SRFC Management Presentation

SRFC Workgroup 1/30/24

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Sacramento River Fall Chinook Management

- Framework
  - Reference Points
    - Generic definitions
    - Current SRFC approach
  - Conservation Objective
    - Generic definitions
    - Current SRFC approach
  - Harvest Control Rule
    - Current SRFC approach
    - Other approaches for US West Coast salmon stocks
- Current stock status, recent abundance, and trends

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2.1 THEORY

Optimum yield (OY) means the amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account protection of marine ecosystems. It is prescribed on the basis of the maximum sustainable yield (MSY) from the fishery, reduced by any relevant economic, social, or ecological factors, and provides for rebuilding of an overfished stock, taking into account the effects of uncertainty and management imprecision.

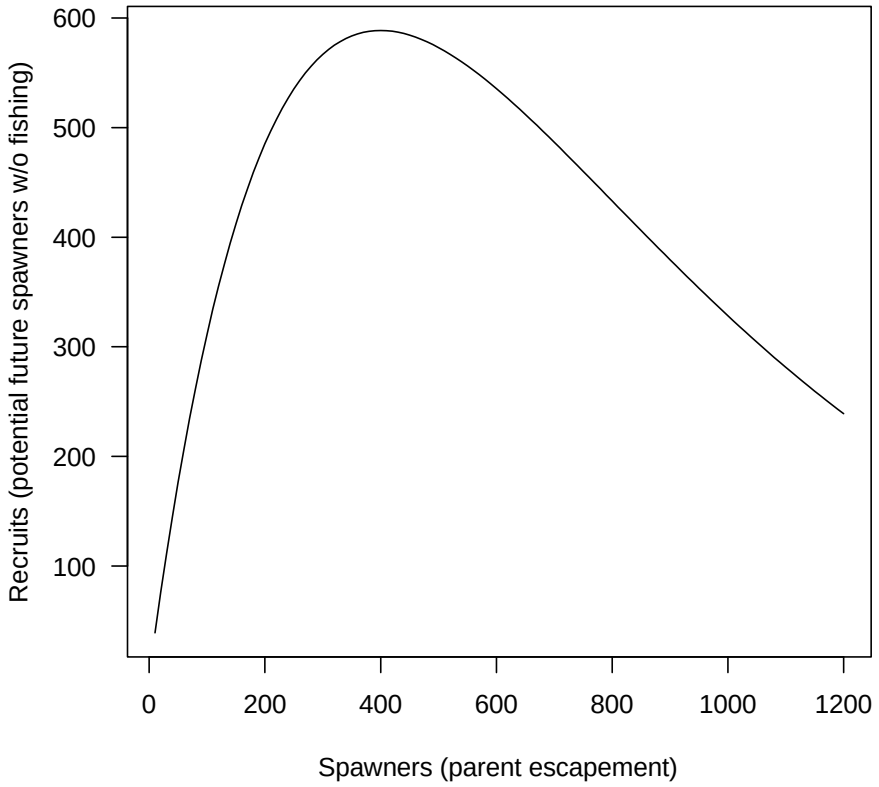
MSY is a theoretical concept that, for the purposes of the Magnuson-Stevens Act, is defined as the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions and fishery technological characteristics, and distribution of catch among fleets. In Council management of naturally spawning salmon stocks, MSY is usually approached in terms of the number of adult spawners associated with this goal (S_{MSY}). Often, data are insufficient to directly estimate S_{MSY}. In these cases, the Council may use MSY proxies derived from more general estimates of productive capacity and implement harvest strategies that may be expected to result in a long-term average catch approximating MSY.

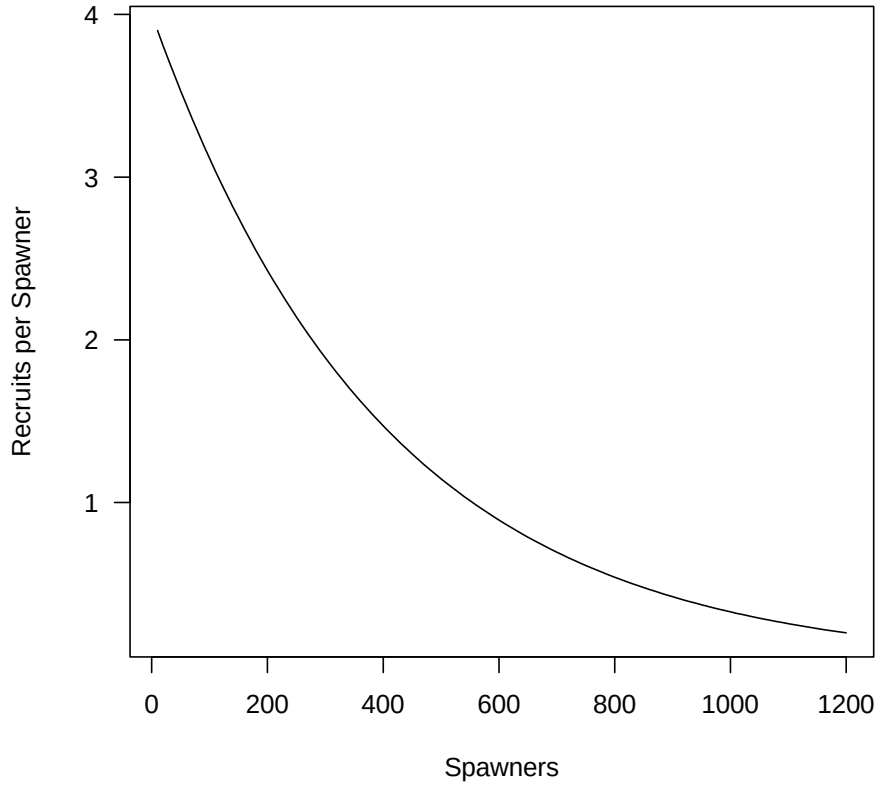
Salmon FMP (https://www.pcouncil.org/documents/2022/12/pacific-coast-salmon-fmp.pdf/), page 13

Estimating S_{MSY} – data-rich scenarios

- For PFMC-managed stocks, we typically assume a Ricker spawner-recruit relationship

$$R = \alpha S e^{-\beta S}$$





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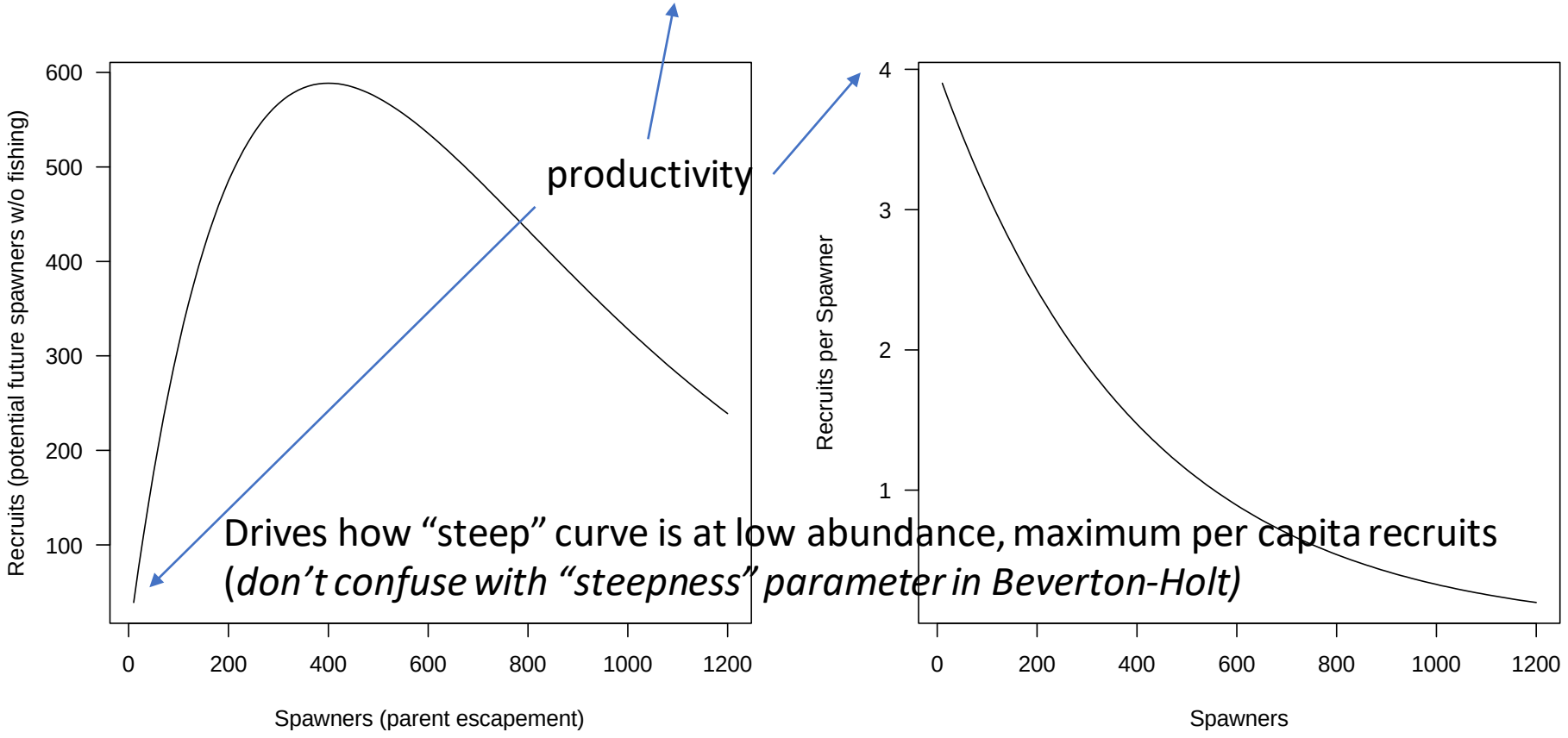

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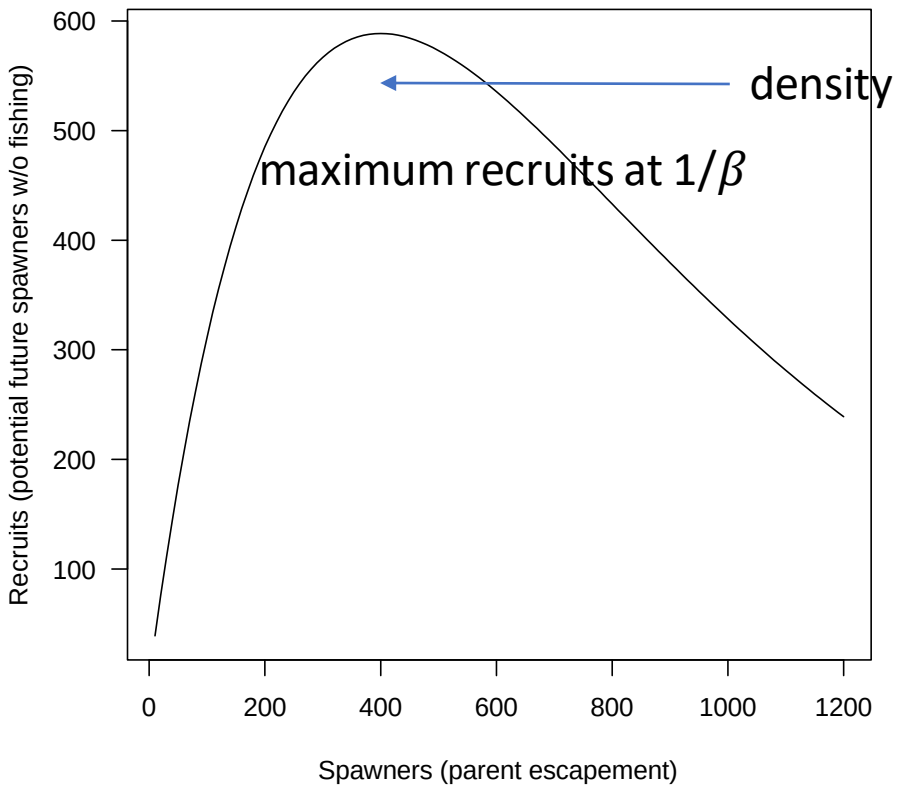
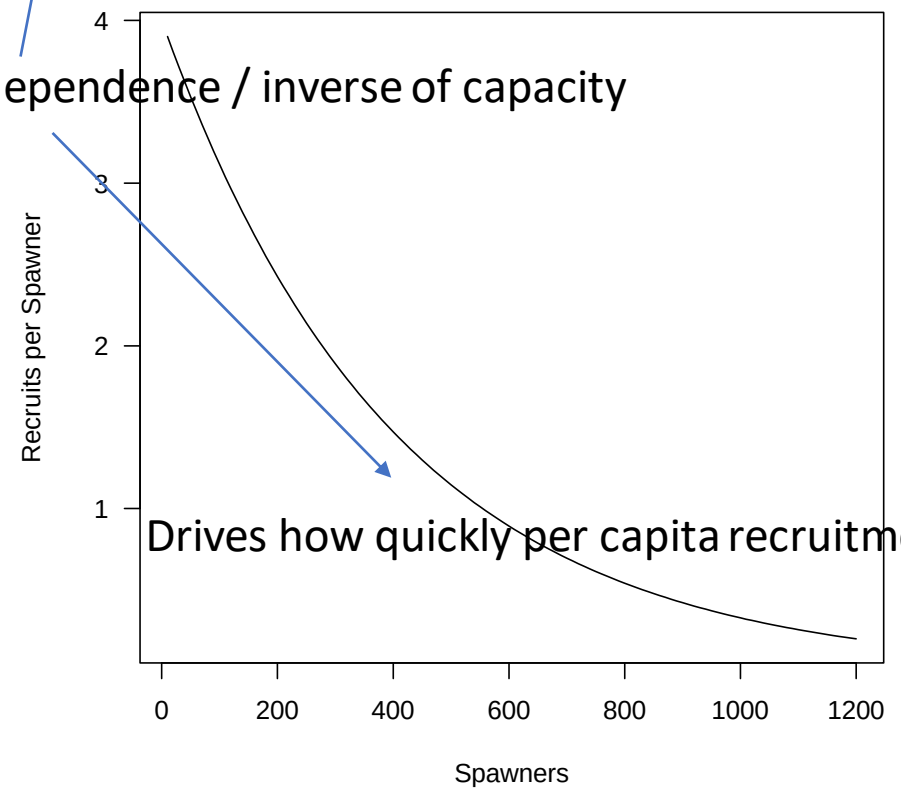


density dependence / inverse of capacity



Drives how quickly per capita recruitment drops off

Estimating S_{MSY} – data-rich scenarios

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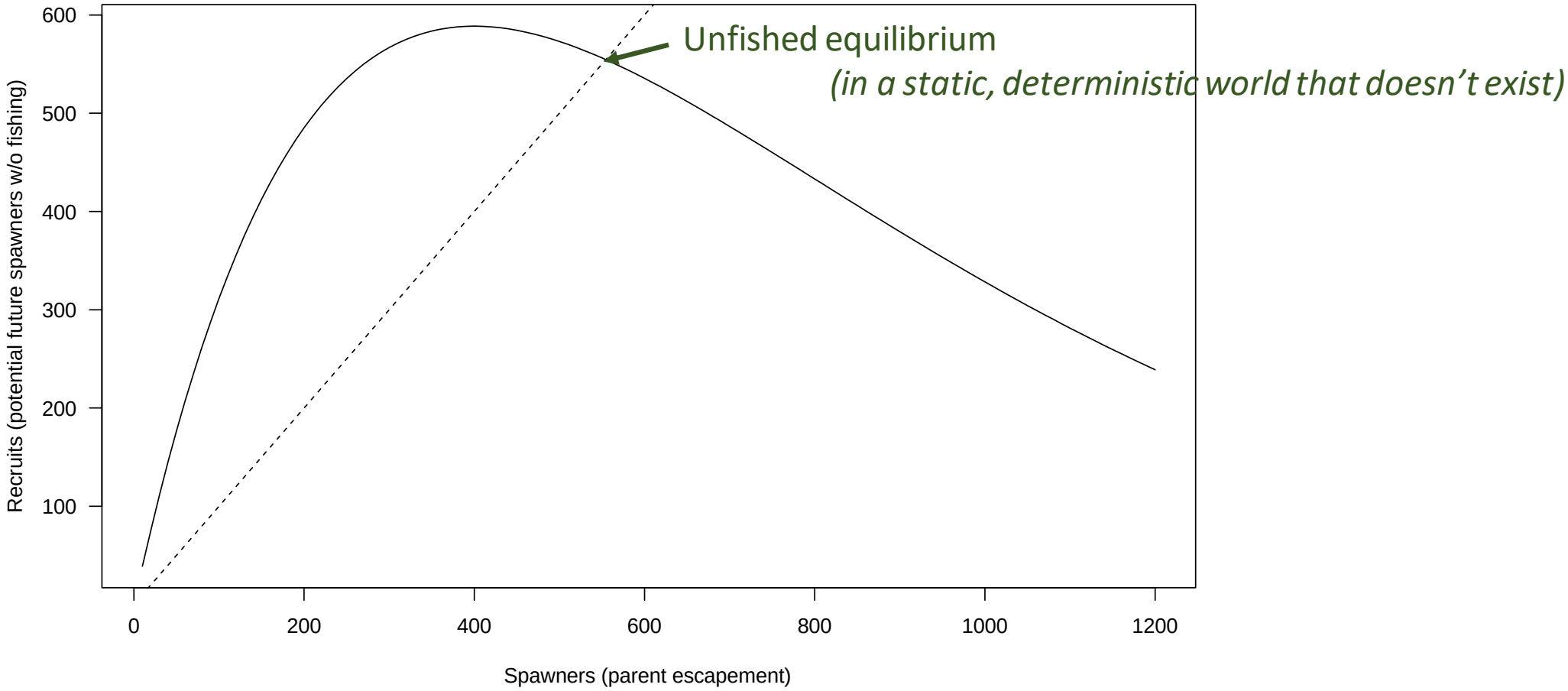

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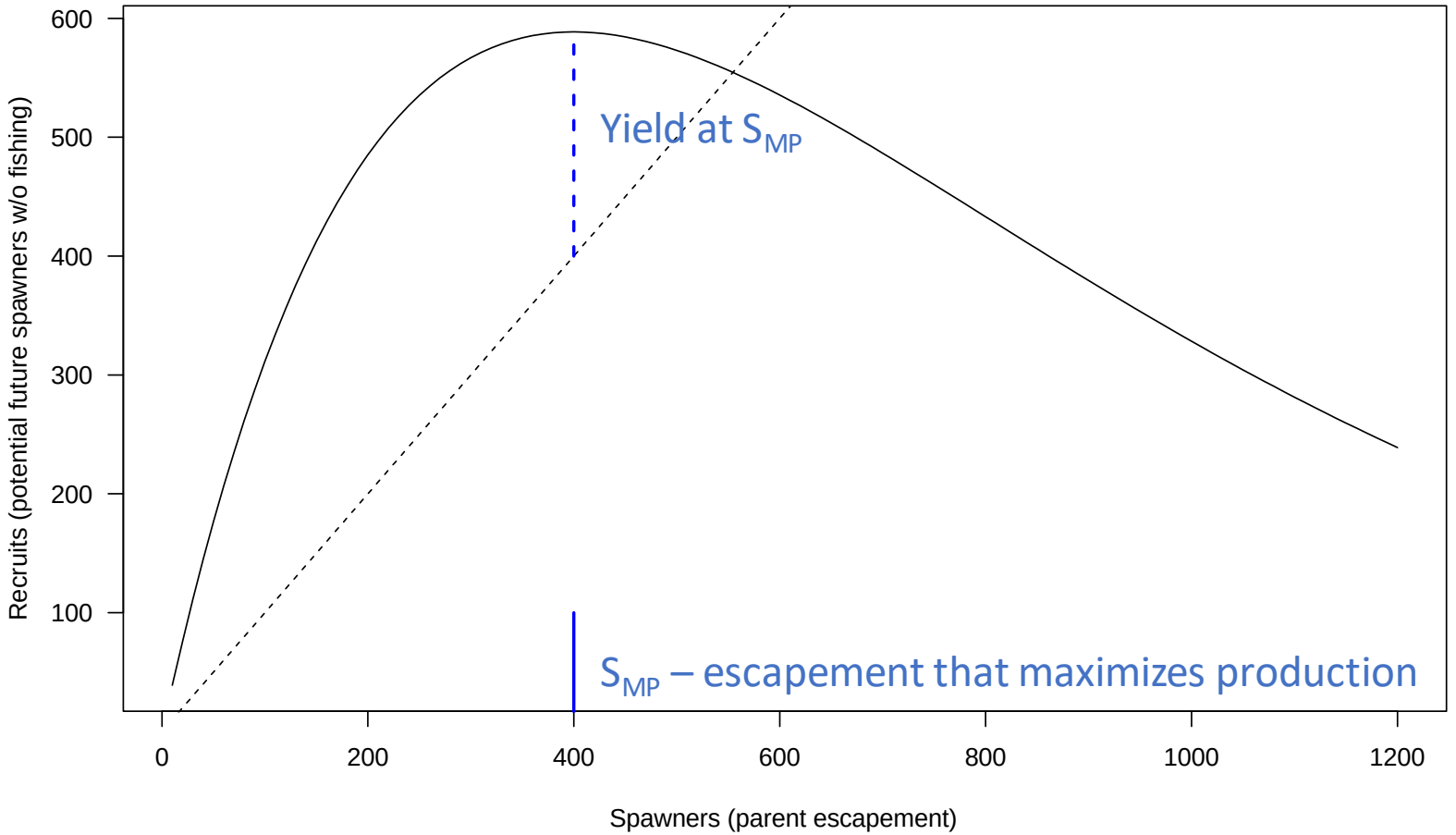

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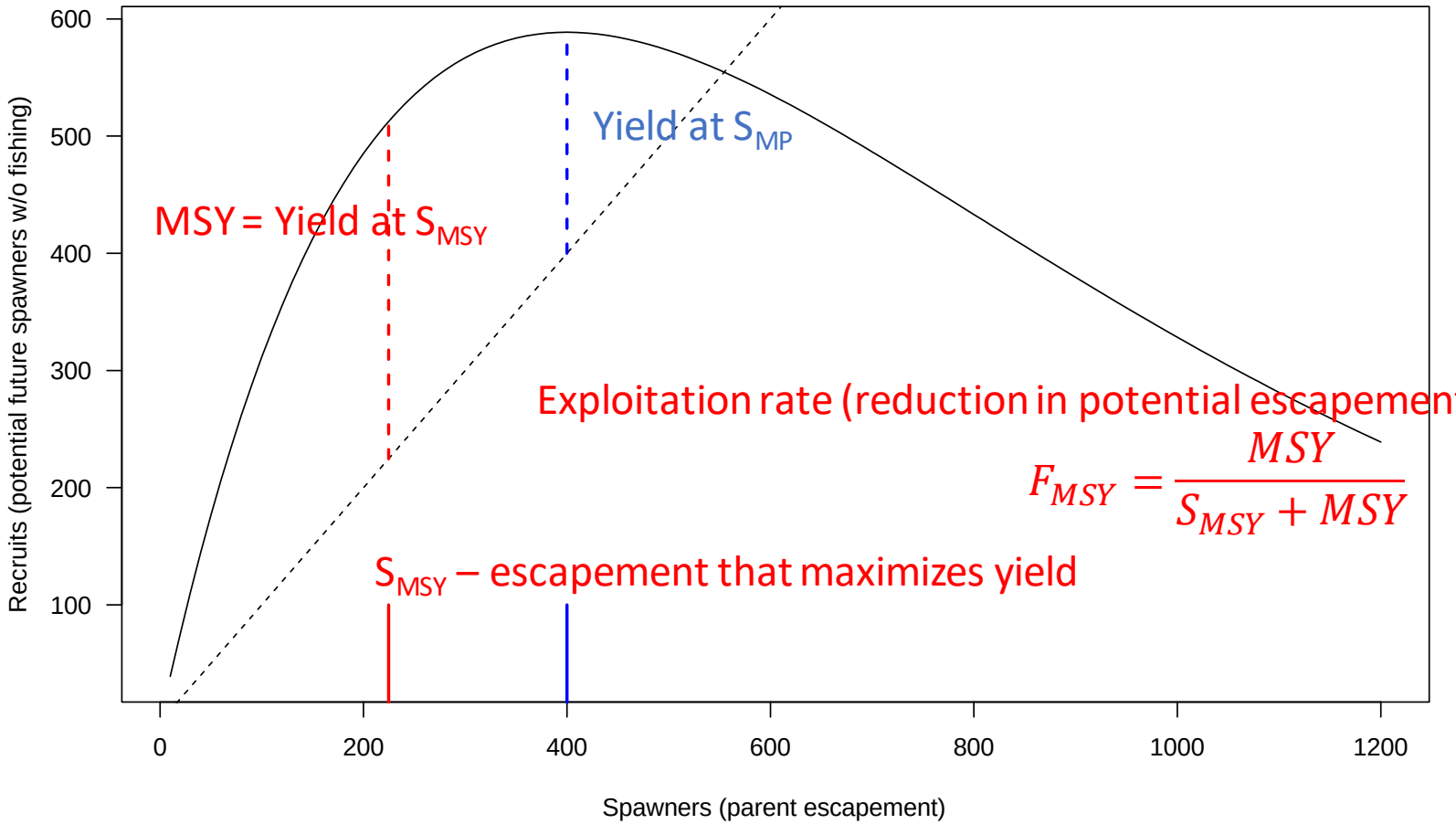
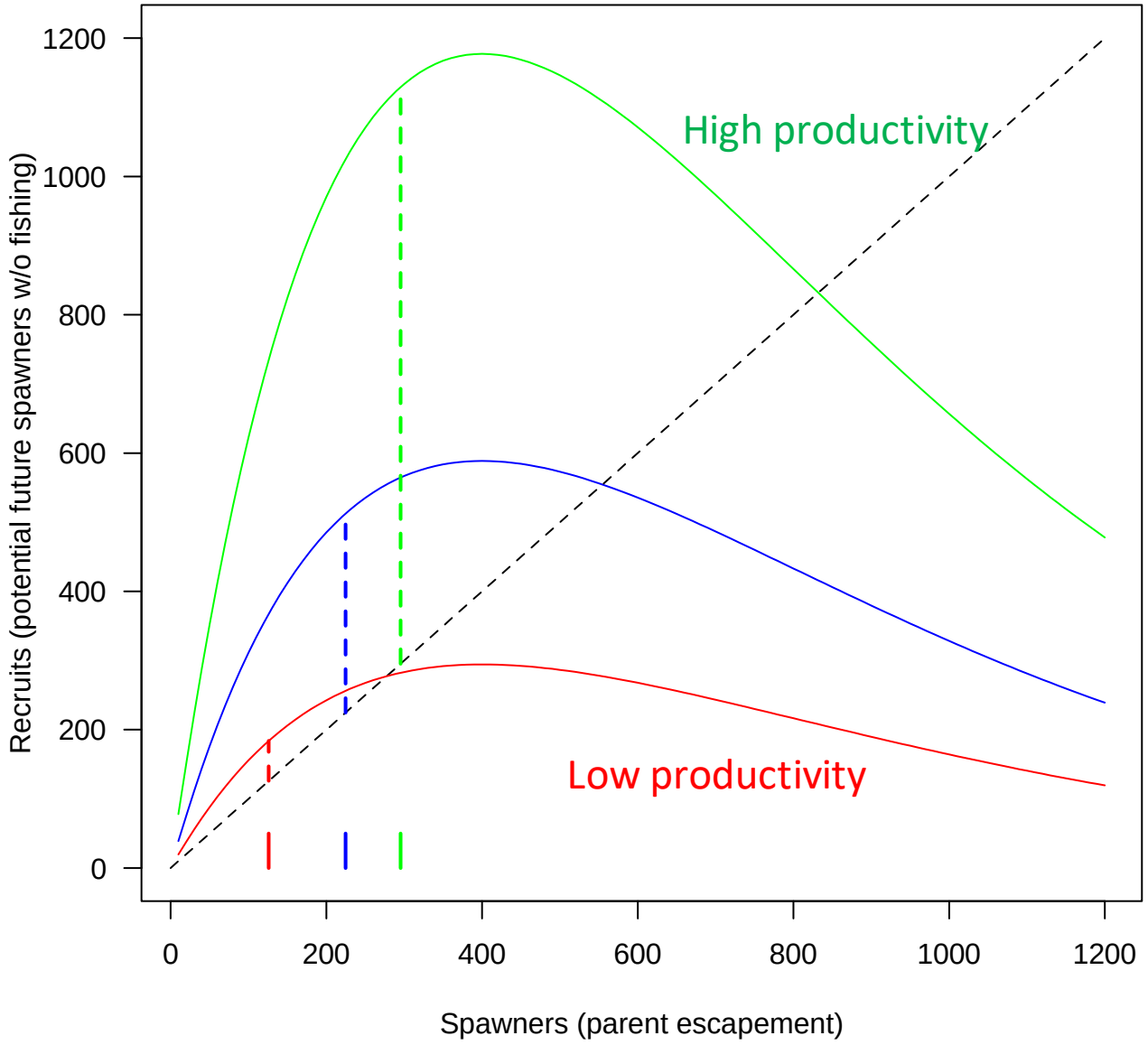


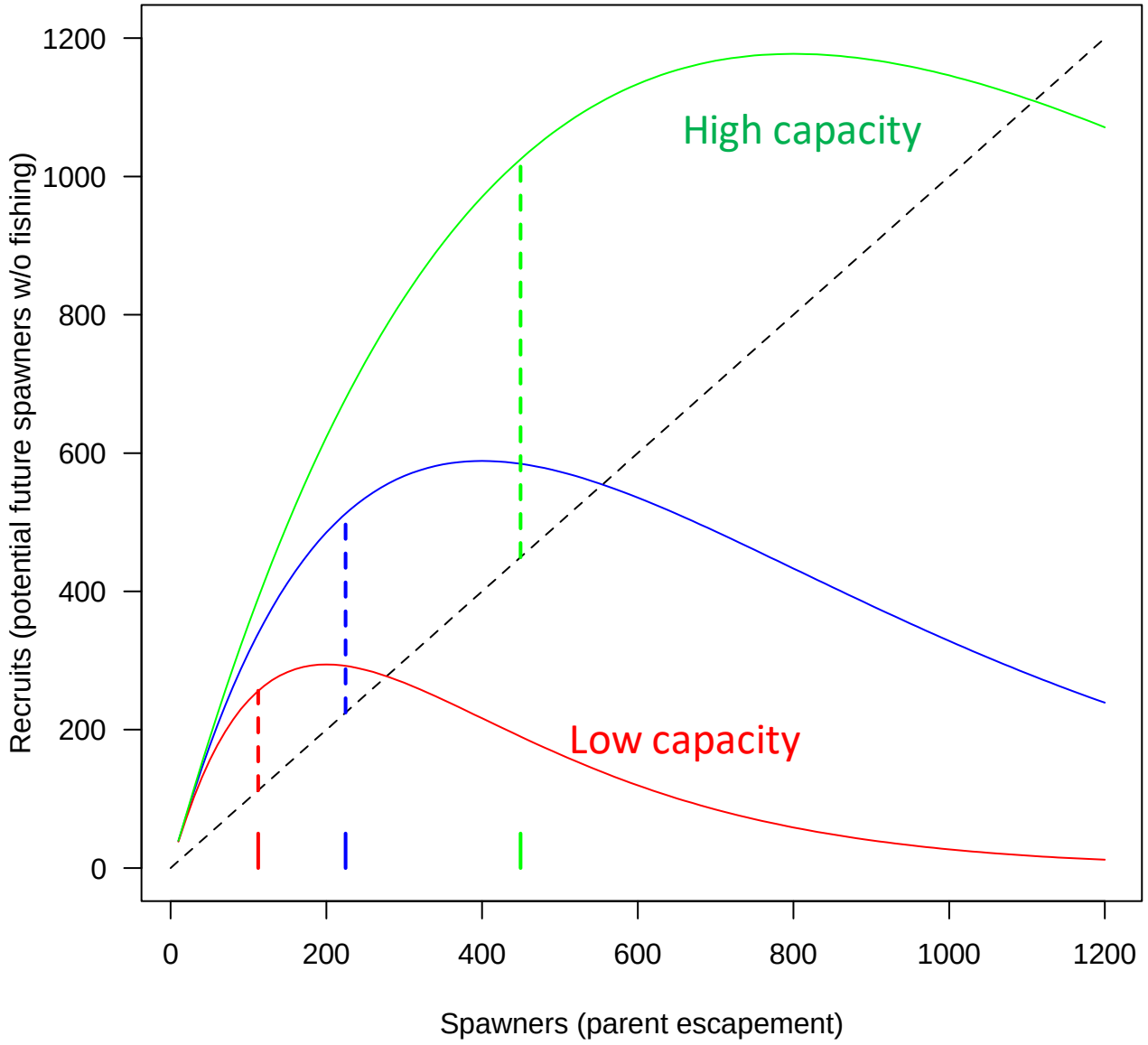
Exploitation rate (reduction in potential escapement) corresponding to MSY

$$F_{MSY} = \frac{MSY}{S_{MSY} + MSY}$$

Effects of changing productivity (alpha) while holding capacity (beta) constant



Effects of changing capacity (beta) while holding productivity (alpha) constant



Estimating S_{MSY} – data-rich scenarios

- For PFMC-managed stocks, we typically assume a Ricker spawner-recruit relationship
- But a Ricker is not the only, or even necessarily the most plausible, form a spawner-recruit relationship can take!
  - Expect a lot of variability
  - Any model is an abstraction
- Even in data-rich situations, numerous statistical pitfalls in fitting these relationships
  - Best practices: Adkison 2022, https://doi.org/10.1080/23308249.2021.1972086
- And all of this theory so far assumes:
  - Natural-area spawners are the only source of recruits
  - All spawners escaping fishing go to natural areas

Reference points

- S_{MSY}, F_{MSY} in data-rich scenarios derived as we just discussed
  - Overfishing: postseason estimate of exploitation rate is higher than F_{MSY}
  - p. 16 of FMP *(note: F_{MSY} also called MFMT)*
- Minimum Stock Size Threshold (MSST) typically 75% or 50% of S_{MSY}
  - A stock is overfished if 3-yr geometric mean escapement is less than MSST
  - p. 75 of FMP
  - Should be at least 50% of SMSY (p. 14 of FMP)
- F_{ABC} is 95% of F_{MSY} if spawner-recruit relationship fit to data for that stock, 90% if using proxy
  - p. 29 of FMP

Reference points for SRFC

- Current reference points for SRFC are not based on a fitted spawner-recruit relationship
- F_{MSY} is set to 0.78, the proxy value established as the mean of estimates for other Chinook stocks for which spawner-recruitment relationships had been fit at the time of adoption
  - And thus F_{ABC} = 0.70 (90% of 0.78)
- S_{MSY} is set to 122,000 "adults" (age-3 or older) spawning in Sacramento Basin hatchery and natural areas combined, regardless of origin
  - p. 21 of FMP
  - MSST = 91,500 (75% of S_{MSY})
  - strays into system count, strays out of system do not count
  - "jacks" do not count
  - 122,000 is also the lower bound of the "conservation objective" (coming soon)

Spawner-“recruit” relationships published for SRFC

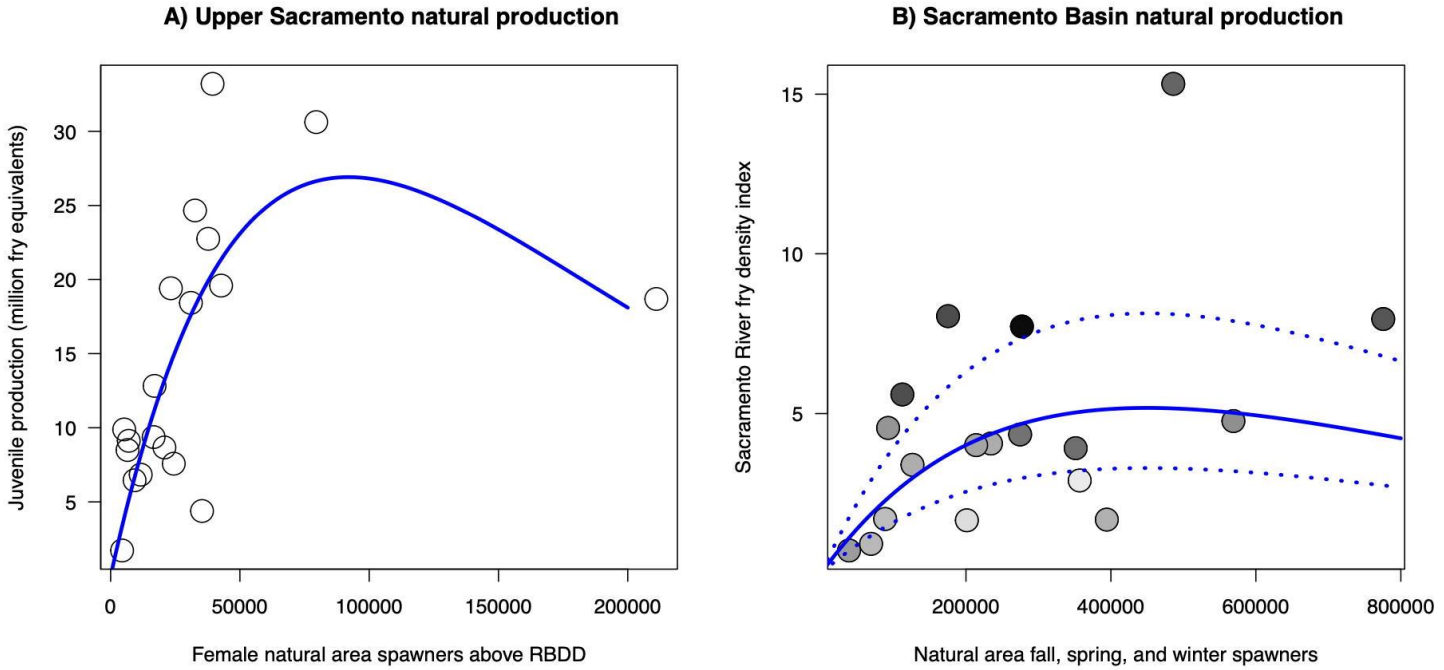


Figure 3 Juvenile production in natural areas as a function of escapement for fall Chinook above Red Bluff Diversion Dam (**A**) or fall-, spring-, and winter-run Chinook Salmon throughout the Sacramento Basin (**B**). Panel (**B**) also incorporates an effect of flow as described in Munsch et al. (2020) but note that the peak production is estimated to occur at the same escapement regardless of flow. The *solid line* indicates modeled production at mean flow, with the *dashed lines* indicating flow levels one standard deviation above (*upper*) or below (*lower*) the mean flow. The *darkness of the filled circles* indicates the flow index for each year (darker = higher flow, see Munsch et al. [2020] for details).

- Note “recruits” here are not potential escapement in absence of fishing, cannot directly derive yield or S_{MSY}

Satterthwaite 2023 https://escholarship.org/uc/item/17v0z83w

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FMP definitions and stated goals

- p. 19: "The Council's conservation objectives for natural stocks may (1) be based on estimates for achieving MSY or an MSY proxy, or (2) represent special data gathering or rebuilding strategies to approach MSY and to eventually develop MSY objectives."
- p. 51: "With respect to California stocks, ocean commercial and recreational fisheries operating in this area are managed to maximize natural production consistent with meeting the U.S. obligation to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas."

FMP description, Table 3-1, p. 21

122,000-180,000 natural and hatchery adult spawners (MSY proxy adopted 1984). This objective is intended to provide adequate escapement of natural and hatchery production for Sacramento and San Joaquin fall and late-fall stocks based on habitat conditions and average run-sizes as follows: Sacramento River 1953-1960; San Joaquin River 1972-1977 (ASETF 1979; PFMC 1984; SRFCRT 1994). The objective is less than the estimated basin capacity of 240,000 spawners (Hallock 1977), but greater than the 118,000 spawners for maximum production estimated on a basin by basin basis before Oroville and Nimbus Dams (Reisenbichler 1986).

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The distinction between natural and hatchery stocks has become lost in these portions of the river. Natural spawners are those that spawn in the wild regardless of their origin. The only major tributary with a truly natural run is the Yuba River. Runs in this river have been remarkably stable from 1971-81, averaging about 10,000 adults. The run increased sharply in 1982 to 23,000. The stability of the Yuba River escapement suggests that present and past management practices have not reduced the productivity of natural stocks.

-PFMC (1984) p. 3-19

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- Williamson and May (2005 NAJFM 25:993) – 7 microsatellite loci
  - "genetically homogeneous population...lack of genetic distinction and the lack of temporal differences in allele frequencies between hatchery and naturally spawning fish indicate that considerable gene flow occurs between fall-run Chinook salmon throughout the Central Valley"
- Meek et al. (2020 CJFAS 77:534) – genomic study
  - "greater population structure across the Central Valley than previously documented ... evidence for differentiation and adaptation ... despite high levels of gene flow"

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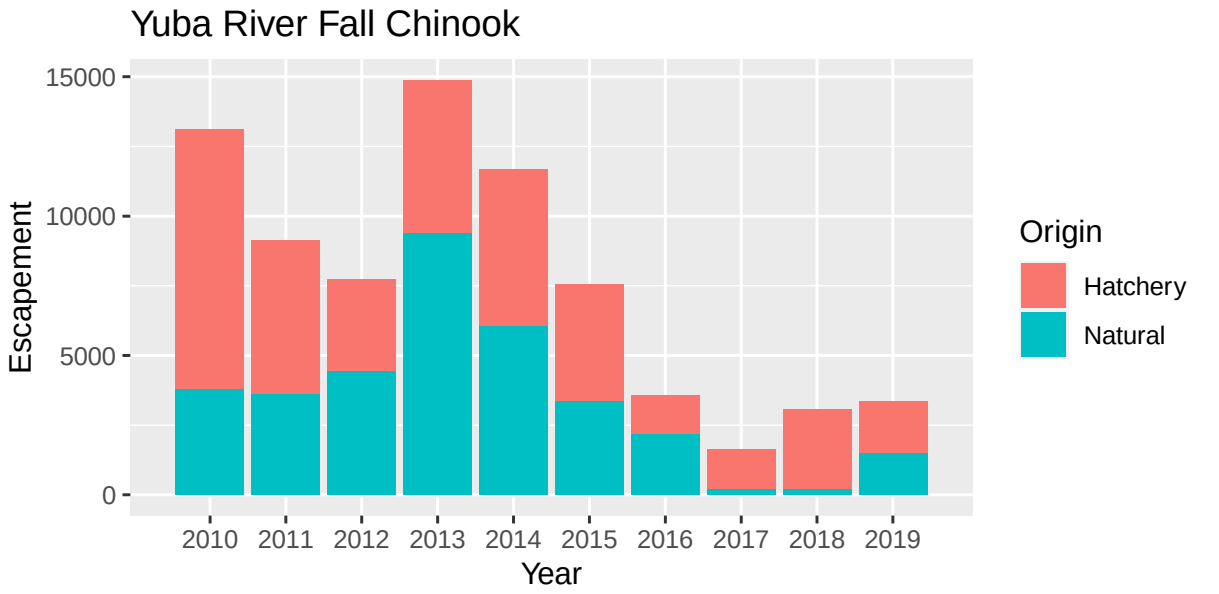

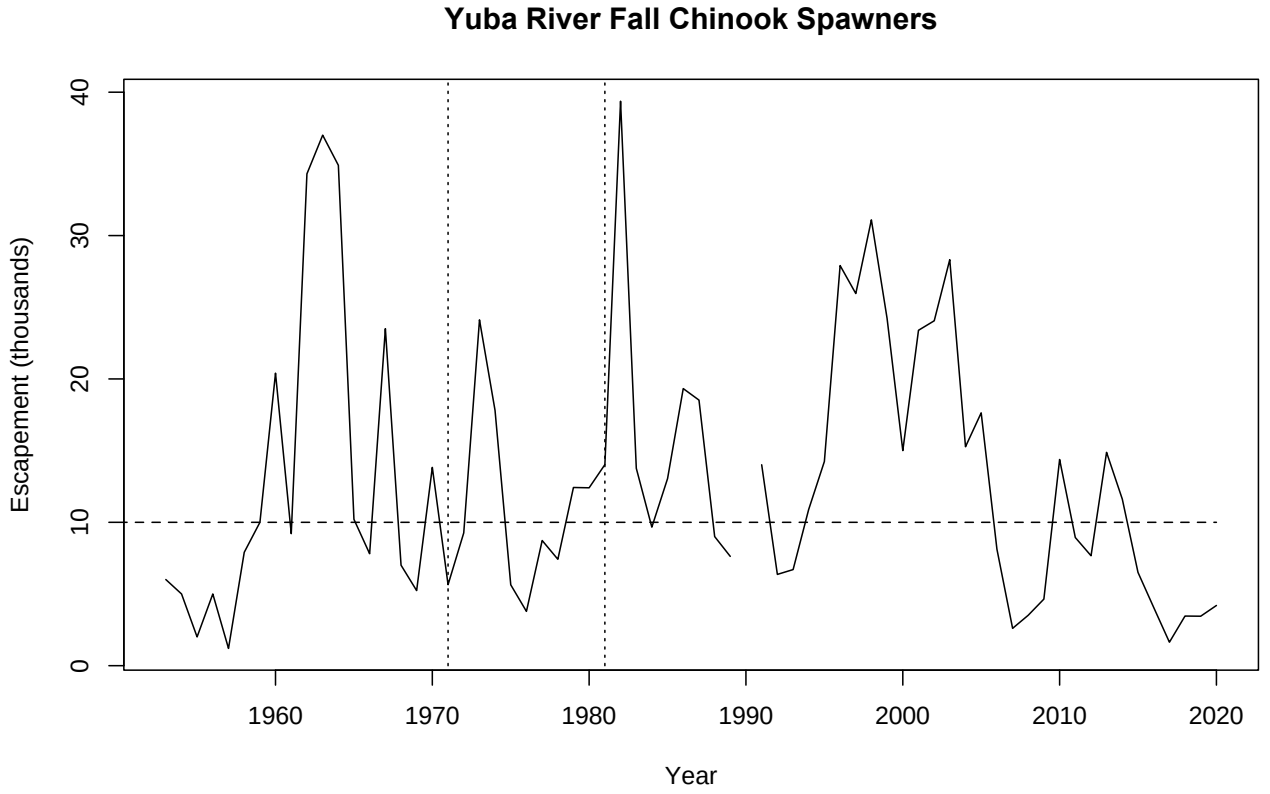

Compiled from CWT recovery reports at:
https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/CentralValleyCFMProgram.aspx

Source: Azat (2021)

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Attempting to reproduce these averages using GrandTAB, Will comes up with different and much larger numbers, adding up to ~350K vs 180K

See Satterthwaite 2022 for details
https://www.pcouncil.org/documents/2022/10/d-2-attachment-1-methodology-review-materials-electronic-only.pdf/#page=50

p… …SY
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Will basically agrees on Hallock (actually says 245K), but can't reproduce this 118K number based on his reading of Reisenbichler 1986

See Satterthwaite 2022 for details
https://www.pcouncil.org/documents/2022/10/d-2-attachment-1-methodology-review-materials-electronic-only.pdf/#page=50

Why a range / where did the lower bound come from?

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.

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- https://archive.redding.com/news/red-bluff-diversion-dam-to-be-permanently-decommissioned-for-salmons-benefit-ep-299376979-353718741.html/

Gates have been fully open since 2011

Permanently locked open in 2013

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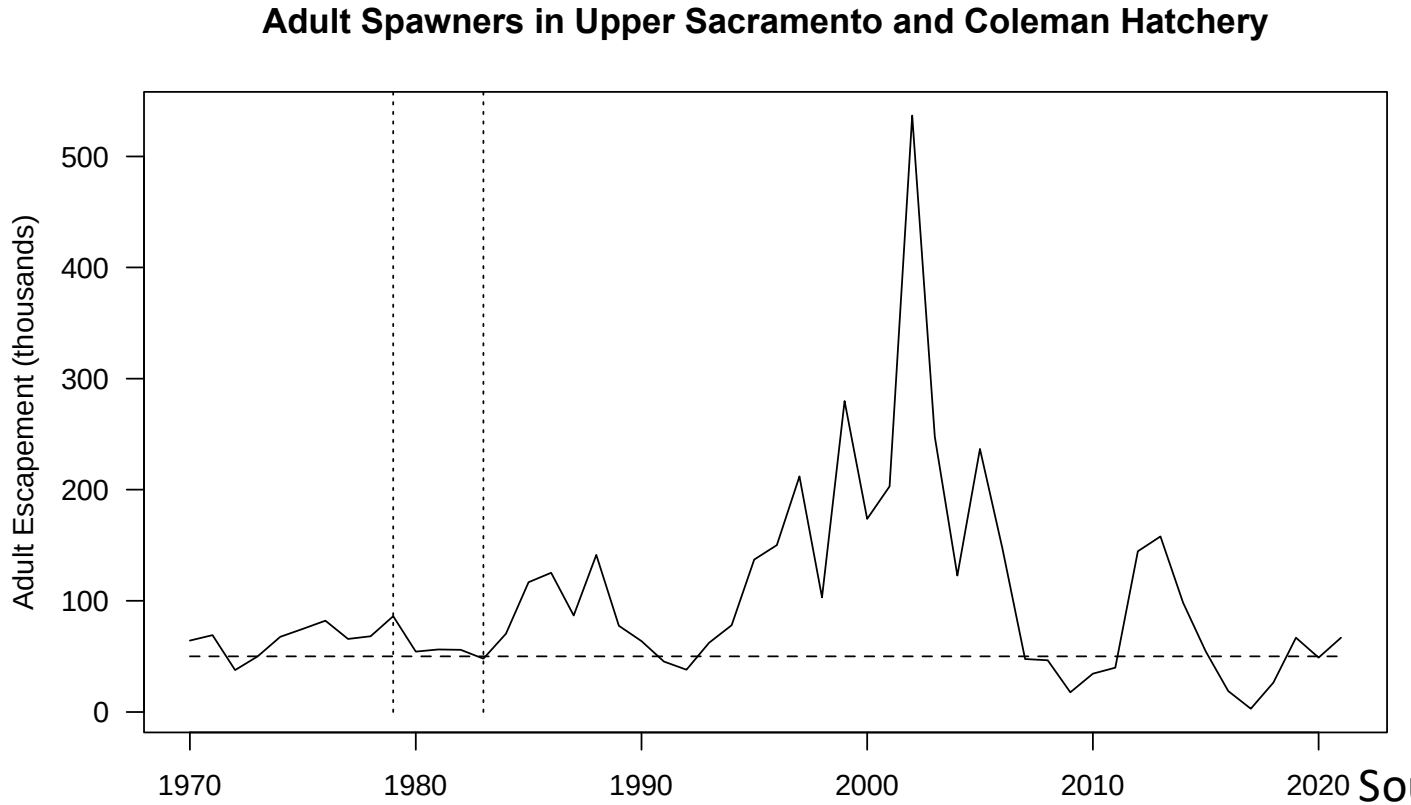
Note:
the 50K and 72K figures are for returns to hatcheries plus natural areas combined.



Source: Review Table B-1

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SRFC Harvest Control Rule (p. 33 of FMP)

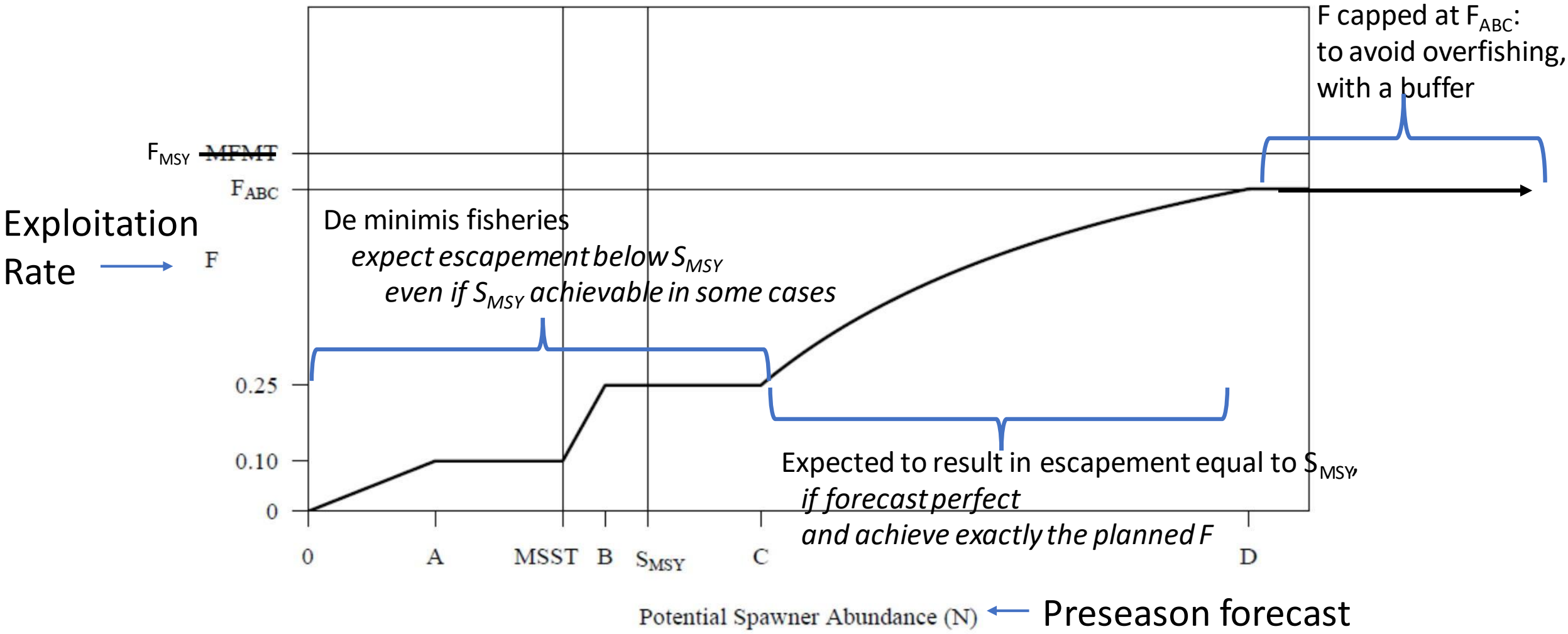

FIGURE 3-1. Control rule for Sacramento River and Klamath River fall Chinook. Abundance is pre-fishery ocean abundance in spawner equivalent units, and F is the exploitation rate. Reference points in the control rule are defined in the text.

Other PFMC salmon harvest control rules

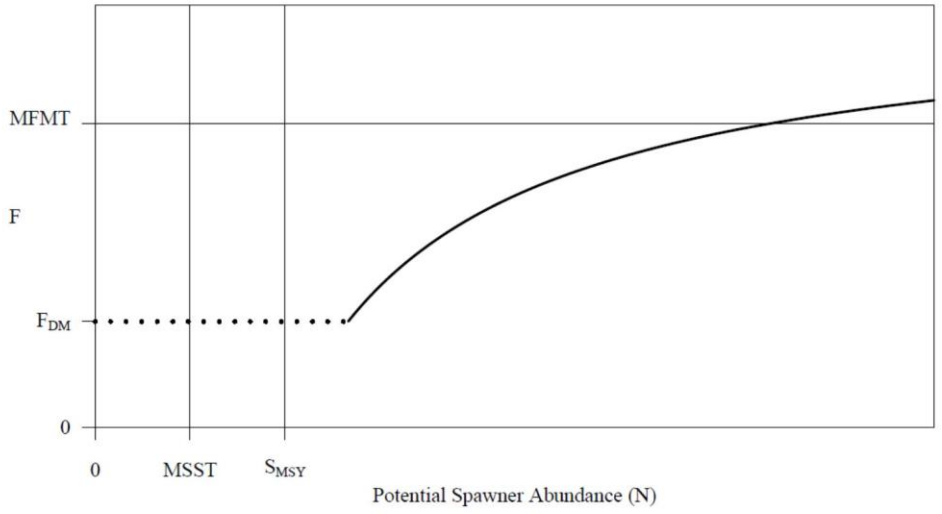

FIGURE 3-2. Control rule for several Chinook and coho stocks managed under the terms of the PST. Abundance is pre-fishery ocean abundance in spawner equivalent units, and F is the exploitation rate. Reference points in the control rule are defined in the text.

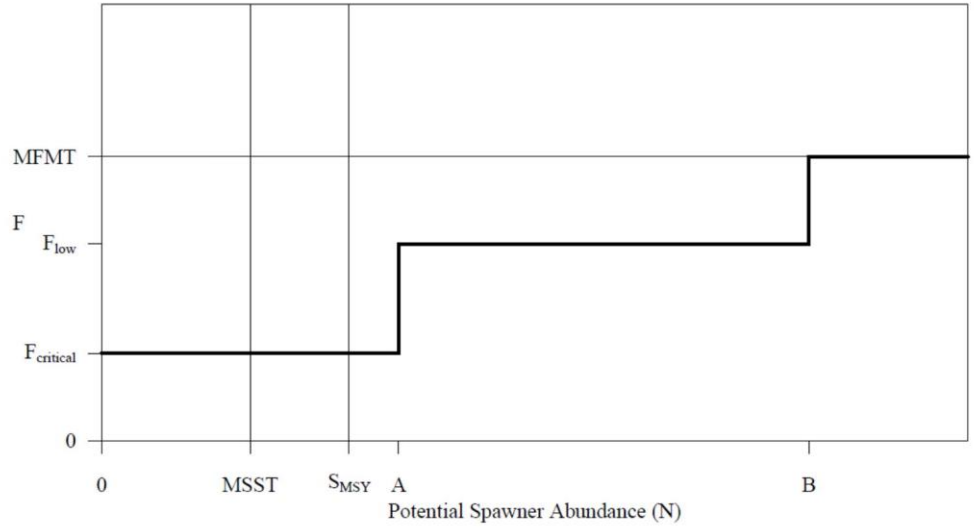

FIGURE 3-3. Control rule for Puget Sound coho. Abundance is pre-fishery ocean abundance in spawner equivalent units, and F is the exploitation rate. Reference points in the control rule are defined in the text.

TABLE 3-2. Allowable fishery impact rate criteria for OCN coho stock components.

PARENT SPAWNER STATUS		MARINE SURVIVAL INDEX (based on return of jacks per hatchery smolt) Low (<0.0009) — Allowable Total Fishery Impact Rate	Medium (0.0009 to 0.0034)	High (>0.0034)
High:	Parent spawners achieved Level #2 rebuilding criteria; grandparent spawners achieved Level #1	≤15%	≤30%[a/]	≤35%[a/]
Medium:	Parent spawners achieved Level #1 or greater rebuilding criteria	≤15%	≤20%[a/]	≤25%[a/]
Low:	Parent spawners less than Level #1 rebuilding criteria	≤15% ≤10-13%[b/]	≤15%	≤15%

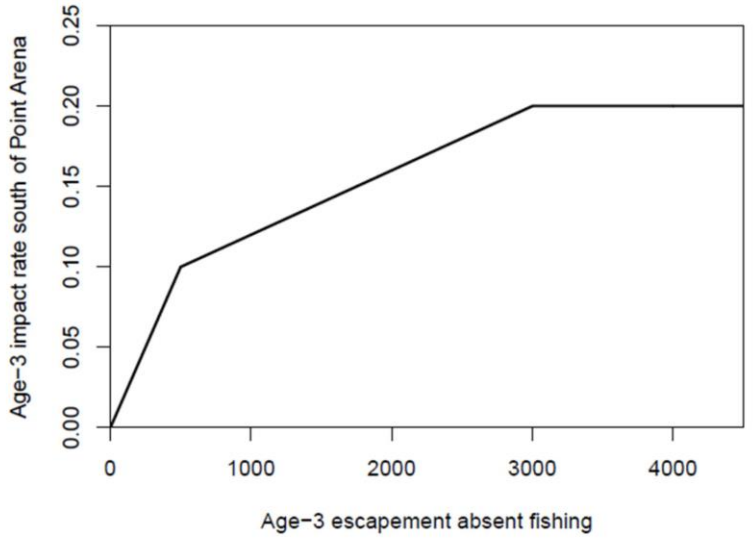

FIGURE A-3. Sacramento River winter Chinook impact rate control rule. The maximum forecast age-3 impact rate for the area south of Point Arena, California, is determined by the forecasted age-3 escapement absent fishing.

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SRFC status determinations (as of March 2023)

- Not overfished
  - 2020-2022 escapements of 138,091; 104,483; and 61,850
  - Geometric mean of 96,276, above MSST of 91,500
  - *(was overfished based on escapement end years 2017-2019, not defined prior to Am. 16)*
- Not subject to overfishing in 2022
  - 2022 exploitation rate estimated as 0.754, below F_{MSY} proxy of 0.78
- At risk of approaching an overfished condition
  - 2023 forecasted SI (escapement absent fishing) of 169,767
  - 2022 regulations expected to result in F=0.50 if repeated in 2023
    - Would be expected to lead to escapement of 84,750
  - Geometric mean of 104,483; 61,850; and 84,750 is 81,817; below MSST
  - *Of course, actual 2023 regulations were quite different from 2022*
- If realized 2023 escapement < 118,543, will meet criteria for overfished
  - This is approximate since 2022 escapement estimate may be revised slightly

Total SRFC adult abundance index (SI)

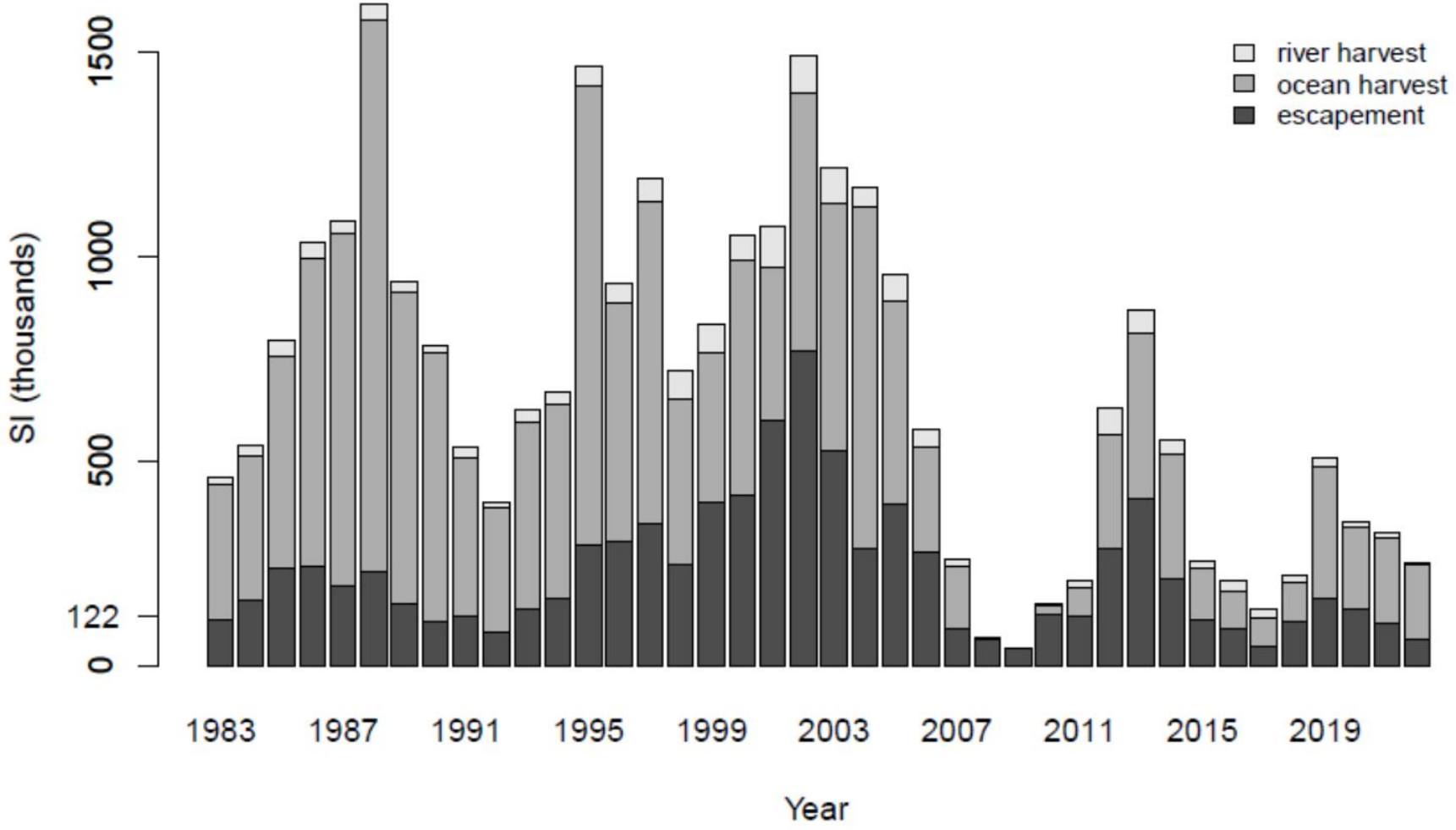


FIGURE II-1. The Sacramento Index (SI) and relative levels of its components. The Sacramento River fall Chinook S_{MSY} of 122,000 adult spawners is noted on the vertical axis.

Source: Preseason Report 1

Total SRFC adult escapement by location (*not* origin)

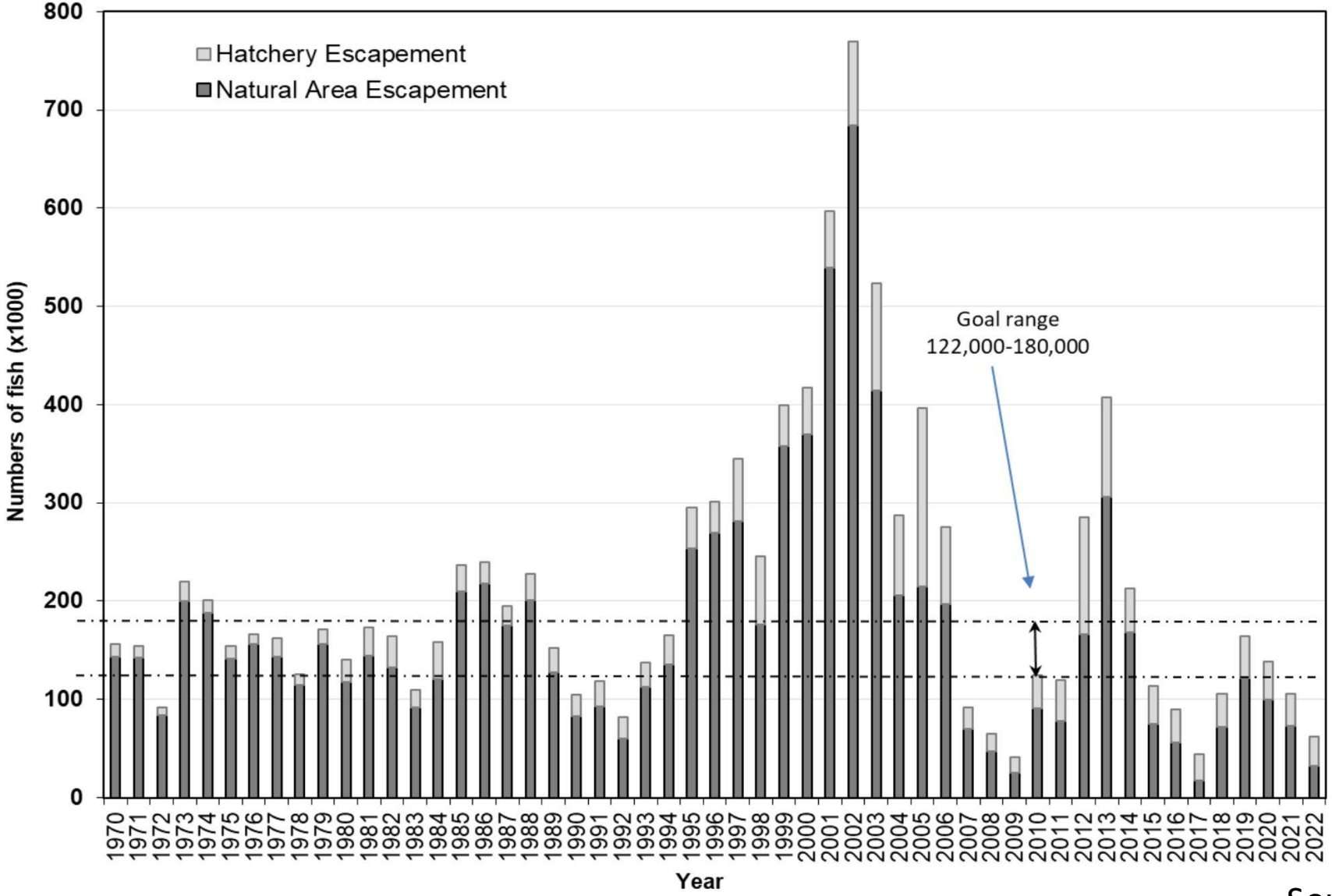
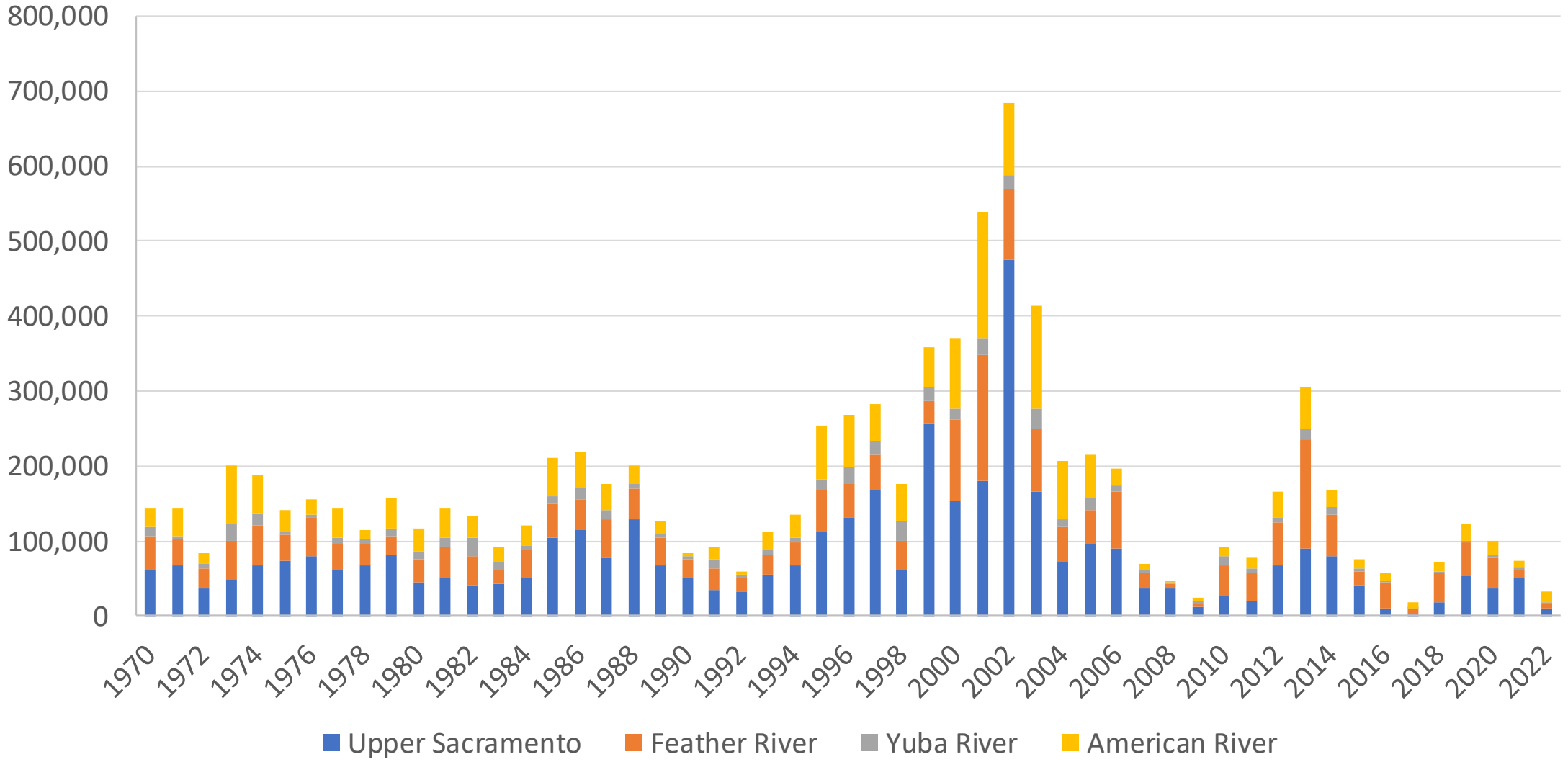


Figure II-1. Sacramento River adult fall Chinook spawning escapement, 1970-2022.

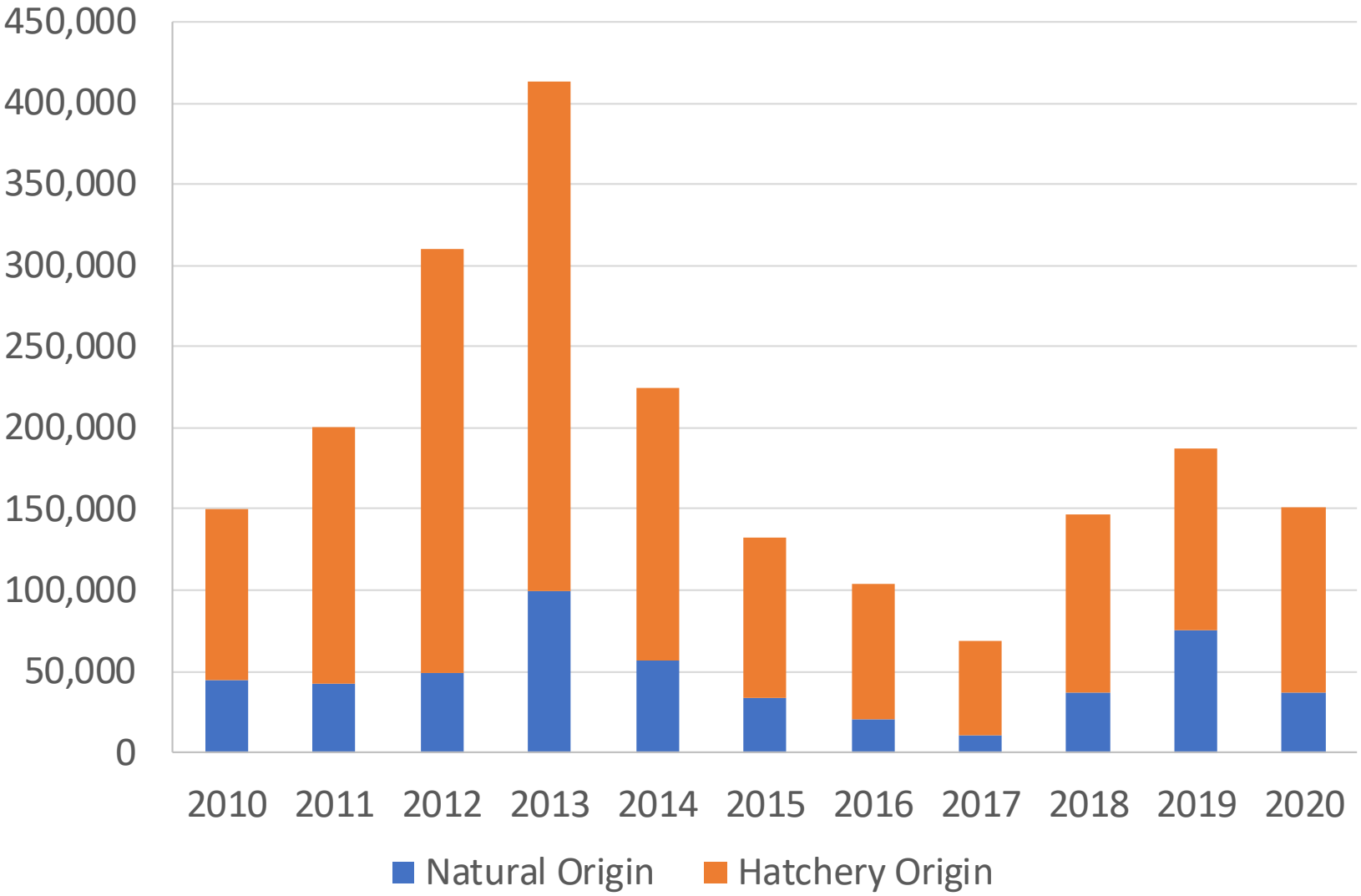
Source: Review of Ocean Fisheries

Natural-area SRFC adult escapement by location



Source: Review of Ocean Fisheries, Table B-1

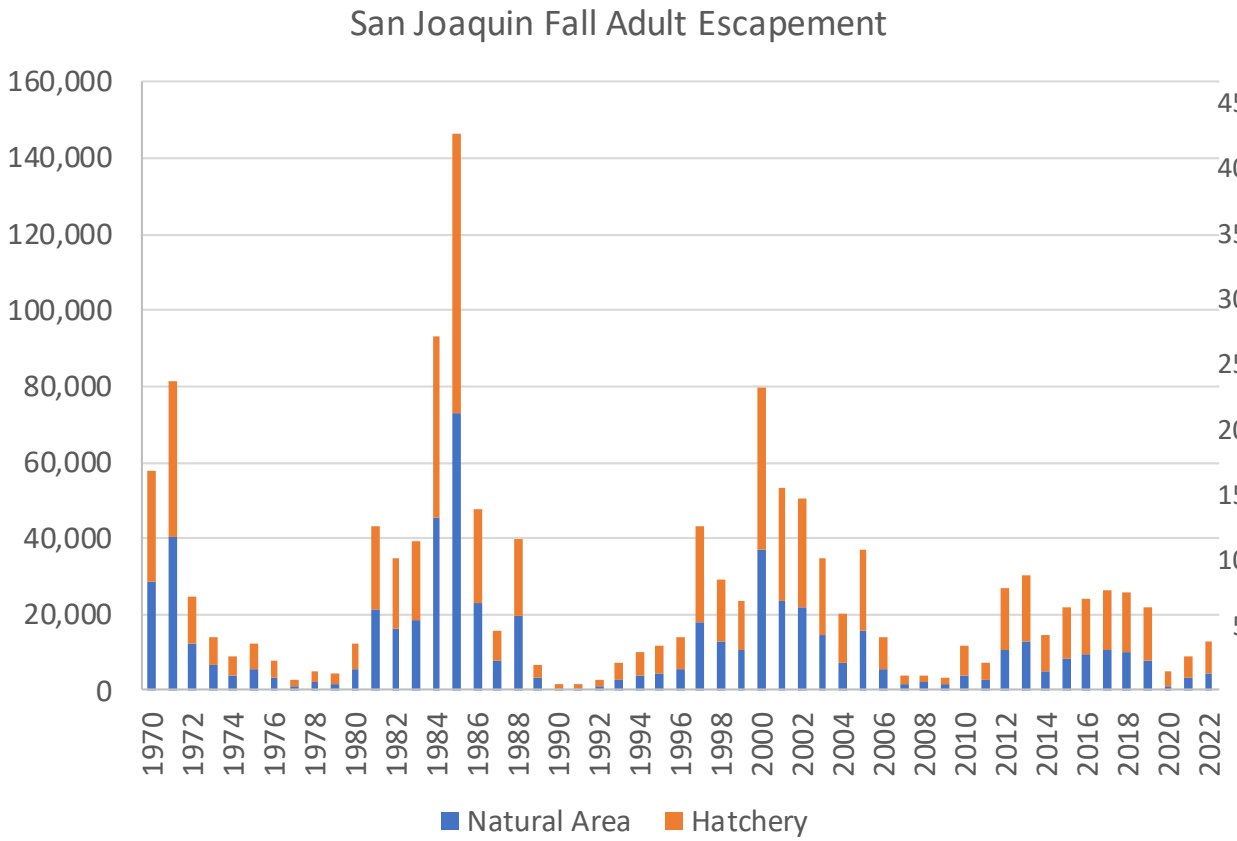
SRFC escapement by origin (all ages, all locations)

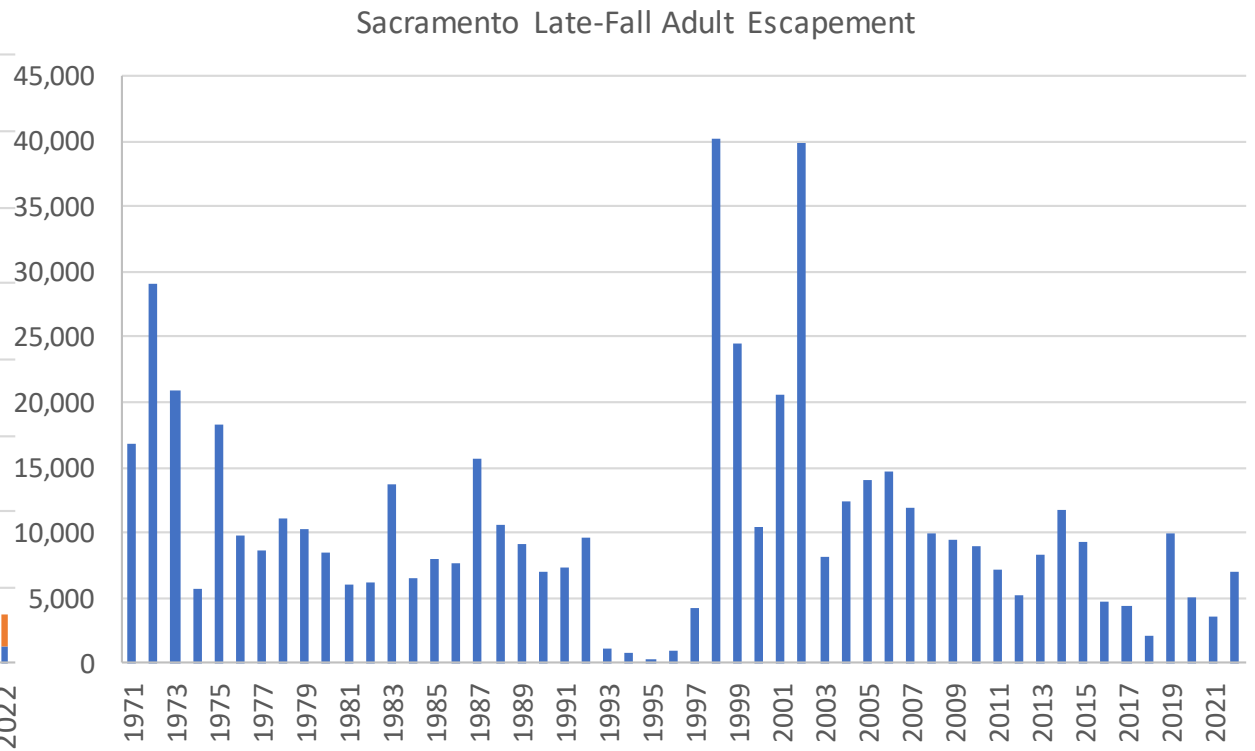


Source: Satterthwaite 2023 updated with Dean and Lindley 2023

Other components of CV fall stock complex

(San Joaquin fall is by location, not by origin)





Source: Review of Ocean Fisheries, Tables B-2 and B-3

Challenges

- Merits of conservation objective and/or S_{MSY} being for hatchery and natural areas combined versus natural areas alone? Merits of including origin?
- Merits of objectives for Sacramento Basin as a whole versus sub-area goals, consideration of San Joaquin and/or late-fall?
- Suitability of average of past escapements from a reference period as basis for reference points?
  - Especially if that average can't be reproduced?
- Can we estimate S_{MSY}? F_{MSY}?
- Can we estimate S_{MP}?
  - Can we relate S_{MP} to likely value of S_{MSY}?
  - What if S_{MP} isn't capable of self-replacement?
- Should conservation objective's focus be on yield (FMP p. 19, generic) or production (FMP p. 51, CA-specific)?
- How are we "taking into account the effects of uncertainty and management imprecision" (FMP p. 13)? How could we be?
- How do we get there from here?