


Kootenay Lake Advisory Team

October 26th, 2023

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
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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 2023 (what did we do?)
 - ▶ Provide some analysis/ideas to help inform discussions around Key Questions.
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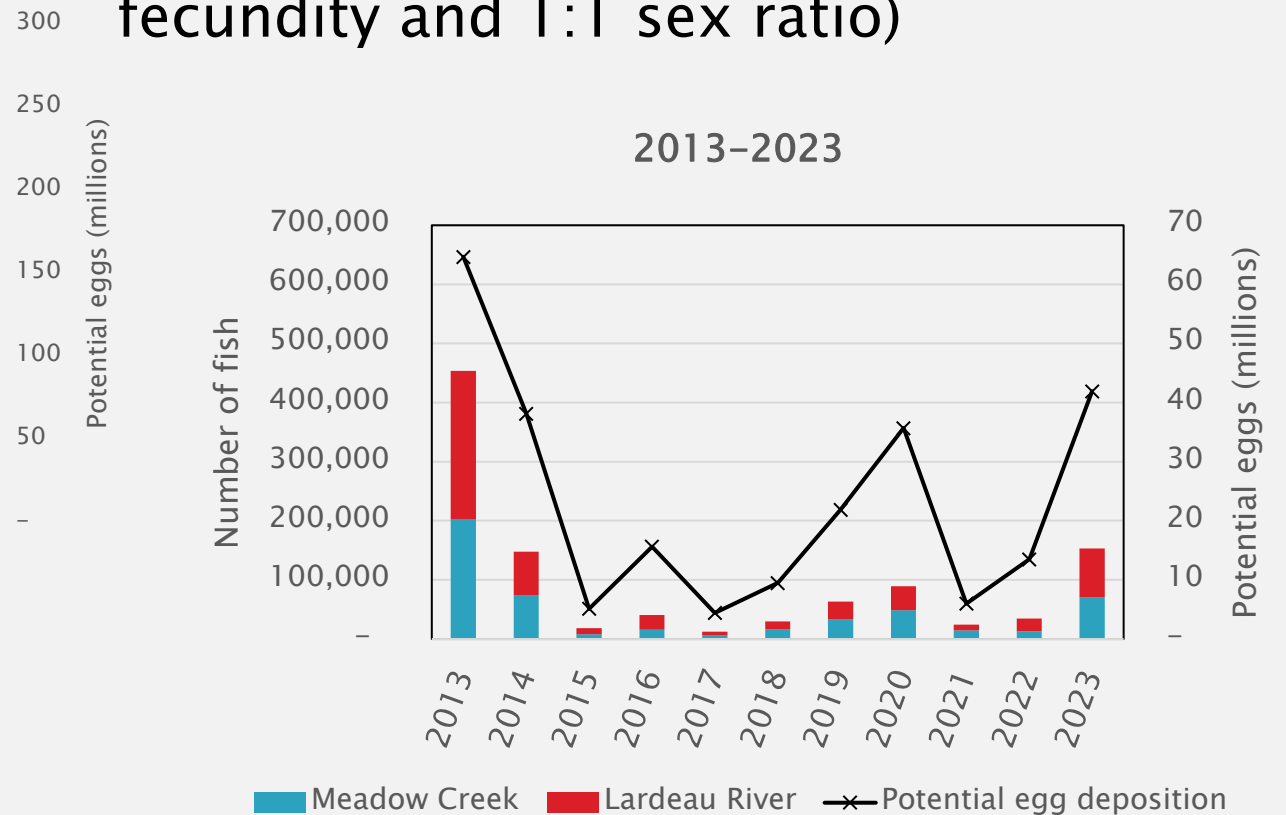
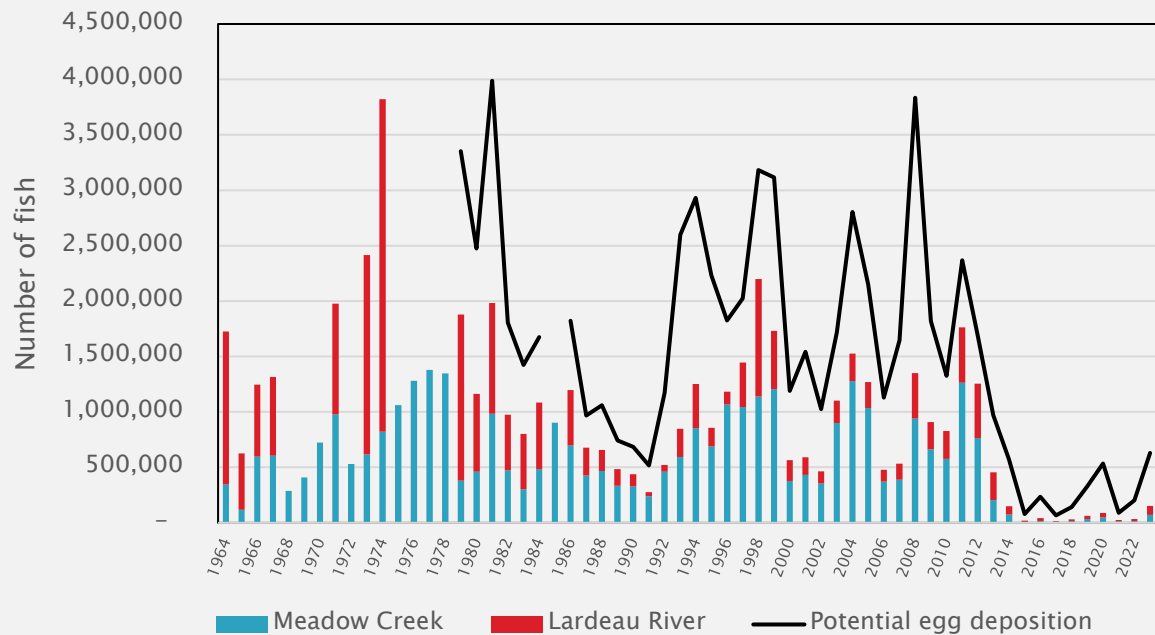
Meadow Creek Spawning Channel 2023

▶ Escapement:

- Meadow Creek 70,700
- Lardeau/Duncan 82,250

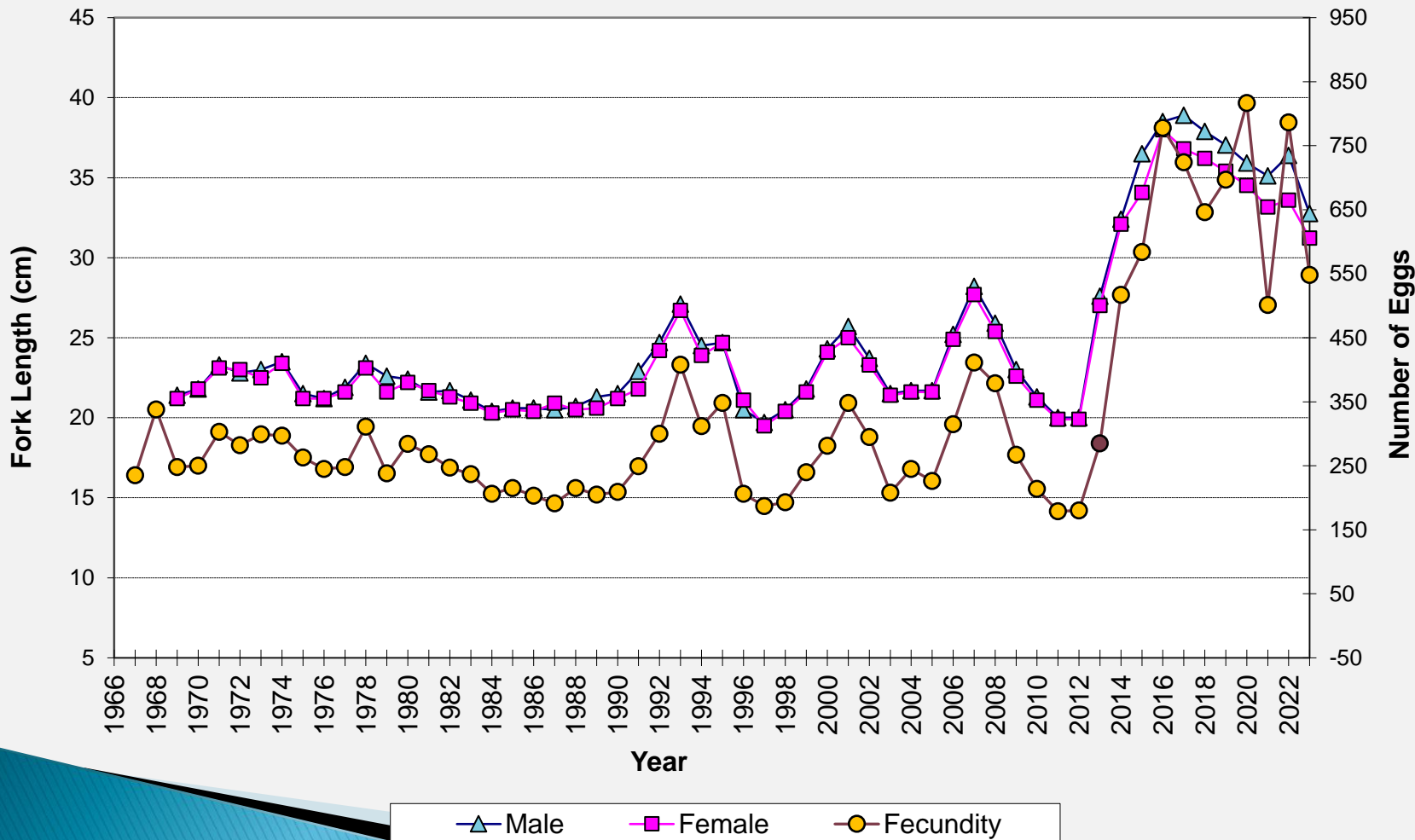
▶ Egg Deposition = 41.9 M eggs (using 2023 fecundity and 1:1 sex ratio)

North Arm Kootenay Lake Kokanee Spawner and Egg Deposition Estimates



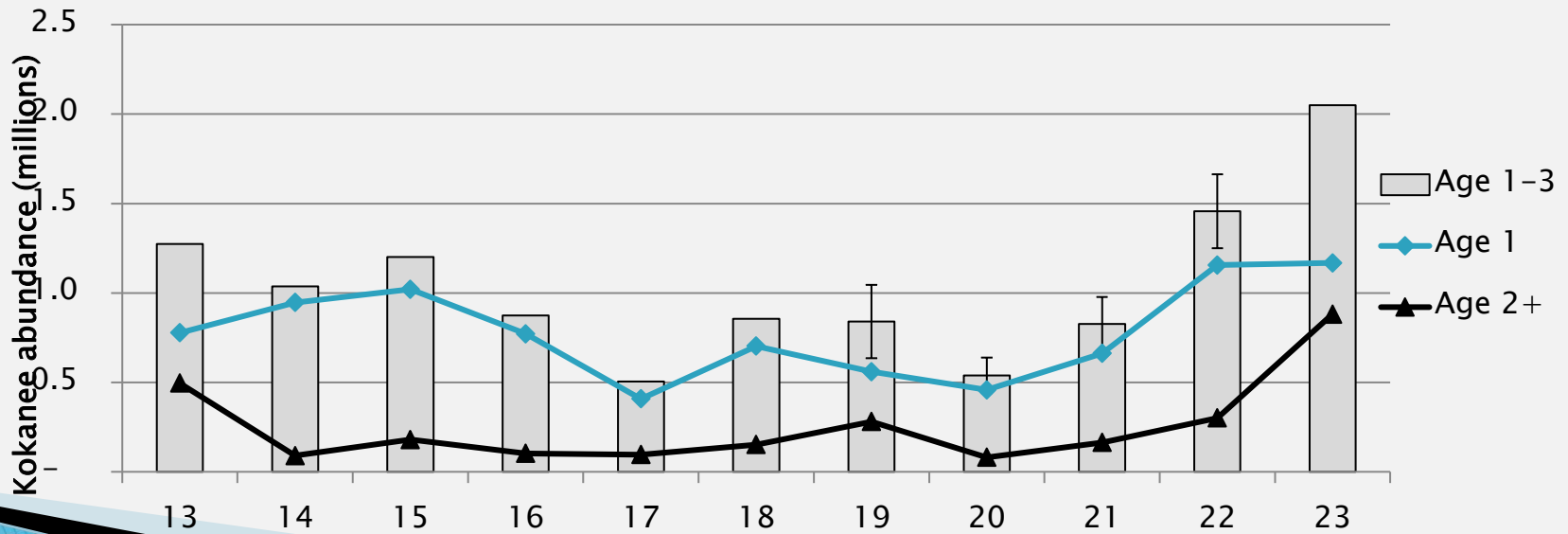
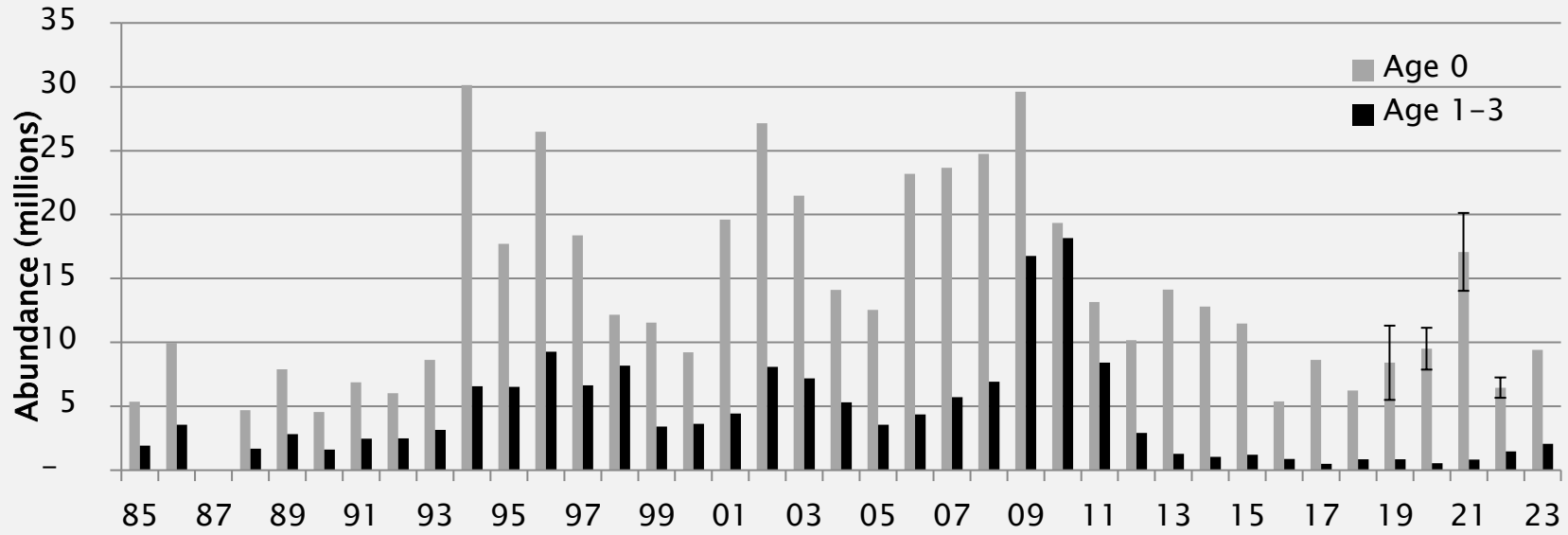
Meadow Creek – Spawner Data

Length-Frequency/Fecundity 1967-2023 Meadow Creek Spawning Channel



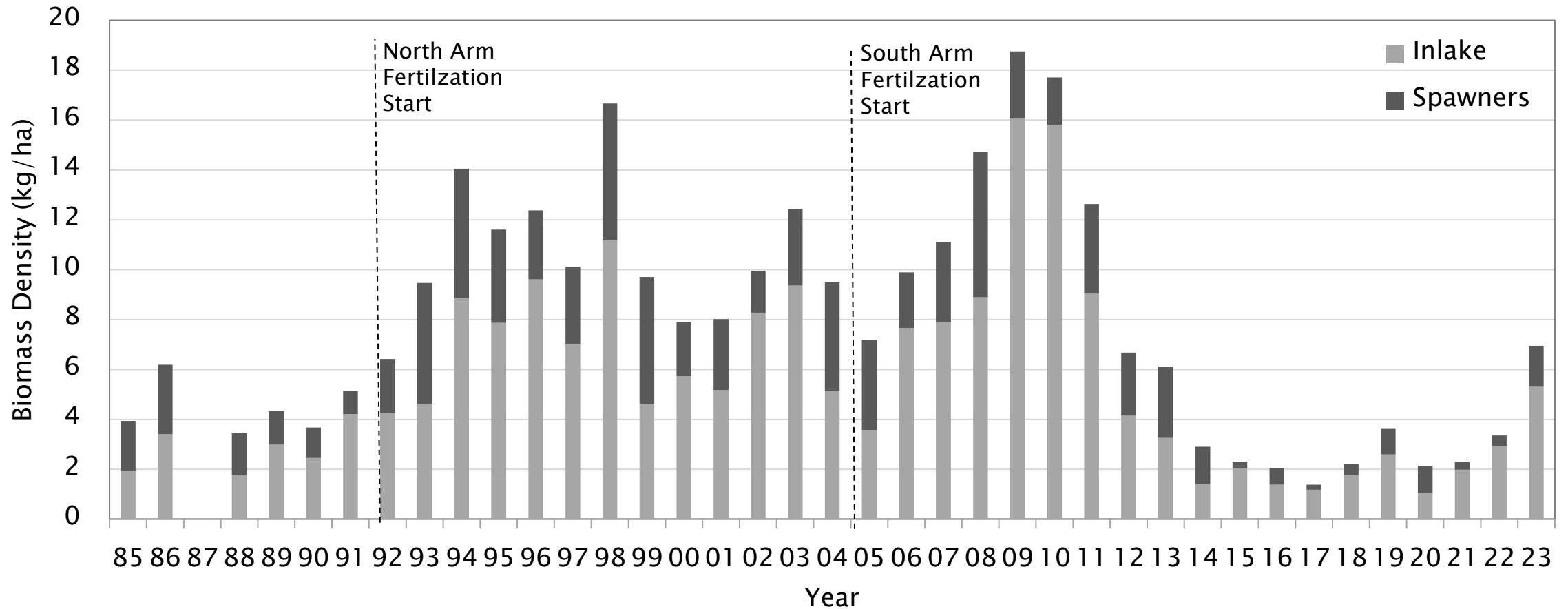
- ▶ Mean size of spawners:
 - Male = 32.7 cm
 - Female = 31.23 cm
- ▶ Mean fecundity (eggs/female) = 548 eggs

In-lake Kokanee abundance



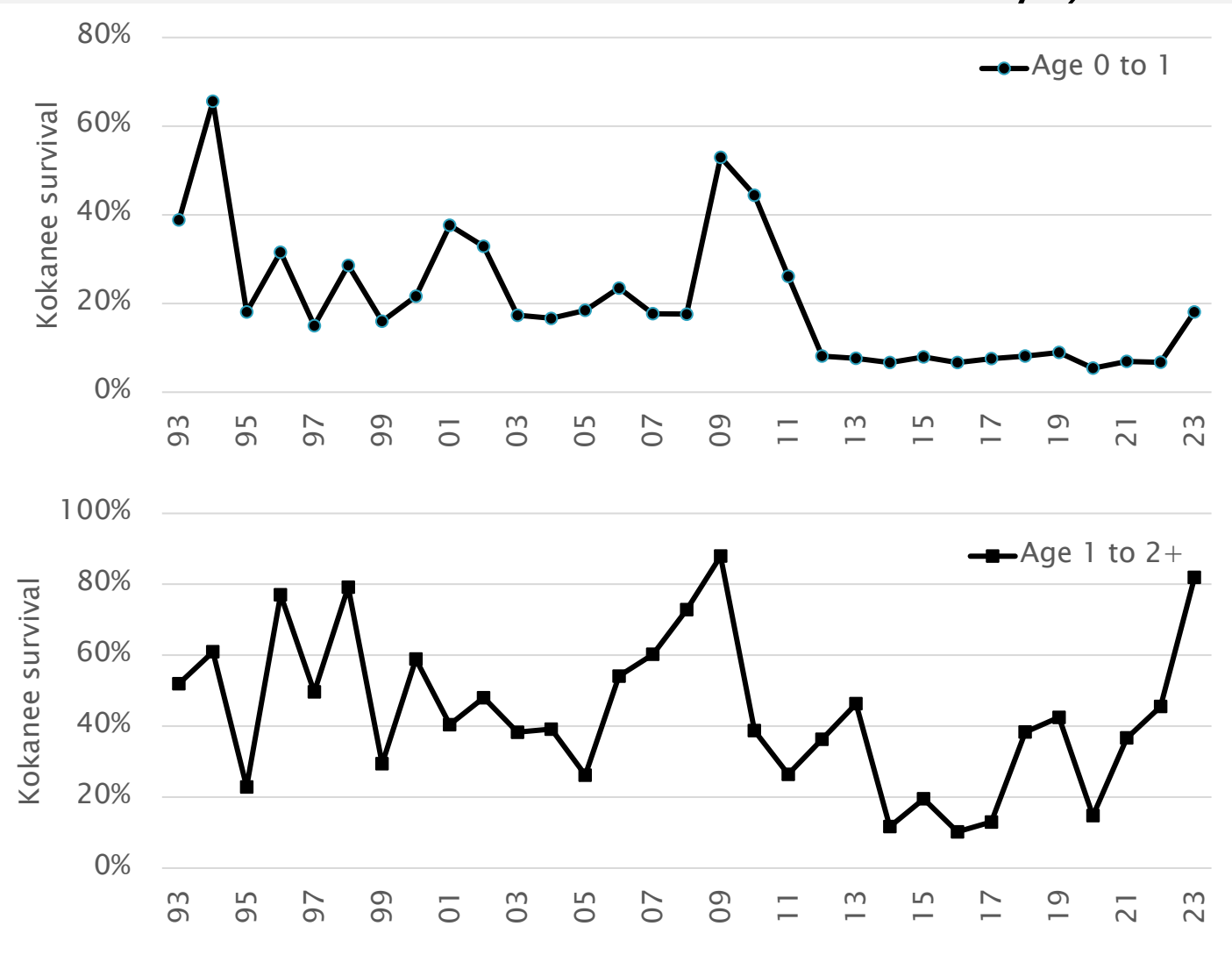
2023 data are preliminary.

Kokanee Biomass



2023 data are preliminary.

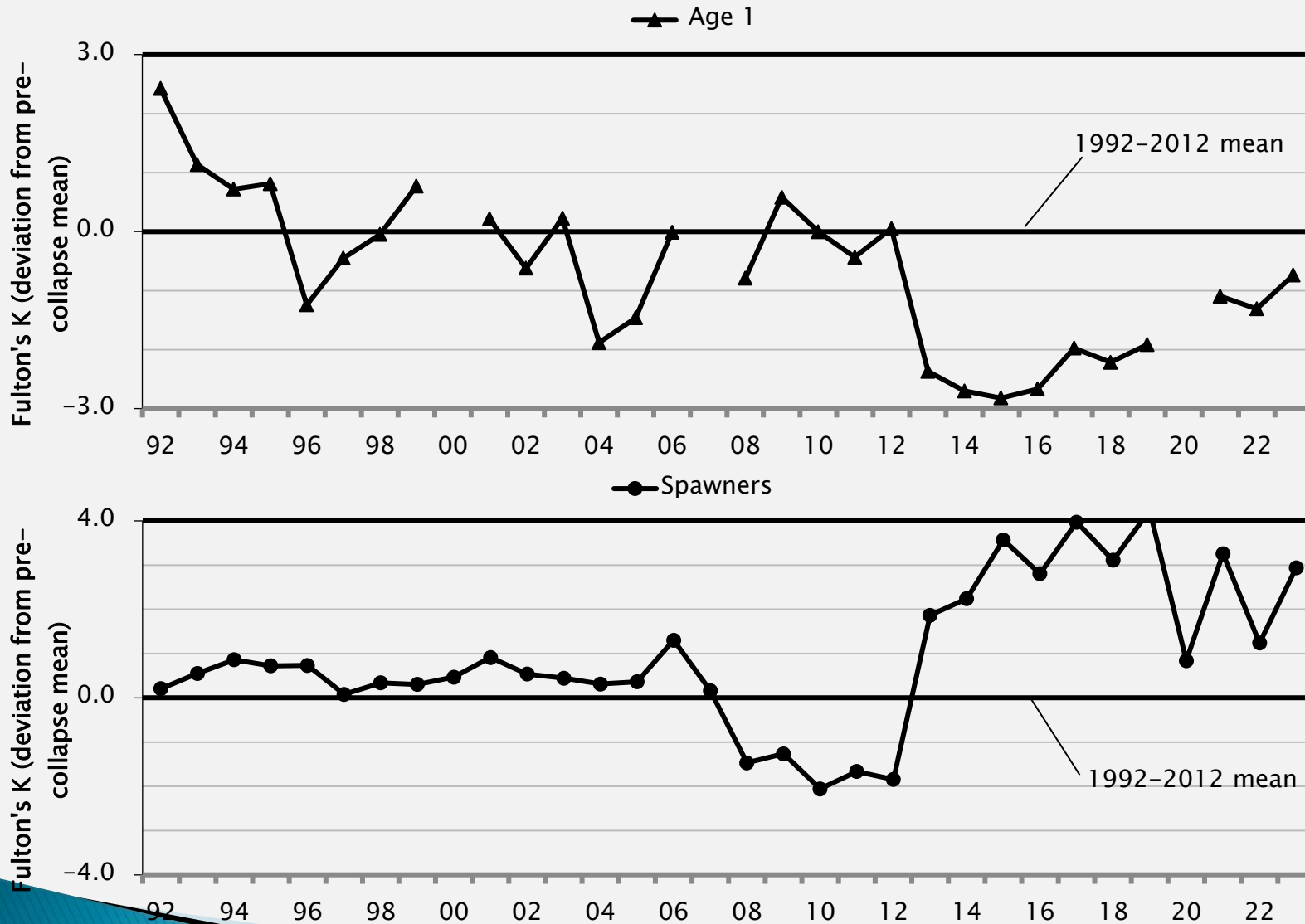
Kokanee cohort survival (September acoustic surveys)



- Egg to fall fry survival has been excellent through post-collapse period

2023 data are preliminary.

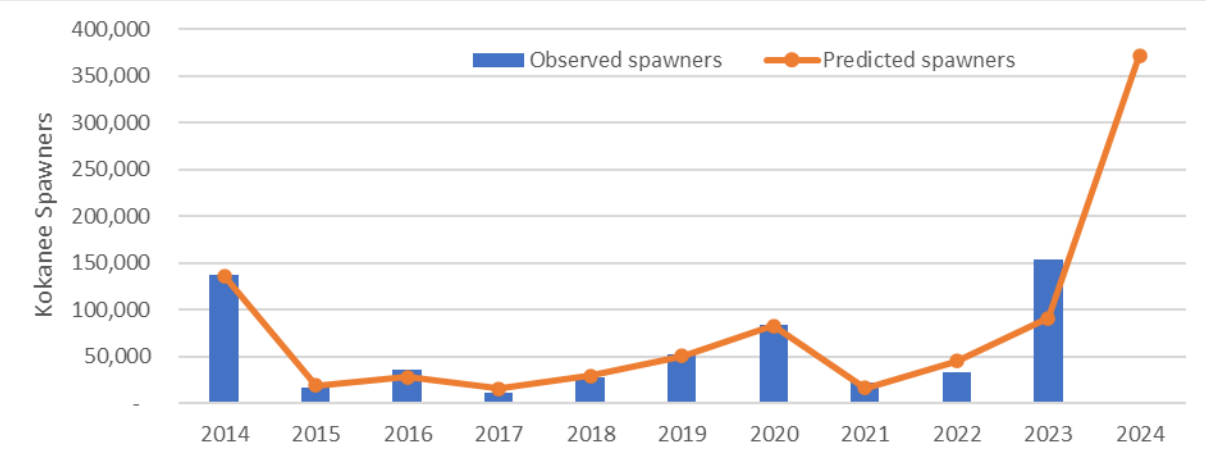
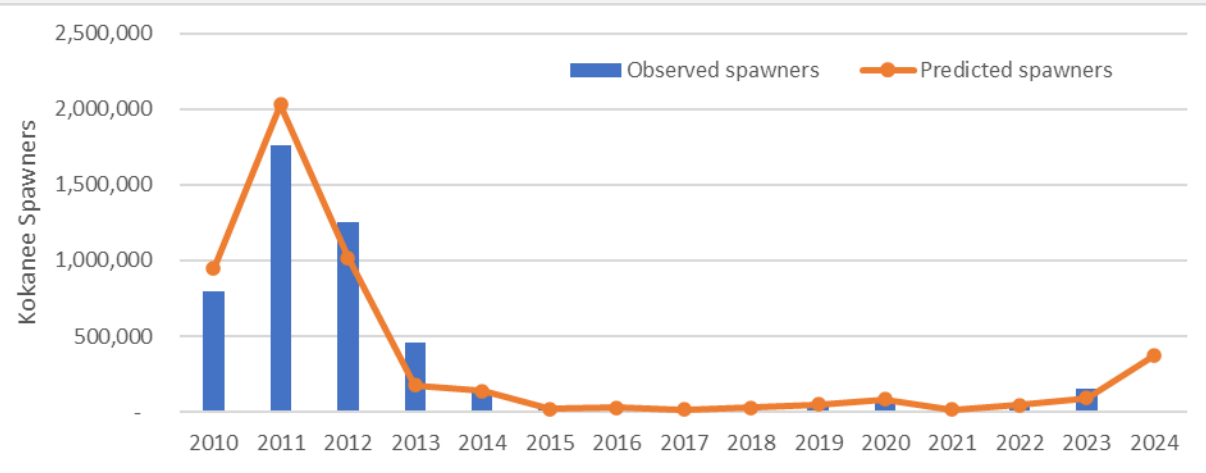
Kokanee condition



- Age 1 were small with a low condition factor during the post-collapse period.
- Age 0 condition trend continued to improve in 2023 and is well within the pre-collapse range.
- The spawner condition trend demonstrates the expected response to abundant zooplankton post-collapse.

2023 data are preliminary.

Kokanee 2023 spawner forecast

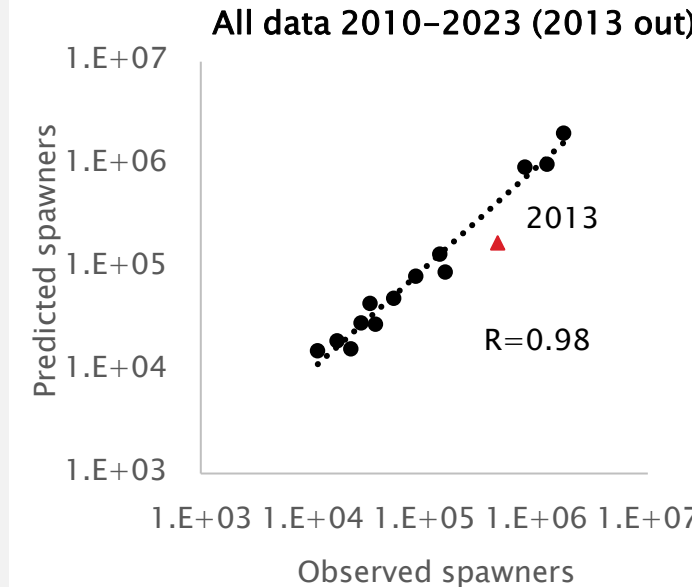
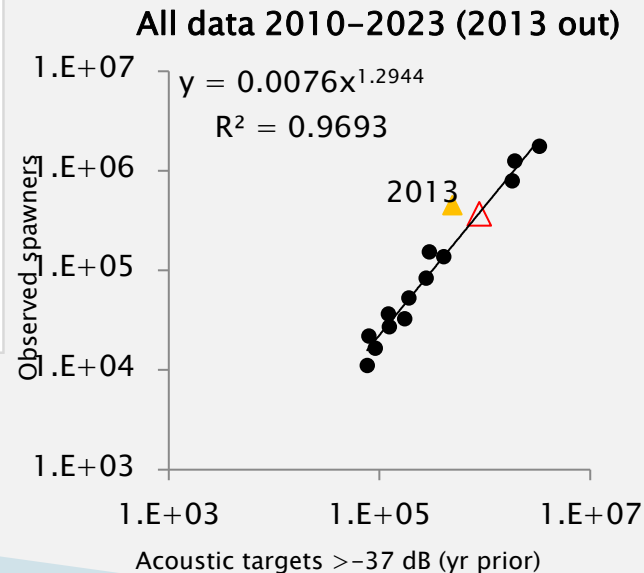


2023 data are preliminary.

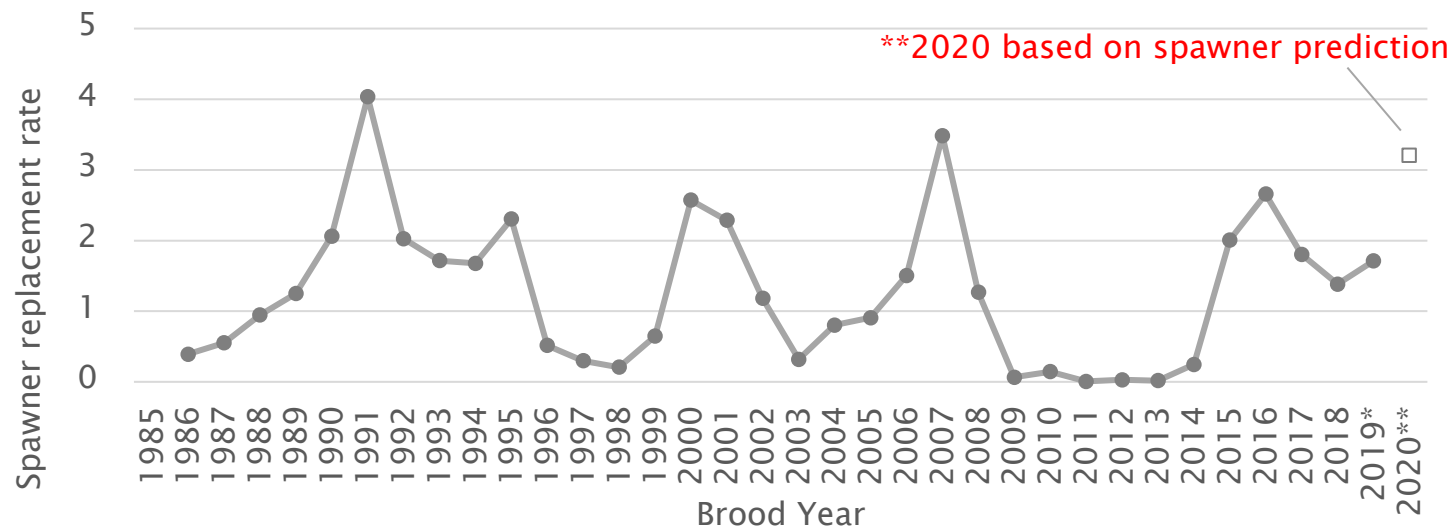
Sp yr	Acoustic # (yr prior)	Spawners*		Pred/Obs
		Observed	Predicted	
2010	1,817,987	794,054	947,680	119%
2011	3,273,665	1,764,100	2,028,965	115%
2012	1,920,997	1,255,843	1,017,751	81%
2013	491,807	453,592	174,494	38%
2014	406,284	137,772	136,270	99%
2015	90,751	16,617	19,582	118%
2016	121,052	36,462	28,431	78%
2017	76,242	11,090	15,629	141%
2018	123,738	27,198	29,251	108%
2019	189,415	53,117	50,753	96%
2020	276,838	83,787	82,941	99%
2021	78,971	22,044	16,357	74%
2022	172,876	32,670	45,092	138%
2023	297,228	153,673	90,932	59%
2024	882,064		371,658	

Average - 97%
SD - 29%

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



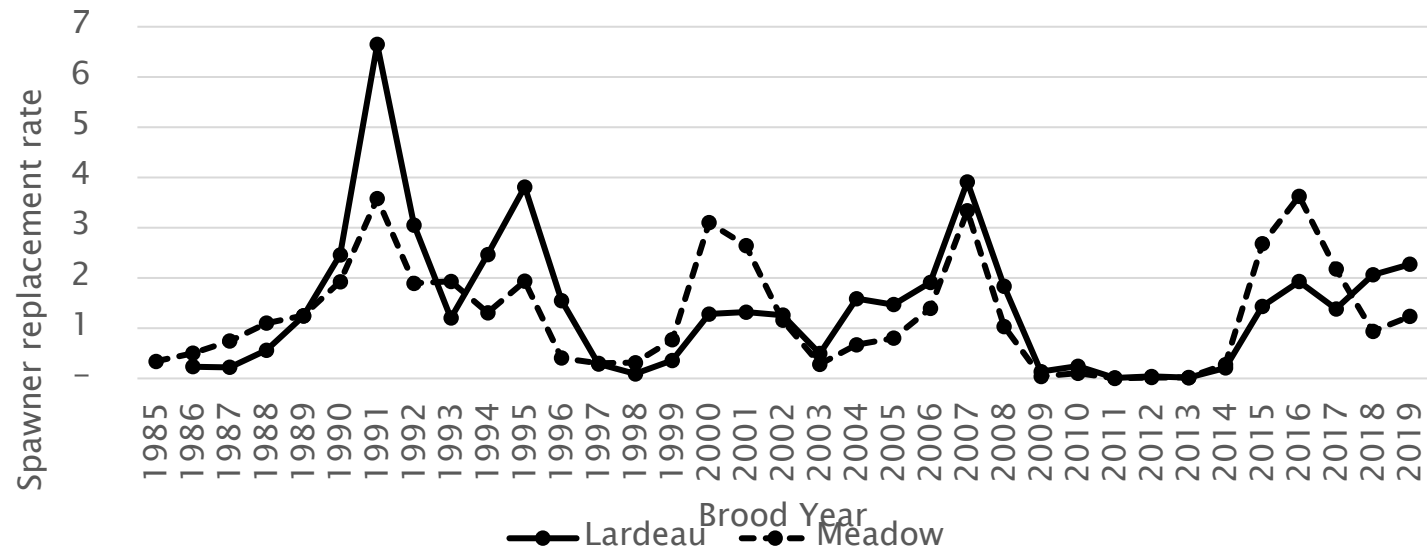
Kokanee spawner replacement



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

Meadow replacement rate better than Lardeau for 2015–2017 BY's suggesting egg plants/fry stocking played a role improving Meadow returns. The trend has since shifted for 2018 & 19 BY's.

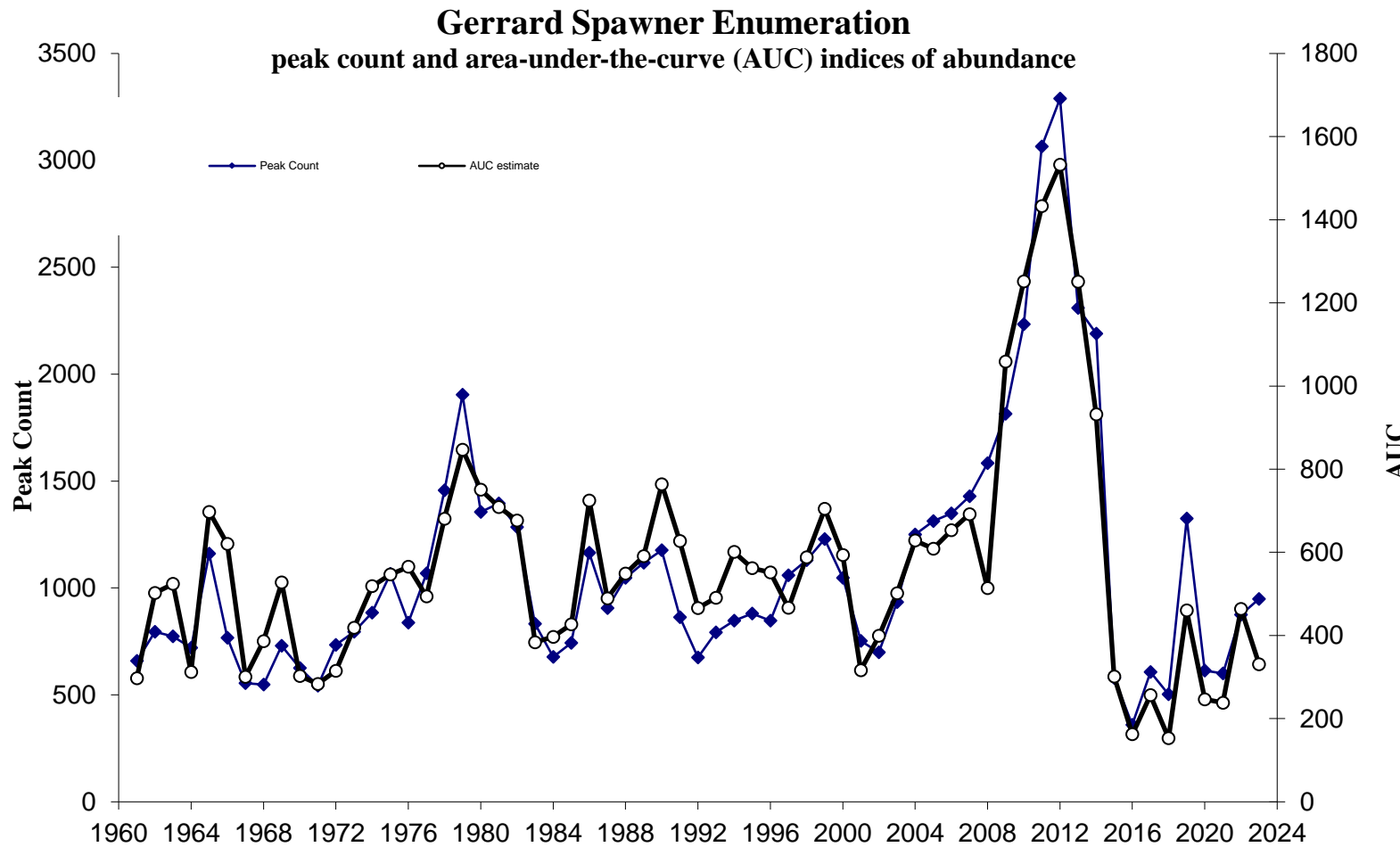
No 2020 estimates by tributary (cannot predict tributary specific estimates).



*2019 BY estimates do not include 2024 age 4 component

**2020 BY estimate based on 2024 spawner forecast and 2023 spawner age structure estimates.

Gerrard Spawner Escapement



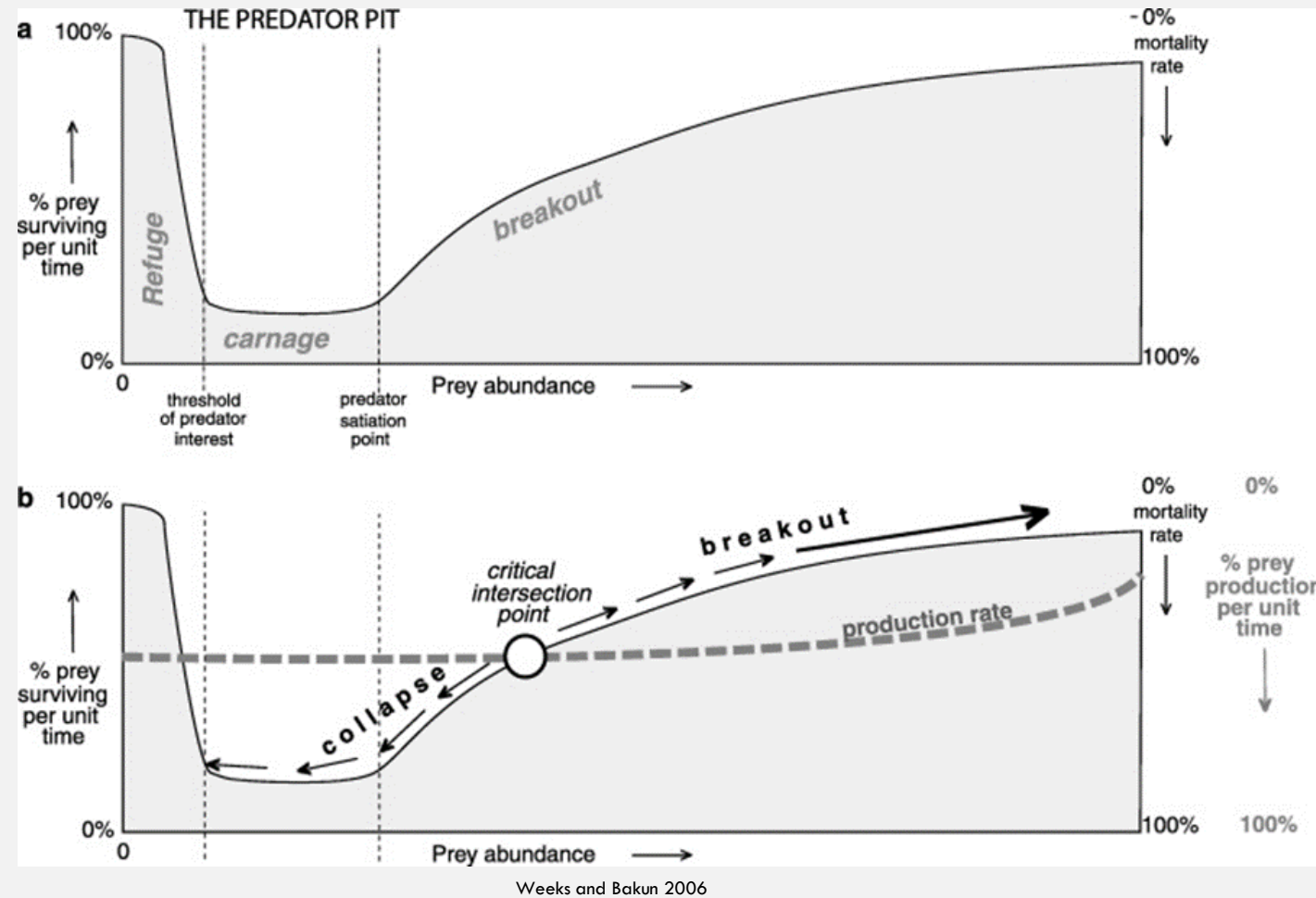
- ▶ AUC estimate = 331
- ▶ Avg spawner size = 55 cm (increasing since 2021)
- ▶ 2022 spawner age = 4.9 (decreasing?)

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		4.9	34	Angling/Tanglenetting
2023	54			441	Angling/Tanglenetting/Gillnetting

Predator Monitoring & Research

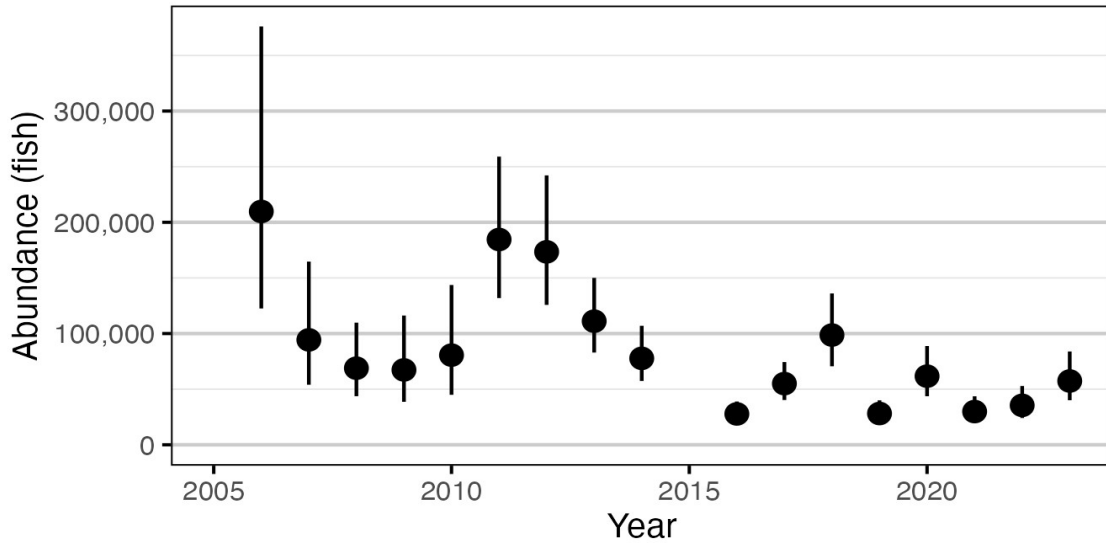
Greg Andrusak, RPBio

provincial Rivers management Biologist (MOF)



Age 1 & 2 Recruits (abundance)

Age 1



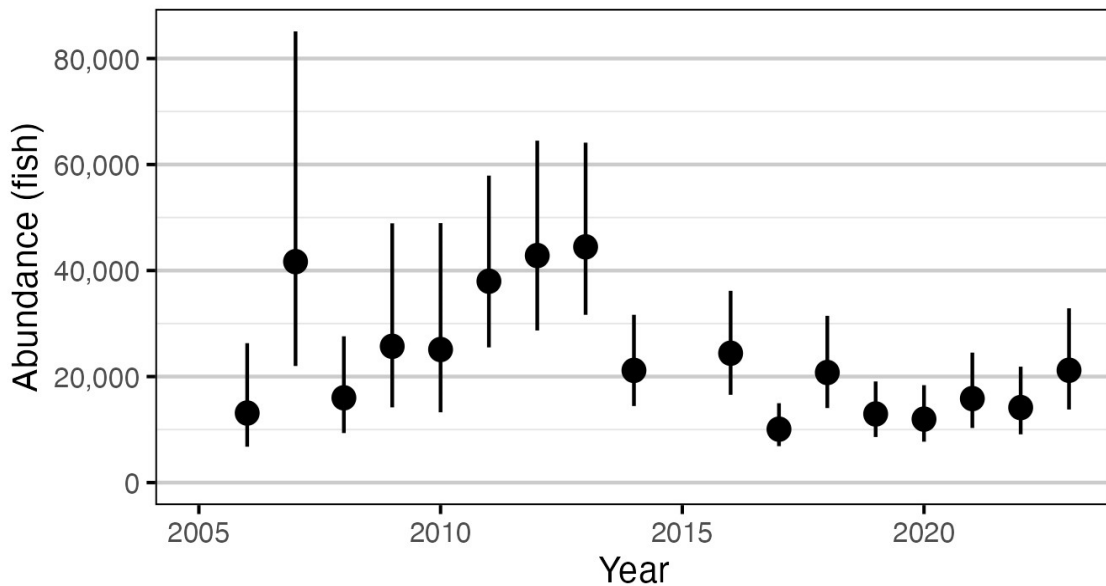
Age 1 (95% CRI)

Year	estimate	lower	upper
2006	209,728	122,549	376,050
2007	94,320	53,987	164,687
2008	68,869	43,679	109,785
2009	67,304	38,644	116,182
2010	80,605	44,944	143,645
2011	184,536	131,885	259,044
2012	173,446	125,764	242,165
2013	111,117	82,920	150,051
2014	77,707	57,388	106,966
2016	27,757	19,866	38,897
2017	55,002	40,256	74,363
2018	98,647	70,582	136,067
2019	28,130	19,811	39,967
2020	61,680	43,647	88,784
2021	29,868	20,601	43,591
2022	35,454	24,100	52,846
2023	57,341	40,049	83,885

Age 2 (95% CRI)

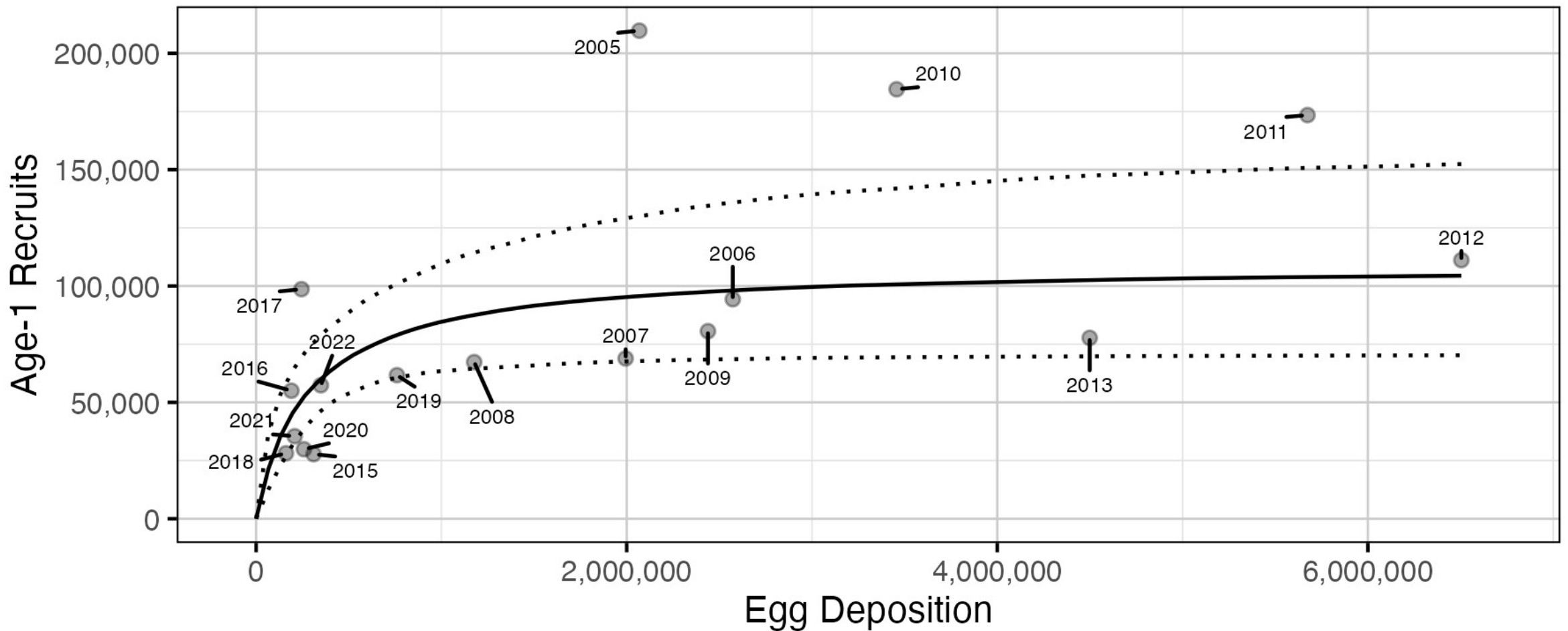
Year	estimate	lower	upper
2006	13,119	6,771	26,298
2007	41,674	21,994	85,112
2008	15,994	9,343	27,594
2009	25,708	14,190	48,906
2010	25,101	13,260	48,948
2011	37,988	25,505	57,908
2012	42,826	28,695	64,500
2013	44,468	31,654	64,123
2014	21,167	14,443	31,654
2016	24,401	16,558	36,176
2017	10,076	6,872	14,972

Age 2

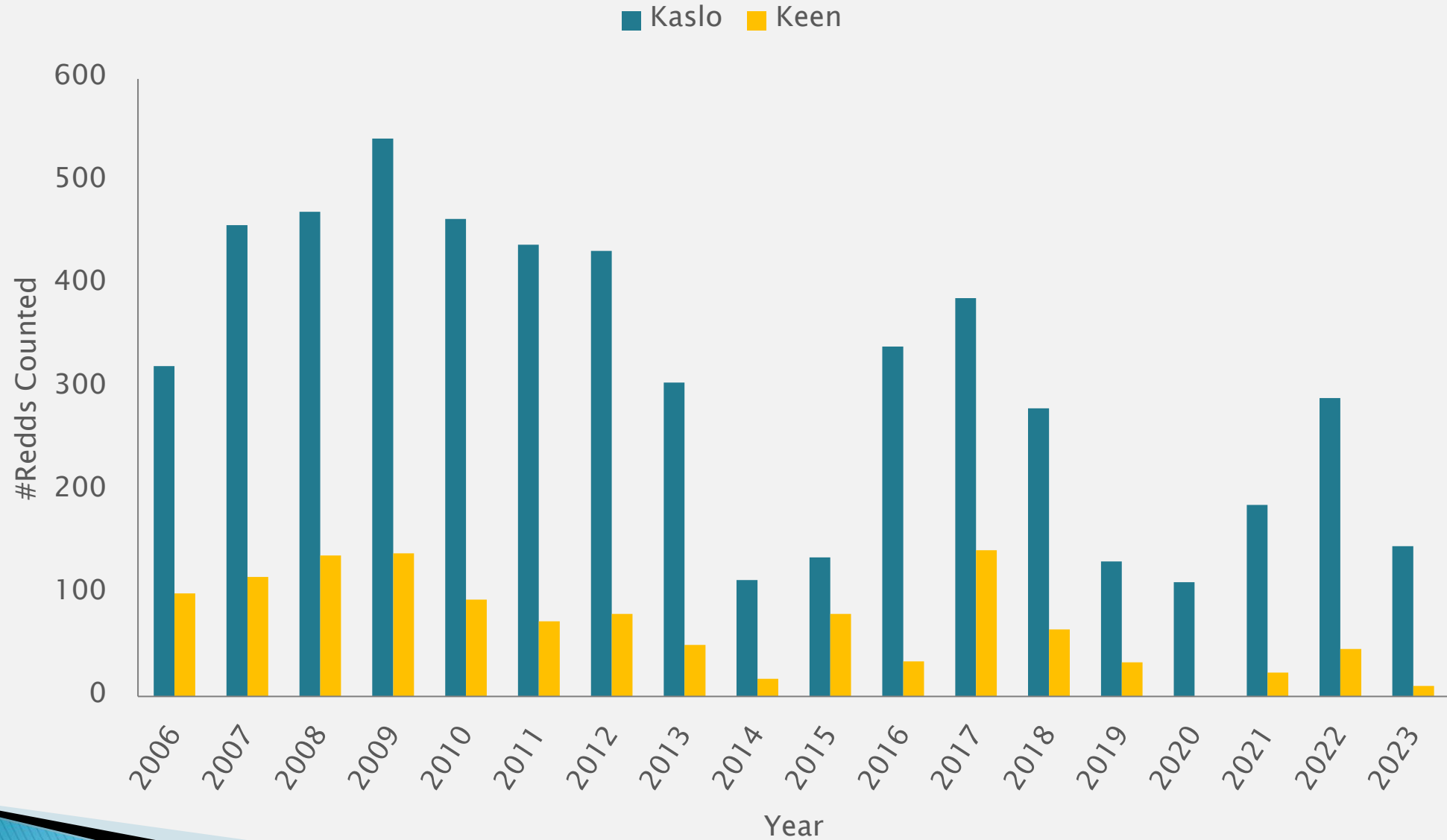


Gerrard Stock Recruitment

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



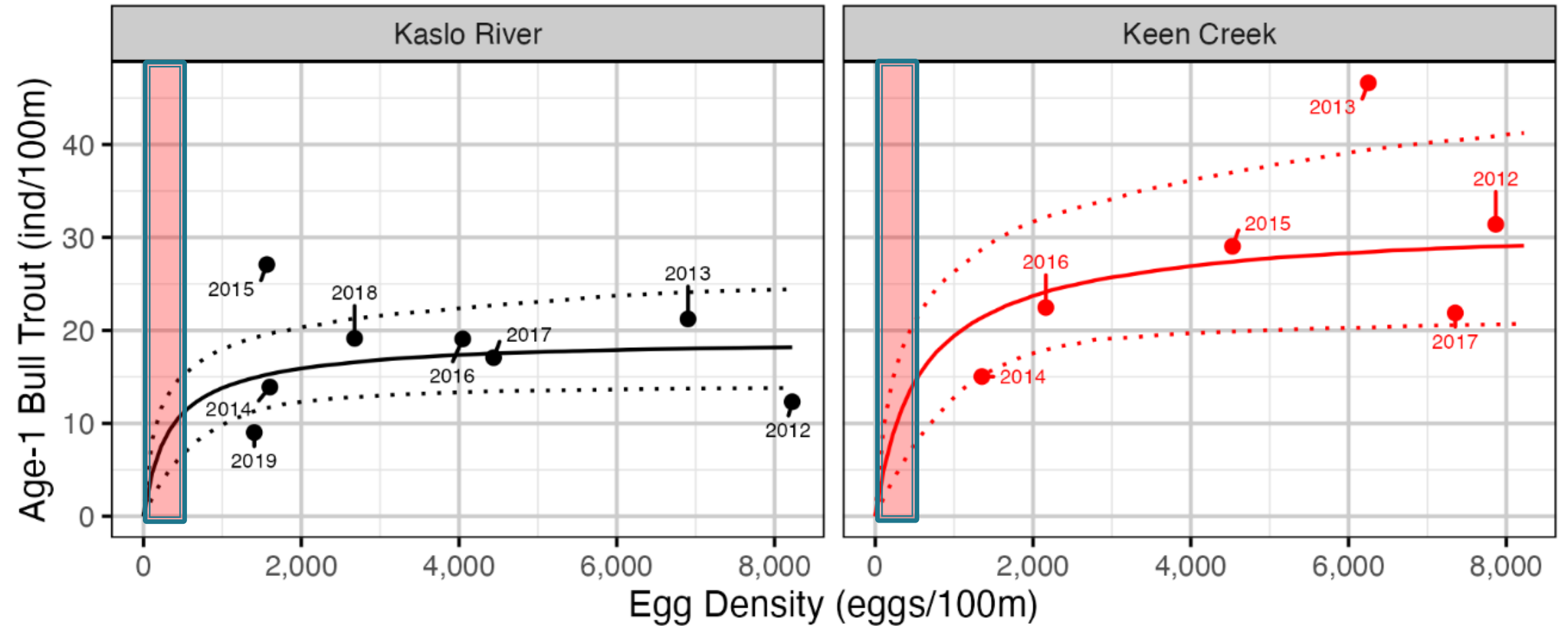
Kaslo River Redd Counts



KASLO BULL TROUT STOCK RECRUITMENT

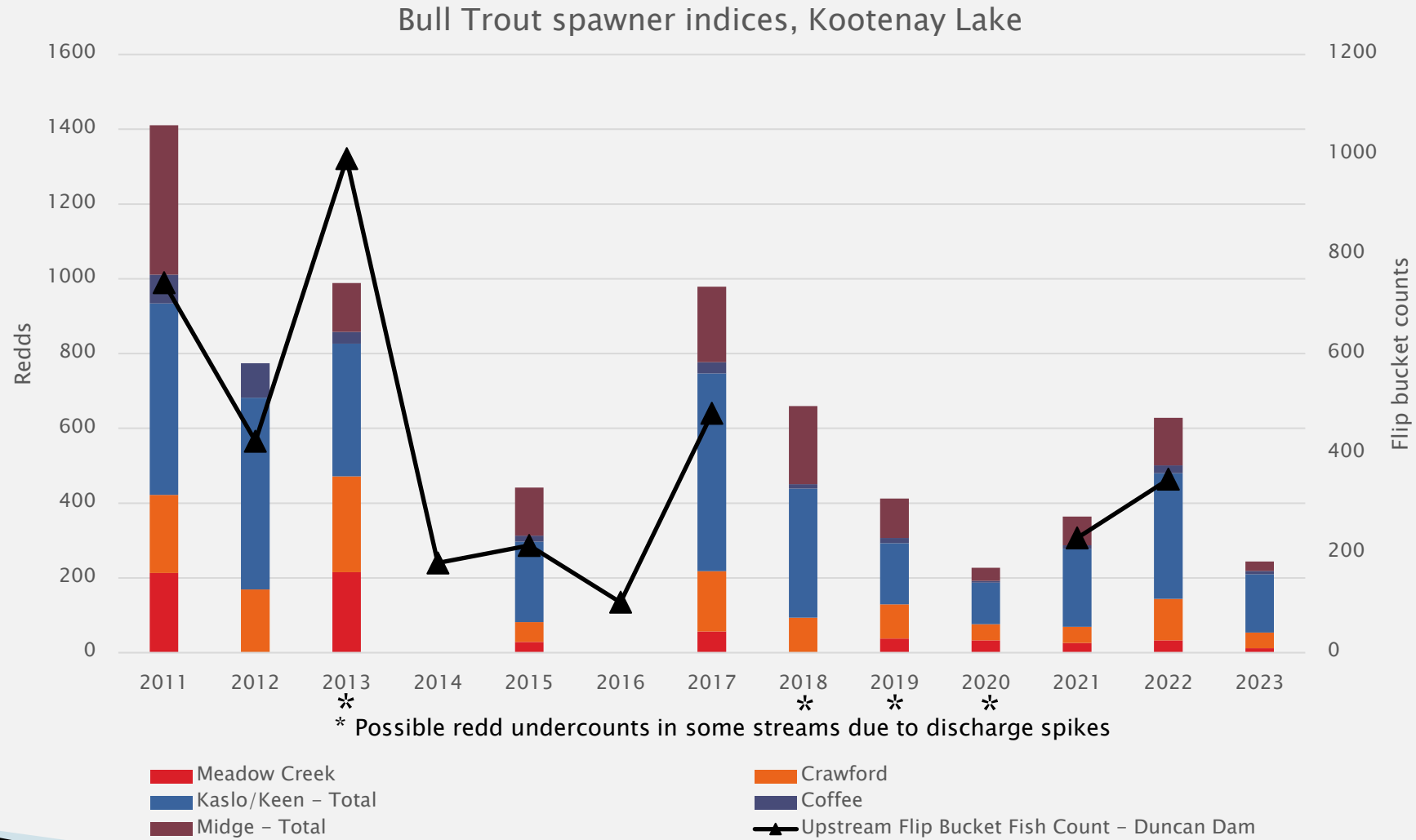
LRP=532 eggs/100m for Kaslo River

LRP= 326 eggs/100m in Keen Creek

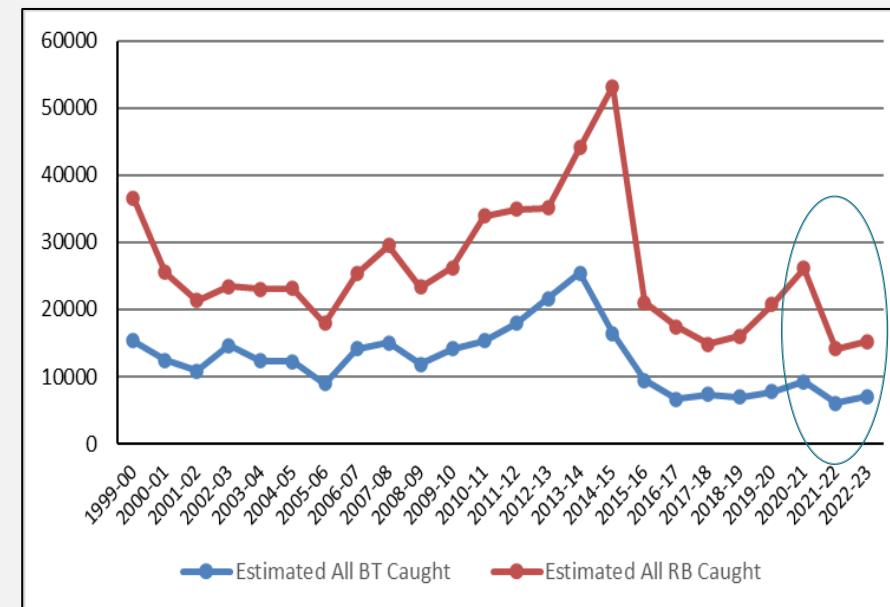
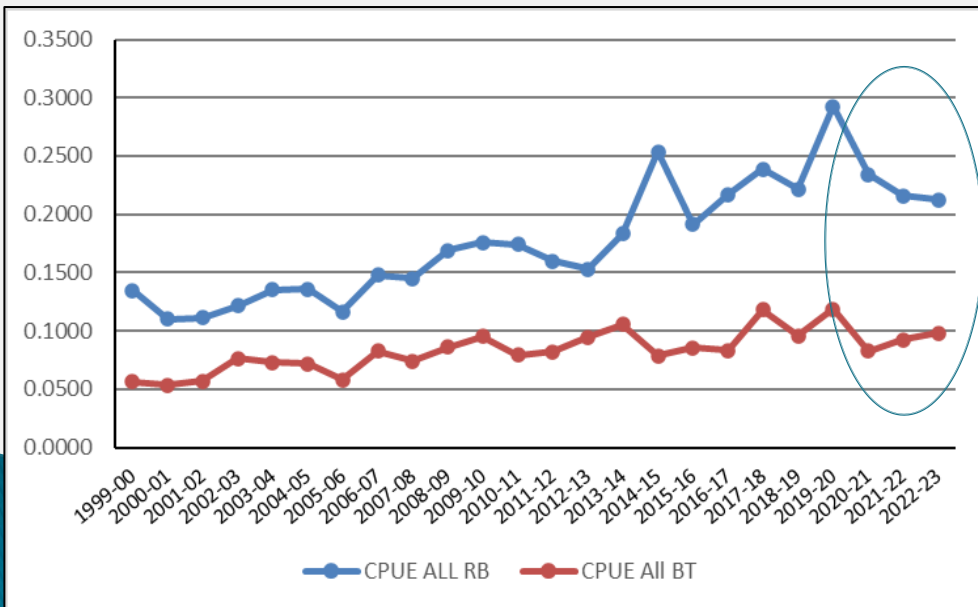
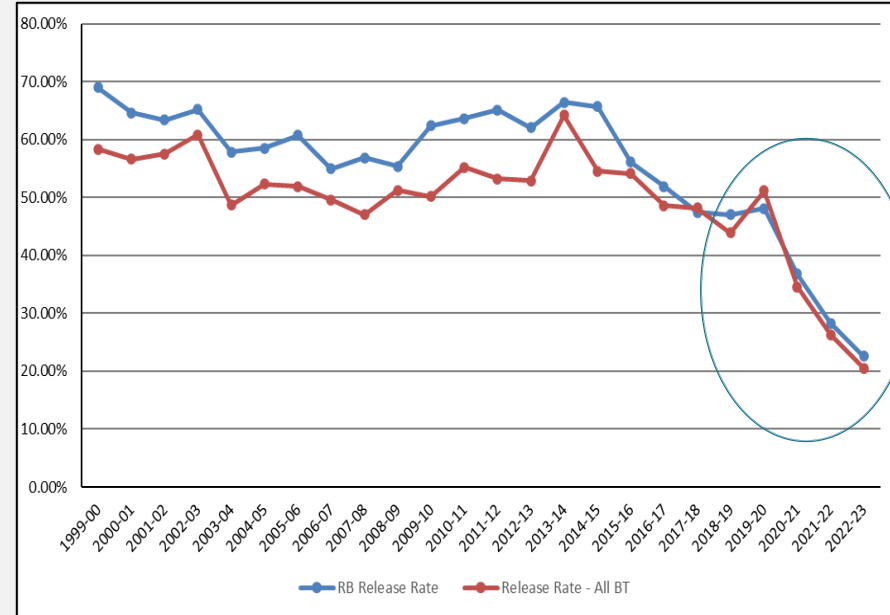
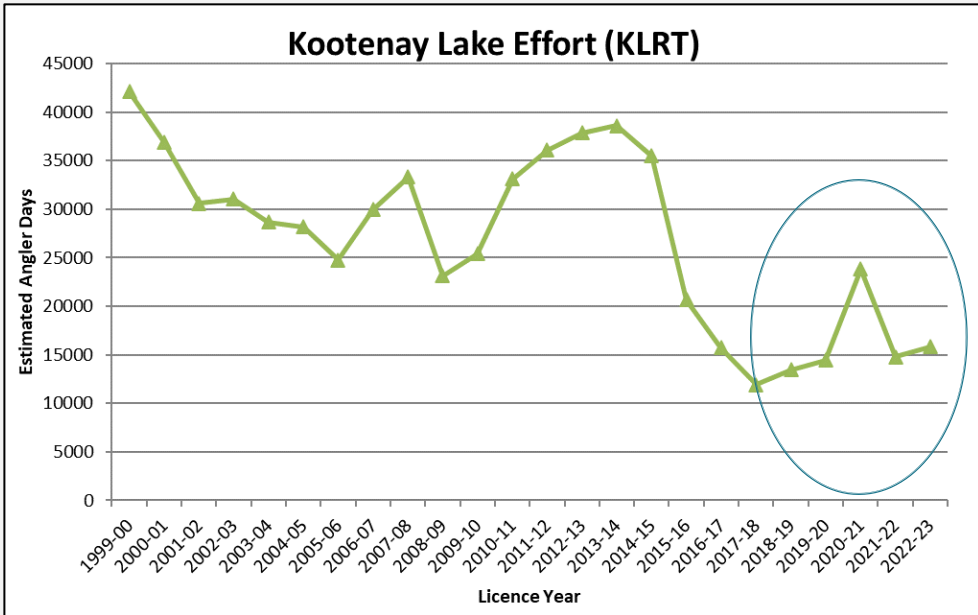


- LRP KASLO = 25 REDDS OR 55 FISH
- LRP LAKE WIDE = 125 REDDS OR 250 FISH

BT spawner abundance



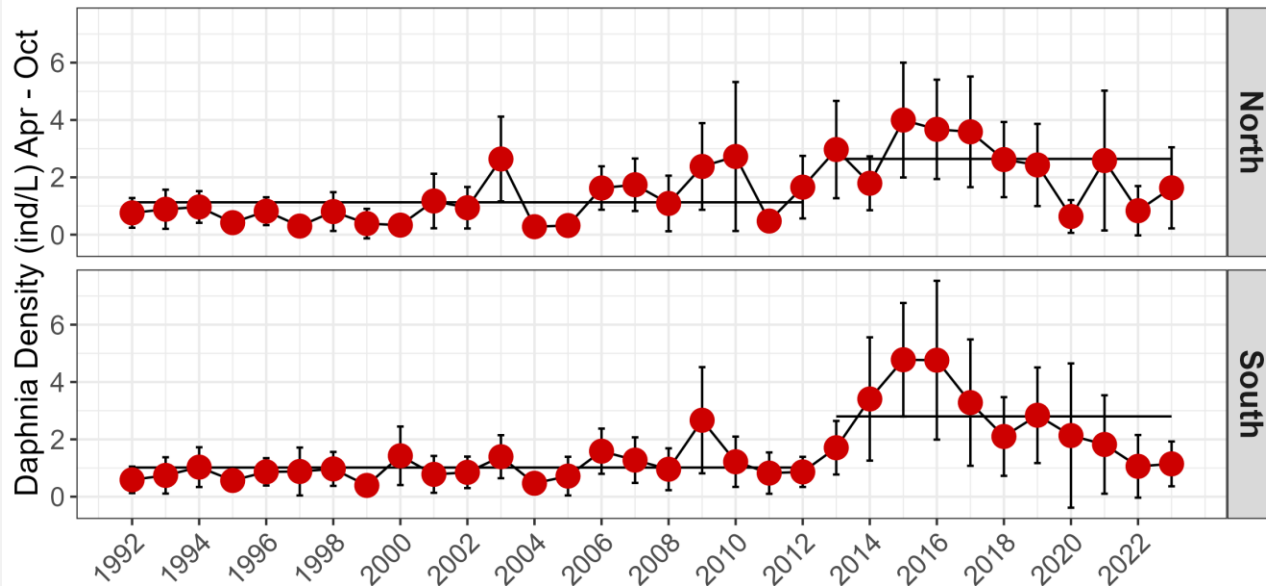
Fishery Trends– KLRT Creel



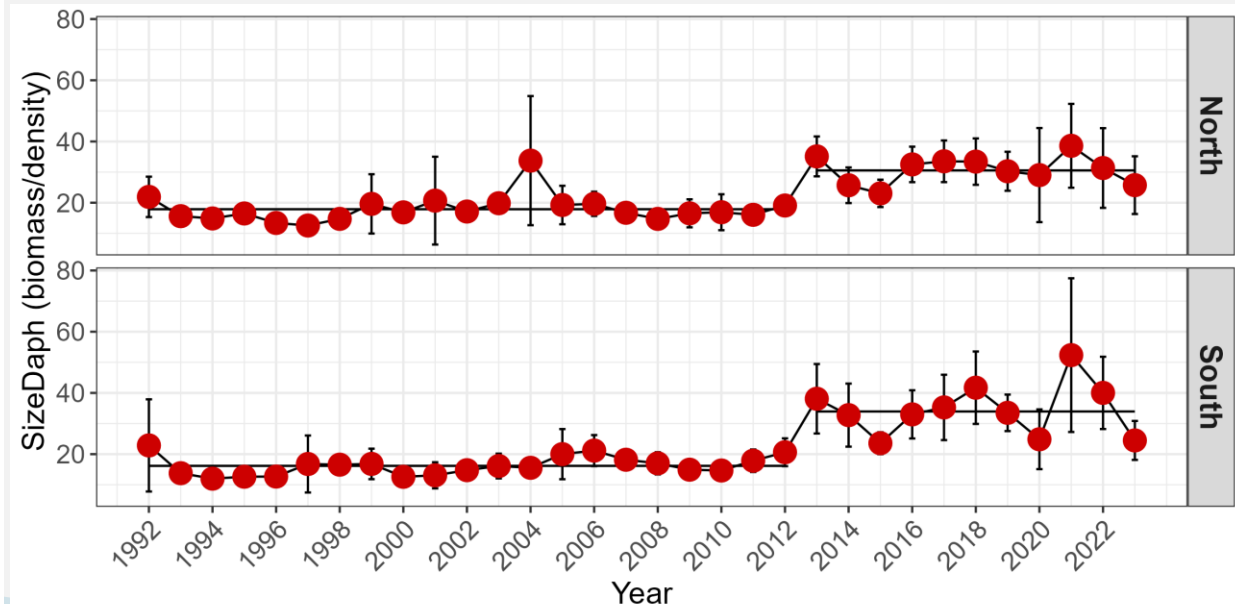
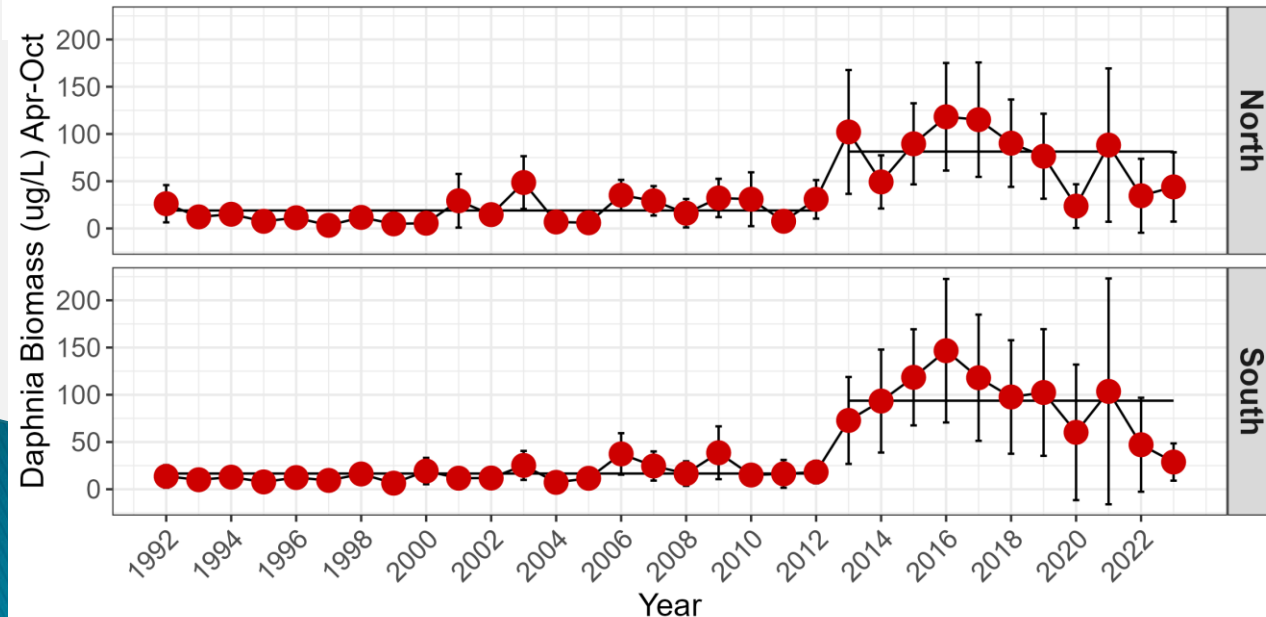
- ▶ Effort: trending up since 2018
- ▶ Release rates: consistent decline for both sp. since 2020
- ▶ CPUE: continued divergence between RB and BT CPUE since 2020
- ▶ Catch: slight increase in overall catch for both species in 2022-23

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

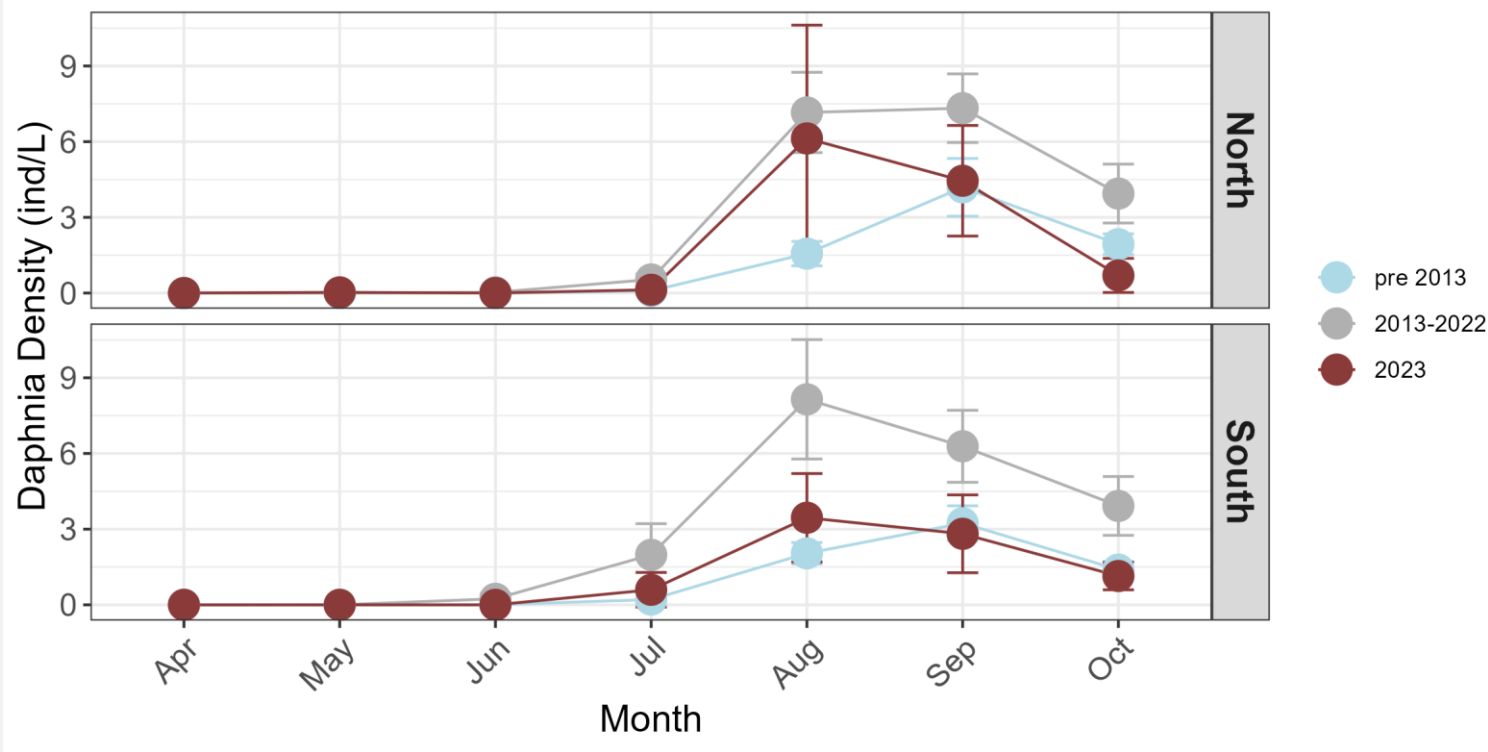
NRP Update - Daphnia Results



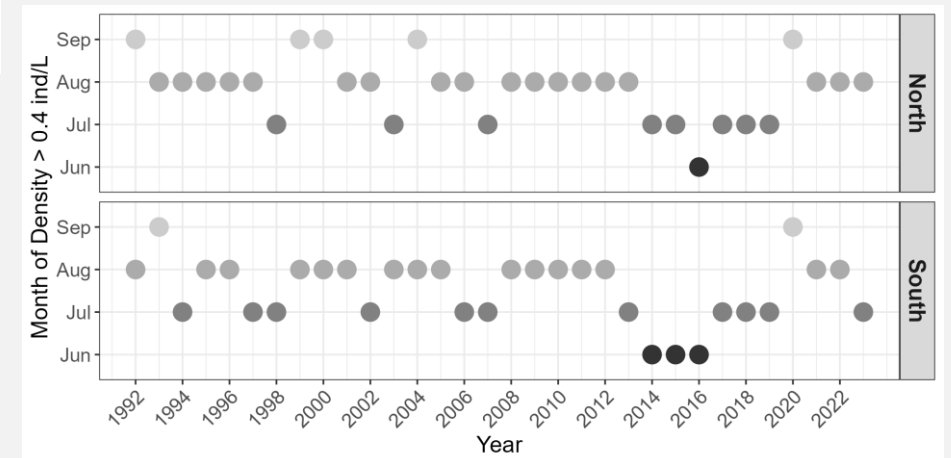
- Daphnia in 2023 was below average for both density and biomass for collapsed era
- Size of Daphnia below average for collapsed era
- Overall low daphnia response in 2023



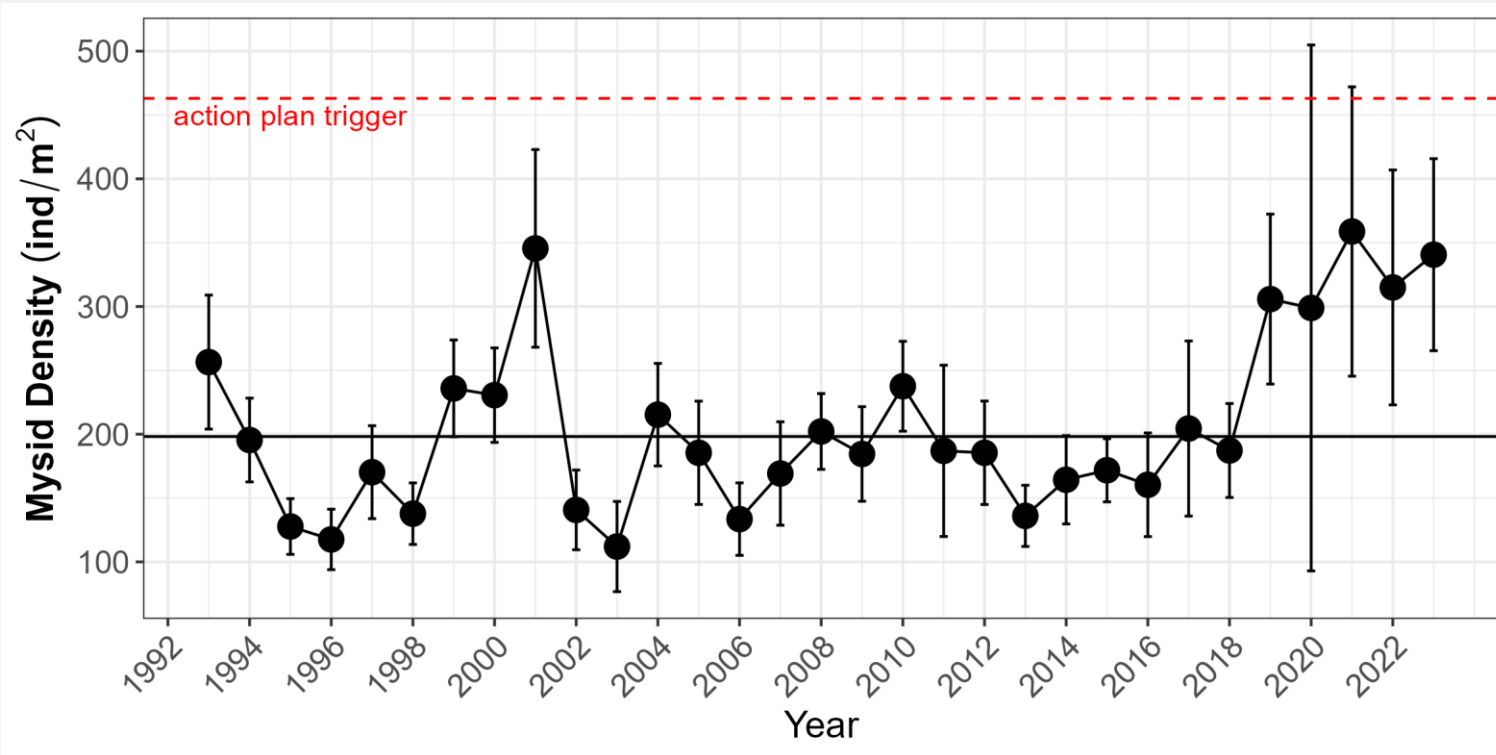
NRP Update - 2023 Daphnia Results



- ▶ Daphnia densities increased in July/Aug (typical seasonal pattern).
- ▶ Densities 0.4 ind/L were observed in Aug in the North Arm (average) and in July in the South Arm (earlier than average)
- ▶ Lower densities in 2023 likely not from climate conditions.
- ▶ Arrow Lakes Reservoir was above average Daphnia in 2023
- ▶ Indicates lower daphnia responding to increased grazing from Kokanee

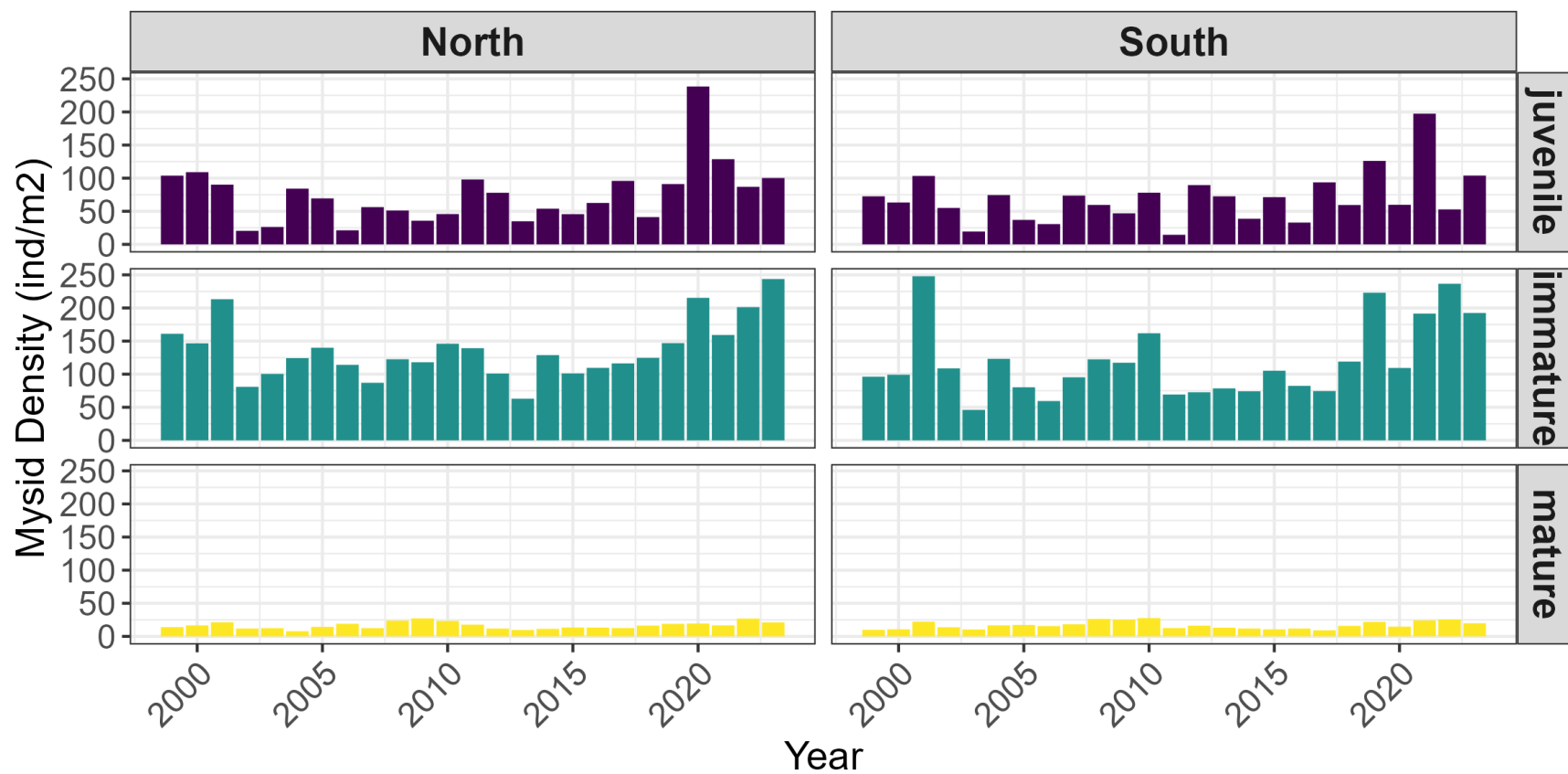


NRP Update – Mysids



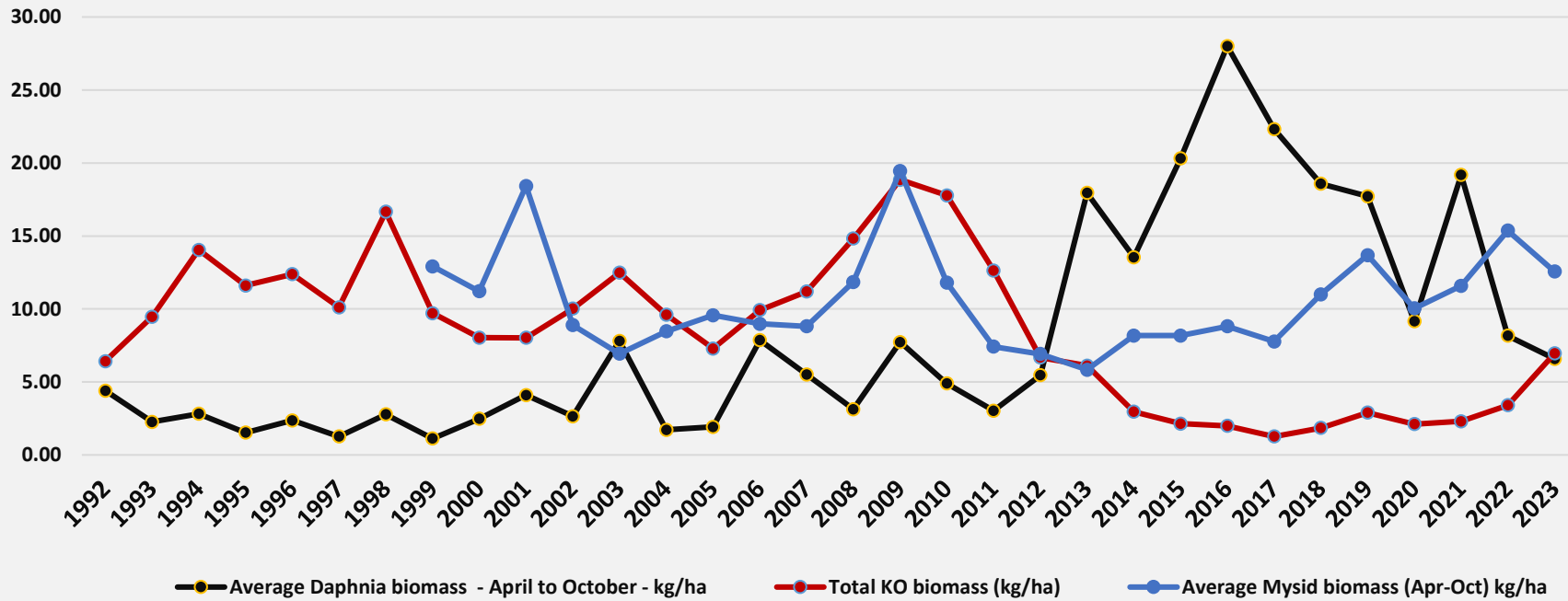
- ▶ Annual mean is still below threshold identified in Action Plan (Redfish, 2016)
- ▶ Mysid densities have been above long-term average since 2019

NRP Update – Mysids by developmental stage

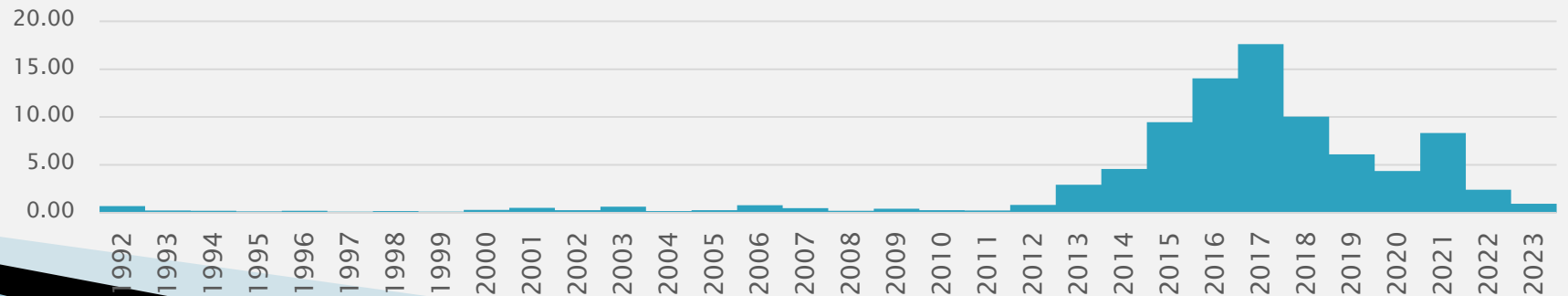


<u>Mysid mean size and range (mm) for each developmental stage</u>		
	mean	range
Juvenile	4 mm	3-6 mm
Immature	11 mm	8-15 mm
Mature	14 mm	10-17 mm

NRP Update - Daphnia, Mysid and Kokanee Annual Trends



Ratio Daphnia/Kokanee biomass



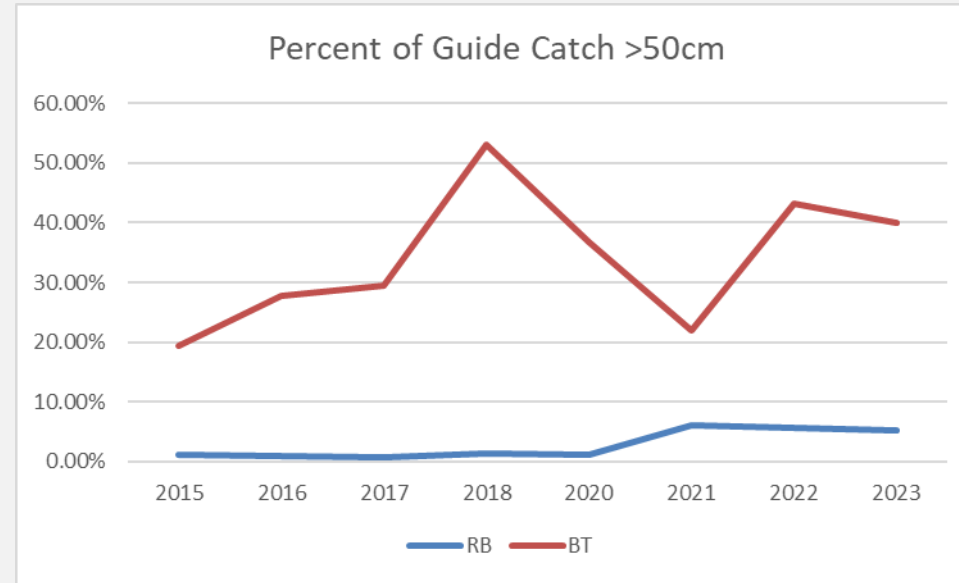
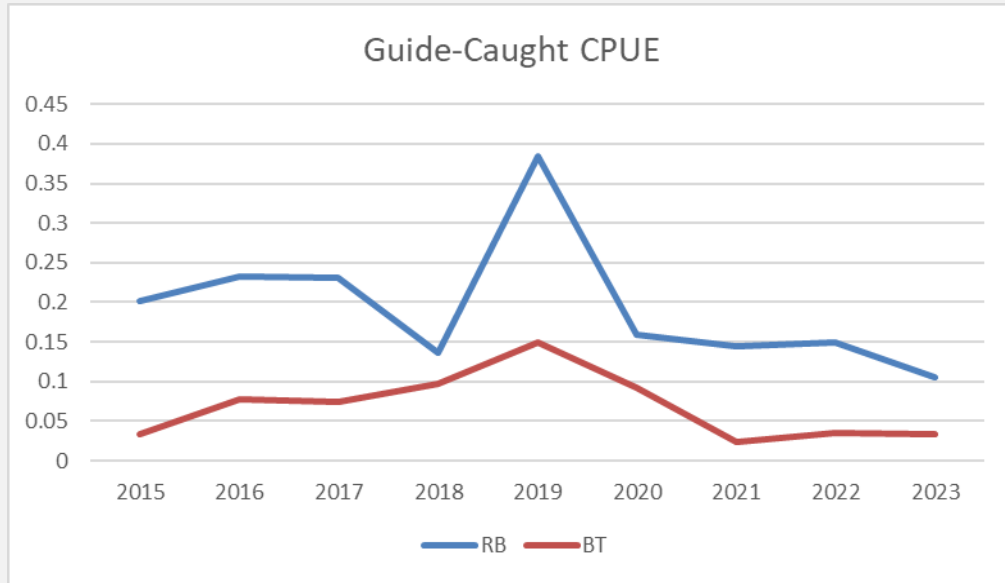
2023 Implementation and Key Questions

Action Update: Nutrient Restoration Program

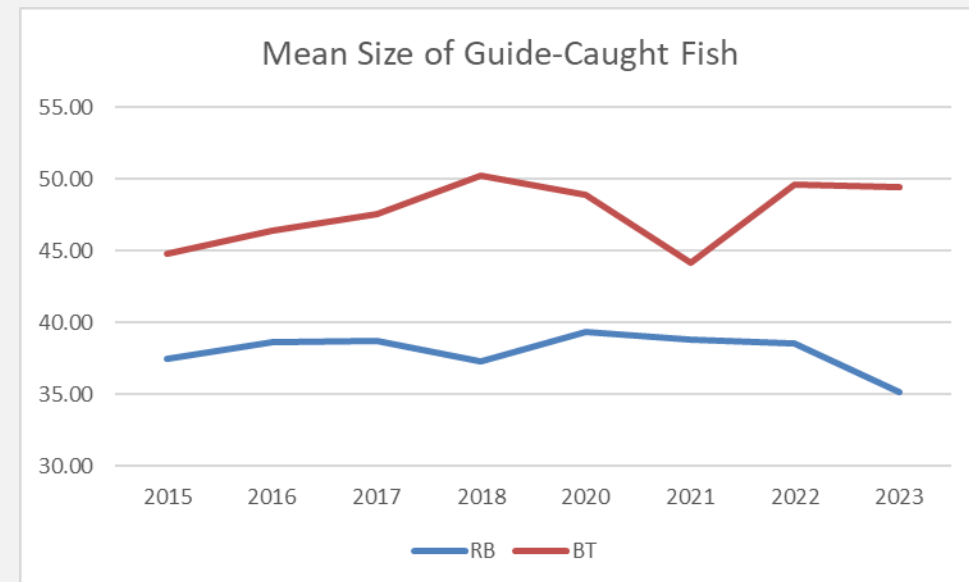
- ▶ South Arm NRP
 - No additions in 2023
- ▶ North Arm NRP
 - Continued in 2023



Piscivore Monitoring Update



- ▶ Piscivore Monitoring Program Results (preliminary: April–Oct 7, 2023, all other years include all months of sampling)
- ▶ 1812 RB and 362 BT removed since the beginning of the program
- ▶ CPUE unchanged for both species (slight decline RB)
- ▶ Average size: BT unchanged in 2023, slight decrease for RB
- ▶ % of RB/BT >50cm relatively unchanged in 2023
- ▶ KLAIE will provide additional data on catch rates and sizes with much higher sample size but data still forthcoming

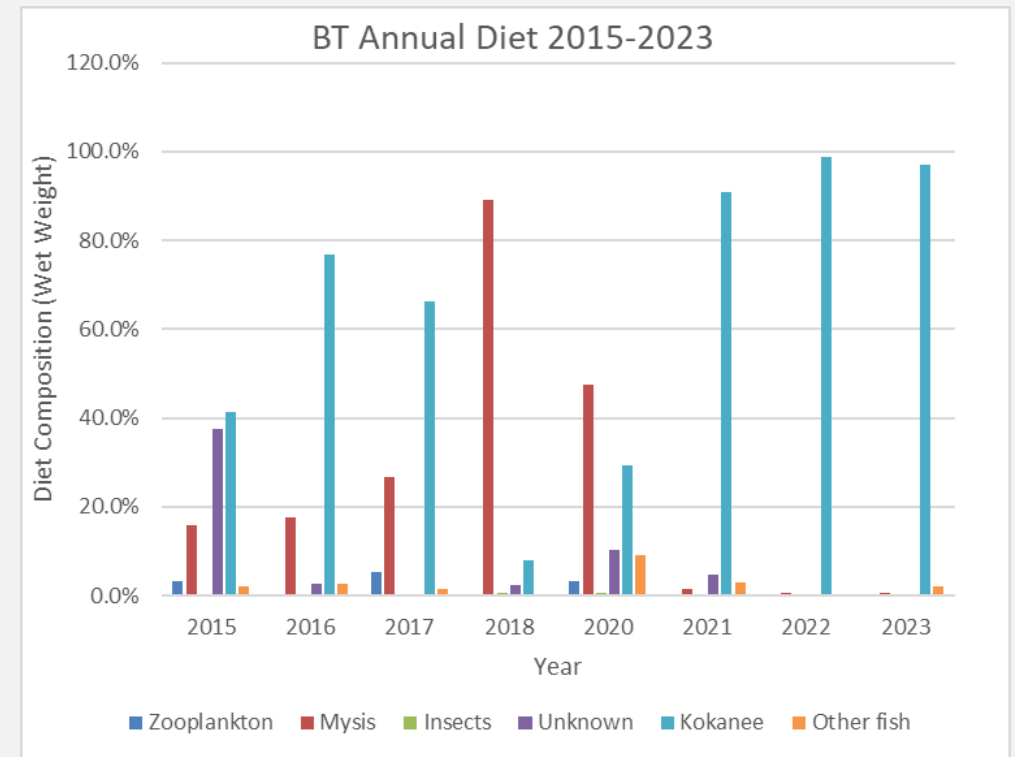
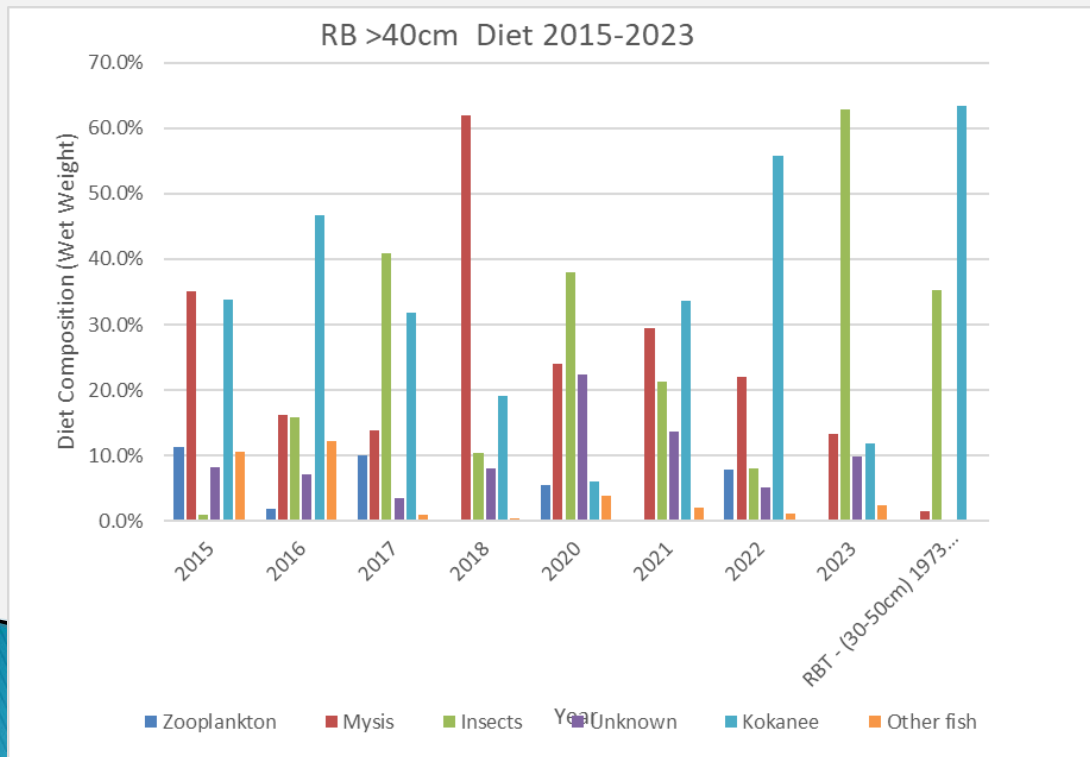


Piscivore Monitoring Update

Diet Sampling

Piscivore Monitoring Program Results (preliminary: April–Oct 7, 2023, all other years include all months of sampling)

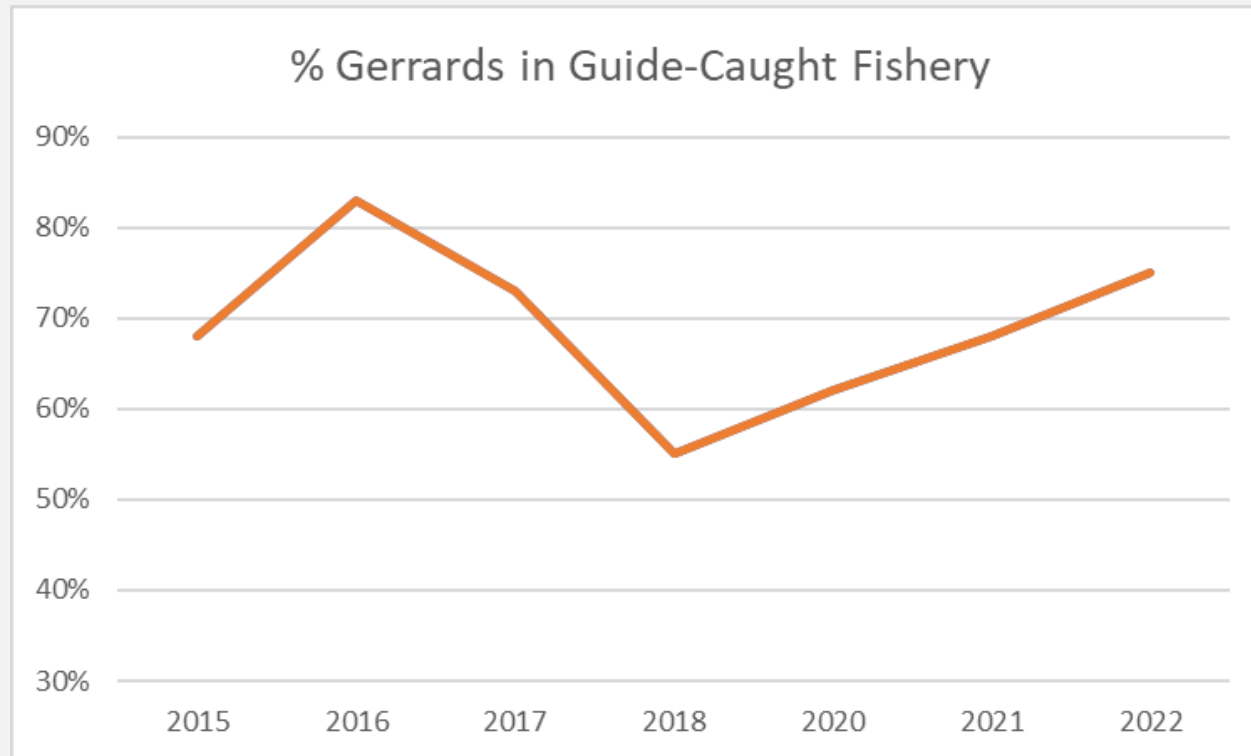
- Diet data suggests feeding conditions for BT are consistent w pre-collapse conditions in 2023 and over last three years; BT feeding almost exclusively on kokanee
- Diet data for RB >40cm in 2023 show lower kokanee composition relative to 2021–2022
*uncertainty n=26



Piscivore Monitoring Update

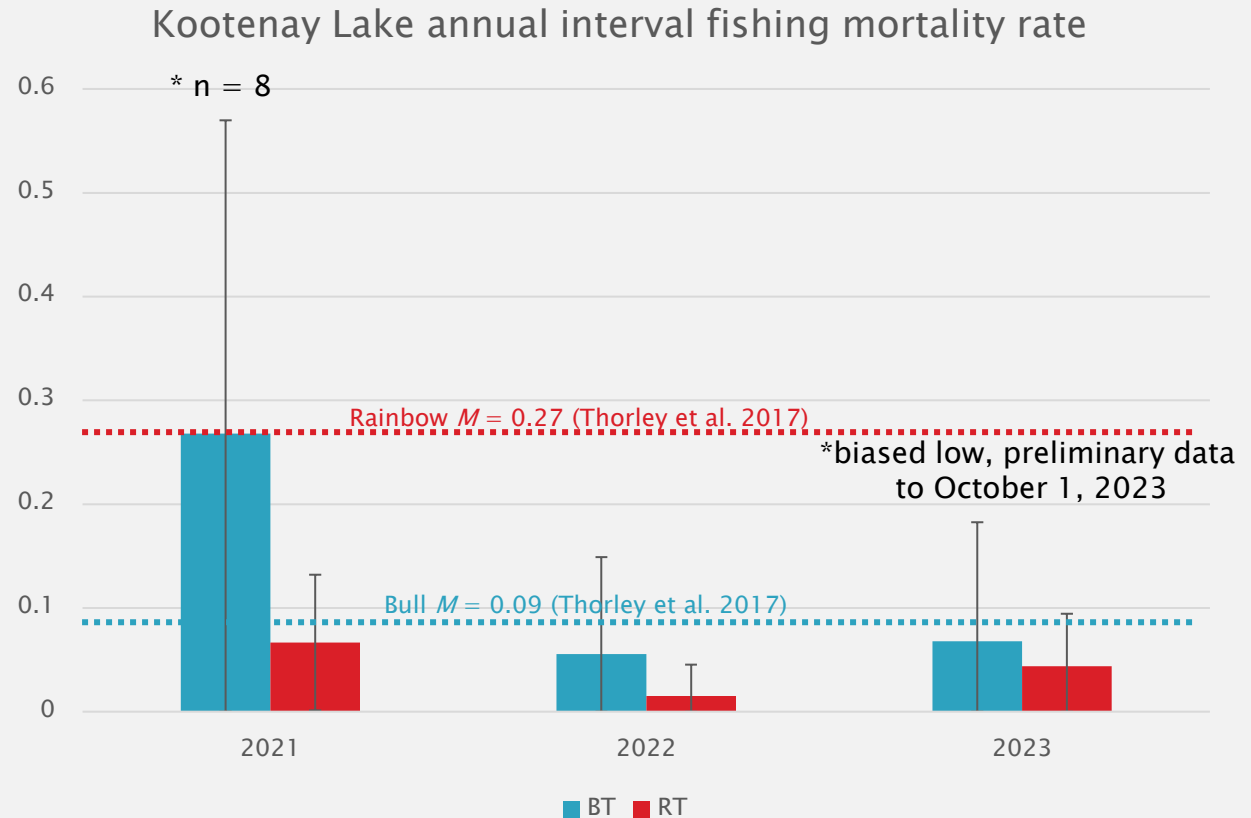
Genetics

- ▶ % Gerrards in fishery on upward trend since 2018
- ▶ 2023 data not available until March 2024 (in progress)



Piscivore Monitoring Update: Exploitation rates – data to date

- ▶ Since 2021, 41 Bull trout and 120 Rainbow trout have been tagged with high reward tags
- ▶ Annual exploitation estimates are trending a bit higher in 2023 than 2022, but difficult to determine with low sample size (especially for BT)
- ▶ Exploitation can be translated to fishing mortality; the rate will not impact recruitment for rainbow, but might for BT using a common fisheries management reference point ($F > M$)



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.

Key Question – Do we continue piscivore monitoring in 2024?

- ▶ Key data:
 - Catch rate, size, genetics (% Gerrard), age structure, diet composition, exploitation
 - Used for bioenergetics modeling
- ▶ 2023 data:
 - RB: catch rate declining, mean size declining, kokanee in diet proportions declining
 - BT: catch rate and mean size unchanged, continued high kokanee diet proportions since 2021
 - Genetics: upward trend in % Gerrard since 2018
 - Exploitation: exploitation estimates trending higher for both species, possible recruitment effects for BT
- ▶ Some uncertainty in data due inter-annual seasonal sampling variation, small sample sizes, comparison of previous full year of data to preliminary data (2 mos left of sampling) in 2023
- ▶ Need for continuity for recovery period?

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 ~2.2 mil eggs into MCSC Oct 25/Nov 2/Nov 6(source: Columbia R at Fairmont+Hill)
- ▶ 280,000 eggs into Summit Ck (South Arm) on Oct 27

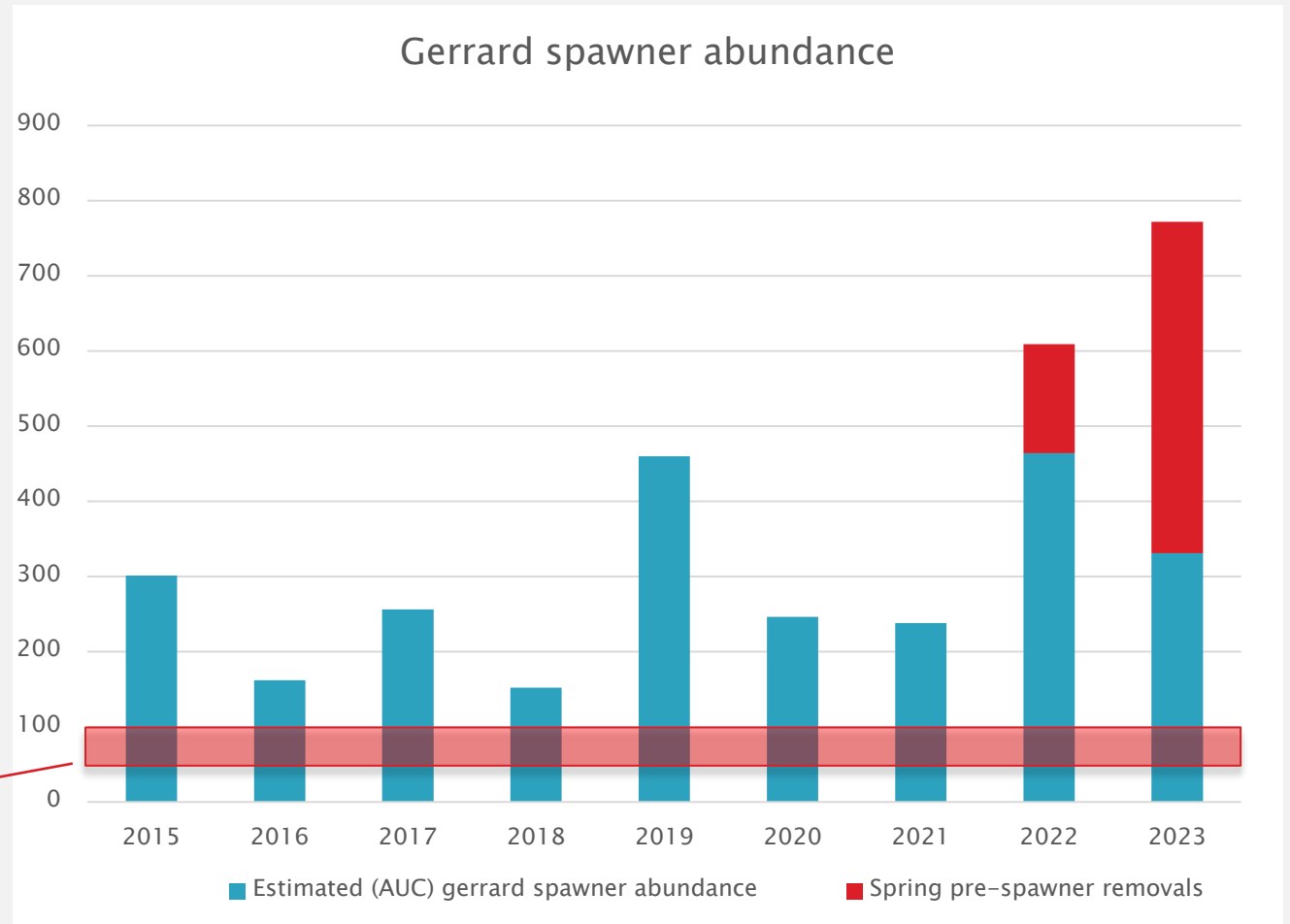


Key Question: Do we stock in 2024?

- ▶ 2024 spawner forecast is ~370k, 16% 0–1 survival
- ▶ Do we stock?
 - Action Plan: Trigger of 65,000–140,000 spawners, <11% 0–1 survival
 - Should we be looking at egg deposition instead?
- ▶ 55,923,742 eggs in 2024 based on forecast of 370k (assumes fecundity of $n=344$, $f=0.44$)*based on spawner density/FL, FL/fecundity relationship
- ▶ Creston Rod and Gun Club: Funding available to stock in 2024

Action Update: Predator Conservation

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



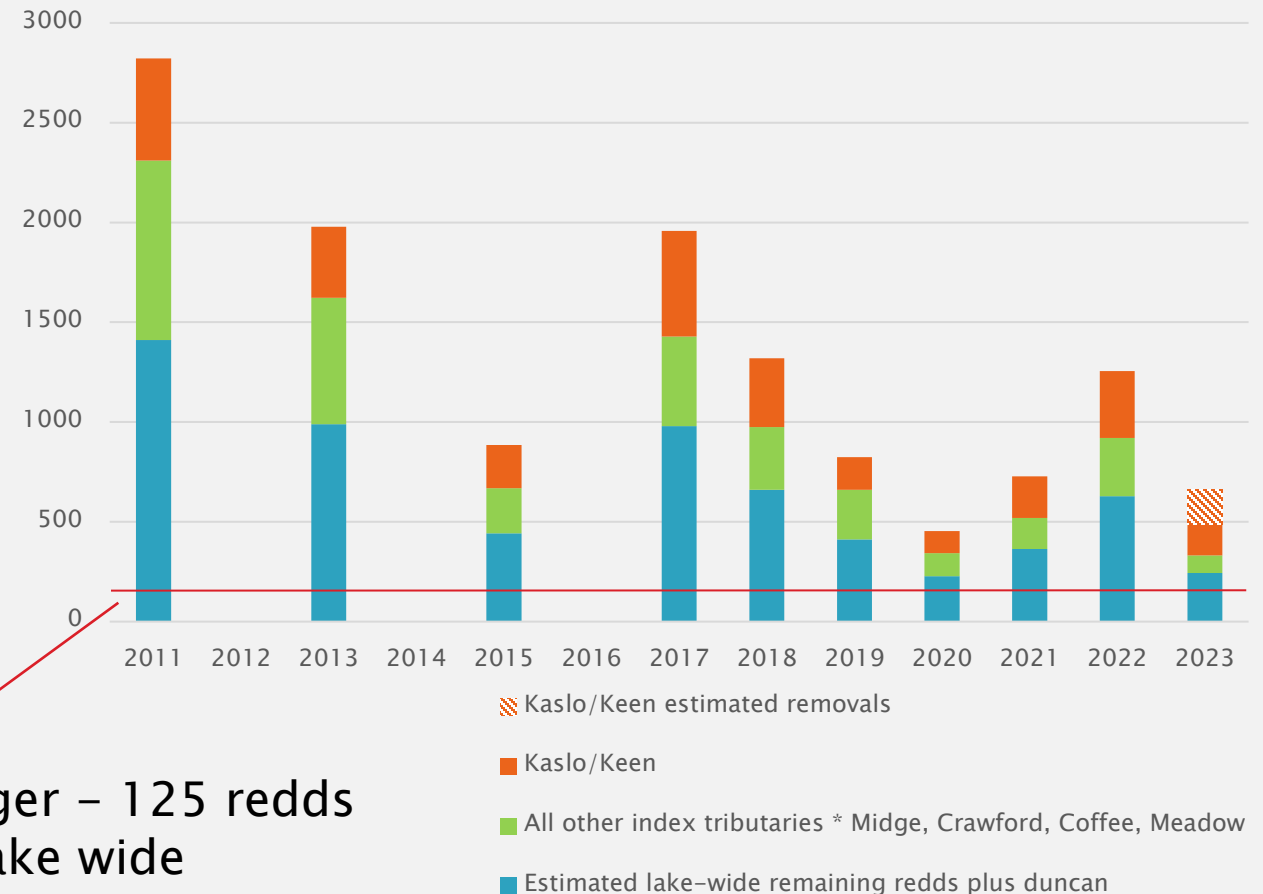
Action Update: Predator Conservation

▶ Bull trout:

- Trigger <25 redds/250 spawners in Kaslo River and lake-wide index respectively
** revised in 2021
- 2023 redd count in index tributaries (~50–70% of lake-wide spawners) was 244 (~3–4X the conservation trigger)
- Action: Reduce exploitation through regulations; ***action not triggered***

Conservation trigger – 125 redds
~ 250 spawners lake wide

Kootenay Lake bull trout redd abundance



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

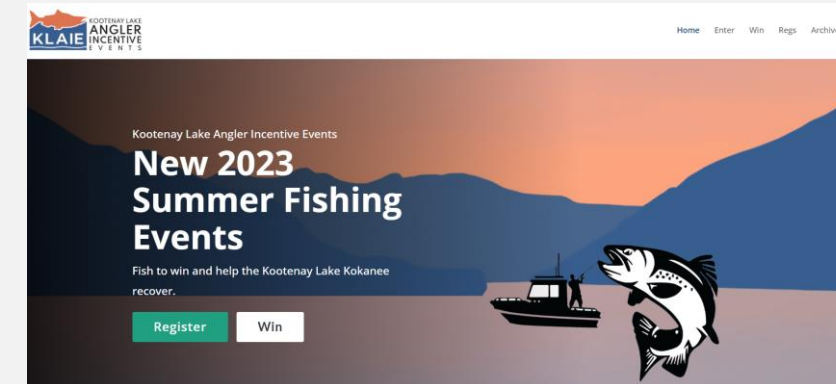
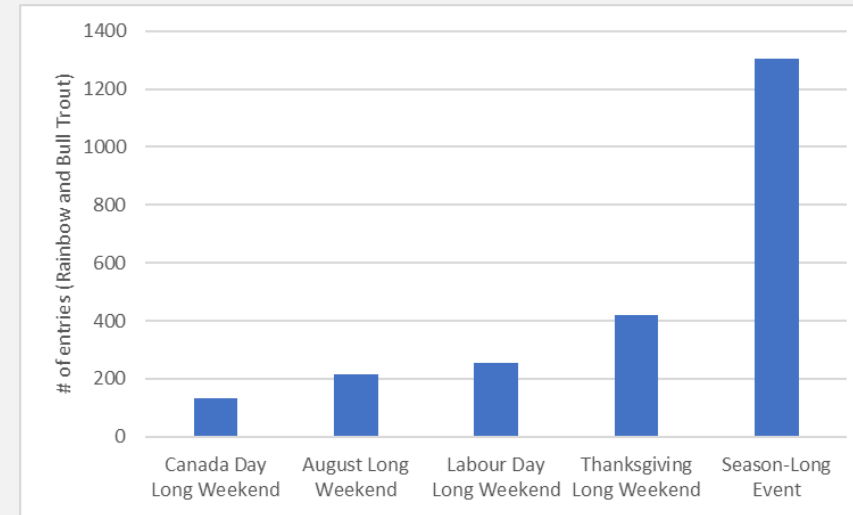
Recreational Fishery Regulations

- ▶ 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 = 5/day any size (revised April 2023)
 - RB = 10/day any size, 20/year >50cm (revised April 2023)

Action Update: Predator Management

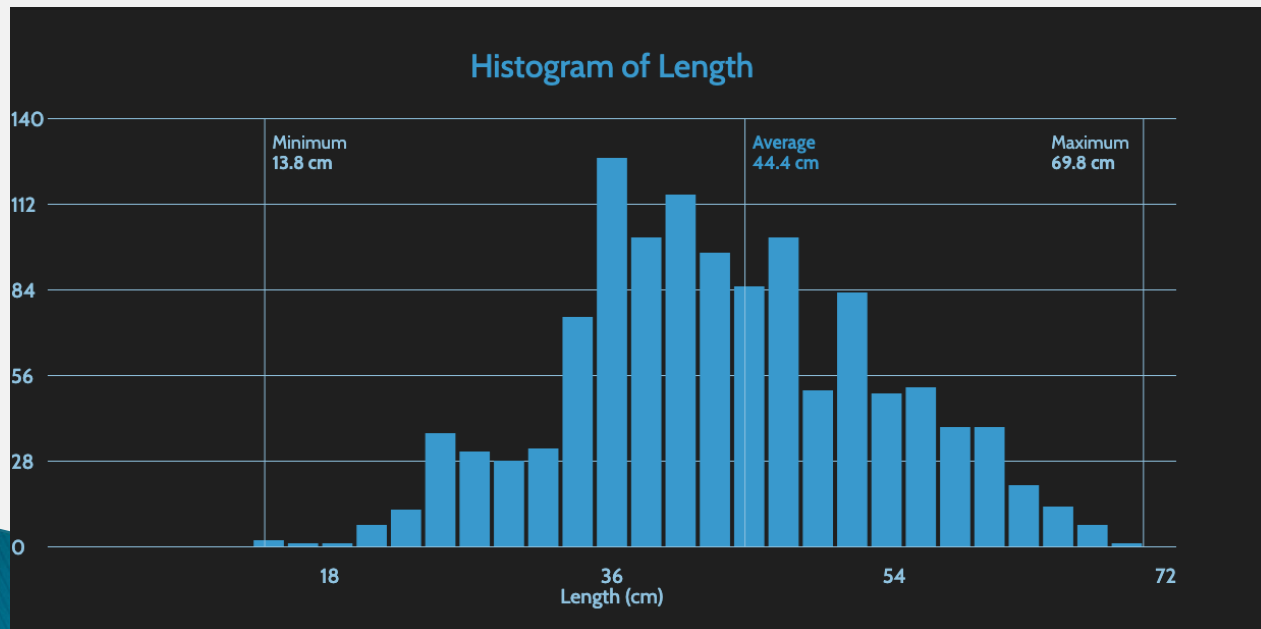
Kootenay Lake Angler Incentive Events

- ▶ Derby-style program
 - Angler's Atlas and the MyCatch app
 - Four long-weekend events and one season-long event (July 1–October 31st)
 - 2337 entries to date (ongoing until end of Oct, doesn't include 'rejected entries')
- ▶ Creel 2023 (April–Oct): 171 interviews
 - Know about draw: Increase from 91% and 90% in Y1 and Y2 to 100% in Y3, compared to KLAIE 95%
 - Participation rate: Increase from 83% in Y1 and Y2 to 98% in Y3, compared to 94% KLAIE
 - Slight decrease in awareness/participation from original KLAIP, why?
 - New media platforms (Facebook/website)?
 - Some unable to participate due to requirement of app use?

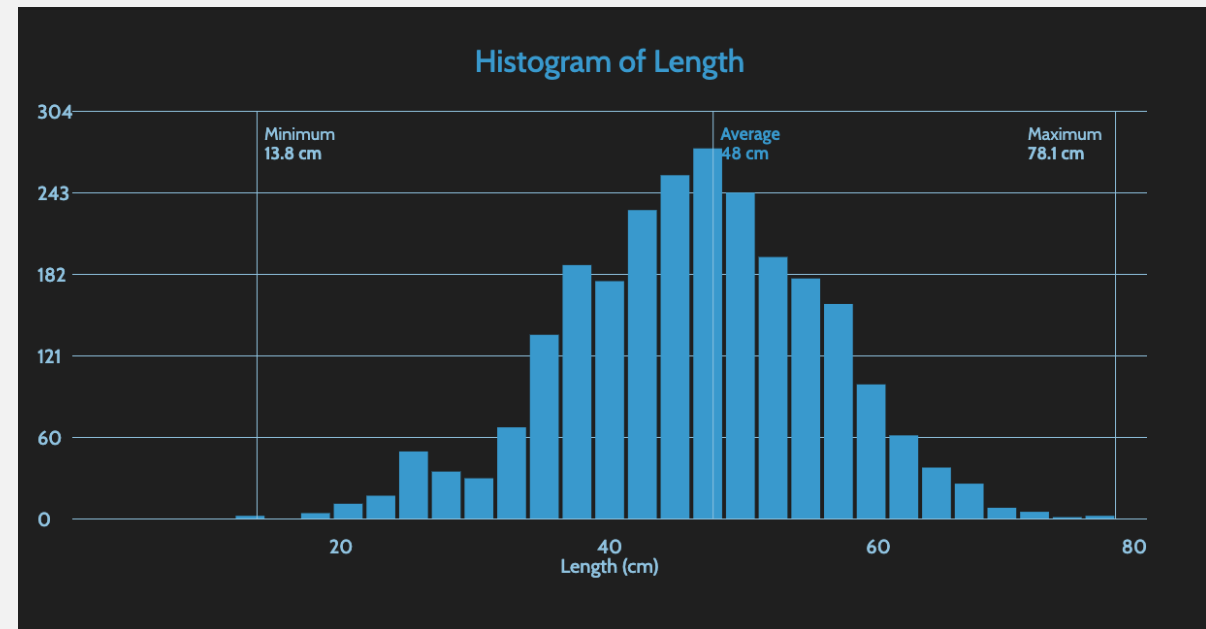


Action Update: Predator Management Kootenay Lake Angler Incentive Events

- ▶ KLAIE length data:
 - RB: n=1206
 - BT: n=1131
 - Suggests near 50:50 ratio



Rainbow Trout



Bull Trout

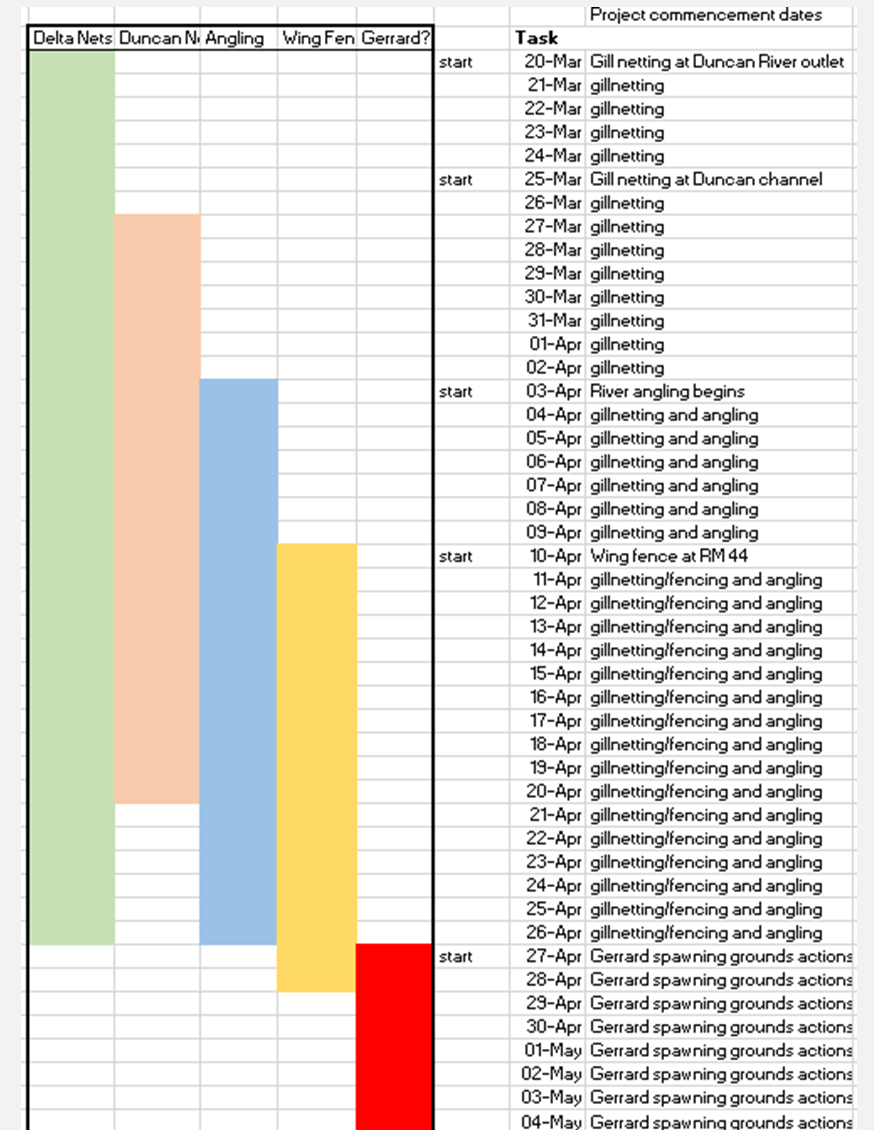
Action Update: Predator Management Kootenay Lake Netting Pilot Fall 2023

- ▶ Work conducted by KNC
- ▶ 4 floating nets @ 250 ft long x 8 ft deep
- ▶ Soak time= 34.75 hrs, 1 RB captured
(CPUE=0.03 fish/hr)
- ▶ Fished North, Centre and South Arm, near tributaries and pelagic, floating and weighted



Action Update: Predator Management Gerrard Reduction 2023 Program

- ▶ 2023–2024 Gerrard spawner reduction program
- ▶ Goal: to reduce Gerrard recruitment by 50%
- ▶ Multi-tiered and collaborative approach involving First Nations, Government, Private Consultants and Angling Guide volunteers
 - Netting at the north arm of Kootenay Lake (Indigenous community members)
 - Netting at the Duncan and Lardeau River (Mountain Water Research)
 - Angling in the Duncan and Lardeau River (all)
 - Netting at Mobbs Creek (Ministry)
 - Targets Gerrards at every step of migration



Action Update: Predator Management Gerrard Reduction 2023 Program

▶ Raft Angling

- Up to 3 rafts daily
 - No jetboat (1979 unit broke down; replaced for 2024)
 - >125 hrs of angling in rafts (290 rod hours)
 - 26 (23*) Gerrards and 22 bull trout caught
 - >15 staff, angling guide volunteers, 2 regions
 - RB avg length = 576mm, *removed RB < 450mm n=3
- *Group of smaller RB in Duncan R, unlikely to be Gerrards based on previous length data on spawning grounds



Action Update: Predator Management

Gerrard Reduction 2023 Program

- ▶ Lake netting – first point of interception
- ▶ Conducted by First Nation community members
- ▶ 341 (338*) Gerrards and 113 bull trout removed
- ▶ RB avg length = 539mm, *removed RB <45cm, n=3



Action Update: Predator Management Gerrard Reduction 2023 Program

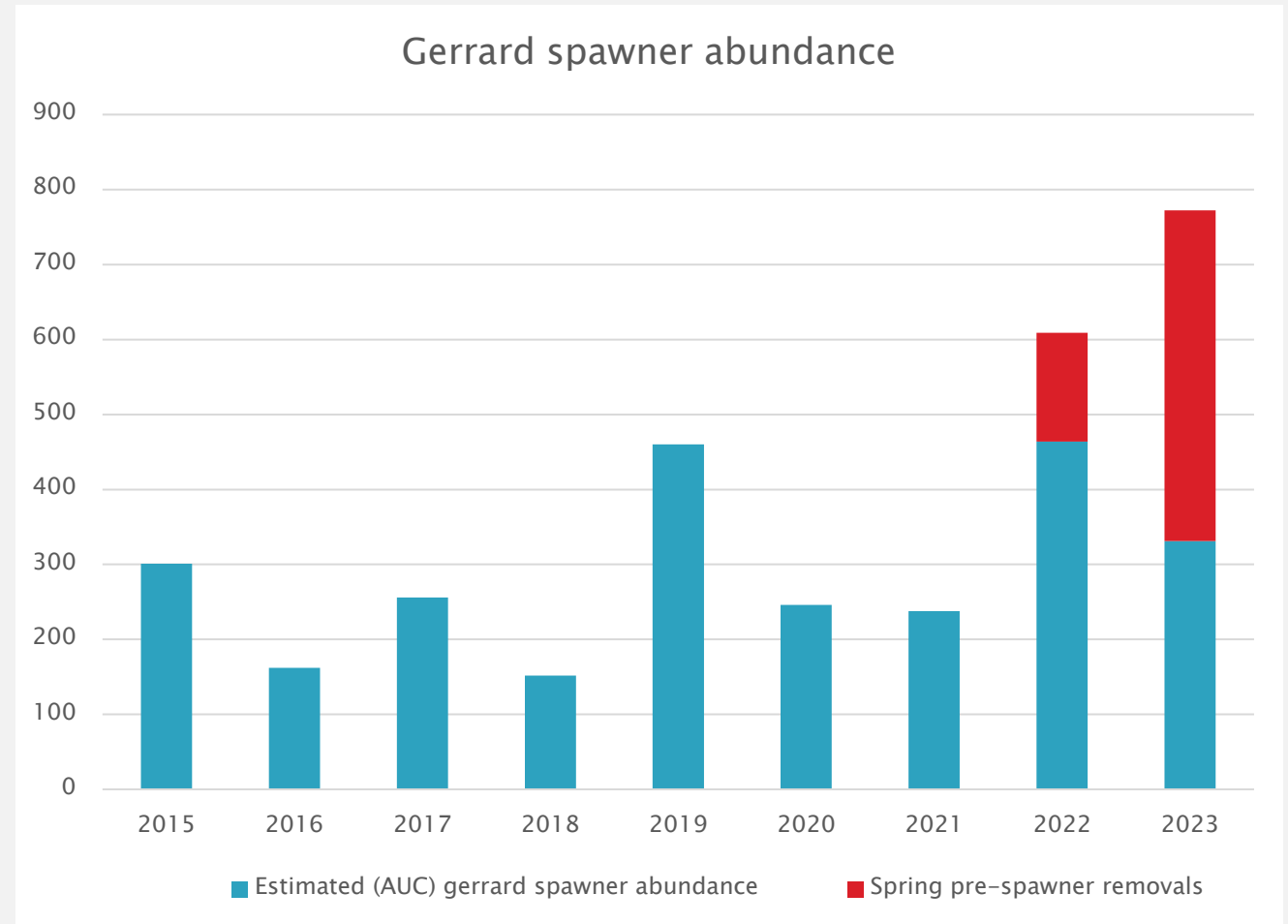
- ▶ Netting/Angling/Fences
- ▶ Contract – Mountain Water Research
- ▶ Angling via jetboat:
 - 38 (25*)Gerrard Rainbow Trout removed
 - 88 Bull Trout removed
 - RB avg length= 544mm, *removed RB <450mm n=13
- ▶ Netting (Duncan and Lardeau):
 - 57 (*55) Gerrard Rainbow Trout removed
 - 36 Bull Trout removed
 - RB avg length= 556mm,
* removed Rb <450mm, n=2
- ▶ Lardeau Fence
 - 350 ft fence
 - Blew out overnight



Gerrard Reduction Program 2023

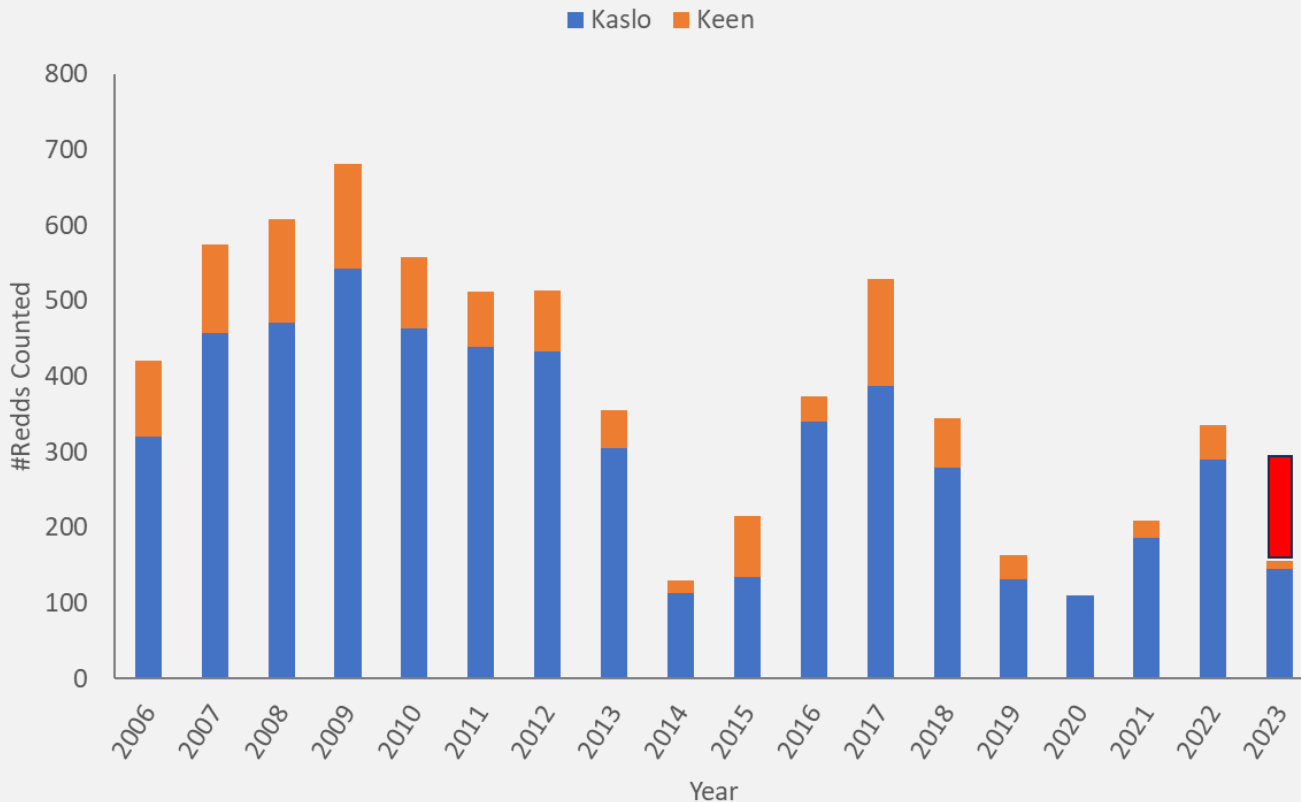
Impact on spawner abundance

- ▶ Removed 441 Gerrard spawners
- ▶ Final Gerrard AUC = 331 (772 spawners absent removals)
- ▶ Incidentally removed an additional 643 bull trout from the program



Action Update: Predator Management

Kaslo Bull Trout Reduction 2023



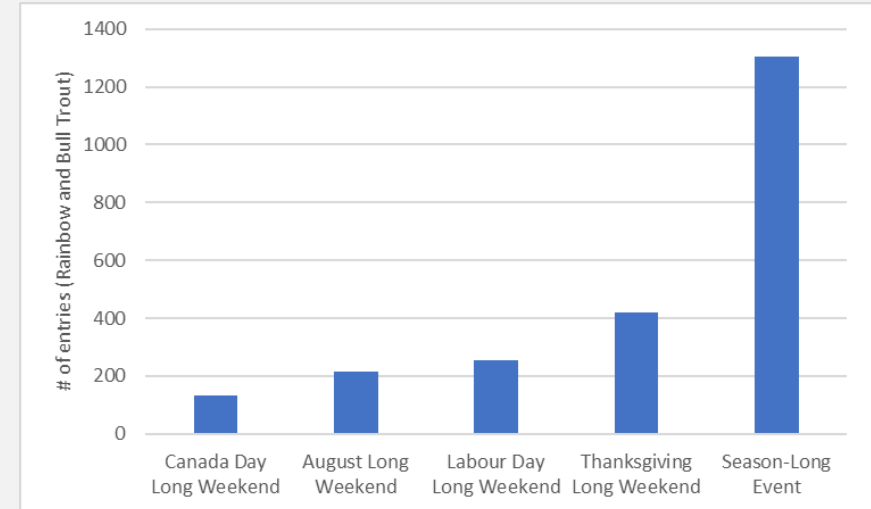
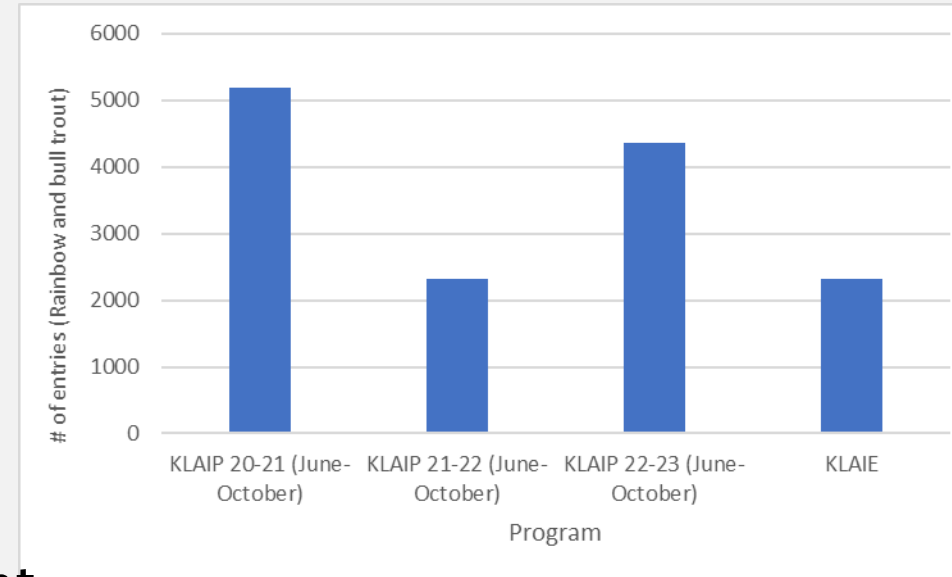
- 384 adult spawners removed for watershed
- Translates into 192 redd reduction for watershed
- ~160 redd reduction on Kaslo or 320 adults
- ~32 redds reduction in Keen or 64 adults
- Fence, gillnetting and angling primary methods of removal

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



How did the KLAIE compare to the KLAIP?

- ▶ June to October results:
 - KLAIE entries much lower than Year 1 and 3 of KLAIP, similar to Year 2
 - KLAIE entries likely low– program continues until end of Oct, doesn't include 'rejected entries'
- ▶ Some evidence program is gaining momentum
 - Increasing catch as program continues (inconsistent with historical monthly catch data)
- ▶ Exhausted all in-lake reduction programs, only lever remaining
- ▶ Public perception of removing harvest incentives before recovery?

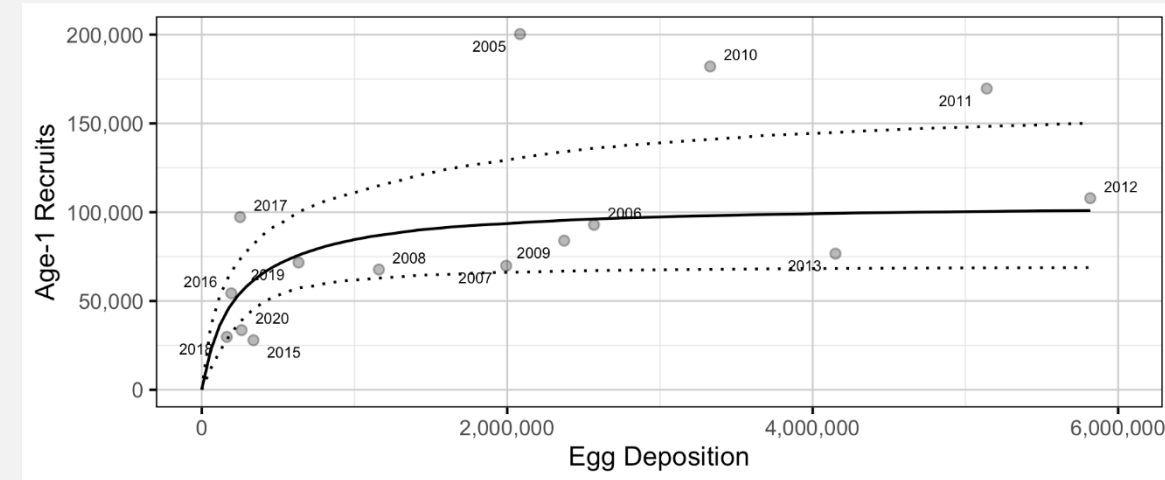


**Key Question: What Predator Management
Actions should we implement in 2023
(recruitment actions, future benefit)?**

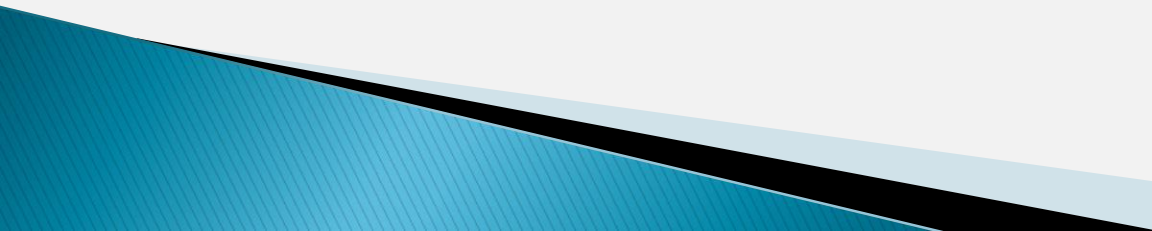


Recruitment action: Effect of 2023 removals on Gerrard recruitment

- ▶ 2023 efforts resulted in capture of 441 pre-spawners, thus reducing estimated spawner abundance from 772 to 331
- ▶ Using Beverton–Holt parameters of Andrusak et al. 2023 (stock recruit curve to the right), this is predicted to result in a substantial reduction up to 50% of age 1 juveniles in 2024.
- ▶ However predicted estimates of recruitment reduction estimates are uncertain at this time and will require an assessment to determine actual recruitment from the predator program activities from 2023

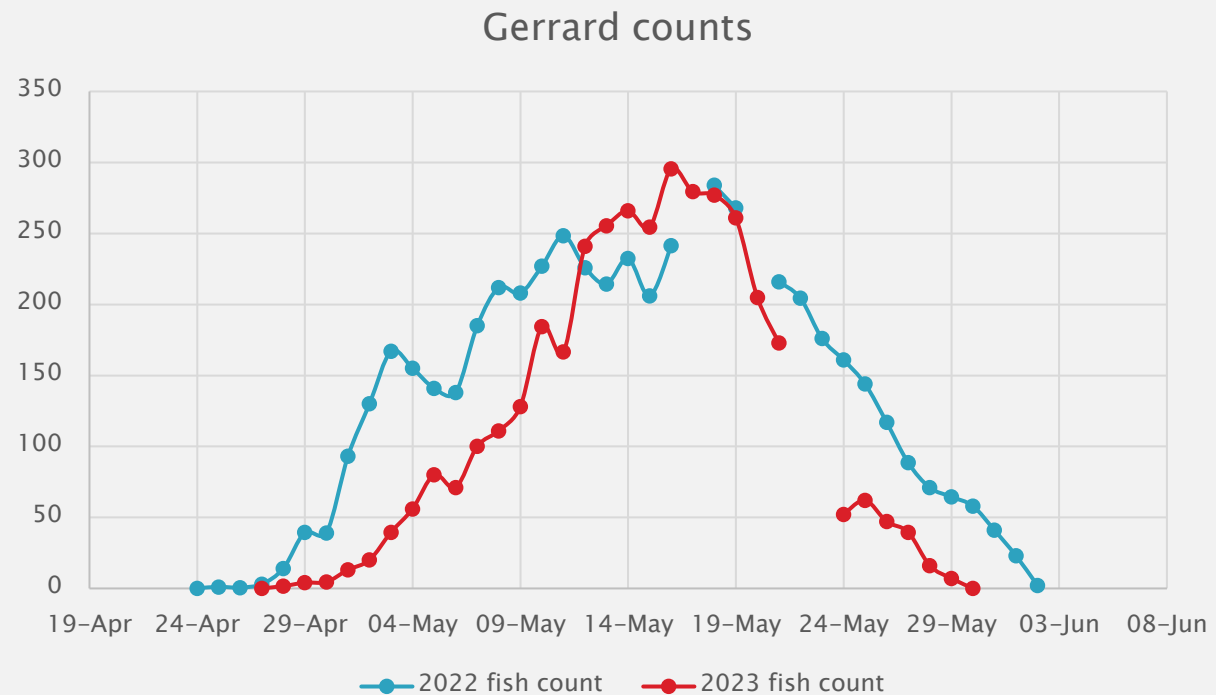


Possible recruitment action – efishing Gerrard redds

- ▶ In the prior KLAT, we presented electrofishing eggs at Gerrard as a possible recruitment action to be piloted
 - ▶ Subsequent scoping revealed a pilot would be difficult to conduct – no local consultants with appropriate equipment existed so no further progress made on scoping effectiveness
- 

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

- ▶ MoF staff provided test fisheries in 2022 and 2023, and catch rates from these years can be used to simulate what the catch could be in an open fishery
- ▶ Assuming 2023 catch rates were abnormally low due to cold temperatures, delayed freshet, river entry and peakier run, then 2023 and 2022 could be used for lower and upper catch rate scenarios
- ▶ If opening a fishery resulted in a constant effort of 20 rod hrs per day, a reasonable estimate for an open fishery would be 94 – 217 fish caught under similar spawner abundance scenarios
- ▶ 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)
 - Catch rate follows a normal distribution, peaking in late April in any given year
 - Effort is constant through the season.



Summary:

What do we know about Kokanee?

- ▶ Multiple lines of evidence that suggest things are improving for kokanee
 - Hydroacoustics data:
 - Improved North Arm spawner escapement in 2023 (~152k, egg deposition of 41.9 million eggs), ~370k forecasted for 2024 (~55 million eggs)
 - 0–1 survival forecasted to ~20% (0–1; only slightly below pre-collapse average) and ~80% (1–2; above pre-collapse average)
 - NRP:
 - Daphnia biomass, density and size below average for post-collapse era (may suggest increased grazing from kokanee?)
- ▶ Possible upcoming weak spawner year classes – 2025/2026?

Summary:

What do we know about Rainbow Trout?

- ▶ Angling Regulations:
 - 10/day any size, 20/year >50cm
- ▶ Piscivore monitoring data:
 - Suggests lower kokanee composition relative to the previous two years (uncertainty due to low sample size)
 - CPUE decreasing, mean size decreasing
 - Possible increased exploitation in 2023 relative to 2022, but consistently low overall
- ▶ Spawner AUC remains well above conservation triggers (331 in 2023 after removals)
- ▶ 2024 actions?:
 - In-lake:
 - KLAIE: intended to increase harvest, program appears to be gaining momentum
 - Lake-netting: minimal effect
 - Recruitment:
 - Continuation of 2023 actions? Spawner reduction actions could result in a recruitment reduction benefit of up to 50% in 2024 (20,000 juveniles)
 - Additional options?: Lardeau angling- potential to remove an additional 94-217 fish
 - Other?

Summary:

What do we know about Bull Trout?

- ▶ Angling regulations:
 - 5/day any size
- ▶ Piscivore monitoring data:
 - Suggests good feeding conditions for bull trout (high kokanee diet composition)
 - Catch rates increased slightly
 - Size relatively unchanged
- ▶ Possible increased exploitation in 2023 relative to 2022 (uncertainty due to low sample size)
- ▶ Spawner abundance:
 - Lake-wide spawner abundance lower, especially Southern tributaries
 - Kaslo R spawner abundance up from 2022 if removals included (fence project significantly reduced Kaslo R spawner abundance, 384 spawners removed)
 - Lake-wide and Kaslo spawner abundance remains above conservation threshold in 2023 (at least 3–4x higher)
- ▶ 2024 actions:
 - In-lake:
 - KLAIE?: intended to harvest, evidence project gaining momentum
 - Recruitment:
 - Continuation of 2023 activities?: Kaslo fence project
 - Other?

Thank you!

