SRWG Updates

will.satterthwaite@noaa.gov

6/30/25

Updates

- B. Methodology Review Items
  - S_{MSY}, conservation objective items added to preliminary list of topics
  - Forecast uncertainty / evaluation of risks and benefits again deferred
  - Questions raised around S_{MSY} analysis
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Important decisions in fitting spawner-recruit relationships

- Functional form (e.g. Ricker, Beverton-Holt, nonparametric, etc.)
  - Council guidance to "derive an updated S_{MSY} value per the formula described in Agenda Item F.2, Attachment 2" necessitates Ricker, as is used/assumed for most if not all PFMC-managed stocks
- Metric of recruits (e.g. cohort reconstruction, fry, SI, etc.)
  - Strengths and weaknesses first described in SWRG 2024, to be expanded further
  - SSC and STT both highlighted importance of accounting for origin
- Use of covariate(s)
  - E.g. survival for Klamath (STT 2005), survival & flow for Rogue (Confer and Falcy 2014)
  - Failure to account for influential covariate can lead to incorrect inferences
- Temporal coverage
  - Potentially constrained by choice of recruitment metric (data availability issues)
  - Statistical considerations
  - Nonstationarity/representativeness considerations

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Options for natural-area Spawner-Recruit relationship

- Cohort reconstruction is “gold standard” for estimating recruits, but covers a limited range of years (and thus escapements and flows)
  - Will never be able to apply prior to BY 2007
  - Gap in CWT sampling of ocean harvest in early 2020 may slightly compromise several brood years that would have been subject to harvest then
  - Lack of genetic sampling for returns of unmarked, PBT-only fry releases compromised analysis of BY 21-22 and may compromise future BY
  - No telling when we’ll get another high escapement + high flow year (and then 4+ year lag to reconstruct the resulting cohort)
- Munsch et al juvenile index covers a broad range of years, and is peer-reviewed
  - But may be reasonable to expect further density-dependence after juvenile stage
  - Unmarked fry may complicate extensions into future
  - And correlation to cohort reconstruction is modest (but nonzero) – could ocean covariates help?
- Upper Sacramento / RBDD fry equivalents seems like a relatively secure data source spanning many years
  - But may be reasonable to expect further density-dependence after juvenile stage
  - Only a portion of the system (but a critical one experiencing recent shortfalls)
- SI x prop. natural-origin escapement likely similar to (in years covered and broad/relative results) but inferior to (in data quality) cohort reconstruction
  - But slightly less data-demanding (no scale ages needed) in terms of year coverage

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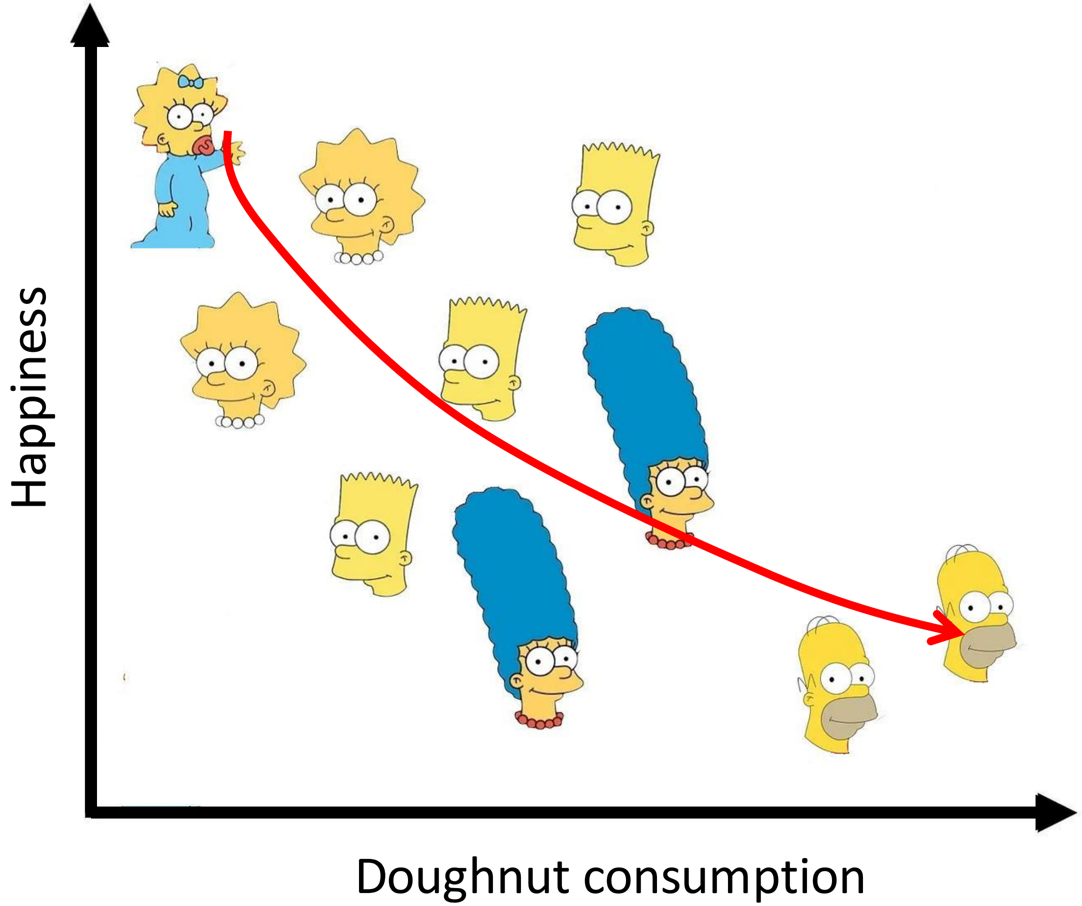
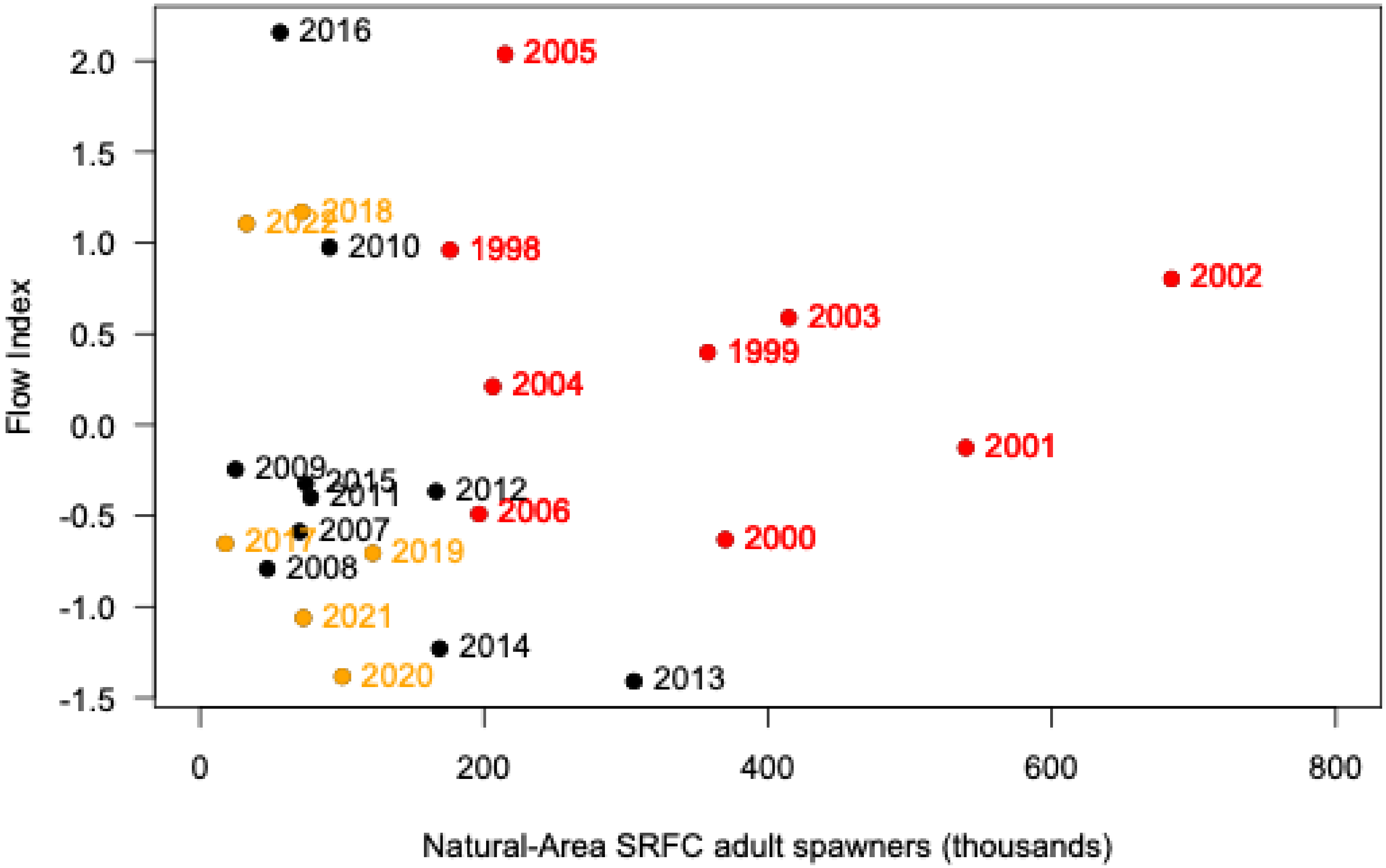
Importance of accounting for influential covariates



adapted from “Simpson’s Paradox” — When You Derive A Wrong Insight From Your Analysis

https://medium.com/analytics-vidhya/simpsons-paradox-when-you-derive-a-wrong-insight-from-your-analysis-ee488b346427


Natural-origin recruits from cohort reconstruction vs flow
Recruits (potential n.o. escapement)
0
50000
150000
250000
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Flow index (z-score)



Flow Index
Natural-Area SRFC adult spawners (thousands)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0
200
400
600
800
2016
2005
2018
2022
2010
1998
2002
2003
1999
2004
2001
2009
2015
2011
2012
2006
2007
2017
2019
2000
2008
2021
2014
2020
2013

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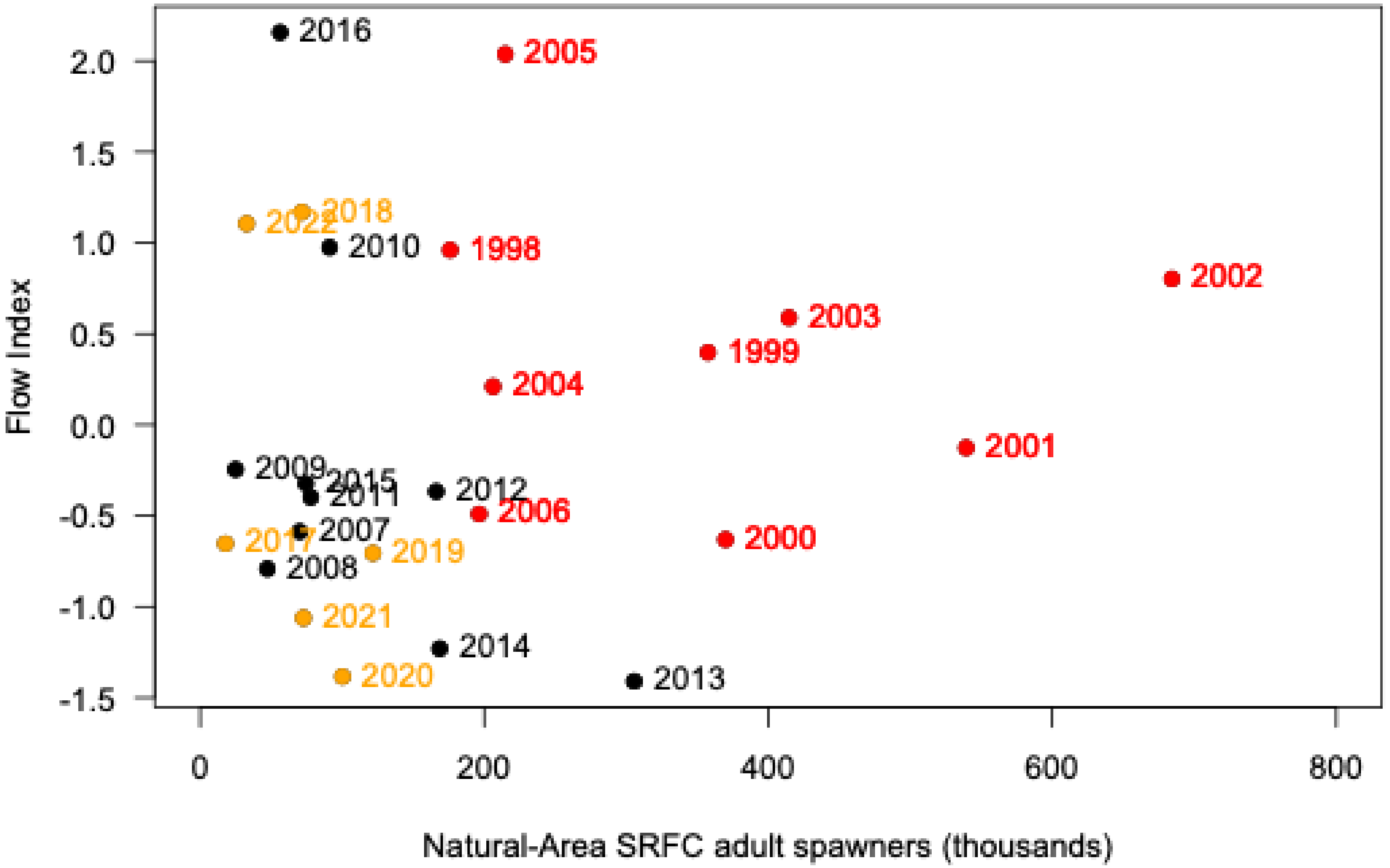

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2.0
1.5
1.0
0.5
0.0
-0.5
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-1.5
0
200
400
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2016
2005
2018
2022
2010
1998
2002
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1999
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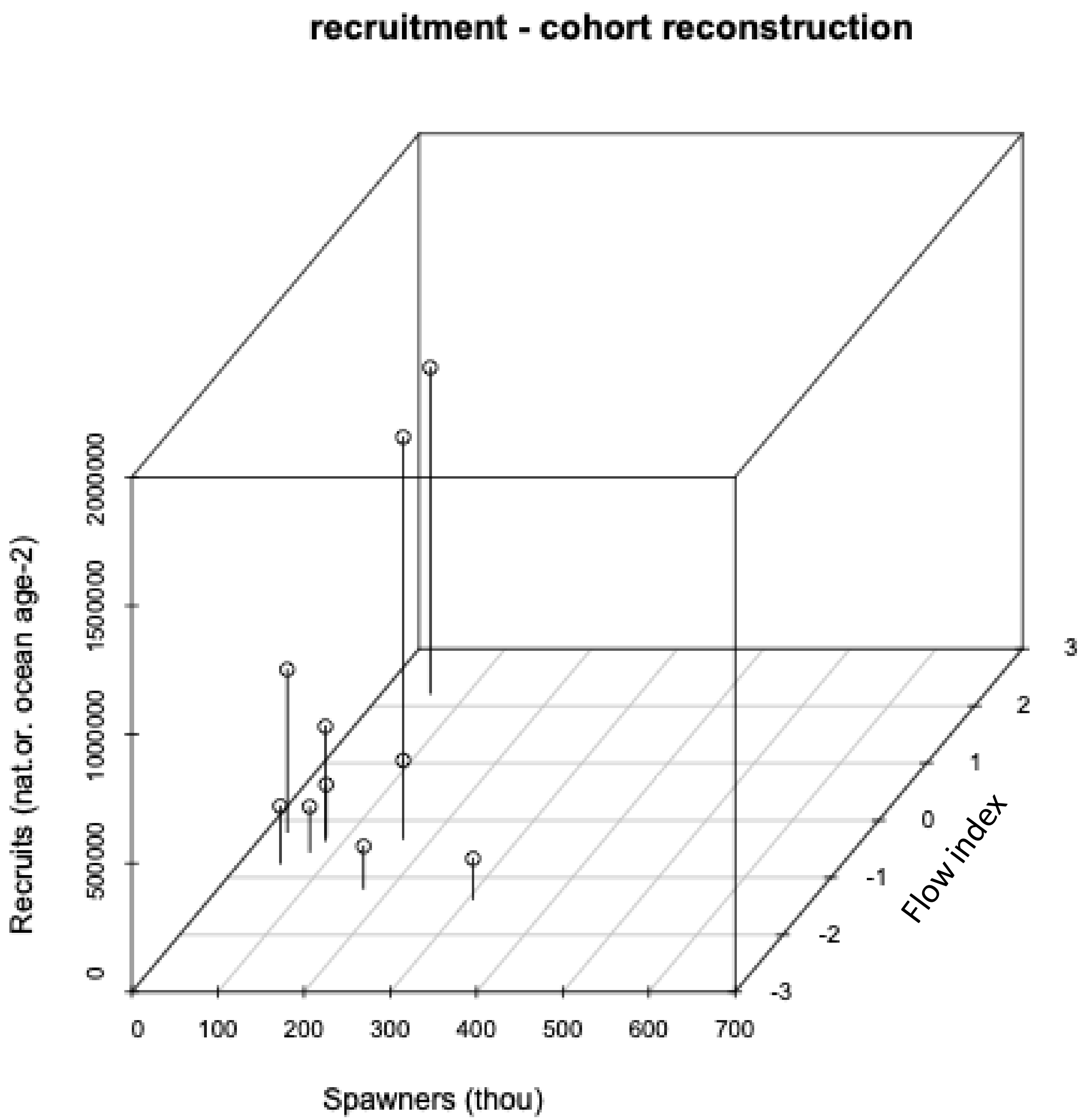
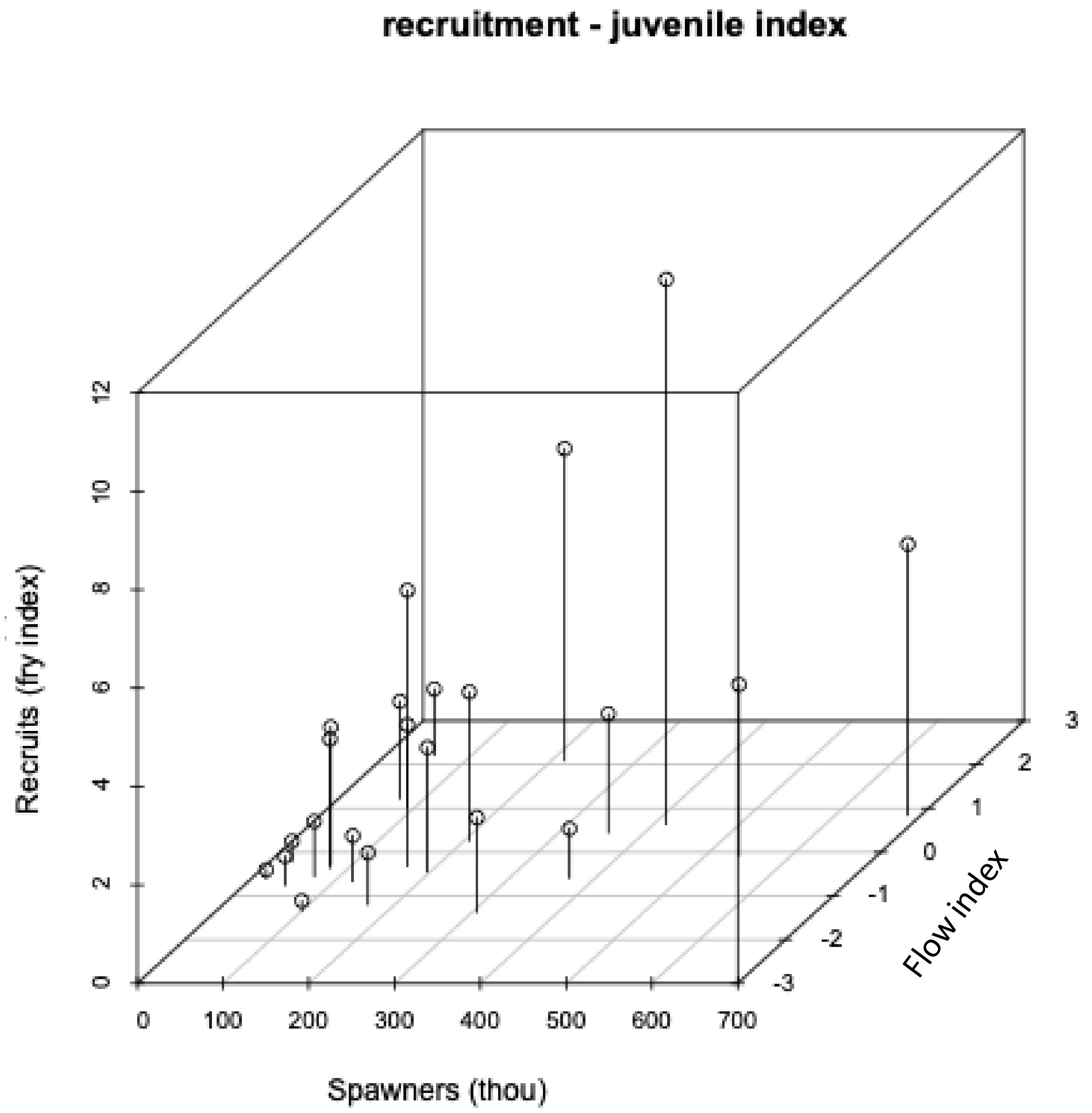
2009
2015
2011
2012
2006
2007
2017
2019
2000
2008
2021
2014
2020
2013


recruitment - cohort reconstruction
Recruits (nat.or. ocean age-2)
0
500000
1000000
1500000
2000000
Spawners (thou)
0
100
200
300
400
500
600
700
Flow index
-3
-2
-1
0
1
2
3


recruitment - juvenile index
Recruits (fry index)
0
2
4
6
8
10
12
Spawners (thou)
0
100
200
300
400
500
600
700
Flow index
-3
-2
-1
0
1
2
3

Recommendations for estimating and detecting time-varying spawner-recruit dynamics in fish populations

Catarina Wor[a,*], Dan A. Greenberg[a], Carrie A. Holt[a], Brendan Connors[b], Megan L. Feddern[c], Cameron Freshwater[a], Gregory L. Britten[d,e], Mackenzie Mazur[a]

[a] Fisheries and Oceans Canada, 3190 Hammond Bay Road, Nanaimo, V9T 6N7, British Columbia, Ca
[b] Fisheries and Oceans Canada, 9860 W. Saanich Rd., Sidney, V8L 5T5, British Columbia, Canada
[c] Fisheries Resource Analysis and Monitoring Division, Northwest Fisheries Science Center, National Ma Administration, 2725 Montlake Blvd E, Seattle, 98112, WA, USA
[d] Biology Department, Woods Hole Oceanographic Institution, Woods Hole, 02543, MA, USA
[e] Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Ca

- **Result:** Changes in productivity are easier to estimate and detect than changes in capacity and there are small losses in performance when using time-varying productivity estimation models for stationary conditions. **Recommendation:** Prioritize models with a random-walk in productivity for modeling time-varying dynamics in spawner-recruit relationships. If evidence for non-stationarity is weak, then revert to a stationary model. Capacity changes should only be considered when there is strong corroborating evidence.

A R T I C L E I N F O

Keywords:
Time-varying dynamics
Simulation-evaluation
Model selection

A B S T R A C T

Models that account for time-varying
of changing biological and environm
on a semelparous life history to evaluate the performance of various Ricker spawner-recruit models including stationary, random-walk, and regime shift models, that offer various interpretations of time-varying dynamics. Estimation models that allowed parameters to vary following random-walks tended to perform equally well or outperform regime shift and stationary models. However these results were not consistent across all scenarios examined. We also evaluated the performance of model selection criteria commonly used to identify time-varying processes. Both likelihood based model selection criteria (AICc and BIC) and cross-validation methods (LFO) were found to be unreliable, with a few exceptions. Changes in productivity were more identifiable than changes in capacity or both parameters, which were often indiscernible from stationary dynamics. The magnitude of parameter change and extent of residual variability (unexplained
and lower error being easier to accurately estimate and select. Given this
curacy of parameter estimates with time-varying models, and unreliable nature
mmend that analysts conduct case-specific simulation-evaluations when model
nd divergent management implications.

- **Result:** Estimation models with time-varying capacity are rarely reliable. **Recommendation:** Time-varying capacity models should only be explored when there is strong corroborating evidence, with plausible mechanisms, suggesting that capacity has changed.

https://doi.org/10.1016/j.ecolmodel.2025.111159

Importance of sufficient temporal coverage / samples

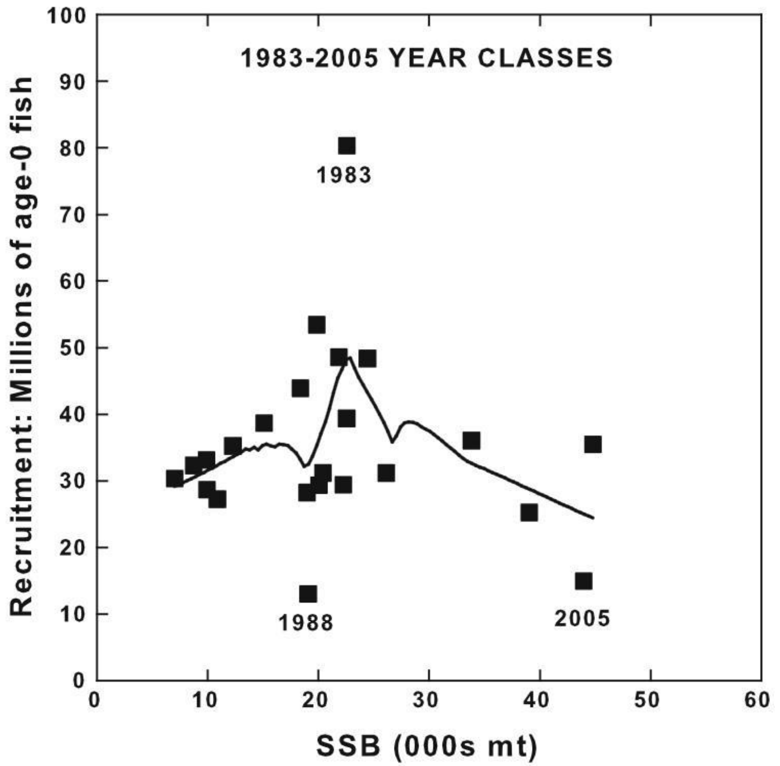


Fig. 12 Spawning stock biomass (SSB; 000s metric tons [mt]) and recruitment (millions of age-0 fish) estimates for summer flounder from the final 2006 assessment (Terceiro 2006b). Bold line is a lowess smoother with tension = 0.5

"They're ta
That may b
wetlands, t
are inshore
the point tl

"But I just t
understanc
seems that
in nature a
century the
less then tl

"And I thin
we've got a
stock biom
And that m

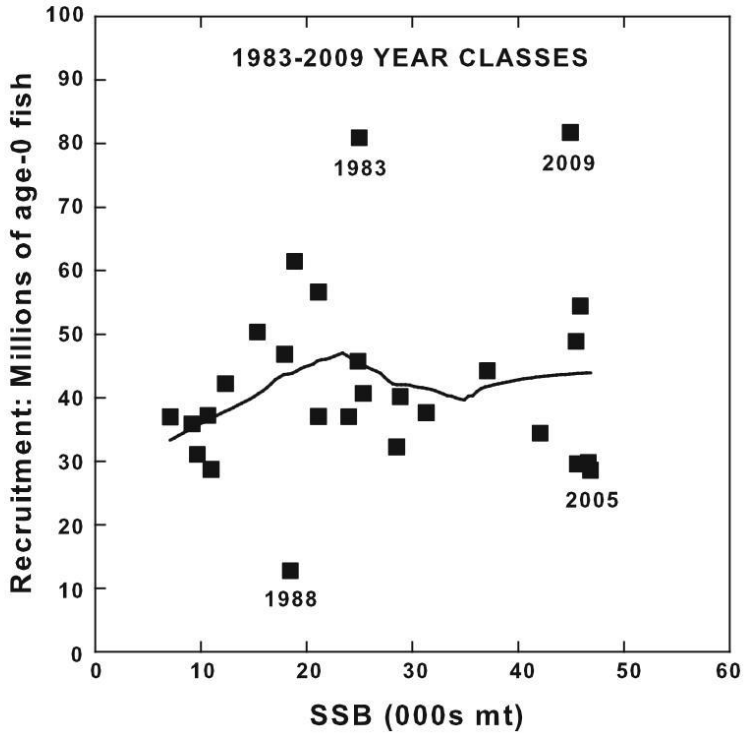


Fig. 13 Spawning stock biomass (SSB; 000s metric tons [mt]) and recruitment (millions of age-0 fish) estimates for summer flounder from the 2010 assessment (Terceiro 2010). *Bold line is a lowess smoother with tension = 0.5*

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ever existed
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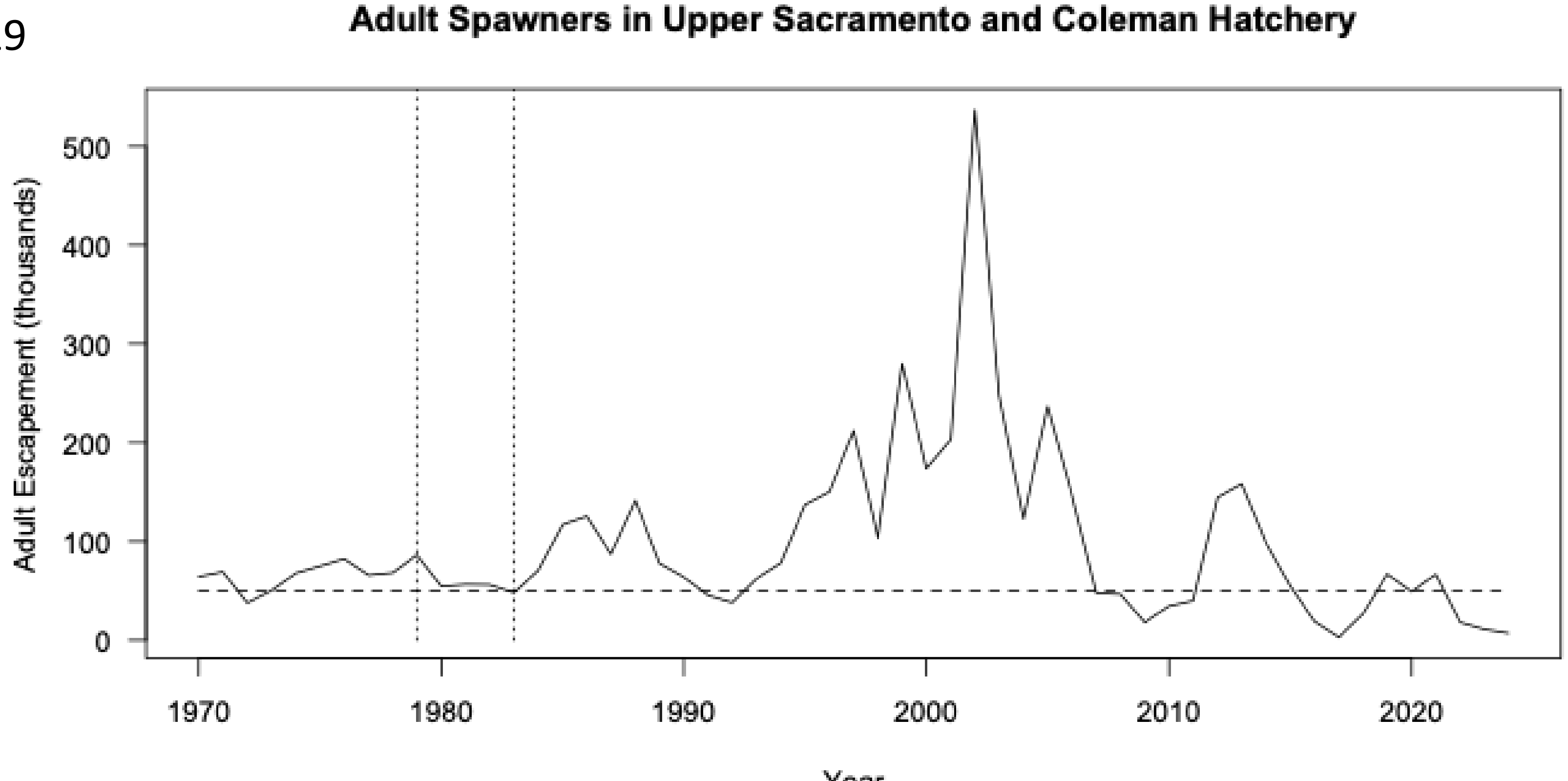
tock, that
er spawning
cruitment.
2006)

Tercerio, M. 2011. The summer flounder chronicles II: new science, new controversy, 2001-2010. Rev Fish Biol Fisheries 21:681-712.

For these reasons, an interim spawning escapement goal range for the Sacramento River is established until such times as the problems caused by the Red Bluff Diversion Dam are rectified, and the full production of salmon in the Upper Sacramento River can be realized. For the period 1979 to 1983, Upper Sacramento fall chinook runs have fallen from 81,700 to 51,500 adult chinook. The rate of decline appears to be slowing and will likely stabilize at about 50,000 adults. Therefore, the lower end of the aggregated Sacramento River goal range of 122,000 adult chinook is based on 50,000 upper-river adult chinook and 72,000 lower-river adult chinook.

-PFMC 1984, p. 3-19



Source: Review Table B-1

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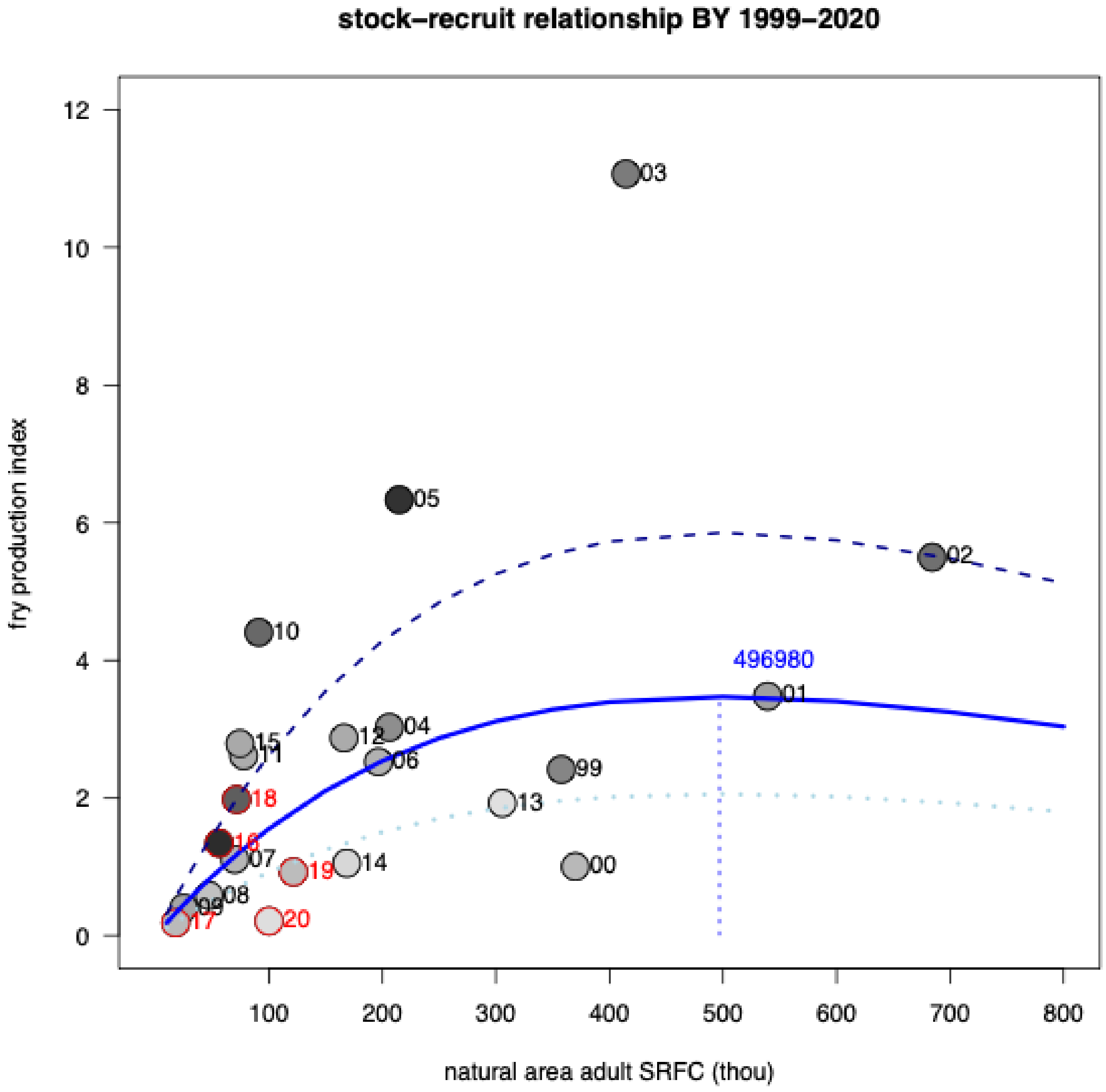
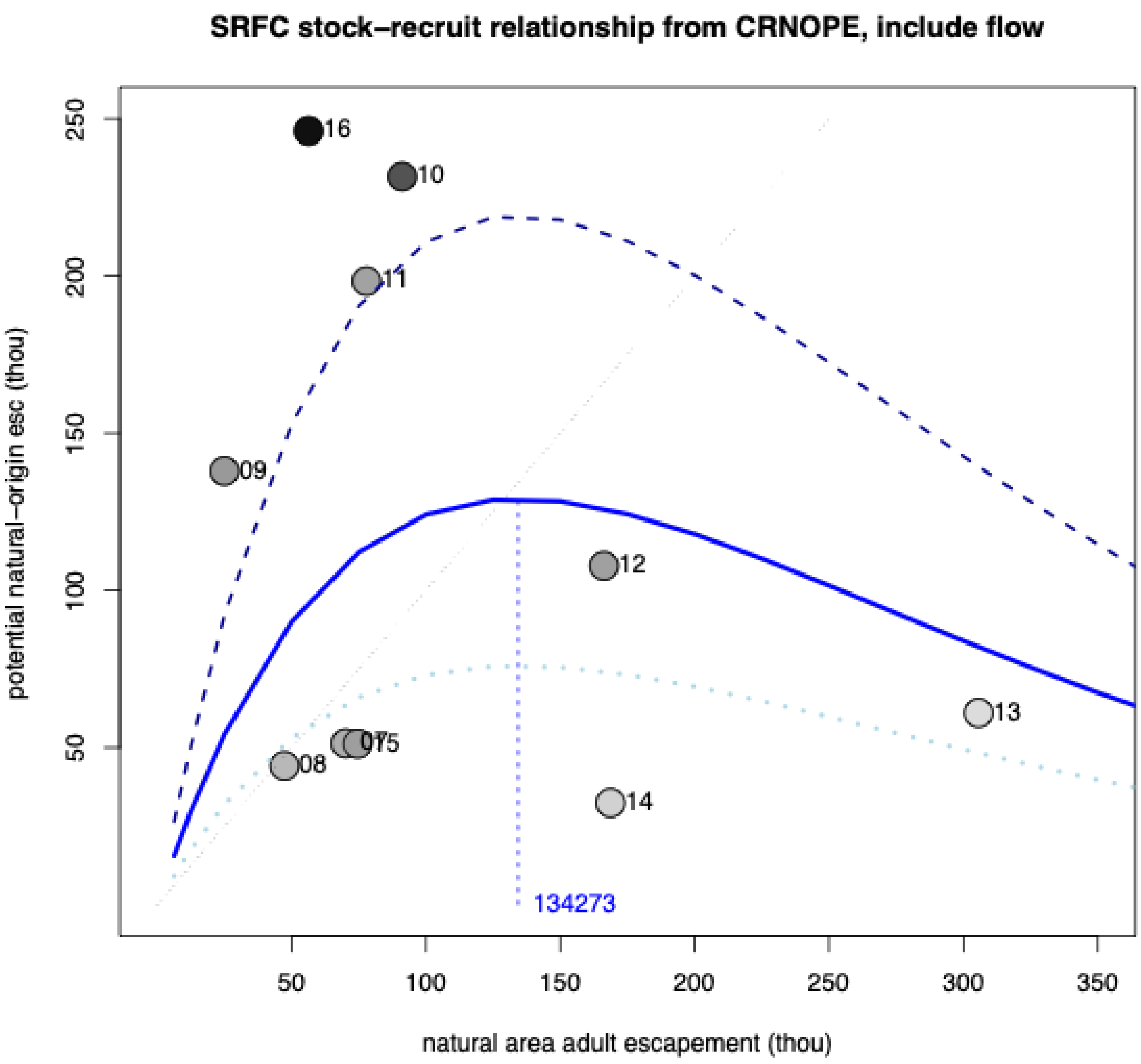
Preferred S_{MSY} analysis: Extended Munsch et al. fry index



Exclude BY 1998, 2021, and 2022 due to fry releases

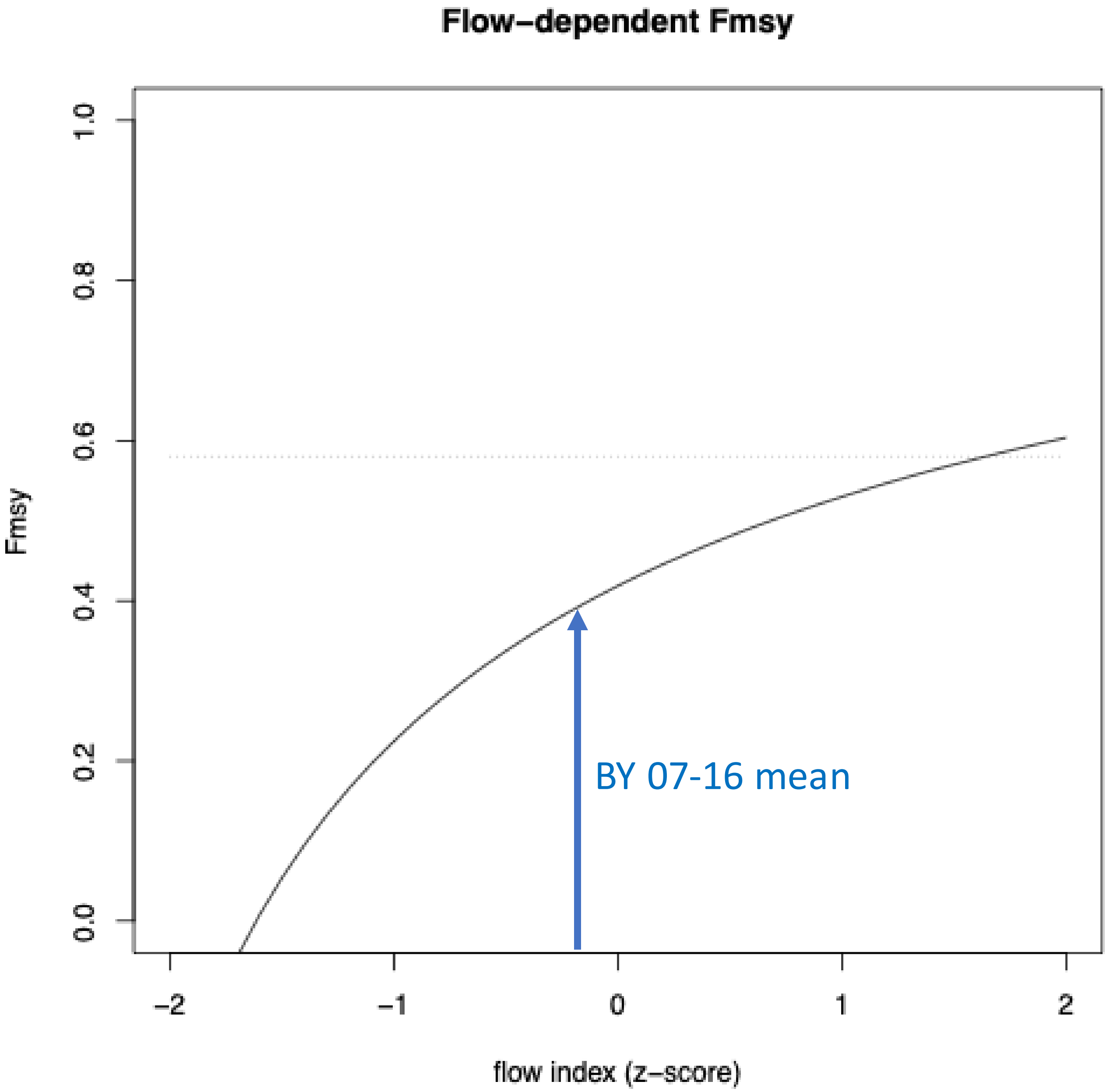
Alternative analysis: Potential natural-origin adult escapement from cohort reconstruction

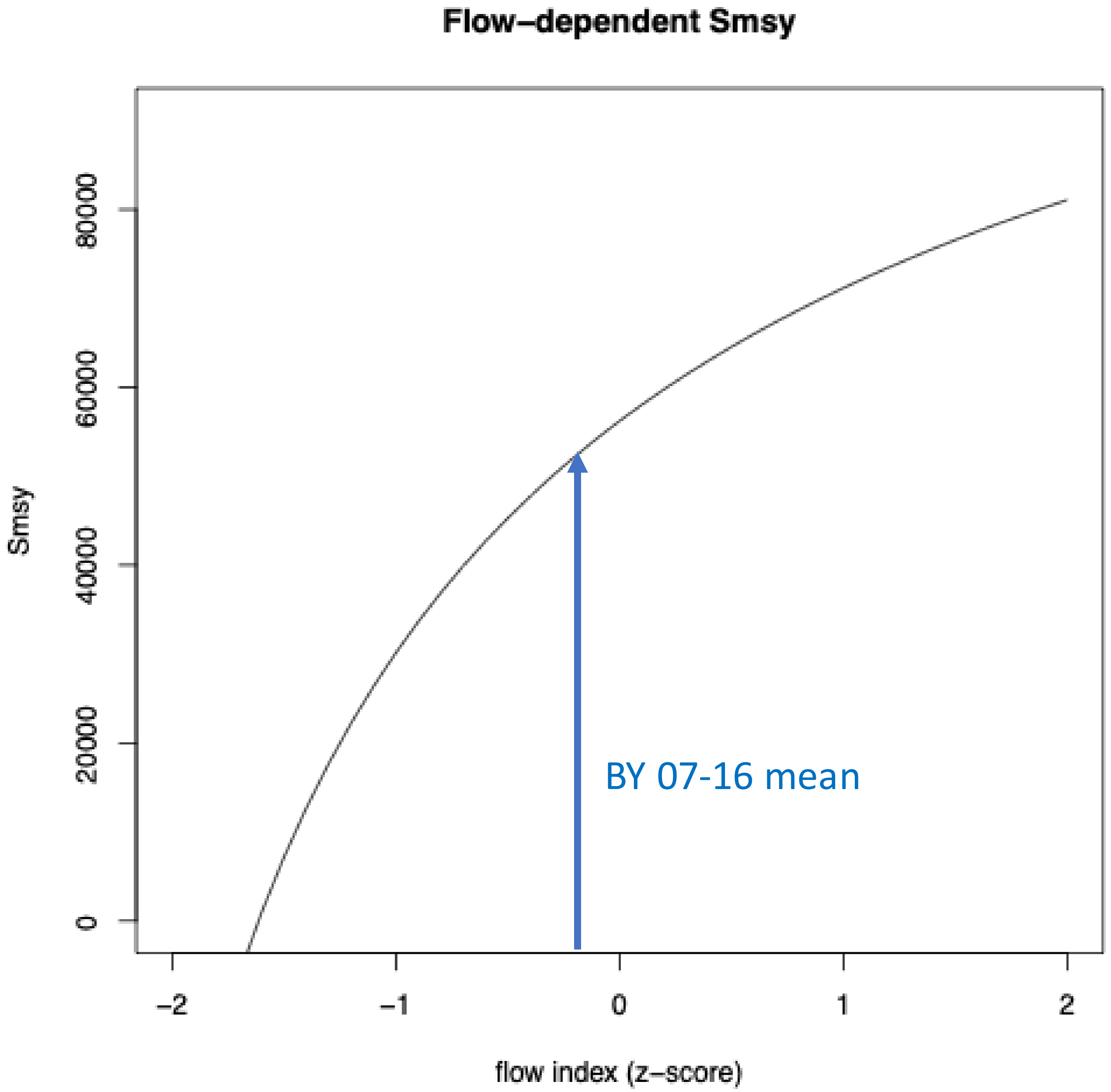


Limited to BY 2007-2016
Limited range of escapements
Highest escapement at lowest flow
Highest flows at low escapements

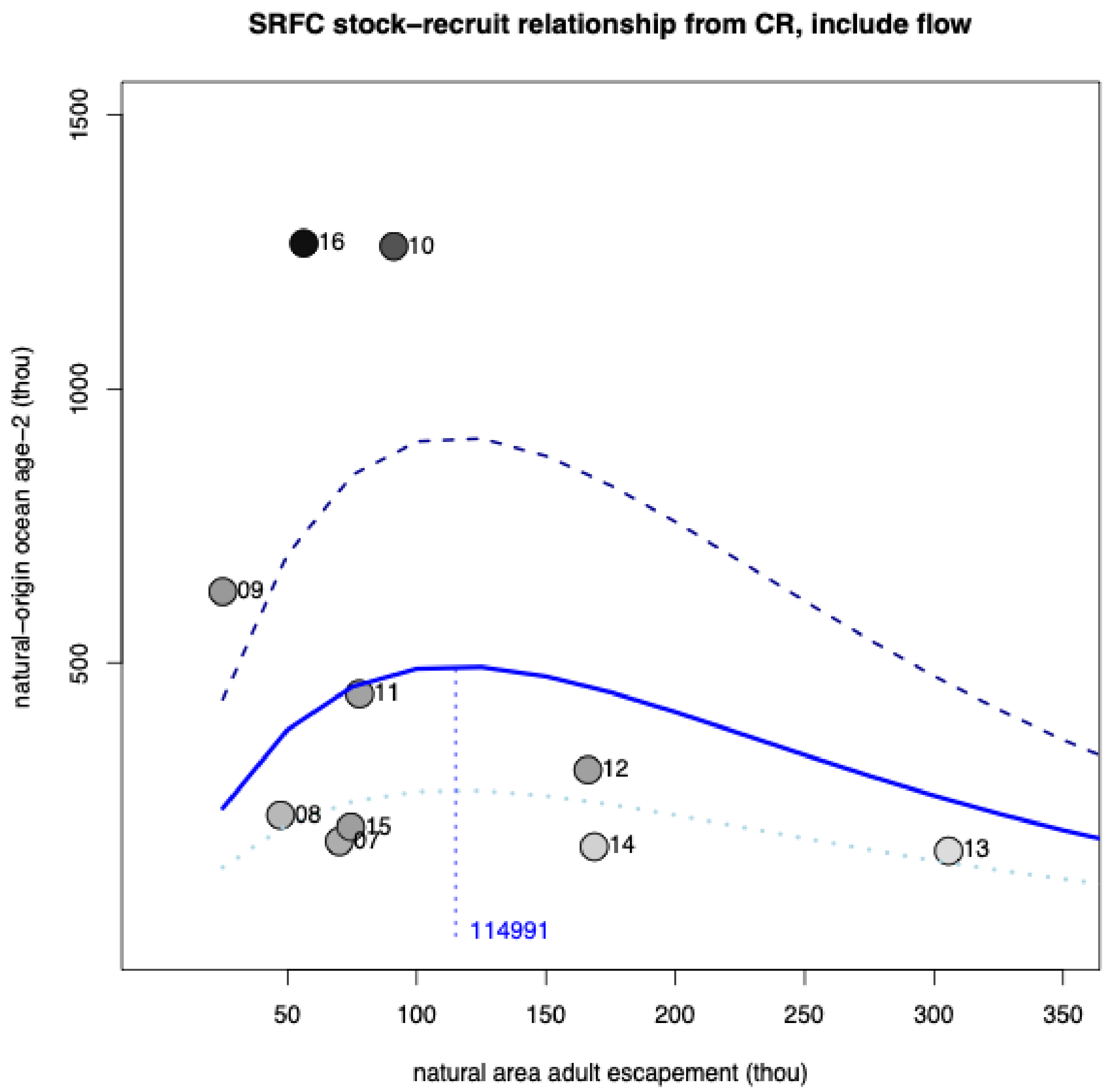
IF treat this like STT 2005 treated Klamath (i.e. assume no hatchery influence):

S_{MSY}=56,209 implicitly *natural-origin* in natural-areas
F_{MSY}=0.42
(at BY 1999-2020 mean value of flow covariate)

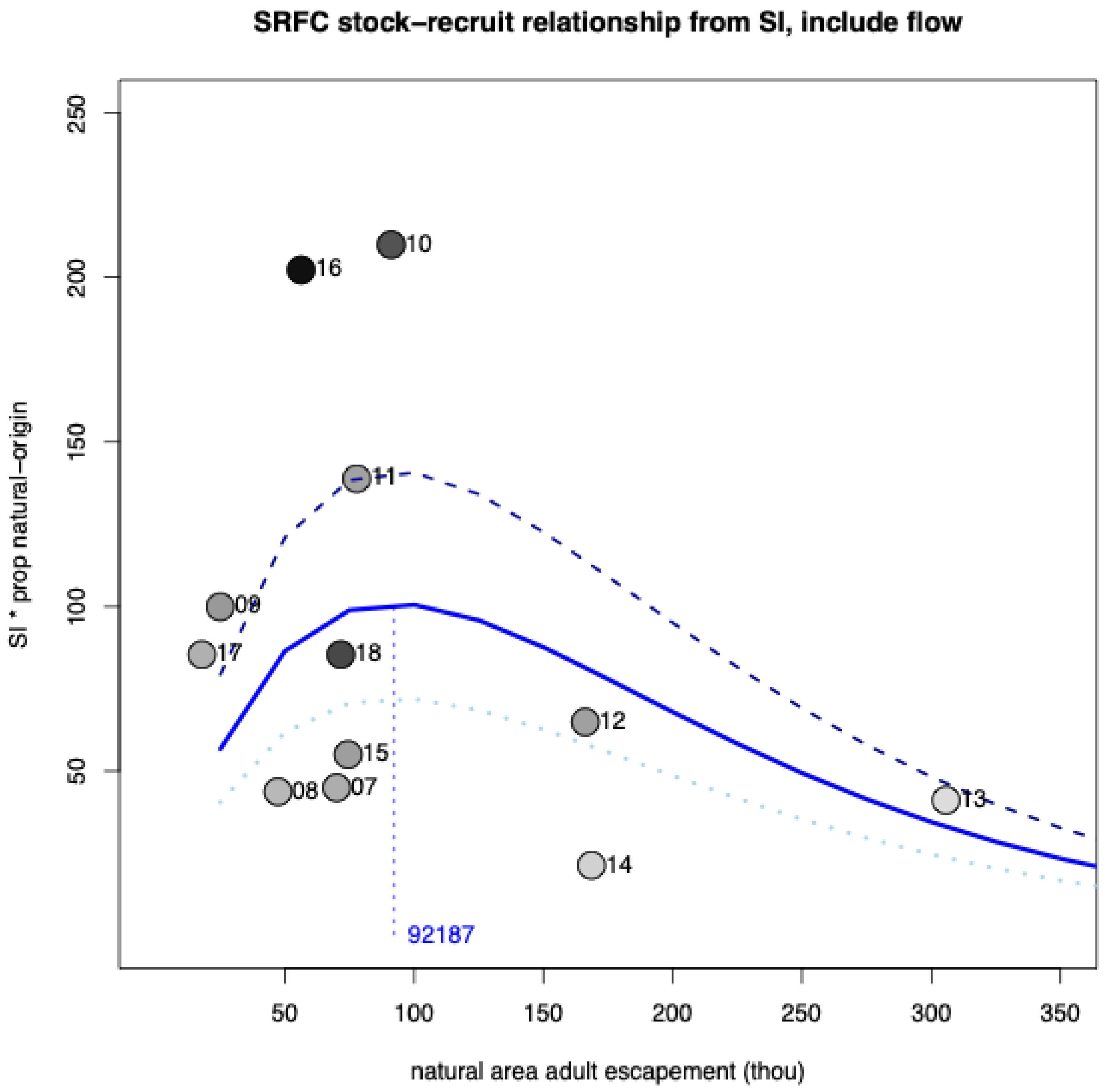

Flow–dependent Fmsy
Fmsy
0.0
0.2
0.4
0.6
0.8
1.0
−2
−1
0
1
2
flow index (z–score)
BY 07-16 mean


Flow–dependent Smsy
Smsy
0
20000
40000
60000
80000
−2
−1
0
1
2
flow index (z–score)
BY 07-16 mean

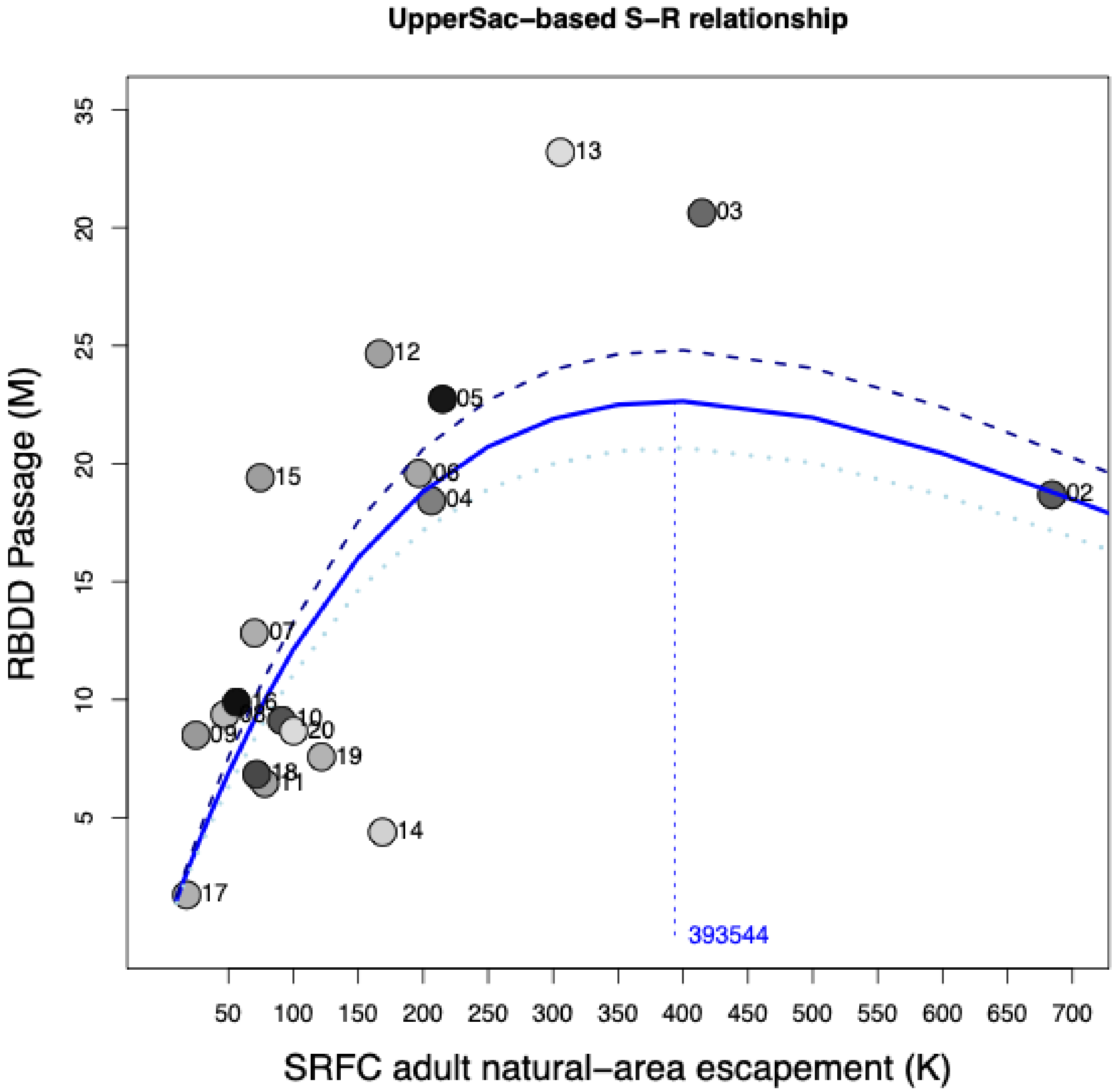
Alternative analysis: natural-origin age-2 ocean abundance from cohort reconstruction



Alternative analysis: SI x proportion natural



Alternative analysis: RBDD fry passage



Choice of brood years for fry index

JUNE 2015

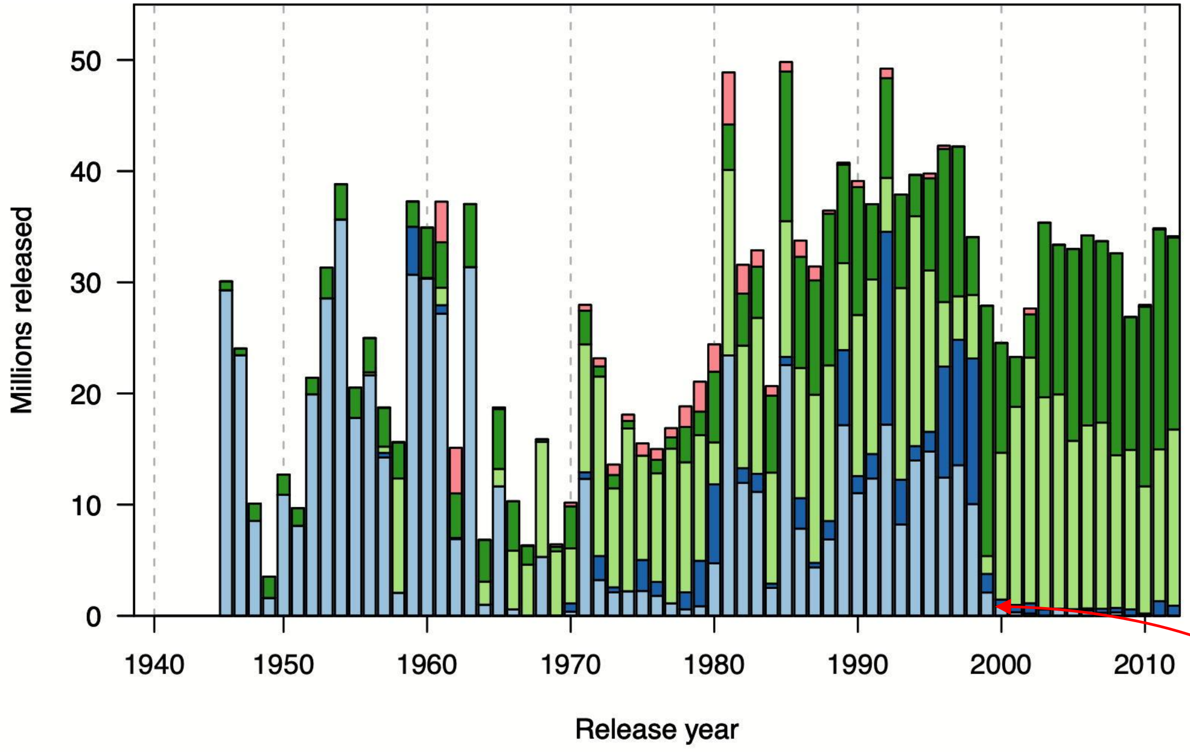


Figure 5 Release life-history types, presented as total released per type across all years and hatcheries. Life-history types are based on size (fry: <55 mm, light blue bar; fingerlings: ≥55 to <70 mm, dark blue bar; smolts: ≥70 to <87.5 mm, light green bar; advanced smolts: ≥87.5 to <140 mm, dark green bar; yearlings: ≥ 140 mm, pink bar). Note that the discrepancies between figure 1 and figure 5 are due to the decision rule to only include fish whose release begin and end months are the same for life history analyses presented in this plot.

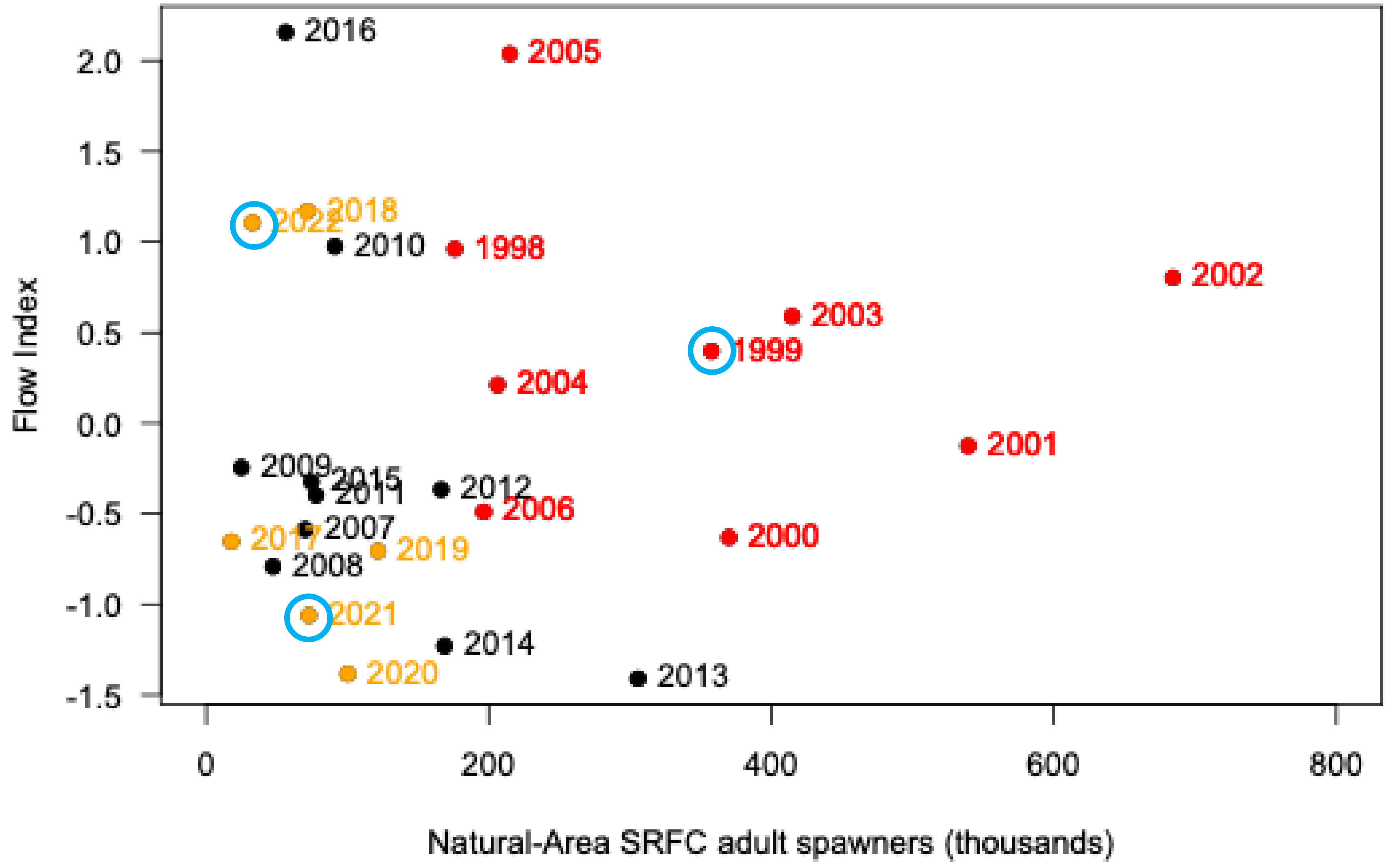
Huber and Carlson (2015)

Restarted fry releases:

BY 21: 1.9M

BY 22: 2.8M + 0.3M + 1.1M

BY 98 / RY 99



Flow Index
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2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0
200
400
600
800
2016
2005
2018
2022
2010
1998
2002
2003
1999
2004
2001
2009
2015
2011
2012
2006
2007
2017
2019
2000
2008
2021
2014
2020
2013

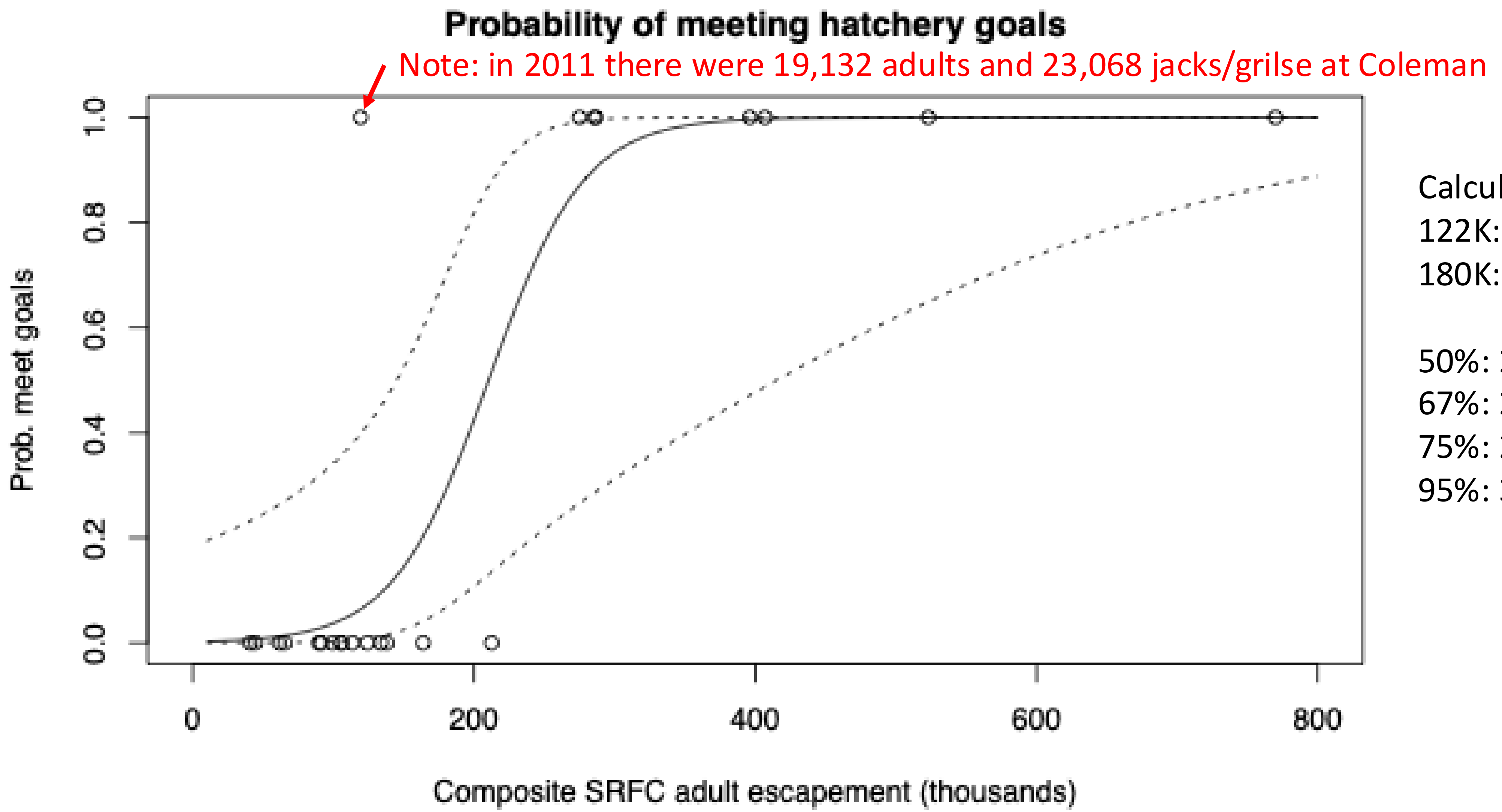
Management and policy implications

- S_{MSY} is a reference point used for status determination. Does National Standard 2 mean this must be based on Best Scientific Information Available, full stop?
- Thinking through implications of much larger S_{MSY}
  - Stock more likely to be “overfished”, which is perhaps better described as “depleted”
    - Hard to argue SRFC is not depleted, regardless of role of fishing vs. other factors
  - That does not mean fishing necessarily closed, just “de minimis” questions must be addressed
    - potential for critically low natural spawner abundance, including considerations for substocks that may fall below crucial genetic thresholds
    - the status of co-mingled stocks
    - indicators of marine and freshwater environmental conditions
- Thinking through implications of smaller S_{MSY}
  - If yield is mainly through access to hatchery fish, hard to argue you gain much future yield by letting more natural production occur (assuming no change in listing status etc.)
  - Meeting a “conservation objective” that considers hatchery needs may require targeting escapement greater than a small natural-area S_{MSY}
  - Stock can be depleted without being legally “overfished”

Updated hatchery goals for incorporation into conservation objective analysis

- Provided by CDFW hatchery staff
  - Including inferences for Coleman National Fish Hatchery
- Numbers reflect egg take goal to meet new production targets, scaled by average fecundities, sex ratios, grilse, spawn rates, survivals
- Numbers reflect <u>total</u> spawners, including males and grilse/jacks
  - Feather River Fish Hatchery CVFC Production: 11,778 fish
  - Nimbus Fish Hatchery CVFC Production: 8,611 fish
  - Coleman National Fish Hatchery CVFC Production: 31,958 fish

Starting in 2002 (to match Satterthwaite 2023) - 2024



Calculated probabilities:

122K: 7%

180K: 29%

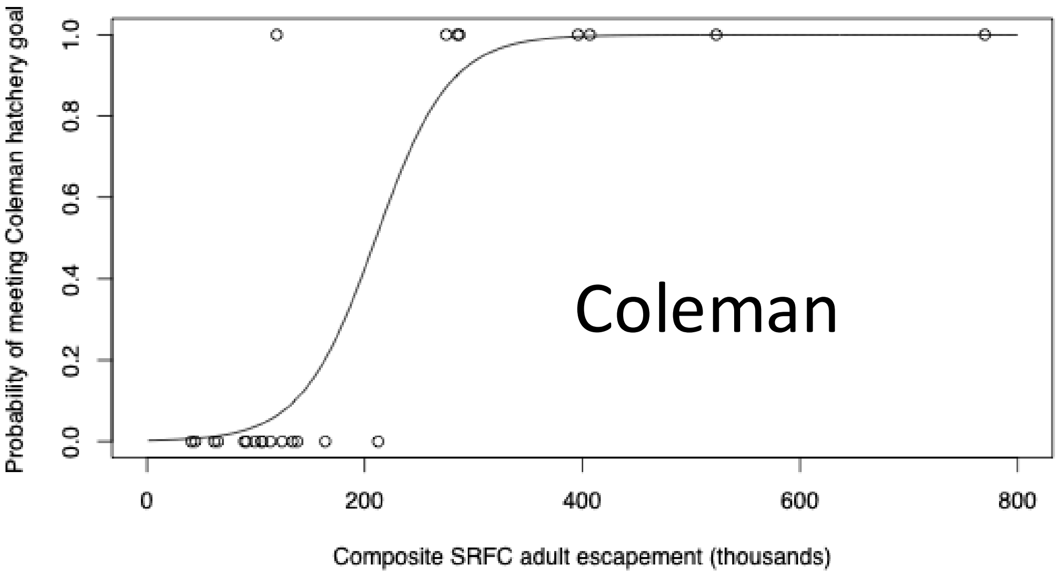
50%: 211K

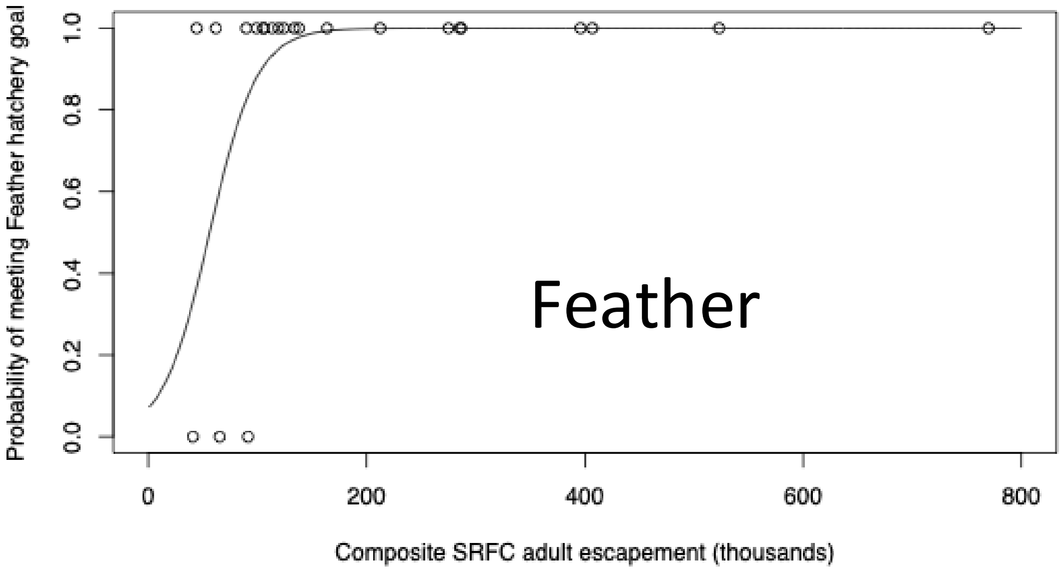
67%: 235K

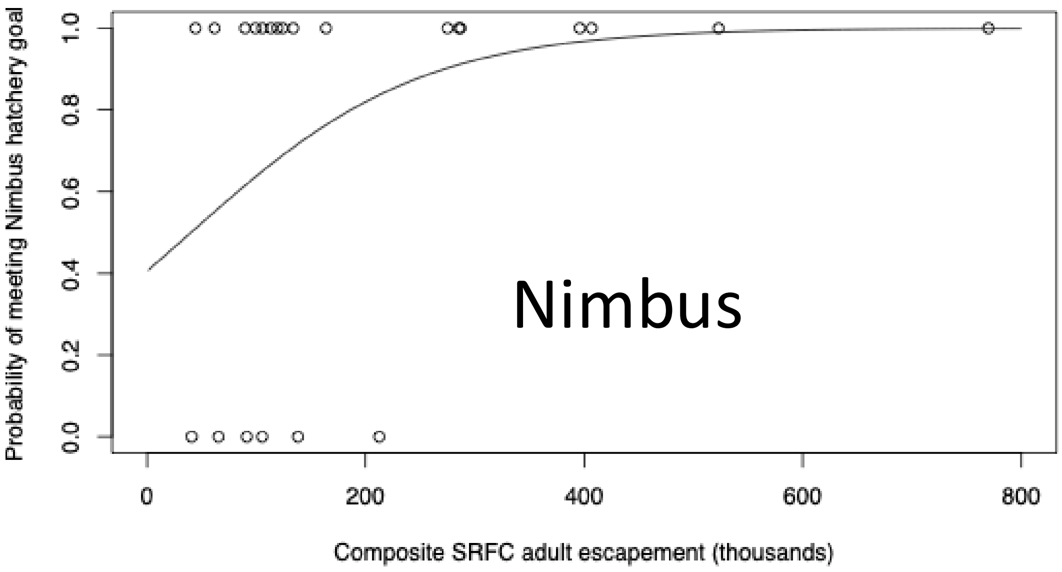
75%: 248K

95%: 311K

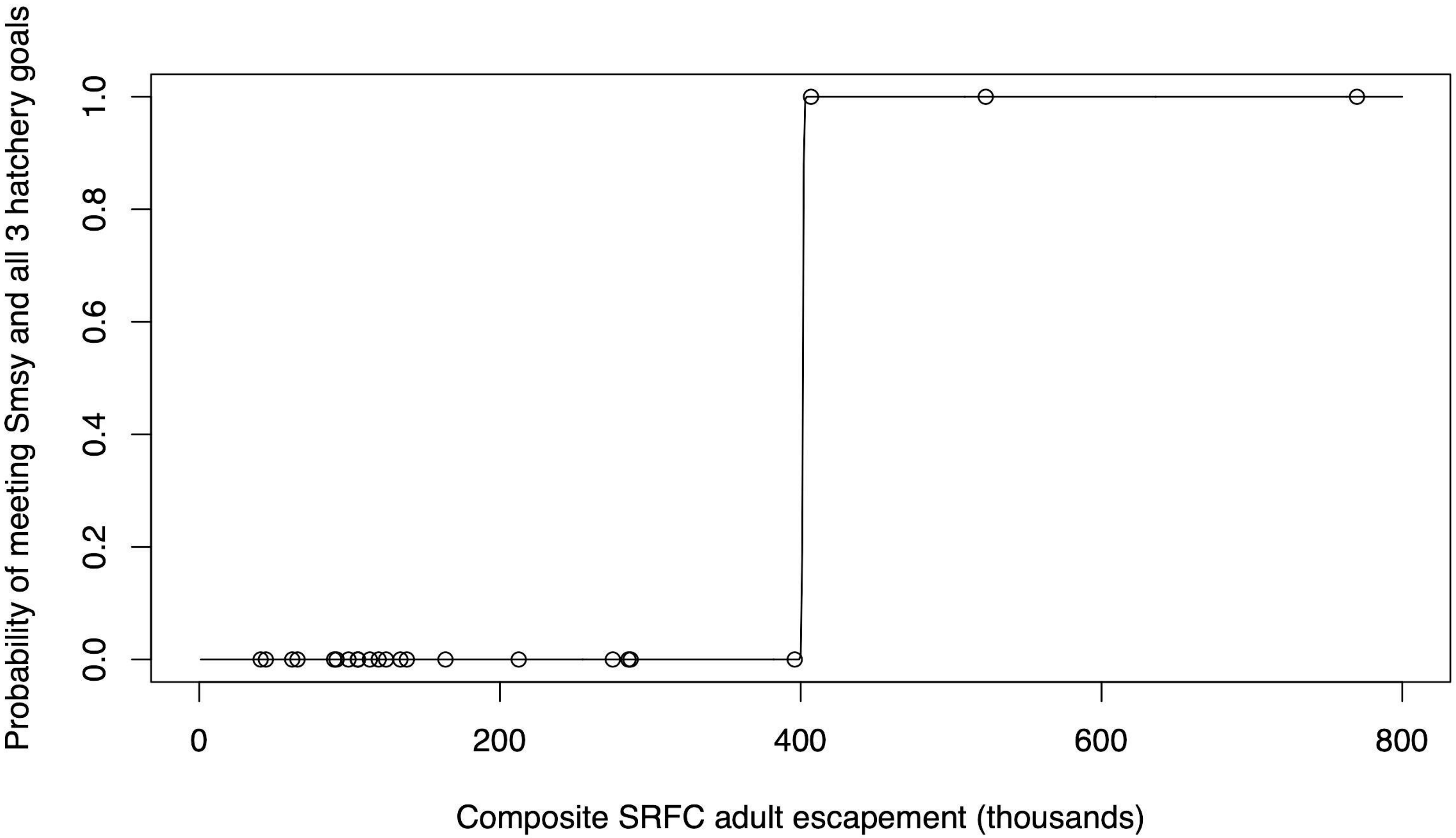
Hatchery-specific models (based on 2002-2024)







What if we also require natural-area escapement > potential S_{MSY}=290,000 (using 2002-2024 inputs)



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Reports

- Do we need/want to say anything for September methodology topic selection?
- What (if anything) to provide for methodology review re: updated hatchery goals? (Could be a question posed to SSC and STT in September, but not much time to respond to their feedback.)

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