The isolated nature and estimated potential spawning length of the Otematata River (33km) and Clear Stream (13km) made a foot count of these waterways to gain information on where sockeye spawn impractical. To remedy this, Meridian Energy funded a one-off flight to create representative reaches. The Otematata flight was postponed from 2019 to 2020 due to no sockeye being present. Gibson (Waitangi) Stream was estimated using information from NIWA scientists who were netting in the lower reaches. Gibson Stream typically does not support a sockeye run as it dries near the bridge and the lower reaches are particularly armoured with willow roots.

In early-March this year, a large congregation of sockeye at the tailwater of the Benmore Dam was reported by Meridian staff. CSI staff visited the site and confirmed they were sockeye but were unable to estimate numbers due to the large flow through the dam. Sockeye seemed particularly attracted to the dam cooling water on the true right of the tailwater. It is unknown whether these fish would have stayed and attempted to spawn in the tail race or headed downstream to find more suitable spawning water. The presence of sockeye in the Loch Laird camp stable braid in mid-March is an indicator that some may have moved downstream. Plans to check the area in late-March were stymied by the COVID-19 lockdown. Habitat in Benmore Dam tailrace is unlikely to allow for successful spawning.

Lake Ohau

The Hopkins River Catchment at the head of Lake Ohau was flown in March 2019, which gave us good representative reaches to incorporate into the monitoring programme. There are no recorded sightings of spawning sockeye in Lake Ohau tributaries that do not flow into the Hopkins River.

Landowners suggested that we have been underestimating the relative importance of spawning in springs in the mid-reaches of the Dobson, and this flight confirmed this information. Sockeye were present in most spring-fed tributaries of the Dobson and the Hopkins below the Dobson confluence. No sockeye were seen in the Hopkins above the Dobson confluence.

The 2019 sockeye run in the Lake Ohau Catchment is very likely to be the highest ever. The majority of spawning was as is typical, Larch Stream with an estimated total run of 15,300. The largest ever run of sockeye into Larch stream was over 18,000 in 1979. This was however, before the construction of the Ruataniwha spillway that prevented sockeye from moving freely between lakes Ohau and Benmore.

Lake Pukaki

Glentanner Stream remains the key spawning stream for Lake Pukaki. Reports of sockeye spawning in streams up the Jollie River have yet to be confirmed. It's also likely that some of the springs and stable braids in the lower Tasman River would support sockeye spawning.

Lake Waitaki

For the first time since 2015, sockeye spawned in the Aviemore Spawning Race (ASR). Sockeye in Lake Waitaki are assumed to be the product of spills due to their sporadic appearances. It's probable that Lake Waitaki is not suitable for sustaining sockeye as the juveniles are likely to be attracted or swept downstream by the swift current near the dam and short water residence time (Graynoth E. , 1995). Sockeye were not recorded in the two natural spawning tributaries of Lake Waitaki. The larger of the two, Awahokomo Stream, was dry throughout the spawning season. The other potential spawning tributary, Wharekuri Stream, was not checked due to access difficulties but is likely to have supported a small spawning run.

Lake Ruataniwha

The upper Ohau River had a small run of sockeye in the 2018 spawning season but none were observed in 2019. Due to the large spread of sockeye in 2020 it seems very likely that at least a small run of sockeye spawned in the upper Ohau River. Spawning counts were not carried out due to the COVID-19 lockdown. It is possible, but not confirmed, that sockeye spawn in the dam tail race at the head of the lake.

Waitaki River

Sockeye spawning in lower Waitaki River tributaries are a product of spills from the Waitaki Lakes and are incredibly unlikely to contribute to a self-sustaining sockeye population.

A count of the lower reaches of the Awakino gave an estimate of 130 sockeye spawning. There were also sockeye seen by staff in low numbers in the lower Hakataramea River and associated springs. Reports were received of "hundreds" of fish spawning in one of the Waitaki braids enhanced by the joint CSIFGC and Meridian programme. Staff were unable to confirm these were sockeye due to the COVID-19 lockdown but it's unlikely they would be anything other than sockeye. The identified braid is approximately 7km downstream of the dam, meaning that sockeye had to swim past a significant amount of suitable spawning area.

Based on the above limited information it's possible that thousands of sockeye spawned in lower Waitaki River tributaries. These fish were raised in the Waitaki Lakes and could have significantly increased the spawning populations there had spills not occurred.

Spawning Densities

Figure 3 shows the density of sockeye spawning in the Upper Waitaki Catchment for the 2020 spawning season. Density is shown as total sockeye run over lineal km of river, so does not account for the braided nature of these streams. The highest spawning densities in order were in: the Aviemore Spawning Race, Glentanner Stream, Larch Stream and the lower reaches of the Twizel River. Spawning density followed a similar pattern to previous year where densities were highest near the lake and diminished heading upstream. The Ahuriri followed this pattern to a lesser extent, probably due to sockeye only spawning in reaches that contained stable side streams.

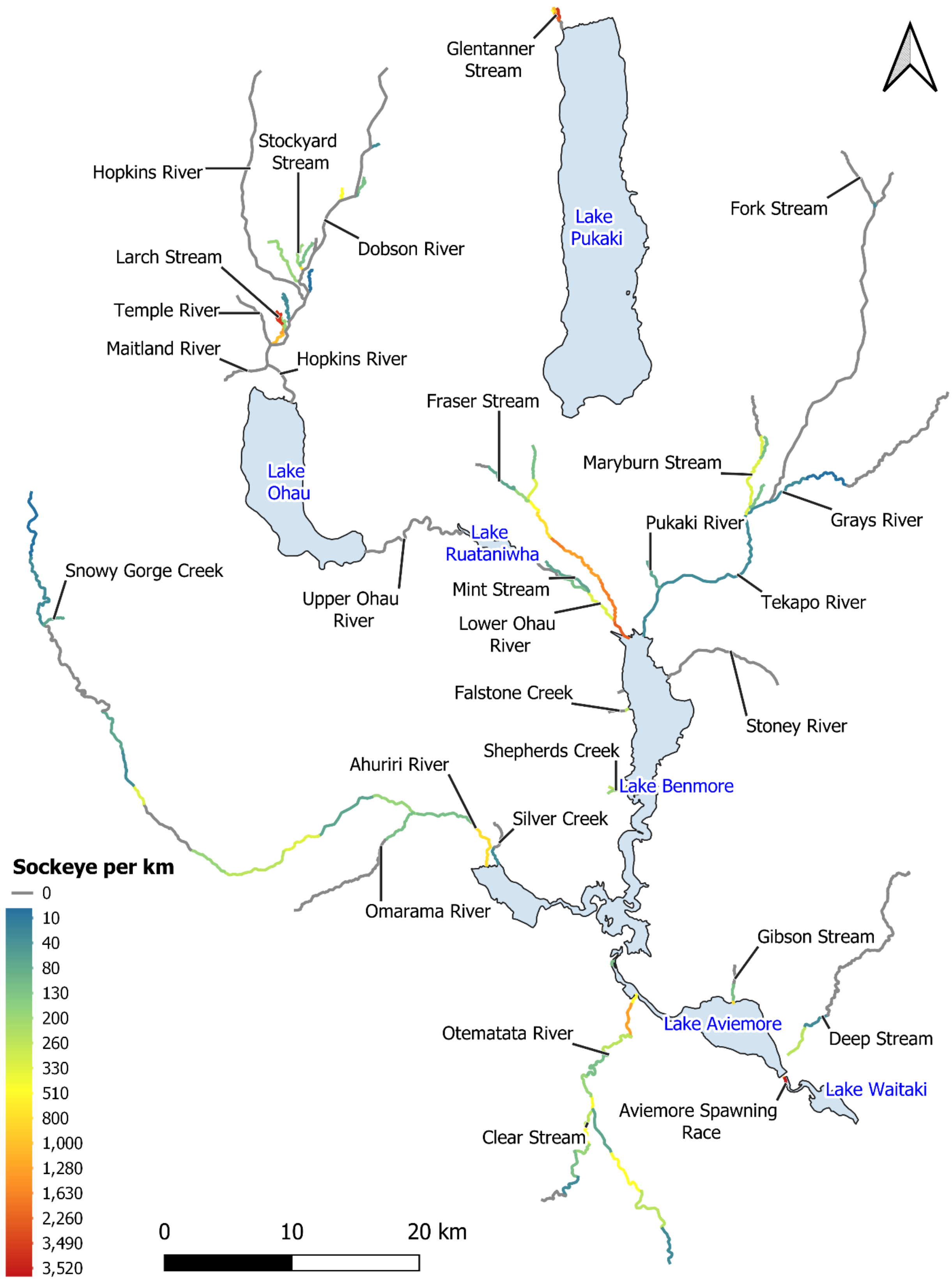

Figure 3: Sockeye spawning densities for the 2020 spawning season.

Length Analysis

Spawning sockeye showed a marked decline in fork length between 2019 and 2020 (Figure 4). The lengths were collected in different ways between the two years: measuring post-spawn dead fish in 2019 and electric fishing in 2020. It was noted in 2019 that collecting dead fish appeared to be biased towards larger fish however the results are different enough to assume the size difference was genuine and not solely an error caused by different measuring methods. A non-parametric permutation test showed a significant difference in fork length between the two years ($p = 4.1e^{-14}$).

In 2019 only 3.6% of spawning sockeye that were measured were below the CSIFGC minimum takeable length of 300mm. In 2020 this increased to 73%.

There are multiple possible explanations for the change in the size of spawning sockeye. It's likely that the total population including all year classes present in the lake has increased over this period. An increased population may have created competition for food and a subsequent drop in growth rates. Another potential cause of the drop in size was the large floods in December causing an increase in turbidity. An increase in turbidity limits light penetration, reducing the primary productivity, which over time will reduce the size of sockeye. It's unlikely that reduction in food production in the final four months of the fishes lifespan would explain the significant drop in their final size.

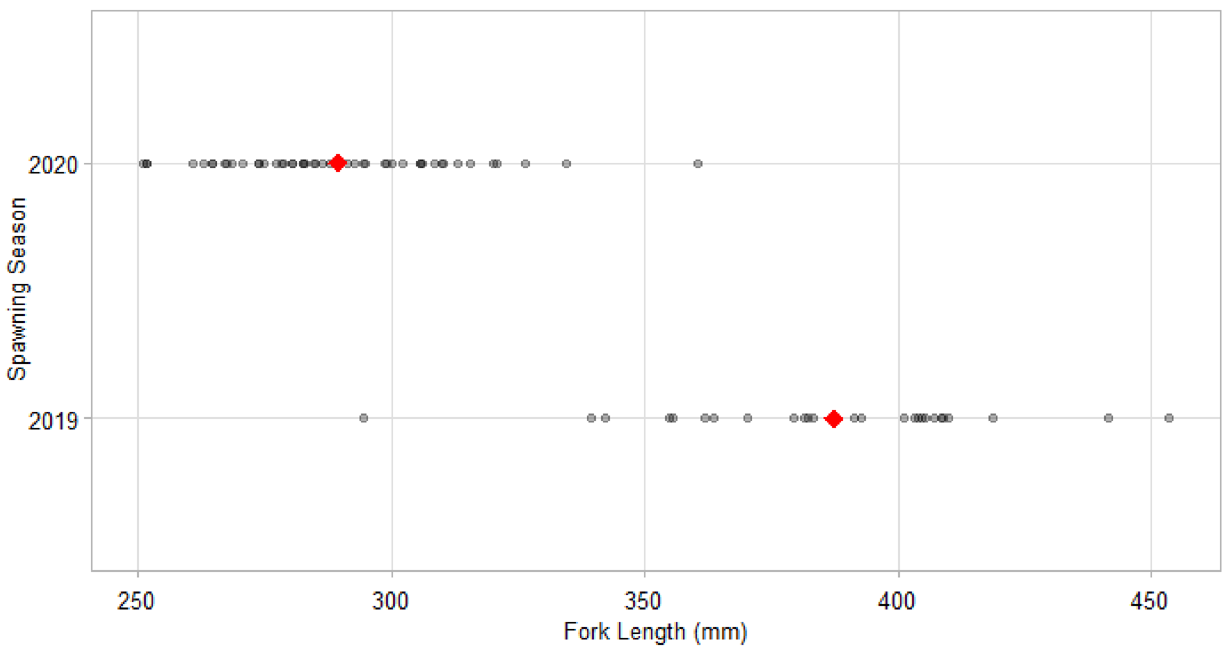

Figure 4: Strip chart showing lengths of salmon spawning in Lake Benmore tributaries for 2019 and 2020 (n_{2020}= 48, n_{2019}= 28). The mean for each year is marked with a red diamond.

Monitoring Programme

An ideal monitoring programme for sockeye would consist of a yearly helicopter flight at or near the peak of the sockeye run, It would take approximately 2.5 staff days flying time, but would cover the entire catchment and account for changes in where sockeye spawn. A full helicopter survey of the catchment every year however is expensive, estimated at $12,000 per year. An alternate to helicopter surveys would be to complete foot surveys in selected sections of recognised sockeye spawning sites. This alternate method is discussed below.

The three-year helicopter survey programme has identified which tributaries contain the highest number of sockeye (Table 1), and the sections of each tributary that contain the highest spawning density (Figure 3). This information alongside staff knowledge of which areas can be practically surveyed on foot has been combined to create a prioritised list of "representative reaches". These representative reaches will be walked in future years near the peak of spawning (10^{th}- 20^{th} of March). Staff will count live sockeye. These counts will then be scaled up using historical information to convert counts on a certain date to total run and total run on a section of river to total run for a catchment or identified sub-catchment. To account for the large and expansive sockeye runs and the importance of the fishery in Lake Benmore, the catchment has been divided in to four sub-catchments: Twizel River, lower Ohau River, Tekapo River and the Ahuriri Arm.

Lake Benmore

The lower 4 km of the Twizel River (Figure 5) will be surveyed on foot to estimate the rest of the Twizel River and Fraser Stream. This lower section accounts for approximately 36% of the Twizel River Catchment spawning. This section is difficult to survey, however, due to willow infestation, so it may have to be swapped out in future for a section with lower spawning density, further up the catchment.

The lower 5 km of the lower Ohau River (Figure 5) from the mouth to the confluence of Mint Stream will be surveyed on foot to estimate the rest of the lower Ohau River and Mint Stream. This represents ~88% of the lower Ohau Catchment spawning run (excludes Twizel River and tributaries).

The bottom 2 km of the lower Ohau below the Twizel River confluence will also be used to estimate the minor tributaries that run directly into the lake. This proportion is not as constant as others used in this programme but as the minor tributaries account for only ~2.3% of Lake Benmore spawning, the time savings are justified. A count of Falstone Creek should be undertaken if staff are in the area to improve this estimate.

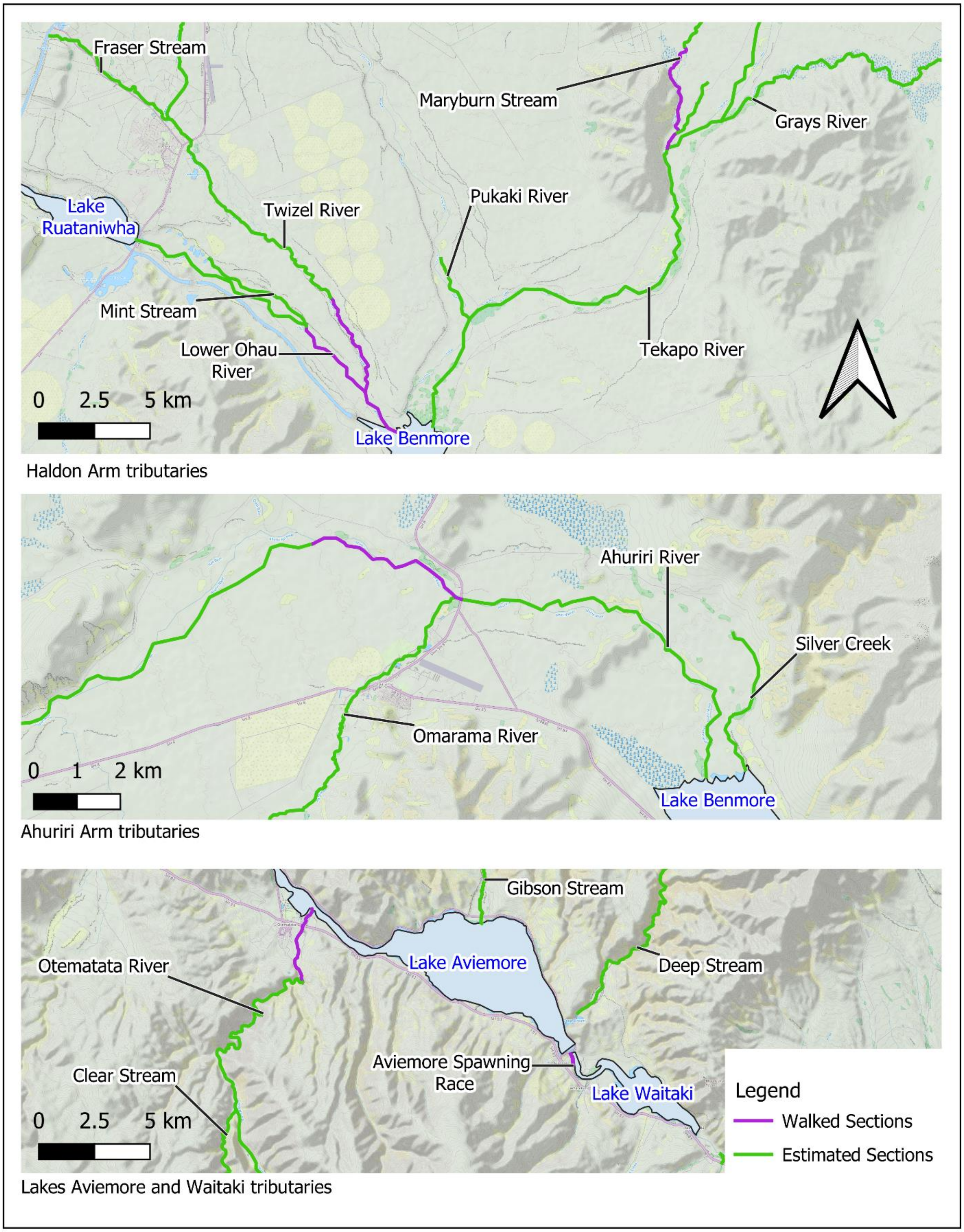

Figure 5: Reaches to be surveyed for lakes Benmore, Aviemore and Waitaki tributaries.

The lower 4.5km of the Maryburn from the confluence with the Tekapo River to the pylons contains ~56% of Tekapo River Catchment spawning. This section is relatively remote and difficult to survey. The section is infested with significant stands of willows and alders, which increase the time taken to survey and the difficulty of sighting fish. This visibility was also an issue for the helicopter survey, so the representative reach should represent a relatively consistent proportion of spawning. This section should be trialled to determine the practicality of walking and if it's determined to be too difficult, a section with lower spawning density further up the catchment should be surveyed. Spot checks of easy to access Tekapo River points should be included while travelling to and from the Maryburn if time allows. A spot check of the Pukaki River should also be carried out if time allows. Runs in the Pukaki River appear to be tied to spilling in the river.

The Ahuriri River (Figure 5) presents the most challenges to monitor without the use of a helicopter. Runs are sporadic and expansive and the river is difficult to survey due to its flow and braided nature. The 4 km section above SH8 has been chosen because it has relatively high spawning density and is not too challenging to survey. Staff would have to walk up one side and down the other to try and survey all the small stable side braids that the sockeye spawn in. If this section proves too difficult, the lower Omarama would be an easier, but likely less representative, option in future. The proposed section contains approximately 6% of Ahuriri Arm spawning, meaning our Ahuriri Arm estimate will be a weak point of this monitoring programme.

Overall for Lake Benmore, we intend to survey the ~8% of potential spawning area, which accounts for ~34% of total spawning in the Lake Benmore Catchment.

<u>Lake Aviemore</u>

The lower 4 km of the Otematata River (Figure 5) will be surveyed to estimate spawning in the Lake Aviemore Catchment as this section accounts for ~29% of Lake Aviemore spawning. It is currently unknown how well the Otematata run relates to that in Deep Stream, the other significant spawning ground. The relationship between these two streams should be investigated further if time allows.

<u>Lake Ohau</u>

Larch Stream is the historic home of sockeye in New Zealand and yearly monitoring of its entirety offers consistency with historical records. If a second staff member is available and the Hopkins is low enough to ford, then Stockyard Stream should also be surveyed. Larch stream represents around 62% of Lake Ohau spawning.

<u>Lake Pukaki</u>

Glentanner Stream is the only firmly established spawning stream in the Lake Pukaki Catchment so it should be monitored yearly. Other springs that contribute to Lake Pukaki spawning should be investigated if time allows.

<u>Lake Waitaki</u>

When sockeye are present in Lake Waitaki, Aviemore Spawning Race is the only consistent spawning location. Aviemore Spawning Race should be checked early in March as sockeye spawning in the race are small enough to get through the fish barrier at the top of the race. Sockeye that get above the race are unable to spawn successfully and likely to die. If sockeye are present in the race, the smaller mesh screen should be installed.

Monitoring Programme Summary

In addition to the waterways described above, a preliminary survey should be carried out in early March consisting of checks of bridges and easy access points throughout the Waitaki Catchment to determine where sockeye are present is useful for planning surveys. This was crucial in reducing flight hours during the helicopter programme. The time involved with this is minimal and can be incorporated with a canal ranging day.

The sockeye monitoring programme aims to survey 8.5% of recognised Waitaki Catchment spawning area, which accounts for an estimated 45% of total spawning. Table 2 outlines the time requirements for staff to complete the yearly monitoring. This time allocation should be considered against a five staff day allocation for a helicopter survey (2.5 survey days,.5 electric fishing and 2 days reporting). A helicopter survey offers a reduced staff load, while significantly increasing the percentage of the catchment that can be surveyed.

Table 2: Staff time required for monitoring and reporting on Waitaki Catchment sockeye spawning.

Lake	River surveyed	Staff days
Lake Benmore	Lower Ohau River	1
	Twizel River	1
	Maryburn River	1
	Ahuriri River	1
Lake Aviemore	Otematata River	1
Lake Pukaki	Glentanner Stream	0.5
Lake Ohau	Larch Stream	1
Lake Waitaki	Aviemore Spawning Race	0.5
	Preliminary checks	0.5
	Surveying total	**7.5**
	Electric Fishing	0.5
	Reporting	2
	Total time required	**10**

The lower reaches of the Twizel River should be electric fished yearly, to obtain length measurements from ~50 fish. This work is to assess if significant changes in the size of sockeye are occurring.

An external cost of $200 would allow staff to stay at campgrounds in the Mackenzie Country for 3-4 nights and reduce the amount of staff time and vehicle travel required to implement this monitoring programme.

Staff will collect otoliths from sockeye in the catchment when time allows. Information from otoliths will be used to assess changes in age structure and growth rates.

Discussion

The three-year helicopter monitoring programme has quantified sockeye as a significant resource at an all-time high. Although sockeye are caught in Lake Benmore, the total harvest is likely to be a small fraction of a percent of the available population. Conditions for sockeye in the Waitaki Catchment are ideal at the moment leading to spawning numbers in the tens of thousands. While these ideal conditions last, even a large increase in angling and harvest is not going to have a significant effect on juvenile production. Staff believe that for a large proportion of tributaries, spawning areas are over saturated and an increase in spawning runs is unlikely to increase adult sockeye recruitment.

The helicopter monitoring programme has provided the information needed for the CSIFGC to allow Waitaki Lakes anglers to make use of a significant, relatively new recreational resource. It has also laid the groundwork for future monitoring to ensure the sockeye population is not over-exploited if conditions for sockeye change.

Staff recommend that regulations for Waitaki lakes sockeye be amended to allow for increased harvest of sockeye. The recommended option is to change the bag limit from "4 trout and 2 salmon" to "4 sports fish". The key benefit of this regulation change is that it increases the opportunity to make use of the abundant sockeye population

In all CSIFGC lakes that are not open to the sea, all of the Chinook salmon present are of non-wild origin and should be regarded as "put and take" fisheries. Chinook salmon in the Waitaki Lakes that are not caught by anglers will inevitably die without spawning successfully so regulations should be set to encourage their harvest.

Staff have recognised that anglers struggle to differentiate between any of the four salmonid species present in the Waitaki Lakes (sockeye, Chinooks, browns and rainbows) and that their identification is worse on smaller fish. A change to a "sports fish" limit rather than a "trout" and "salmon" limit is easier for anglers to understand and for rangers to enforce.

There would potentially be a slight drop in total trout harvest from this regulation change. If an angler catches two salmon (sockeye and/or Chinook) under the current regulations they would be able to make up the rest of their bag with an additional four trout. Under proposed regulations they would only be able to take an additional two trout.

Staff also recommend a reduction in the size limit from 300mm to 250mm in all lakes in the CSIFGC Region. This regulation is to encourage and allow the harvest of smaller salmon. This regulation also allows the harvest of sockeye in years where the fish are smaller. The only lake in the CSIFGC Region where Chinook salmon contribute positively to sea-run populations is in Lake Heron where the size limit is already 250mm and is already the focus of a separate, ongoing research project and management review.

Currently anglers are only allowed to fish for sockeye in flowing waters before the first of March. Sockeye don't enter freshwater until around the 20th of February, so this regulation only allows anglers to target spawning run sockeye in flowing water for 9-10 days. Staff recommend this regulation remains in place as it allows anglers a short window to catch and get a photo of sockeye in full spawning colours while protecting the vast majority of spawning.

Larch Stream is recognised as the home of NZ sockeye. It is by far the most studied and surveyed spawning stream and until recently contained the majority of total catchment sockeye spawning. Currently the trout fishing season in Larch Stream closes at the end of January to avoid disturbance of spawning sockeye. However, the just completed, three-year helicopter programme has shown that reasonably stable and larger sockeye spawning populations have established throughout the Waitaki Catchment and closing the trout season early in Larch Stream is no longer justified.

Staff recommend that the closing date for trout fishing in Larch Stream trout season be extended from the last day in January to the last day in April to line up with other high-country waters where sockeye spawn e.g., the Twizel River. Sockeye spawning would still be protected regardless of a change to the trout fishing regulations as it would remain illegal to target sockeye in Larch Stream or any other spawning tributary after the last day in February. The monitoring programme will allow us to identify changes in sockeye populations and if these are in jeopardy, the closure of the Larch Stream trout fishery should be reinstated.

The monitoring programme proposed in this paper offers a time- and cost-efficient method to monitor sockeye fisheries. However, it is also recognised that the sockeye population is changing over time and that representative reaches identified by the helicopter monitoring project may not provide an accurate index indefinitely. To adapt to changes over time, staff recommend a five-yearly helicopter survey of the entire upper catchment to monitor changes to spawning populations and habitat. Ideally the five-year period should be flexible so it can be carried out in a year with a large spawning run, this would be determined in early March on the preliminary check day. Staff recommend this five-yearly helicopter survey is included in discussions on the upcoming Meridian reconsenting process.

Recommendations

1. **THAT THE FOLLOWING CHANGES TO CSIFGC REGULATIONS BE CONSIDERED AT THE NEXT ANGLER NOTICE REVIEW:**

    1.1. THE BAG LIMIT IN LAKES PUKAKI, OHAU, BENMORE, AVIEMORE AND WAITAKI ARE CHANGED FROM "4 TROUT AND 2 SALMON" TO "4 SPORTS FISH".

    1.2. THE MINIMUM SIZE FOR SALMON IN CSIFGC LAKES IS REDUCED FROM 300MM TO 250MM.

    1.3. THE OPEN SEASON FOR TROUT FISHING IN LARCH STREAM IS CHANGED FROM "1ST SATURDAY IN NOVEMBER TO 31ST JANUARY" TO "1ST SATURDAY IN NOVEMBER TO 30TH APRIL" (Note: S*ockeye fishing season in all streams and rivers remains closed after the last day in February).*

2. **THAT THE ATTACHED MONITORING PROGRAMME IS ACTIONED IN THE 2020/21 OWP.**

3. **THAT STAFF ARE AUTHORISED TO DISCUSS A FIVE-YEARLY HELICOPTER SURVEY WITH MERIDIAN IN THE UPCOMING MERIDIAN RECONSENTING PROCESS.**

Acknowledgments

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