Kootenay Lake Advisory Team

November 17-18, 2021

Virtual Meeting

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

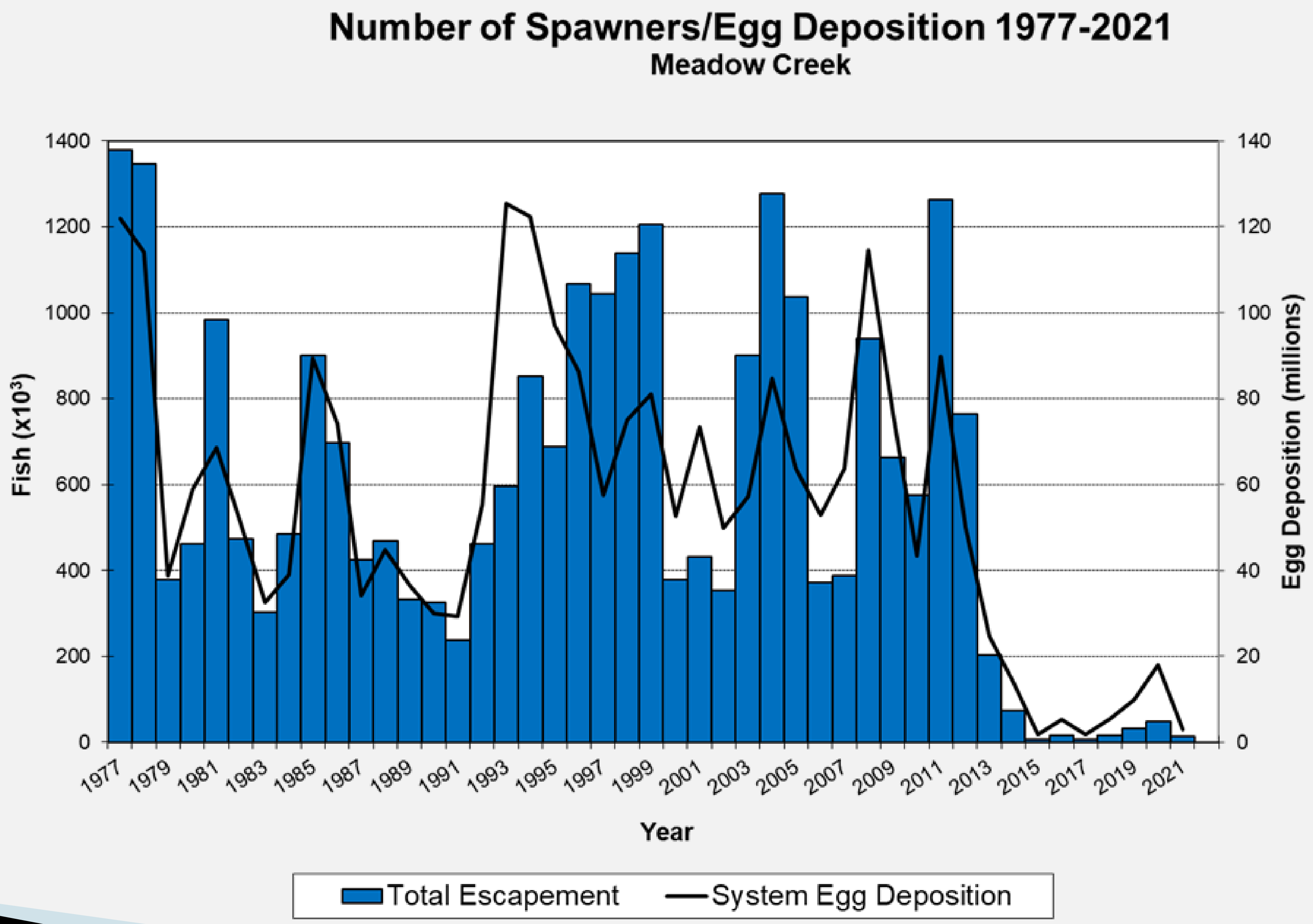
- Acknowledgments for funding – Nutrient program funding (including monitoring; FWCP, KTOI, BC Hydro, ENV, FLNR) Action plan implementation and enhanced monitoring (FFSBC, FLNR, FWCP, and HCTF)

- 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…

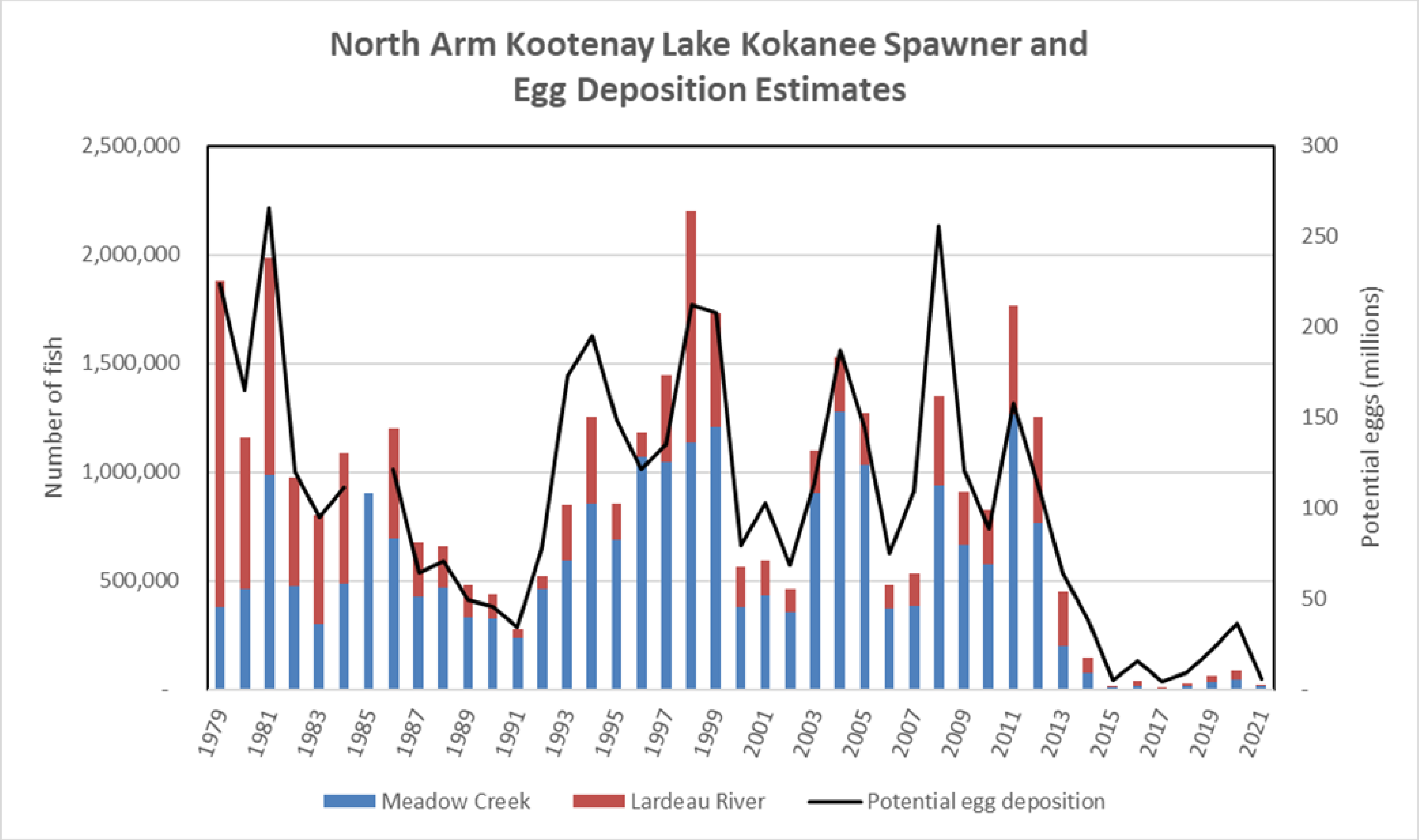
Outline

- Biological Response Update
- Review Actions, Triggers, and Implementation update from 2021 (what did we do?)
- Provide some analysis/ideas to help inform discussions around Key Questions.

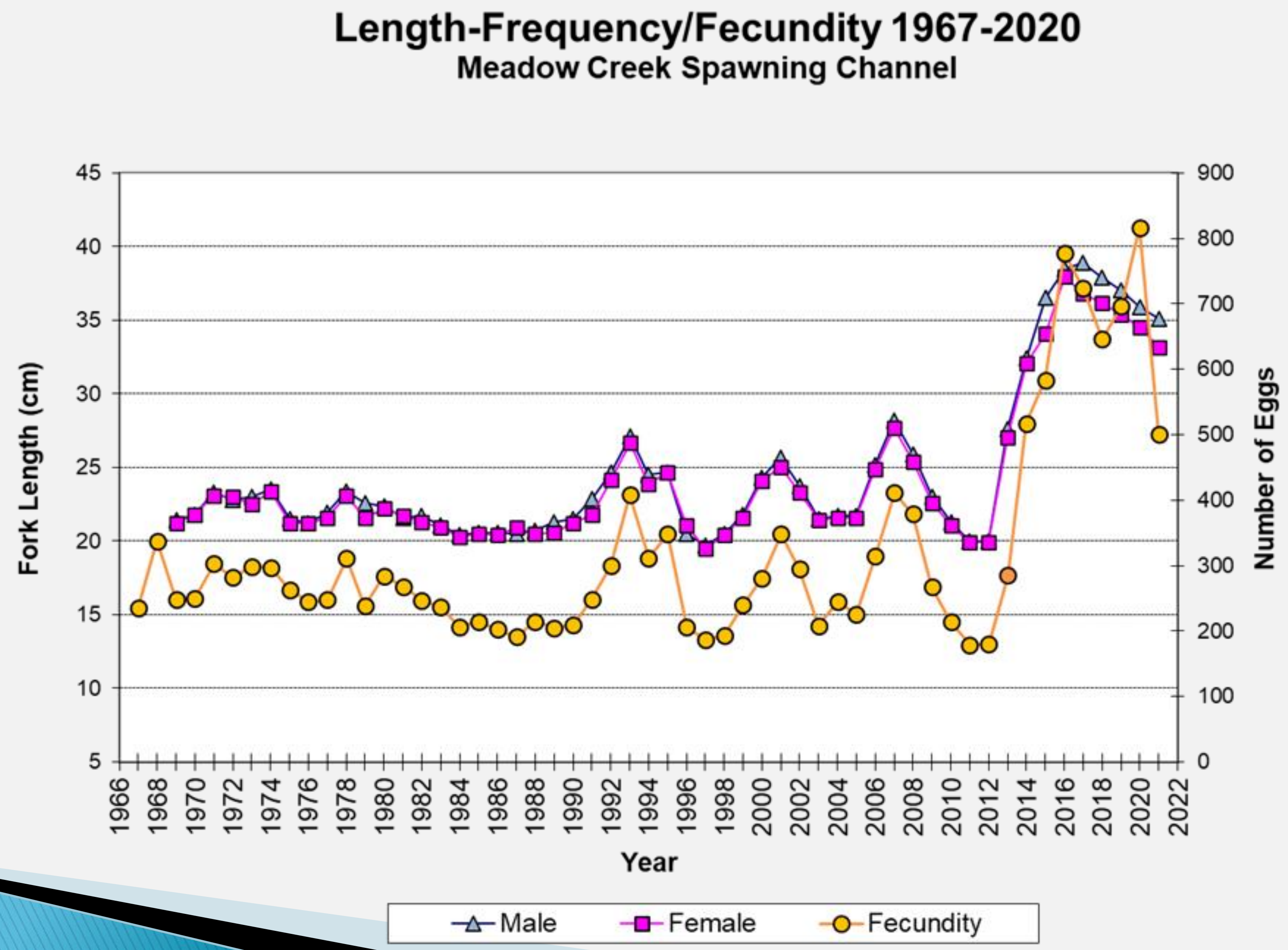
Kootenay Lake North Arm Kokanee Escapement



Kootenay Lake North Arm Kokanee Egg Deposition



Meadow Creek Kokanee Size and Fecundity



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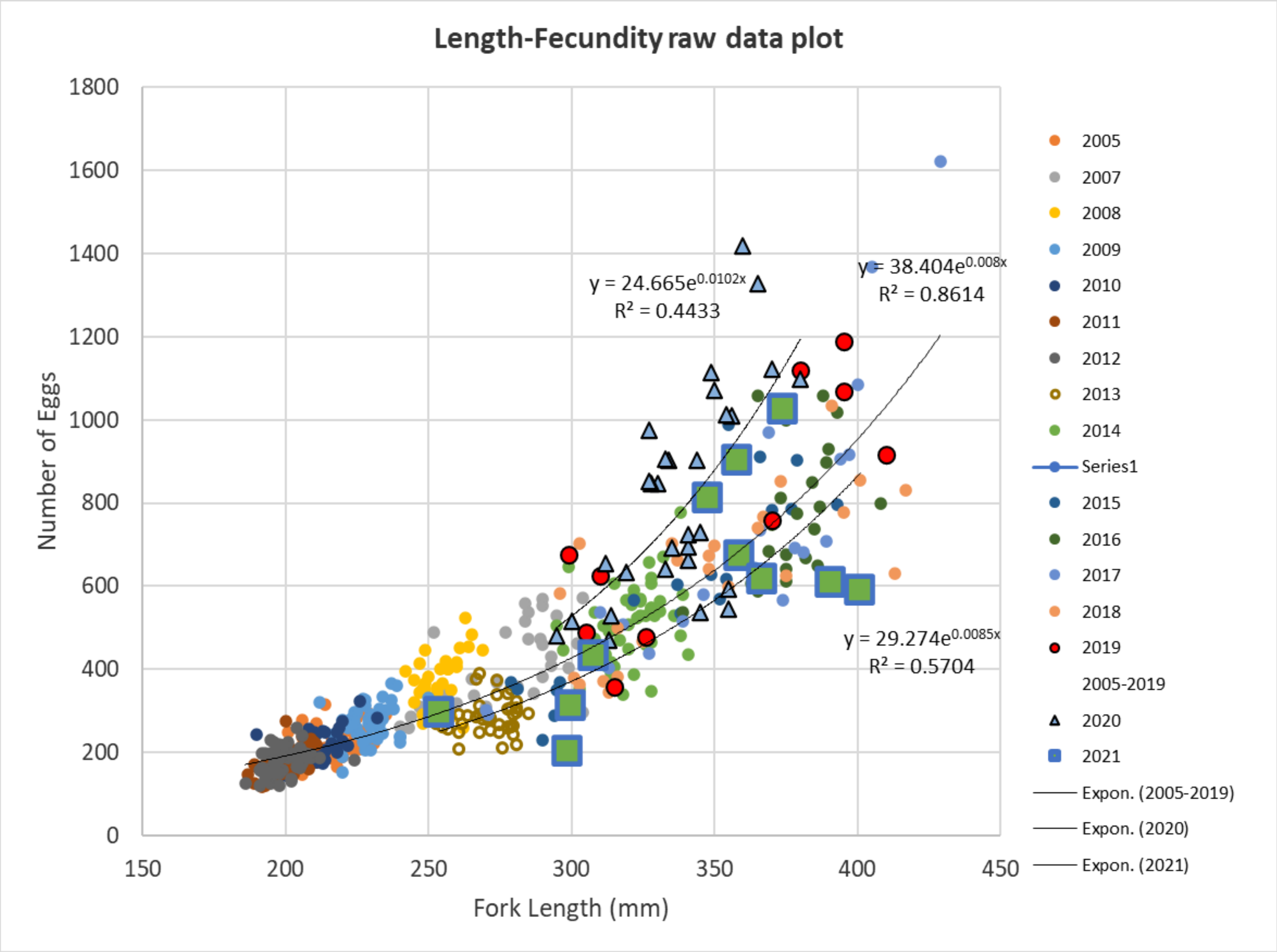
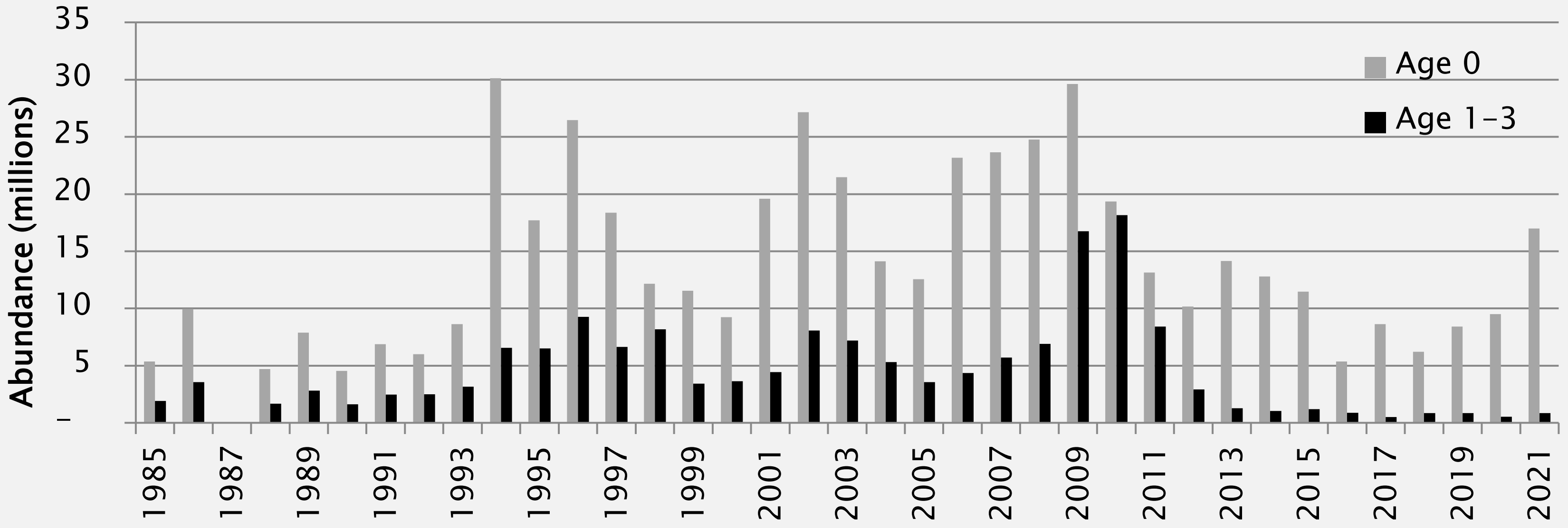
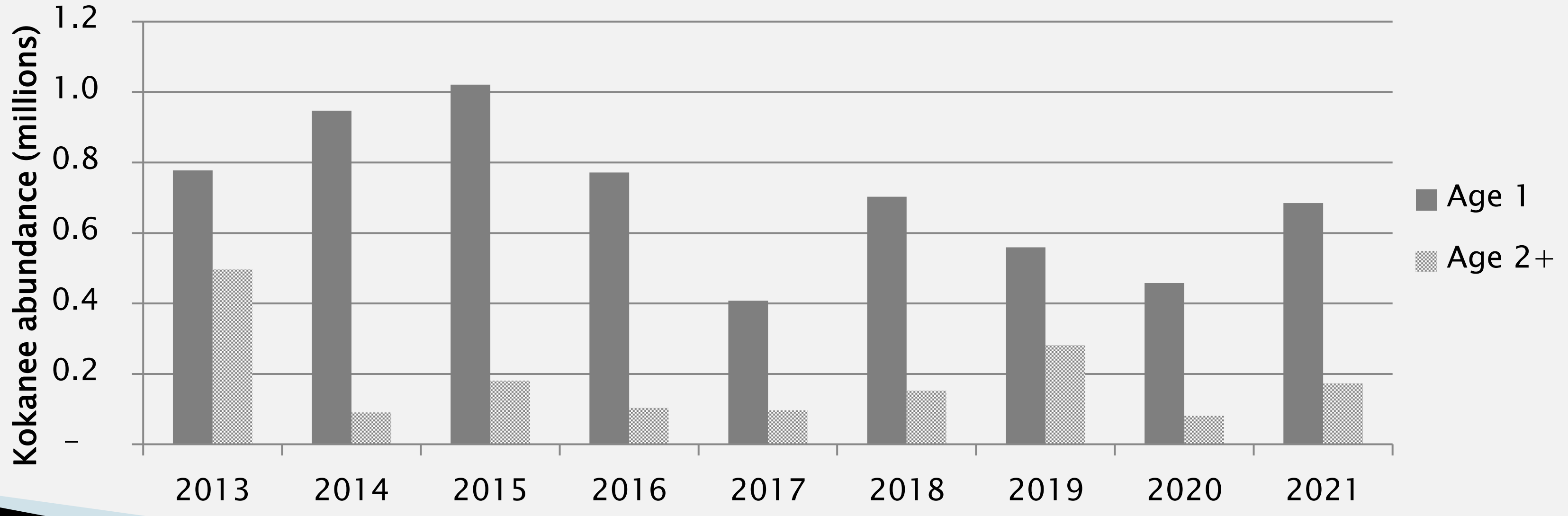


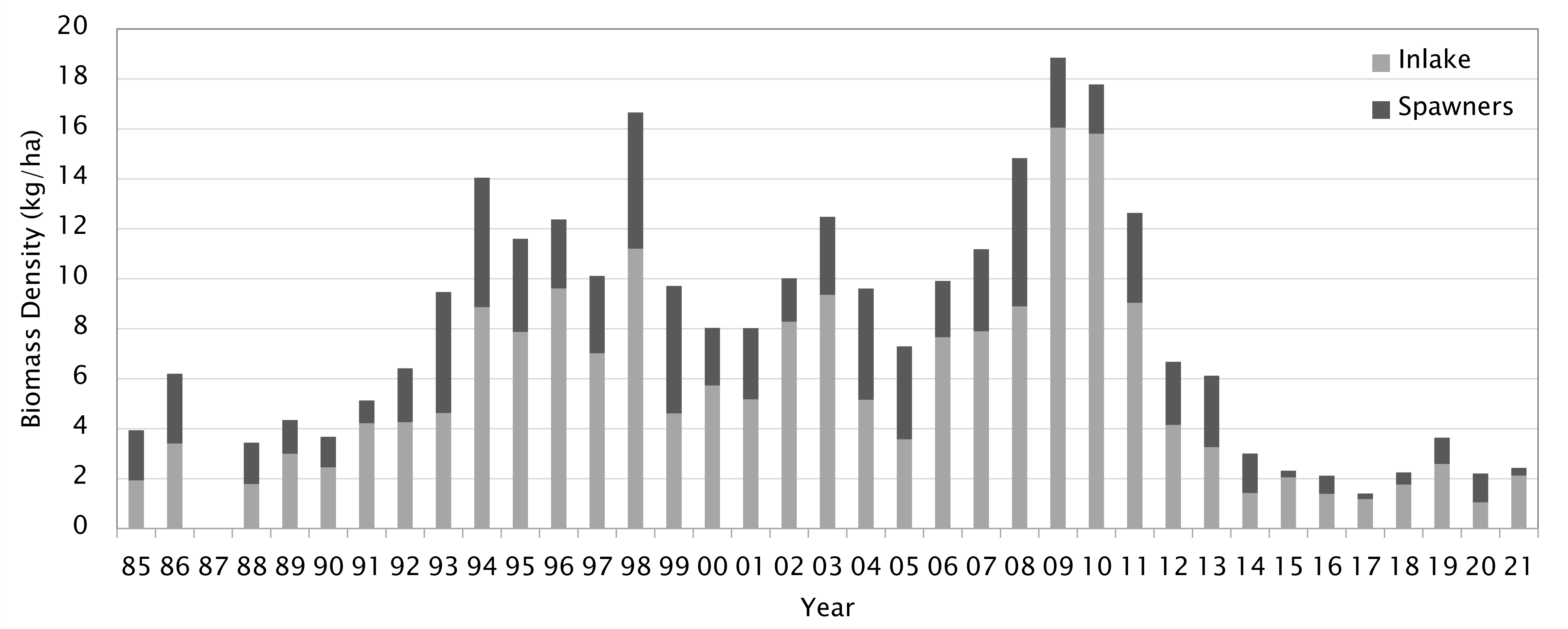
In-lake Kokanee abundance





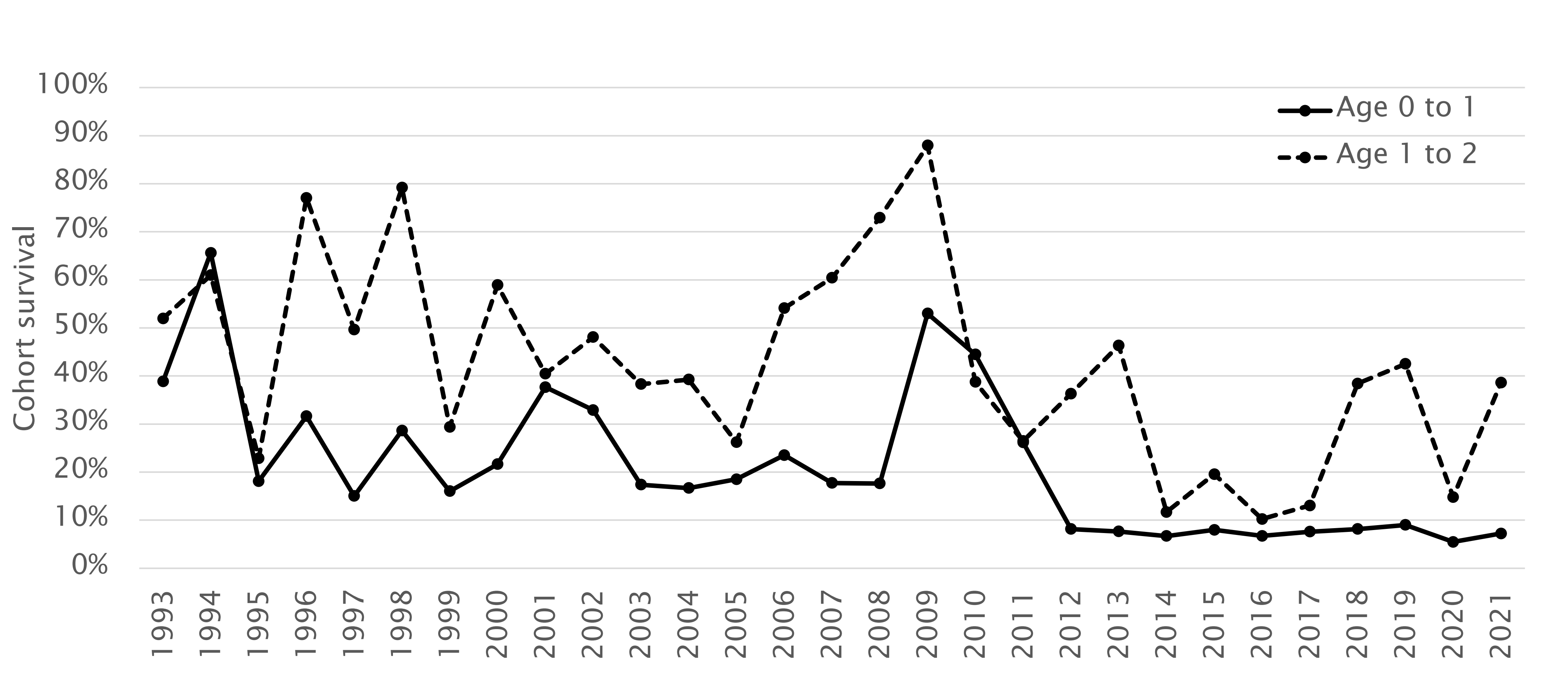
Acoustic abundance trends from FWCP funded fall surveys of Kootenay Lake. 2021 data are preliminary.

Fall Kokanee biomass density



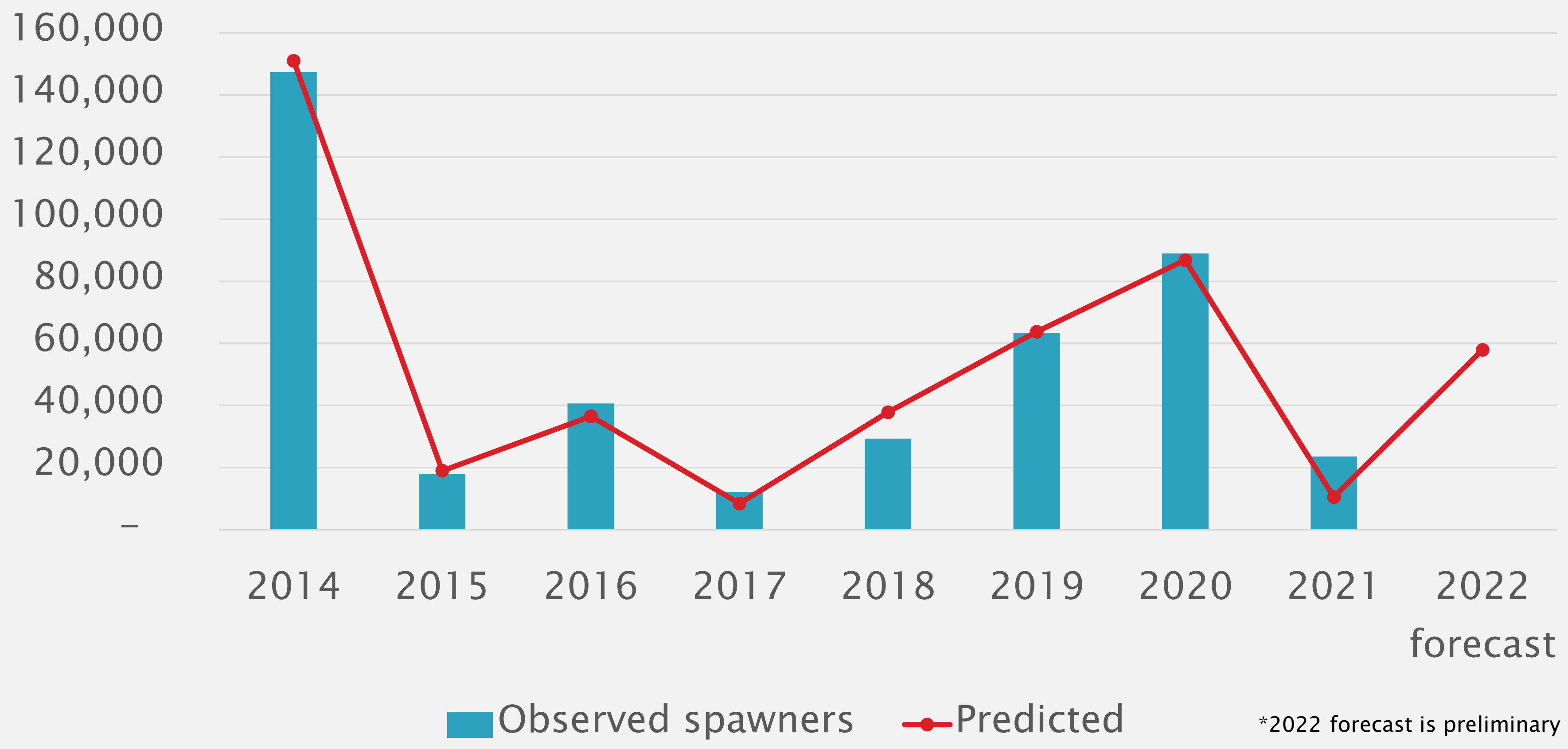
Kokanee biomass trends from FWCP funded fall surveys of Kootenay Lake. 2021 data are preliminary.

Kokanee cohort survival (September acoustic surveys)



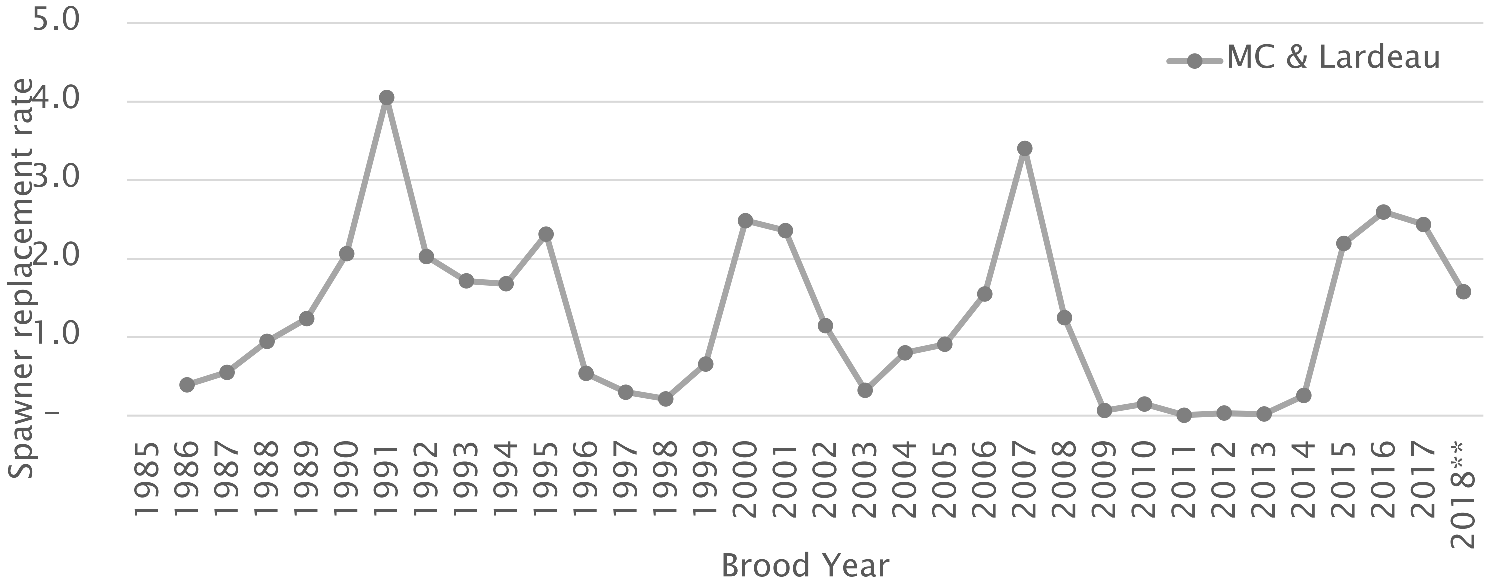
Kokanee survival trends from FWCP funded fall surveys of Kootenay Lake. 2021 data are preliminary.

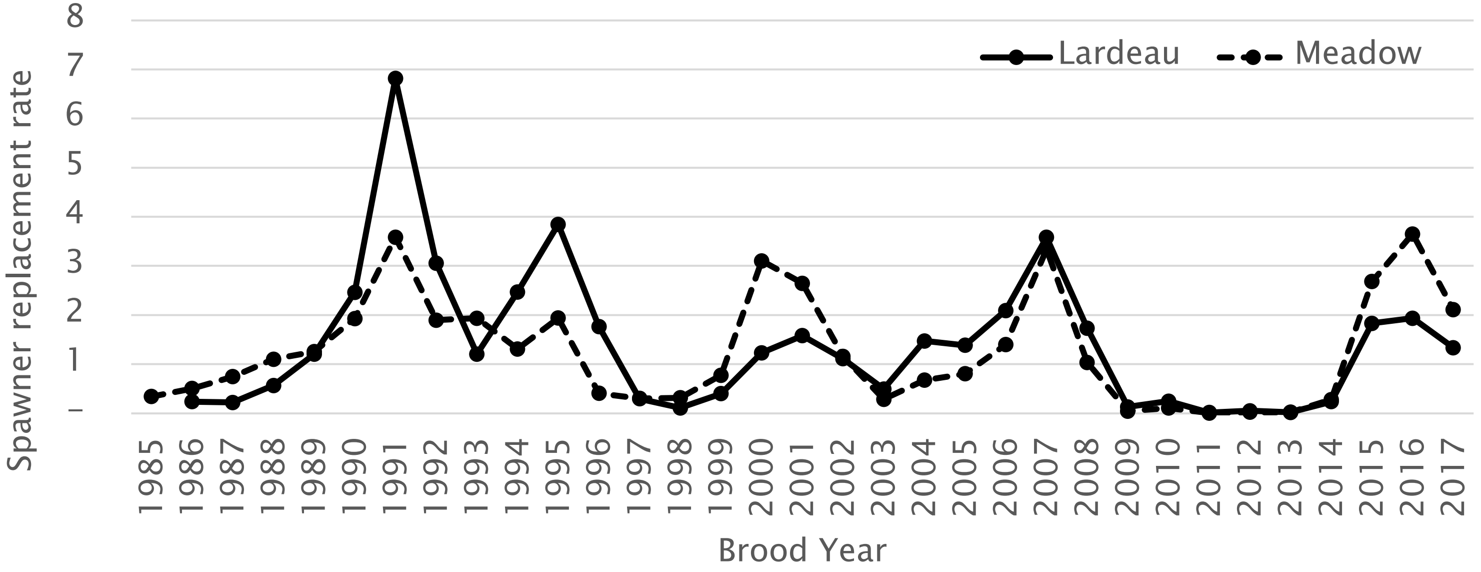
Kokanee spawner forecast



Spawner forecast for North Arm Kootenay Lake Kokanee spawners. 2022 forecast based on preliminary acoustic data from the fall 2021 survey.

Kokanee spawner replacement





1. Does not account for egg plants (or fry stocking) which began in Meadow Creek for the 2015 BY. 2016-2018 BY's had substantial egg plant contributions (2017 was the highest).

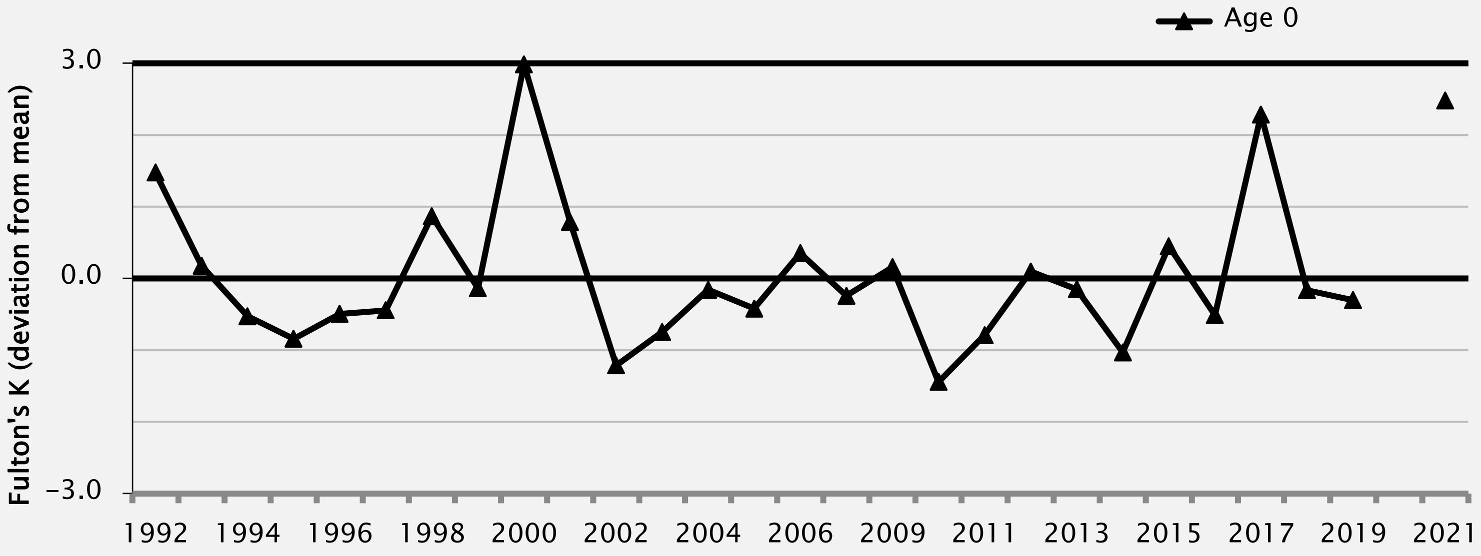
3. Meadow replacement rate better than Lardeau for 2015-2017 BY's suggesting egg plants/fry stocking may have played a role improving Meadow returns.

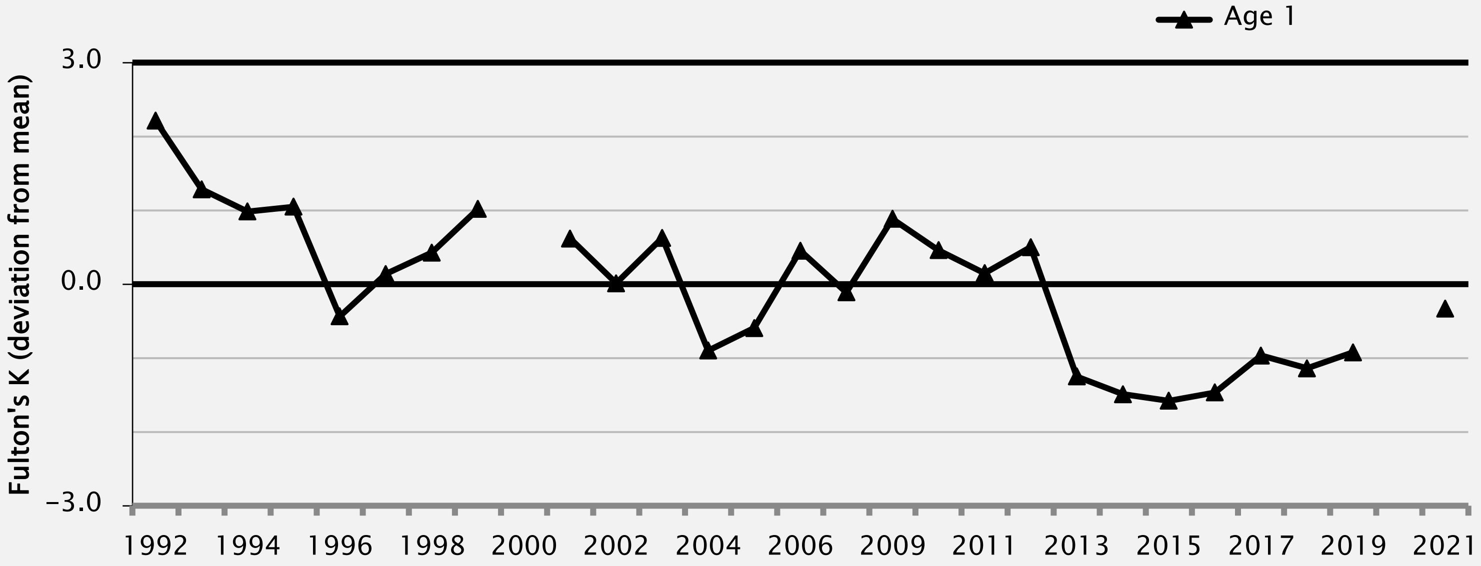
4. Presumably, egg plants/fry stocking did not impact Lardeau spawner replacement estimates.

Spawner replacement for North Arm Kootenay Lake Kokanee spawners

****2018 BY estimate based on 2022 spawner forecast and average spawner age structure.**

Kokanee fall Kokanee condition





Data from FWCP funded fall trawl surveys of Kootenay Lake. 2021 data are preliminary.

Kootenay Lake Bull Trout Redd Counts 2021

Northern tributaries	
Upstream Flip Bucket Fish Count - Duncan Dam (M. Casselman, BC Hydro, pers. comm.)	230
Hamill (including Clint)	na
Poplar	1
Meadow Creek (including Matt)	24
Central tributaries (North Arm)	
Crawford	39
Kaslo-mainstem*	186
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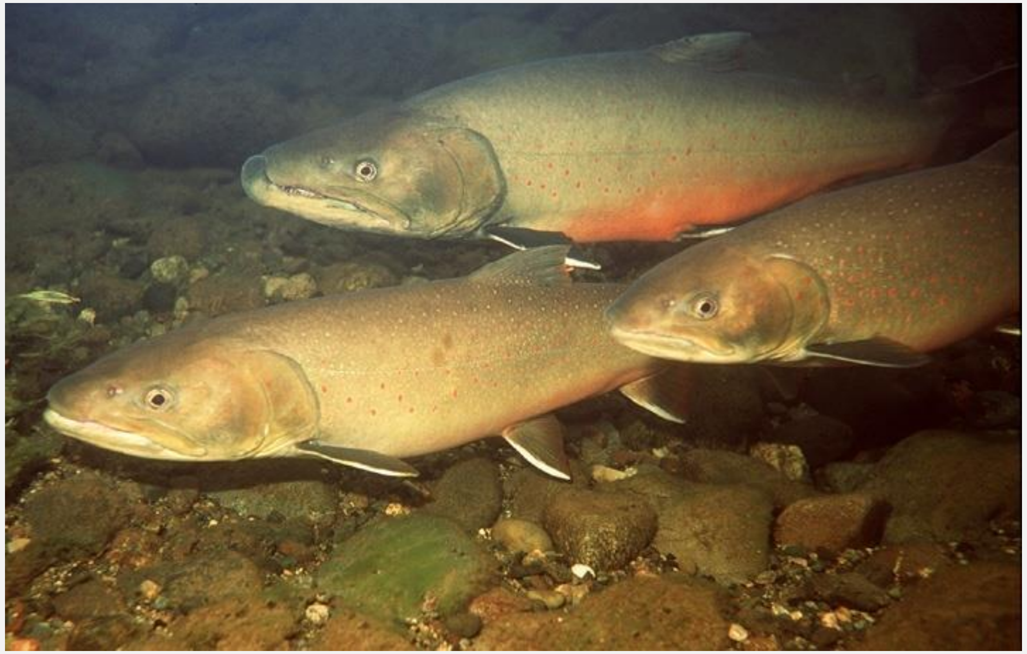
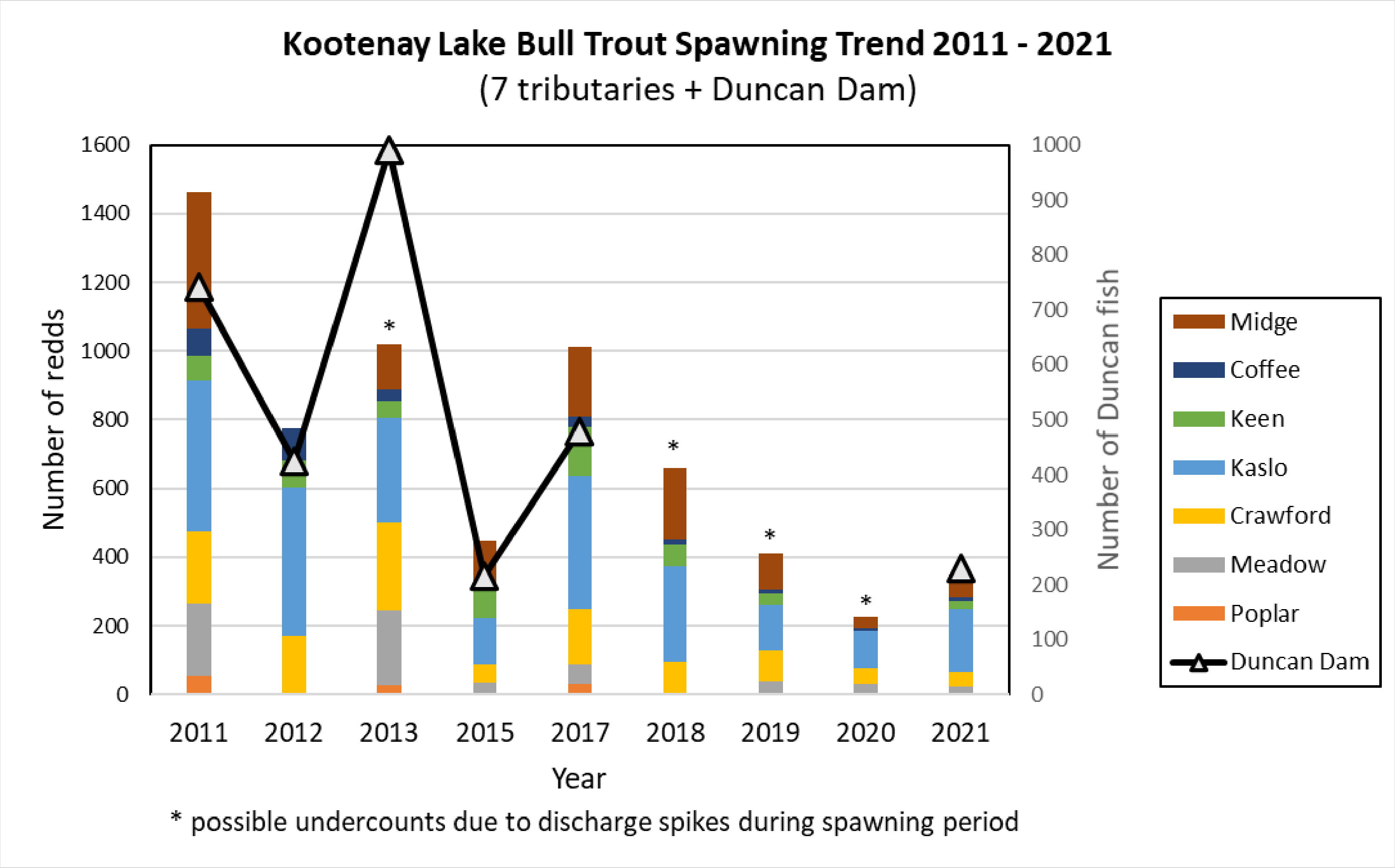
Cultus	na

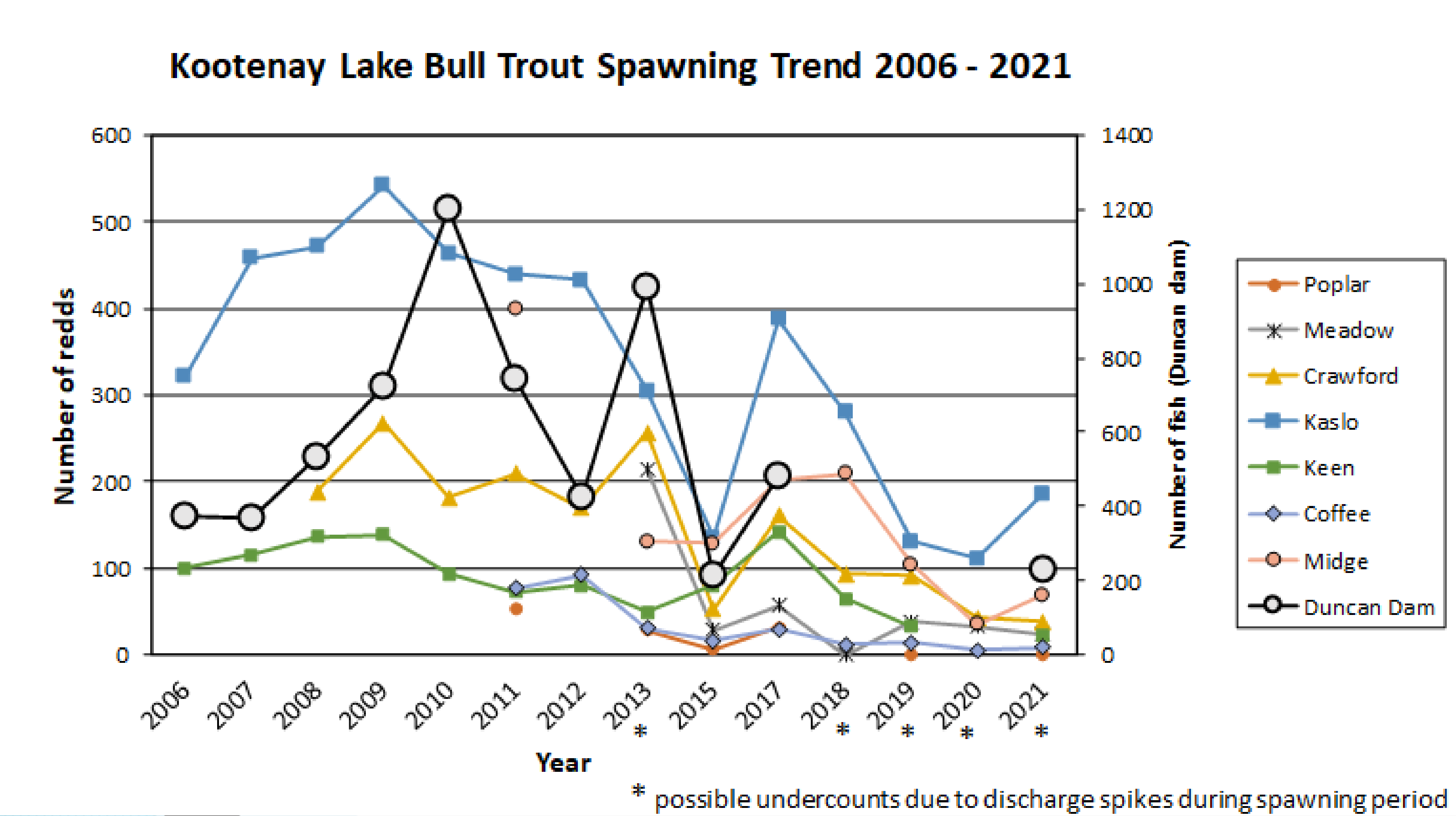
* funded by HCTF



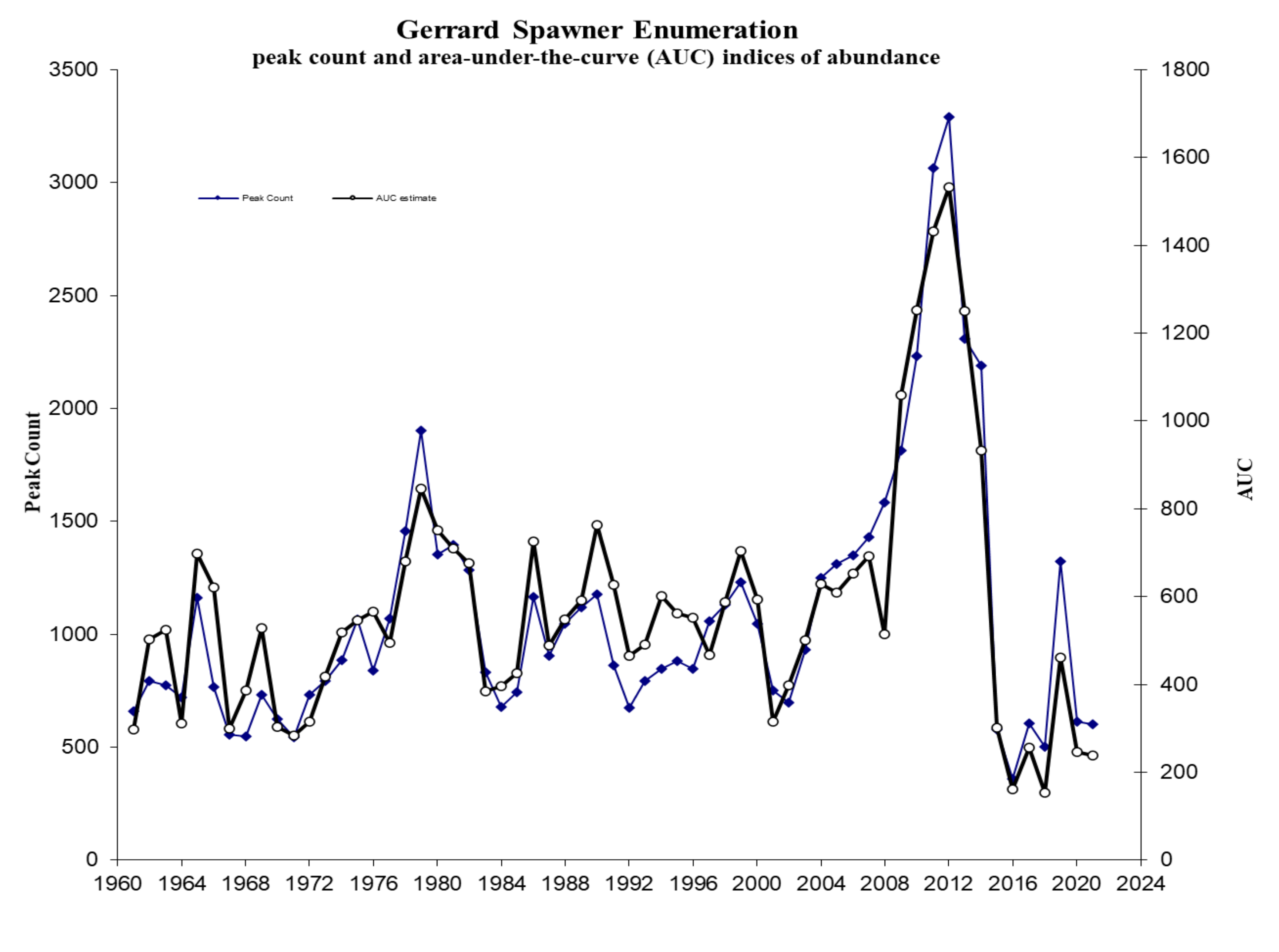
Kootenay Lake Bull Trout Redd Counts 2021



Kootenay Lake Bull Trout Redd Counts



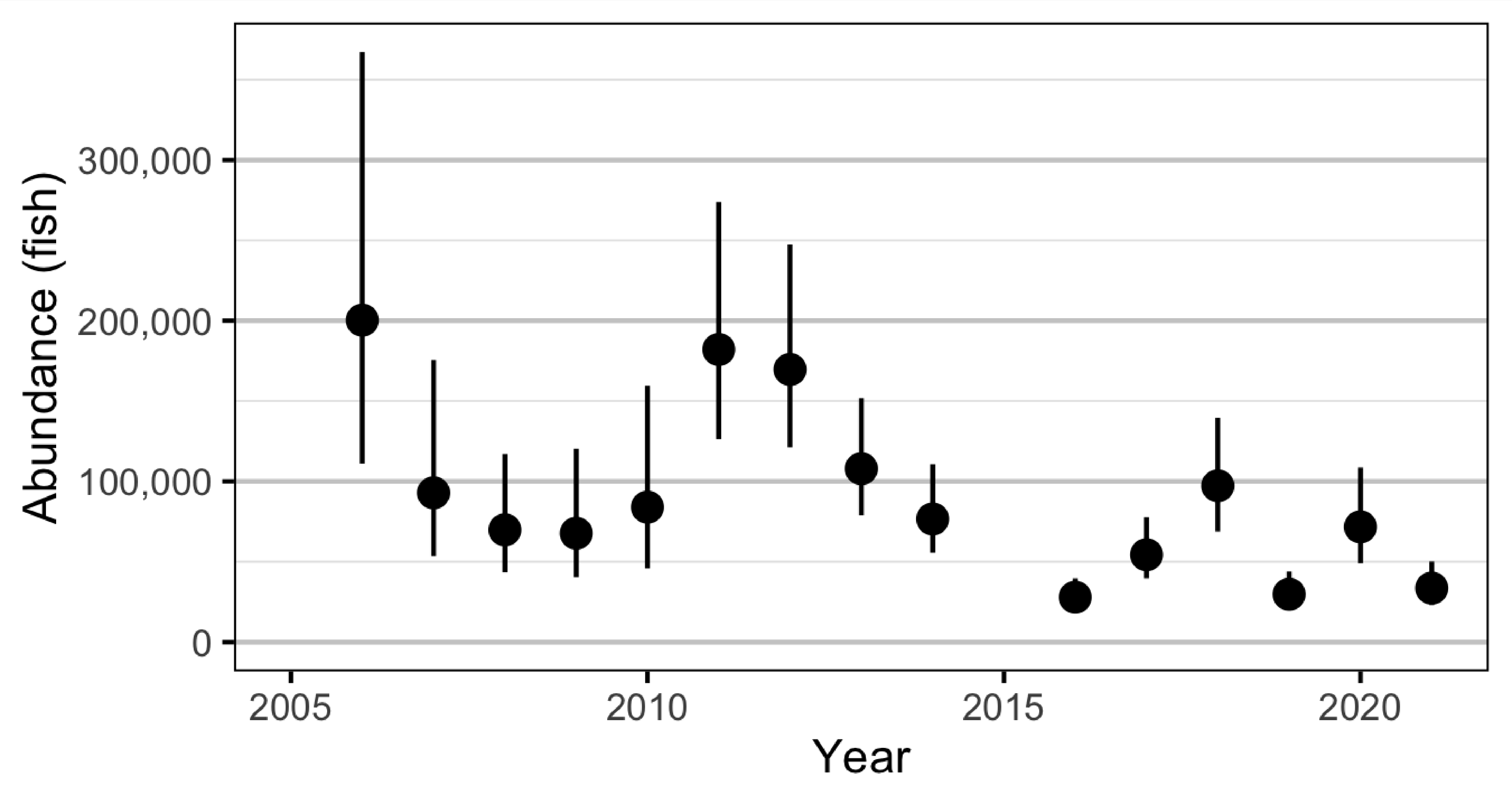
Gerrard Spawner Abundance



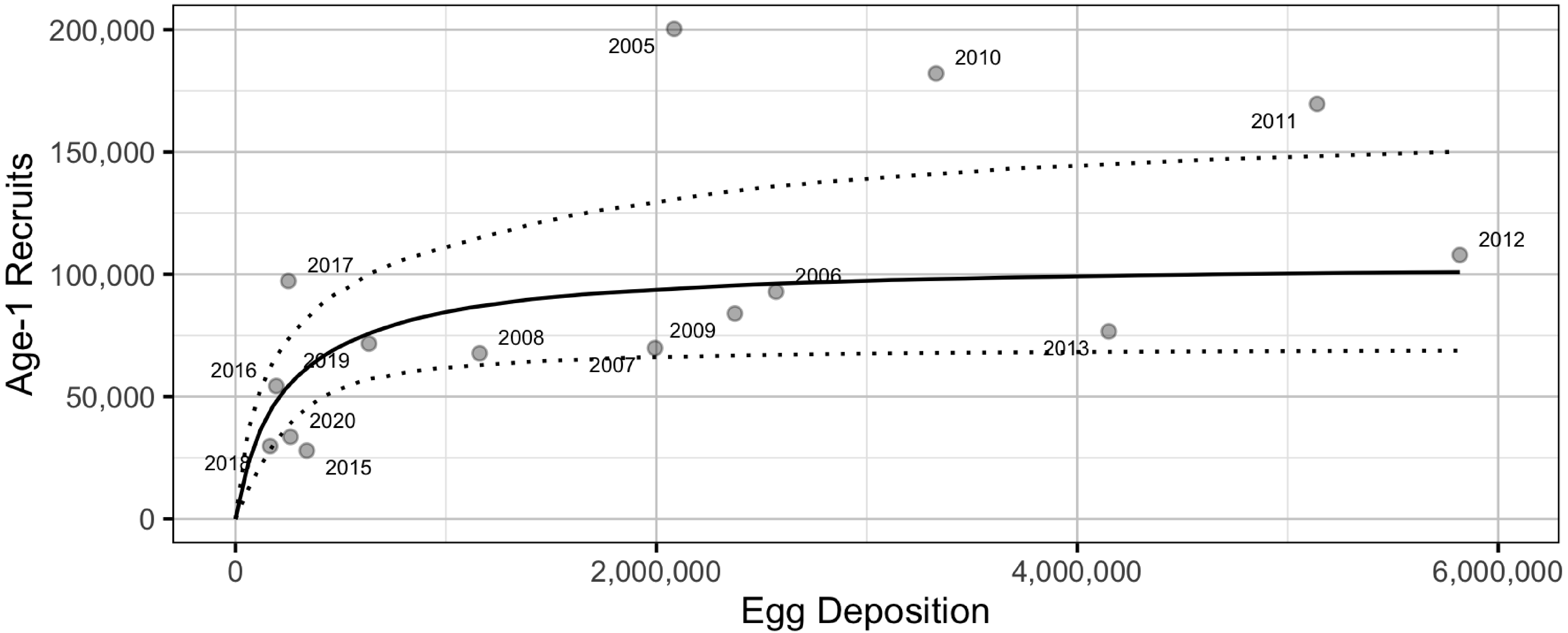
Gerrard Spawner Bio Data				
Year	Mean FL (cm)	mean Wt (Kg)	Mean Age	Sample Size
1949–59	67		5.3	54
1979	83			11
1980	83			8
1981	79	5.8		10
1982	83	7.2		21
1991	83	7.4		15
1992	78	7.1		23
1994	75	6.8	6.0	17
1998	81	7.3	6.4	18
2004	72	7.1		25
2005	77	4.4		25
2006	83	6.9		37
2010	73	4.5		59
2014	78		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

- 2021 escapement – 238
- Spawner size decreasing

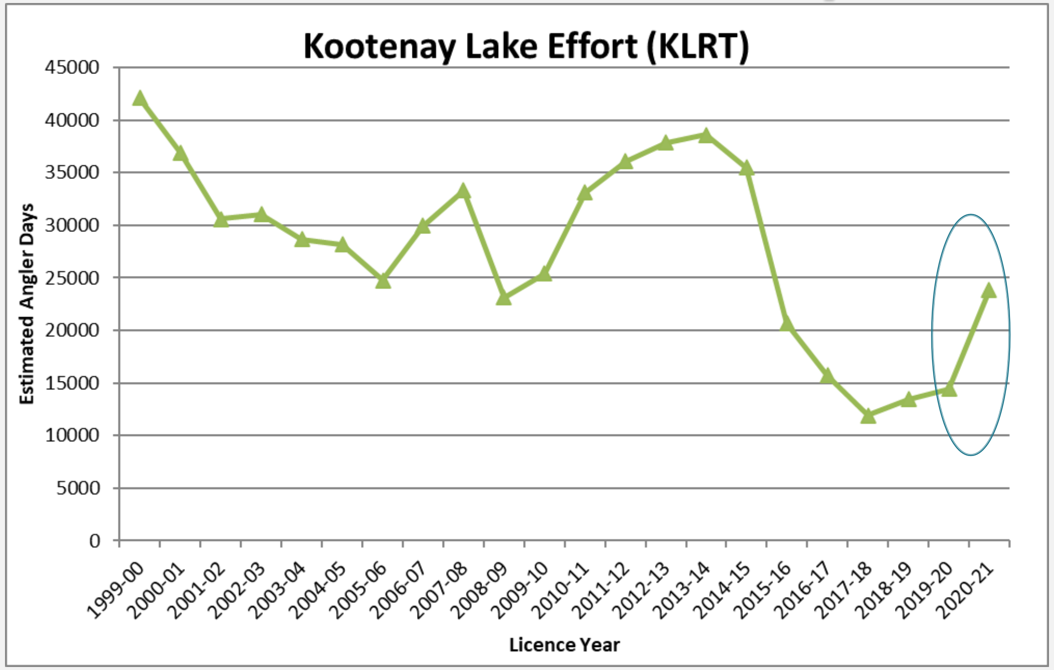
Gerrard Age 1 Recruits

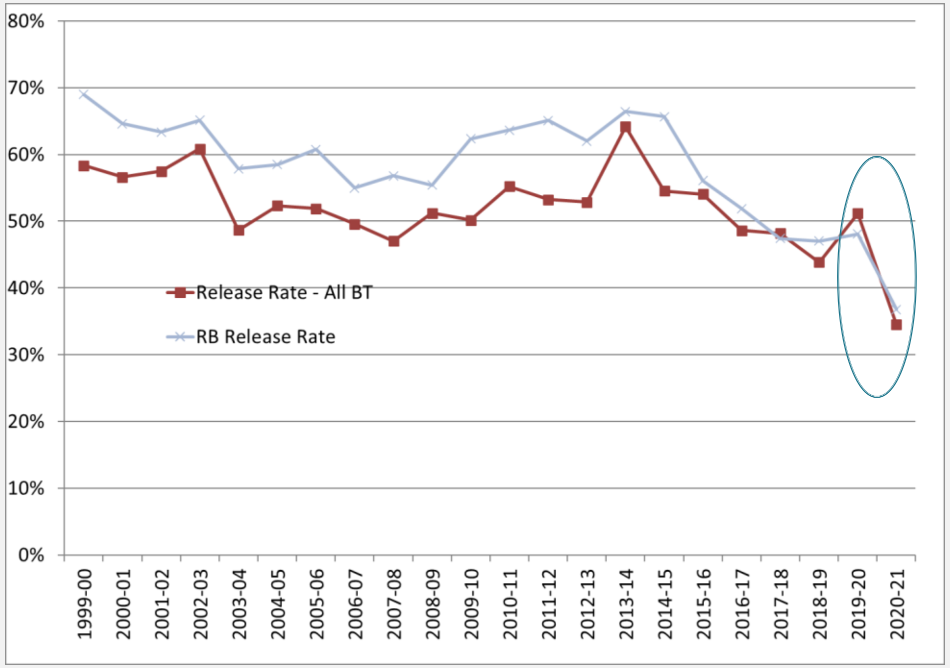


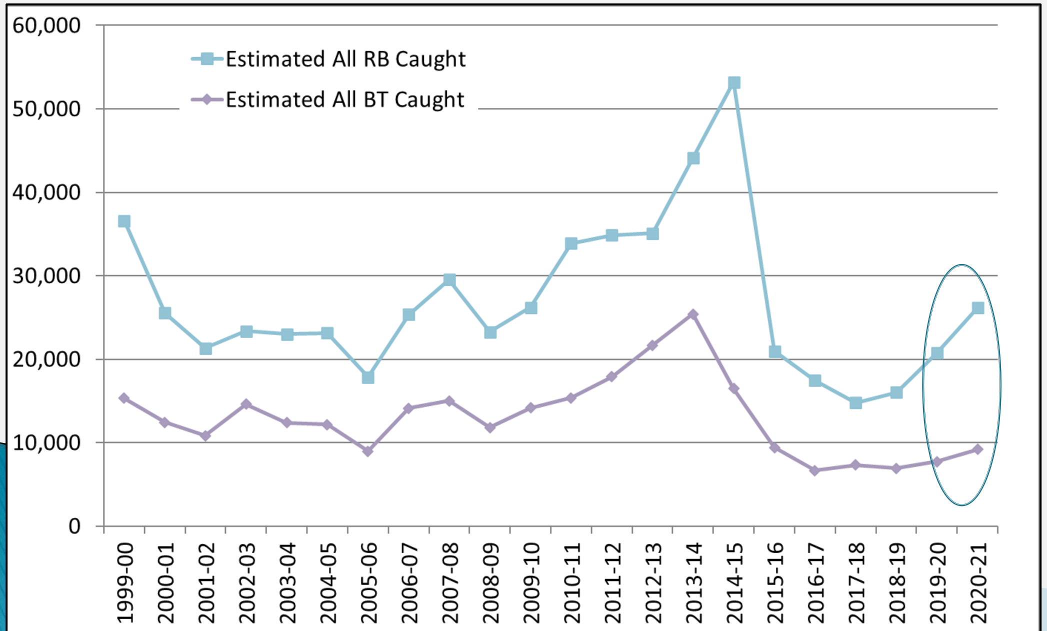
Gerrard Stock Recruitment



Fishery Trends– KLRT Creel







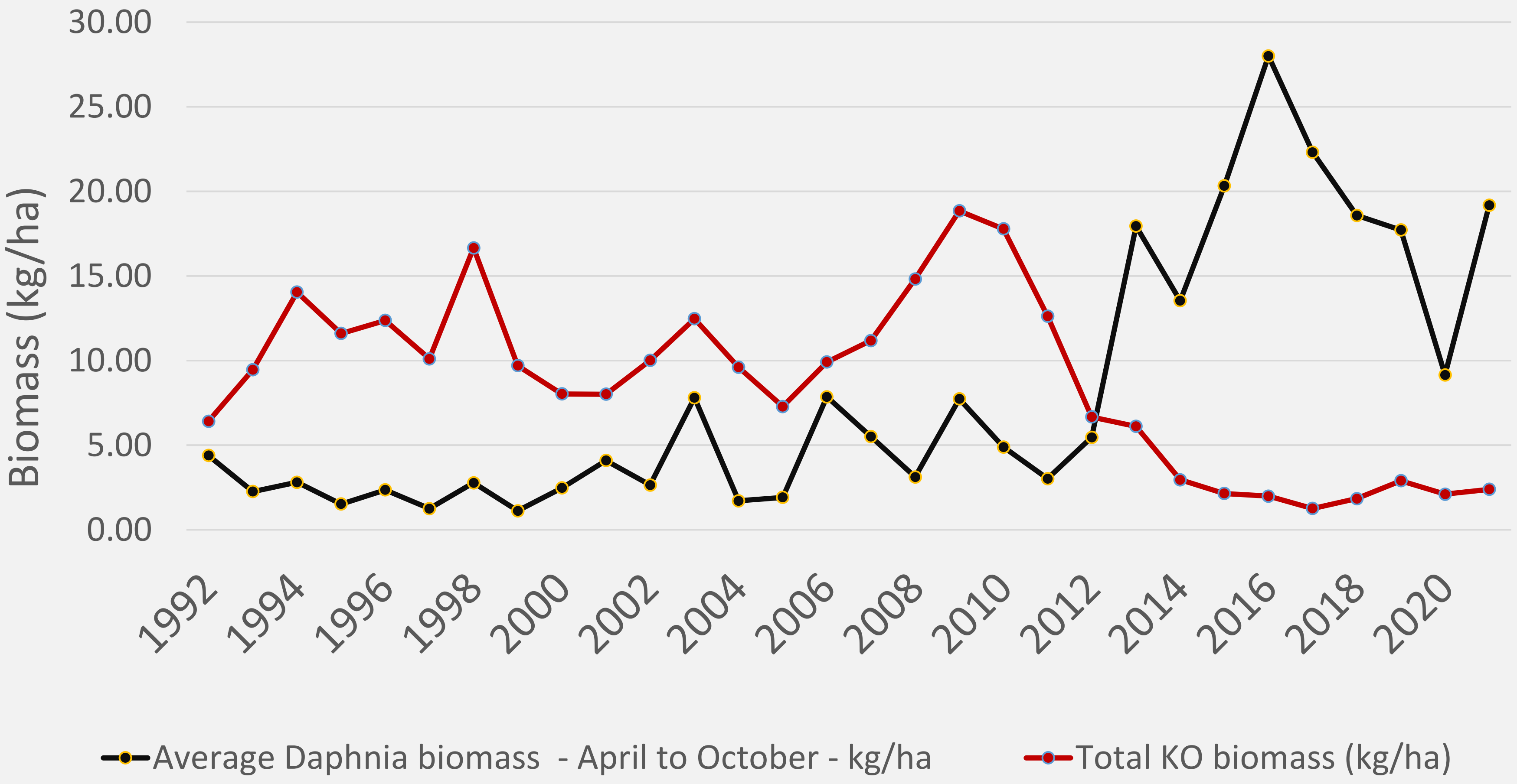
- 2020/21 effort, catch and harvest increase
- Aligns with 2020-21 Kootenay Lake Angler Incentive Program/effort increases associated with COVID

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

Nutrient Restoration Program

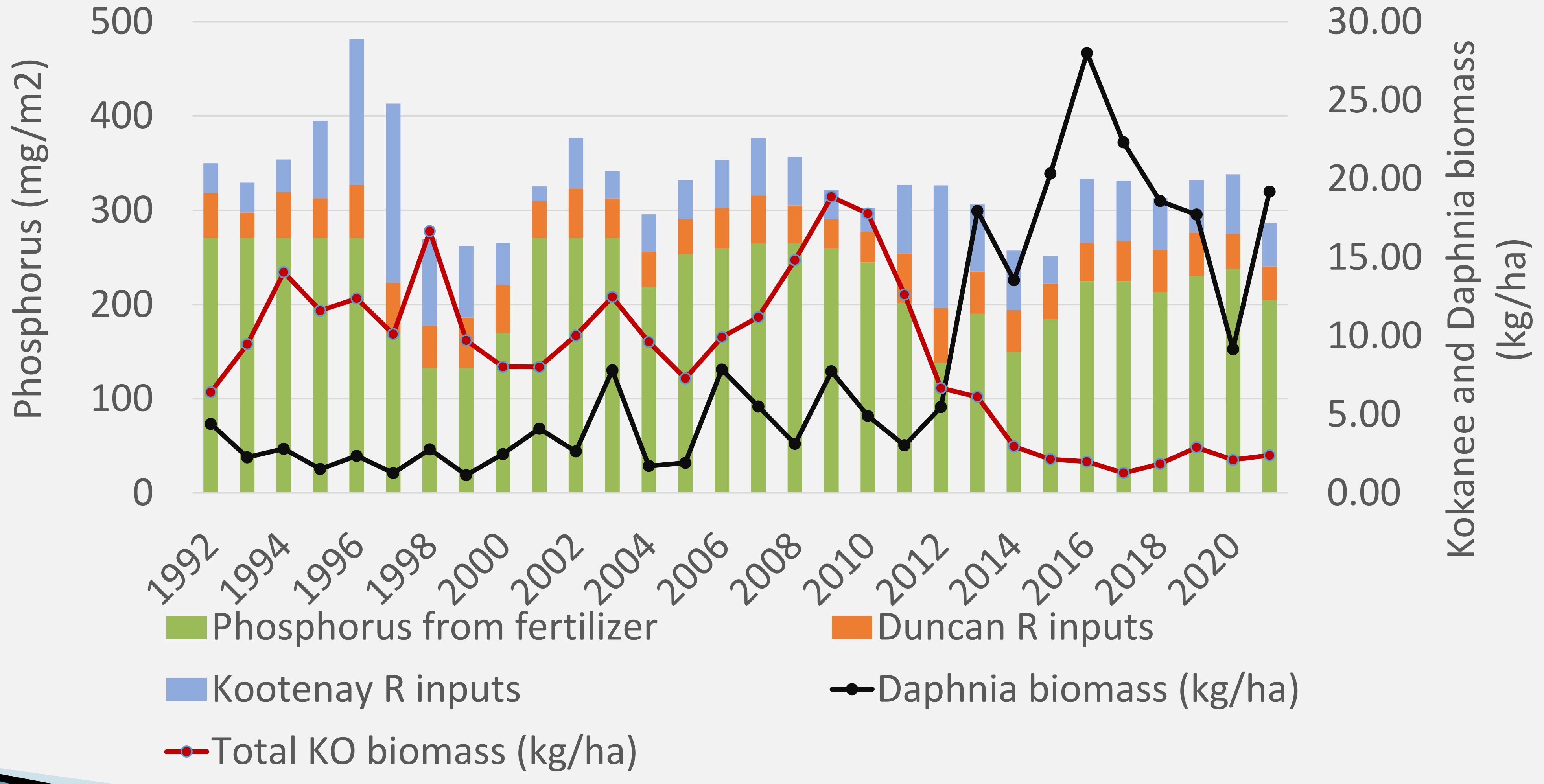
Valerie Evans and Tyler Weir

Average Daphnia and total ko biomass (kg/ha)



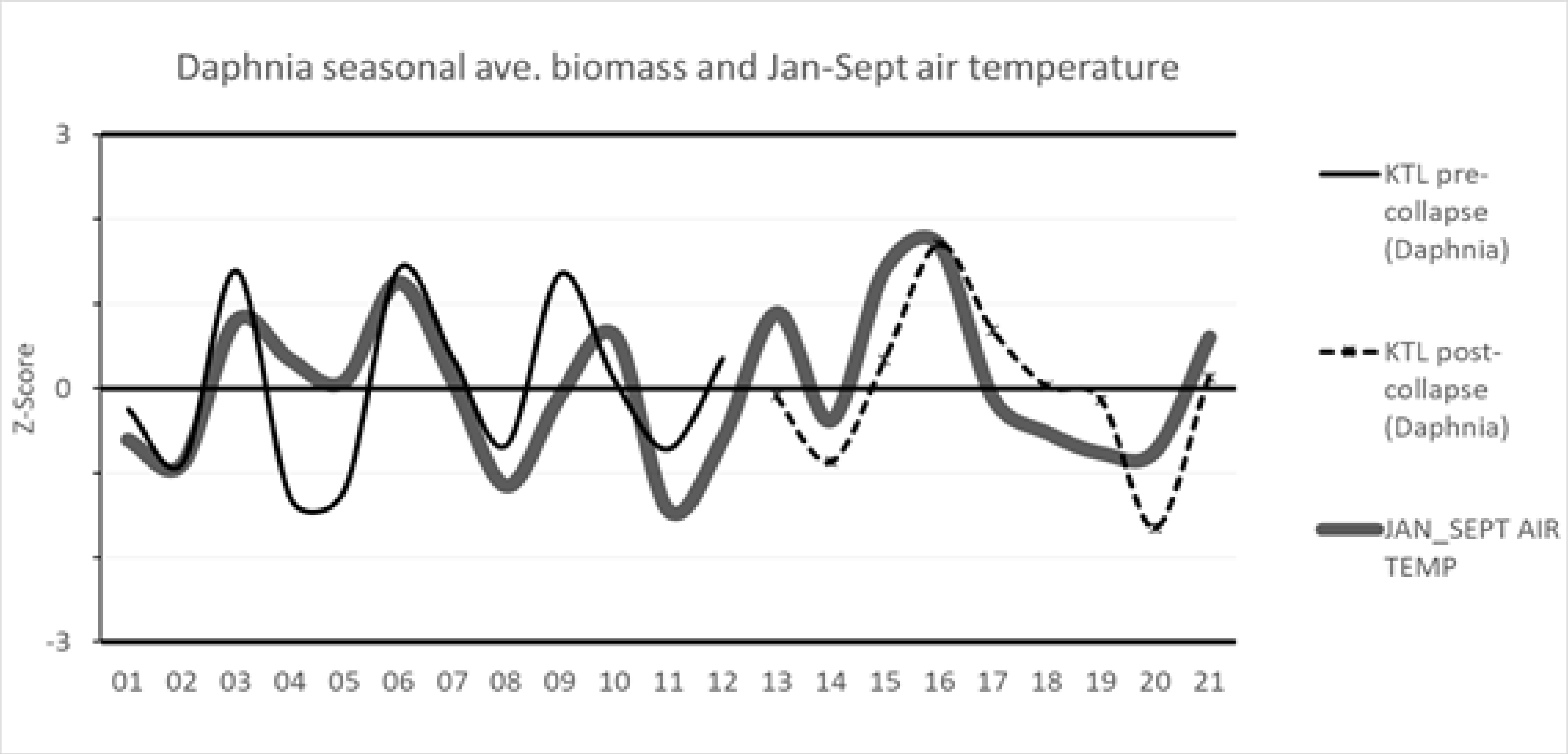
** preliminary*

P additions (mg/m2) to Kootenay Lake – average *Daphnia* and total ko biomass (kg/ha)

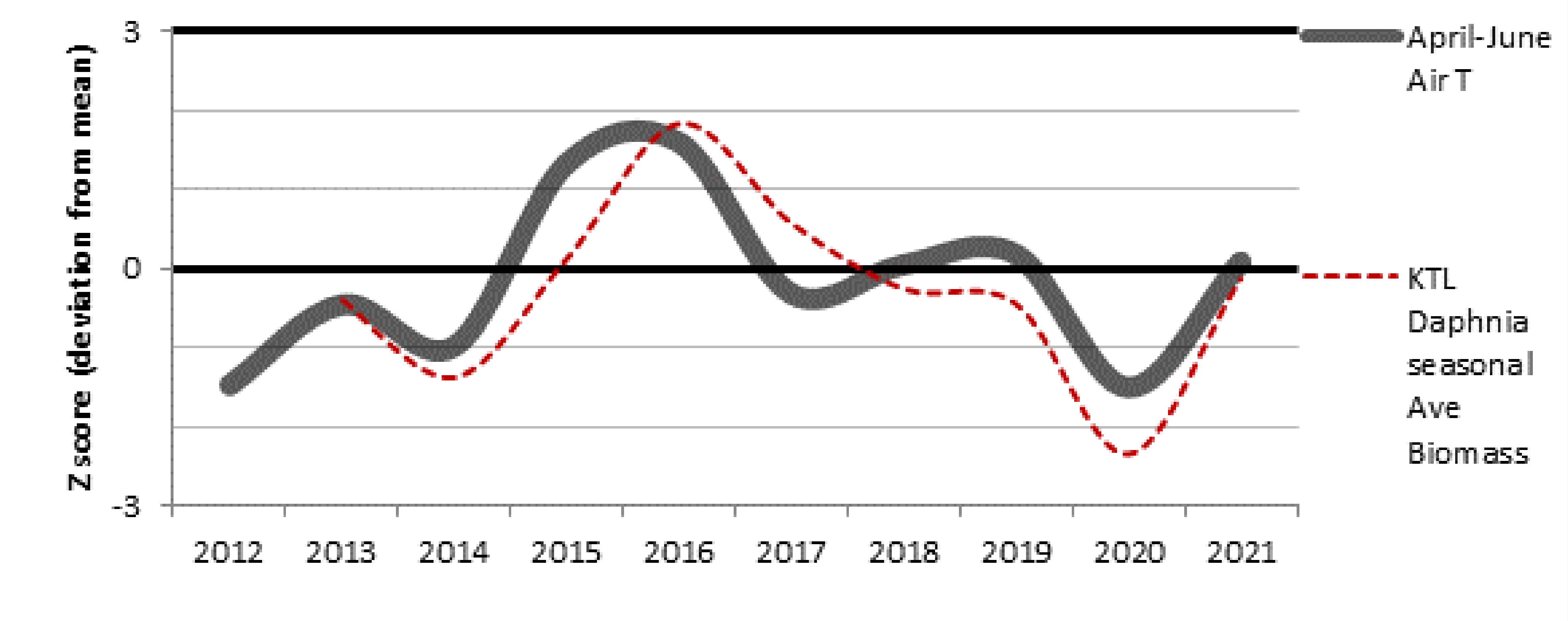


** preliminary*

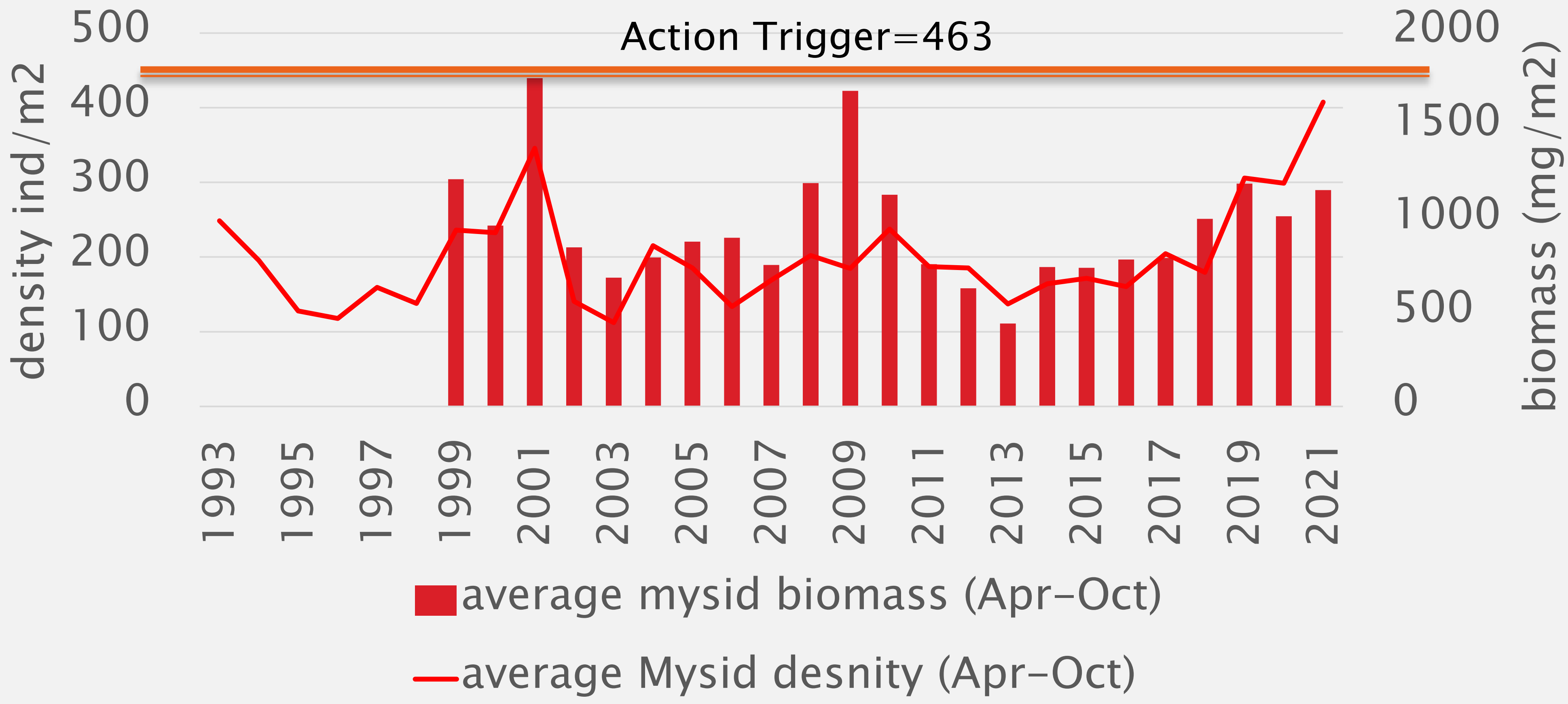
Kootenay *Daphnia* & temp. trends



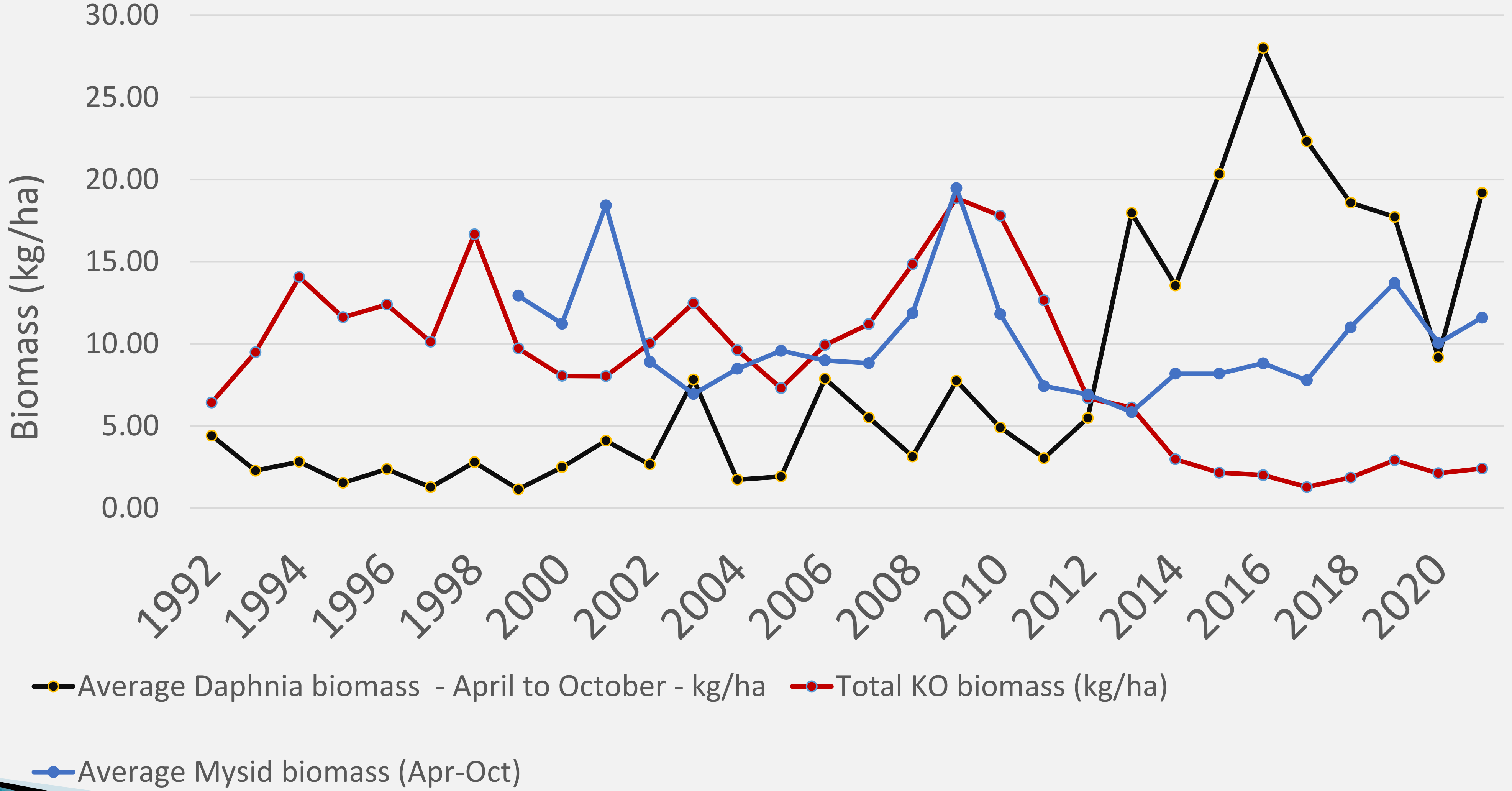
Kootenay *Daphnia* & temp. trends



Avg. annual Mysid Density and Biomass

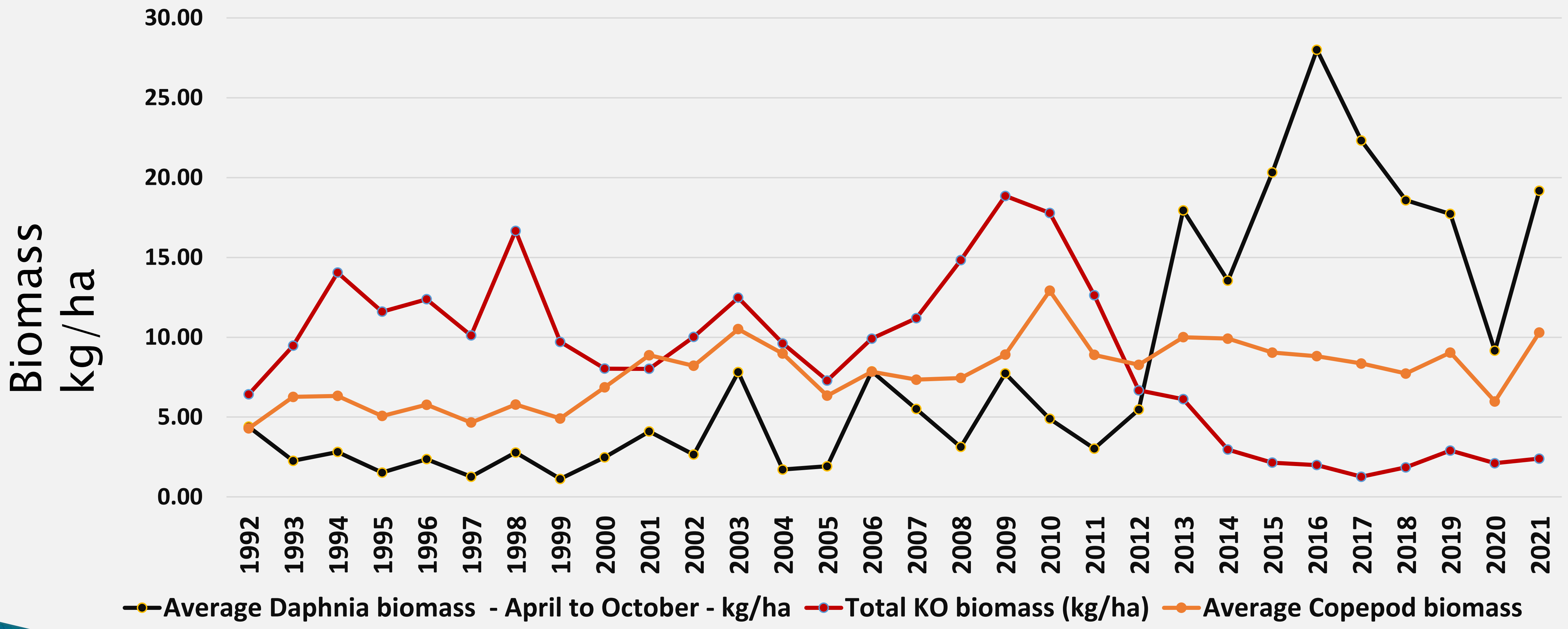


average *Daphnia*, Mysid and total ko biomass (kg/ha)



** preliminary*

Average Daphnia biomass, Copepod biomass and total kokanee biomass (kg/ha)



Copepod biomass is average from April to October; total kokanee biomass is in-lake from hydroacoustic survey and spawner biomass (hydroacoustic survey occurs in September after spawners have left the lake)

Summary: Biological Response Update

- North Arm kokanee egg deposition, spawner escapement (, fecundity/size all down in 2021
- High 2021 KO fry population, small increase in age 0-1 KO survival, large increase in age 1-2 KO survival, estimated escapement of ~60,000 spawners in 2022
- BT escapement consistent downward trend since 2017, slight increase in 2021
- Gerrard escapement similar to 2020, spawner size decreasing
- KLRT: Increase in fishery catch, harvest, and effort in 2020-2021
- Daphnia biomass up in 2021 compared to 2020
- Mysid biomass and density on consistent upward trend since 2017, still below AP trigger

2021 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*

- Feasibility report will be developed this winter, followed with future discussion

Action Update: Nutrient Restoration Program

- NRP Program Reviews:
  - ISRP review – Kootenai Tribe of Idaho (BPA funded)
  - 5 additional years of funding – 2021 to 2025 (received confirmation in June 2021)

- ISRP Recommendations:
  - Continue to investigate the fertilization responses and the effects of rainbow trout and bull trout suppression for the next few years.
  - A more comprehensive investigation of zooplankton community dynamics (trends in all zooplankton community components should be re-evaluated).
  - Fertilization activities be re-evaluated in 2025 to learn if and why kokanee are recovering.
  - Food webs are complicated; actions could have unintended consequences

Action Update: Nutrient Restoration Program

- FWCP funded review – currently undertaking an independent third party technical review of the NRP

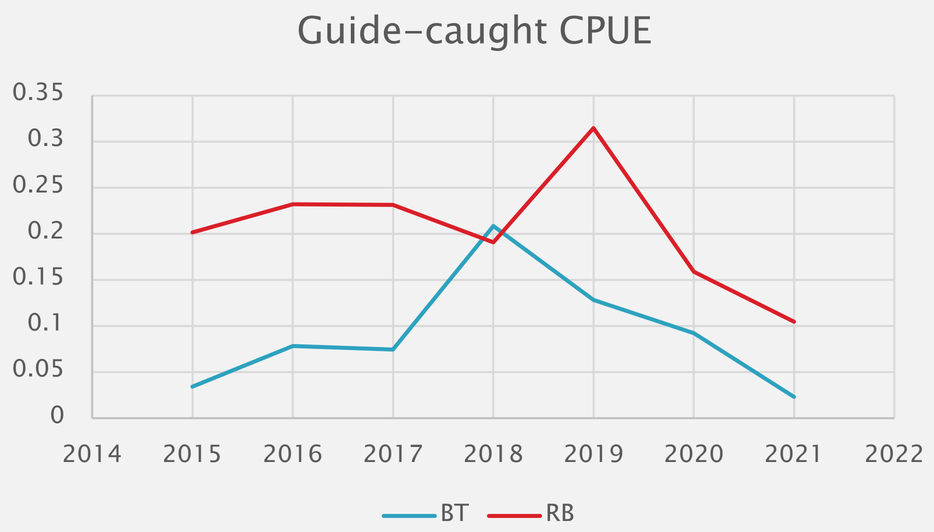
- Outcomes of this technical review will contribute to the ongoing and future discussions and engagement on the NRP's approach and delivery.

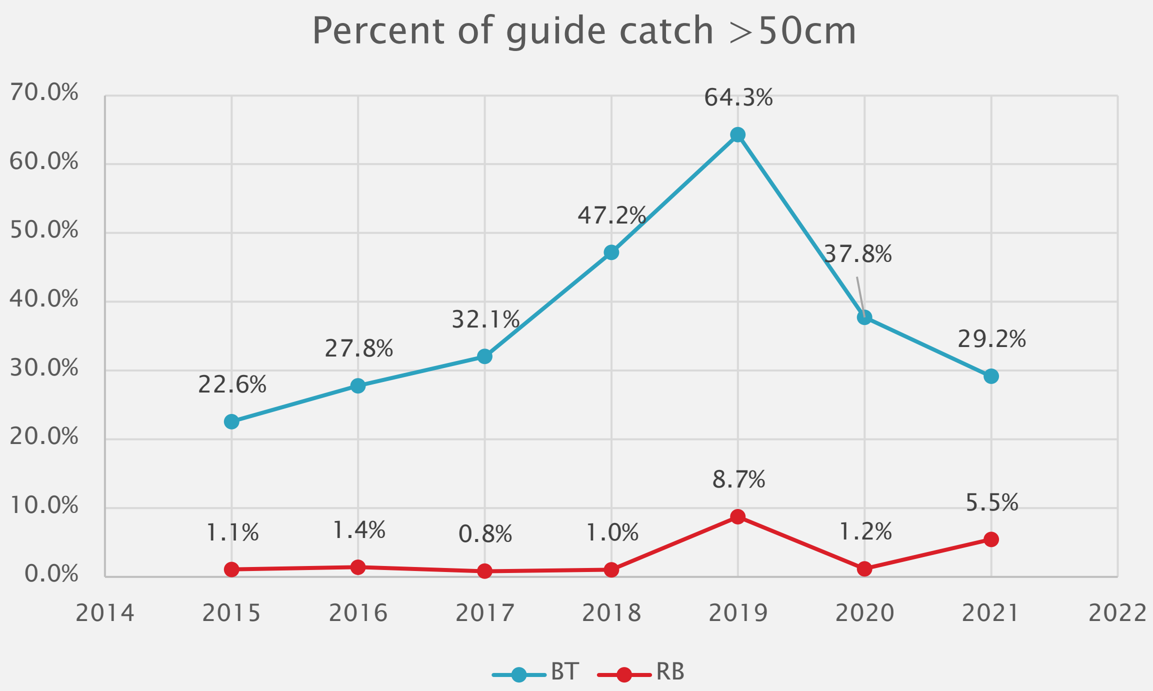
- The review will focus on the technical aspects of the program, as per the associated priority action, and are intended solely as technical documents to inform other [FWCP] discussions, such as reviewing NRP objectives with program partners, engaging with First Nations and communities, and incorporating Indigenous knowledge and values into FWCP projects.

- Priority Action:

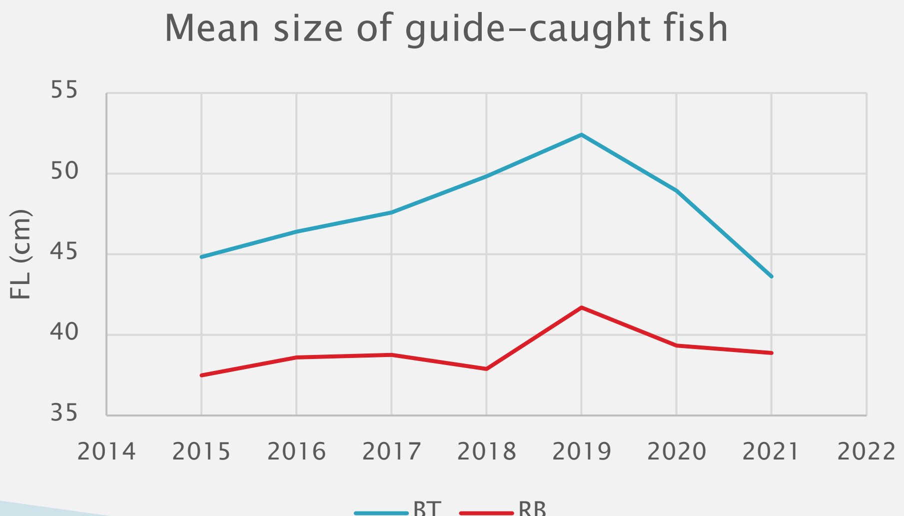
• Implement and adaptively manage nutrient restoration programs in Kootenay Lake and Arrow Lakes Reservoir to sustain in-lake productivity at levels sufficient to support secondary productivity (forage for Kokanee).

What's the State of Kootenay Lake in 2021?



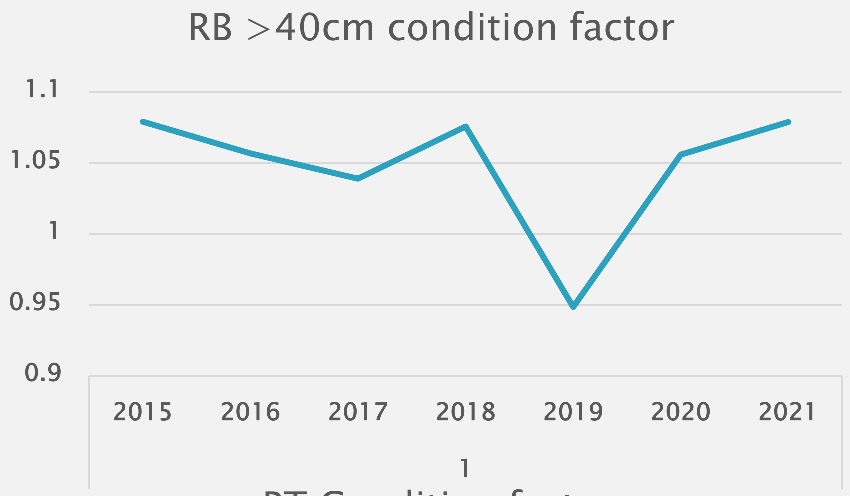


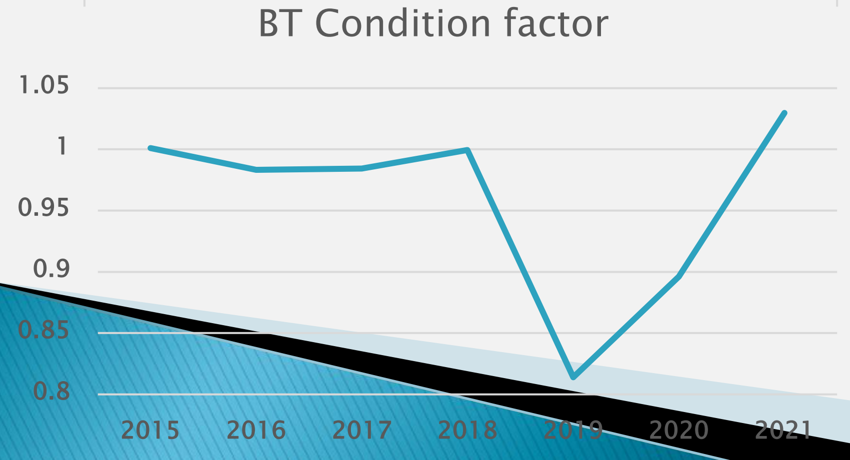
- Piscivore Monitoring Program Results (preliminary)
  - CPUE falling (indirect indicator of density/abundance)
  - Fish size dropping in catch (but proportionally more RB >50cm – fishery effect/growth compensation counteracting each other

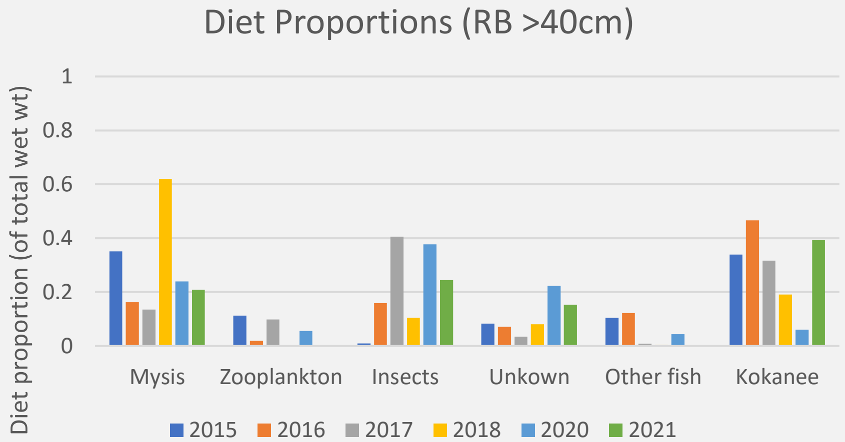


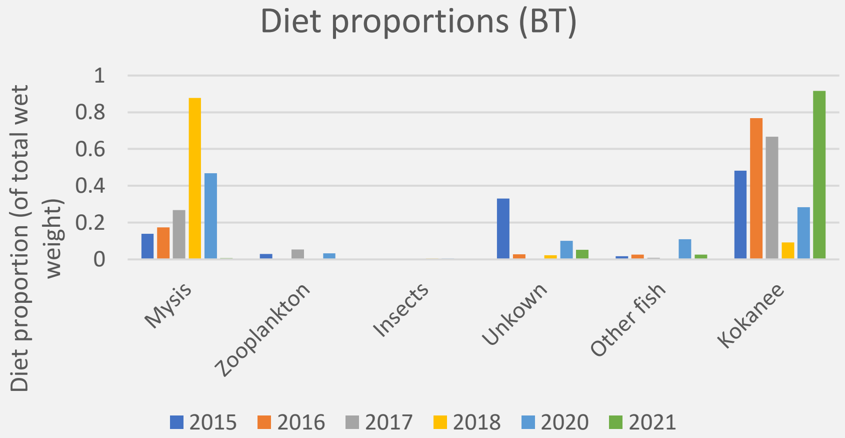
What's the State of Kootenay Lake in 2021?

- Piscivore Monitoring Program Results (preliminary)
  - Diets and conditions both suggest feeding conditions for predators dipped in 2018-20 and have rebounded in 2021
    - Indication that predator/prey ratio is trending in right direction * Note, RB estimates in 2021 are preliminary and likely to become more piscivorous with later fall samples included







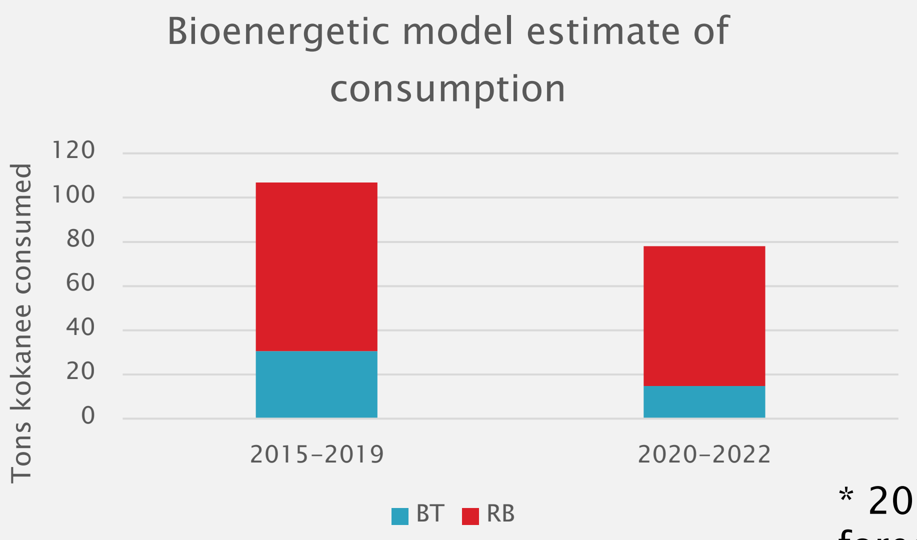


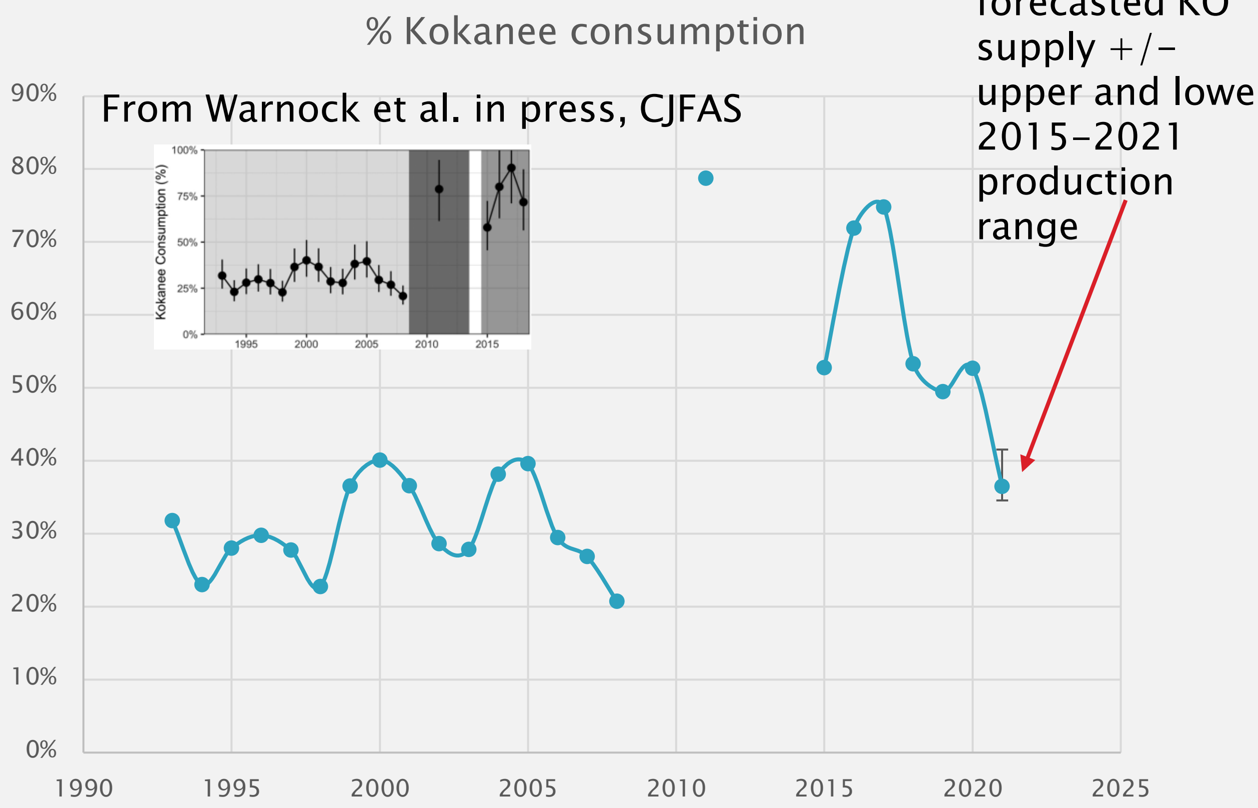
What's the State of Kootenay Lake in 2021?

- Piscivore Monitoring Program Results (Preliminary):
  - RB Genetics– declining % Gerrard?:
    - 2015–2017 average= 73.4% Gerrards
    - 2018= 59% Gerrards, 2020= 49% Gerrards
    - Uncertainty, but could support declining in-lake abundance
  - Exploitation Study (ongoing):
    - Tagged 60 RB in spring 2021
    - Tagged 16 BT in fall 2021, ongoing
    - 6 tag returns to date

What's the State of Kootenay Lake in 2021?

- Multiple independent lines of evidence in predators suggest in-lake piscivore abundance has declined since 2019 relative to the prior several years.
- Meanwhile, age 0 KO abundance in fall of 2021 has never been higher
- Predators appear to be nearing satiation with KO, and both predator and age-1 KO condition has rebounded
- Bioenergetics – consumption to supply ratio?
  - Re-run 2015-2019 estimate for 2020-2022 assuming:
    - BT population has 2X fishing mortality
    - RB population has 2X fishing mortality, 50% recruitment and pre-collapse KO diet proportions
  - Not a crystal ball, but bioenergetics estimate suggests actions are working and we may be on the cusp of recovery?





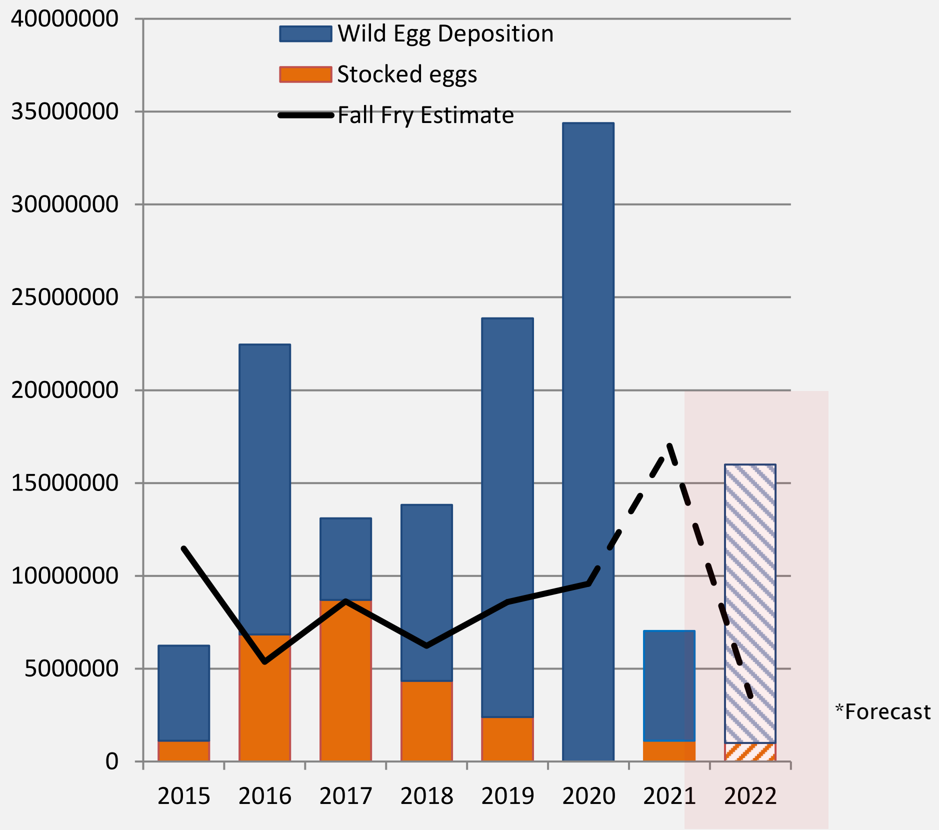
Action Update: Kokanee Supplementation

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

- Stocked ~1.1 million eggs into MCSC in fall 2021
- 2021: egg supply– ~7 million, ~17 million fall fry

Key Question: Do we stock in 2022?

- 2022 spawner forecast is ~60k, 15 mil eggs
- Without stocking, fall fry likely to be 3.5 mil in 2022
- 2022 stocked egg supply uncertain, but could be ~ 1.75 mil (12% of estimated wild egg deposition)
  - Lots of uncertainty at Hill Ck, Whatshan= ~750,000, forecasted egg supply at Tyee likely ~1 million

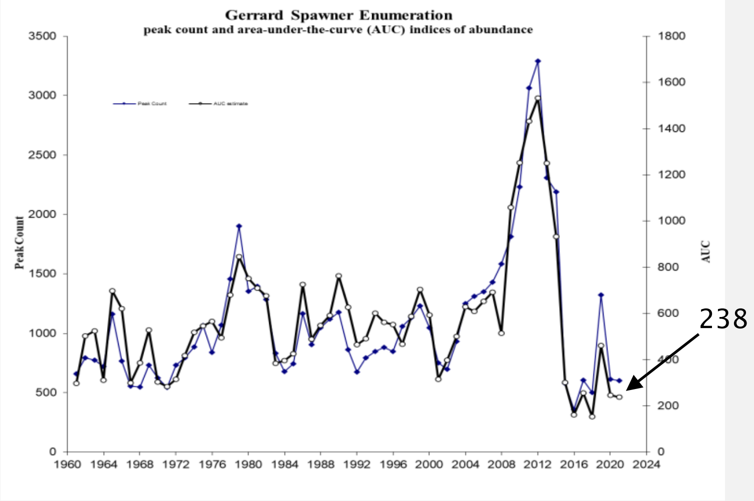


*Forecast assumptions:

- egg to fall fry similar to previous 5-year mean (~50%)
- 2022 spawners 60k (50% F) and fecundity ~500

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***

Northern tributaries	
Upstream Flip Bucket Fish Count - Duncan Dam (M. Casselman, BC Hydro, pers. comm.)	230
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Cultus	na

* funded by HCTF

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

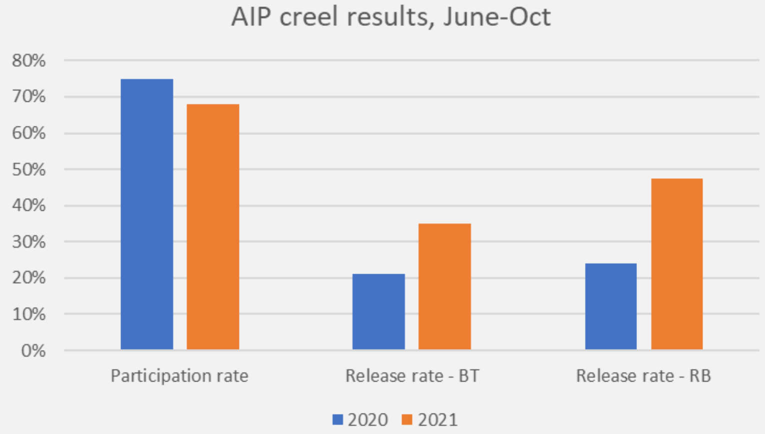
Recreational Fishery Regulations

- 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 (2 >50cm), 10/year >50cm

Action Update: Predator Management
Kootenay Lake Angler Incentive Program

- 2020-2021 Program– 10,689 entries
- 2021-2022 Program June-October– 2,776 entries (ongoing; program runs until May 2022)

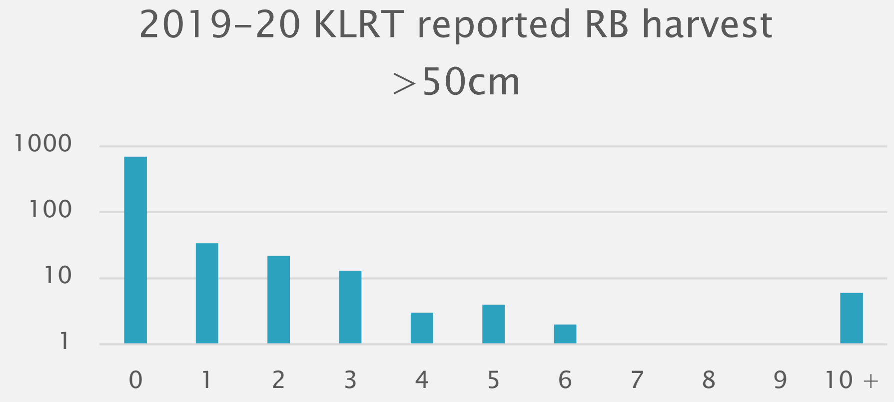
- Creel 2020- 2021 vs 2021-2022 (June-Oct)
  - 61% vs 58% hold a KLRT license… compared to 77.5% in 2011
  - Reduction in release rate for both species in 2021-22

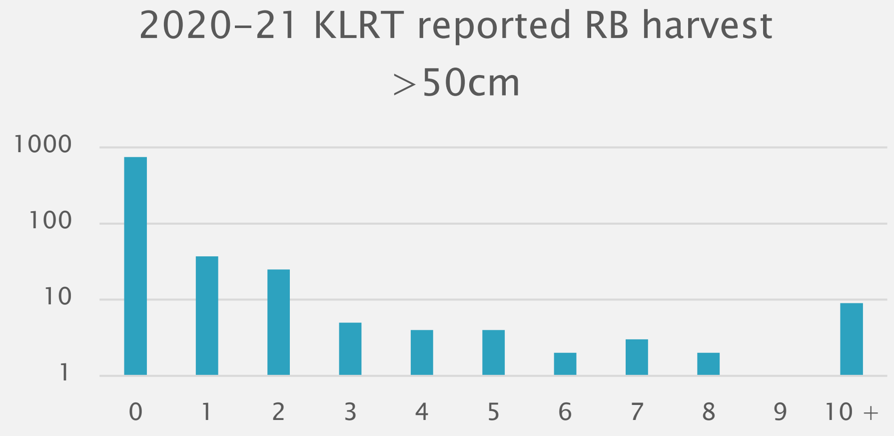


Key Question: What predator management actions should be implemented in 2022? (in-lake, immediate benefit)

Are current fishing quotas limiting anglers?

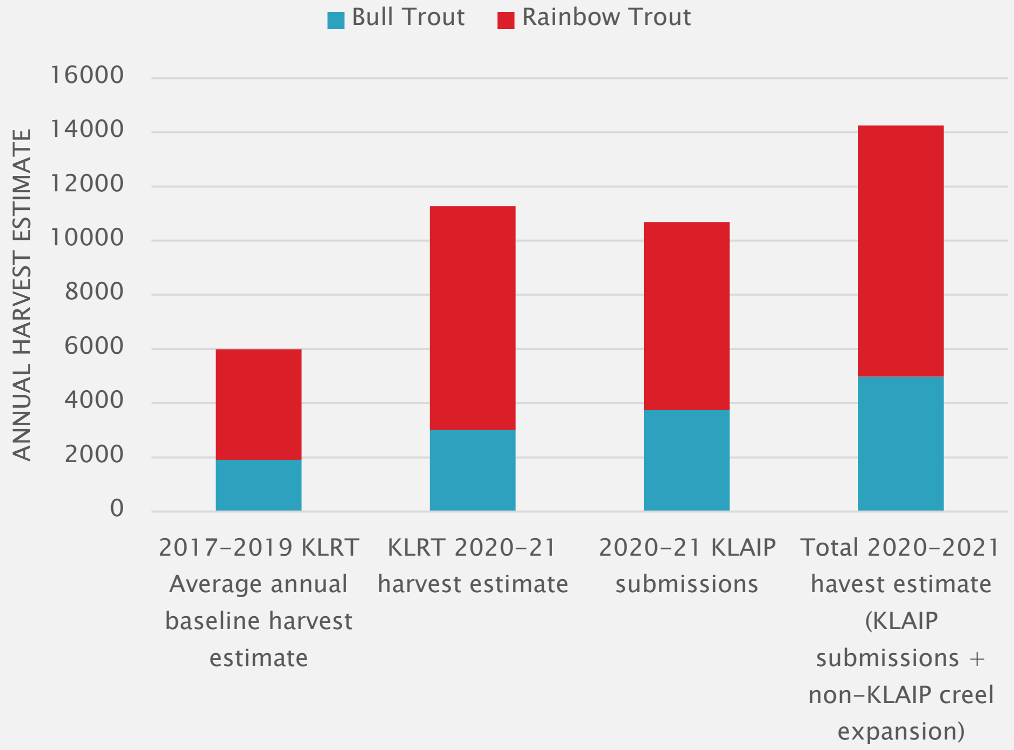
- Current quotas: RB 5/d (2>50), 10/yr; BT 3/d any size.
- Are further quota increases justified?
- Daily limits: In 2020 and 2021, KLAIP creel suggested daily catch rates were almost never limiting the current quotas (<1% of interviews).
- RB 2>50 daily limit: In 2020 and 2021, Kerry Reed never caught more than 2 RB in a day >50cm (that size regulation is not limiting)
- RB 10/yr >50: In 2019-21, only ~10 responses (out of ~1000 surveys; ~1%) suggested 10 or more RB >2kg were harvested.
- Therefore, liberalizing quotas further will do little to change exploitation.

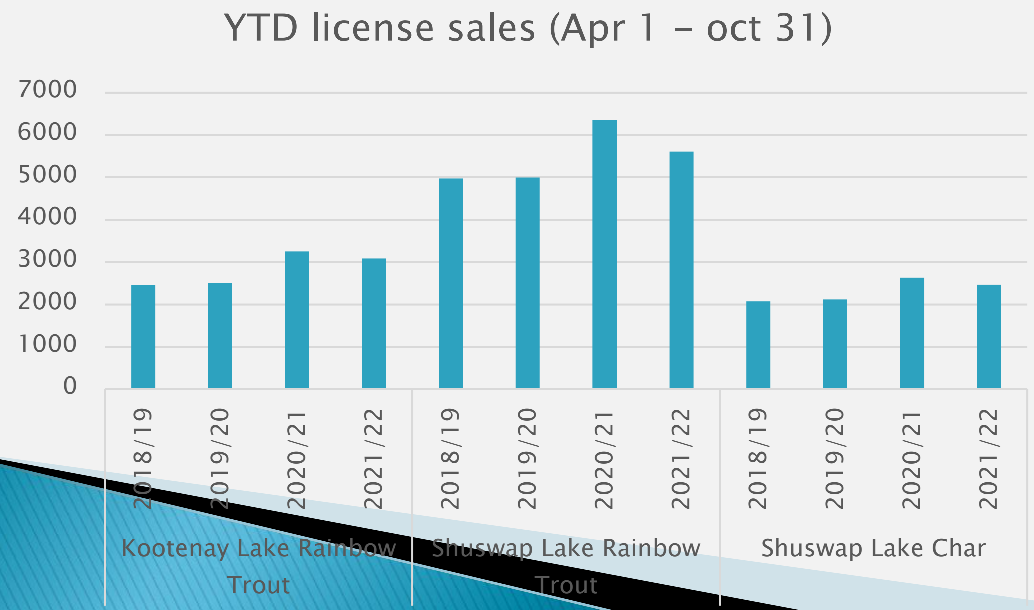


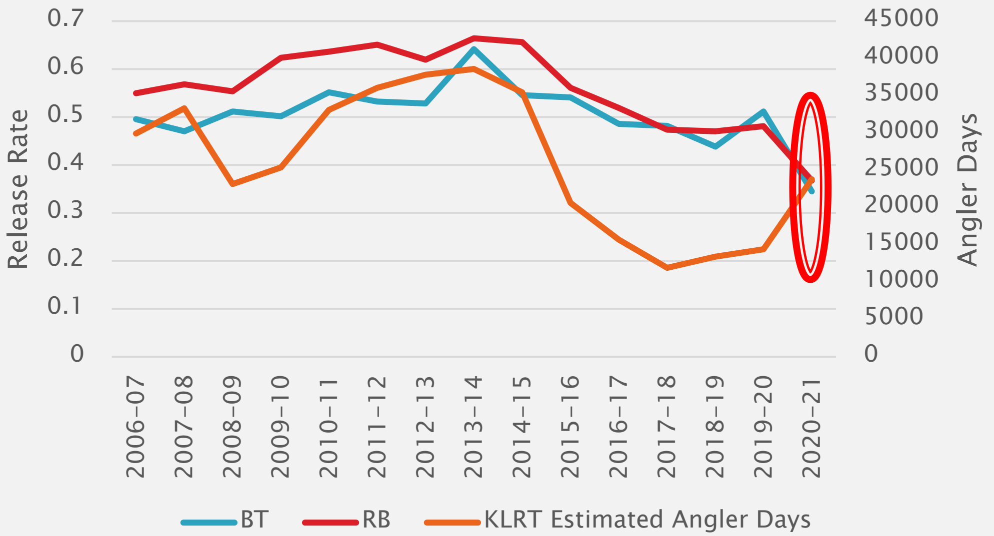


KLAIP – Effect in the first year?

- 10,689 fish entered in 2020-21
- Clear independent signal in KLRT data. KLRT suggested an overall harvest expansion of 85% (Rainbow) and 57% (Bull) from the 2015-2020 baseline
- Either way of calculating finds ~12K-14K piscivores removed from the lake in 2020-21 – approximately double the fishing mortality of 2017-19.
- So 2020-21 was a huge angling year
- How did it work? About 81% of this increase is attributed to effort increase, and only 19% from release rate changes, inferred from KLRT.
- Effort increases may have benefitted from COVID years (trends also seen in Shuswap)

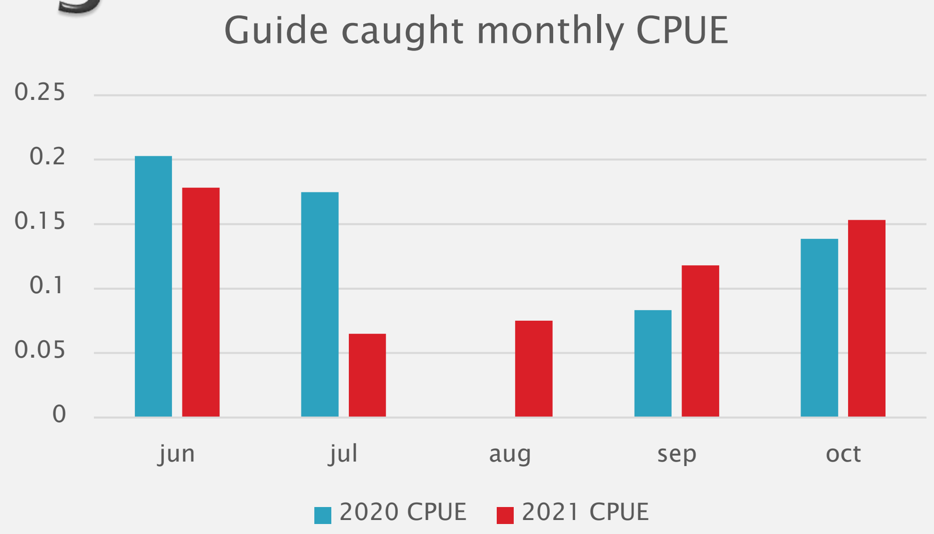


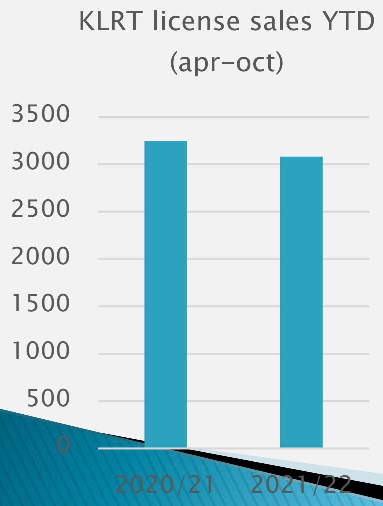


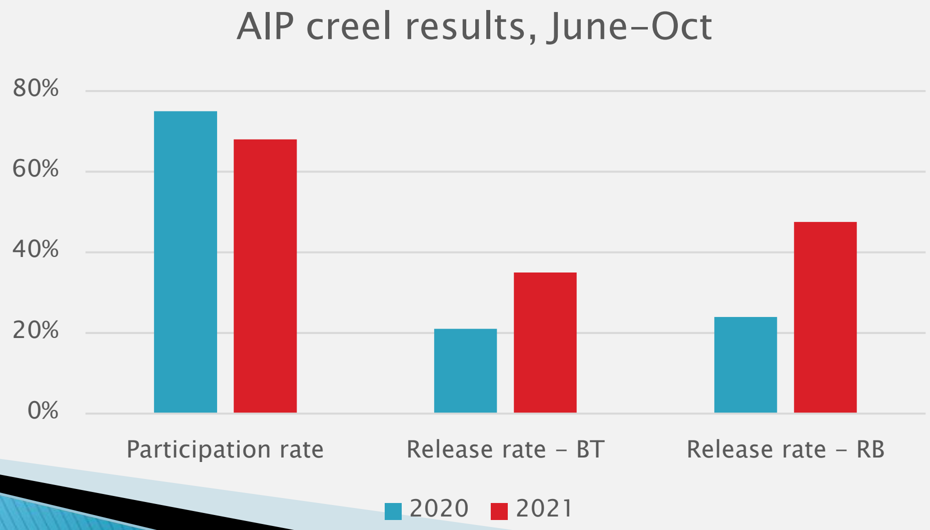


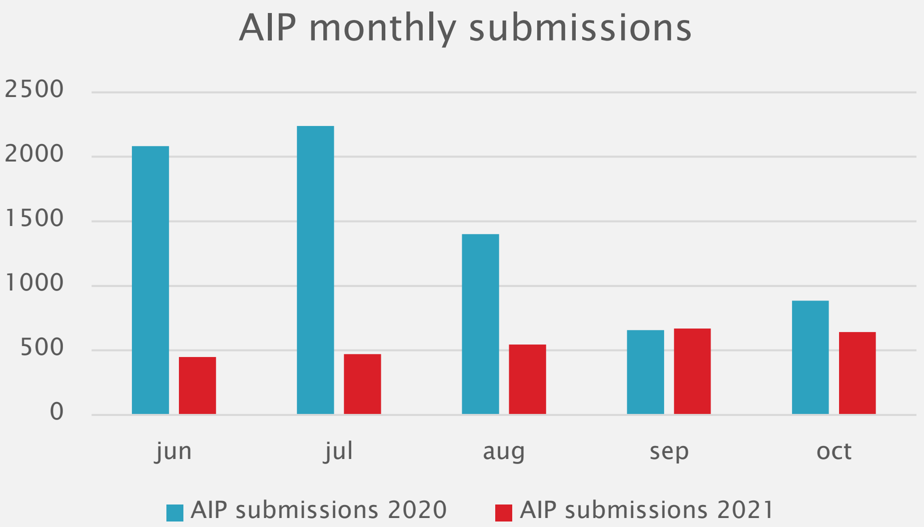
Kootenay Lake Angler Incentive Program
Is it still working?

- Entries way down in June-Aug but not Sept
- Catch rate? – probably some effect (only Jul)
- Lower Effort? – No indication by license sales or KLAIP creel time fished/day
- Lower participation? – AIP creel suggests not
- Release rate change (smaller fish? smaller prize in AIP? Locals vs tourists?)
- Interpretation – AIP is probably still working, but many things are outside our control.









Improving the Kootenay Lake Angler Incentive Program 2022-2023

- How can we improve next year's program?
  - Increasing prize value may help improve program participation (i.e., a single $30,000+ prize)
  - Collaborative options to improve outreach and awareness/support of the program
  - Different options for fish submission (increasing harvest rate for smaller predators)
  - High-reward tags?
  - Other?

Key Question: What Predator Management Actions should we implement in 2022 (recruitment actions, future benefit)?

BT in Kaslo River – how much room is there above the conservation threshold?

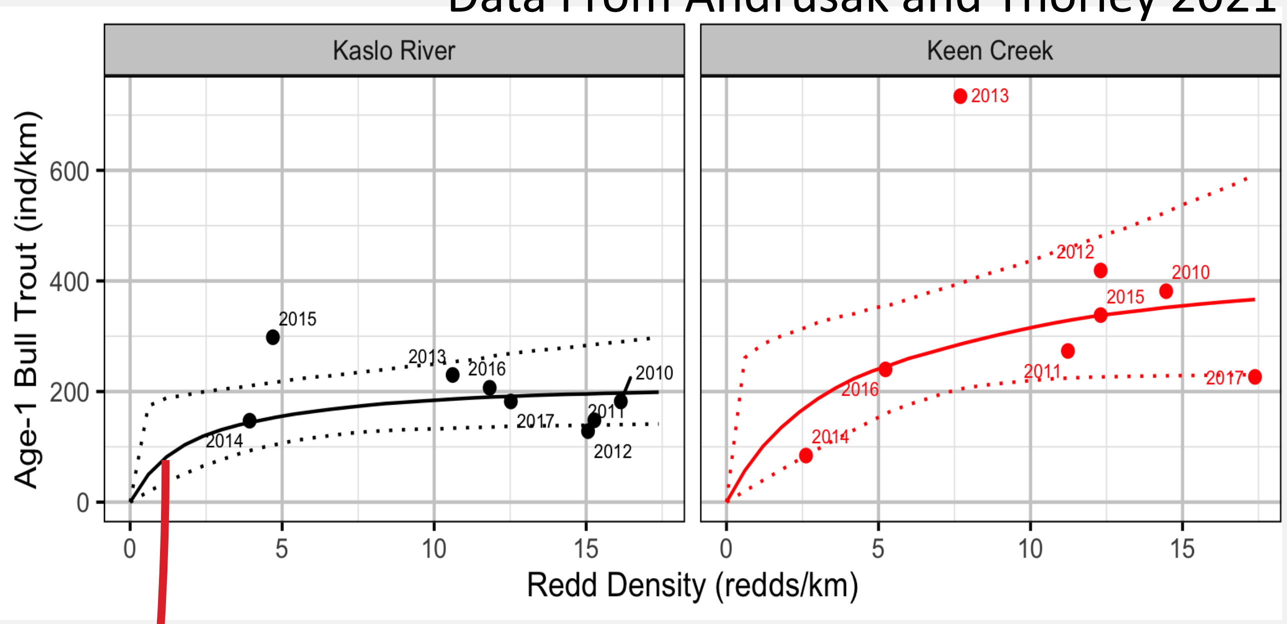
- Lake-wide conservation threshold of 250 spawners; we remain significantly above this – >1000 fish in 2021 despite lower in-lake abundance (compensation?).

- The Kaslo River makes up 22% of lake-wide abundance, thus it's unlikely lake-wide spawner abundance would be below 250 if Kaslo remains above 55 spawners.

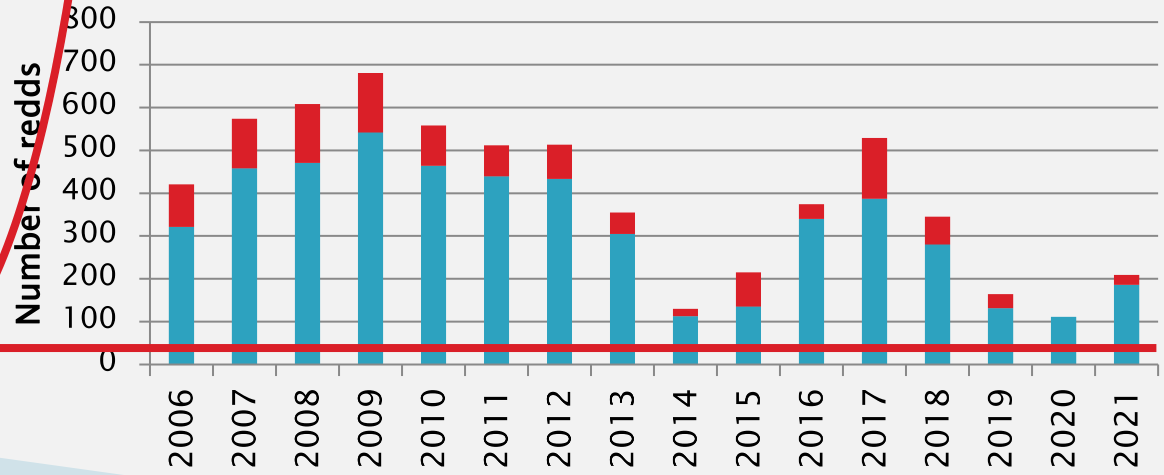
- 55 spawners in the Kaslo (25 redds) would produce 28% of carrying capacity of recruits using Beverton-Holt SR parameters of Andusak and Thorley 2021 – best available info at the time suggests a significant recruitment effect of reducing the spawning population to this level.

- Therefore, if lake-wide spawner number remains well above thresholds there is minimal conservation risk of reducing Kaslo spawners to 55 or more fish (~1 redd/km or 25 redds)

Data From Andrusak and Thorley 2021



Bull Trout Redd Counts in Kaslo River System: 2006-2021



Recruitment Effect of Bull Trout Removals

- How many T of KO saved if we reduced BT from Kaslo to 55 spawners?
  - Simplifying assumptions – Kaslo is ~20% of rearing area for Kootenay Lake; keen is disregarded for density dependent movement
  - Result – 14% reduction in BT lake-wide age-4 abundance in ~5 years (assuming all other source populations have 100% recruitment)
    - if implemented in 2022, 2027 is probably the first year of action having significant effect.
- This could be expanded to other tributaries for more of a recruitment effect, but less feasible/more uncertain to implement because:
  - No real system-specific SR data
  - Less accessible
  - Lower juvenile carrying capacity
  - Metapopulation dynamics (Duncan)

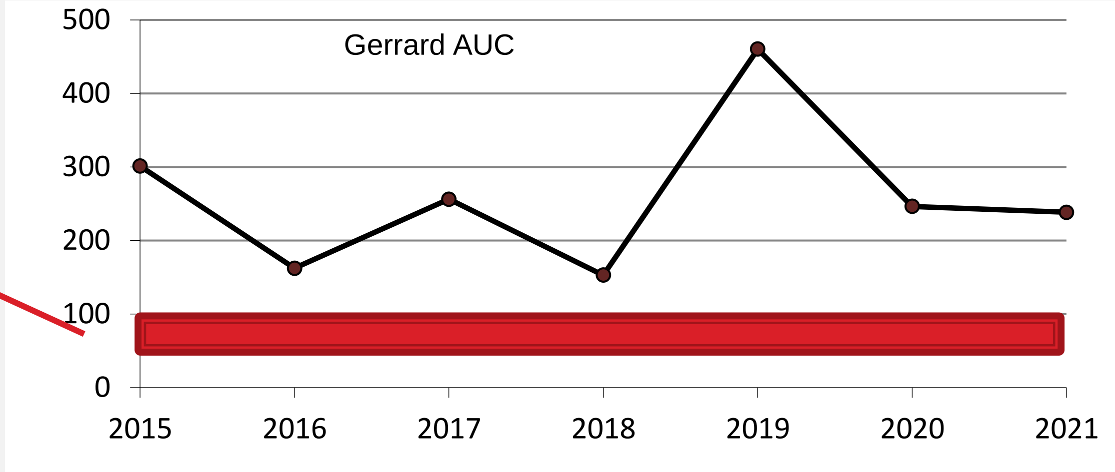
Options to Reduce Bull Trout Recruitment

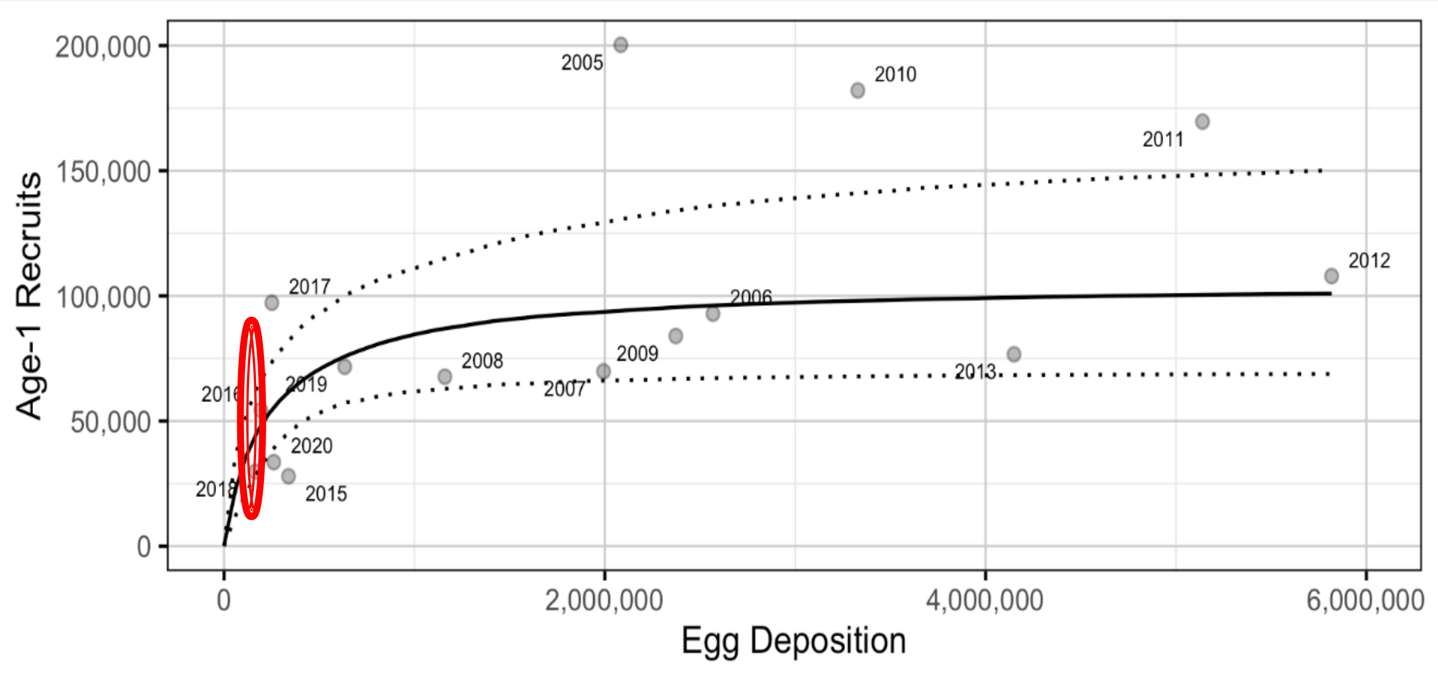
Methods to reduce BT recruitment:

- Direct (controlled):
  - Kaslo fence (intercepting pre-spawn BT), feasible depending on inter-annual Q variability
  - Other?
- Angling removals (uncontrolled):
  - Rescind angling closures on high BT producing systems like Kaslo, Hamill, Meadow, Crawford and Midge (uncontrolled)

Gerrards – recruitment effect of 50-100 spawners

- Spawner abundance remains consistently above conservation thresholds, despite lower prior recruitment and higher fishing mortality.
- At current fecundity (2051 eggs), the latest SR Beverton-Holt parameters from Andrusak and Thorley 2021 suggest 100 spawners (50 females) = ~34,000 recruits or ~1/3 carrying capacity (104,000)
- 95% CI on this is ~23,000 – 98,000 recruits
- 50 spawners = 20,000 (95% CI 11,000-49,000) recruits.



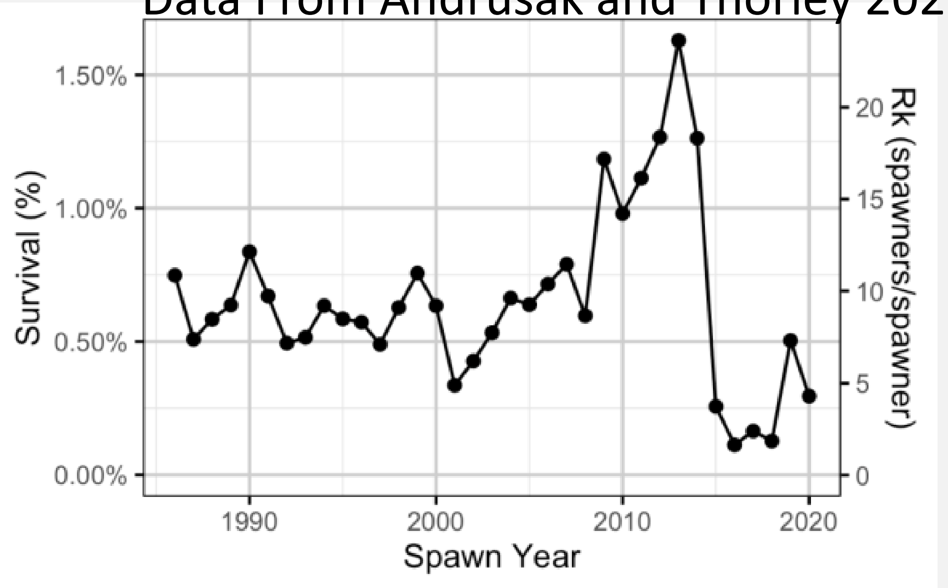


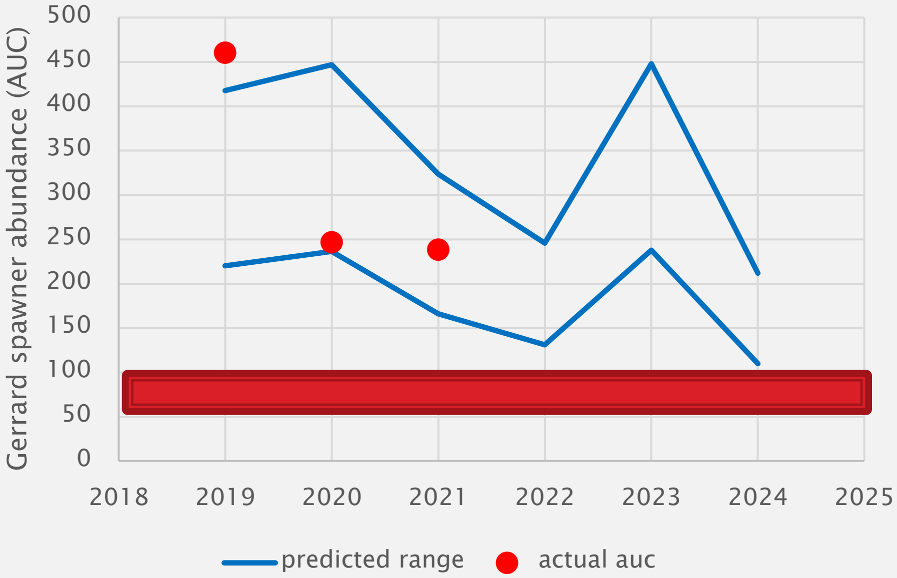
Data From Andrusak and Thorley 2021

Uncertainty in Forecasting Gerrard Spawner Abundance

- A simplifying assumption of the 2017 rearing cohort contributing primarily to 2022 adult returns (as age 6/7 spawners) should conservatively result in 131-246 spawners at Gerrard using conservative parr-adult survival value ranges of Andrusak and Thorley (2021).
- Although generally accurate at predicting spawner abundance last 3 years, lots of uncertainty (spawner age, cohort abundance in flanking years varies)
- Implies that there are conservatively 31-146 Gerrard spawners returning next year "surplus" to KLAT conservation threshold of 100 fish.
- Being too conservative (remove 31 fish?) will likely undershoot and have very little recruitment effect; being too liberal (remove 146 fish) could remove ALL spawners.
- Range is helpful, but not precise enough to guide specific removal target.

Data From Andrusak and Thorley 2021

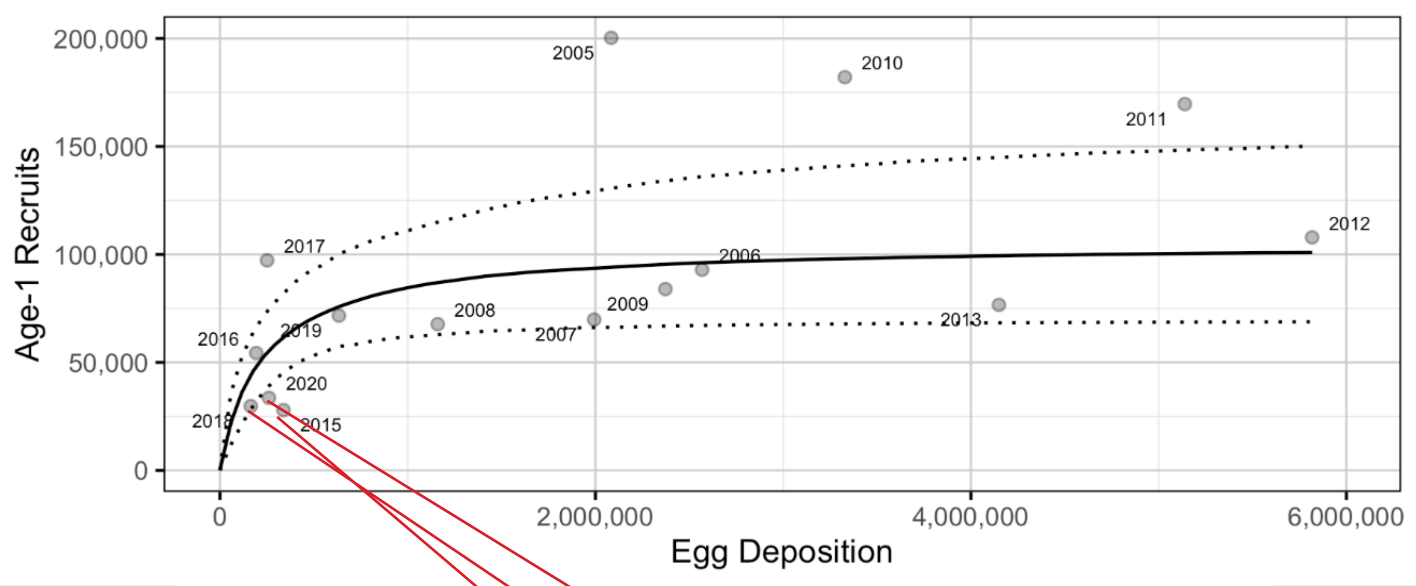


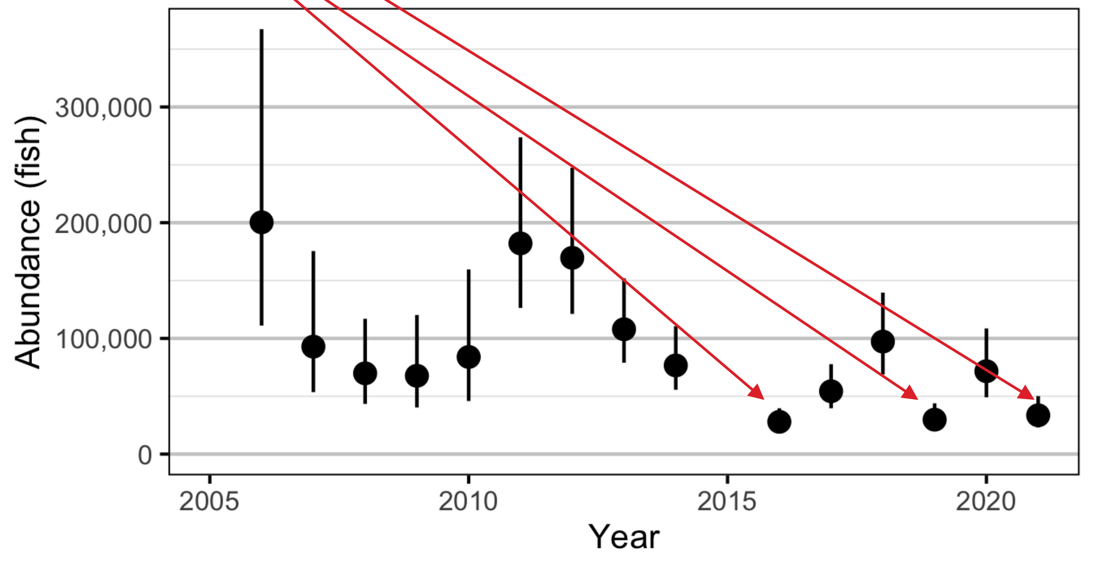


But even if we could predict spawner abundance and hit a recruitment target, it already happened for us naturally!

- Gerrards have fallen to around or below 50% of juvenile carrying capacity in 4 of the last 6 years
- Nevertheless, this recruitment appears to have been sufficient to maintain KO in a predator pit (2016-17 age-1 cohorts had been in the lake for a few years and are now largely aged out of population) – the effect of this should have been most meaningful in ~2019-2021.
- There may be compensation happening – we don't understand why – survival (cannibalism? food/growth?) and/or spawn probability (growth/condition).
- So in order to have a greater effect than what already happened, spawner removals will have to "knife edge" around 50-100, or the effect will be meaningless.

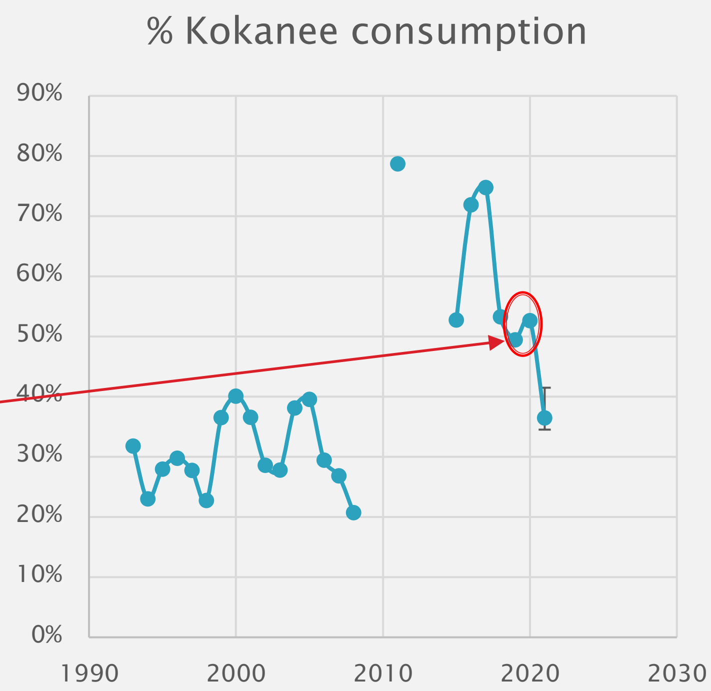
Data From Andrusak and Thorley 2021





Gerrards – summary of uncertainties and benefits

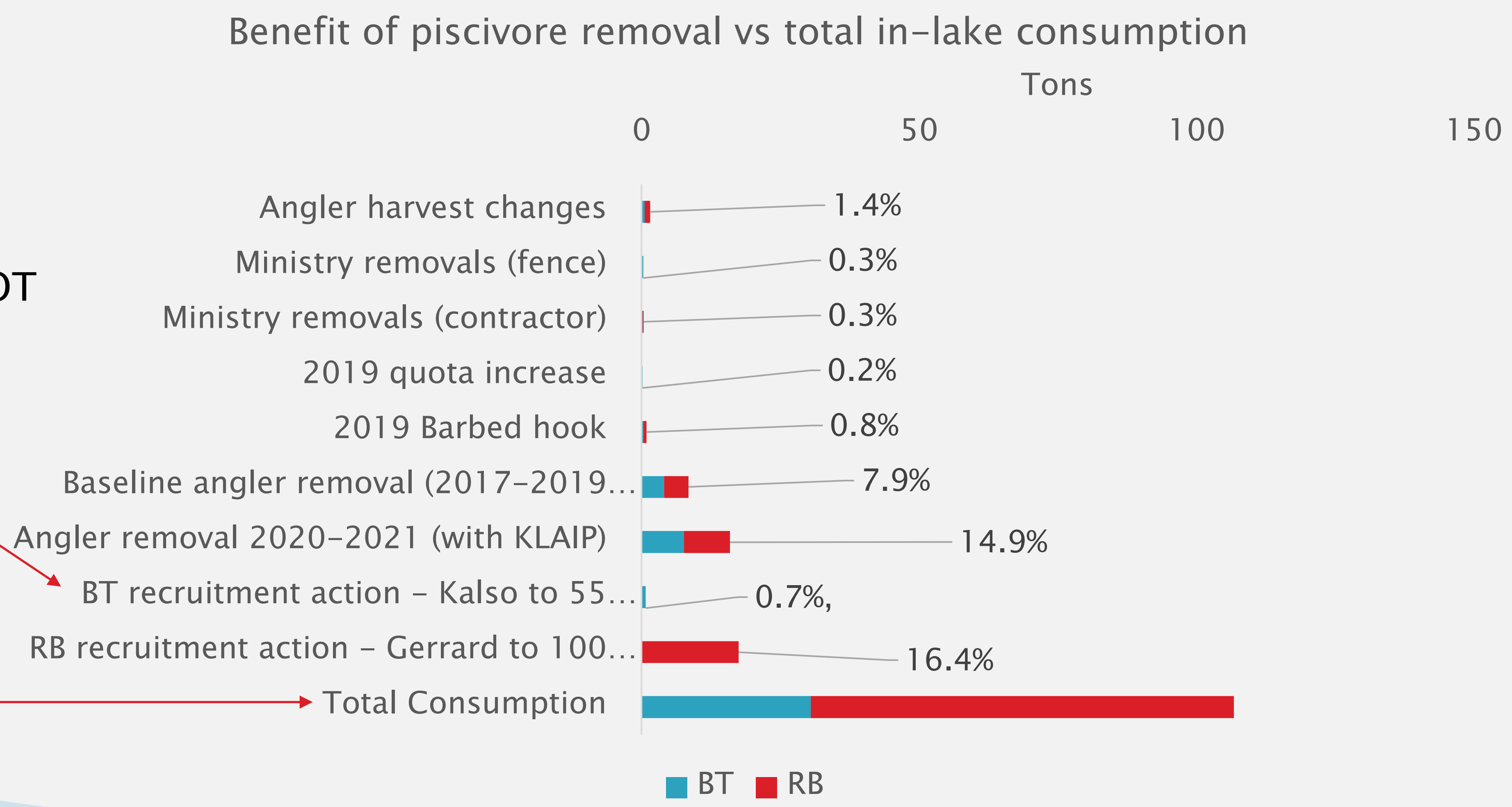
- The upshot – our conservation thresholds are knife-edge with actually having meaningful recruitment effects
- 3 layers of uncertainty:
  - 1) We can't confidently hit a spawner abundance (really egg deposition) target by knowing in advance how many Gerrard spawners show up
  - 2) Even if we hit a spawner abundance target around our conservation threshold, SR data suggests wide variations in juvenile recruitment (greater chance the lower the number of spawners)
  - 3) And even if we reduce recruitment, a natural experiment on this didn't pull us out of the hole naturally with 2 consecutive years at 1/3-1/2 recruitment for 2016-2017 age-1 cohort years; the effect happens 3-4 years in the future (a 2022 action would primarily manifest in 2025-2026.
    - Recovery perhaps didn't happen 2019-2021 because it was just bad timing with lower KO supply/productivity conditions? Compensation mechanisms?
- Nevertheless, reducing Gerrard recruitment can't be bad for kokanee recovery, and may combine with higher fishing mortality or align with better KO supply in the future (greater chance of conditions all aligning for threshold predator satiation and prey recovery)
- There is no other way to reduce age 3-4 abundance in the lake other than remove spawners or directly remove juveniles



Options to Reduce Gerrard Recruitment

- Reduce RB recruitment (spawners)
  - Feasibility of fence/gillnet/seine at Gerrard and tanglenetting at mouth of Duncan
    - Requires conservation plan?
- Reduce RB recruitment (juveniles)
  - Rotary Screw Traps – low feasibility due to safety etc.
  - Electrofishing
  - Passive capture via traps/net at the mouth of the Duncan
  - Effect is faster than reducing spawners?

Current vs future actions in KO saved



* This is the only action that has NOT happened

*2015-2019 estimate

Summary

- Biological Update
- 2021 Implementation and ongoing actions
- Key Questions:
  - Do we stock in 2022?
  - What predator management actions should be implemented in 2022? (in-lake, immediate benefit)
  - Key Question: What Predator Management Actions should we implement in 2022 (recruitment actions, future benefit)?

Thank you!