2023-24 Sea-Run Salmon Management

North Canterbury Region

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Document Control			
Version	**Updated**	**Updated By**	**Changes**
1.1	6 September 2024	E. Craig, N Dellaway, H Sanders Garrick	Original document created

Executive Summary

Anglers are required to obtain a sea-run salmon licence to be able to fish for sea-run salmon in the Central South Island and North Canterbury Fish & Game regions. This licence allows anglers to harvest a season bag limit of two salmon, and anglers are required to record the details of harvested salmon on their season bag limit card. In the 2023-24 season, a total of 11,622 sea-run salmon licences were issued. At the end of the season, Fish & Game ask for harvest information back from anglers, even if no fish were kept. By the cutoff date, 2,351 valid season bag card returns (20.2% of all licence holders) had been received. The remainder of harvest by anglers that hadn't returned their information was then estimated by phone survey.

During the 2023-24 sea-run salmon season, anglers harvested an estimated 518 salmon in the North Canterbury and Central South Island Fish & Game regions. The majority of harvest occurred on the Rakaia River, but more than 95% of reported harvest occurred within the 4 major sea-run salmon fisheries: the Rakaia, Rangitata, Waimakariri, and Waitaki rivers. Approximately 65.7% of recorded harvest occurred on rivers in the North Canterbury region while 34.3% of recorded harvest occurred on rivers in the Central South Island. Relative to the 2022-23 season, estimated harvest decreased on every observed river. The majority of reported salmon harvest occurred in March and April, but timing of harvest varied by river. Average date of harvest was later than during the 2022-23 season. The average length of harvested salmon was 61cm, smaller on average than those reported during the 2022-23 season.

Five spawning counts were carried out on the headwater streams on each of the three indicator rivers (Rakaia, Rangitata and Waimakariri rivers), with additional aerial and foot counts of Mellish Stream (Rakaia River tributary). Area under the curve (AUC) methodology was used to estimate the total escapement (spawning) estimate for each river. Estimates of escapement are 327 salmon on the Waimakariri River 878 salmon on the Rakaia River, and 250 salmon on the Rangitata River. Escapement proportions[1] were 83% on the Rakaia River, 73% on the Rangitata River, and 70% on the Waimakariri River.

The combined escapement estimate for the three indicator rivers used in the Adaptive Management Strategy is 1,455 salmon. This places this season's escapement estimate within the 'low' management band of the threshold management strategy, indicating a season bag limit of two salmon for the 2024-25 season. This year's low escapement and harvest numbers are following a trend of decline in recent years, most likely driven by environmental changes. External factors above the norm may also have had an impact; the May 2021 Ashburton flooding event likely would have impacted on spawning success for the now 3-year cohort returning this year. In years such as these with lower spawning returns, the adaptive management strategy and sea-run salmon season bag

[1] Proportion of the total salmon run that reached spawning waters

limit is a crucial tool in reducing harvest and increasing escapement proportions. Further reviews of the adaptive management strategy may aim to take escapement proportions into consideration and be integrated into bag limit setting.

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1.0 Sea-run salmon licence

In order to fish for sea-run salmon in the Central South Island and North Canterbury Fish & Game regions, anglers must obtain a sea-run salmon licence[2] which includes a bag limit card for recording fish harvest details. The 2023/24 season was the third season in which a licence was required to fish for sea-run salmon. In the preceding 2021/22 and 2022/23 seasons, a total of 9,438 and 12,859 licences were sold respectively. With the marked increase in the number of licences sold, coupled with the high proportion of licence holders that did not go fishing for sea-run salmon in the 2023/24 season (Sanders Garrick, 2023), a decrease in licence sales was expected for the 2023/24 season.

By the conclusion of the 2023/24 season, a total of **11,622** licences had been issued, a decrease of only 1,237 on the previous season. In total, 4,542 licences (39%) were issued in Central South Island, and 5,899 licences (51%) in North Canterbury (Table 1 & Figure 1). This constituted 90% of all licences sold in New Zealand. The remaining 10% of licences were sold predominantly to other South Island regions (Otago [4.4%], Nelson/Marlborough [2.4%], Southland [1.6%], and West Coast [0.5%]). All North Island regions combined comprised only 1.1% of all licence sales. These proportions were similar to the previous season, with only a small increase in the proportion of licences sold in Central South Island and North Canterbury, and a corresponding decrease in all other regions.

Table 1. Number of sea-run salmon licences issued in the 2021/22, 2022/23 and 2023/24 seasons across South Island regions and combined North Island regions.

Licence Region	2021/22	2022/23	2023/24
Nelson/Marlborough	567	437	280
West Coast	120	93	64
North Canterbury	5,081	6,385	5,899
Central South Island	2,603	4,882	4,542
Otago	655	625	512
Southland	216	257	193
All North Island regions	196	180	132
Total	9,438	12,859	11,622

[2] For the purposes of this report, from here on sea-run salmon licences will simply be referred to as 'licences'.

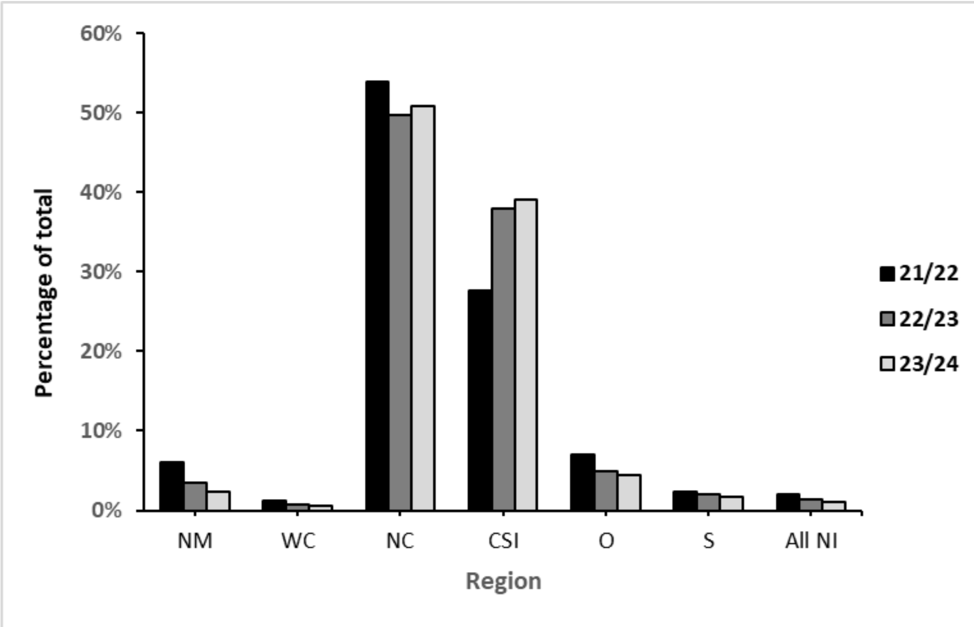

Figure 1. Percentage of total sea-run salmon licences issued by each South Island region (N/M=Nelson/Marlborough, WC=West Coast, NC=North Canterbury, CSI=Central South Island, O=Otago, S=Southland) and combined North Island regions (All NI).

Whole season Adults held the most licences once again (45% of total), followed by Family (29%), and Loyal Seniors (12%) (Table 2). Due to the reduction in licence sales in the 2023/24 season, almost all licence types had a decrease on the previous season with the exception of Juniors and Non-Residents. Proportion of the total sales remained similar for all Resident groups, however a large increase in the number of Non-Residents purchasing licences suggests a return of non-resident salmon anglers to New Zealand post-COVID, or a greater uptake in sea-run salmon fishing by non-residents.

Table 2. Comparison of number of sea-run salmon licences issued in the 2021/22, 2022/23 and 2023/24 seasons across whole season licence types.

Licence type	**2021/22**	**2022/23**	**2023/24**
Adult	4,560	6,021	5,253
Family	2,841	3,976	3,442
Loyal Senior	1,321	1,495	1,402
Junior	307	560	575
Child	165	370	347
Local Area	222	352	318
Non-Resident	22	59	285
Day (in error)	0	26	0
Total	9,438	12,859	11,622

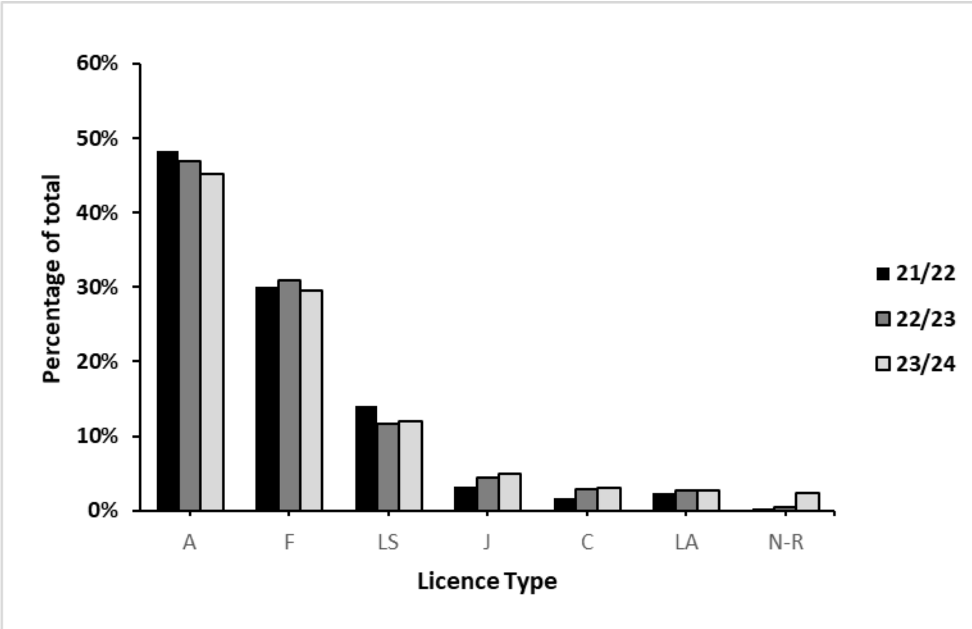

Figure 2. Percentage of total sea-run salmon licences issued by whole season licence type (A=Adult, F=Family, LS=Loyal Senior, J=Junior, C=Child, LA=Local Area, N-R=Non-resident). Sea-run salmon licences issued to day licence holders in error are not shown.

2.0 Sea-run salmon harvest

2.1 Introduction

Fish & Game manages sea-run salmon in the North Canterbury and Central South Island regions using a seasonal bag limit. Anglers who purchase a licence to fish salmon receive a bag limit card, which they are required to fill out immediately upon harvest of a salmon. Details listed on the card include the date and location of harvest and the sex and length of the fish. The information gathered during this survey is used to assess the health of the sea-run salmon fishery in the central eastern portion of the South Island of New Zealand, and help guide management actions in accordance with the adaptive management plan (Webb & Terry 2020).

2.2 Methods

In 2024, anglers were asked to return their bag limit card by 7 May, following the close of the sea-run salmon season on 1 May. Bag limit cards could be returned via online form, email, post, or in person at either the Central South Island or North Canterbury offices. Anglers who did not harvest any salmon were asked to indicate on their card whether they went fishing for sea-run salmon. Fish & Game accepted entries until 15 May to allow time for postal delivery.

On 15 May, anglers who had not voluntarily submitted their bag limit cards were identified as potential phone survey participants, and a subset was selected using a random stratified sampling method. Using previous harvest survey data, we identified anglers who are known to have harvested at least one salmon between the 2018-19 and 2022-23 fishing seasons. These anglers constituted the “known success” stratum, while all remaining anglers were classified to the “no known success” stratum, or anglers with no recorded salmon harvest since the 2018-19 season. We used the sample function in program R (R Core Team 2022) to randomly select 200 anglers from the known success stratum and 1,800 anglers from the no known success stratum, with the goal of collecting 100 and 900 surveys, respectively. Phone surveys were conducted between 15 May and 20 June 2024.

We compared harvest between anglers who returned their bag cards voluntarily and those who were surveyed during phone interviews using a generalized linear model with a Poisson distribution. Similarly, we compared harvest between anglers with known success and anglers with no known success using a generalized linear model with a Poisson distribution. We used results of these models to determine whether data from multiple survey strata should be combined or remain separate while calculating harvest estimates.

Harvest from voluntary returns was not extrapolated to any non-respondents, as the mean harvest of those who returned their bag cards voluntarily was substantially different from those who did not. Additionally, harvest was substantially different between the two phone survey strata. Thus, all strata were maintained while calculating harvest estimates.

An estimate of harvest was calculated by extrapolating the mean harvest/active angler across each stratum according to the formula:

$$H_i = T_i \times P_i \times \bar{Y}_i$$

In which, for stratum i, H represents estimated harvest, T represents the total number of anglers, P represents the participation rate (i.e., the proportion of licenced anglers who actively fished), and $\bar{Y}$ represents the mean harvest per angler.

We extrapolated these results to 594 anglers in the known success stratum and 8,686 anglers in the no known success stratum to produce an estimated harvest for each stratum. Estimated harvest was calculated for all non-respondents by calculating the weighted total mean from the phone survey strata according to the formula:

$$\hat{Y} = \sum F_i \bar{Y}_i$$

In which $\hat{Y}$ represents the weighted mean and, for stratum i, F represents the proportion of total respondents and $\bar{Y}$ represents the mean (Arnold et al. 2023).

Total variance was calculated from the phone survey data according to the formula:

$$S_Y^2 = \frac{1}{N-1}\left(\sum (N_i - 1)S_i^2 + \sum N_i\left(\bar{Y}_i - \hat{Y}\right)^2\right)$$

In which variance of the weighted mean, $\hat{Y}$, is represented by S_Y^2, S_i^2 represents variance for stratum i, $\bar{Y}_i$ represents mean harvest of stratum i, and N and N_i represent the total and stratum sample sizes (Arnold et al. 2023).

A 95% confidence interval was calculated around the harvest estimate for each stratum and total harvest according to the formula:

$$Z_{\alpha} \times \sqrt{\frac{S_Y^2}{N}}$$

In which Z is the z-score for a confidence interval of a given value of α: 1.96 for a 95% confidence interval. Total harvest was calculated as the sum of harvest reported from voluntary returns and the total estimate from phone interviews.

We assessed the distribution of harvest dates across all anglers who reported valid harvest dates, and across the 4 major sea-run salmon fisheries (Rakaia, Rangitata, Waimakariri, and Waitaki) for anglers who also reported valid location of harvest.

We assessed the average length of harvested salmon across all anglers who reported valid lengths, and across the 4 major sea-run salmon fisheries for anglers who also reported valid location of harvest. We used a simple linear model to evaluate the relationship between length and river catchment.

2.3 Results

2.3.1 Voluntary Card Returns

Before the 15 May cut off, we received 2,351 valid bag card returns (20.2% of all licence holders). Of those, 50.9% reported that they did not fish for sea-run salmon during the 2023-24 season. Thirty-eight-point-six percent (908 anglers) reported that they fished for sea-run salmon but did not harvest any fish. Only 246 anglers (10.5%) reported that they harvested salmon (Figure 3).

2.3.2 Phone Surveys

We surveyed 996 anglers in total: 109 anglers from the known success stratum and 887 from the no known success stratum. Of the anglers surveyed, 679 (68.2%) did not go fishing, 292 (29.3%) went fishing but did not harvest salmon, and 25 (2.5%) successfully harvested salmon (Figure 3). Only 6 anglers (0.6%) reported successfully harvesting their limit of 2 salmon. The mean number of salmon harvested by those who went fishing was 0.10 fish/angler (± 0.020).

Mean salmon harvest amongst anglers who returned their bag cards voluntarily had a mean harvest rate of 0.27 fish/angler (± 0.017), nearly 3 times the mean harvest of those who were surveyed during phone interviews. The two groups were statistically distinct ($F_{1, 1469} = 28.3$, $p < 0.001$; Figure 4), therefore we did not extrapolate data from voluntary returns to non-respondents.

Amongst anglers with known success, 73.4% of those surveyed actively participated in the 2023-24 salmon season, with an average harvest of 0.26 fish/active angler (± 0.058). Amongst anglers with no known success, 26.7% of those surveyed actively participated in the 2023-24 salmon season, with an average harvest of 0.04 fish/active angler (± 0.017). The two strata were statistically distinct ($F_{1, 315} = 24.7$, $p < 0.001$; Figure 5).

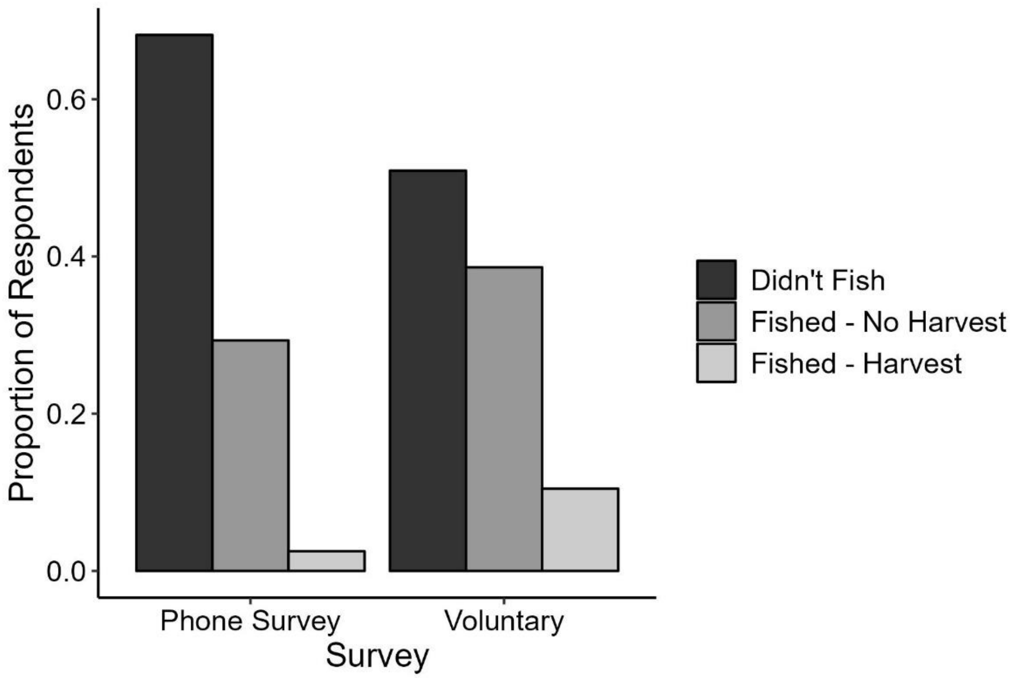

Figure 3. The proportion of respondents who didn't fish, fished but didn't harvest, and both fished for and harvested sea-run salmon in the North Canterbury and Central South Island regions of Fish & Game by survey type during the 2023-24 season.

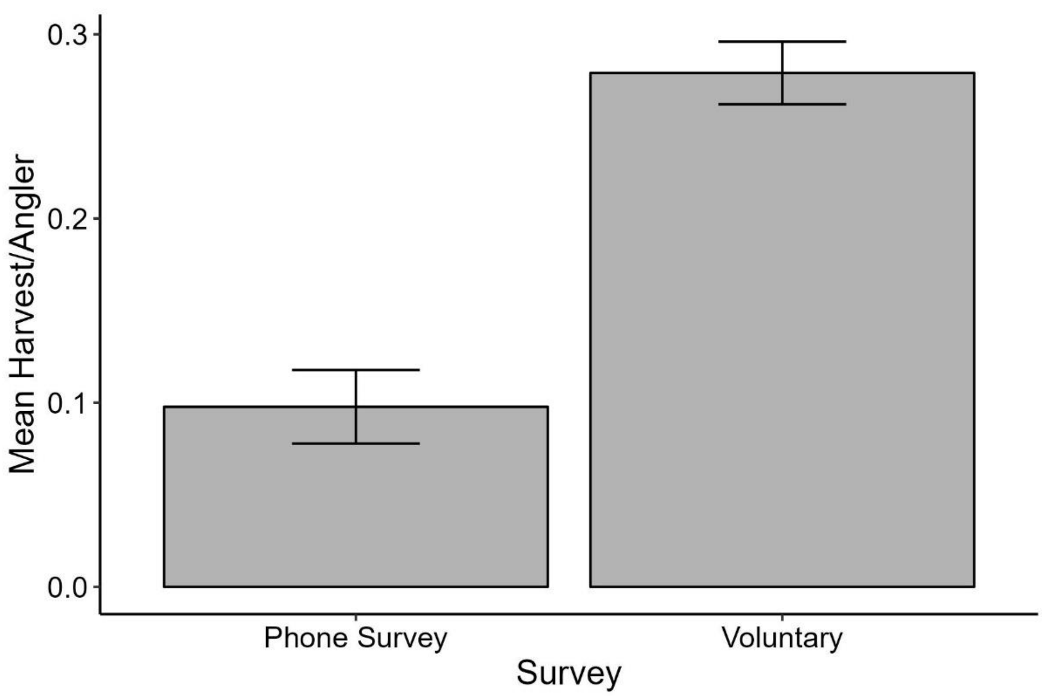

Figure 4. Mean harvest of sea-run salmon by survey type for anglers in the North Canterbury and Central South Island regions of Fish & Game during the 2023-24 season. Error bars represent standard error.

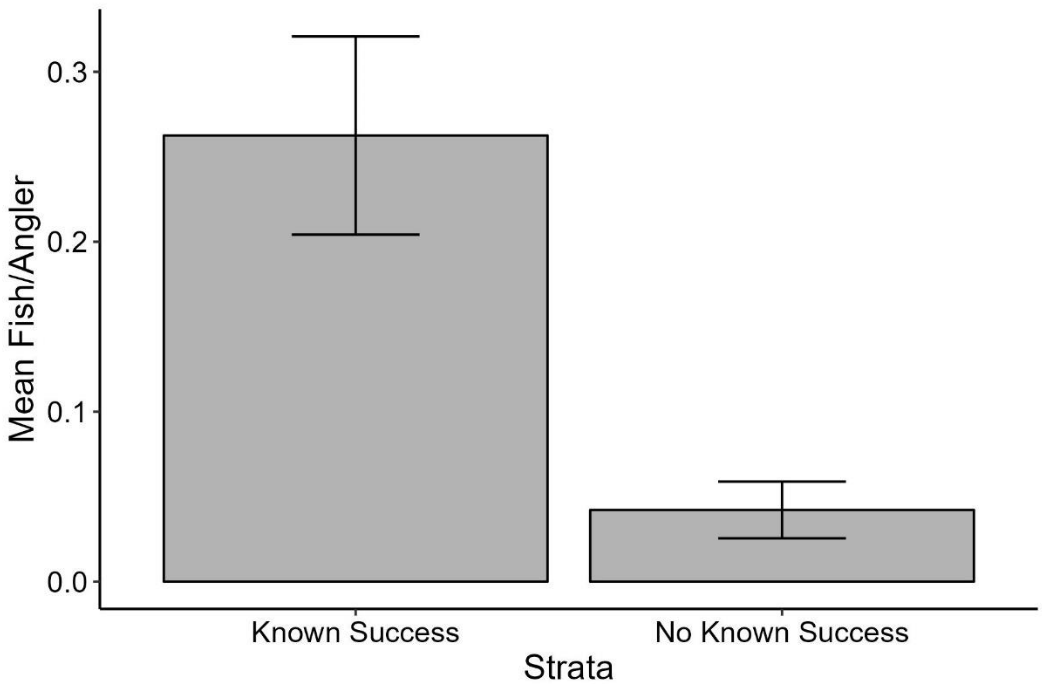

Figure 5. Mean harvest of sea-run salmon by phone survey stratum for anglers in the North Canterbury and Central South Island regions of Fish & Game during the 2023-24 season. Error bars represent standard error.

2.3.3 Estimated Harvest

Voluntary respondents reported a total harvest of 322 salmon. Estimated harvest was 114.4 (± 49.8) salmon for the known harvest stratum and 97.9 (± 75.9) salmon for the no known harvest stratum. Total estimated harvest was 517.8 (± 55.9) salmon (Figure 6).

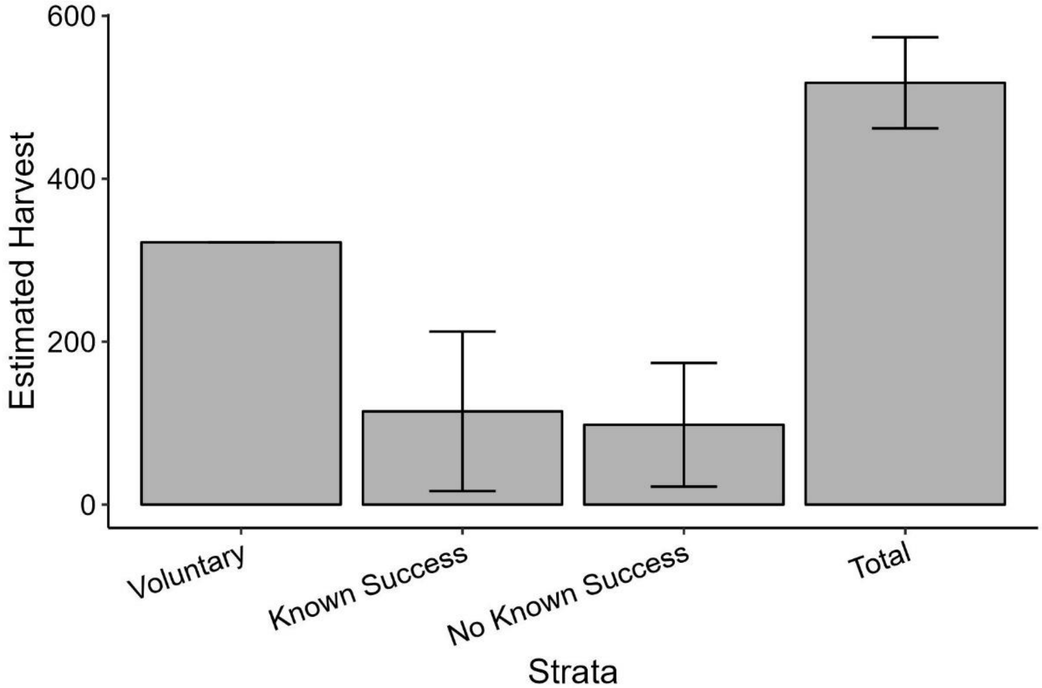

Figure 6. The estimated salmon harvest and 95% confidence interval on the estimate for each survey stratum, North Canterbury and Central South Island regions of Fish & Game, 2023-24 season.

2.3.4 Harvest by River

More than 95% of the reported salmon harvest occurred on the Rakaia, Rangitata, Waimakariri, and Waitaki rivers (Table 3). Angler effort was greatest on the Waimakariri River, followed by the Rakaia, Rangitata, and Waitaki rivers, respectively.

Harvest varied substantially by river, both within and between survey strata (Figure 7). Total estimated harvest was greatest for the Rakaia River (185.5 ± 45.4 salmon), followed by the Waimakariri River (142.8 ± 37.8 salmon), the Rangitata River (94.0 ± 39.4 salmon), and the Waitaki River (93.7 ± 18.5 salmon), Estimated harvest on each of the 4 major rivers has decreased relative to the 2022/23 season (Figures 8-12).

Table 3. The reported harvest, estimated harvest (with 95% confidence interval), and reported number of active anglers by survey stratum for the 2023-24 sea-run salmon season in North Canterbury and Central South Island Regions of Fish & Game, broken down by each of the 4 major sea-run salmon fisheries.

Reported Harvest					
	All Rivers	Rakaia	Rangitata	Waimakariri	Waitaki
Voluntary	322	115	48	81	61
Known Success	21	6	1	8	6
No Known Success	10	4	4	2	0
Total	353	125	53	91	67

Estimated Harvest					
	All Rivers	Rakaia	Rangitata	Waimakariri	Waitaki
Known Success	114.4 ± 49.8	32.7 ± 22.8	5.4 ± 10.7	43.6 ± 25.4	32.7 ± 18.5
No Known Success	97.9 ± 75.9	39.2 ± 37.6	39.2 ± 36.8	19.6 ± 27	NA
Total	**517.8 ± 55.9**	**185.5 ± 45.4**	**94.0 ± 39.4**	**142.8 ± 37.8**	**93.7 ± 18.5**

Active Anglers Surveyed					
	All Rivers	Rakaia	Rangitata	Waimakariri	Waitaki
Voluntary	1,154	396	195	542	151
Known Success	80	22	8	25	11
No Known Success	237	79	38	101	24
Total	1,471	497	241	668	186

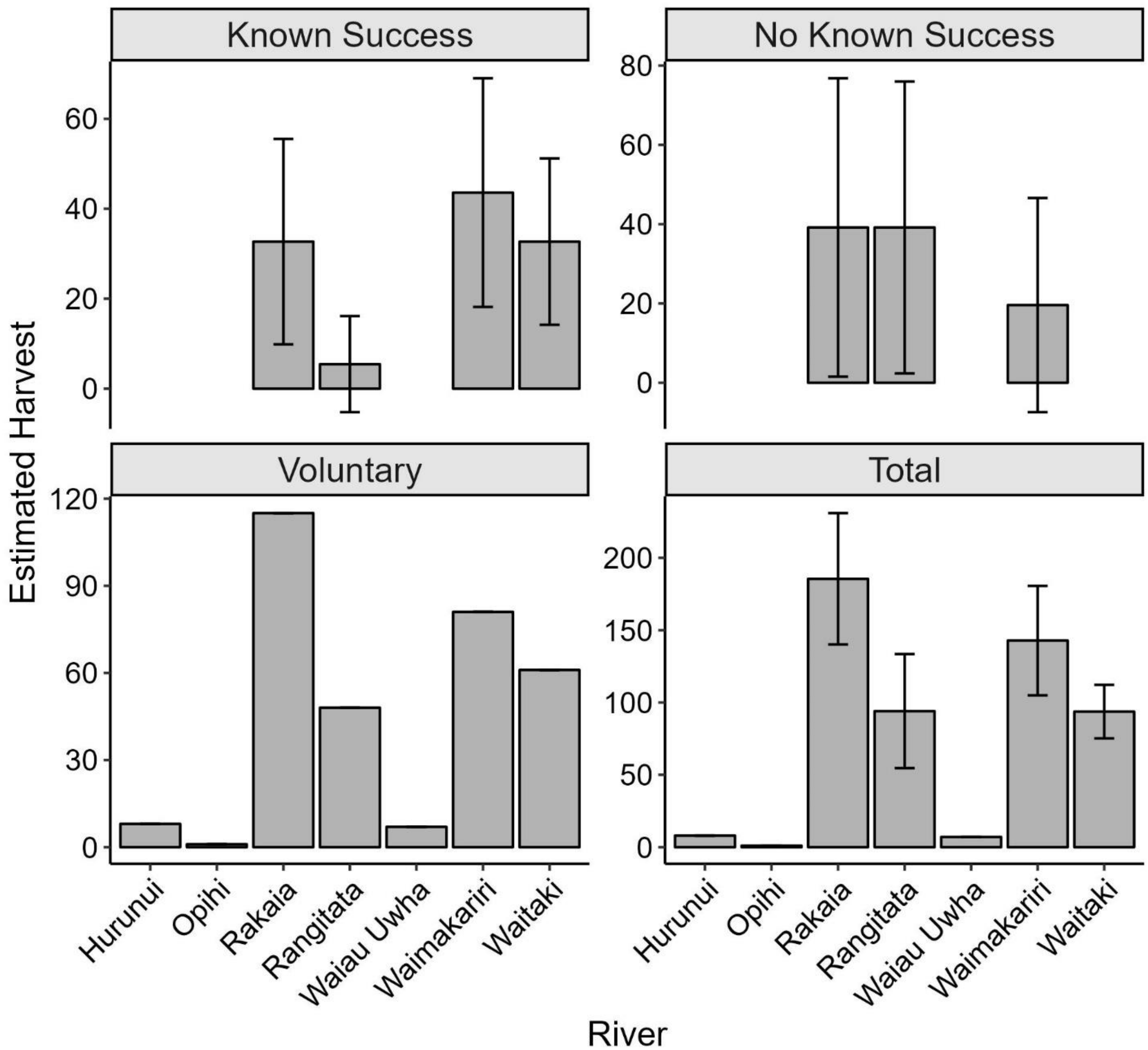

Figure 7. Estimated sea-run salmon harvest in the North Canterbury and Central South Island regions of Fish & Game during the 2023-24 fishing season by river for each survey stratum.

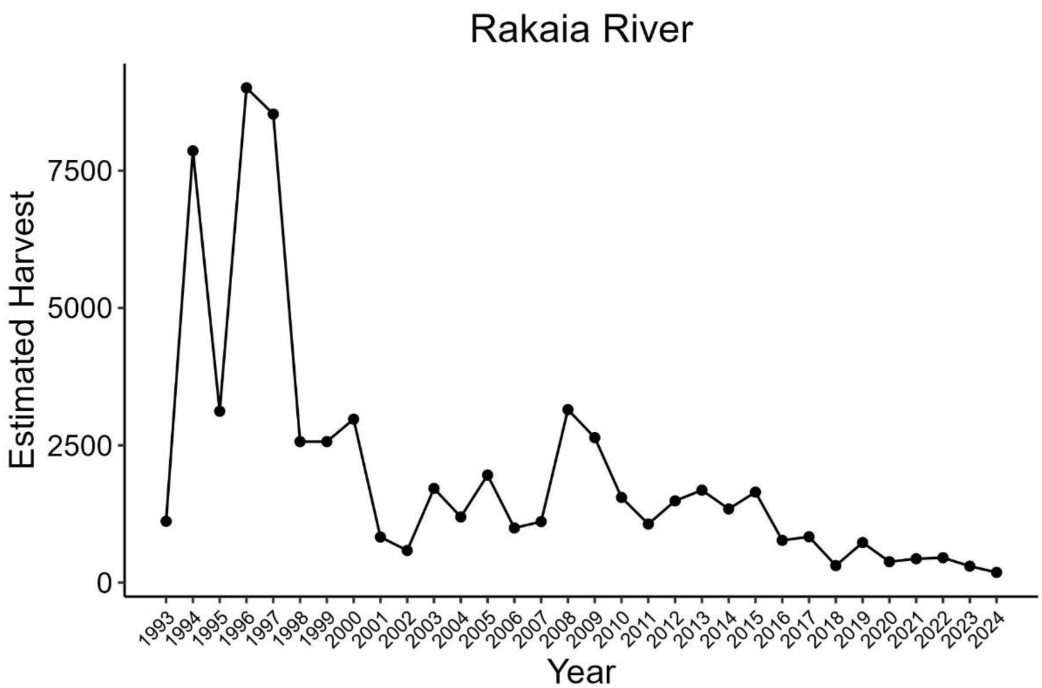

Figure 8. Estimated sea-run salmon harvest in the Rakaia River Catchment, 1993-2024.

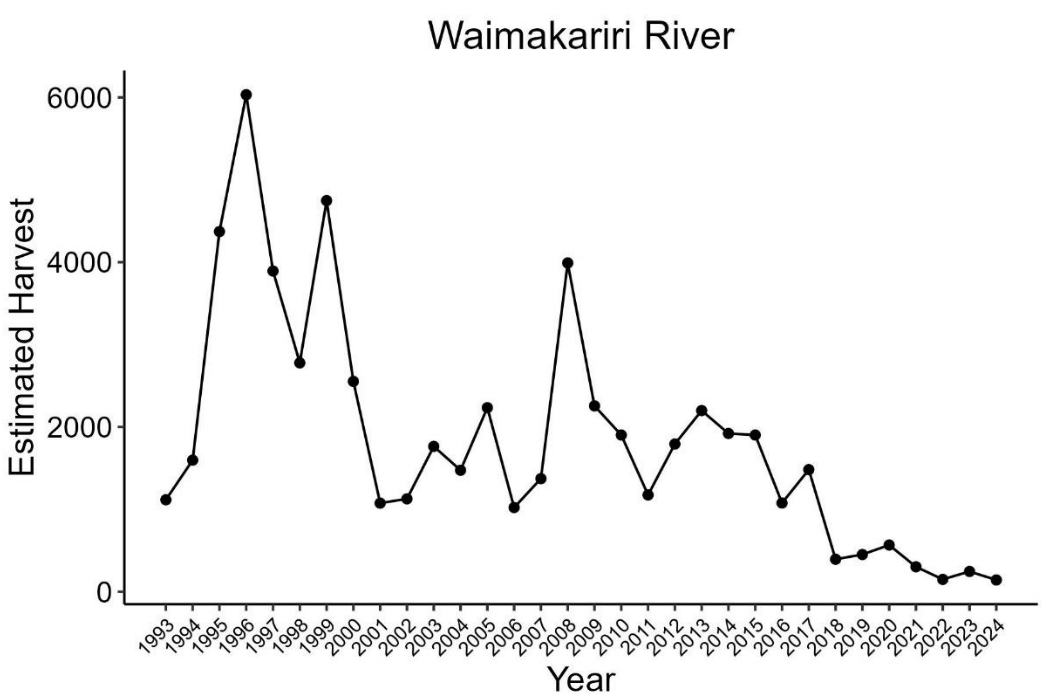

Figure 9. Estimated sea-run salmon harvest in the Waimakariri River Catchment, 1993-2024.

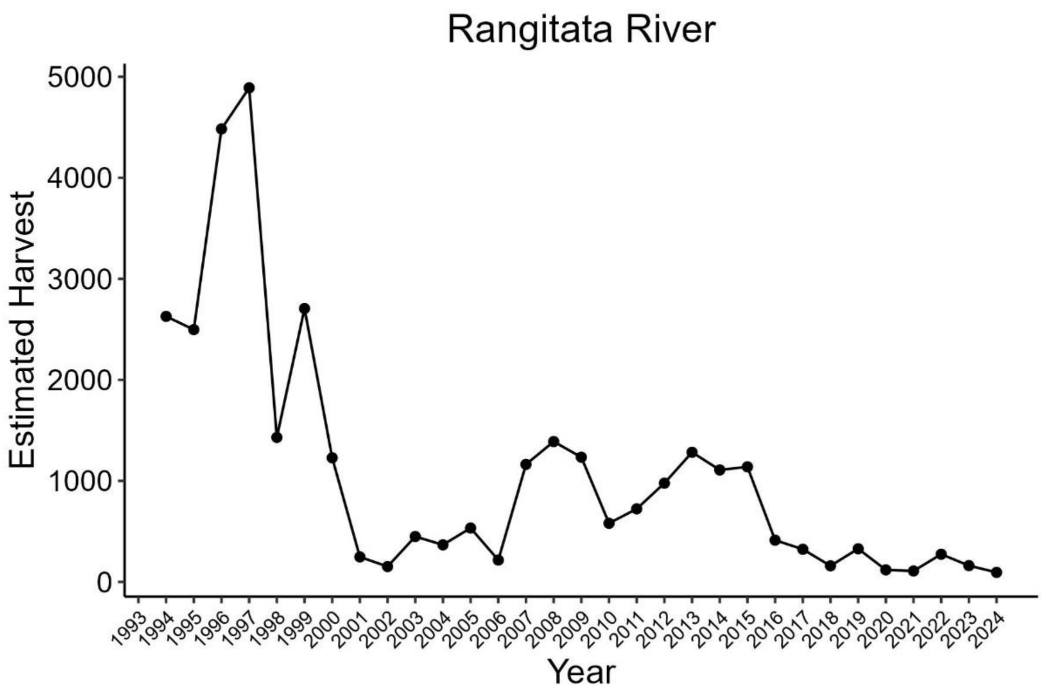

Figure 10. Estimated sea-run salmon harvest in the Rangitata River Catchment, 1993-2024.

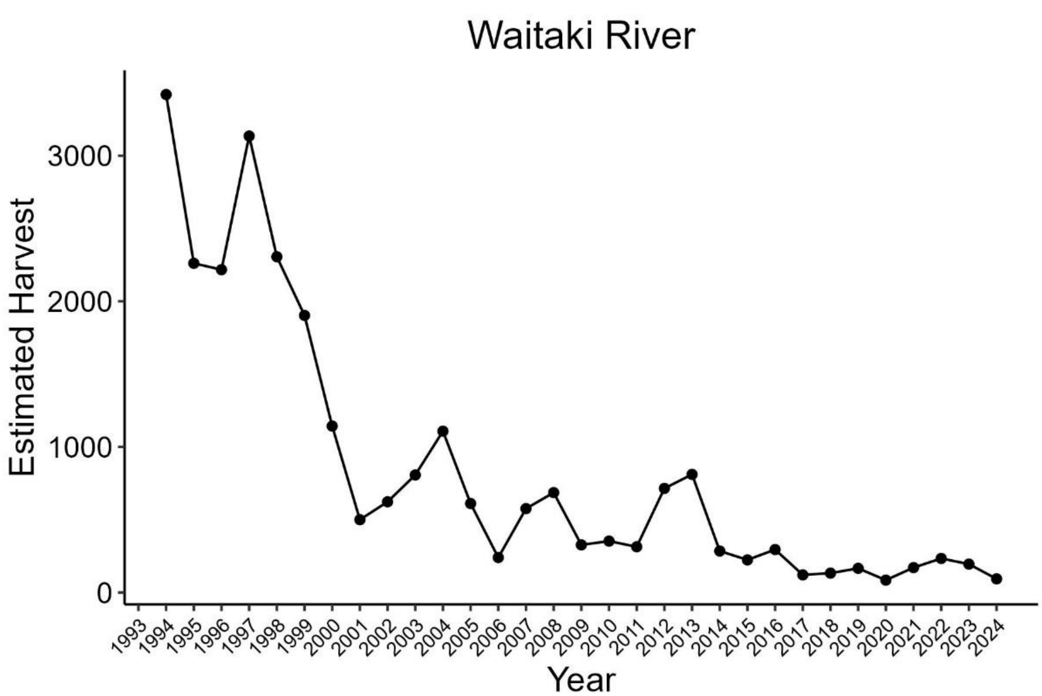

Figure 11. Estimated sea-run salmon harvest in the Waitaki River Catchment, 1993-2024.

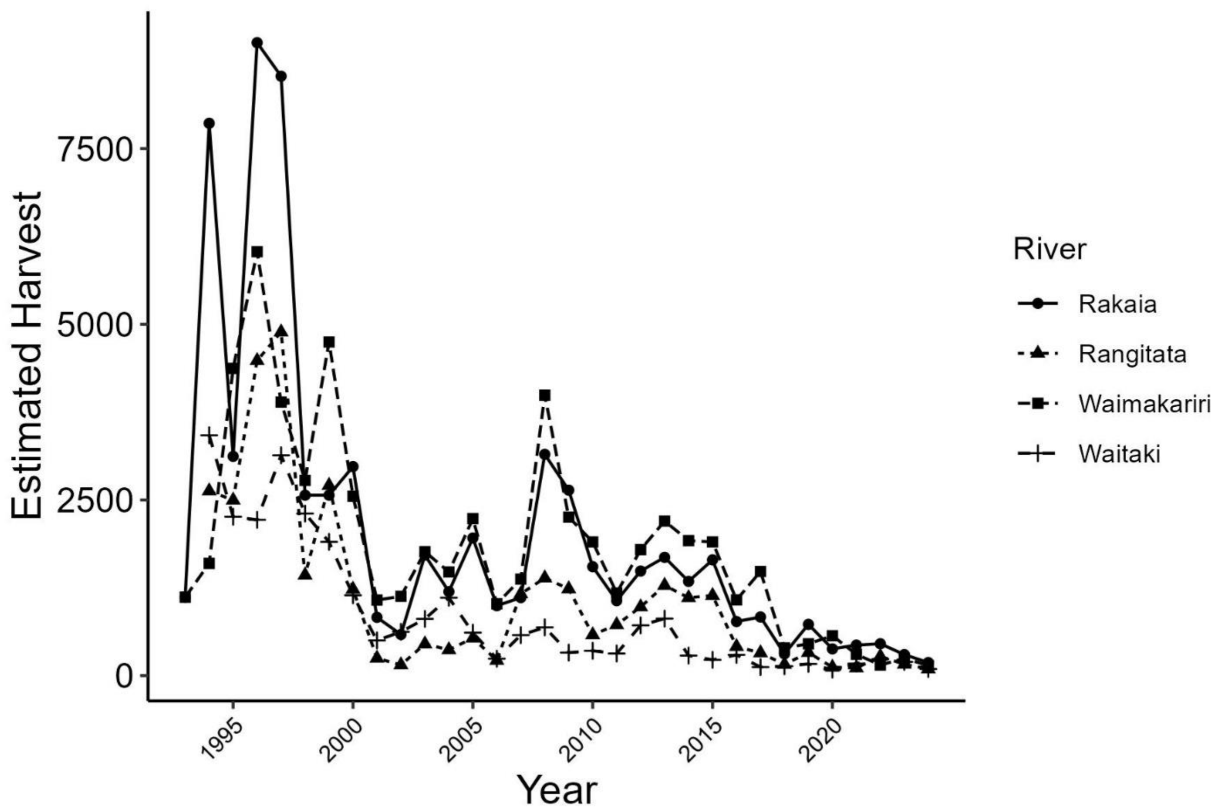

Figure 12. Estimated sea-run salmon harvest across the 4 major salmon fisheries in the North Canterbury and Central South Island regions of Fish & Game, 1993-2024.

2.3.5 Date of Harvest

The majority of salmon were harvested during March (31.4%) and April (31.4%), followed by February (28.0%). Less than 5% of reported harvest occurred before the first of the year (Figure 13). Timing of harvest varied by river (Figure 14). In the Rakaia catchment, harvest was similar in February and March, with 80% of total reported catch occurring within this 2-month span. In the Rangitata catchment, harvest was similar in February and March, with 75% of total reported catch occurring within these 2 months. Harvest in the Waimakariri catchment peaked in April at 51% of total reported catch. Nearly all of the reported catch in the Waitaki catchment occurred during April (77.8%). Date of harvest was later this season than during the 2022-23 season for overall harvest and 3 of the 4 major salmon rivers. Date of harvest in the Rangitata catchment was similar to the previous season.

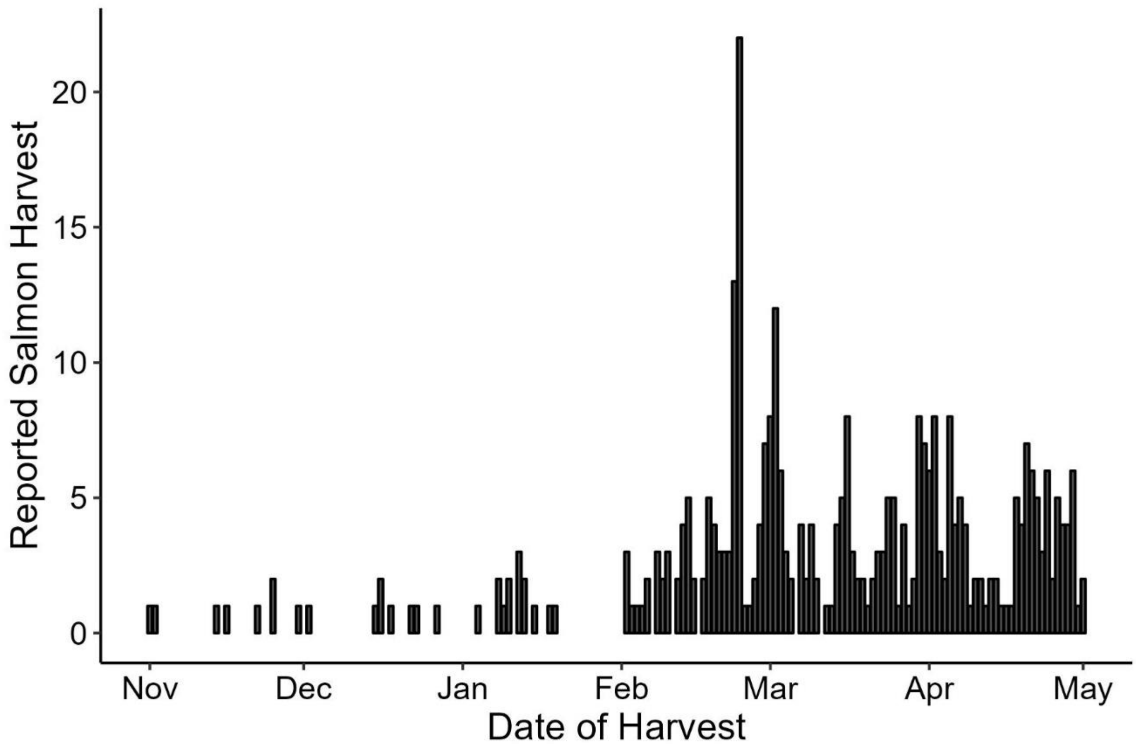

Figure 13. Date of harvest for all sea-run salmon harvested during the 2023-24 fishing season in North Canterbury and Central South Island Regions of Fish & Game, as reported by anglers.

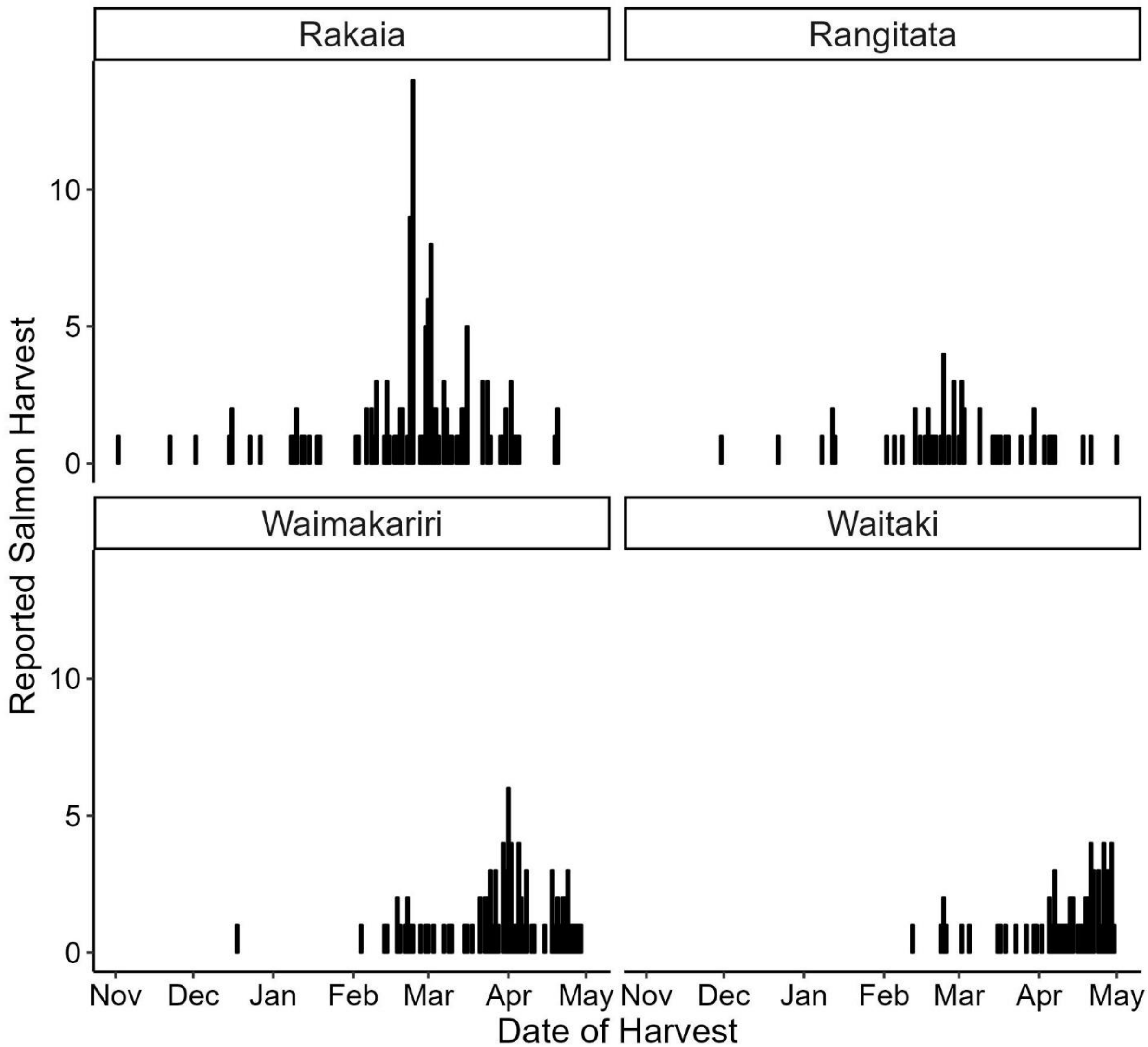

Figure 14. Date of harvest for sea-run salmon harvested during the 2023-24 fishing season on the 4 major sea-run salmon fisheries in North Canterbury and Central South Island Regions of Fish & Game, as reported by anglers.

2.3.6 Spatial Distribution of Catch

A valid river reach of catch was reported for 353 harvested salmon. Harvest was more evenly spread across the reach of the major sea-run salmon rivers, unlike the 2022-23 season when the majority of rivers had the highest reported harvest at the mouth or lower reach (Table 4).

Table 4. Percent of reported sea-run salmon harvest by reach for 7 major salmon fisheries in the North Canterbury and Central South Island regions of Fish & Game during the 2023-24 season, as reported by anglers.

North Canterbury

River	Reach	Description	Harvest (%)
Hurunui	1	Mouth and tidal reaches	75.0
	2	Above tidal reaches to SH1	0
	3	SH1 to Mandamus confluence	12.5
	4	Above Mandamus confluence	12.5
Rakaia	1	Mouth and tidal reaches	25.6
	2	Above tidal reaches to SH1	17.6
	3	SH1 to gorge bridge	21.6
	4	Above gorge bridge	17.6
	5	Not specified by angler	17.6
Waiau Uwha	1	Mouth and tidal reaches	14.3
	2	Above tidal reaches to SH1	14.3
	3	SH1 to Hanmer Bridge	28.6
	4	Above Hanmer Bridge	0
	5	Not specified by angler	42.9
Waimakariri	1	Mouth and tidal reaches	25.3
	2	Above tidal reaches to SH1	19.8
	3	SH1 to gorge bridge	25.3
	4	Above gorge bridge	4.4
	5	Not specified by angler	25.3

Central South Island

River	Reach	Description	Harvest (%)
Opihi	1	Mouth and lagoon	100.0
	2	Above lagoon to Temuka Junction	0
	3	Above Temuka Junction	0
Rangitata	1	Mouth and lagoon	35.8
	2	Above lagoon to SH1	11.3
	3	SH1 to Arundel Bridge	15.1
	4	Arundel to bottom of gorge	13.2
	5	Gorge and above	11.3
	6	Not specified by angler	13.2
Waitaki	1	Mouth and lagoon	10.4
	2	Above lagoon to SH1	41.8
	3	SH1 to Stonewall	32.8
	4	Above Stonewall	0
	5	Not specified by angler	14.9

2.3.7 Size of Salmon

On average, the size of salmon harvested was similar between all four of the major sea-run salmon fisheries ($F_{3, 289} = 2.3$, $p = 0.08$) (Table 5). For each river, the average length of harvested salmon was lower than the reported average length from the 2021-22 season.

Table 5. Mean, maximum, and 1st-3rd quartile length (cm) of sea-run salmon harvested during the 2023-24 fishing season in North Canterbury and Central South Island Regions of Fish & Game, as reported by anglers. Values are provided for all fish reported, and by river for the 4 major sea-run salmon fisheries.

Length (cm)	All Rivers	Rakaia River	Rangitata River	Waimakariri River	Waitaki River
N	309	106	50	78	59
Mean	61.2	60.9	64.0	61.0	59.1
Maximum	84.0	78.0	84.0	84.0	78.0
Most Common	60 - 66	60 - 65	61 - 68	59 - 67	58 - 65

2.3.8 Fin Clips

Out of 353 actual fish reported (322 from voluntary and 31 from phone survey), only 3 fin clipped fish were reported; one in each of the Rakaia, Waimakariri and Waitaki rivers (Table 6). This is a large reduction on fin clips reported for the 2022-23 season (47 fish). Interestingly, no fin clipped fish were reported on the Rangitata River where the McKinnon's Creek hatchery is located.

Table 6. Counts of finclipped fish harvested by anglers during the 2023-24 fishing season in North Canterbury and Central South Island regions. Counts reported from all fish data collected in both voluntary and phone surveys.

	Rakaia River	Waimakariri River	Waitaki River
Voluntary returns	1	1	0
Phone Survey	0	0	1
Total	1	1	1

2.4 Discussion

Both estimated harvest and the size of harvest have declined relative to the 2022-23 season. This is the second consecutive year we have observed a decline in the number of salmon harvested. Additionally, the size of salmon harvested has decreased relative to last season. This is likely related to the warmer than normal ocean temperatures over the past few years, resulting in suboptimal living conditions for ocean dwelling salmonids affecting growth. However, it is also important to note that one goal of implementing the 2 salmon season bag limit was to reduce harvest relative to the size of the run. Thus, it will be crucial to evaluate estimated harvest in relation to run size before drawing any conclusions. Data (not sufficient for reporting) on catch and release was collected during the survey and some anglers did advise that they practiced catch & release during the season but did not harvest any fish. Anecdotal reports from anglers suggested the overall smaller size of salmon this season led them to release fish they otherwise would have kept, which may also have contributed to the decrease in harvest compared to previous seasons.

We caution against using the size estimates presented in this report to draw conclusions about the true size or age structure of the salmon population, as bag limits encourage catch and release fishing. It is likely that many anglers release smaller salmon, biasing the size estimates to be larger than what is present in the river. Similarly, date of harvest is likely skewed late to provide longer fishing opportunities for anglers. Thus, both of these metrics should be regarded carefully. Reports of fin clips should also be used with caution when estimating harvest of hatchery-origin fish as this data relies on anglers correctly identifying such fish. There has been minimal education for salmon anglers on how to identify a fin clipped fish; those new to salmon angling or those who have not been previously involved with fin-clipping may not be aware of the practice.

In addition to biasing salmon size and the timing of harvest, catch and release fishing encouraged by the seasonal bag limit may reduce harvest relative to predictions developed before the introduction of the bag. Specifically, while many anglers delay harvesting their second fish in order to prolong their season, some forego harvesting a second salmon in order to fish up until the last day of season. Therefore, predictions of harvest under a bag limit developed using data collected before the introduction of a seasonal bag are likely conservative estimates.

Salmon suffer negative physiological impacts from handling and exposure to higher ambient temperatures that can lead to death even when the fish are released. Estimates of mortality caused by catch and release fishing vary by fish treatment and environmental factors, but are typically ~10% (Raby et al. 2015). While Fish & Game has taken measures to improve fish treatment during catch and release fishing, it will be critical to develop more robust methods to assess catch and release fishing in order to adequately estimate angling related mortality not accounted for in the harvest estimate.

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3.0 Sea-run salmon escapement

3.1 Introduction

Central South Island and North Canterbury Fish & Game regions have been conducting monitoring of sea-run salmon returns since 1993. Salmon entering rivers to spawn are either caught by anglers (and therefore removed from the population) or avoid anglers and continue upriver to spawn (escapement). Over the decades a steady decline in escapement has been observed, particularly in the late 90s and early 00s. This information has previously been used alongside angler harvest in setting daily bag limits.

Following further declines in the mid-late 2010s, the Adaptive Management Strategy (Webb & Terry, 2020) was developed and resulted in the adoption of a season bag limit for sea-run salmon in the Central South Island and North Canterbury regions at the start of the 2021-22 season. The main aim of the season bag limit was to reduce overall angler harvest, resulting in increased escapement to the headwaters for spawning. Limiting harvest is most important in years where total escapement may be low; historic harvest proportions[3] reached as high as 65% in the Rakaia River, 46% in the Rangitata River, and 77% in the Waimakariri River.

The season bag limit for each season is determined using the 'Threshold Management Strategy', which depends on the previous three season's escapement estimates for the three 'indicator' rivers (Rakaia River, Rangitata River, and Waimakariri River). The 2022-23 season had a season bag limit of two salmon and resulted in a marked decline in the total proportion of the total run estimate being harvested by anglers on the Rakaia and Waimakariri rivers (12% and 25% respectively). Harvest proportions on the Rangitata River did not drop as dramatically, but still was the second-lowest harvest proportion since 1993. The season bag limit for the 2023-24 season remained at two salmon. The expectation was that the harvest proportion for this season remained similarly low compared to previous years with no season bag limit.

[3] The percentage of total estimated run of salmon harvested by anglers throughout the season.

3.2 Methods

3.2.1 Three indicator rivers

Historically, the ‘area under the curve’ (AUC) method was used to calculate estimated escapement. The AUC method estimates total escapement based upon multiple periodic spawning counts and the residency time (RT) of the spawning fish (English et al., 1992). This was used on the Rakaia, Rangitata and Waimakariri rivers from when counts began in 1993 through to 2013, where financial constraints at North Canterbury meant multiple spawning counts could not take place in the region (and therefore AUC could not be used). Between 2013 and 2020, the ‘peak count’ method was used for the Rakaia or Waimakariri rivers, estimating escapement numbers based off a single count at the time of peak spawning. The resumption of multiple aerial counts in 2021 allowed for the resumption of the AUC method for all three indicator rivers.

Five aerial counts were carried out on designated spawning streams in the Rakaia, Rangitata and Waimakariri rivers in 2024 (Table 7). The Hurunui and Waiau Uwha rivers were not counted this season, as AUC estimates require at least 3 data points (counts), and additional flights was not within the North Canterbury budget. Aerial counts follow standardised methods developed by NIWA (Unwin, 1994) on the same known spawning streams each year to maintain consistency. Staff flew over each of the spawning streams, counting all visible salmon in the waterway from the designated starting point. Dead salmon are also counted in the first aerial count. Some streams (e.g., Bush Stream Inner) require staff to do foot counts as it is not possible to count from the air due to vegetation. While a tributary to the Rakaia River, Mellish Stream and Lake Heron are counted by Central South Island staff at the same time as the Rangitata River counts as it lies within their region. Four aerial counts of the lake and stream are conducted, followed up by a final foot count of the lake edge and stream. Mellish Stream estimates cannot be made using AUC, and instead ‘peak count’ methodology is used to estimate spawning numbers.

Table 7. List of designated spawning streams in the Rakaia, Rangitata and Waimakariri catchments counted via aerial survey used in escapement estimates.

Rakaia River	Rangitata River	Waimakariri River
Double Hill Flats	Deep Creek	Bealey Spring
Double Hill Stream	Deep Stream	Bush Stream (inner and outer)
Glenariffe Stream		Cass Hill Stream
Goat Hill Stream		Cora Lynn Stream
Hydra Waters		Lower Casey Stream
Manuka Point Stream		One Tree Swamp
Mellish Stream		Sawmill Stream
Wilberforce Swamp		Thompson Stream
		Turkey Flat Stream
		Winding Creek

Once all aerial counts were completed, escapement estimates were made for each spawning stream using the Salmon AUC programme in Matlab (Version 1.0, NIWA).

For each river, estimates for each stream were added together to give the total escapement estimate (See Appendix for examples of AUC graph output). It's important to remember that this estimate is a population index and is not intended to represent the total number of fish in the catchment.

3.2.3 Total run size and harvest/escapement proportions

Escapement estimates are added to harvest estimates to calculate a total estimated run size, i.e., how many salmon were estimated to be in the whole season's spawning run. Expanding on this, the harvest proportion can be calculated for each river by dividing the estimated harvest by the estimated total run. Conversely, the "escapement proportion", i.e., the proportion of the run that successfully made it to the spawning streams, can be calculated in the same way by dividing the population index by the total estimated run. The "escapement proportion" is what is graphed in Section 3.3.

3.3 Results

3.3.1 Rakaia River

The escapement estimate for the Rakaia River in the 2023-24 season is **878** salmon (See Appendix for individual stream estimates). This is lower than the 2022-23 season estimate (1332 salmon), although still higher than escapement estimates between 2017-2020. Adding harvest, the total estimated run size for the Rakaia River is **1064** salmon (Figure 15), and the estimated escapement proportion is **83%**, one percent higher than the previous season (Figure 16)

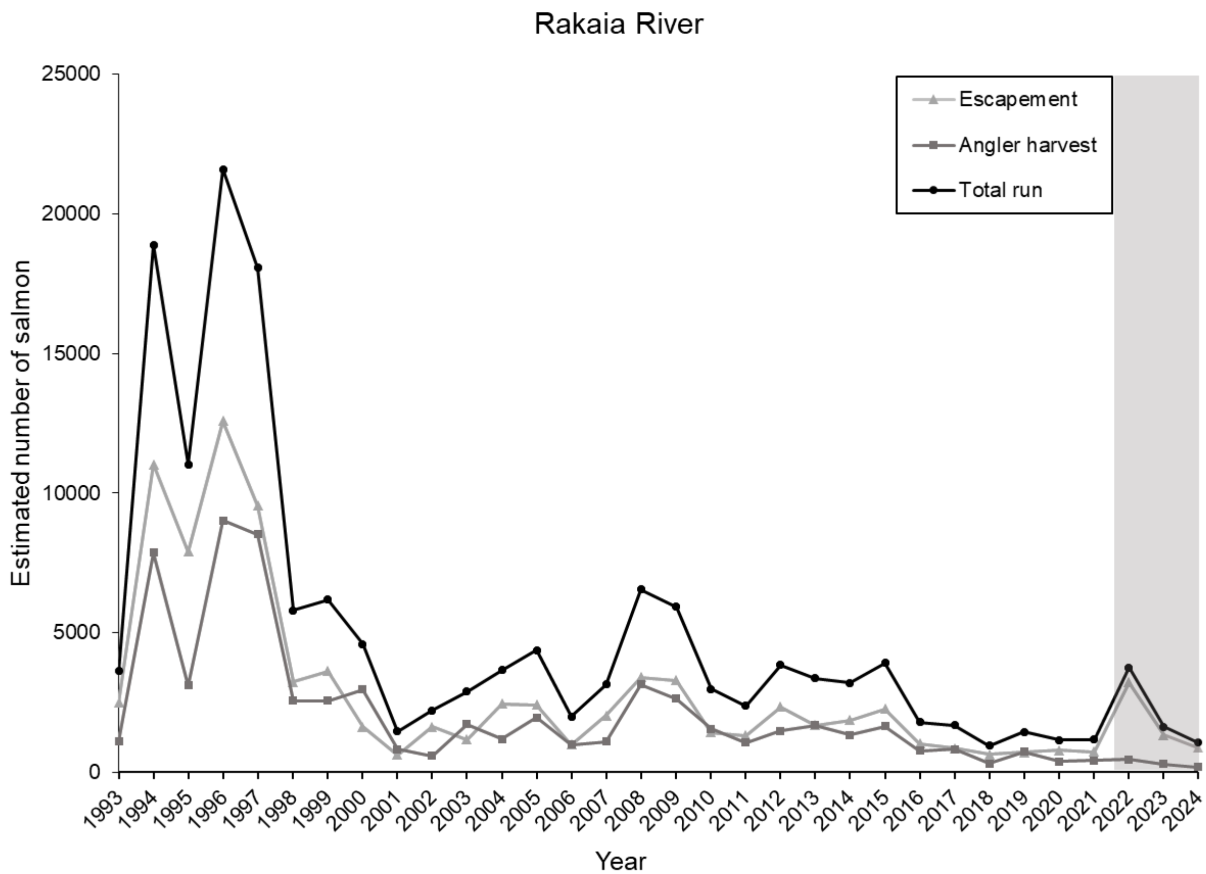

Figure 15. Estimated sea-run salmon escapement, angler harvest and total run on the Rakaia River, 1993-2024. Grey shaded area indicates years in which the sea-run season bag limit system was in place.

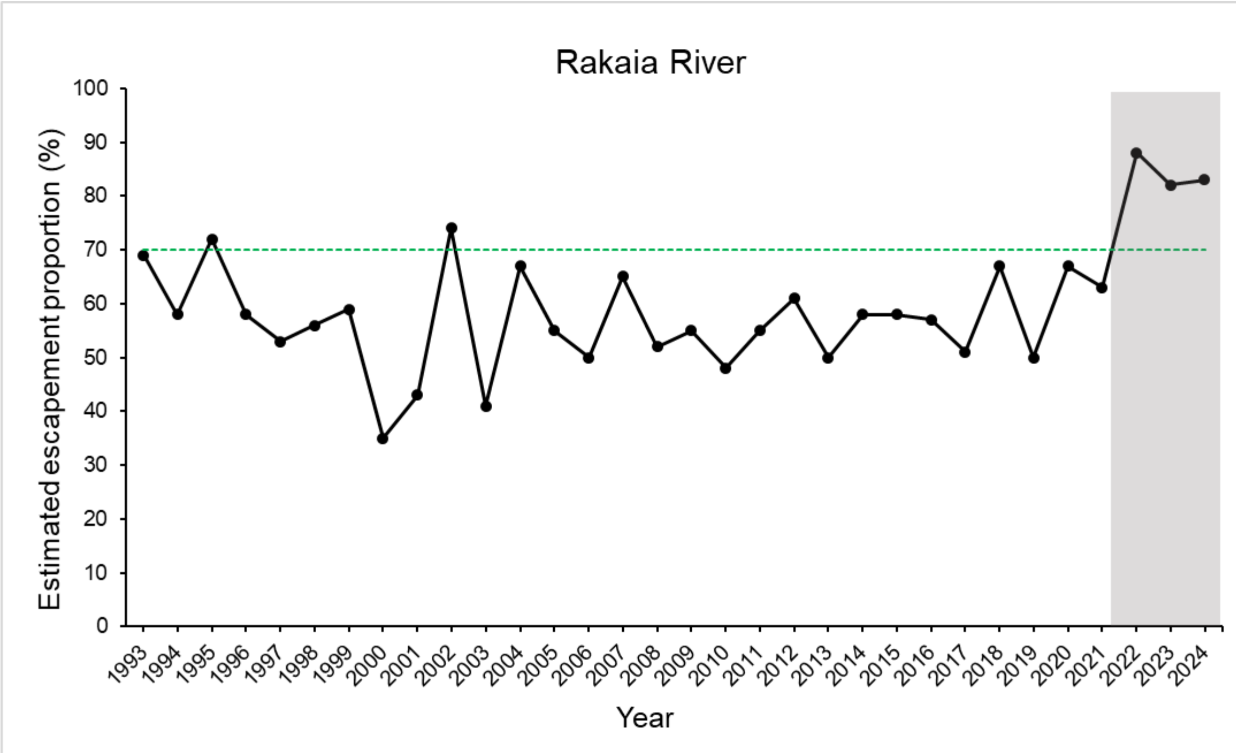

Figure 16. Escapement proportion of the total run on the Rakaia River, 1993-2024. Grey shaded area indicates years in which the season bag limit system was in place. Green dotted line indicates a 70% example 'threshold' for escapement of the total run.

3.3.2 Rangitata River

The escapement estimate for the Rangitata River in the 2023-24 season is **250** salmon, and the estimated escapement proportion is **73%**, More information on the Rangitata River will be added to this report when available.

3.3.3 Waimakariri River

The escapement estimate for the Waimakariri River in the 2023-24 season is **327** salmon (See Appendix for individual stream estimates). This run is smaller than the 2022-23 season, and is one of the smaller runs so far, almost identical to that of the 2019 run. Adding harvest, the total estimated run size for the Waimakariri River is **470** salmon (Figure 17). The estimated escapement proportion is **70%**, three percent less than the previous season (Figure 18).

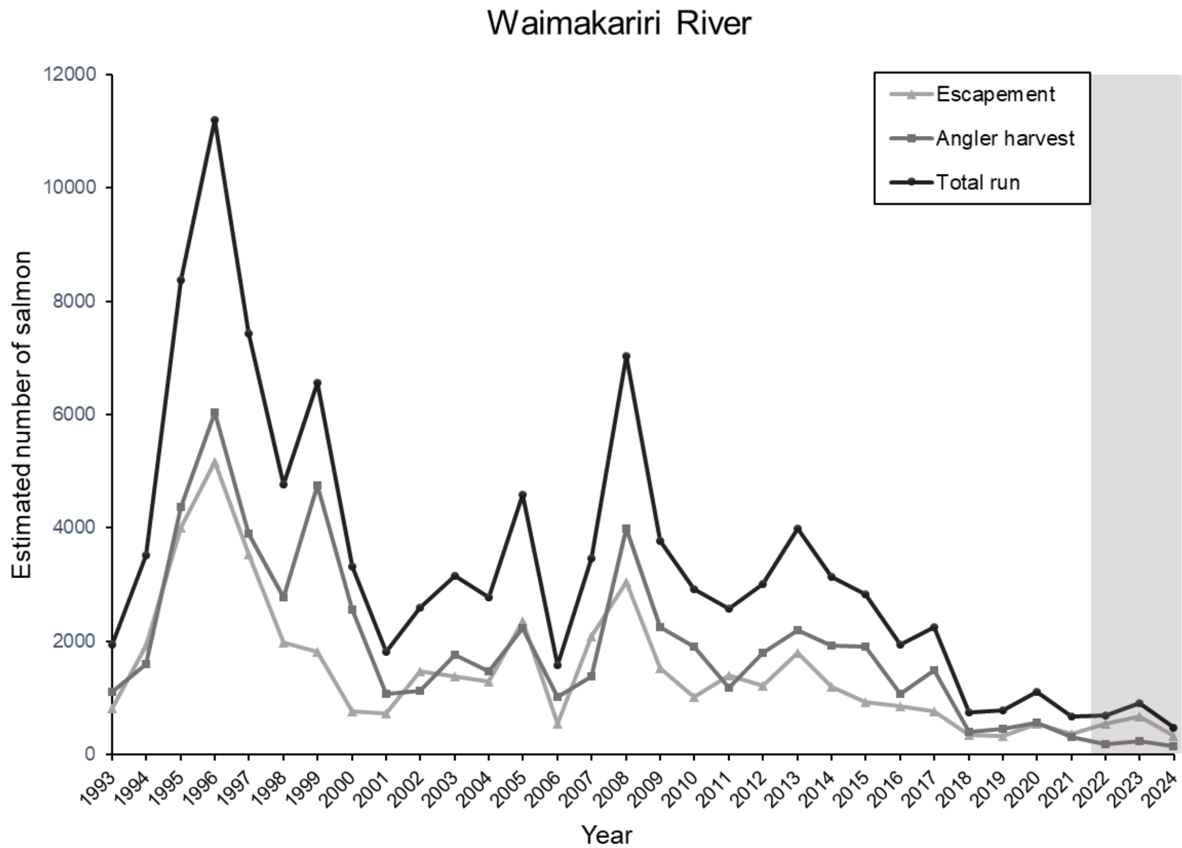

Figure 17. Estimated sea-run salmon escapement, angler harvest and total run on the Waimakariri River, 1993-2024. Grey shaded area indicates years in which the sea-run season bag limit system was in place.

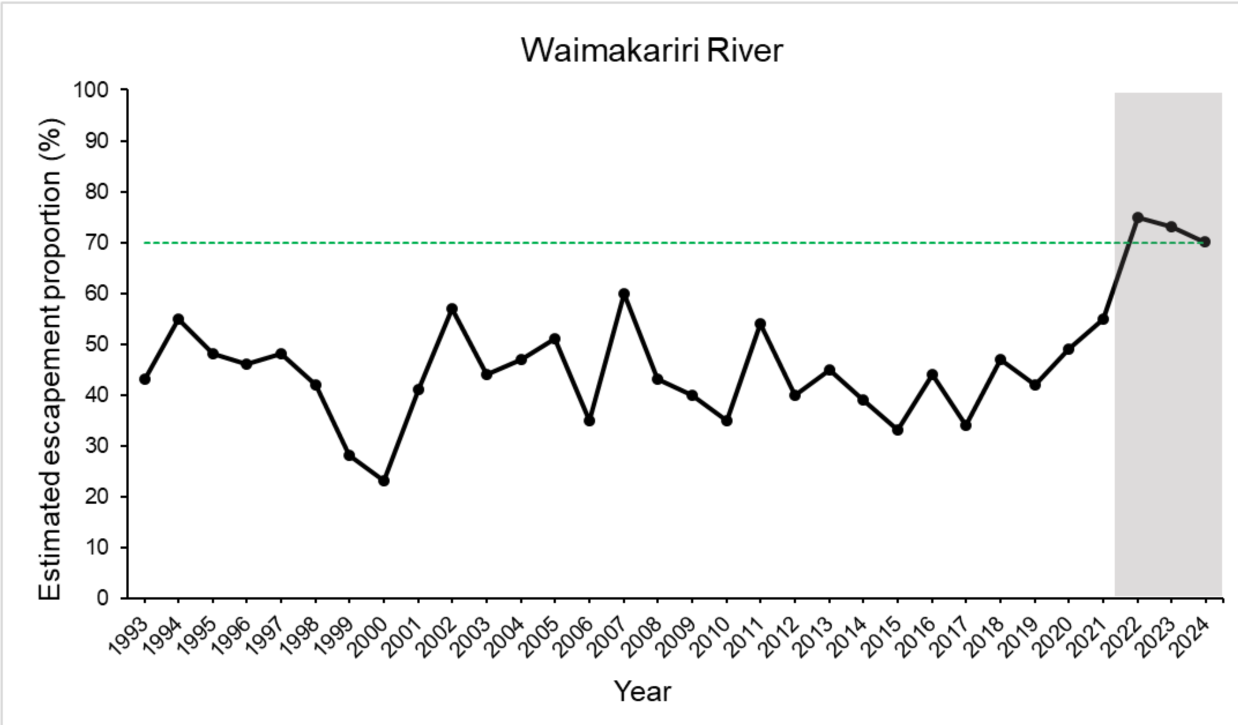

Figure 18. Escapement proportion of the total run on the Waimakariri River, 1993-2024. Grey shaded area indicates years in which the season bag limit system was in place. Green dotted line indicates a 70% example 'threshold' for escapement of the total run.

4.0 Adaptive management

Approximately three-quarters of all South Island sea-run salmon caught by anglers are taken from the Waimakariri, Rakaia and Rangitata rivers. Based on these rivers' contributions to the South Island East Coast sea-run salmon fishery, their shared population trends, and their on-going population monitoring programmes, in 2020 the Central South Island (CSI) and North Canterbury (NC) Fish & Game Councils adopted a joint Adaptive Management Strategy across the three rivers for setting annual sea-run salmon fishing regulations. The strategy aims to manage angler harvest to ensure an adequate number of sea-run salmon reach their spawning waters each year, and to provide a healthy recreational sports fishery long-term.

4.1 Methods

When CSI and NC Fish & Game Councils were considering how to rebuild the sea-run salmon fishery, priority was assigned to identifying a minimum acceptable spawning population size for the combined annual spawning totals for the Waimakariri, Rakaia and Rangitata river fisheries.

Four spawning population bands were identified that would characterise the health of the spawning populations with the upper band (healthy) being the level at which the fishery would be considered healthy and where minimum harvest conditions would apply. The second and third bands (moderate and low) would be subject to increasing restrictions on harvest to help prevent the fishery falling below the third band. The fourth band (severe) would have maximum harvest restrictions without closing the fishery and this level has been determined to be just below the sum of the lowest recorded spawning population sizes in each of the rivers over the long-term monitoring record. This system is referred to as the "Threshold Management Strategy".

Following identification of spawning population targets CSI and NC regions considered how angler harvest would be managed to achieve spawning targets. At that time both regions had a one fish daily bag limit and a range of detailed season length and area conditions. Introduction of a season bag limit was recommended by scientific advisors as the favoured method to reduce harvest and rebuild spawning numbers. A season bag limit offered a simple and consistent method to achieve staged population targets. The simplicity came from the need to change only the size of the bag limit to reach a target rather than a range of different season, area and timing conditions. Consistency would be achieved from its equal application to all salmon anglers fishing all rivers.

Using the 26-year record of harvest and spawning population sizes that existed in 2020, significant modelling of the impact of different season bag limits on population sizes was completed. Overall, the scenario that assigned a 5% reduction in harvest to the healthy band, 20% reduction to the moderate band and 40% reduction to the low band had the least impact on anglers of the scenarios modelled and generated significant long-term increases in spawning, angling, and total run population sizes. Reductions in harvest of 5%. 20% and 40% could be achieved with season bag limits of 10, 4 and 2 fish respectively (Table 8). Below the low band threshold of 1,200 spawners, while the fishery may not be closed, restrictions would be very severe e.g., a one-fish season bag limit in addition to season length and closed area restrictions.

Table 8. Current Threshold Management Strategy combined escapement bands for the Rakaia, Rangitata and Waimakariri rivers and the season bag conditions triggered from these.

Management band	Combined escapement	Season bag applied
Healthy	Greater than 7,800	10
Moderate	5,101 to 7,800	4
Low	1,200 to 5,100	2
Severe	Less than 1,200	1

In the situation where the spawning population declined through a threshold from a stronger population band to a lower population band, the management strategy provided for immediate increase in restriction in harvest by reduction of the season bag limit for the following fishing season. This enables Fish & Game to cautiously manage harvest ahead of a possible multi-year declining population trend.

In the opposite situation, where the spawning population rises above a threshold and into a heathier population band, the management strategy requires the spawning population to remain in a higher band for a minimum of three years before the season bag is changed to allow for increased harvest. The delay in relaxing the season bag limit is to ensure that the spawning population increase is a true reflection of a stronger population trend that is able to sustain higher harvest and not a single-year anomaly where allowing increased harvest would be detrimental. Increasing harvest on the strength of a single year's increase in the spawning population could lead to yoyoing of the population in reaction to annual changes in harvest conditions.

4.2 Results

The 2023-24 season combined Waimakariri, Rakaia and Rangitata rivers escapement estimate is **1455** salmon and places the status of the fishery in the 'low' management band (Figure 19). This means the season bag limit for the 2024-25 season remains at two sea-run salmon. This is consistent with estimates made at the May 2023 Council meeting for setting the season bag limit in the 2023 Angler's Notice.

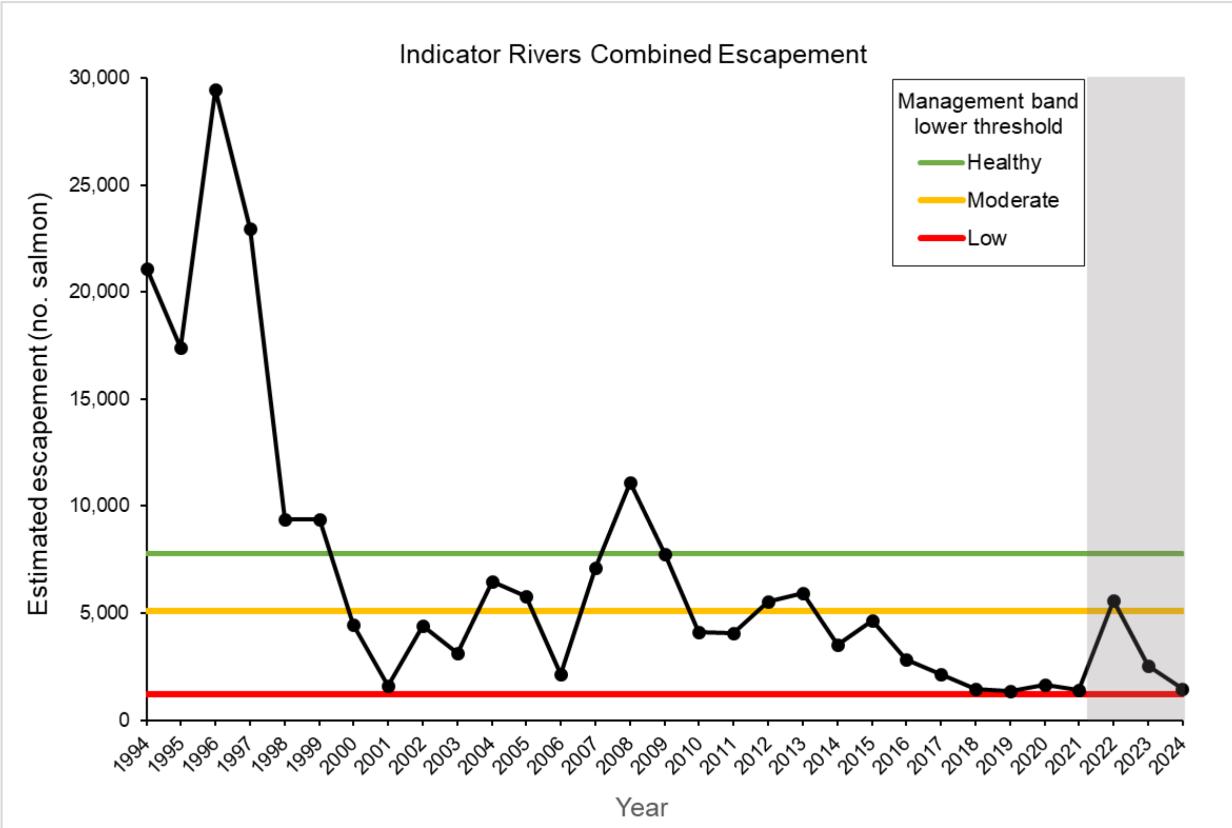

Figure 19. Combined escapement across the three indicator rivers (Rakaia, Rangitata, Waimakariri) used for threshold management in comparison to the management band lower thresholds (healthy, moderate, and low), 1993-2024. Grey shaded area indicates years where season bag limit system was in place.

5.0 Discussion

Monitoring of wild salmon in the Waimakariri, Rakaia and Rangitata rivers provides a record of annual angler catch, spawning population size, total run size and trends across the last 30 years. These fisheries, plus the Waitaki across its shorter period of record, show very similar population trends, either increasing or decreasing together on an annual basis and they all share the current critically low state. Similar trends can be seen in salmon spawning rivers of the other Fish & Game regions; salmon spawning estimates in the Wairau River headwaters in Nelson/Marlborough region were the lowest this season since 2008, and salmon were also of similar size and condition to Canterbury salmon (Nelson/Marlborough Annual Fisheries Report 2023-24).

The similarity in trends across the four rivers and particularly for the Waimakariri, Rakaia, and Rangitata rivers for their longer periods of record, indicate the significance of the reduction in salmon numbers that occurred around 1998 to 2001. The trends also show the absence of improvement since that time, and strongly suggests that salmon survival in these rivers is very likely controlled by common influences when salmon are in a common environment. This provides strong support for consistent management and consideration of them as one harvest management unit. Further reductions to the combined escapement estimates occurred around 2017 and have remained low since. While there may be a number of contributing factors behind these declines, changing marine environmental conditions is thought to be key, and similar trends in decreasing population declines and salmon size has been seen in Alaskan Chinook salmon populations (Siegel, McPhee & Adkinson, 2017). A study modelling future survival in relation to SSTs showed “populations rapidly declined in response to increasing sea surface temperatures and other factors across diverse model assumptions and climate scenarios” (Crozier & *et al*, 2021). Salmon growth rates can also decline in years of warmer ocean temperatures when food availability is low, resulting in smaller fish overall within the population (Daly & Brodeur, 2015). Long term trends in sea surface temperature (SST) have seen higher rates of increase in SSTs on the east coast compared to other areas of the South Island, most notably south of Banks Peninsula immediately off the coast of the Rakaia and Rangitata rivers, between 1981 and 2017 (Sutton & Bowen, 2019). Assuming these trends have continued, it is likely the declines in the east coast salmon population seen in recent years could be a consequence of these environmental changes.

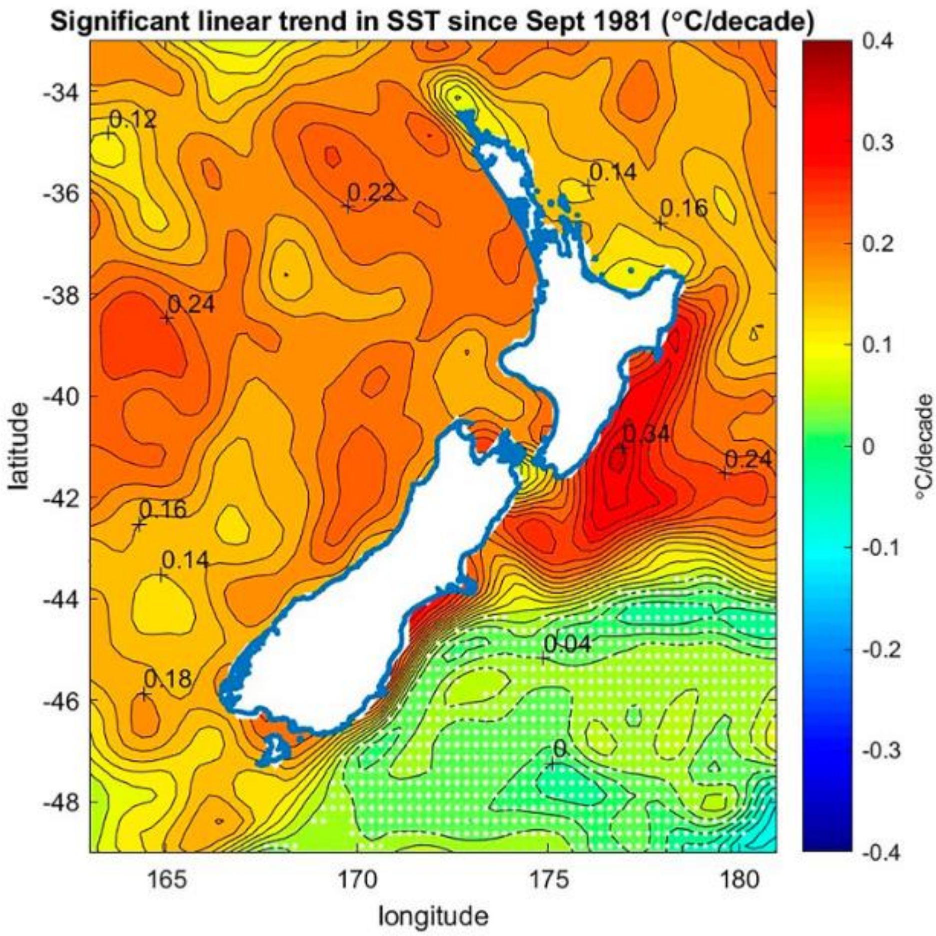

Figure 20. The linear trend in New Zealand sea surface temperatures 1981–2017. Contour intervals are 0.02°C/decade. Sourced from Sutton & Bowen (2019).

In years such as this where returns are low, the higher escapement proportions seen again this season on the Rakaia and Waimakariri rivers suggest that the season bag limit for sea-run salmon is still working well. This is most evident in the Waimakariri River, where this season's escapement estimate was half the previous season, but the escapement proportion was fairly similar (70% down from 73%). Prior to introduction of the season bag limit, escapement proportions had only reached above 70% on two occasions for the Rakaia River (1995 and 2002). Furthermore, prior to the season bag limit the escapement proportion on the Waimakariri River had never reached above 60% of the total run since recording began in 1993.

While the Threshold Management Strategy requires the spawning population to remain in a higher band for a minimum of three years before the season bag is increased, the move back to a lower band from the previous season means there now needs to be three seasons in the moderate or healthy population bands before an increase would be made to the season bag limit. Assessing harvest/escapement proportions may also be a useful tool if integrated into the Adaptive Management Strategy, (e.g., setting harvest/escapement proportion targets). The 2024-25 season is a full 3-year salmon life cycle from the implementation of the sea-run salmon season bag limit; escapement numbers will be observed closely in 2025, after which a review of the strategy and Threshold management will likely follow. With this season's escapement estimate sitting in the low management band, until a review is completed the season bag limit of 2 salmon would still be in place over the next 3 years. If further declines continue due to environmental impacts, more measures may need to be taken in addition to the season bag limits in order to maintain higher escapement proportions to work towards the long-term recovery of the Canterbury sea-run salmon population.

6.0 References

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7.0 Appendix

Table 9. Total population indices of the Rakaia River tributaries calculated using AUC. Asterix denotes waters in which Peak Count method was used.

Stream	Total est. escapement
Double Hill Stream	62
Double Hill Flat Streams	31
Glenariffe Stream	142
Goat Hill Stream	16
Hydra Waters	270
Lake Heron/Mellish Stream*	106
Manuka Point Stream	244
Wilberforce Swamp	7
Total	878

Table 10. Total population indices of the Waimakariri River tributaries calculated using AUC. Poulter streams include Lower Casey Stream, Bush Stream (inner and outer) and Thompson Stream. Upper Waimakariri streams include Bealey Spring, Sawmill Stream and Turkey Flat Stream.

Stream	Total est. escapement
Cass Hill Stream	121
Cora Lynn Stream	30
One Tree Swamp	28
Poulter streams	103
Upper Waimakariri streams	7
Winding Creek	38
Total	327

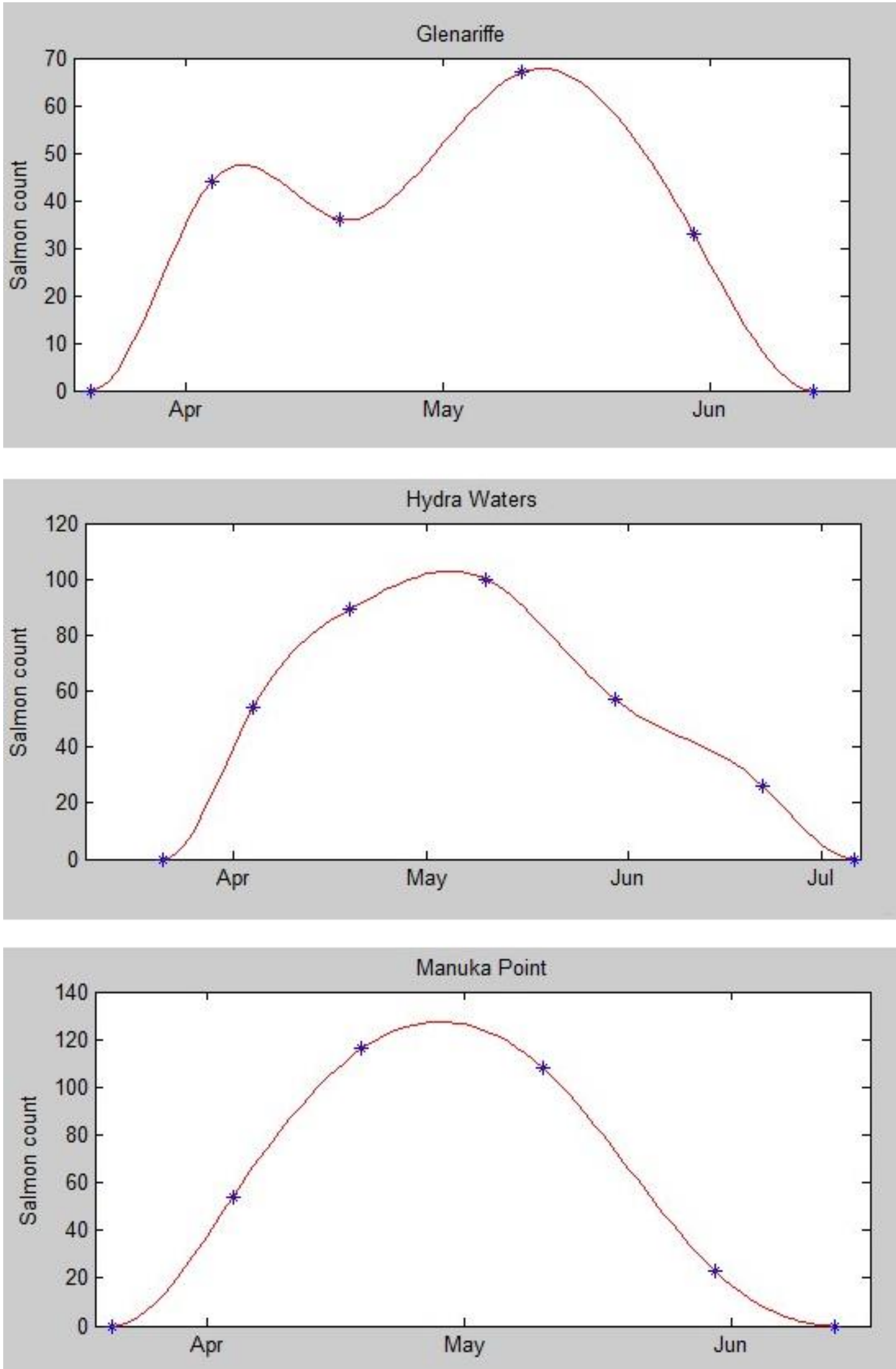

Figure 21. AUC graphing for four spawning streams on the Rakaia River, showing how the data is fitted to a curve. The area under the curve is used to calculate the total population estimates when taking residency time into consideration. Each stream has a unique curve, showing peak returns to each of the streams occur at different times.

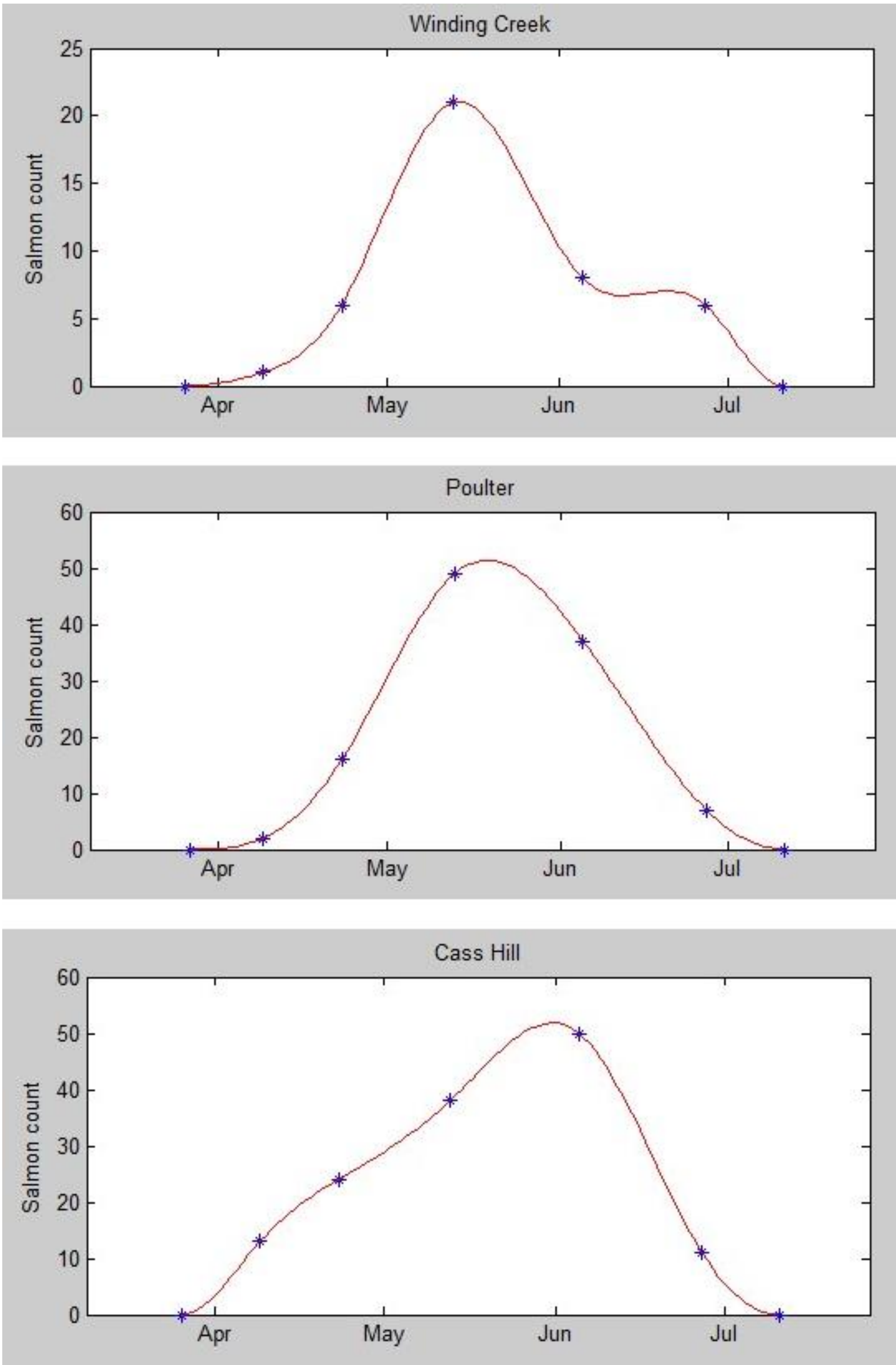

Figure 22. AUC graphing for four spawning streams (or combination of streams – e.g., Poulter) on the Waimakariri River, showing how the data is fitted to a curve. The area under the curve is used to calculate the total population estimates when taking residency time into consideration. Each stream has a unique curve, showing peak returns to each of the streams occur at different times.