Kootenay Lake Advisory Team

October 26-27, 2022

Nelson, B.C.

Kootenay Lake First Nations Acknowledgement

- Territory of the Ktunaxa Nation and people as well as the Salishan speaking peoples
- Salishan refers to the language grouping that includes Okanagan (Syilx), Sinixt and Secwepemc

Thank you to Funders and Contributors

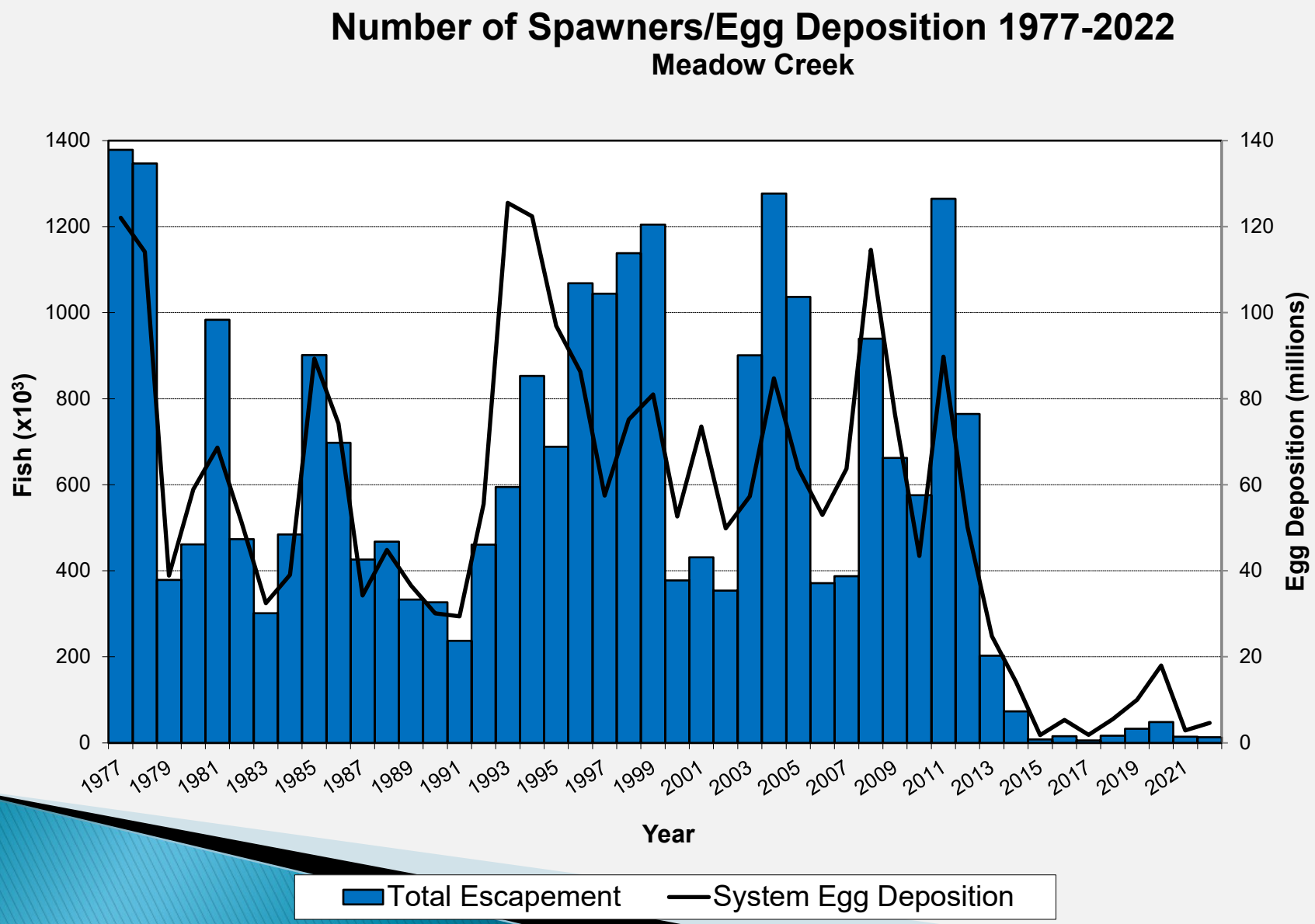
- Acknowledgments for funding – Nutrient program funding (including monitoring; FWCP, KTOI, BC Hydro, ENV, FLNR) Action plan implementation and enhanced monitoring (FFSBC, FLNR, FWCP, and HCTF)

- Acknowledgments for contributors – too many to list…truly a collaborative, multi-faceted effort to recover Kootenay Lake. We thank all Advisory Team members, research technicians, FFSBC staff, nutrient program delivery team, external contractors delivering monitoring components…

Outline

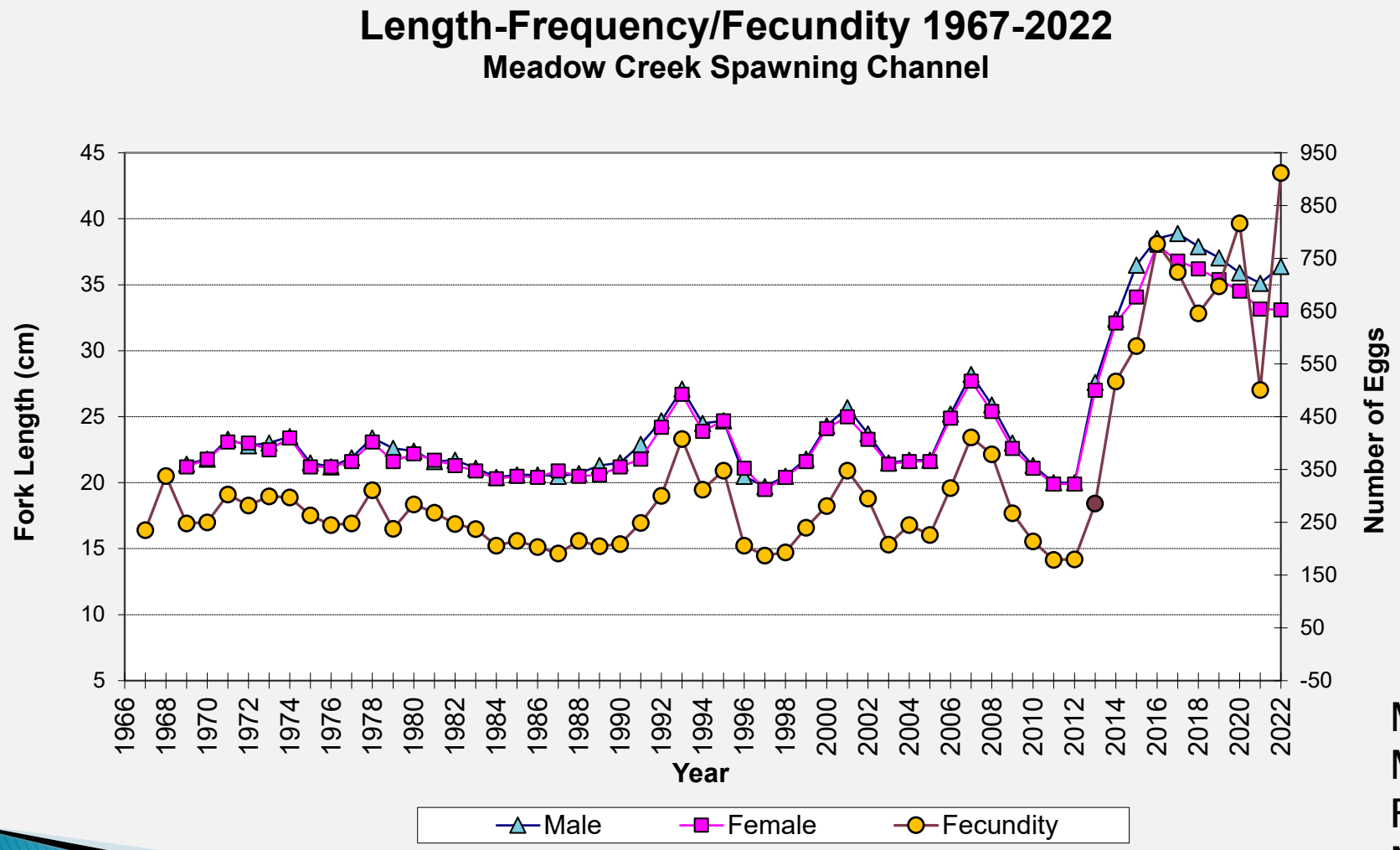
- Biological Response Update
- Review Actions, Triggers, and Implementation update from 2022 (what did we do?)
- Provide some analysis/ideas to help inform discussions around Key Questions.

Meadow Creek 2022



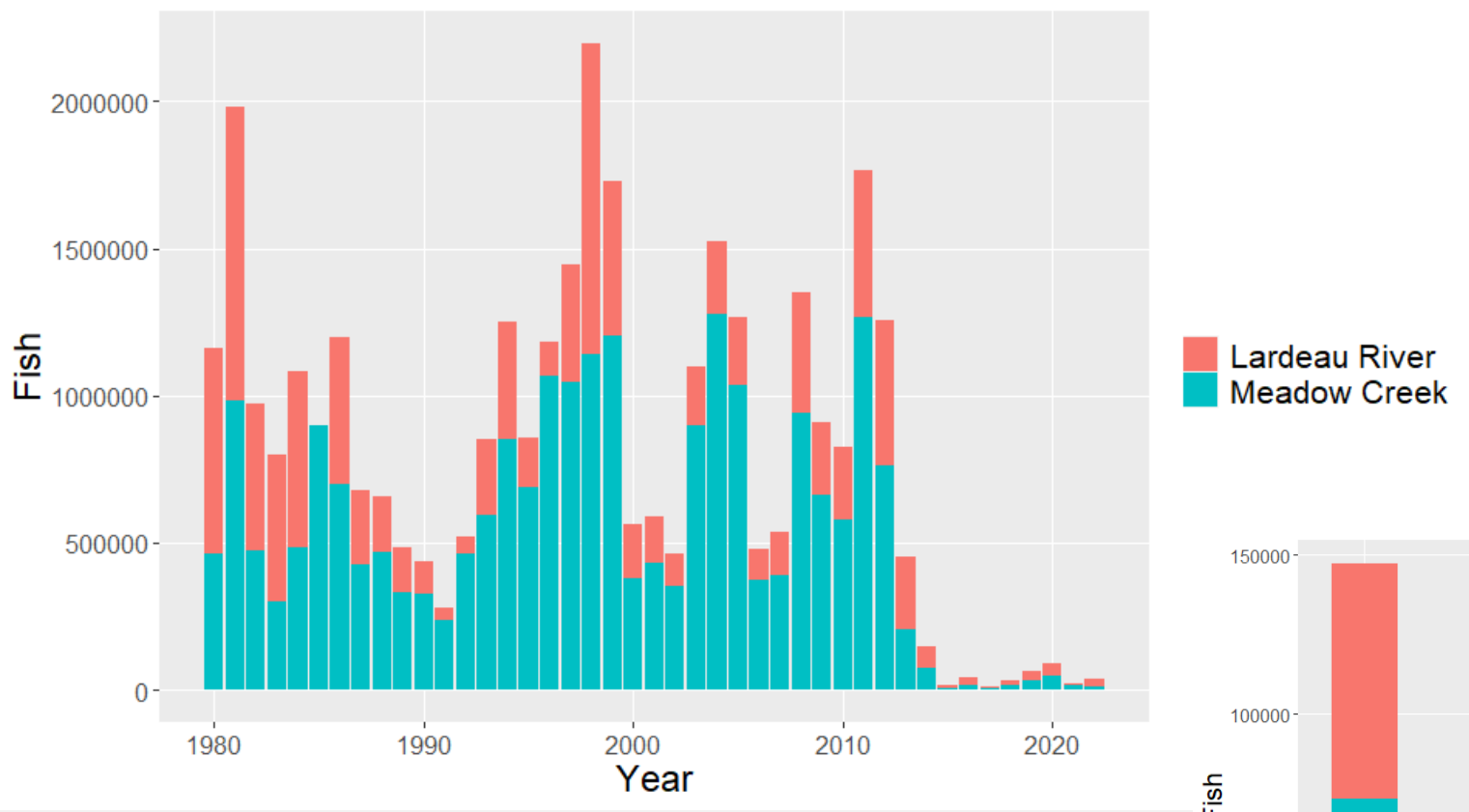
Preliminary age results show age 3+ spawners (BCPAL)

Meadow Creek – Spawner Data

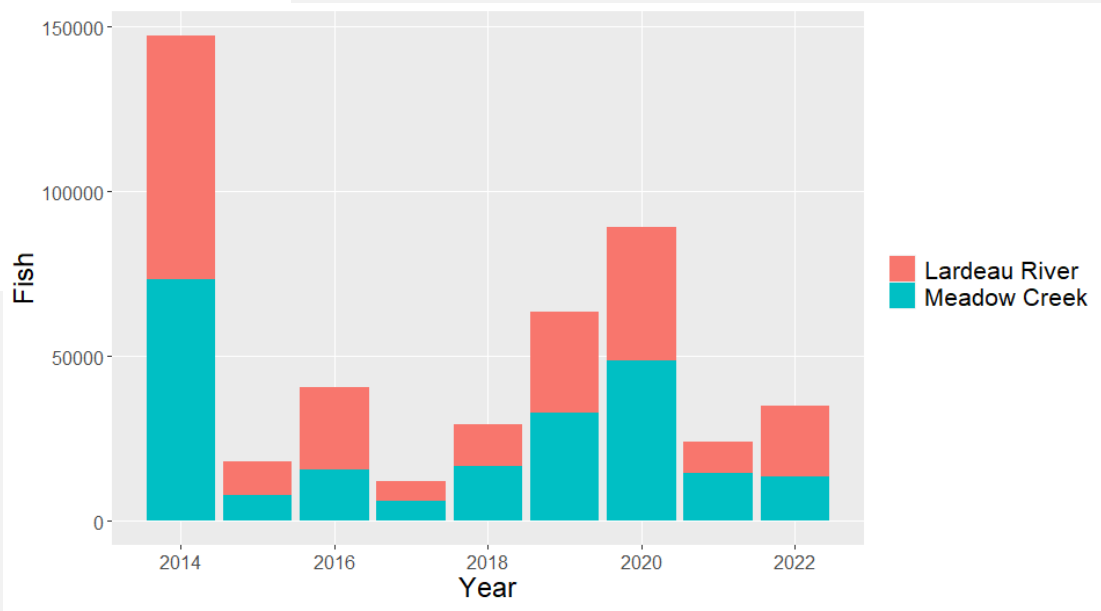


Mean size of spawners:
Male = 36 cm
Female = 33 cm
Mean fecundity
(eggs/female) = 912 eggs

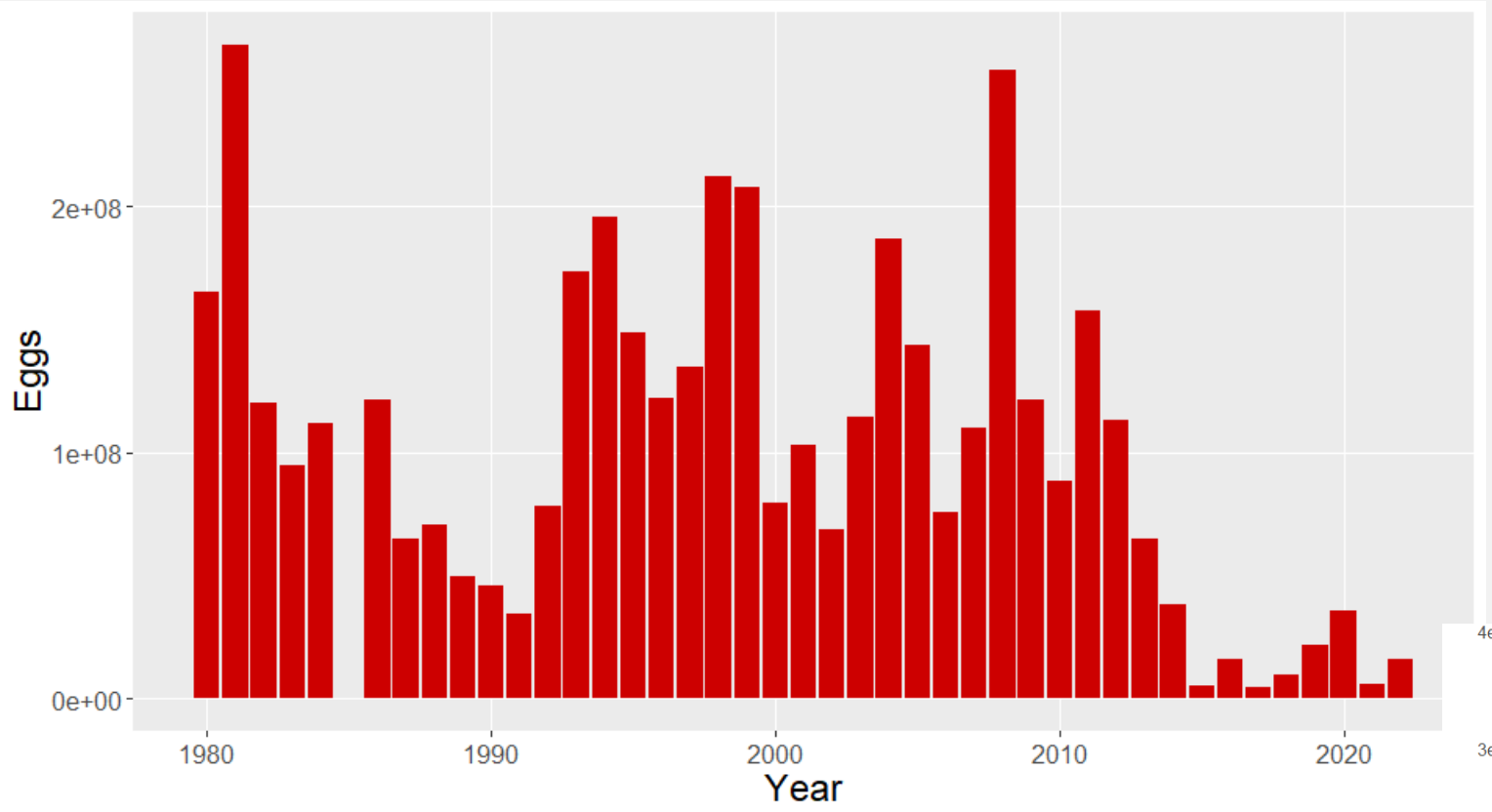
North Arm Escapement



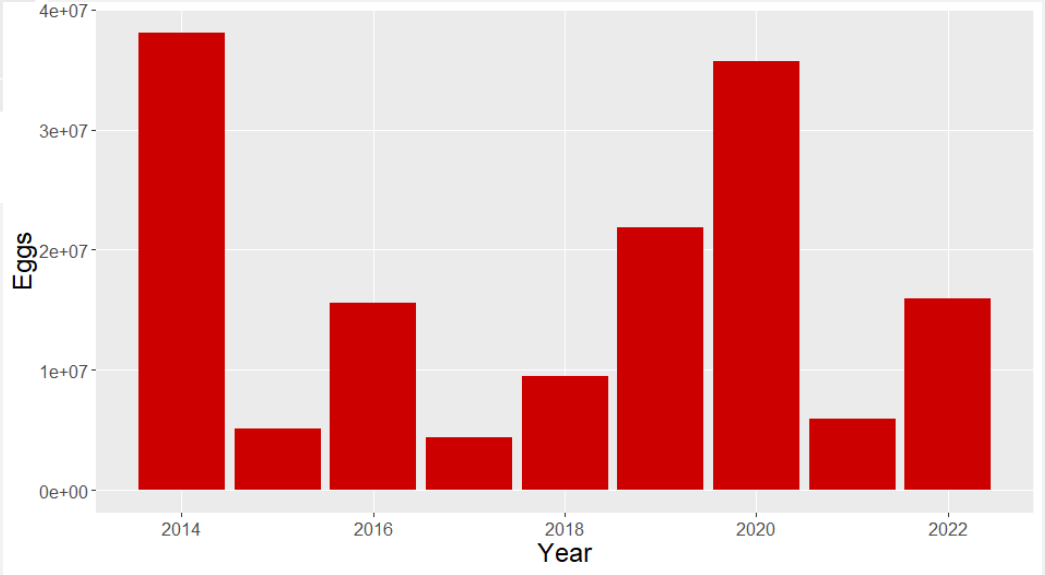
~35K Spawners to North Arm
62% to Duncan/Lardeau



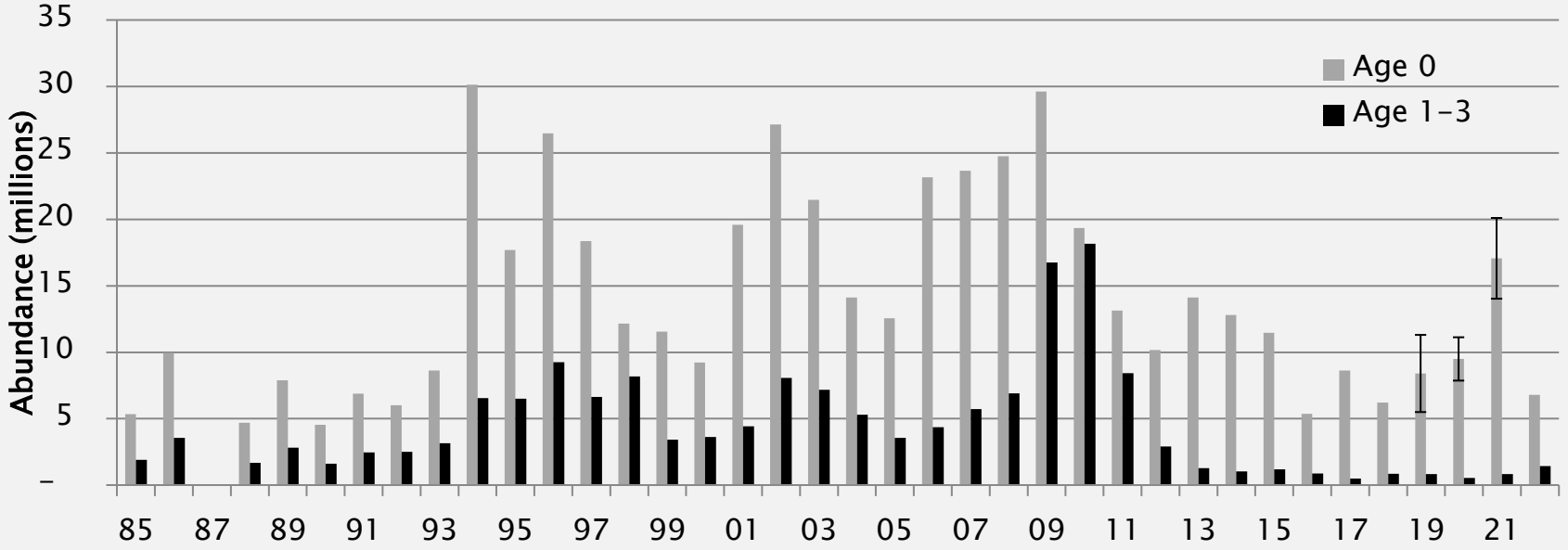
North Arm Egg Deposition

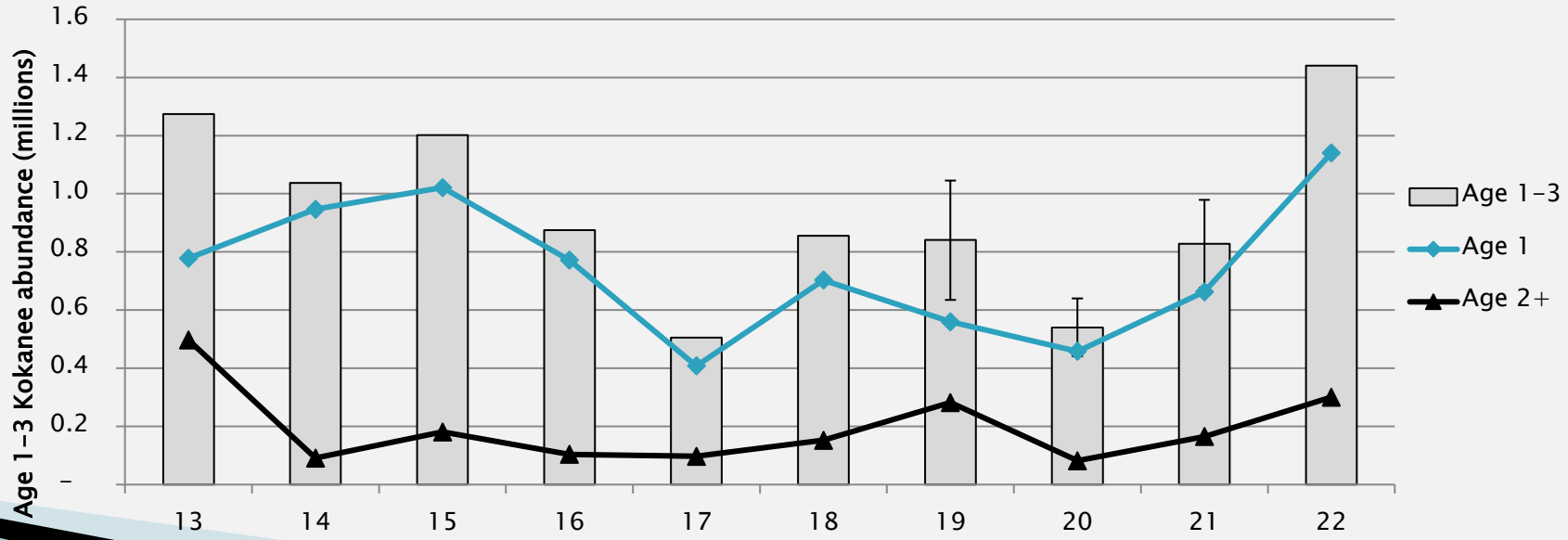


2022 North Arm estimate egg deposition ~ 16 million eggs
*using MCSC fecundity and 1:1 sex ratio



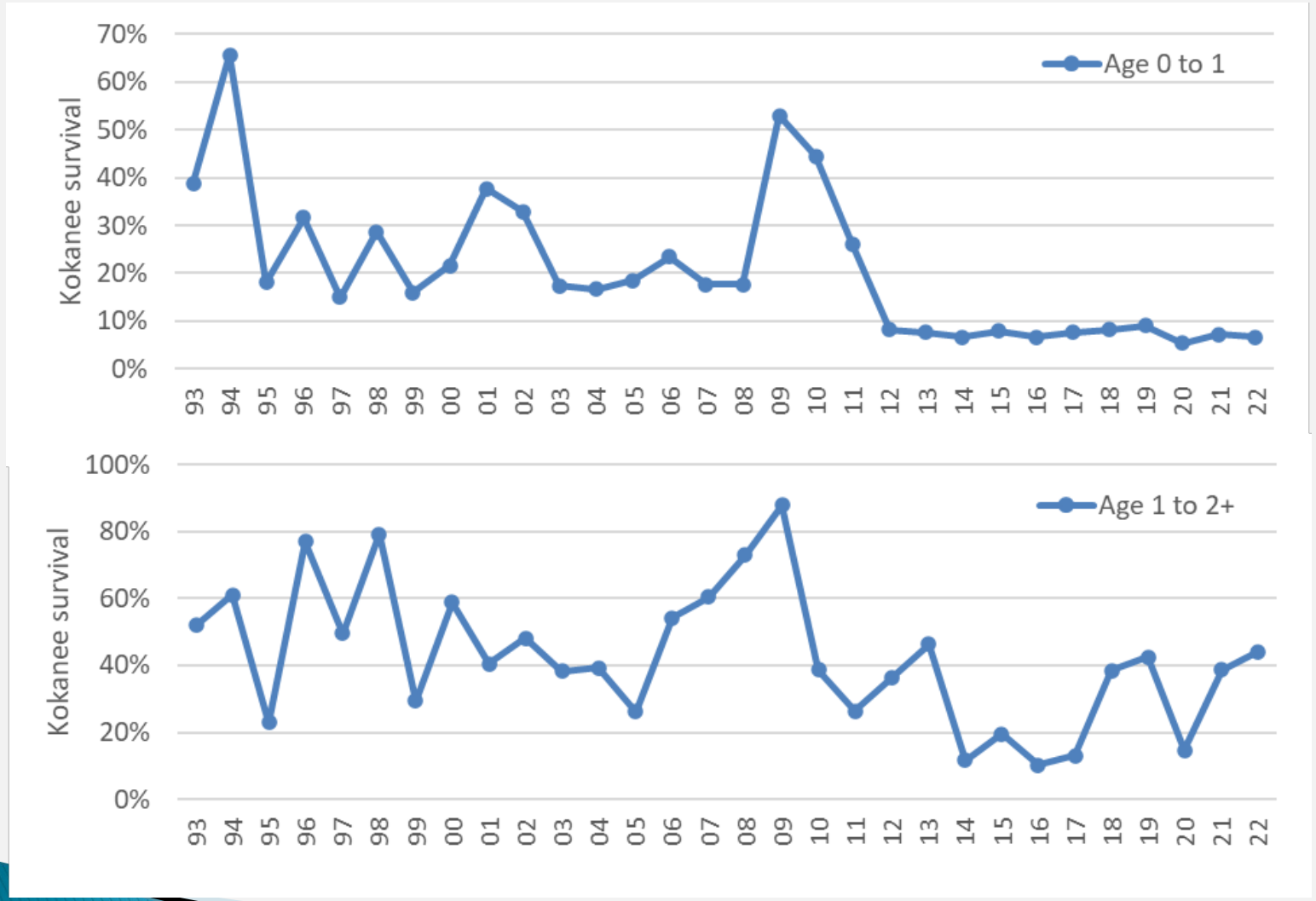
In-lake Kokanee abundance





2022 data are preliminary.

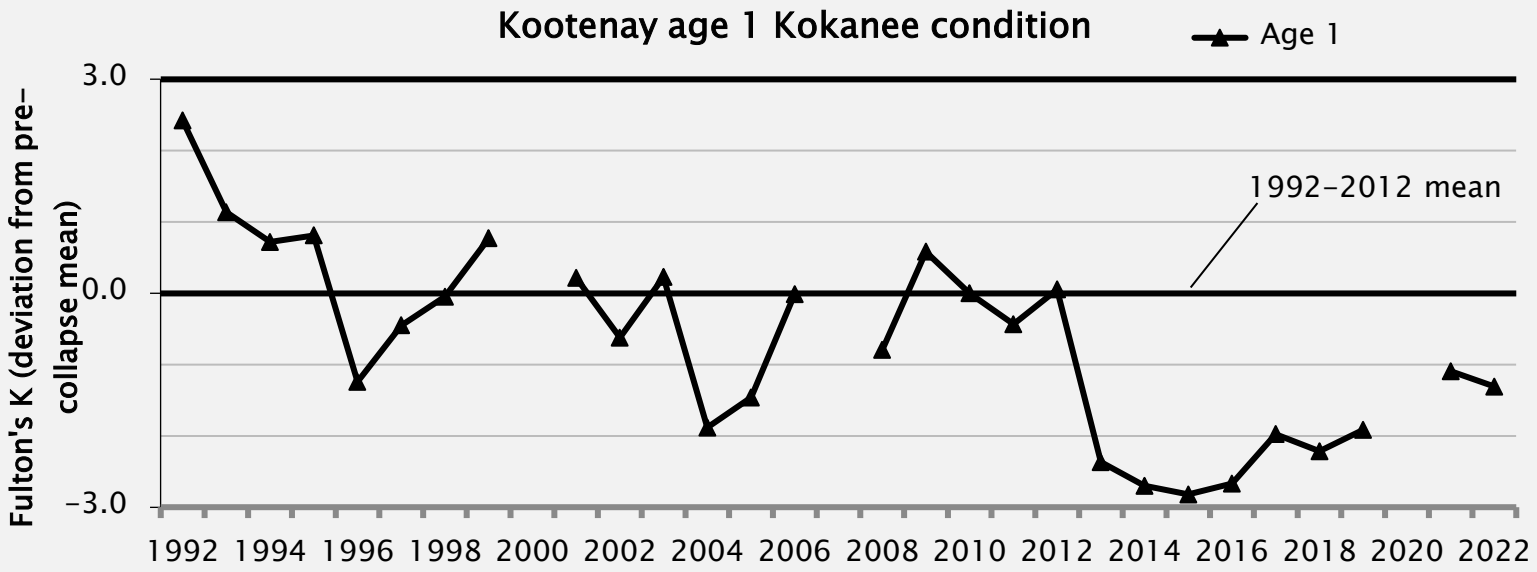
Kokanee cohort survival (September acoustic surveys)

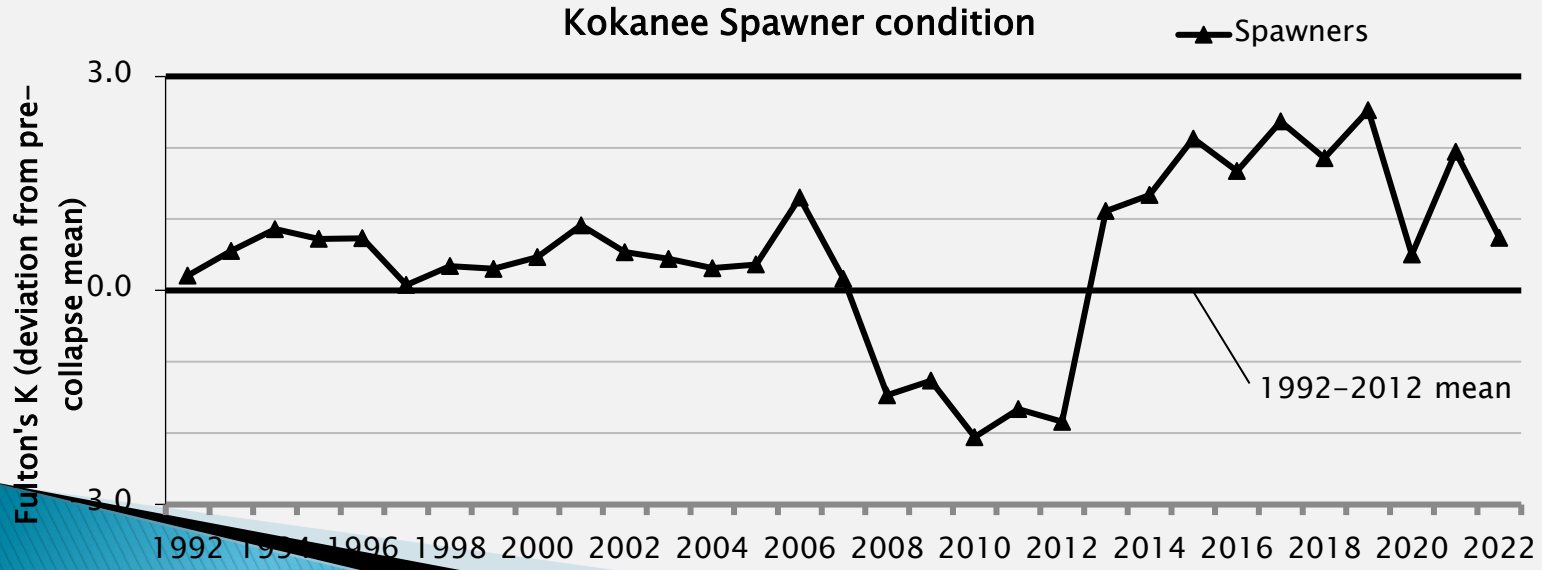


- Egg to fall fry survival has been excellent through post-collapse period.
- Age 0-1 was 7% in 2022 (Fall 2021 to fall 2022).
- Age 1-2 survival was 44% in 2022.

2022 data are preliminary.

Kokanee fall condition

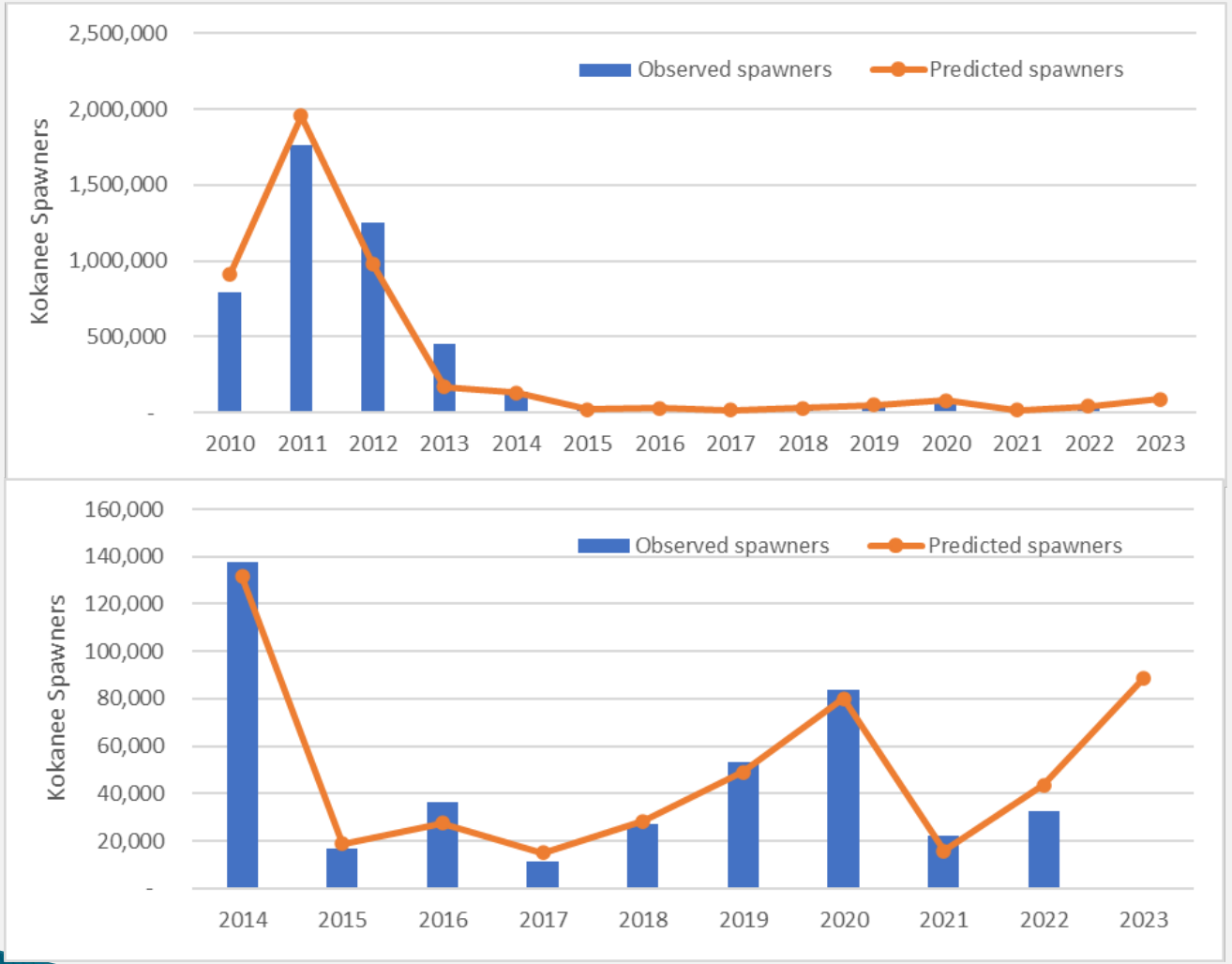




2022 data are preliminary.

- Despite abundant food, age 1 have been small with a low condition factor during the post-collapse period, although the trend appears to be improving.
- Spawner condition trend demonstrates the expected response to abundant zooplankton post-collapse..

Kokanee 2023 spawner forecast

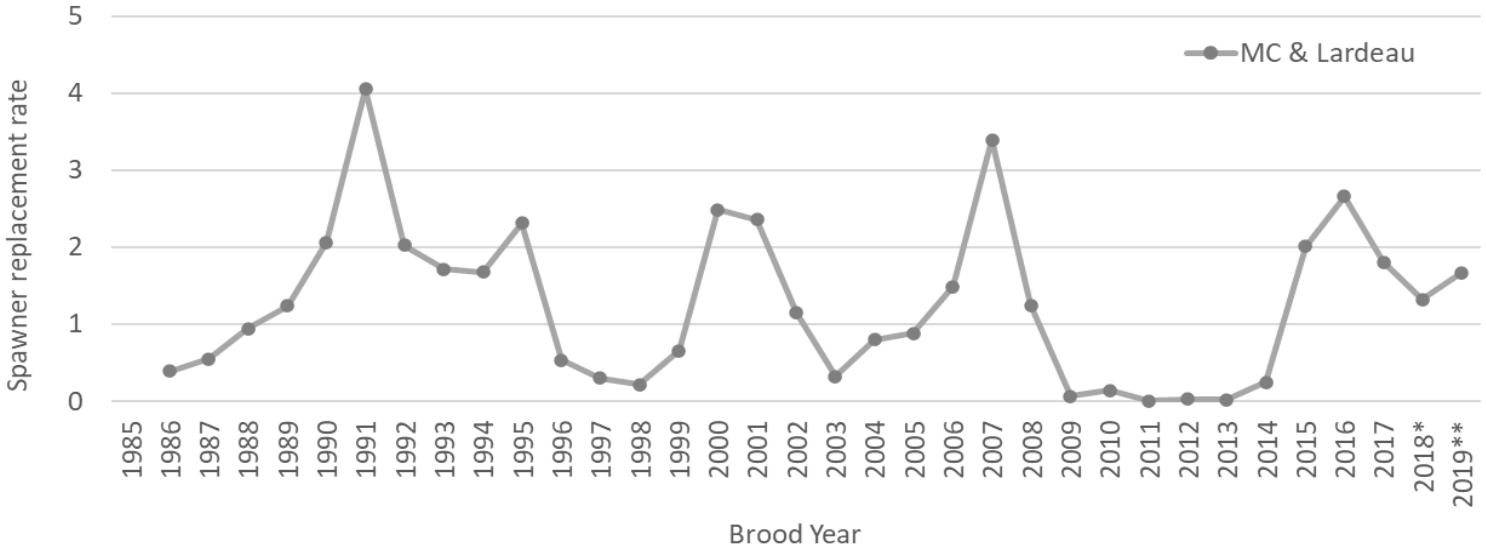


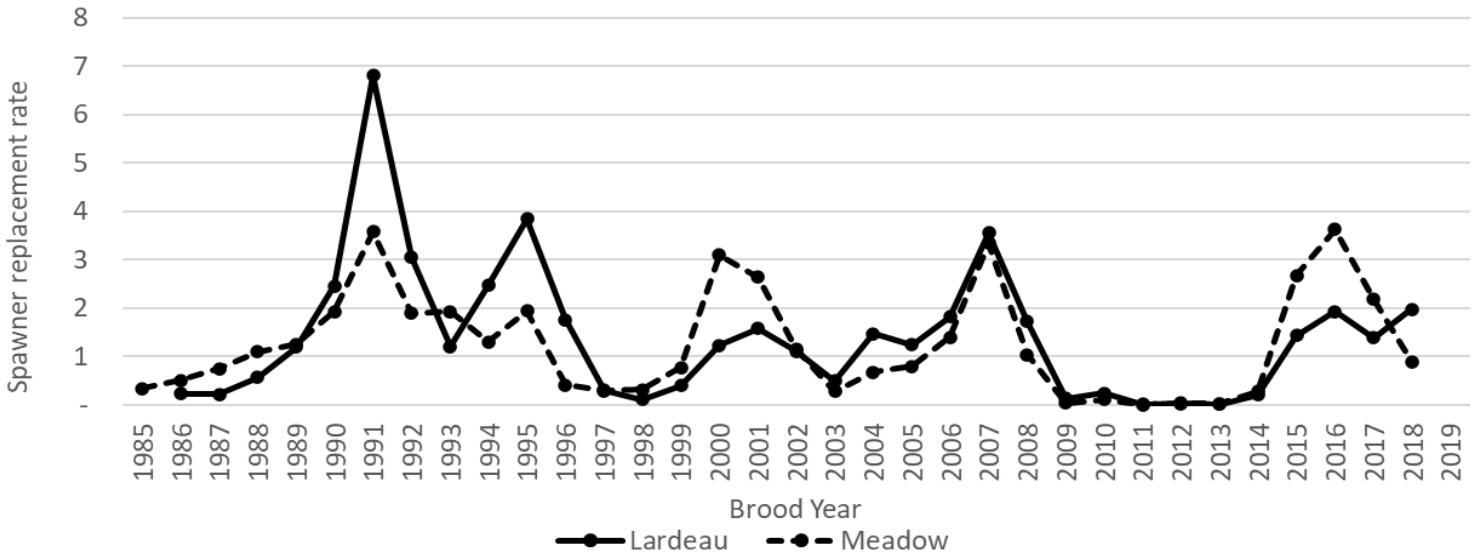
Sp yr	Acoustic # (yr prior)	Spawners*		Pred/Obs
		Observed	Predicted	
2010	1,817,987	794,054	914,861	115%
2011	3,273,665	1,764,100	1,958,045	111%
2012	1,920,997	1,255,843	982,475	78%
2013	491,807	453,592	168,577	37%
2014	406,284	137,772	131,664	96%
2015	90,751	16,617	18,936	114%
2016	121,052	36,462	27,489	75%
2017	76,242	11,090	15,115	136%
2018	123,738	27,198	28,281	104%
2019	189,415	53,117	49,059	92%
2020	276,838	83,787	80,155	96%
2021	78,971	22,044	15,819	72%
2022	172,876	32,670	43,589	133%
2023	**300,000**		**88,935**	**Average - 102%**
				SD - 21%

***Meadow Creek escapement + Lardeau spawner peak count (unexpanded raw count)**

2022 data are preliminary.

Kokanee spawner replacement





Does not account for egg plants (or fry stocking) which began in Meadow Creek for the 2015 BY.

Total spawner replacement remains >1 for 2018, and for 2019 based on predicted return.

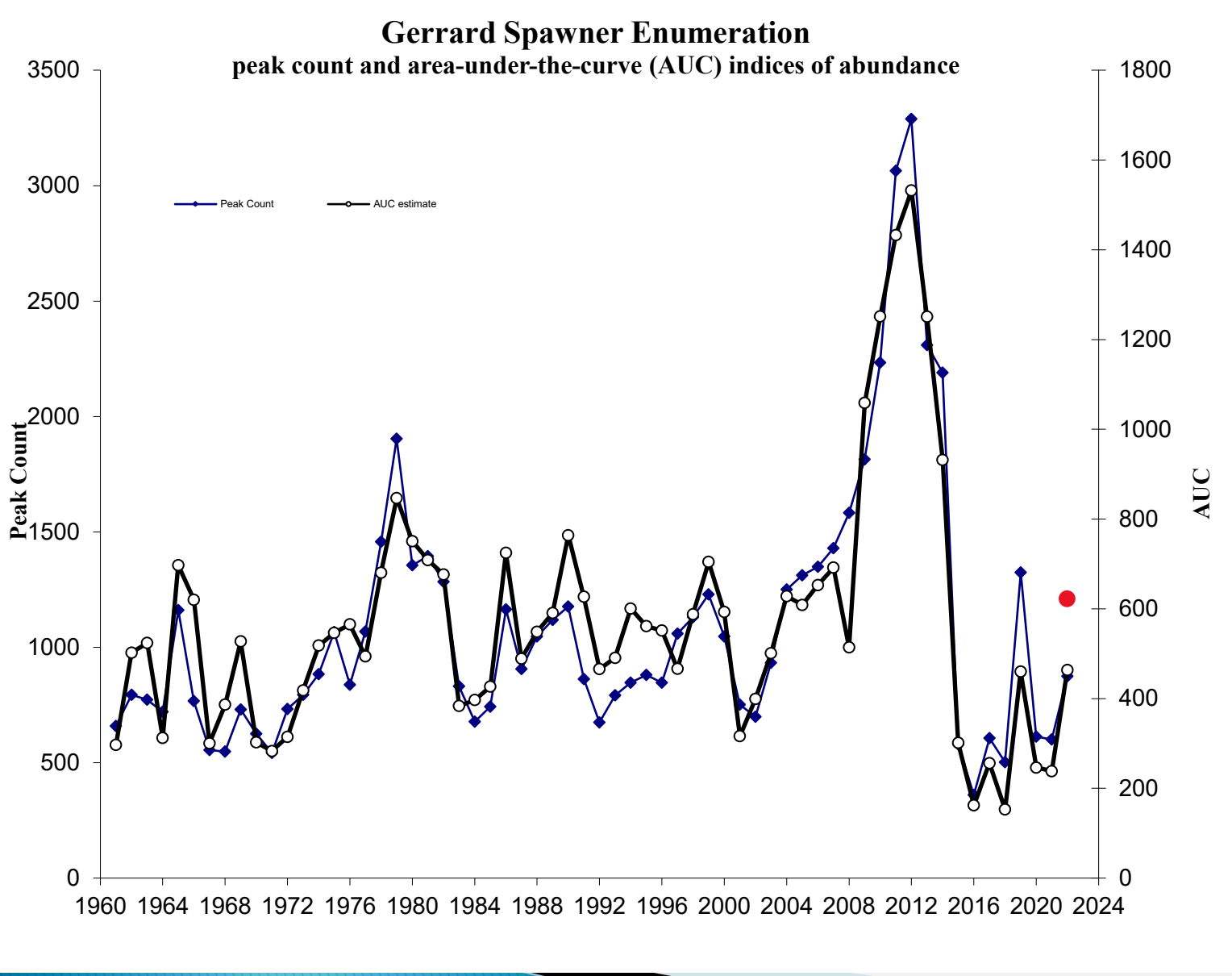
Meadow replacement rate better than Lardeau for 2015-2017 BY's suggesting egg plants/fry stocking played a role improving Meadow returns. Surprisingly, the trend has shifted for 2018 BY and Meadow R/S <1 (both will increase slightly if there are any 2023 age 4 spawners).

No 2019 estimates by tributary – can not predict tributary specific estimates.

*2018 BY estimates do not include 2023 age 4 component

**2019 BY estimate based on 2023 spawner forecast and 2022 spawner age structure (100% age 3).

Gerrard Spawner Abundance



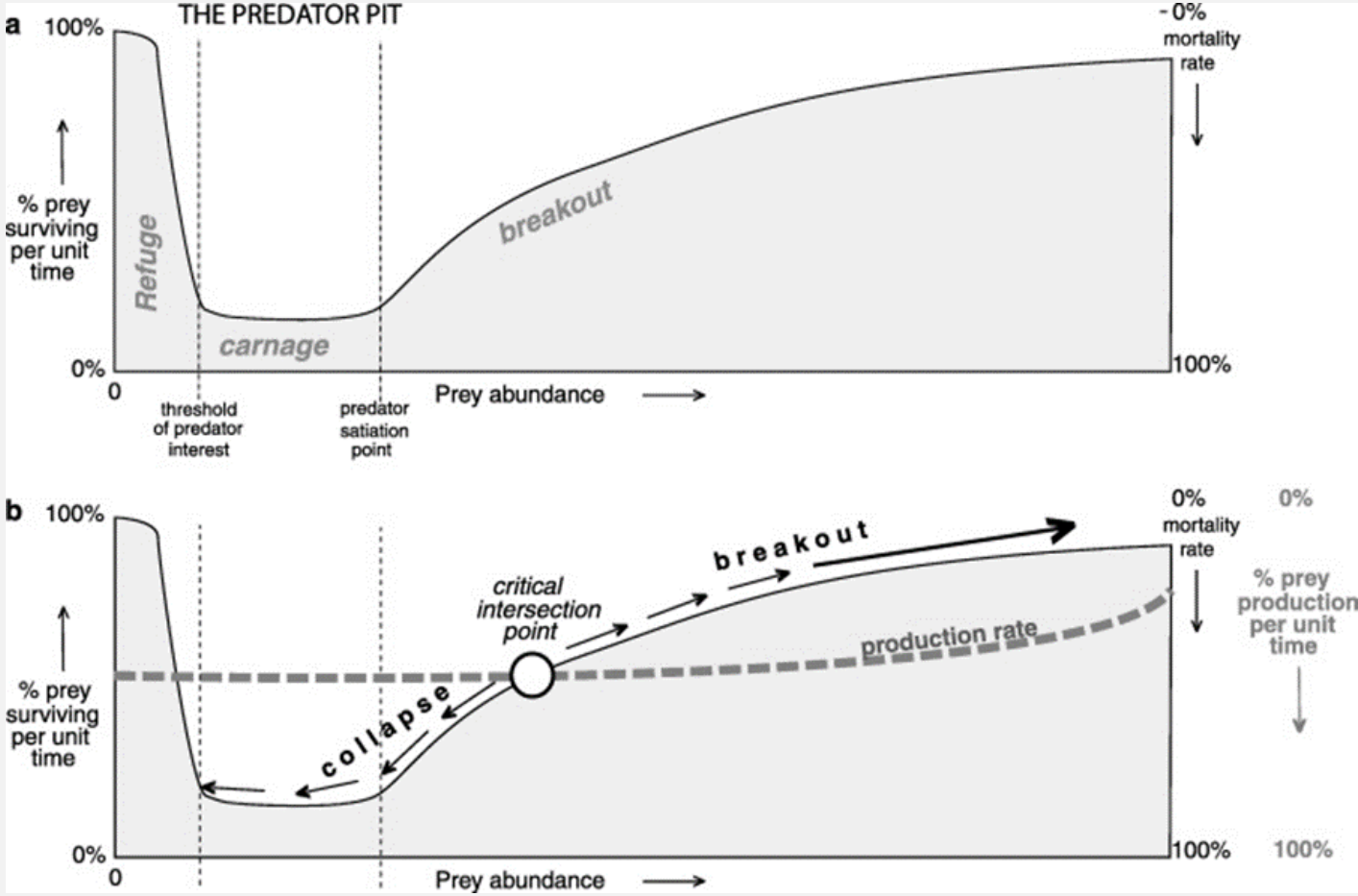
Gerrard Spawner Bio Data					
Year	Mean FL (cm)	mean Wt (Kg)	Mean Age	Sample Size	Collection Method
1949 -59	67		5.3	54	Hatchery (seine?)
1979	83			11	Hatchery (seine?)
1980	83			8	Hatchery (seine?)
1981	79	5.8		10	Hatchery (seine?)
1982	83	7.2		21	Hatchery (seine?)
1991	83	7.4		15	Hatchery (seine?)
1992	78	7.1		23	Hatchery (seine?)
1994	75	6.8	6.0	17	Hatchery (seine?)
1998	81	7.3	6.4	18	Hatchery (seine?)
2004	72	7.1		25	Angling
2005	77	4.4		25	Tangle Net/Angling
2006	83	6.9		37	Tangle Net/Angling
2010	73	4.5		59	Hatchery (seine)
2014	78			20	Angling
2016	58	1.9	5.8	24	Angling
2017	53	1.4	5.9	20	Angling
2018	54	1.7	4.9	20	Angling
2019	63	1.6	5.9	39	Angling
2020	54	1.3	5.9	27	Angling
2021	52	1.2	5.5	23	Angling
2022	53			34	Angling/Tanglenetting

- 2022 escapement – 464
- Spawner size similar to last two years
- Avg fecundity = 2750 (2022 samples)
- AUC=624 without spring removals

Kootenay Lake Predator Info

Greg Andrusak, RPBio

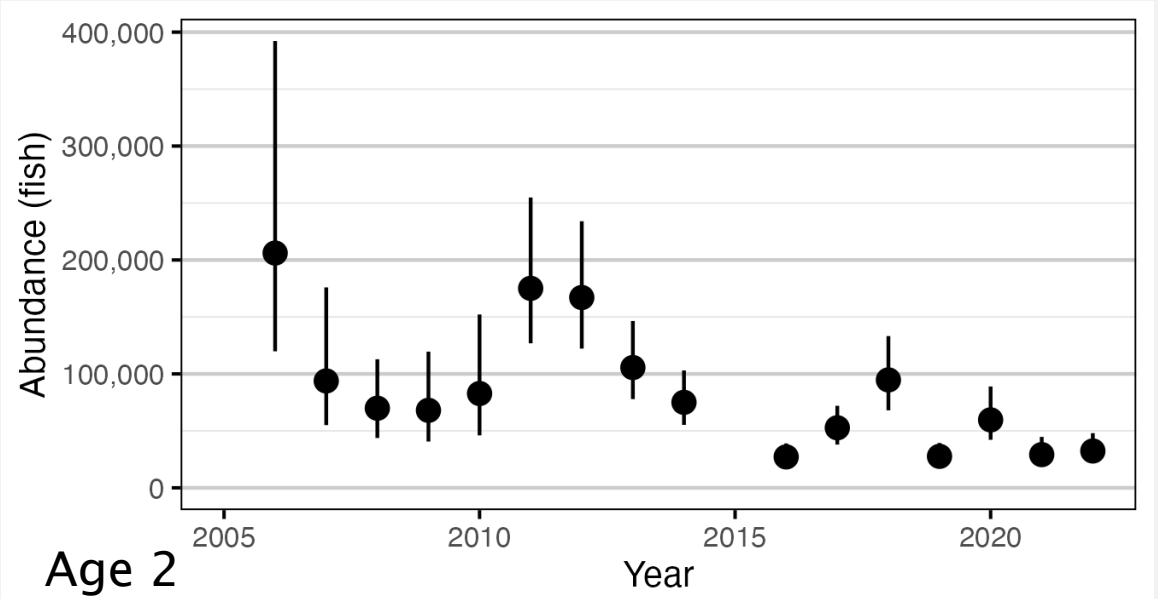
Provincial Rivers Management Biologist (MoF)



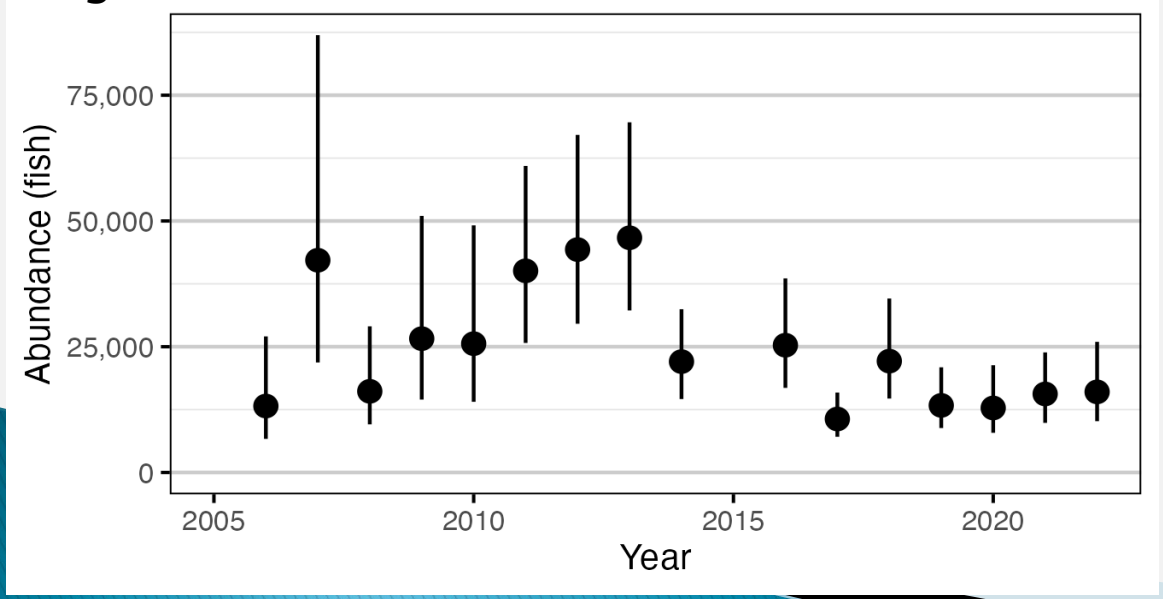
Weeks and Bakun 2006

Age 1&2 Recruits (abundance)

Age 1



Age 2



Age 1 (95% CRI)

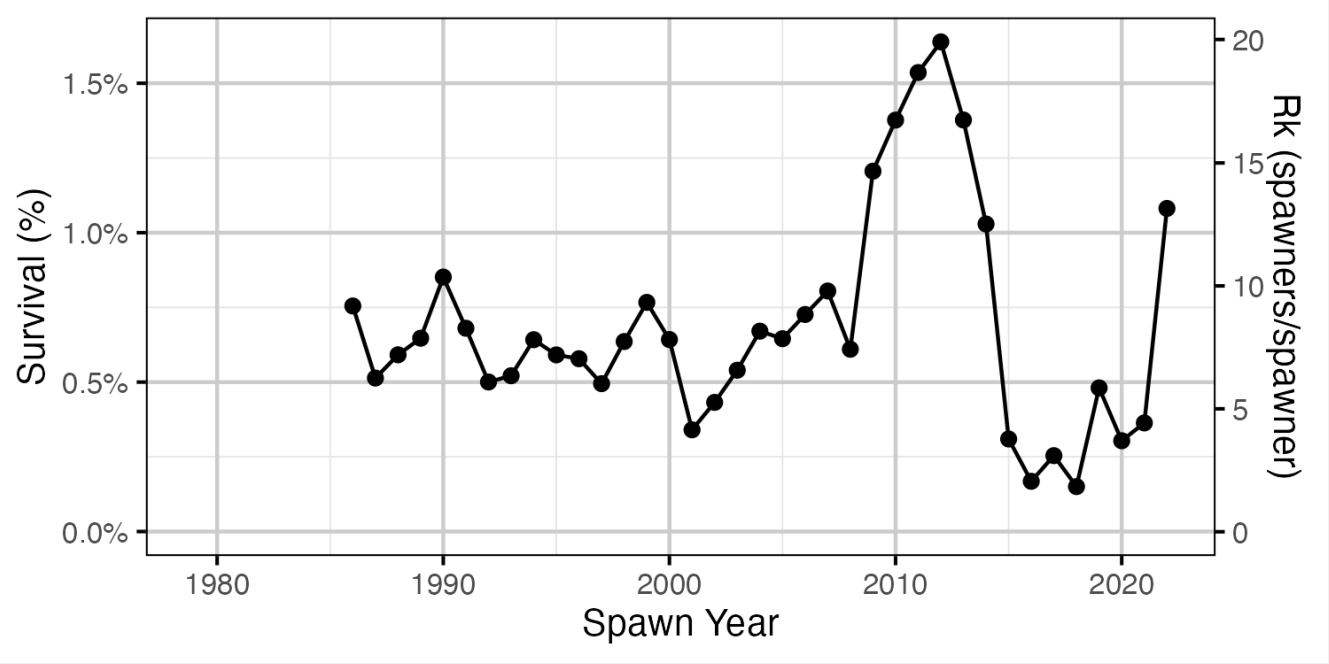
Year	estimate	lower	upper
2006	206,069	119,846	392,219
2007	93,814	55,058	175,912
2008	69,856	43,740	112,845
2009	68,008	40,634	119,517
2010	82,776	46,044	152,154
2011	175,081	126,873	254,833
2012	167,054	122,202	234,017
2013	105,558	77,886	146,454
2014	75,027	55,233	103,021
2016	27,128	19,075	38,967
2017	52,698	37,980	71,983
2018	94,706	68,037	133,190
2019	27,631	19,514	39,337
2020	59,628	42,157	88,942
2021	29,139	20,034	44,689
2022	32,330	21,804	47,967

Age 2 (95% CRI)

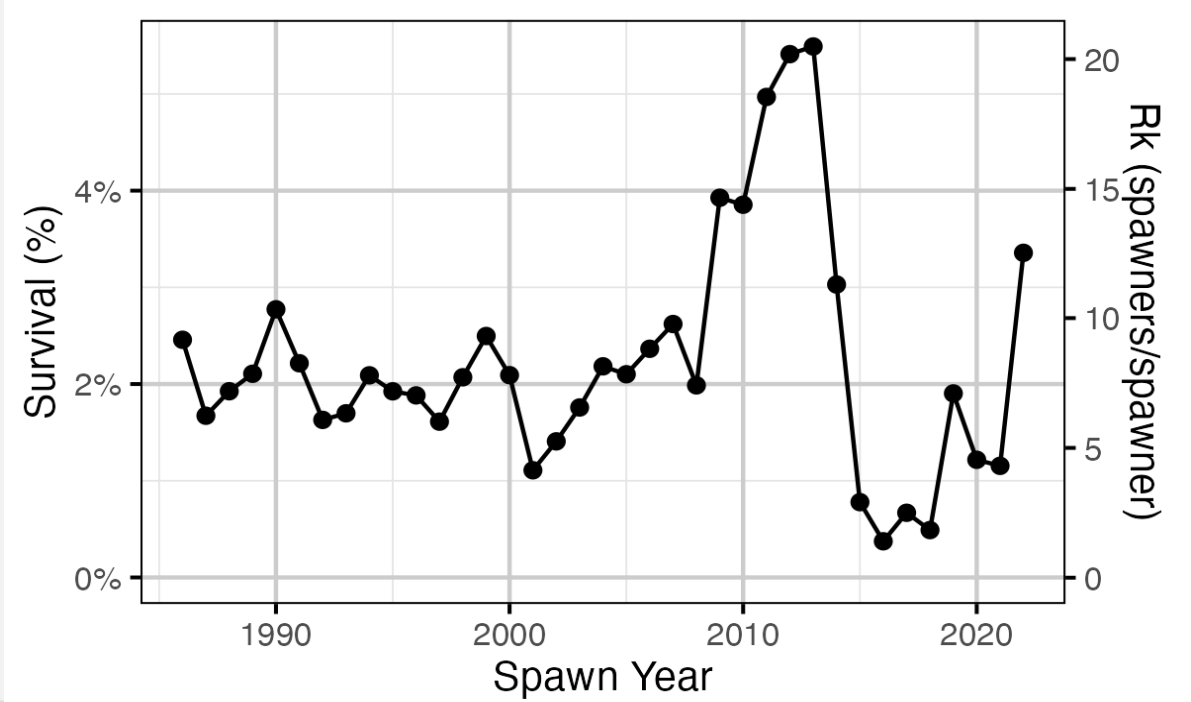
Year	estimate	lower	upper
2006	13,208	6,683	27,048
2007	42,192	21,869	86,940
2008	16,135	9,567	29,051
2009	26,604	14,494	51,007
2010	25,608	14,053	49,128
2011	40,087	25,750	60,941
2012	44,311	29,568	67,109
2013	46,662	32,213	69,613
2014	22,039	14,597	32,454
2016	25,299	16,820	38,584
2017	10,631	7,098	15,886
2018	22,138	14,695	34,581
2019	13,337	8,834	20,908
2020	12,824	7,887	21,319
2021	15,610	9,862	23,869
2022	16,024	10,198	25,970

Survival age 1 or age 2 to adult (in-lake)

Age 1

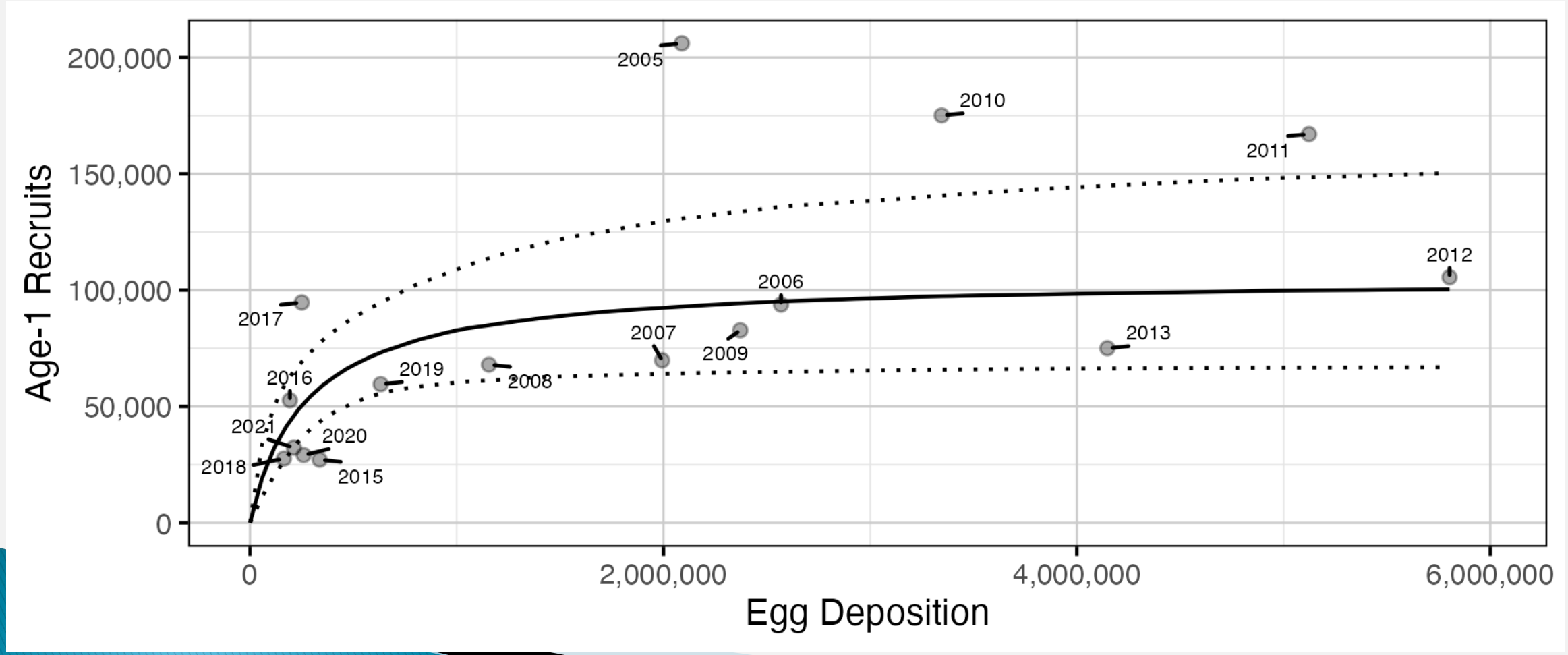


Age 2

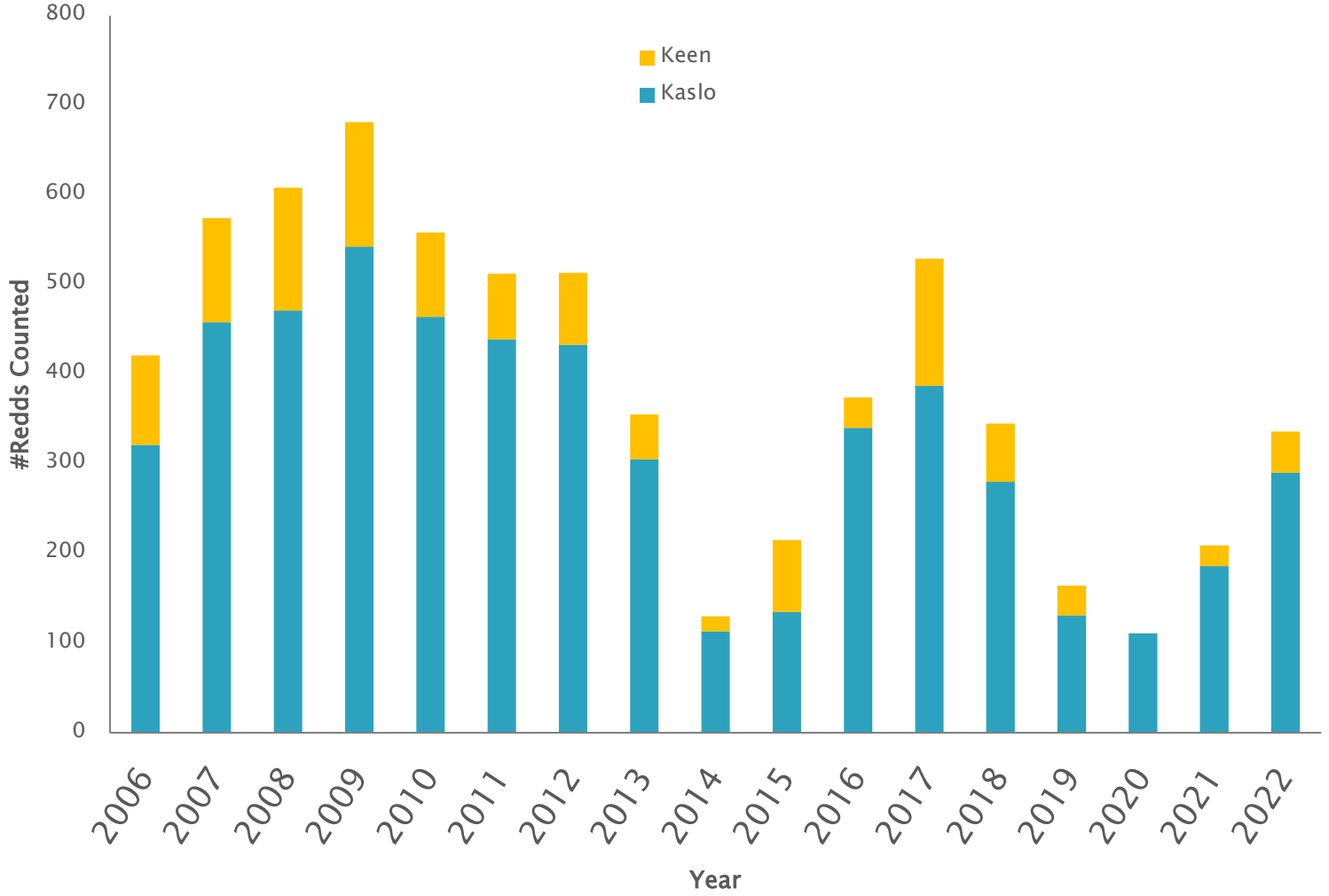


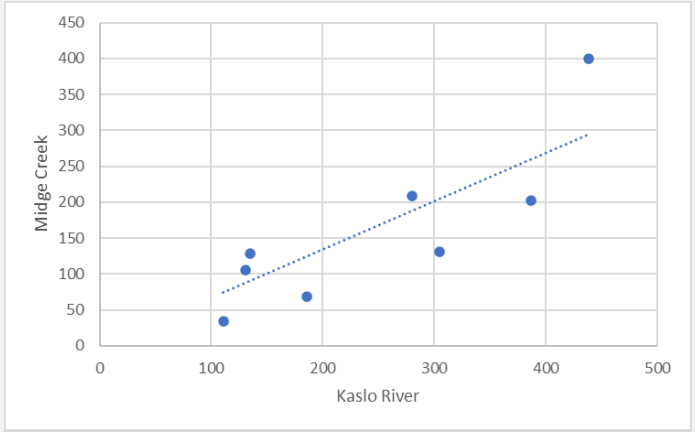
Gerrard Stock Recruitment

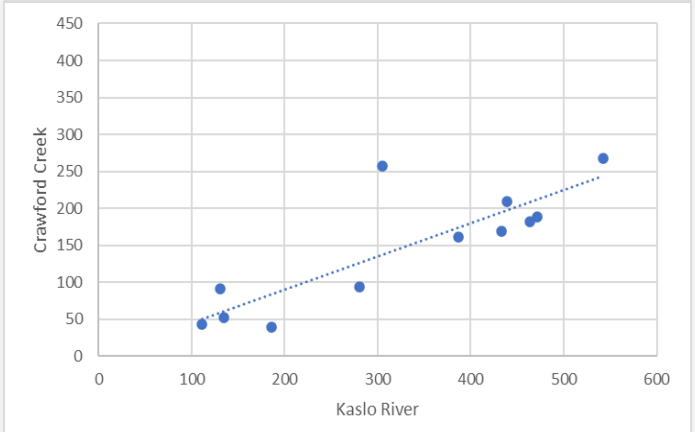
LRP=210,000 eggs (80% CRI 110,000-470,000) or 63 spawners (80% CRI 35-157)

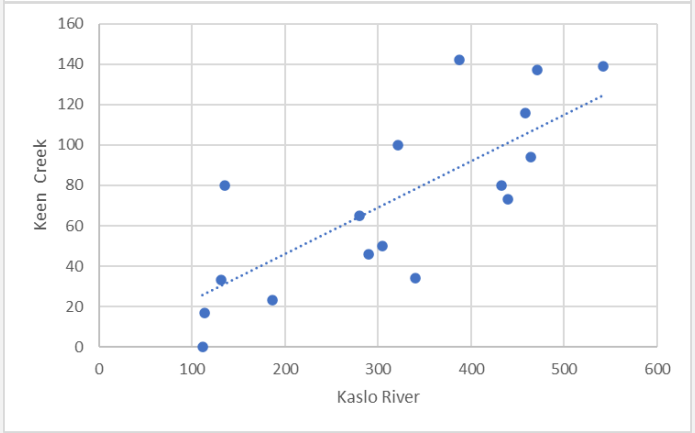


Kaslo River Redd Counts





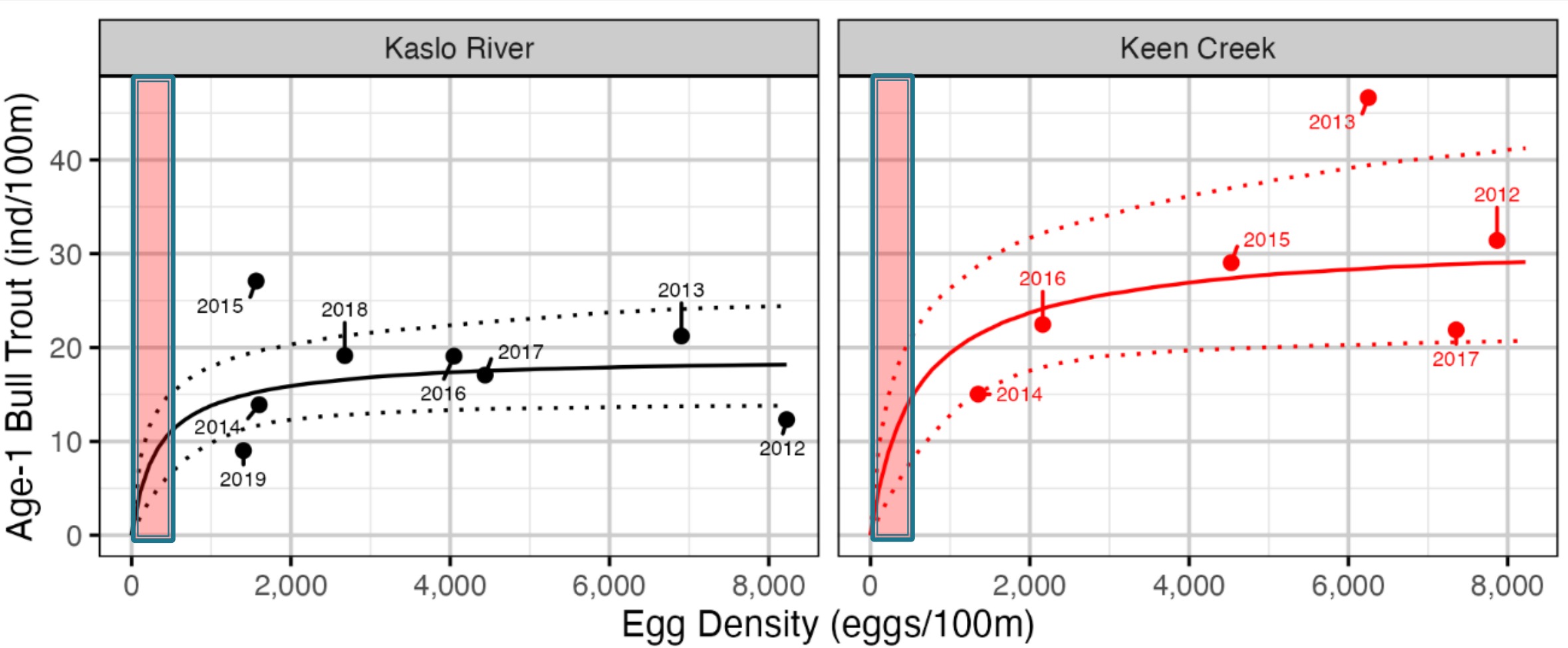




KASLO BULL TROUT STOCK RECRUITMENT

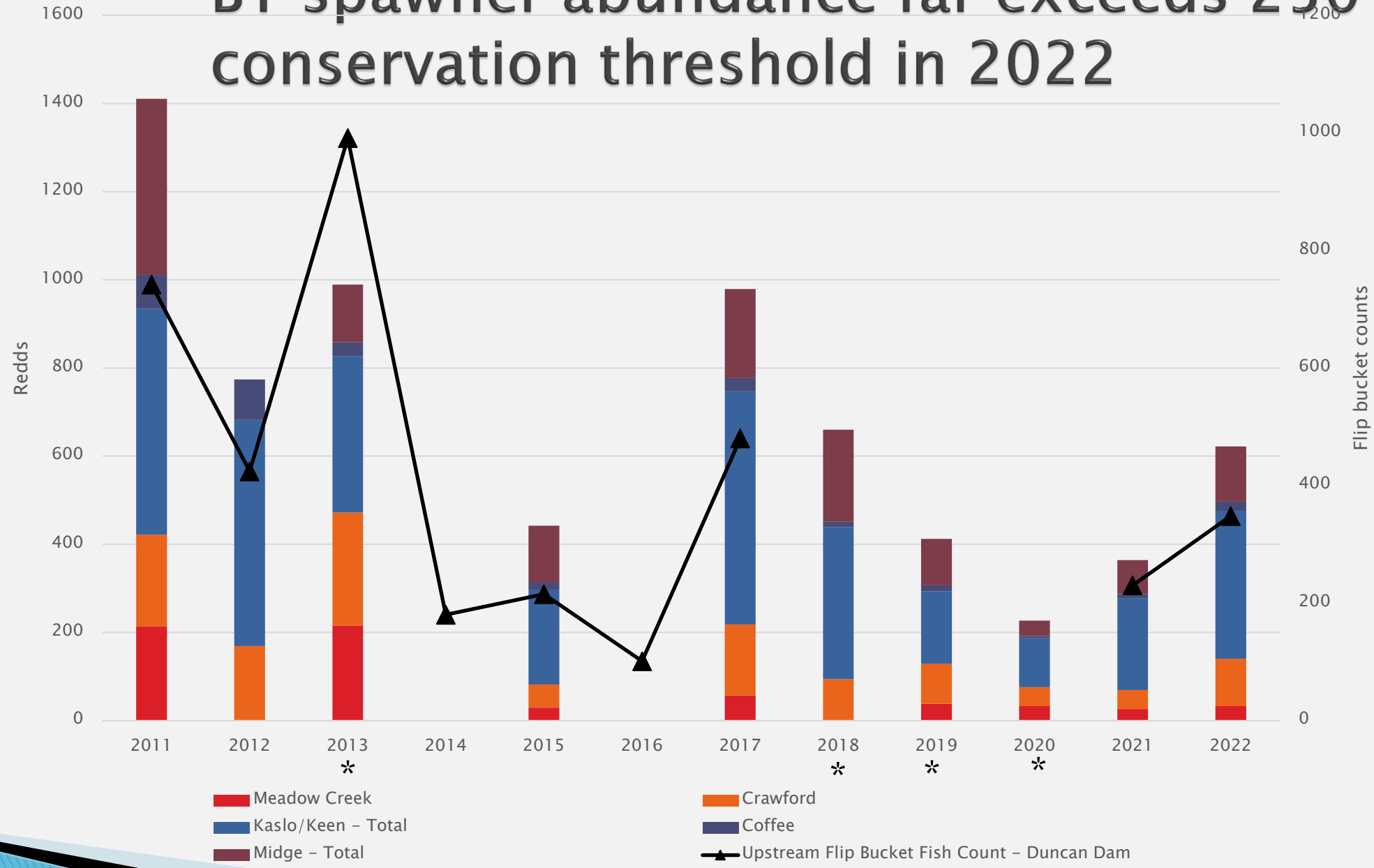
LRP=532 eggs/100m for Kaslo River

LRP= 326 eggs/100m in Keen Creek



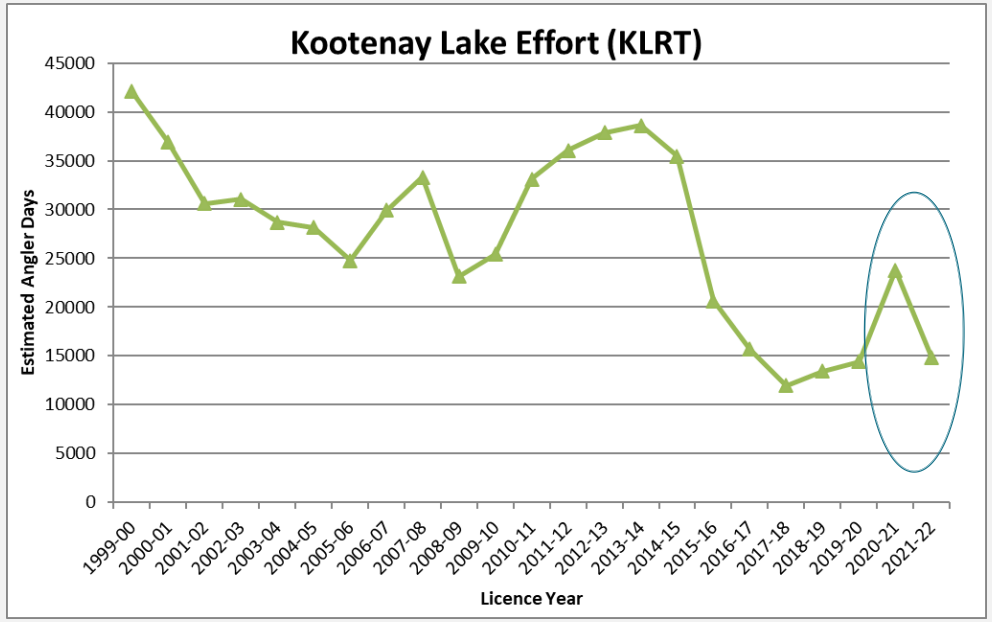
- LRP KASLO =25 REDDS OR 55 FISH
- LRP LAKE WIDE = 125 REDDS OR 250 FISH

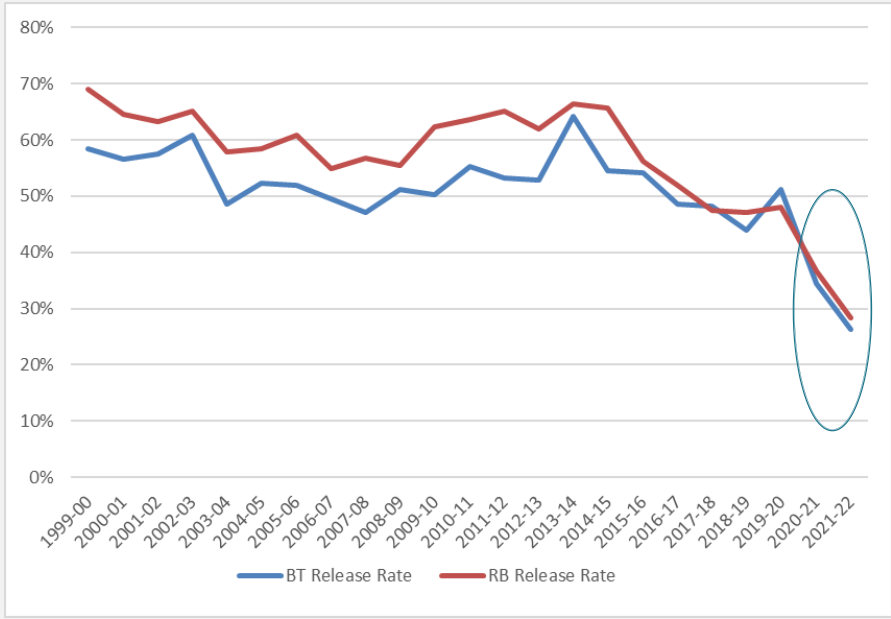
BT spawner abundance far exceeds 250 conservation threshold in 2022

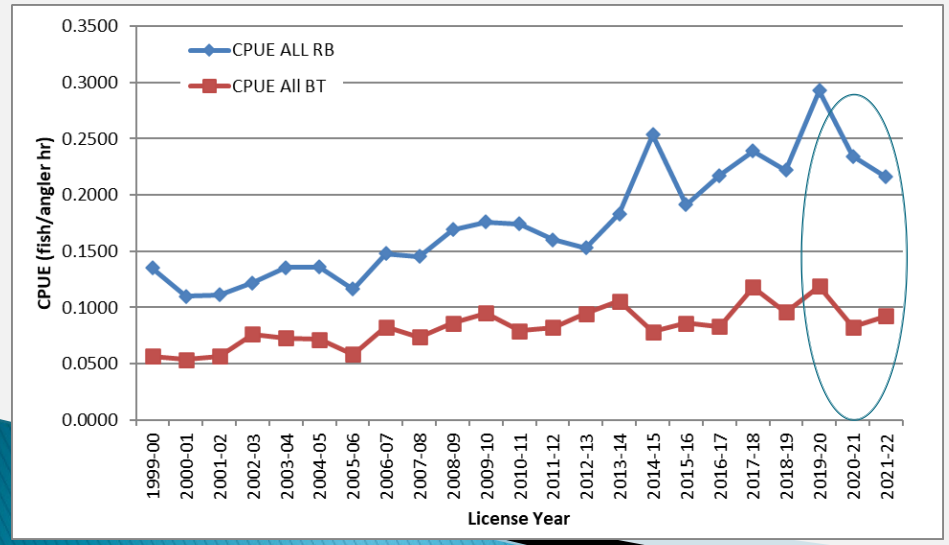


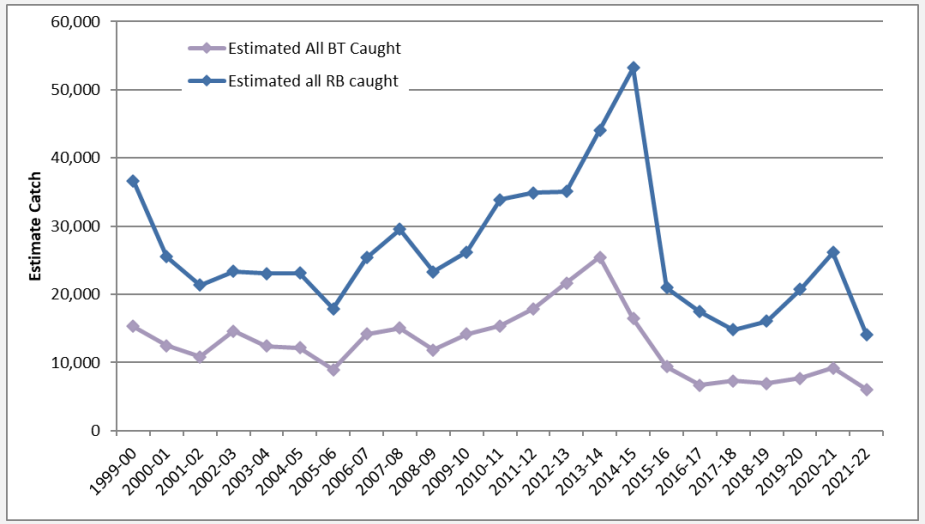
* Possible redd undercounts in some streams due to discharge spikes

Fishery Trends– KLRT Creel





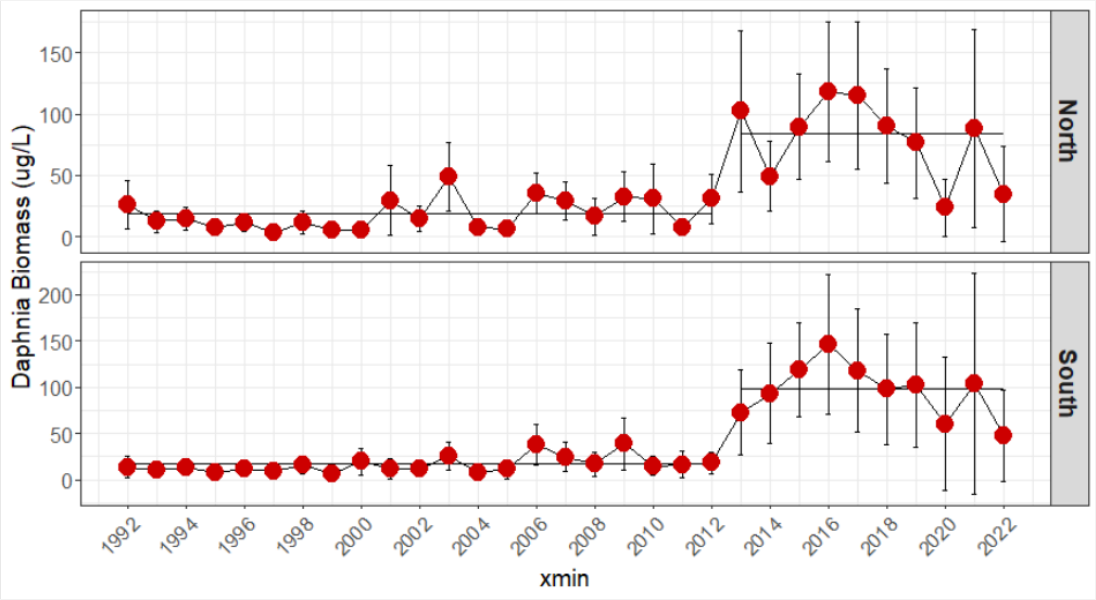




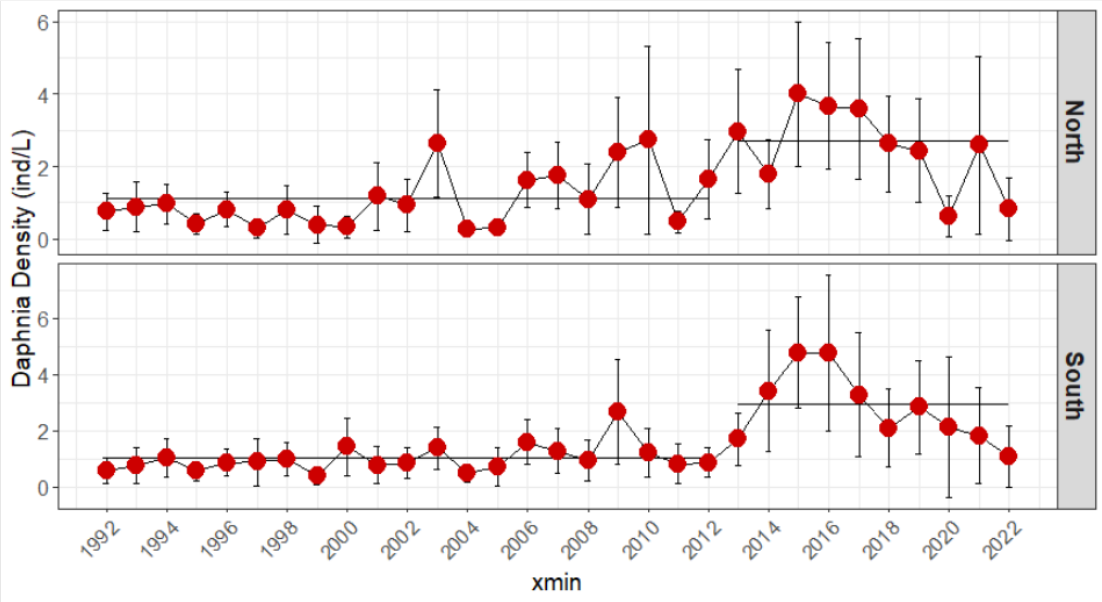
- 2021/22 effort decrease
- Divergence between RB and BT CPUE
- Decline in 2021–22 catch
- Notable declines in release rate
  - KLAIP launched in 2020

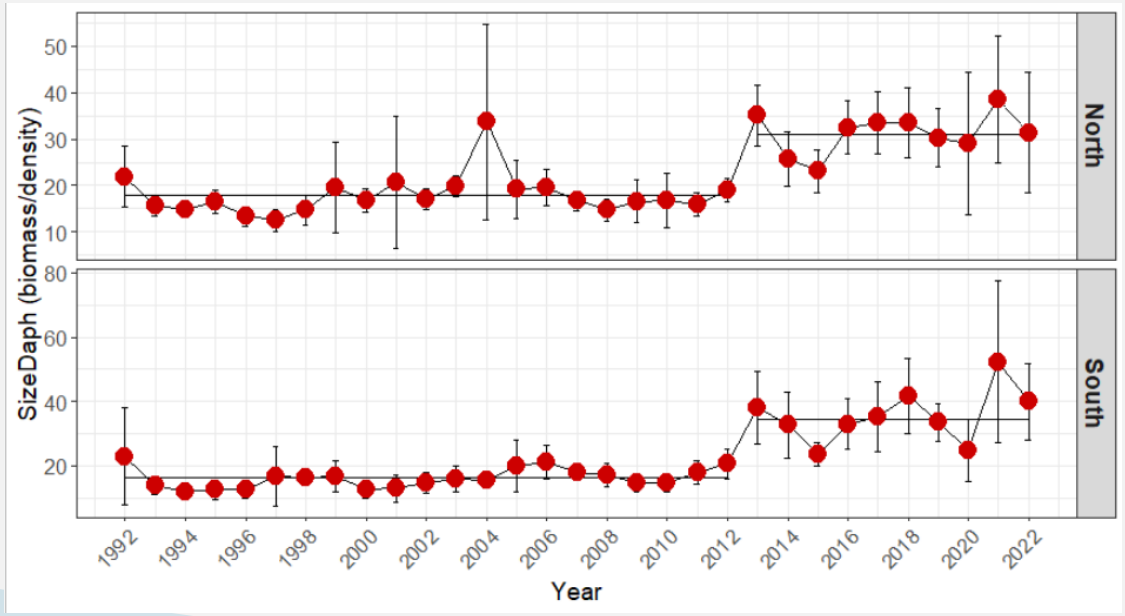
** Catch values could be inflated by ~50%–100%

NRP update – Daphnia Results

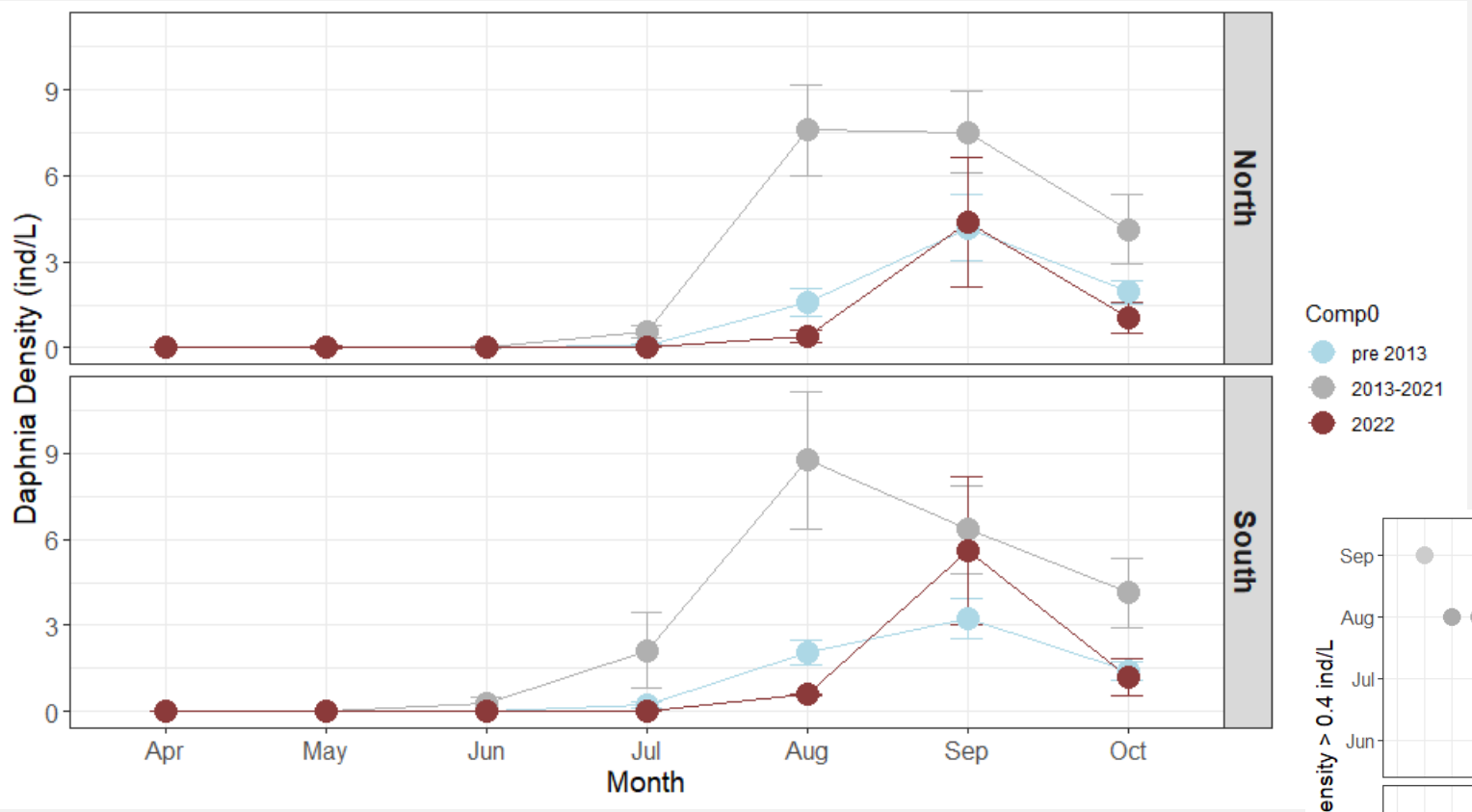


- Daphnia Biomass is higher in the KO collapse era, though low in 2020 and 2022 in the North Arm
- Daphnia Density higher than average in KO collapse era
  - Showing decreasing trend
- Size of individual Daphnia (biomass/density ratio) is above average in collapse era

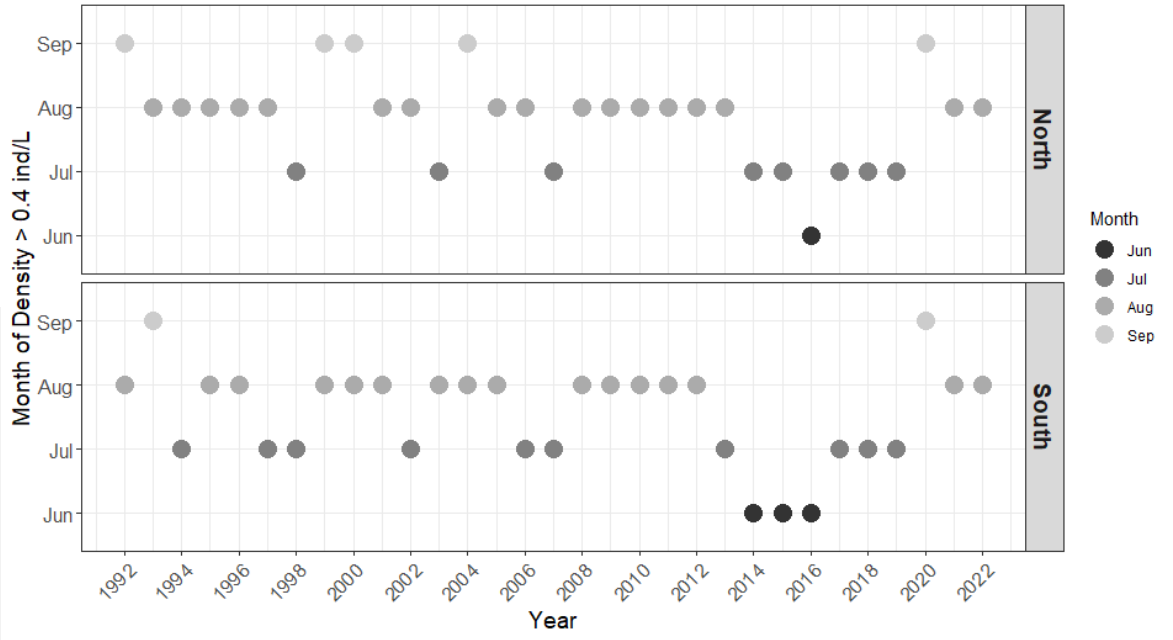




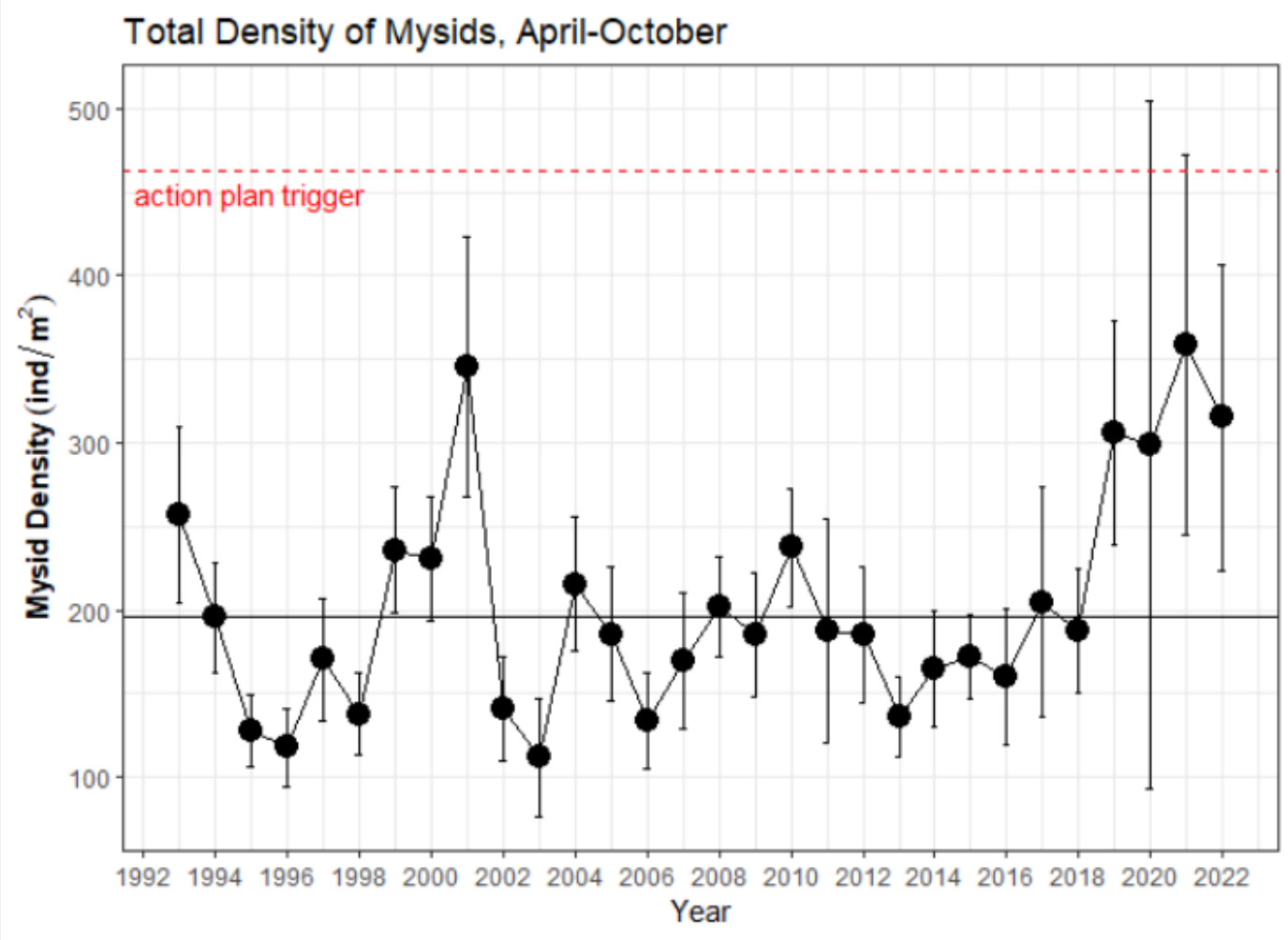
NRP update – 2022 Daphnia Results



- Daphnia Densities were low until September in 2022.
- Likely due to cooler spring
- Densities reached nerka consumption threshold in August, average for NRP, late for post KO collapse

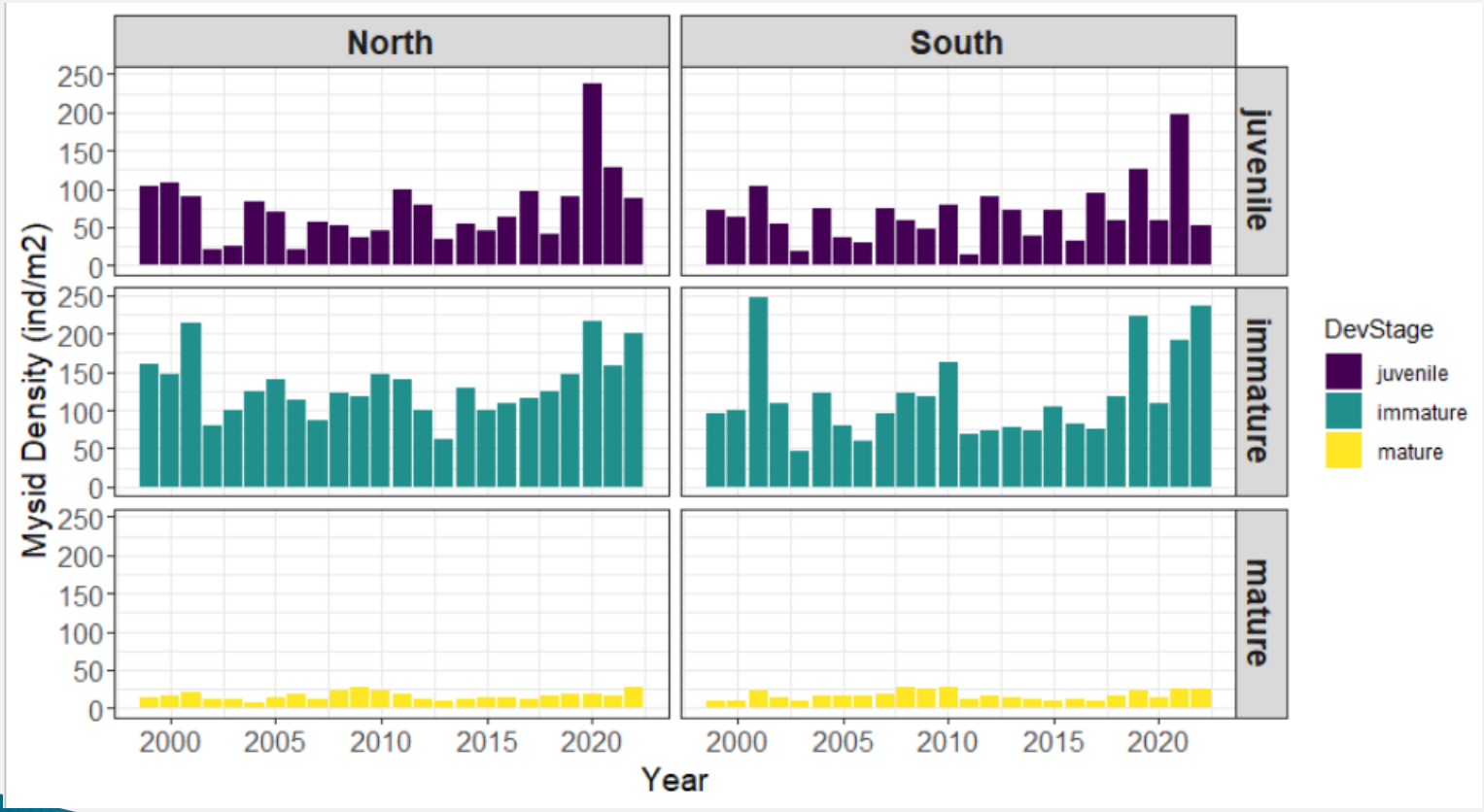


NRP update – Mysids



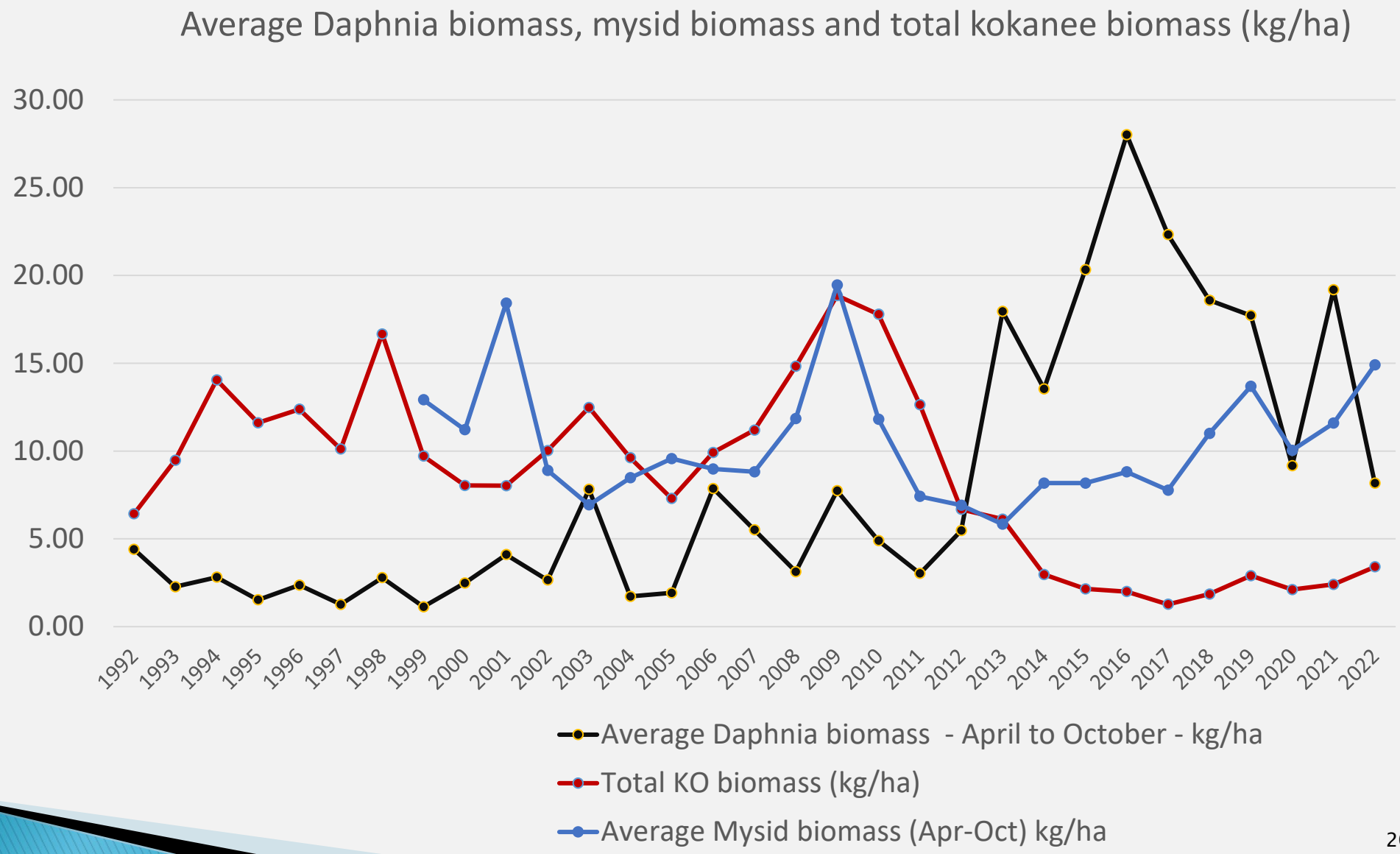
- The annual (Apr–Oct monthly means) are still below the KLAP target of 463 ind/L
- Mysid densities have been above average 2019–2022

NRP update – Mysids by developmental stage



Mysid mean size and range (mm) for each developmental stage			
	Juvenile	Immature	Mature
mean	4 mm	11 mm	14 mm
range	3–6 mm	8–15 mm	10–17 mm

NRP update – Daphnia, Mysid and Kokanee Annual Trends



2022 data preliminary

Summary: Biological Response Update

- North Arm Spawners
  - ~ 35,000 spawners to North Arm (62% to Duncan/Lardeau)
  - Spawner size high (at post collapse mean) and fecundity highest on record
  - Age 3+ spawners
- Hydroacoustics: Small decrease in age 0-1 KO survival, age 1-2 KO survival highest since collapse, highest age 1-3 KO in-lake abundance since collapse, forecasted ~90,000 spawners in 2023
- Bull trout spawner abundance increased in 2022 (>600 redds)
- Gerrard escapement increased in 2022 (AUC=464), spawner size unchanged
- KLRT: decline in effort and catch for both species, consistent downward trend in release rate
- NRP update
  - Daphnia densities were low in 2022, though biomass and size were above than the pre KO collapse mean
  - Mysid densities were above average in 2022

2022 Implementation and Key Questions

Action Update: Mysis

Mysis Removal

- Action – Evaluate feasibility, mysis removal
- Trigger – Explore feasibility, removal if density/biomass > 463 ind/m2 (2 SD > mean)
- ***Action not triggered***

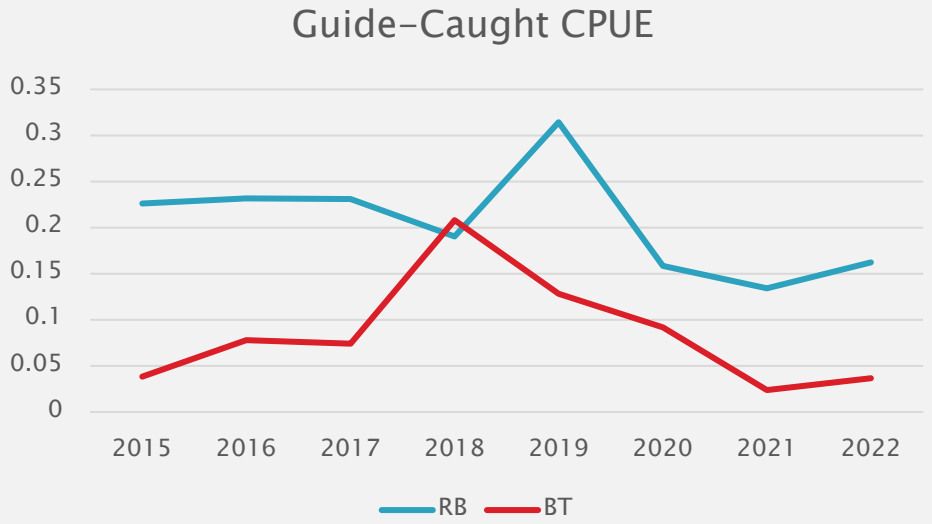
- Continue feasibility report, followed by future discussion

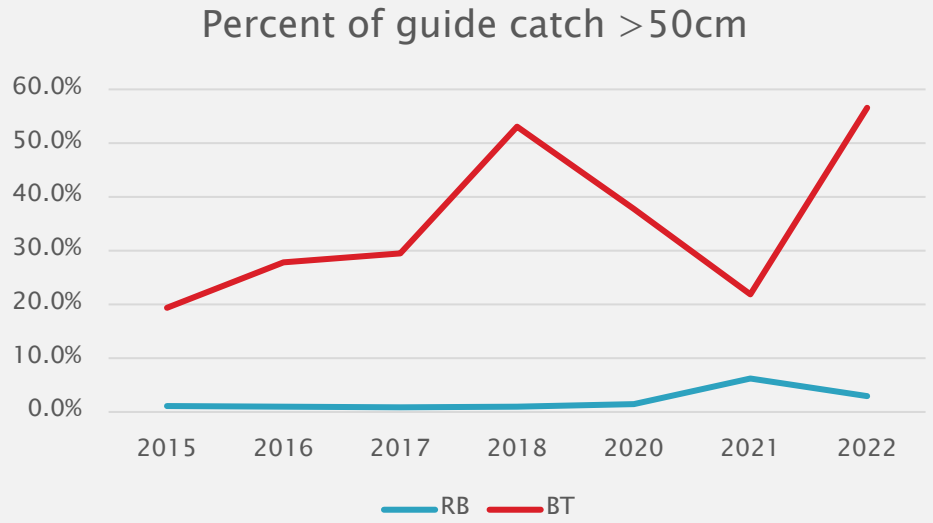
Action Update: Nutrient Restoration Program

- South Arm NRP
  - High ambient nitrogen again in 2022, a trend observed since 2012.
  - Recommendation is to cease the South Arm NRP while nitrogen levels are high

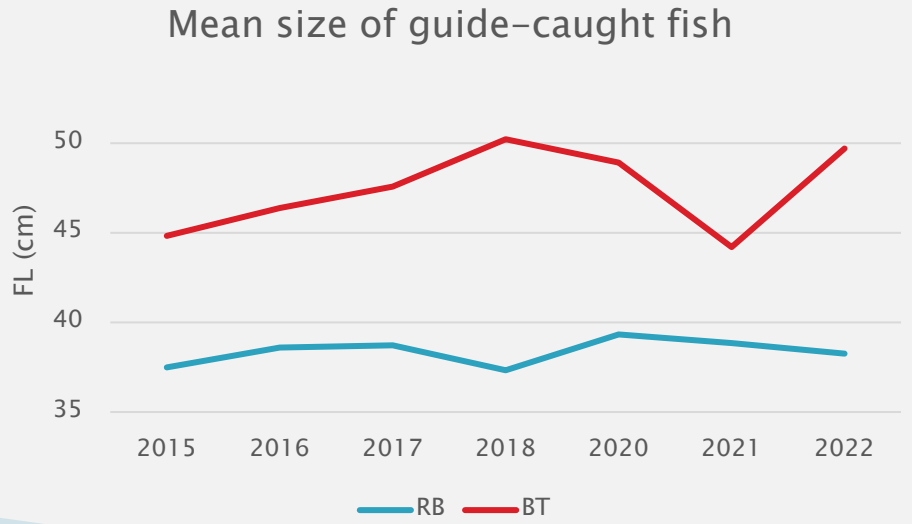
- North Arm NRP
  - FWCP Board directed independent review underway. Final report circulated 3rd week of November.
  - NRP supports Kokanee recovery, high spawner size and fecundity.
  - Current recommendation to continue North Arm NRP with recent years (since 2016) loadings.

What's the State of Kootenay Lake in 2022?



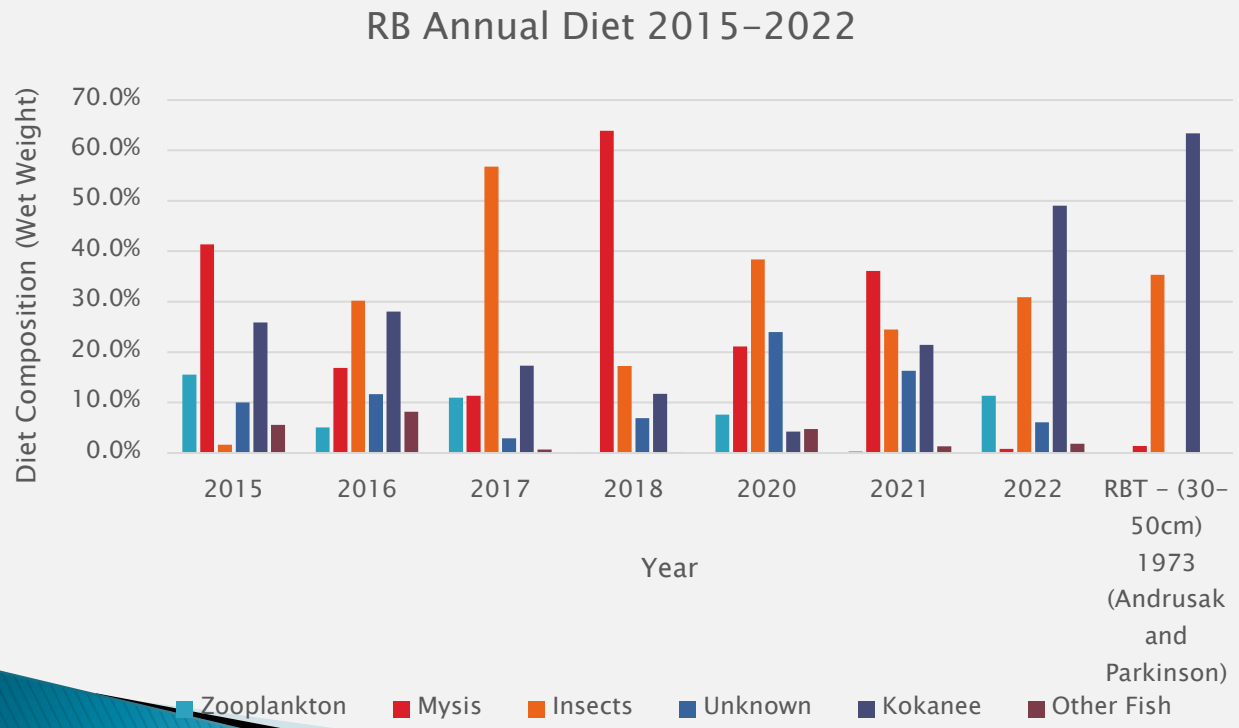


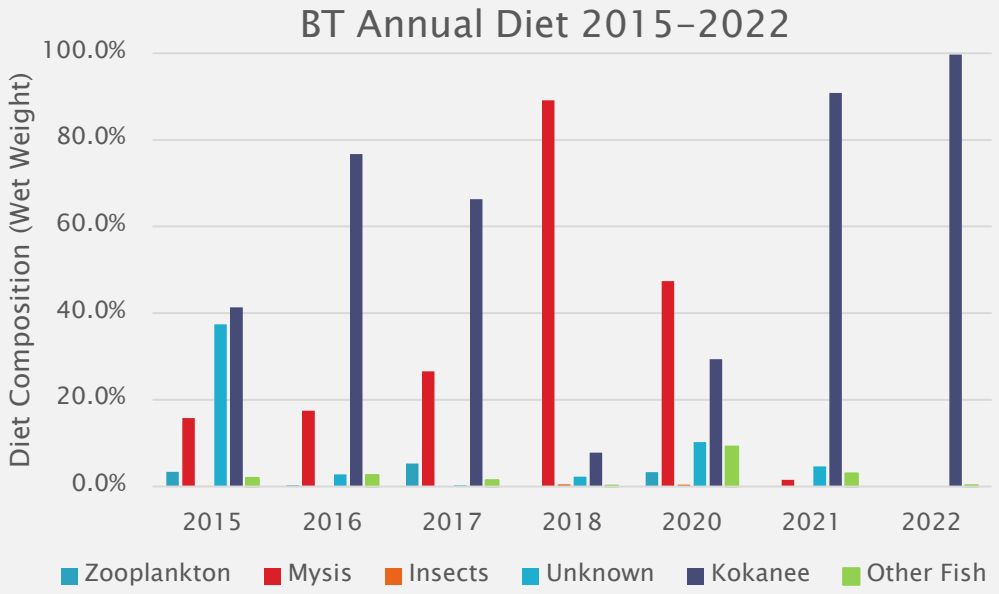
- Piscivore Monitoring Program Results (preliminary 1 mo sampling remaining)
- Increase in CPUE for both sp. in 2022
- Increase in BT size in 2022, relatively unchanged for RB



What's the State of Kootenay Lake in 2022?

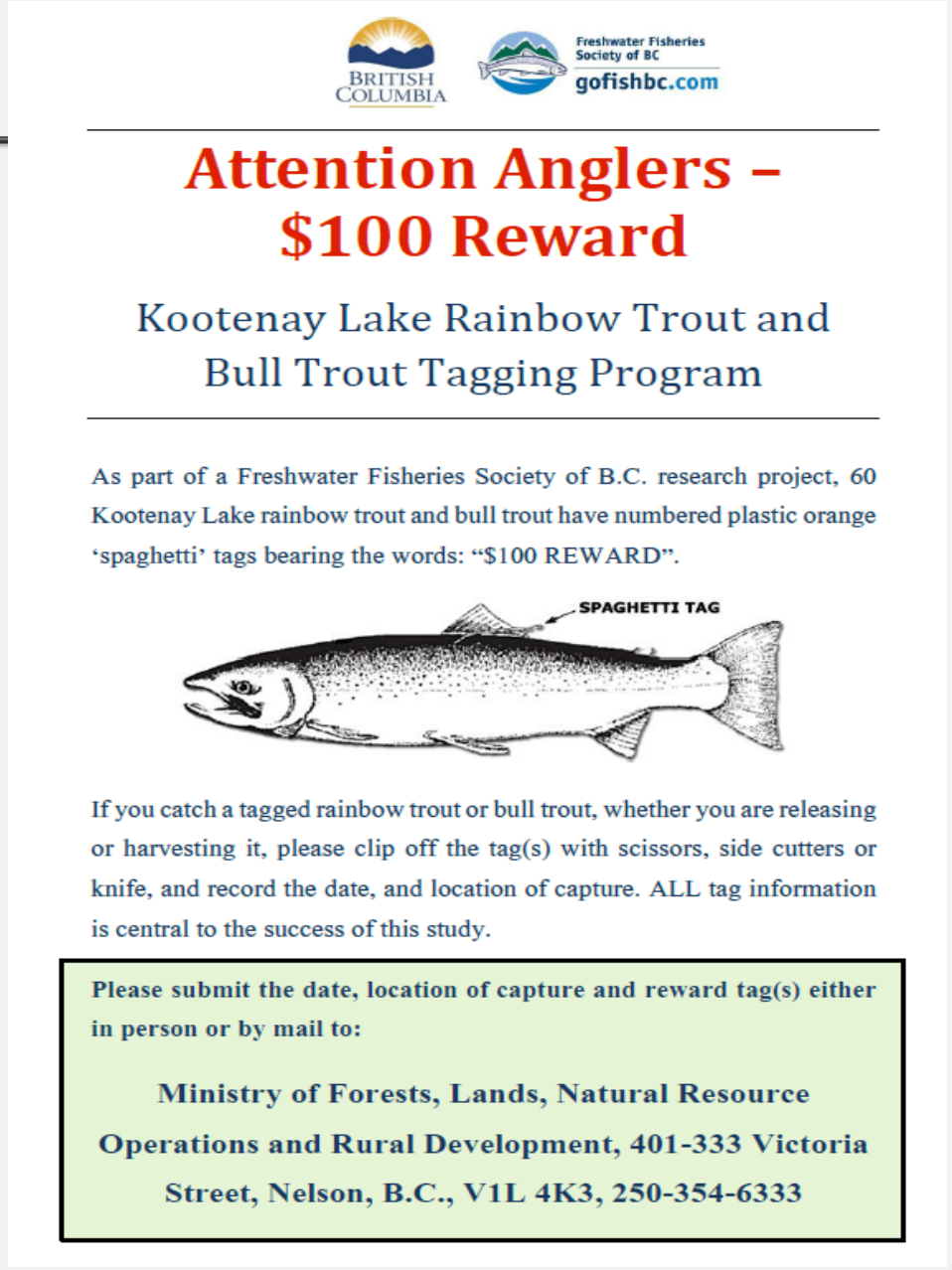
- Piscivore Monitoring Program Results (preliminary)
  - Diet data suggests feeding conditions for both species has improved
  - Kokanee in stomachs highest since start of program for both species, BT feeding almost exclusively on kokanee
  - RB diet similar to pre-collapse





Exploitation rates – 2021-22 data

- In 2021, 60 Rainbow Trout and 18 Bull Trout were tagged with 100$ reward tags. 5 Rainbow Trout tags and 3 Bull Trout tags were returned within a year.
- Instantaneous exploitation rates were calculated adjusting for instantaneous natural mortality (2013) and tag loss values previously reported by Thorley and Andrusak (2017). 100% reporting rate was assumed.
  - Rainbow Trout = 0.11
  - Bull Trout = 0.30
- These exploitation rates suggest that annual interval fishing mortality of Rainbow Trout was low in 2021-22 (effectively ~8%), whereas Bull Trout was higher (effectively ~19%), when considering retention rates (72 and 74% respectively from same year of KLRT).
  - These interval fishing mortality rates can be compared to the exploitation study (average 2008-2013) of Thorley and Andrusak (2017) for RB (~5% pre collapse) and for BT (~10% pre collapse).



BRITISH COLUMBIA

Freshwater Fisheries Society of BC
gofishbc.com

Attention Anglers – $100 Reward

Kootenay Lake Rainbow Trout and Bull Trout Tagging Program

As part of a Freshwater Fisheries Society of B.C. research project, 60 Kootenay Lake rainbow trout and bull trout have numbered plastic orange 'spaghetti' tags bearing the words: "$100 REWARD".

If you catch a tagged rainbow trout or bull trout, whether you are releasing or harvesting it, please clip off the tag(s) with scissors, side cutters or knife, and record the date, and location of capture. ALL tag information is central to the success of this study.

Please submit the date, location of capture and reward tag(s) either in person or by mail to:

Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 401-333 Victoria Street, Nelson, B.C., V1L 4K3, 250-354-6333

Thorley, Joseph L., and Greg F. Andrusak. "The fishing and natural mortality of large, piscivorous Bull Trout and Rainbow Trout in Kootenay Lake, British Columbia (2008–2013)." *PeerJ* 5 (2017): e2874.

In-lake fishery – is this a recruitment action for either species?

- Reward tag fishing mortality rates suggest possible overfishing of BT but not even close for RB when considering rules of thumb for reference points based on natural mortality
  - *F* should not exceed *M* for long-lived, slow growing species and a lower ratio for fast growing, short lived species.
- Thorley and Andrusak (2017) calculated *M* as 0.27 (*F* = 0.08 in 2021) and 0.09 (*F* = 0.22 in 2021) for rainbow and bull trout respectively under good growing conditions.
- In-lake fishery has not and can not result in recruitment effects alone for Rainbow without unrealistic increases in effort.
- Are BT growth overfished or recruitment overfished? Prior literature of BT stock-recruit dynamics (Johnston at al. 2007) and redd count/juvenile counts thus far (Andrusak et al. 2022) suggests BT are highly sensitive to growth overfishing but not recruitment overfishing (some weak evidence in Keen Creek but not Kaslo River).
- Evidence suggests BT recruitment overfishing is either not (or not strongly) occurring or strongly compensated by higher in-lake survival.
- In either case, higher in-lake fishing mortality still helps with predator-prey ratio and contributes to complementary recruitment actions

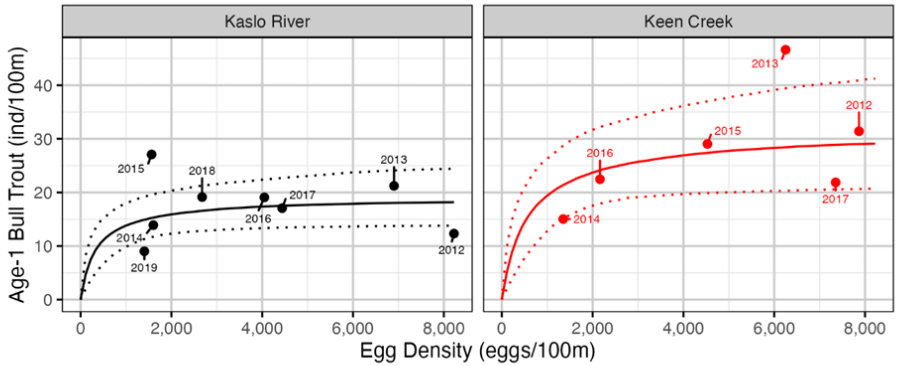


Figure 20. **The estimated eggs to age-1 stock-recruitment relationship (with 95% CIs). The points are labelled by spawn year.**

Andrusak, G.F., Thorley, J.L. and Amies-Galonski E.C. 2022. Kootenay Lake Bull Trout Productivity and Capacity for Defining Management Reference Points-CAT # 20-4-555-2022. Prepared for the Habitat Conservation Trust Foundation and the Ministry of Forests, Lands and Natural Resource Operations, Nelson, BC. July 2022. 32 pp+

Johnston, F. D., Post, J. R., Mushens, C. J., Stelfox, J. D., Paul, A. J., & Lajeunesse, B. (2007). The demography of recovery of an overexploited bull trout, Salvelinus confluentus, population. *Canadian Journal of Fisheries and Aquatic Sciences*, *64*(1), 113-126.

Action Update: Kokanee Supplementation

- Action: Stock 5 million eyed eggs; trigger: KO escapement 65,000–140,000, <11% age 0–1, <17.0 million fry

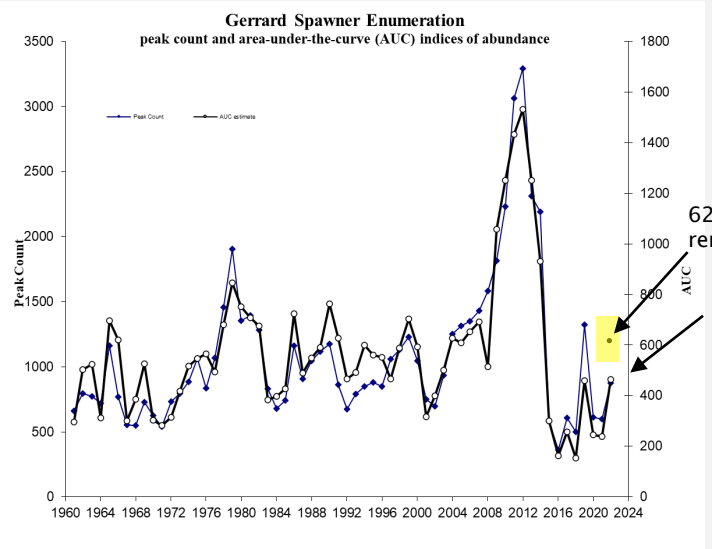
- Plans to stock ~1.4 mil eggs into MCSC in early November 2022 (source: Tyee+Hill)

Key Question: Do we stock in 2023?

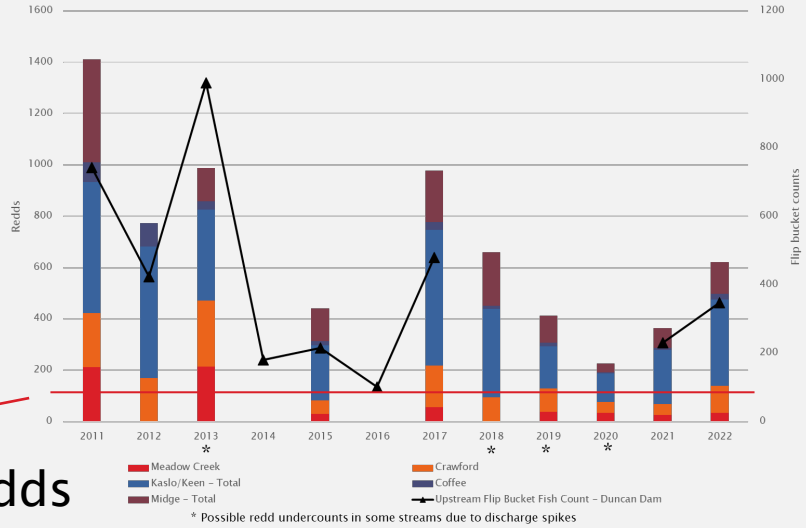
- 2023 spawner forecast is ~90k
- YES: Based on trigger of 65,000-140,000 spawners, <11% 0-1 survival
- Possibly need to redefine trigger?:
  - How do we interpret this as spawner #s increase? Assess based on egg deposition instead?
  - For how many years?
  - Smaller team to work on this over the next year.

Action Update: Predator Conservation

- Gerrards:
  - Trigger <50-100 spawners for two consecutive years
  - Action: Reduce exploitation through regulations, hatchery supplementation; ***action not triggered***



- Bull trout:
  - Trigger <25 redds/250 spawners in Kaslo River and lake-wide index respectively ** revised in 2021
  - Action: Reduce exploitation through regulations; ***action not triggered***



Conservation trigger - 125 redds ~ 250 spawners

Action Update: Predator Management
Fishing Regulations

Kokanee Angling Closure

- Action – maintain kokanee daily quota=0
- Trigger – <140,000 spawners; age 0-1 <11%, KLRT >2kg RB CPUE mod-high
  - Implemented in 2015, continued

Recreational Fishery Regulations

- Action – liberalize piscivore fishing regulations
- Trigger – <140,000 spawners; age 0-1 <11%
- Current Fishing Regulations:
  - Barbed hooks
  - No north arm closure
  - Piscivore quotas
    - BT = 3/day any size
    - RB = 5/day any size (revised June 1, 2022),10/year >50cm

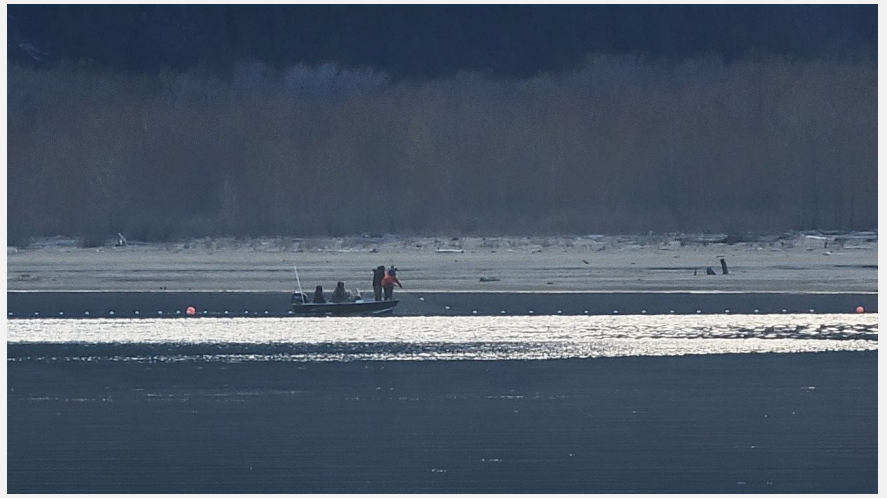
Action Update: Predator Management
Kootenay Lake Angler Incentive Program

- 2020-2021 Program- 10,689 entries
- 2021-2022 Program- 4,140 entries
- 2022-2023 Program June to September- 3,509 entries (ongoing; program runs until May 2023)

- Creel 2022 (June-Oct): 258 interviews
  - KLRT license: Increase from 61% and 58% in Y1 and Y2 to 79% in Y3 (pre-collapse levels)
  - Know about draw: Increase from 91% and 90% in Y1 and Y2 to 100% in Y3
  - Participation rate: Increase from 83% in Y1 and Y2 to 98% in Y3

Action Update: Predator Management
Gerrard Reduction 2022

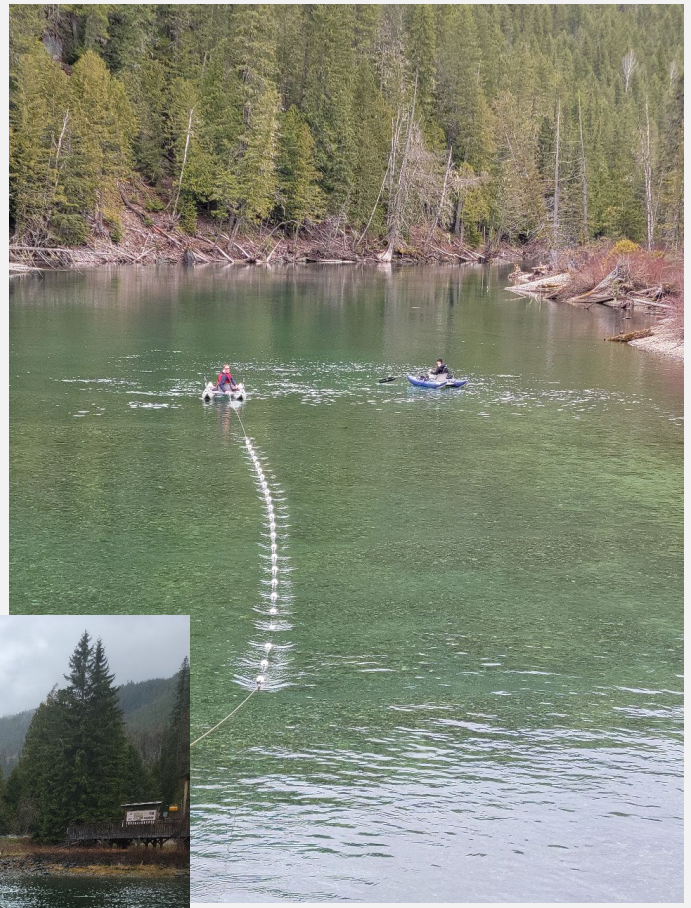
- Tanglenetting at north end of Kootenay Lake:
  - Work contracted to KNC and completed by Flatbow crew (KNC/ONA)
  - March 18th–April 26th 2022 (26 days of sampling), 336 hrs soak time
  - 136 fish captured (62F/72M), 108 taken for FN food fishery, remainder held and released at end of run



Action Update: Predator Management
Gerrard Reduction 2022

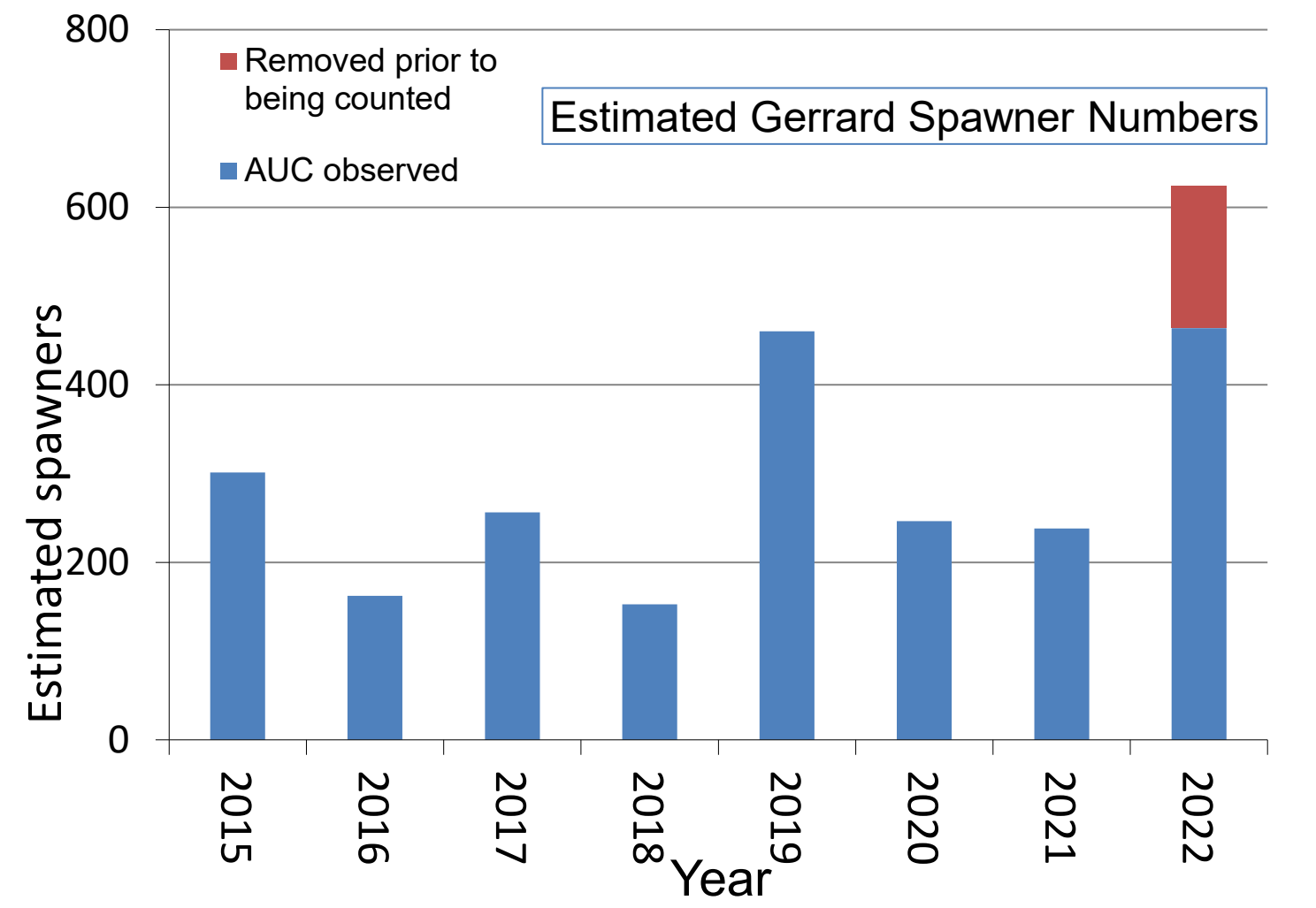
- Angling in the Lardeau River:
  - 4 angling days, 38 rod hours
  - 9 fish captured (4F/5M), all fish held and released at end of run

- Tanglenetting at Gerrard:
  - 2 sampling days, 6 sets
  - 22 fish captured (3F/19M), 1 green F held and released at end of run (+ 1 spent and 1 ripe and stripped)



Gerrard reductions in 2022 – impact on spawner abundance

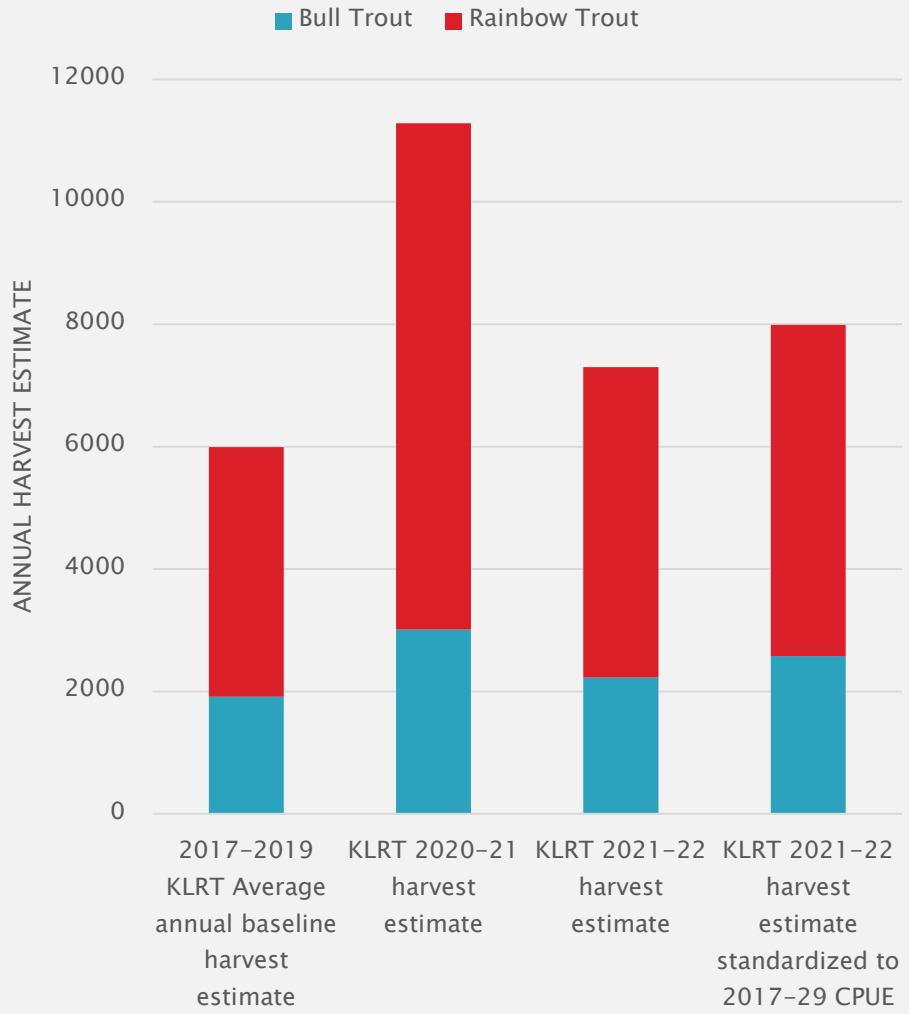
- Total escapement absent any removal efforts estimated at 624 after adjusting for on-site removals (tanglenetting @ gerrard and ONA fishery) and 136+9 fish removed by tanglenetting/Larde au angling



Key Question: What predator management actions should be implemented in 2023? (in-lake, immediate benefit)

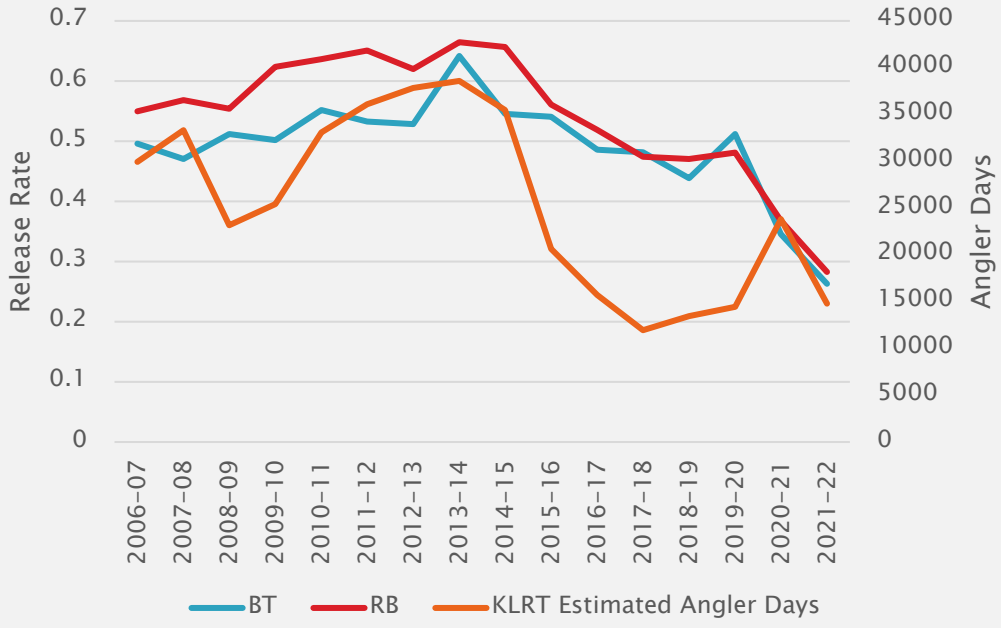
How much of an impact did the KLAIP have in its second year vs the base case?

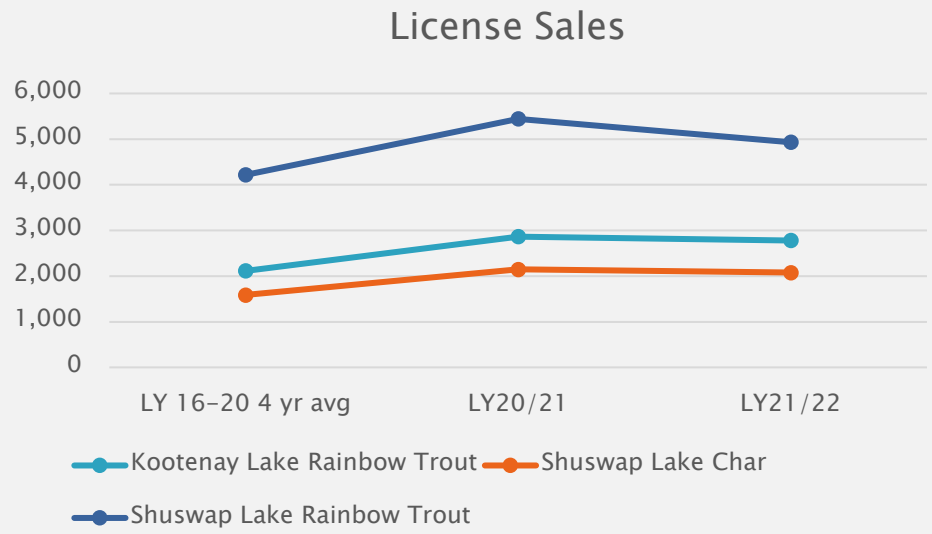
- The 2019-2020 angling year, the first year of the KLAIP resulted in over double the harvest of rainbow trout and bull trout in Kootenay Lake
- In 2020-21, head submissions declined dramatically.
- We can use KLRT data to compare the effect of yr 1 vs yr 2 vs the base case of the prior two years and also adjust for catch rate changes in yr 2 (i.e., it's not really fair to compare 21-22 to 17-19 directly due to fewer fish in the lake).
- KLAIP clearly still has an effect in yr 2, but the effect was nowhere near as dramatic as yr 1.



How does the KLAIP work?

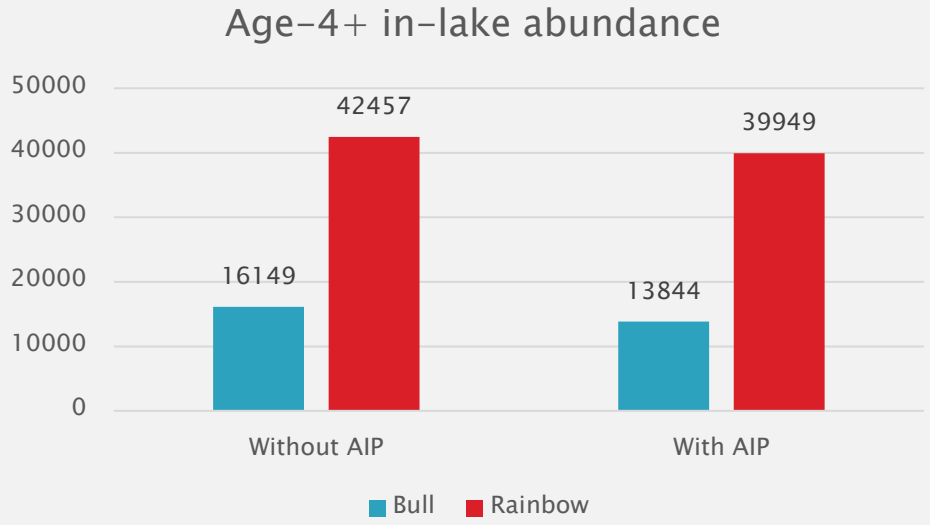
- Yr 1 of the program was primarily driven by an increase in effort (probably not KLAIP driven)
- Any effort increases probably due more to COVID effects than KLRT (see Shuswap as a control)
- Yr 2 of the program was primarily driven by an increase in retention rate (probably KLAIP driven)





What's the benefit of continuing the KLAIP?

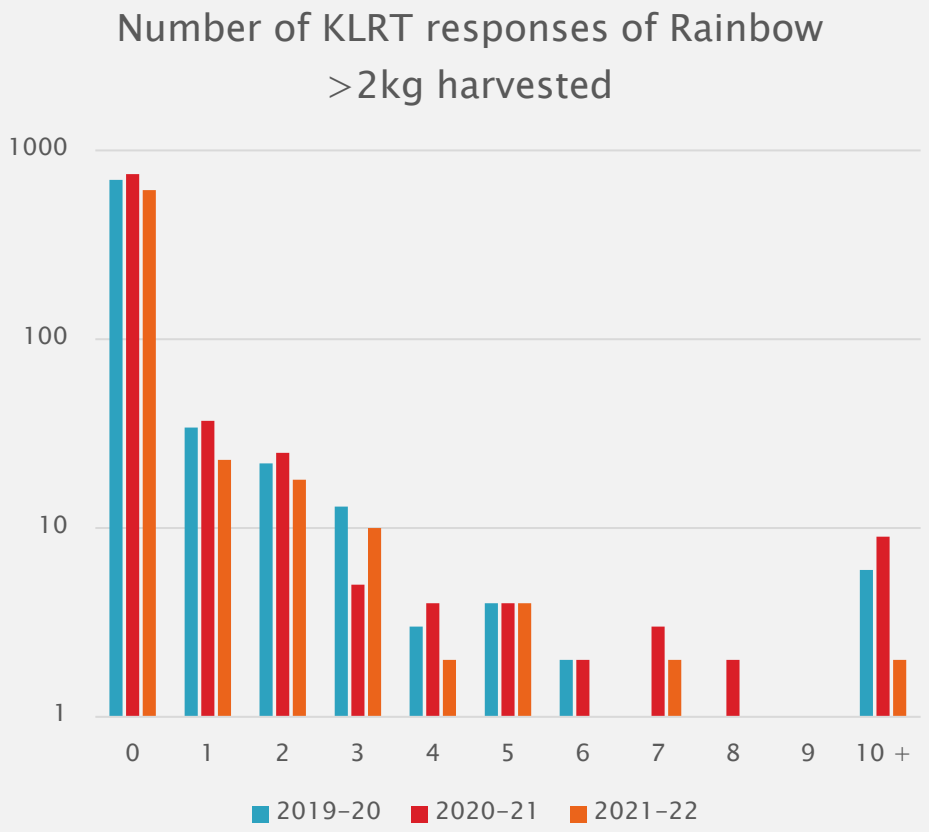
- The KLAIP does NOT affect recruitment, but it does increase fishing mortality on adults
- If KLAIP is run annually for ~5-7 years, then the adult population is brought down by ~8% vs the base case.
  - KLAIP builds upon itself – a fish removed in 2020 still isn't in the lake in 2022 or 2025.
  - Age structured abundance estimate: Annual survival – annual interval fishing mortality differences between exploitation rates in 2008-2013 (Thorley and Andrusak 2017) and 2021 high reward tag study.
- Thus, the effect of running the KLAIP is estimated to lower in-lake KO consumption in the adult population by ~8%
  - lower in total population because younger age classes aren't affected by KLAIP



*Absolute abundance estimates may be overinflated due to outdated natural mortality values.

In-lake action – Further regulation changes

- Current regulations: Bull Trout 3/d, Rainbow 5/d; annual quota 10 >50cm
- Another year of KLRT suggests the 10 annual quota >50 is not anywhere close to limiting
- Prior year analysis suggests current daily quota limits are not limiting (Kerry Reed test fishery rarely catches limits; KLAIP creel rarely reports fish being released beyond limits being caught)
- Still, if predator populations were to rise, daily quotas could be limiting in the future.



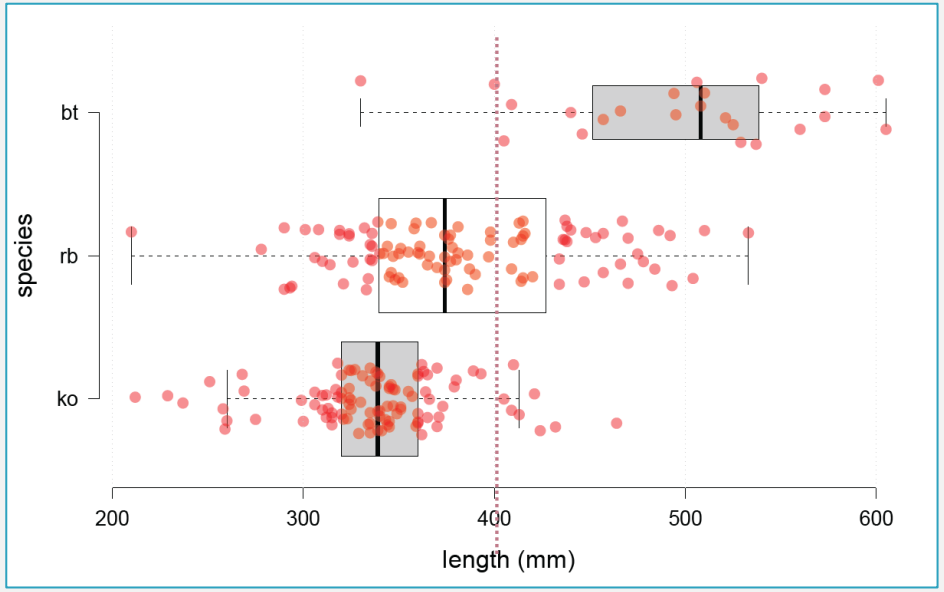
In-lake Gillnetting to Reduce Piscivores

- How many rainbow trout are there in Kootenay Lake – Gerrard VPA

Year	Gerrards age 4 – 6
2023	4400
2024	3200
2025	2800
2026	1000

- 2023 there will be 9000 active piscivores (4400 Gerrard + 2000 non-Gerrard + 2600 BT)
- Potential gill net catch, a scenario:
  - Short pilot then operational, season and location choices will increase catchability and allow targetting of piscivores
  - 10 Gerrard rainbow, 5 insectivore rainbow, 5 bull trout per net day (modest assumption)
  - 50 days of one net
  - 1000 piscivores (one net), namely 10% of piscivores in the lake
  - Scalable to high percentages of in-lake piscivores
- Pros and cons to 2023 netting
  - Kokanee by-catch
  - $ and public optics
  - Immediate and accruing benefits to kokanee in 2023, 2024, 2025, 2026
  - Builds on current and recent actions e.g. Angler Incentive in 2020, 2021, 2022
  - Effectiveness monitoring is feasible
  - Feasible implementation

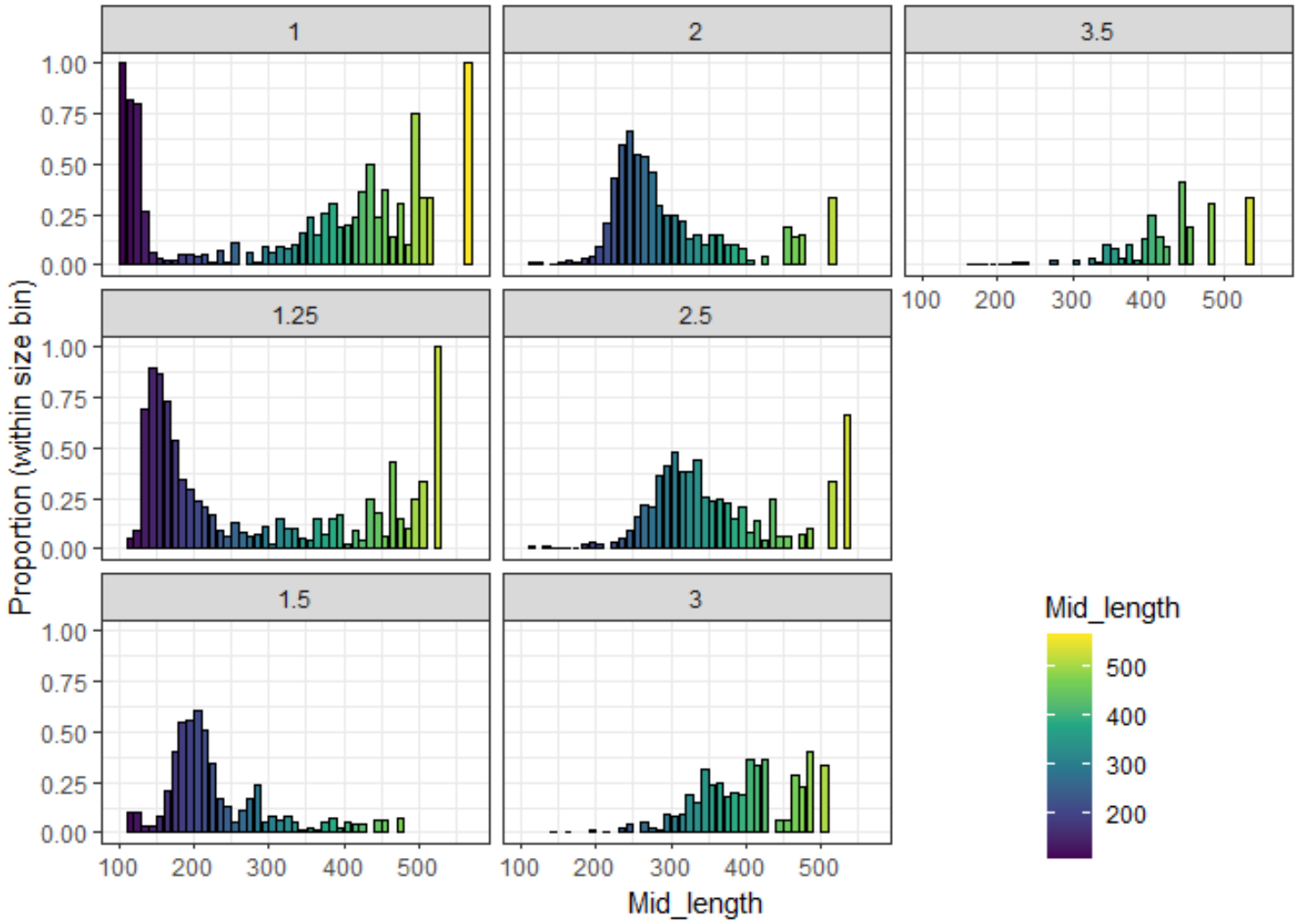
2022 kokanee, rainbow trout, bull trout lengths



In-Lake Gillnetting – What about Kokanee Bycatch?

Paul Askey rainbow trout mark and recapture data:

- Panel number is mesh size (inches)
- Kokanee girth larger than rainbow of same length, less toothy
- Net mesh ≥ 3.5 inches reduces by-catch (2022: 92% of female kokanee < 400 mm)
- Net mesh ≥ 3.5 inches effective for large proportions of piscivores
- Season and location choices, combined with mesh size, will reduce kokanee by-catch to an optimal trade-off



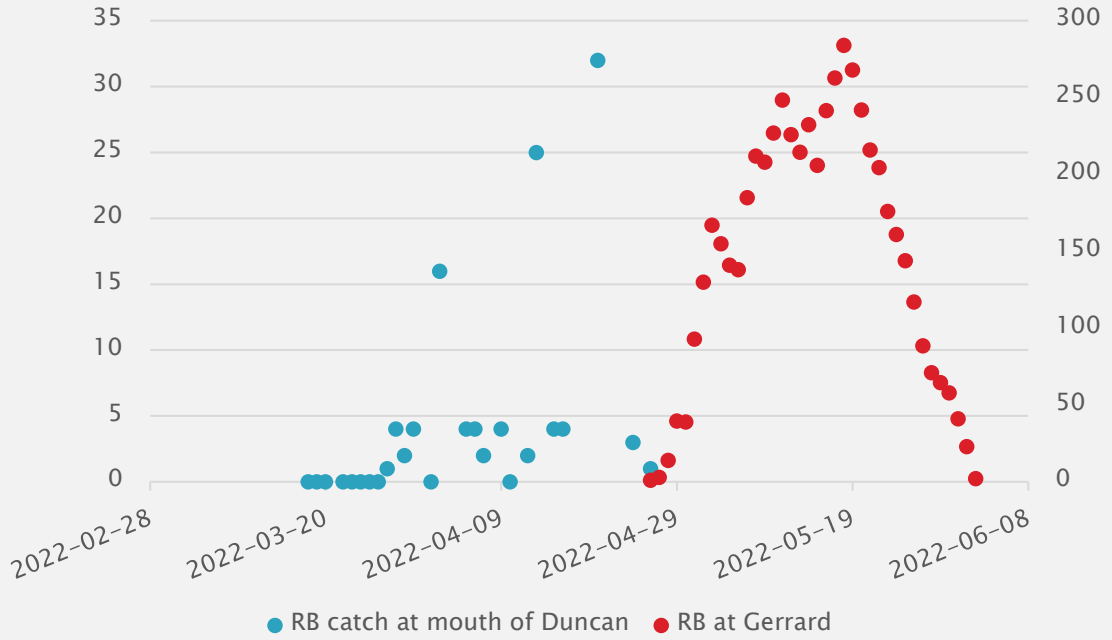
Key Question: What Predator Management Actions should we implement in 2023 (recruitment actions, future benefit)?

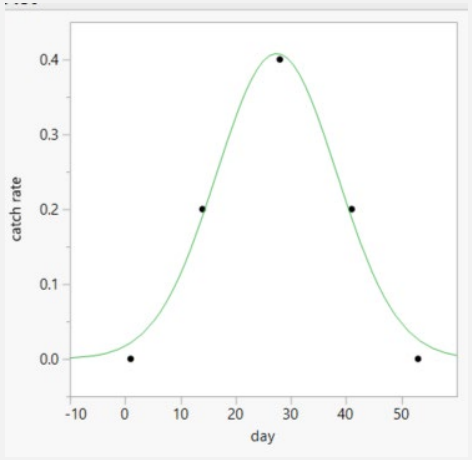
Possible recruitment action – open the Lardeau/Duncan River to spring angling

- The Lardeau River has been closed to all angling for many decades, as has the Duncan River during the spring
- Specifics would need to be thought out (daily quota, open season length, link to an AIP etc.)
- Monitoring should help determine effect of action and info for long-term management strategy. A creel could easily be implemented by leveraging existing guardian program.
- Major disadvantage – the numbers retained will only be an estimate and not a census (i.e., the exact effect will be uncertain)
- Variation on open fishery could be volunteers with collection permits – effort for certainty trade-off.

Possible recruitment action – open the Lardeau/Duncan River to spring angling – what is the predicted effect?

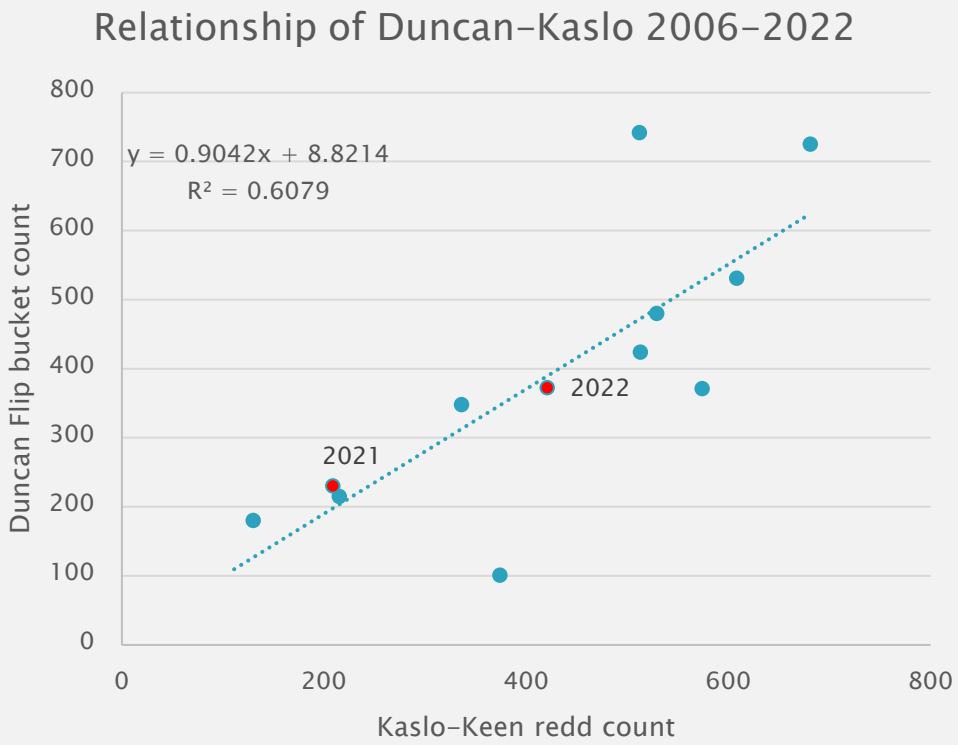
- In 2022, our regional team spent 36.5 rod hours and caught 9 Gerrards in late april, providing an effective test fishery for catch rate (0.4 / hr)
- Using the Duncan as a proxy for effort, there was an estimated ~ 20 rod hrs/d in the summer fishery from Baxter et al.' s 2019 creel.
- The season length was reasonably estimated as 53 days – date of first fish at mouth of Duncan (March 27) to date of peak count at Gerrard (May 18).
- Assuming a normal distribution of catch rate through the season, peaking at 0.4 fish per rod hour at the mid-point between first fish and peak, a daily catch was calculated assuming effort is constant at 20 hours a day.
- Therefore, a reasonable estimate for a 2022 open fishery would be 217 fish caught. Note this is approximately half the AUC estimate observed of 464. Of course, retention rate would not be 100%
- Assumptions
  - Catch rate is assumed to be density-independent with removals (i.e., anglers removing fish doesn't affect subsequent catch rate – we are basically assuming hyperstability)
  - Effort is constant through the season.





Possible recruitment action – open angling on Bull Trout tributaries

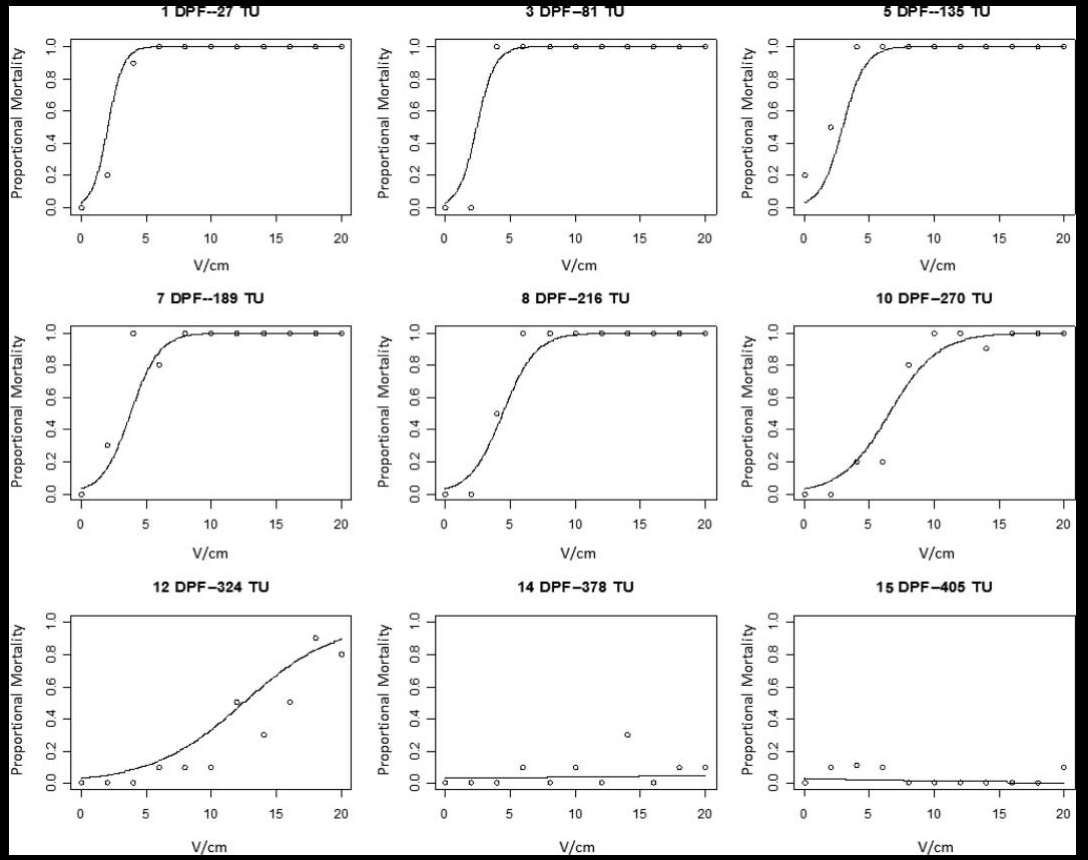
- Bull trout are closed to retention in all tributaries (except Duncan R – 2/d since 2019); some (or sections of some) are completely closed to angling or have seasonal closures.
- Most tributaries are not very accessible; Kaslo and Crawford exceptions
- Despite strong evidence of substantial BT removal in the Duncan R fishery, creel estimates do not return reliable estimates of the impact to escapement.
  - 2019, Baxter et al. 2019 Creel estimated total public harvest of 274 fish and additional contractor harvest of 104 fish, which far exceeds the inferred Duncan flip bucket count (157) from Kaslo escapement regression
  - In 2021 and 2022, we also see that these points do not fall below the regression line, suggesting the fishery had little impact on the flip bucket count (all other years did not have an open fishery)
  - Other streams (e.g., Hamill) may be impacted, but there are no redd counts to assess impact
- Kaslo fishery – compatibility with a fence? Liability if fence works well



* 2 outlier years (2010 and 2013) were removed due to leverage over regression

Possible recruitment action – efishing Gerrard redds

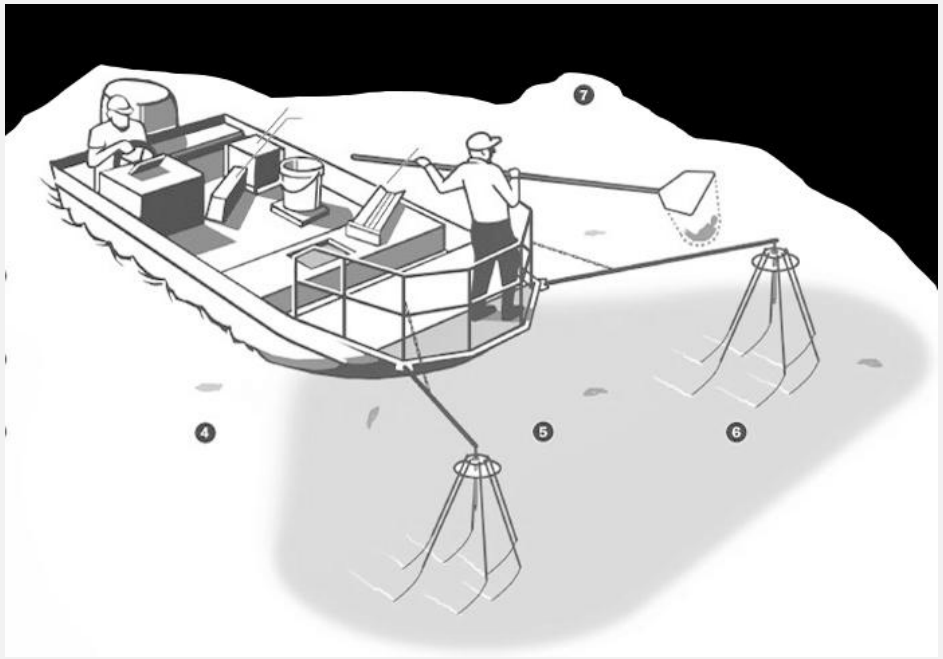
- Literature review found many papers on effect of electrofishing on salmonid eggs and embryos from pre-spawn (i.e., gravid females) to emergence.
- General literature findings:
  - Mortality is mostly affected by developmental stage – embryos are highly vulnerable a few days post-fertilization.
  - Under controlled lab conditions, mortality is often near-complete or complete (80-100%), even in simulated redds.
  - Gross et al. 2015 provide a well-defined relationship of mortality with current, conductivity and thermal units accumulated from fertilization that could be used to refine efisher settings and efishing survey dates based on Lardeau conductivity, water temperatures and spawn timing to maximize mortality. All of these factors are controllable (including conductivity by use of salt blocks).
  - Even if some survive, there may be sublethal effects (developmental abnormalities) that would likely translate to lower early life survival
  - Although many lab studies have been conducted, I could not find any field studies



Gross, J., Farokhkish, B., Cornacione, M., Shaw, S., Nguyen, P. L., & Henry, T. B. (2015). Potential use of direct current electric fields to eradicate rainbow trout embryos from freshwater ecosystems. North American Journal of Fisheries Management, 35(5), 871-879.

Possible recruitment action – efishing Gerrard redds

- Embryos should be highly vulnerable for a 1-2 week window (need to check with thermal units).
- As spawning occurs over an approximate 1-month window, 2-3 1-day sessions would maximize mortality.
- Spawners could be removed as well, but unlikely to have exceptionally high capture efficiency and 2-3 sessions would fail to capture majority of run.
- Uncertainties and challenges
  - Some logistics of timing with flows and equipment would need to be sorted out. A boat efisher would likely be the best equipment.
  - Some fish that spawn d/s of Gerrard would be unaffected, but could also hit Duncan tailrace.
  - Recruitment effect would be difficult to precisely control, but could be measured a year hence based on stock-recruit study.
  - <u>The effectiveness of this action is highly uncertain – it is untested and could work with near-100% efficacy or barely at all.</u>



Possible recruitment action – fence at gerrard

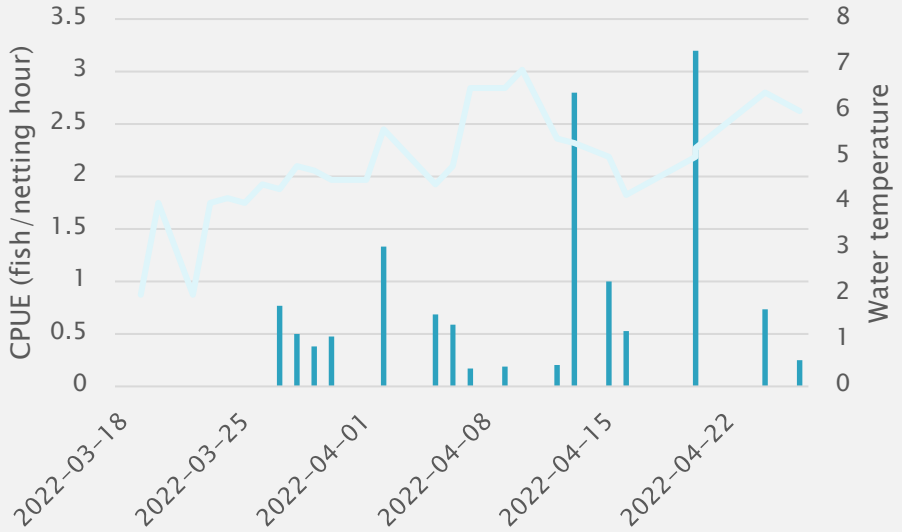
- Been done in the past (provincial – 1980s/1990s and federal efforts 1912–1932; 1939–49, 1952)
  - Early federal efforts were major infrastructure/hatchery; more recent efforts were temporary fences on a gravel sill that collected small proportions of the spawning run for brood collection.
  - 50–350 females in early federal efforts; estimated capture of 33–75% of total spawner abundance at Gerrard depending on year (Irvine 1978).
- Uncertainties and challenges
  - More permanent structure needed to intercept majority of spawning run; temporary fences in the 1980s/90s were never intended to capture whole spawning run – ineffective at higher flows later in run;
  - Parks permit; Sec 11 authorization
  - Some fish spawn downstream of fence location

Possible recruitment actions – net/seine Lardeau/Gerrard spawning site

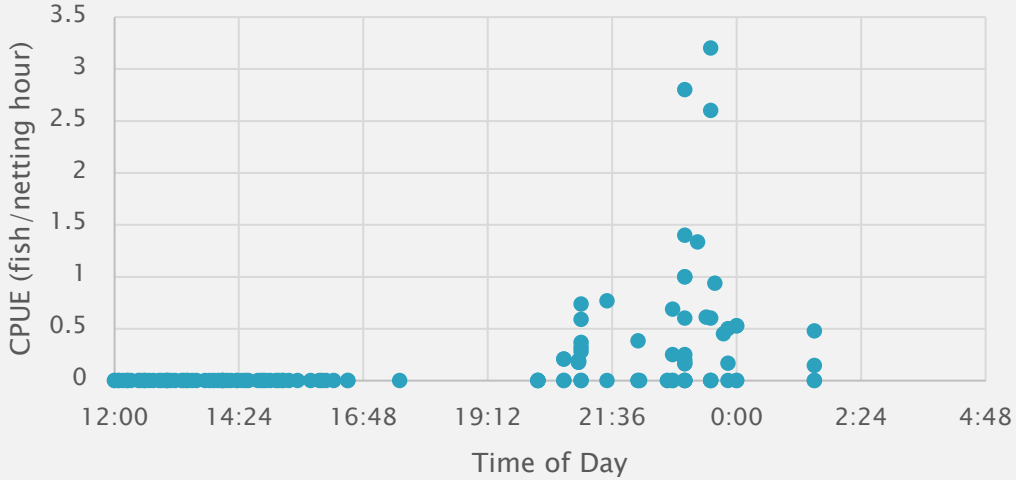
- Several attempts have been made to capture spawners on site at Gerrard since at least the 1960s.
  - Sparrow 1963: 22 females (~1/2 spent) captured in a day of seine effort (May 11) out of a shore count of 212 on the same day (11% of ripe female spawner abundance)
  - Neufeld 2010: 59 fish captured on in one day of seine effort (May 10); only 10 were females and many were spent (too late in the run). The shore count on this day was 462. (2.5% of ripe female spawner abundance)
  - Teather 2022: Tanglenets set on site on May 4 and May 9. 22 fish captured, but only 3 were females and only one was ripe; most effective when nets set parallel to flow. The shore counts on these days were 155 and 208, respectively. (~1% of ripe female spawner abundance)
- Netting and/or temporary net/trap/fences could also be conducted downstream at strategic locations to expand/scale up effort
  - Holding location at Duncan confluence (telemetry data from 2000s)
  - Wing fence on Lardeau
- Cons/uncertainties
  - Netting at Gerrard tends to capture more males than females and many are caught AFTER they have spawned
  - Seine netting difficult at higher flows – crew of ~12 at Gerrard site (Neufeld 2010)

Recruitment action: Tanglenetting at mouth of Duncan River

- 2022 efforts by KNC involved 26 days/nights setting/checking nets between March 18 and April 26, 2022
  - Action is fully scaled in terms of effort, but improvements in capture efficiency may be possible based on 2022 lessons
- Catch is sporadic and at night. Total CPUE was 0.41 fish/net hr
  - Low effort would result in highly variable catch due to randomness of catch/net
- Total catch was 136 Gerrards (63 females or 46%) and 48 Bull Trout
- 34 spawners (10 females, 24 males) were held in net pens at Meadow Creek ~1/2 survived.

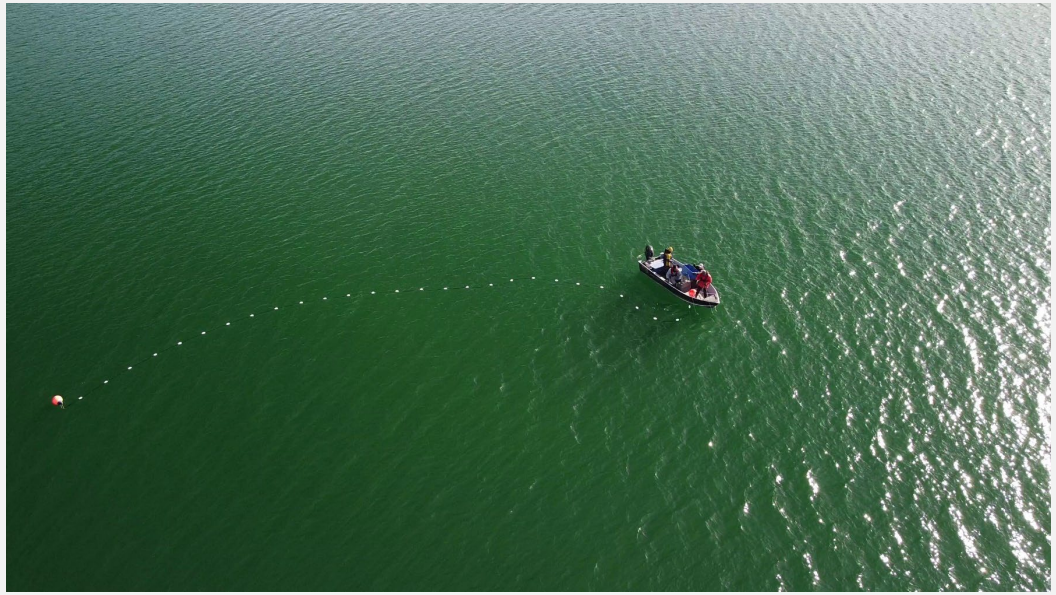


CPUE_RB



Recruitment action: Tanglenetting at mouth of Duncan River

- 2022 efforts resulted in capture of 136 fish, 63 of which were females
- The estimated total proportion of the female run captured by this method in 2022 was 20%
  - This is based on assumption of 50:50 true sex ratio, which is an untested assumption – we tend to always catch more males than females
- Andrusak and Thorley estimates this will result in a modest 11.8% reduction in age-1 recruits in 2023 given the large spawning population in 2022.



Summary of estimated effectiveness of different recruitment actions on spawner escapement

- Rainbow
  - Electrofish Gerrard redds/spawners: 10-90% of eggs (low certainty, untested)
  - Open Fishery on Lardeau: 50% (medium certainty – estimated, untested)
  - Tanglenetting at mouth of Duncan: 20% (high certainty – observed in 2022 for a fully scaled program)
  - Seining/netting: 1-11% of female ripe spawner abundance/d (high certainty – some observed values at Gerrard); scalability somewhat uncertain; untested/uncertain at other sites.
  - Fence at Gerrard: 33-75% for major infrastructure project (high certainty – range observed 1912-1952); significantly less for temporary fence
  - Others? Duncan wing fence
- Bull Trout
  - Fence on Kaslo: Untested except as kelt fence, but even assuming 100%; ~20% of total lake-wide spawner abundance/recruitment
  - Open fishery: Low certainty. No reliable estimate, but assumed to be ineffective in all streams except Kaslo/Duncan(Hamill)/Crawford due to accessibility. Hasn't appeared to affect Duncan flip bucket counts. Doesn't make sense in the Kaslo if fence is operational.
  - Duncan Dam: see prior analyses in earlier KLAT meetings (likely 0 effect on recruitment, but any impacts would affect Duncan fishery more than Kootenay)
  - Others? Tanglenet mouth of Kaslo or Duncan?

Summary

- Biological Update
- 2022 Implementation and ongoing actions
- Key Questions:
  - Do we stock in 2023?
    - Trigger revision?
  - What predator management actions should be implemented in 2023? (in-lake, immediate benefit)
    - KLAIP, fishing regulations, in-lake gillnetting
  - Key Question: What Predator Management Actions should we implement in 2023 (recruitment actions, future benefit)?
    - Rescind angling closures, electrofishing/fence/seine at Gerrard, tanglenetting at mouth of Duncan

Thank you!