Inland Fisheries Service Report

Recreational Fisheries Report

Fisheries Performance Assessment

Technical Report

Penstock Lagoon – July 2016

Inland Fisheries Service
Tasmanian Government

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1. Introduction

1.1. Water Management

Penstock Lagoon is a relatively small and shallow water with a surface area of 1.4 square km's and a maximum depth of 1.8 metres. The lagoon has over a number of years, been subject to significant alterations in water management. Penstock Lagoon was once an important hydroelectric storage for generating power at nearby Waddamana power station. The lagoon was subject to large inflows of cold clear water from Great Lake. In 1993, Waddamana power station was decommissioned. Consequently, water flowing through the lagoon was reduced by many orders of magnitude. Water levels in the lagoon were maintained by diverting water from the Shannon River, which originates from Shannon Lagoon. The quality of water was frequently poor with elevated levels of suspended sediment common. Consequently, during the mid 1990's, the lagoon was subject to elevated turbidity and hence the quality, catch rate and fishing experience declined.

In response to anglers concerns, Hydro Tasmania in-conjunction the Inland Fisheries Service (IFS), trialed various water management options. After some fine tuning, a satisfactory management regime was established. The lagoon now receives water from its own immediate catchment, with the lagoon level maintained at or near full supply. These alterations in water level management have seen the lagoon enter a clear water phase, with turbidity at very low levels. This has implications for overall nutrient cycling, with potentially less nutrients entering the system and available nutrients locked up in macrophyte biomass. Additionally, during the initial decline in turbidity, the IFS stocked the water with 250, 1 kg brown trout, with subsequent annual stockings of adult fish continuing until 2009.

1.2. Trout Fishery

The trout fishery at Penstock Lagoon has for many years been valued for a moderate catch rate of quality brown and rainbow trout. Brown trout have been the mainstay of the fishery with an estimated harvest of between 54%-92% of all trout during 2001-2016, with rainbow trout representing between 8%-46% percent for same period.

With the changes in water management, natural recruitment of both brown and rainbow trout became highly variable. In some cases, no spawning occurred in the spawning canal for multiple years. In response to this variability and falling catch rates, the IFS began a stocking program consisting of both rainbow and brown trout fry. In addition to these stockings, the Service also transferred between 100 - 750 (~ 1 kg) adult brown trout from Great Lake into the lagoon through the period 2001 - 2009. The initial rationale for this was to fill a void in recruitment while brown trout fry grew to a takeable size. This initiative was so successful it was continued, with transfer numbers increased to 500 in 2000 and again to 750 in 2003. However, with the consistent stocking of the lagoon with a combination of diploid and triploid fry since 2003, the ongoing stocking of adult trout could no longer be justified as returns from fry stockings appeared to be high. However, during 2012-14 anglers suggested trout stocks had fallen well below acceptable levels, with low catch rates being experienced by all anglers. In response to these concerns, an initial population survey was conducted during April 2013 to gain knowledge of CPUE using a combination of fyke and box nets. This survey suggested there was a reasonable numbers of large brown trout in Penstock Lagoon, however there was almost a complete absence of brown trout below the legal size limit of 420 mm. This indicated there had been a failure of fry stockings in the preceding three years. Consequently, a further survey was undertaken in July 2014 to examine CPUE, population structure and estimate the population size. The results of the 2013 and 2014 surveys suggested the size of the population was much lower than expected. During 2014, 2015 and 2016, adult brown trout transfers recommencement. These stockings were primarily for fishery assessment purposes however, it became apparent these fish were contributing to a high proportion of angler's catches and displayed significant gains in both weight and length. This (2016) fishery performance assessment confirms this position, with the ongoing stocking of adult brown trout is likely to be the preferred method of restocking.

2. FPA Survey Methodology

2.1 In-Lake Population Surveys

During 2-4 August, 60 box traps were set in both shallow and deep water across all habitat types. All fish on the first day of capture were weighed and measured for fork length with CPUE data recorded for each net over the entire survey. Prior to the survey being conducted, 3,658 adult brown trout sourced from the spawning traps at Great Lake were marked by having their adipose fin hole punched. These adult fish were transferred to Penstock Lagoon for release in preparation for a capture - mark – recapture population estimate. A limited amount of electrofishing using the Smith-Root electrofishing boat was conducted. Unless specified, only the captures from box traps are used in the analysis of the data.

2.2 Stocking Database

The Service keeps electronic records of public water stockings dating back to 1980. These records set out information on location, date of stocking, species, age, origin, stock type and genotype, in addition to some length/weight data and comments e.g. denoting tagged fish. This information provides an historical record of supplementary recruitment into individual waters.

2.3 Annual Postal Survey

Since 1986, the Service has conducted a postal survey seeking information about anglers' catches. The survey comprises of a form sent to ten percent of all categories of anglers, asking set questions about their angling (catch of trout) for the past season. This information is entered into a database and information on catch per day, harvest and angling effort is extrapolated. This provides a long term overview of individual fishery performance in addition to characterising effort.

2.4 Analysis of data

Analyses of mean weight, length and condition factor values were undertaken using unpaired t-tests with a significance level of $P = 0.05$. Population estimation was achieved by performing a single recapture period undertaken over three days, with the data used to estimate the population size under the Petersen CMR population estimator.

3. Results

3.1 In-Lake Survey 2016

During 2-4 August 2016, the Service conducted an in-lake survey at Penstock Lagoon to:

- estimate the size of the brown trout population,
- examine CPUE for brown and rainbow trout,
- assess the abundance and growth of adult brown trout that were fin clipped and released in June 2014 and,
- to assess the population structure of both brown and rainbow trout.

A total of 593 trout were captured, 547 in box traps and 46 by electrofishing. Of the 547 captured in box traps, 417 were brown trout and 130 rainbow trout. The electrofishing boat was used mainly on an opportunistic basis with 28 brown trout and 18 rainbow trout captured.

3.2 Population Estimate

During May – June 2016, 3,658 adult brown trout were transferred from Great Lake to Penstock Lagoon to enable a capture-mark-recapture population estimate. To identify these fish, each individual had its adipose fin hole punched. Hole punching these fish distinguished them from the 2014 adult transfers that were marked with a routine adipose fin clip.

A total of 417 brown trout were captured over a three day period (two nights trapping). Of these fish, 109 were marked with a hole punch in the adipose fin. Table 1 shows the parameters for the estimation, with 13,994 brown trout estimated to be within the lagoon. The associated estimate of bias was at acceptable levels i.e. > 4 and implies a reasonable degree of confidence in the estimate.

Parameter	Result
Total fin clipped released (M)	3,658
Total recaptures (C)	417
Total marked recaptures (R)	109
Population estimate: MC/R = N	13,994
Standard error	1,135
Lower and Upper 95% CI limits	11,770 – 16,218
Estimate bias level: MC/4N =	27.25 (>4 acceptable bias)

Table 1: Petersen population estimate for brown trout Penstock Lagoon 2016.

3.3 Brown Trout 2014

Of the 417 brown trout captured in box traps during the 2016 survey, 82 had adipose fin clips remaining from the capture mark recapture estimate undertake during July 2014. This represents 19.6% of the brown trout captured in box traps. In terms of percentage of the total catch, these fish represented 31.3% of the total catch in 2014 where as in 2016 they represented 19.6%. When the 2016 percentage is extrapolated, taking into account the 2016 population estimate of 13,999 brown trout, the estimate of 2,751 remaining from the 2014 survey is erroneously high. The number of brown trout marked with adipose clips and released into the lagoon during 2014 was 2,000. Consequently, given these fish have been in the lagoon for two years and have grown from 580 g to 1.3 kg, (modal length 360 mm to 520 mm; see figure 1) thus most were above the legal size limit for harvesting for at least one season, this estimate is inaccurate. However, it is apparent these fish represented a significant proportion of the brown trout population during the 2016 survey. This indicates the harvest level for these fish over the last two years has been relatively low.

Table 2 below shows the results of the population estimate undertaken during July 2014. At that time, an estimated 6,400 brown trout were likely to be within the lagoon. Since this survey, 7,950 adult brown trout have been transferred into Penstock Lagoon (includes the 2016 adult brown transfers 3,658) and several cohorts of triploid brown trout, although it appears only the 2013 stocking was successful. Given these past stockings and the rate of removal by anglers, the 2014 and 2016 population estimates appear realistic.

Parameter	**Result**
Total fin clipped released (M)	2,000
Total recaptures (C)	192
Total marked recaptures (R)	60
Population estimate: MC/R = N	6,400
Standard error	670
Lower and Upper 95% CI limits	5,053 – 7,681
Estimate bias level: MC/4N =	15 (>4 acceptable bias)

Table 2: Petersen population estimate for brown trout Penstock Lagoon 2014.

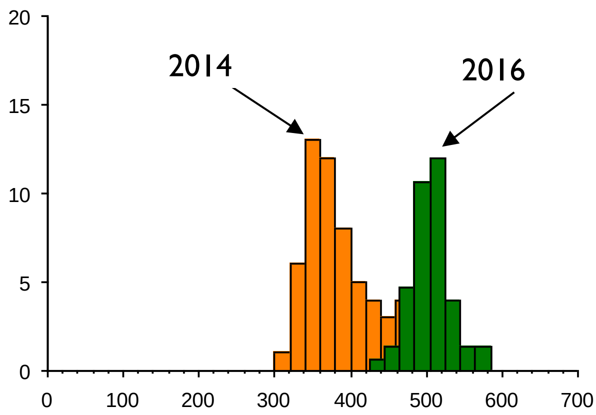


Figure 1: Length frequency for the 2014 adipose fin clipped brown trout, showing the cohort in 2014 and 2016.

3.4 CPUE Information

Over the three days (2 nights) of the survey, 60 box traps (120 sets) were used to capture 417 brown trout. In respect of CPUE, box traps returned 3.48 brown trout per trap (see table 3), with a maximum of 11 fish captured in one individual trap.

The electrofishing boat was also used to sample fish, however its use was limited and mainly opportunistic, with just 60 minutes of electrofishing conducted within the lagoon and 20 minutes in the inflow canal. A total of 28 brown trout were captured within the lagoon, with none captured in the inflow canal, giving a CPUE of 28 fish per hour within the lake sample. This figure is moderately high compared to electrofishing surveys at similar sized lakes.

Method	No. nets	Sample time	Effort	Total No.	CPUE fish
Box traps	60	2 overnight sets	120 net sets	417	3.48/trap
Boat electrofishing	(Lagoon) (Canal)	1) 60 mins 2) 20 mins	60 minutes 20 Minutes	28 nil	28.0/hour nil

Table 3: CPUE for brown trout, Penstock Lagoon 2016.

Method	No. nets	Sample time	Effort	Total No.	CPUE fish
Box traps	60	2 overnight sets	120 net sets	130	1.08/trap
Boat electrofishing	(Lagoon) (Canal)	1) 60 mins 2) 20 mins	60 minutes 20 Minutes	6 12	6.0/hour

Table 4: CPUE for rainbow trout, Penstock Lagoon 2016.

A total of 130 rainbow trout were captured from box traps, representing 24 percent of the total catch from traps. Mean CPUE from box traps was 1.08 rainbow trout per trap (see table 4). Eighteen rainbow trout were captured by electrofishing with 6 from the lagoon and 12 from the inflow canal. CPUE is reported for the lagoon sample only as the canal site is likely to be bias with some spawning rainbow trout present, although most stocked rainbow trout were triploids.

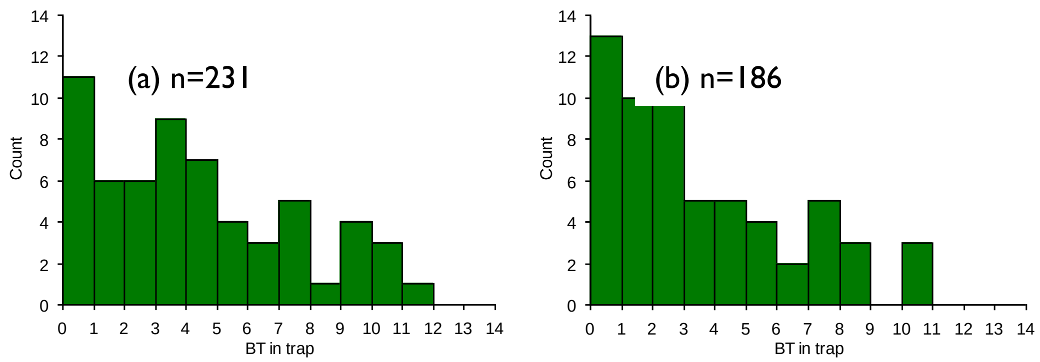


Figure 2a: Capture frequency for box traps for brown trout for day 1 (a) and day 2 (b).

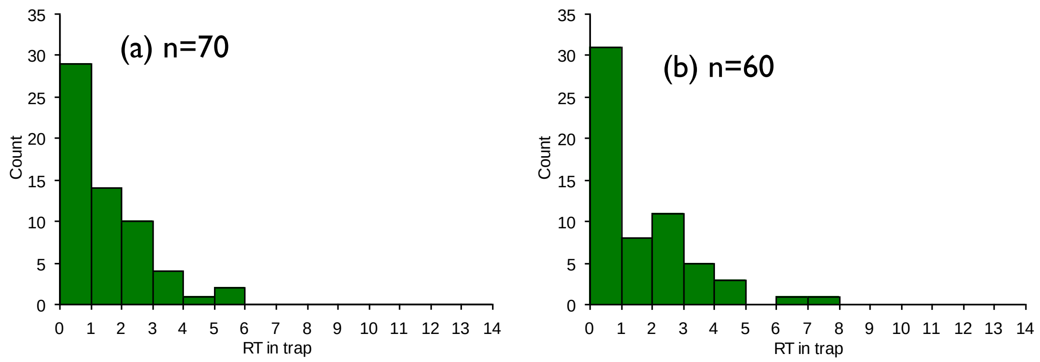


Figure 2b: Capture frequency for box traps for raibow trout for day 1 (a) and day 2 (b).

Forty eight percent of box traps captured between 1-5 brown trout with 6% catching 10 or more. Just 20% of the box trap captured no brown trout (see figure 2a). Half the box trap sets captured no rainbow trout with 44% capturing 1-3 rainbow trout (see figure 2b). The capture rate decreased between day 1 and day 2 for both species with brown trout capture declining 19.5% and 14.2% for rainbow trout.

3.5 Length and Weight Information

Brown Trout

A total of 231 brown trout were weighed, measured and sexed. There were 131 males and 82 females recorded, with 18 brown trout identified as either immature (15) or unknown (3) sex. There was difficulty in sexing some smaller fish in the 360 mm - 420 mm range; this is most likely confounded by the presence of triploid brown trout from a stocking in 2013.

The vast majority of brown trout displayed good growth across all lengths (see figure 3). Fish over 500 mm continued to show good weight gains with very few longer fish displaying lower weight to length ratios (fish condition). It would appear in general, larger (older) brown trout still had some limited growth potential. Furthermore, as evident in the 2014 survey, all fin clipped (clipped and hole punch fish) had similar length/weight relationship to those brown trout that were unclipped, indicating similar growth characteristics.

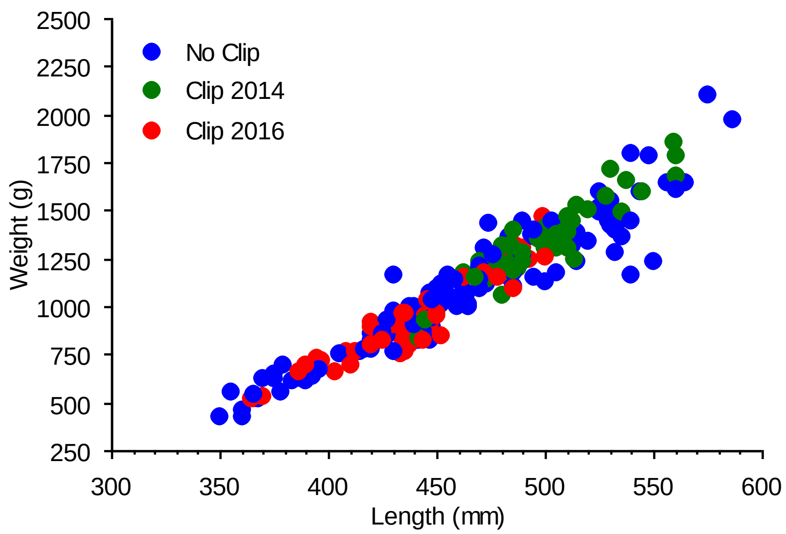


Figure 3: Length weight relationship for brown trout showing non-clipped and fin clipped/hole punched fish transferred during 2014 and 2016 (regression relationship: Y=-1736.037+6.108X; R^2=0.91)

Figure 4 shows the length frequency for all brown trout caputred and measured during the 2016 survey. There appears to be three length classes (see figure 4), however, when the sample is seperated into non-clipped, 2014 adipose fin clip and 2016 hole punched adipose, there are four distinct groupings (see figure 5). The first of these groups consist of 33 fish in the 360-420 mm length class. Of these fish, 22 (66%) did not have any fin clip or punch. Allowing that the adult transfers from the 2015 stocking that were 360^{+} mm, it is unlikely these fish were from an adult stocking. This indicates they were from a stocking of triploid brown trout undertaken during October 2013 (1.4 g release wt.) and January 2014 (6.2 g release wt.). This cohort of triploids therefore represented 9.5% of the total number of brown trout captured and measured from box traps. This adds weight to the evidence from the 2014 survey that while triploid fish are evident, they occur at a lower than expected abundance. In addition, it also indicates the growth of these fish is similar to diploid brown trout of the same age i.e. 3 yo fish (see figure 3).

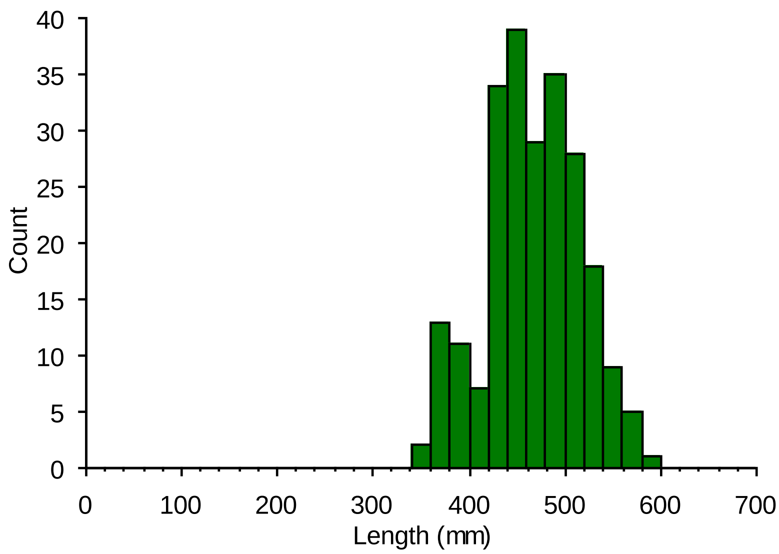


Figure 4: Length frequency for brown trout, Pensock Lagoon 2016.

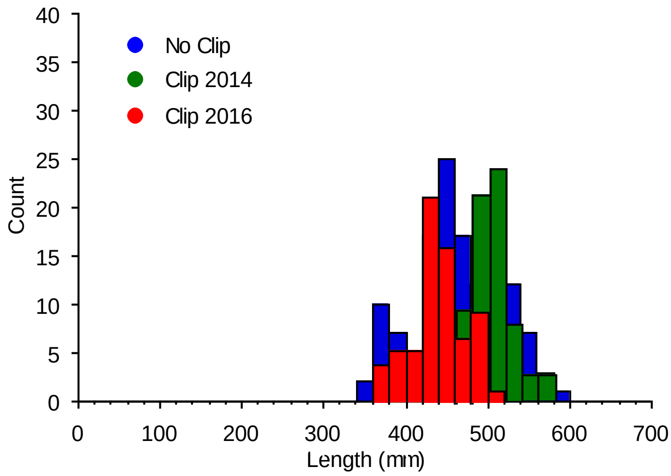


Figure 5: Length frequency for brown trout, Pensock Lagoon 2016 showing non-fin clipped and fin clips from 2014 & 2016.

The second length class consist of the adult brown trout that were adipose hole punched and relaease in May 2016 in readiness for the July 2016 population estimate. The third group are non-clipped fish that mostly consist of 4,292 adult brown trout relased in 2015. The forth disticnt cohort consit of both unclipped fish from previous stockings, most likey adult brown trout prior to 2014, and 2,320 adult brown trout with an adipose clip, release for the 2014 populaton estimate (see figure 5).

The mean length for all brown trout processed (n=231) was 465 mm, with a mean weight 1,106 g, giving an overall calculated mean condition factor of 1.07 K (see table 5 and figure 7). The weight of fish is slightly less than might be expected, this is due to the inclusion of the 3,658 adult brown trout transfers released in May 2016 (see table 5). The non-clipped fish grouping contained both large and small length class fish and therefore was most indicative of the whole sample. The 2014 fin clipped group had significantly higher lengths and weights (see figure 6) with a mean weight of 1,334 g and mean length 498 mm. These fish had grown from approximately 580 g when released in 2014 to 1.3 kg when captured in 2016. The mean condition factor for all brown tout sampled was a generally consistent at 1.07 to 1.08 k for all groups. Most brown trout (82%) were in fair to good condition (see figure 7) with 18 % categorised in poor condition. As nearly all fish were in post spawning condition, this result is reasonable and consistent with most of the State's lake trout fisheries.

Grouping	Measurement	Mean	Std Error	Count	Minimum	Maximum
All brown trout (n=231)	Length (mm)	465	3.22	231	350	586
	Weight (g)	1106	20.65	231	840	2,100
	Cond Factor (k)	1.07	0.01	231	0.74	1.46
Non – clipped (125)	Length (mm)	462	4.79	125	350	586
	Weight (g)	1083	29.54	125	430	2,100
	Cond Factor (k)	1.07	0.01	125	0.74	1.46
Clipped 2014 (54)	Length (mm)	498	3.78	54	425	560
	Weight (g)	1,334	27.32	54	840	1,860
	Cond Factor (k)	1.07	0.01	54	0.92	1.23
Hole punch 2016 (52)	Length (mm)	439	4.66	52	365	500
	Weight (g)	924	30.11	52	520	1,470
	Cond Factor (k)	1.08	0.01	52	0.92	1.24

Table 5: Length, weight and condition factor for all brown trout caputed in box traps, seperated by: Combined sample, non-finclipped, 2014 adipose clips and 2016 adipose hole punch.

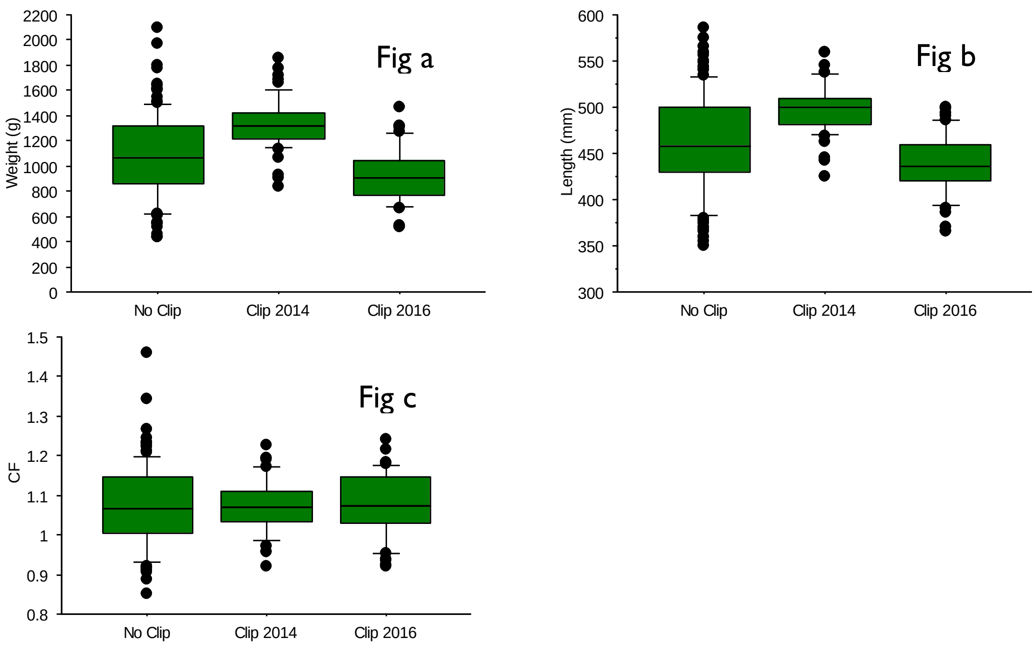
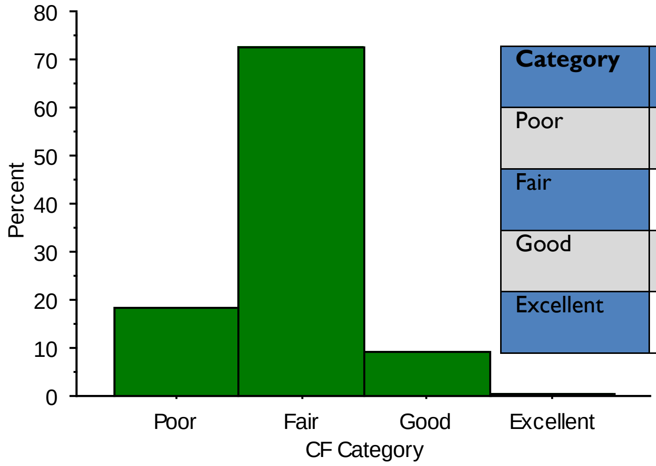


Figure 6: Box plots showing the median and associated upper and lower quartiles for, (a) weight, (b) length and (c) condition factor, separated by fin clip status, Penstock Lagoon 2016.



Category	Count	Percent
Poor	42	18
Fair	167	73
Good	21	9
Excellent	1	~1

Figure 7: Percentage condition factor category and associated number of brown trout, Penstock Lagoon 2016 for all brown trout combined.

From the length frequency data it is estimated at present, 86% of the brown trout within the lagoon meet the legal size limit of 420 mm length. This provides an average length of 479 mm and weight of 1.19 kg for all brown trout over 420 mm. As a result, this suggests that anglers can potentially harvest the vast majority of fish they capture within the confines of the five fish per day limit.

3.6 Comparison 2003, 2013, 2014 & 2016 Surveys

Comparative summary data for all formal in-lake surveys undertaken at Penstock Lagoon since 2003 are shown in figure 8 and table 6. In general, the rate of growth of brown trout is consistent across all years. The 2003 results show a small number of brown trout were growing to a large size in excess of 600 mm length. This size class was present during the 2003 and 2013 surveys but absent in 2014 and 2016. However, all surveys contained a high number of fish in the 500 - 600 mm size range. This result indicates that a significant proportion of fish are not being harvested and they are growing through to this size range. Nonetheless, increased angling effort during the 2015/16 season and its effect on harvest will need to be monitored over the coming seasons (see figure 13 & 15).

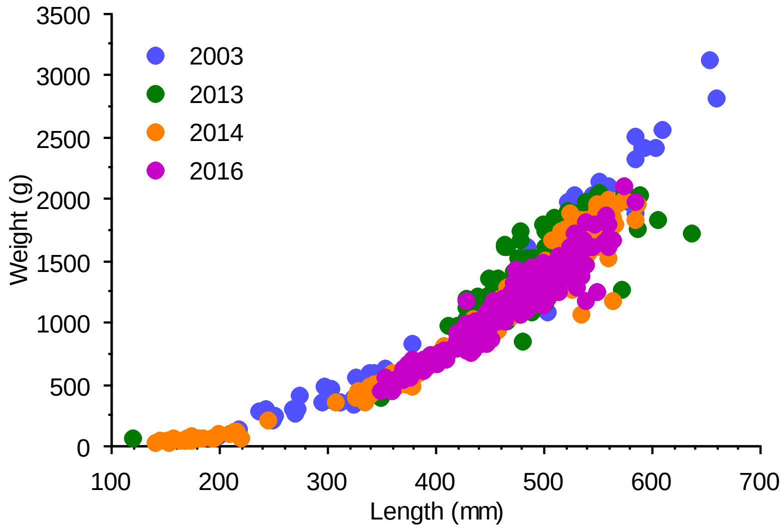


Figure 8: Length/weight regression for comparative surveys undertaken in 2003, 2013, 2014 and 2016, brown trout, Penstock Lagoon.

Figure 9 shows the median and spread of values for weight, length and condition factor for in-lake surveys. During 2003 and 2014, there was a greater spread of fish lengths and weights in comparison to 2013 and 2016. The compressed length data for 2013 and 2016 are likely to be a result of two separate circumstances. The 2013 result is a consequence of poor recruitment (as highlighted in the 2014 survey report, IFS 2014) and low total numbers, with very few smaller fish present; whereas the 2016 result was the outcome of three years of adult transfers (2014 – 2016) and no stocking of juvenile fish. This has resulted in a high proportion (86%) of brown trout population being over the 420 mm size limit.

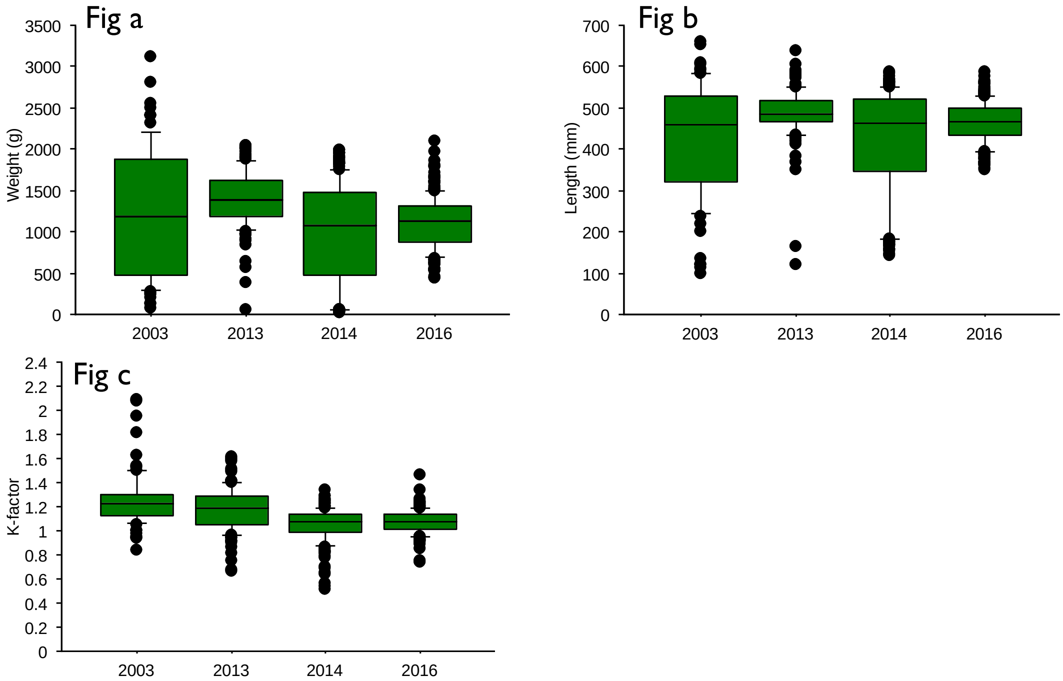


Figure 9: Box plots showing median and associated upper and lower quartiles for, (a) length, (b) weight and (c) condition factor for surveys undertaken in 2003, 2013, 2014 and 2016, for brown trout, Penstock Lagoon.

Variable	Mean	Std dev	Count
Weight 2003	1198	758.4	81
Length 2003	419	136.7	85
CF 2003	1.3	0.2	80
Weight 2013	1391	348.9	131
Length 2013	488	67.9	132
CF 2013	1.2	0.2	131
Weight 2014	976	608.0	192
Length 2014	417	127.6	192
CF 2014	1.1	0.1	192
Weight 2016	1106	313.8	231
Length 2016	465	49.0	231
CF 2016	1.1	0.1	231

Table 6: Length, weight and condition factor of comparative surveys undertaken in 2003, 2013, 2014 and 2014, brown trout, Penstock Lagoon.

3.7 Rainbow Trout 2016

Out of the 130 rainbow trout captured during the 2016 survey, 70 were weighed and measured. The mean weight was 776 g with the mean length being 339 mm. The maximum weight was 1.7 kg while the minimum weight was 390 g (see table 7). The mean weight and length is slightly biased by a stocking of 6,000 yearlings in November 2015. This group of rainbow trout were stocked at a mean weight of 138 g and by July 2016 had reached approximately 569 g, with a mean length of 357 mm (based on the maximum size of this cohort being < 380 mm length; see appendix B). However, it's likely that a number of rainbow trout in this range were also from the stocking of triploid fry during 2014 (see table 8).

Grouping	Measurement	Mean	Std Error	Count	Minimum	Maximum
Rainbow trout (n=70)	Length (mm)	393	6.04	70	315	510
	Weight (g)	776	38.16	70	390	1700
	Cond Factor (k)	1.23	0.02	70	0.56	1.46

Table 7: Length, weight and condition factor for rainbow trout caputed in box traps.

The mean condition factor for all rainbow trout weighed and measured was 1.25 k (see table 7) with two thirds categorised as being in good to excellent condition (see figure 12). The growth of rainbow trout stocked in the lagoon appears to be good with consistent weight gains across all length classes (see figure 10).

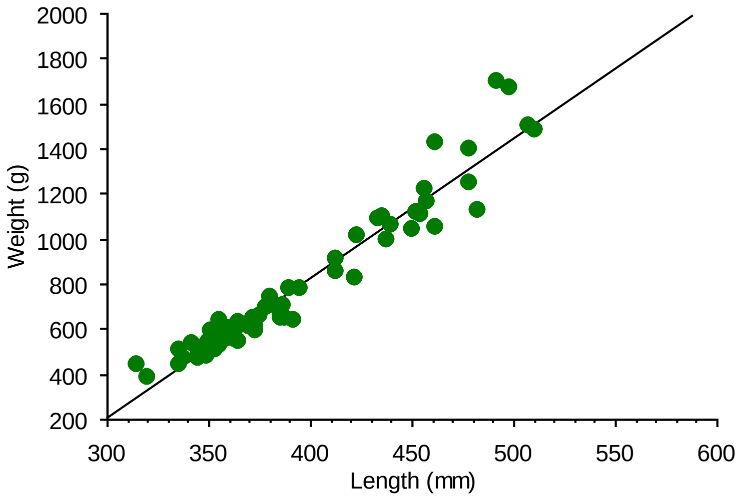


Figure 10: Length weight relationship for rainbow trout
(regression relationship: Y=-1659.04 +6.222X; R2=0.94)

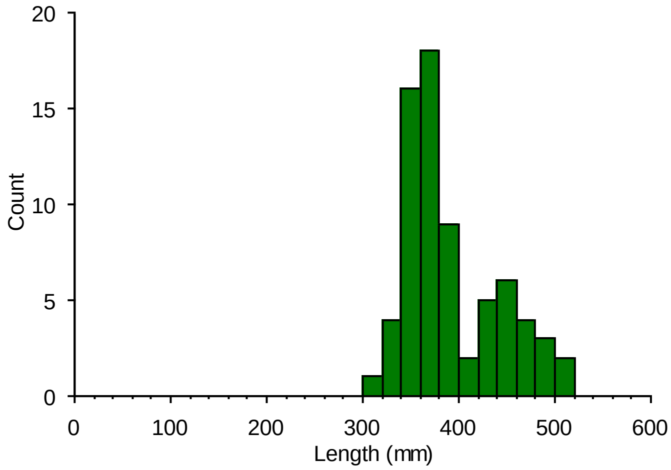
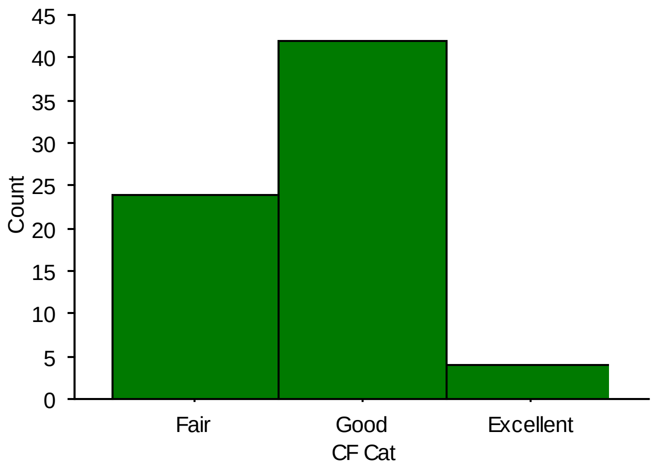


Figure 11: Length frequency for rainbow trout, Pensock Lagoon 2016

Length frequency data indicates two length cohorts. The first and major cohort (300 - 400 mm) is likely to contain rainbow trout from two stocking events, November 2015 (yearlings) and fry from 2014. The second cohort is confounded by fish from two stocking events undertaken in 2011 and late 2013 (see table 8).



Category	Count	Percent
Poor	0	0
Fair	24	34
Good	42	60
Excellent	4	6

Figure 12: Percentage condition factor category and associated number of rainbow trout, Penstock Lagoon 2016.

4. Stocking History

Over the past 14 years, Penstock Lagoon has undergone a number of changes to the trout stocking regime. These changes have been driven by two main factors, access to additional adult brown trout for transfer and the resulting lower than expected contribution that fry and fingerlings from the IFS hatchery made to the fishery. During the early 2000's the lagoon was stocked with a combination of adult brown trout transferred from Liawenee, Great Lake, and both brown and rainbow trout fry from the Salmon Ponds hatchery. With the commissioning of the New Norfolk hatchery in 2007, the focus changed toward producing slightly larger fingerling brown trout and the provision of triploid brown and rainbow trout, rather than adult brown trout (see table 8). There is strong evidence (both from previous surveys and anecdotal) to suggest that adult brown trout have been successful, both in terms of growth and catch rate. The stocking of fry and fingerlings has been assumed successful, as past precedence suggests. However, the degree to which these stocking events have contributed to the sustainability of moderately high catch rates is less certain. As suggested from the results of the July 2014 survey, there was a large gap in recruitment of both brown and rainbow trout fry and fingerling, resulting from the 2010 and 2011 releases of juvenile brown trout, and 2011 and 2012 releases of rainbow trout.

The length frequency analysis from this survey demonstrates that for Penstock Lagoon at least, the stocking of adult brown trout has been successful, in terms of survival, growth, catch rate and overall harvest.

	Species	Number	Age	Type
2007	Brown trout	20000	Fry	Diploid
2008	Brown trout	10000	Fry	Diploid
2009	Brown trout	5000	Fry	Triploid
2010	Brown trout	10000	Fry	Diploid
2011	Brown trout	10000	Fry	Triploid
2012	Brown trout	15000	Fry	Triploid
2013	Brown trout	10000	Fry	Triploid
2014	Brown trout	55000	Fry	Triploid
2007	Brown trout	3500	Fingerling	Diploid
2008	Brown trout	250	Fingerling	Diploid
2009	Brown trout	5000	Fingerling	Triploid
2009	Brown trout	5000	Fingerling	Diploid
2007	Brown trout	490	Adult	Diploid
2008	Brown trout	280	Adult	Diploid
2009	Brown trout	100	Adult	Diploid
2014	Brown trout	2320	Adult	Diploid
2015	Brown trout	4292	Adult	Diploid
2016	Brown trout	3658	Adult	Diploid
2010	Rainbow trout	10000	Fry	Diploid
2012	Rainbow trout	10000	Fry	Diploid
2013	Rainbow trout	35000	Fry	Triploid
2007	Rainbow trout	7000	Fingerling	Diploid
2008	Rainbow trout	5000	Fingerling	Diploid
2009	Rainbow trout	10000	Fingerling	Triploid
2011	Rainbow trout	10000	Fingerling	Triploid
2014	Rainbow trout	50000*	Fry	Triploid
2015	Rainbow trout	6000	Yearlings	Triploid

Table 8: Stocking history for Penstock Lagoon, 2007 – 2016. *(*split between 2013/14)*

5. Angler Postal Survey

Average (mean) fishing effort in the period 2001 – 16 was 8,433 angler days per season, with a low of 4,190 in the period when the fishery was rebuilding after a decline in water quality and low fish stocks in the late 1990's, and a high of around 13,000 days in the three year period 2006 – 2008 (see figure 13). This period of high fishing effort, coincides with a prolonged drought that resulted in low lake levels and poor catches at other major fisheries e.g. Arthurs Lake. Consequently, a large influx of anglers moved from these waters to other less impacted waters, such as Penstock Lagoon. Since this period, fishing effort has trended down to 5,075 days for the 2013/14 season. Following the recommencement of adult brown trout stocking during 2014-16, total fishing effort has rebounded to a new high of 13,759 days for the 2015/16 season. The average number of days fished per angler, per season was 4.3 days (see figure 14).

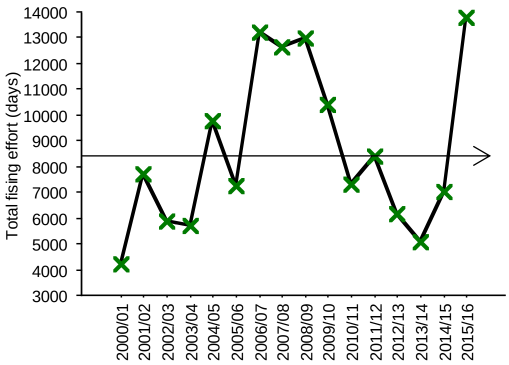


Figure 13: Total angling effort 2000 – 2016.

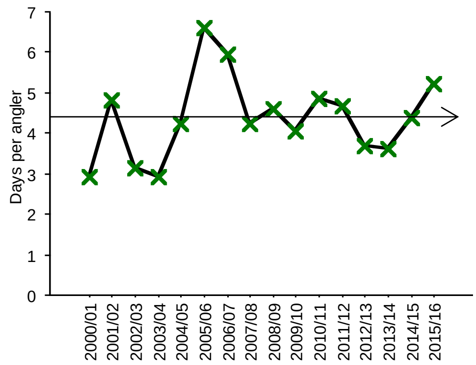


Figure 14: Number of days fished per angler for each season 2000 – 2016.

The mean harvest of brown trout for the period 2000 – 2016 was 8,255. Since the very high harvest in 2006/07 of 22,299 brown trout, the annual harvest figure has trended down to 4,488 brown trout in the 2013/14 season (see figure 15). Following two years of stocking with adult brown trout and a downturn in the Arthurs Lake fishery, the total harvest of brown trout has returned to high levels with an estimated 16,346 brown trout harvested during the 2015/16 season. This level of harvest is unlikely to be sustainable in the longer term and may be detrimental to the values of the fishery (i.e. moderate catch rate of well conditioned fish in the 1.3 – 2.0 kg weight range).

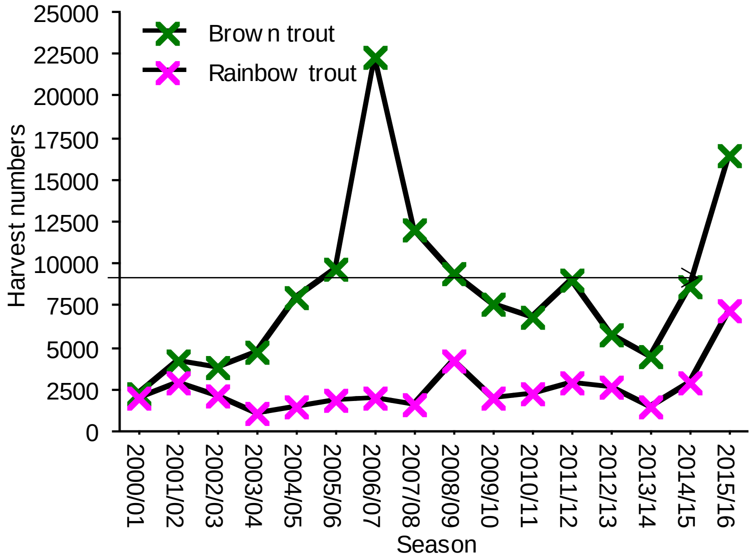
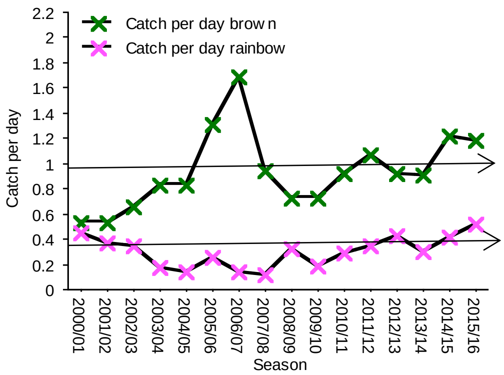


Figure 15: Estimate harvest of brown and rainbow trout 2000 – 2016.

The average daily catch rate for the period 2000 – 2016 was 0.9 brown trout per day. Despite a fall in angling effort and corresponding annual harvest, the daily catch rate over the period 2011 - 2013 remained around the long term average (see figure 16). Since 2014, the daily catch rate has been at strong 1.2 fish per day.

Over the 16 year period from 2000 – 2016, brown trout represented on average 75 percent of the total harvest of all trout, correspondingly, rainbow trout represented 25 percent (see figure 17).



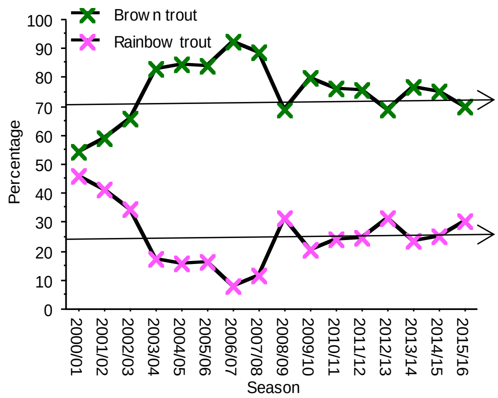


Figure 16: Daily catch rate for brown and rainbow trout, 2000 – 2016.

Figure 17: Percentage harvest for brown and rainbow trout, 2000 – 2016.

The average catch rate for rainbow trout has generally remained around the long term average of 0.3 fish per day (see figure 16), with an average long term annual harvest of 2,500 fish (see figure 15). An increase in both harvest and catch rate for the 2015-16 seasons generally relates to a stocking of 6,000 yearling rainbow trout in November 2015, and an overall increase in total fishing effort for that season.

6. Discussion

The average weight and length for brown trout at Penstock Lagoon was good, although the average condition factor was lower than recorded in two previous surveys conducted during 2003 and 2013, but the same as 2014. The lower condition factor is however, influenced by the fish being in post spawning condition and therefore carrying a lower body weight. The 2003 and 2013 surveys were undertaken at a time when brown trout were in pre spawning condition and therefore had a high weight to length ratio. Indications are by mid-season 2016, the average weight for brown trout in excess of 420 mm will be 1.5 kg with a mean condition factor of 1.2 k-factor, therefore meeting the goals as recommended in the 2014 fishery performance assessment.

The population estimate from the July 2016 survey suggests the estimate of 13,994 brown trout is reasonable and the level of potential bias was low. The estimate for 2014 was 6,400 while for 2016 it was 13,994. Given that almost 8,000 adult brown trout were stocked during 2015-2016 and three fry stocking events during 2012-2014 would have potentially been entering the fishery, this estimate is realistic. This result is despite the apparent high harvest rate as suggested in the Angler Postal Survey. The high capture level of the 2014 fin clipped fish during this survey however, suggests the harvest figures may be elevated and anglers are in fact taking less trout than estimated. If this is the case then this provides further confidence in the population estimate.

The growth of the 2014 fin clipped adult brown transfers was very good, with the modal length class of that cohort growing 160 mm in length (360 mm – 520 mm) over the two year period. Correspondingly, during the same period, the average weight for this cohort increased from 580 g to 1.3 kg. This growth rate is at the higher level of expectation for a wild fishery and is similar to rates observed from previous surveys of Penstock Lagoon during 2003 – 2016. This result suggests there does not appear to be any density dependent factors limiting the rate of growth. Additionally, there is strong evidence from length frequency analysis that the stocking of adult brown trout in 2015 is contributing significantly to the fishery in terms of numbers of available fish.

In the 2014 survey, there was good evidence to suggest that some fry stockings were unsuccessful; this was particularly relevant to triploid brown trout. The 2016 survey confirms this by way of assessment of the length frequency data and the inclusion of fin clipped and hole punched fish. The 2013 triploid brown trout cohort (stocked at 1.4 - 6.2 g fry) had grown to around 380 mm, that is similar to the growth of diploid brown trout of the same age i.e. 3 yo. In addition, this cohort represented only 9.5% of the total number of brown trout captured and measured; indicating either low survival or the number of fish stocked was insufficient.

Since the recommencement of adult brown trout transfers over the past 3 years, fishing effort has rebound to high levels. The effects of continuing high effort and corresponding high harvest totals will need to be closely monitored as these have the potential to undermine the values of the fish, i.e. moderately large well condition fish. Moreover, at present, 86% of the brown trout population is greater than the legal size limit of 420 mm. This is in contrast to the situation for when this size limit was first implemented (2003) where approximately 60 percent of the fish were greater than 420 mm. A review of bag and size limits in relation to maintaining these values would be prudent. The ratio of brown trout to rainbow trout within the fishery is within the goal for the fish at 70:30 respectively.

7. Recommendations

- The primary method for maintaining the fishery is by stocking adult brown trout in the 360 mm – 420 mm length, as these present the best outcome regarding growth and they underpin the existing population structure. These are best sourced from a water that supports this size range i.e. Lake King William or Arthurs Lake.
- The stocking rate for rainbow trout is capped to 50,000 fry per annum or equivalent.
- The goal for the average weight for brown trout in excess of 420 mm is 1.5 kg +/- 0.1 with a mean condition factor of 1.2 k-factor.
- The goal for the average weight for rainbow trout in excess of 400 mm is 1.4 kg +/- 0.2 with a mean condition factor of 1.2 k-factor.
- The target catch rate for brown trout is 0.9 / day +/- 0.2.
- The target catch rate for rainbow trout is 0.5 / day +/- 0.1.
- The target ratio of catch of brown trout to rainbow trout is approximately 60:40 +/- 10%.
- The legal minimum size/bag limit for brown trout to be amended to including both brown and rainbow trout with a maximum of only two fish greater than 500 mm permitted.

8. Appendix

A) Summary statistics for brown trout Penstock Lagoon survey

Frequency Distribution for Length (mm)
Split By: Clip Status Data

From (>=)	To (<)	Total Count	Total Percent	No Clip Count	No Clip Percent	Clip 2014 Count	Clip 2014 Percent	Clip 2016 Count	Clip 2016 Percent
20.000	40.000	0	0.000	0	0.000	0	0.000	0	0.000
40.000	60.000	0	0.000	0	0.000	0	0.000	0	0.000
60.000	80.000	0	0.000	0	0.000	0	0.000	0	0.000
80.000	100.000	0	0.000	0	0.000	0	0.000	0	0.000
100.000	120.000	0	0.000	0	0.000	0	0.000	0	0.000
120.000	140.000	0	0.000	0	0.000	0	0.000	0	0.000
140.000	160.000	0	0.000	0	0.000	0	0.000	0	0.000
160.000	180.000	0	0.000	0	0.000	0	0.000	0	0.000
180.000	200.000	0	0.000	0	0.000	0	0.000	0	0.000
200.000	220.000	0	0.000	0	0.000	0	0.000	0	0.000
220.000	240.000	0	0.000	0	0.000	0	0.000	0	0.000
240.000	260.000	0	0.000	0	0.000	0	0.000	0	0.000
260.000	280.000	0	0.000	0	0.000	0	0.000	0	0.000
280.000	300.000	0	0.000	0	0.000	0	0.000	0	0.000
300.000	320.000	0	0.000	0	0.000	0	0.000	0	0.000
320.000	340.000	0	0.000	0	0.000	0	0.000	0	0.000
340.000	360.000	2	.866	2	1.600	0	0.000	0	0.000
360.000	380.000	13	5.628	10	8.000	0	0.000	3	5.769
380.000	400.000	11	4.762	7	5.600	0	0.000	4	7.692
400.000	420.000	7	3.030	3	2.400	0	0.000	4	7.692
420.000	440.000	34	14.719	17	13.600	1	1.852	16	30.769
440.000	460.000	39	16.883	25	20.000	2	3.704	12	23.077
460.000	480.000	29	12.554	17	13.600	7	12.963	5	9.615
480.000	500.000	35	15.152	12	9.600	16	29.630	7	13.462
500.000	520.000	28	12.121	9	7.200	18	33.333	1	1.923
520.000	540.000	18	7.792	12	9.600	6	11.111	0	0.000
540.000	560.000	9	3.896	7	5.600	2	3.704	0	0.000
560.000	580.000	5	2.165	3	2.400	2	3.704	0	0.000
580.000	600.000	1	.433	1	.800	0	0.000	0	0.000
600.000	620.000	0	0.000	0	0.000	0	0.000	0	0.000
	Total	231	100.000	125	100.000	54	100.000	52	100.000

Frequency Distribution for Weight (g)
Split By: Clip Status Data

From (>=)	To (<)	Total Count	Total Percent	No Clip Count	No Clip Percent	Clip 2014 Count	Clip 2014 Percent	Clip 2016 Count	Clip 2016 Percent
100.0	200.0	0	0.0	0	0.0	0	0.0	0	0.0
200.0	300.0	0	0.0	0	0.0	0	0.0	0	0.0
300.0	400.0	0	0.0	0	0.0	0	0.0	0	0.0
400.0	500.0	3	1.3	3	2.4	0	0.0	0	0.0
500.0	600.0	7	3.0	4	3.2	0	0.0	3	5.8
600.0	700.0	15	6.5	11	8.8	0	0.0	4	7.7
700.0	800.0	14	6.1	7	5.6	0	0.0	7	13.5
800.0	900.0	24	10.4	13	10.4	1	1.9	10	19.2
900.0	1000.0	23	10.0	9	7.2	2	3.7	12	23.1
1000.0	1100.0	26	11.3	19	15.2	1	1.9	6	11.5
1100.0	1200.0	26	11.3	15	12.0	8	14.8	3	5.8
1200.0	1300.0	24	10.4	11	8.8	10	18.5	3	5.8
1300.0	1400.0	29	12.6	10	8.0	16	29.6	3	5.8
1400.0	1500.0	18	7.8	11	8.8	6	11.1	1	1.9
1500.0	1600.0	7	3.0	3	2.4	4	7.4	0	0.0
1600.0	1700.0	8	3.5	5	4.0	3	5.6	0	0.0
1700.0	1800.0	3	1.3	1	0.8	2	3.7	0	0.0
1800.0	1900.0	2	0.9	1	0.8	1	1.9	0	0.0
1900.0	2000.0	1	0.4	1	0.8	0	0.0	0	0.0
2000.0	2100.0	0	0.0	0	0.0	0	0.0	0	0.0
2100.0	2200.0	1	0.4	1	0.8	0	0.0	0	0.0
2200.0	2300.0	0	0.0	0	0.0	0	0.0	0	0.0
	Total	231	100.0	125	100.0	54	100.0	52	100.0

B) Length frequency for rainbow trout less than 380 mm