Freshwater and marine environment

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Freshwater and Marine environment

- TOR: “Consider the effect of environmental variables on the stability and accuracy of”
  - Reference points
  - Conservation objective
  - Harvest control rule

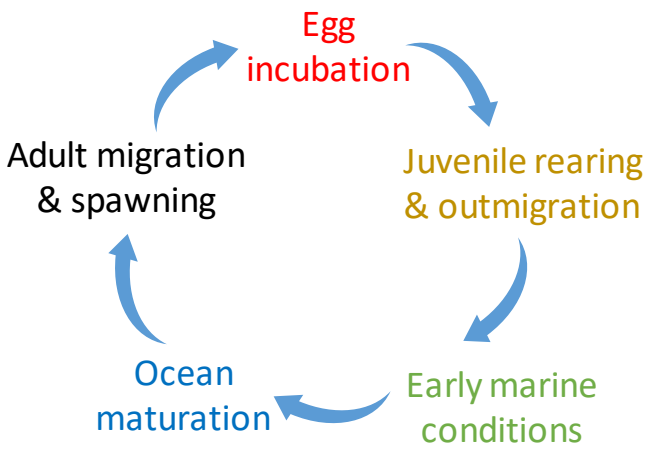
- Hard to do, given existing uncertainties as noted by Will

- Some science center products related to freshwater and marine conditions can be used to inform reference points/conservation objectives or risk assessment

Overview

- Development of multiple “stoplight” indicators of freshwater and marine conditions
- Testing performance of indicators
- How indicators might be used

Factors that potentially influence productivity at different life stages



Incubation temp (Martin et al. 2017)
Redd dewatering (Jager et al. 1997)

Low flows for adults (Strange 2012)
Upstream migration temperature (Fitzgerald et al. 2021)

Spring flows (Munsch et al. 2019)

Release location (Sturrock et al. 2019)

Floodplain rearing (Sommer et al. 2001)

Lower mainstem temp and predation (Michel et al. 2020)

Diet diversity (Thayer et al. 2014)
Ocean temperature (Hinke et al. 2005)

Cross-channel operations (Perry et al. 2010)

Delta water exports (Kimmerer 2008)

Marine predation (Wells et al. 2017)

Upwelling (Wells et al. 2012)
Sea surface temp (Wells et al. 2016)

Migration/release timing (Satterthwaite et al. 2014)

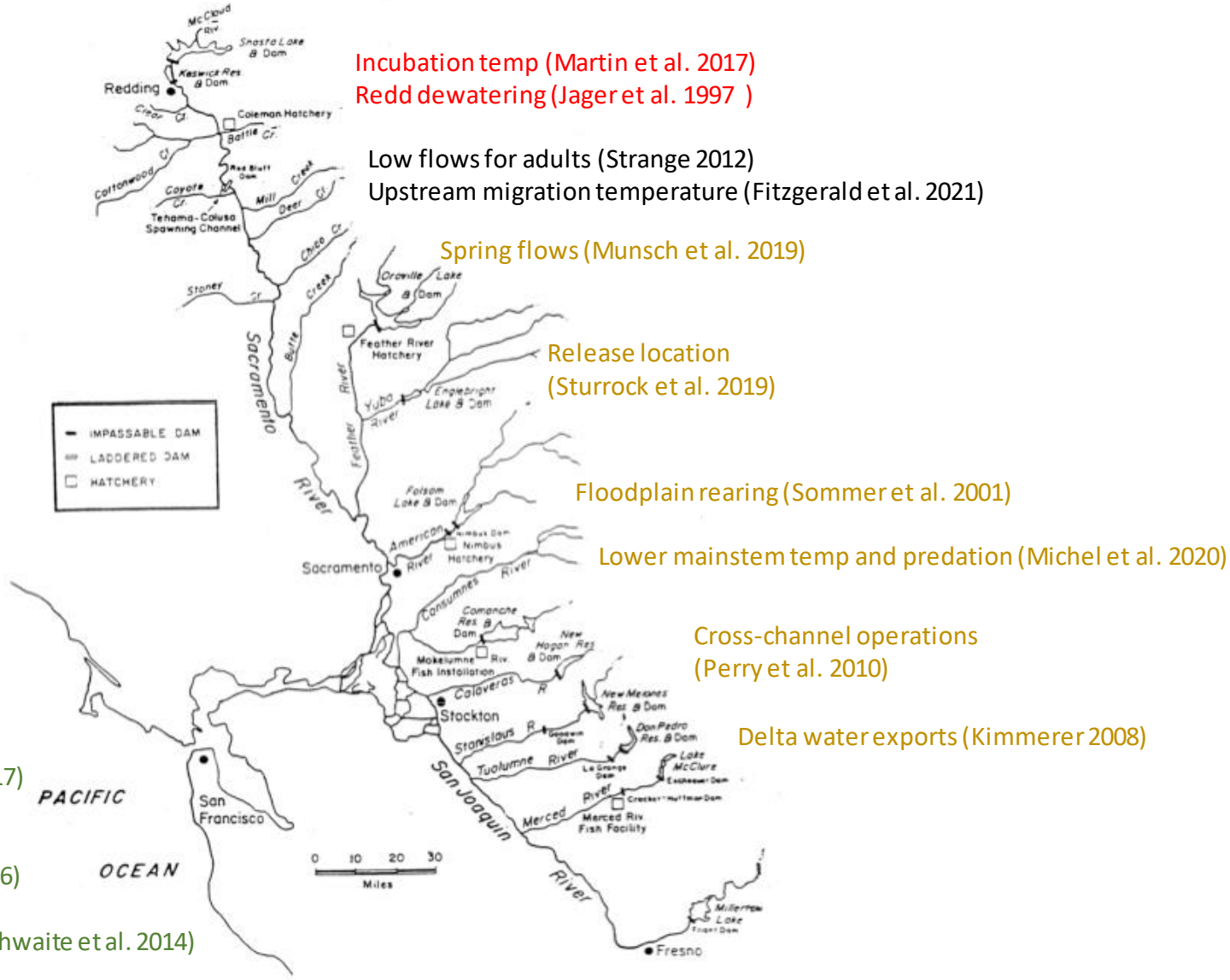


FIGURE 2. Salmon streams in the Central Valley.

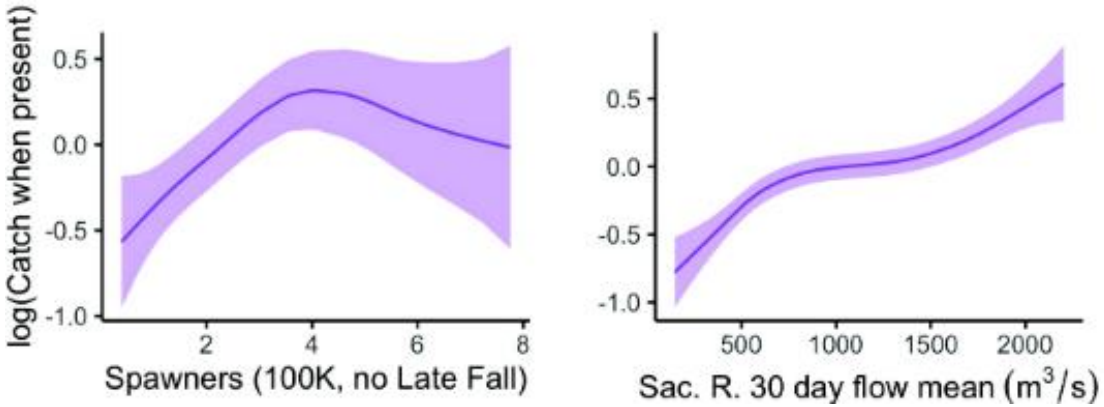
Source: SRFCRT 1994

Indicators from juvenile monitoring programs

Canadian Journal of **Fisheries and Aquatic Sciences**

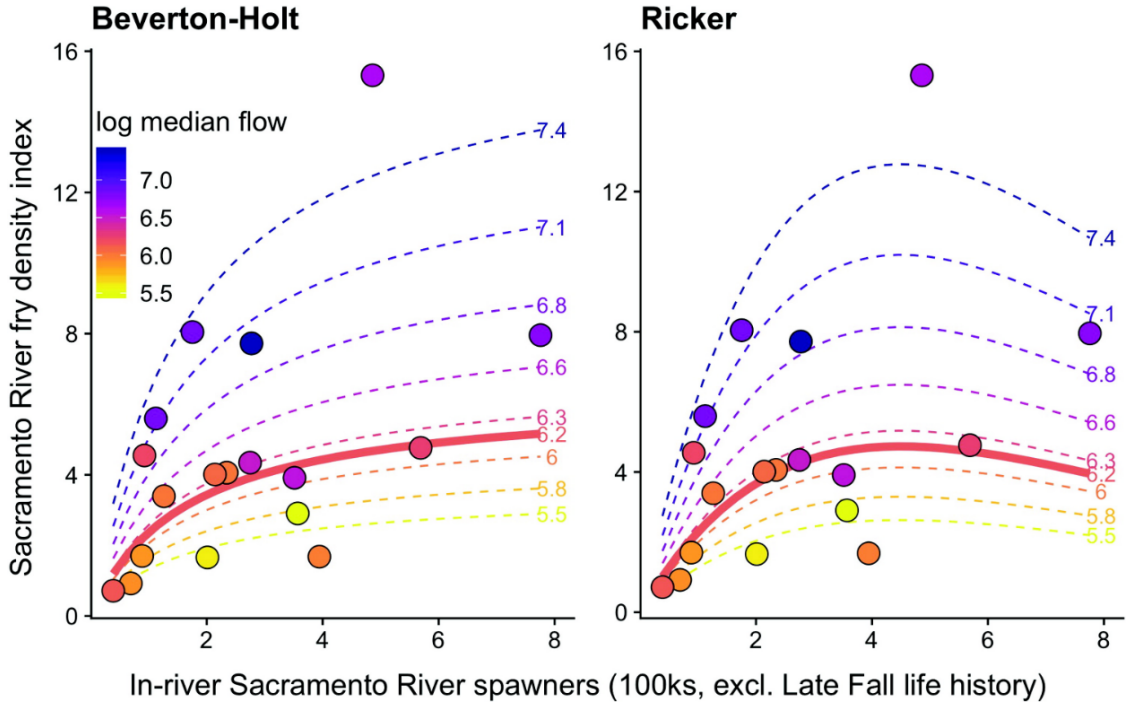
Science for integrative management of a diadromous fish stock: interdependencies of fisheries, flow, and habitat restoration

Authors: Stuart H. Munsch, Correigh M. Greene, Rachel C. Johnson, William H. Satterthwaite, Hiroo Imaki, Patricia L. Brandes, and Michael R. O'Farrell | AUTHORS INFO & AFFILIATIONS



- Larger catches of unmarked fry in the lower river when:
  - Sacramento R flows were higher
  - Spawners < 400K

- Implies that any conservation objective < 400K escapement is losing potential production, particularly in higher flow years

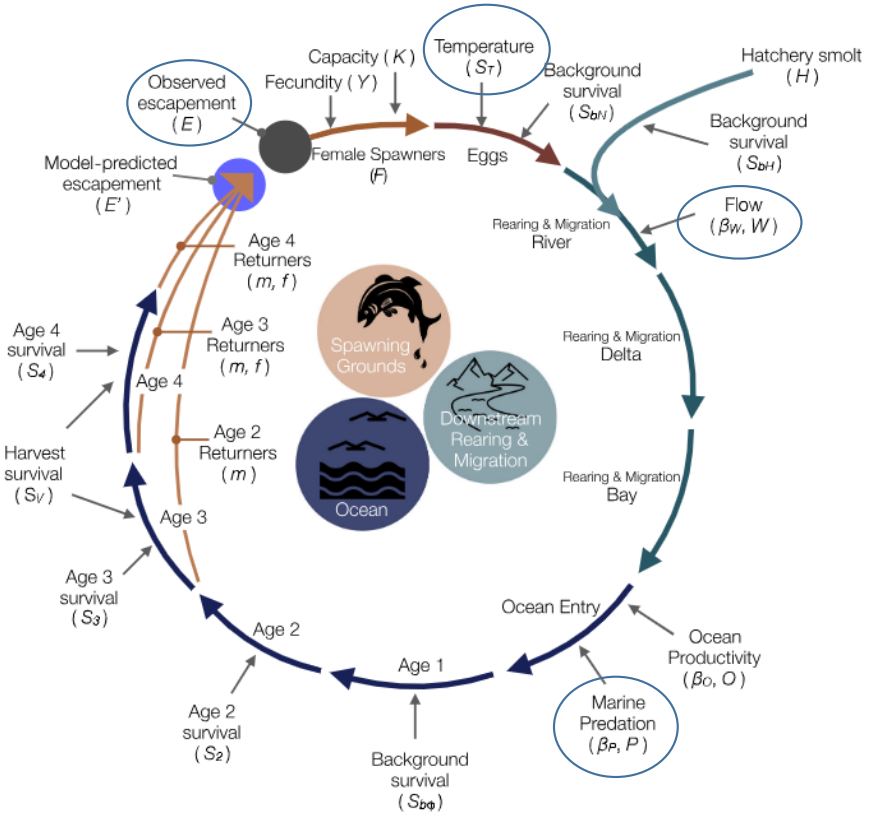


Indicators from life cycle modeling

esa ECOSPHERE

Modeling composite effects of marine and freshwater processes on migratory species

Whitney R. Friedman,[1,2,4,†] Benjamin T. Martin,[2] Brian K. Wells,[2] Pete Warzybok,[3] Cyril J. Michel,[1,2] Eric M. Danner,[2] and Steven T. Lindley[2]



- Life cycle model with habitat covariates
- Included spawning capacity parameter, but it was not strongly supported
- Support for annually variable effects of
  - Temperature during incubation
  - Flow during downstream migration
  - Marine predation by birds
- Basis for four qualitative indicators updated annually by SWFSC for Ecosystem Status Report

Spawning Escapement (t=0)	Incubation Temperature (Oct-Dec t=0)	February Median Flow (t+1)	Seabird Marine Predation Index (t+1)	Chinook Age in Fall 2023
2018: 71,689 (low)	11.7°C (poor)	21,700 cfs (high)	Near average	5
2019: 121,600 (met goal)	11.3°C (suboptimal)	6,030 cfs (very low)	Near average	4
2020: 100,100 (low)	**11.5°C (poor)**	**6,015 cfs (very low)**	**Near average**	**3**
2021: 73,230 (low)	13.0°C (very poor)	4,925 cfs (very low)	Near average	2

Development of habitat indicator stoplight charts - a brief history

- KRFC and SRFC in rebuilding plans after poor productivity from brood years 2012-2014
- Rebuilding plans suggested multiple possible habitat impacts
- Habitat Committee review: track life-stage specific habitat change using indicators
- Habitat Indicators for fall-run stocks first produced in ESR (2020) and have been updated since

SACRAMENTO RIVER FALL CHINOOK
(JULY 2019)

KLAMATH RIVER FALL CHINOOK
(JULY, 2019)

SALMON REBUILDING PLAN,
ENVIRONMENTAL ASSESSMENT*,
MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ANALYSIS*,
REGULATORY IMPACT REVIEW*, AND
INITIAL REGULATORY FLEXIBILITY ANALYSIS*

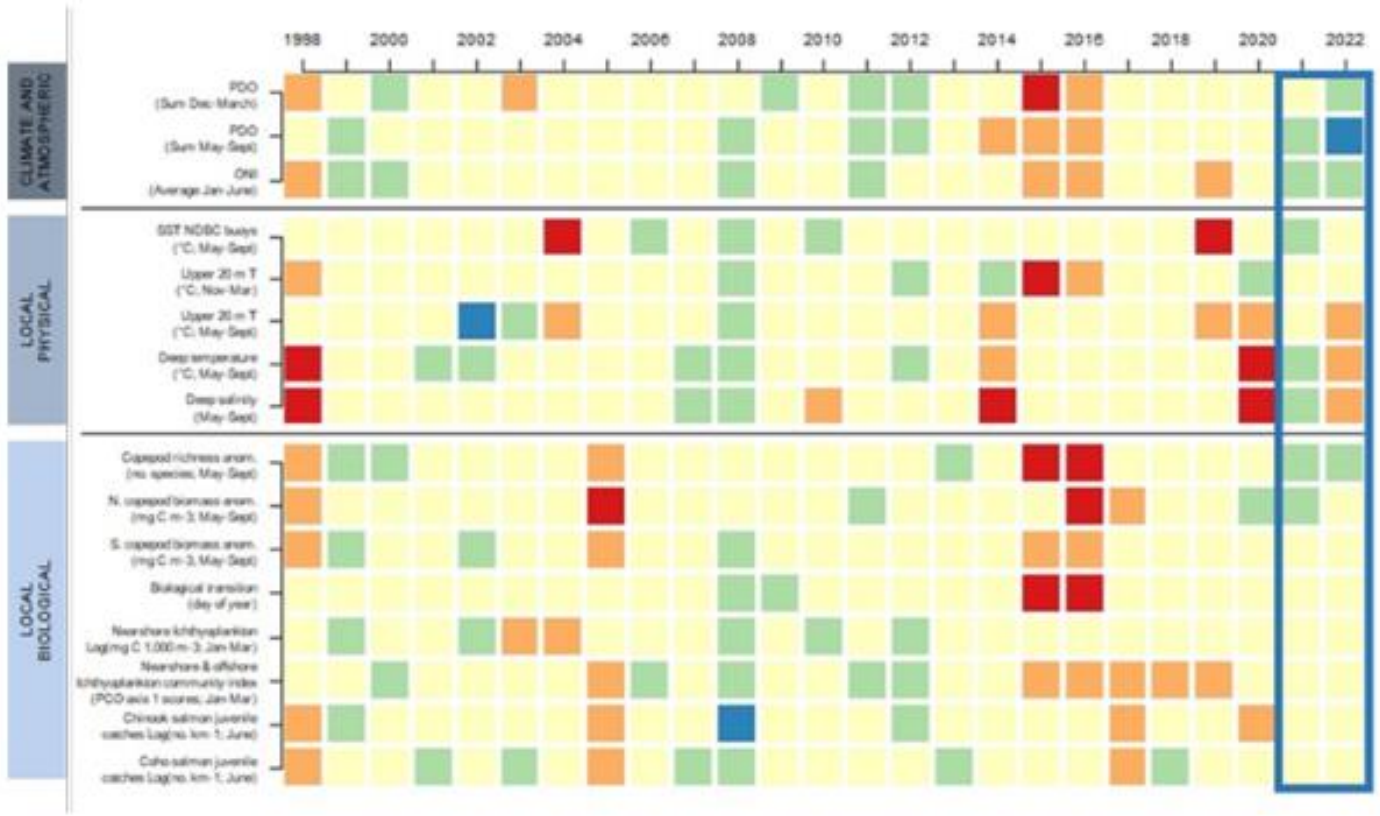
Habitat indicator development

- Indicators should be
  - Theoretically sound
  - Quantitative
  - Annually variable
  - Easily updated annually
  - (Leading indicators)
  - (Management related)

- Convey in a five-color stoplight-format

>2 SDs **below** mean
1-2 SDs **below** mean
Within 1 SD of mean
1-2 SDs **above** mean
> 2 SDs **above** mean
No data

Indicators of ocean ecology of Columbia R smolts



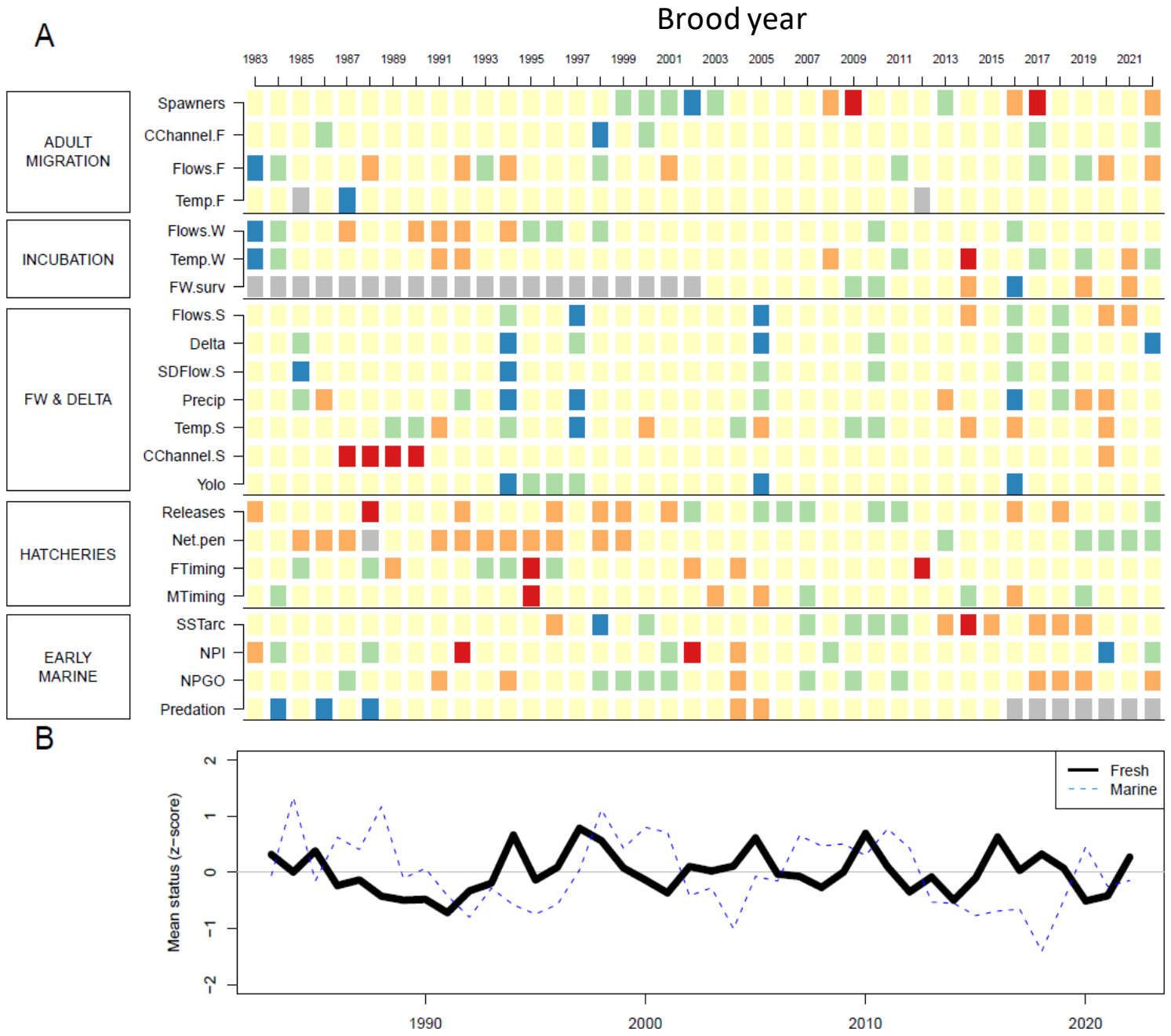
Habitat indicators for fall runs

- Multiple life stages
- Multiple indicators within life stages
- Often defined by specific seasonal time periods
- Hypothesized direction of effect of indicator on cohort productivity

Life stage-specific indicator for Fall Run	Abbreviation	Time period	Expected Effect	Stock
Spawners				
Fall run spawners	Spawners		+	B
Fall closures of Delta Cross Channel	CChannel.F	Se-Oc	+	SRFC
Fall low flows	Flows.U	Se-Oc	+	B
Fall temperatures in mainstem	Temp.U	Se-Oc	–	B
Incubation and emergence				
Fall-winter low flows in tributaries (7Q10)	Flows.I	Oc-De	+	B
Egg-fry temperatures (avg of max daily)	Temp.I	Oc-De	–	B
Egg-fry productivity	FW.surv		+	B
Freshwater/delta residence				
Winter-spring outmigration flows	Flows.O	De-My	+	B
Delta outflow index	Delta	Ap-Jl	+	SRFC
7-day flow variation (SD)	SDFlow.O	De-My	–	B
Maximum flushing flows	Max.flow	No-Mr	+	KRFC
Total annual precipitation	Precip	Annual	+	B
Spring temperatures	Temp.O	My-Jn	–	B
Spring closures of Delta Cross Channel	CChannel.S	Fe-Jl	+	SRFC
Days floodplain bypass was accessible	Floodpln	De-My	+	SRFC
Hatchery releases				
Release number	Releases		+	B
Prop net pen releases	Net.pen		+	B
Release timing relative to spring transition	FW.Timing	Ja-Au	+	B
Release timing relative to peak spring flow	Mar.Timing	Ja-Au	+	B
Marine residence				
Coastal sea surface temperature	SSTarc	Mr-My	–	B
North Pacific Index	NPI	Mr-My	+	B
North Pacific Gyre Oscillation	NPGO	Mr-My	+	B
Marine predation index	Predation		–	SRFC
Krill biomass	Krill	Mr-Au	+	KRFC

Sacramento River Fall-Run Chinook indicators

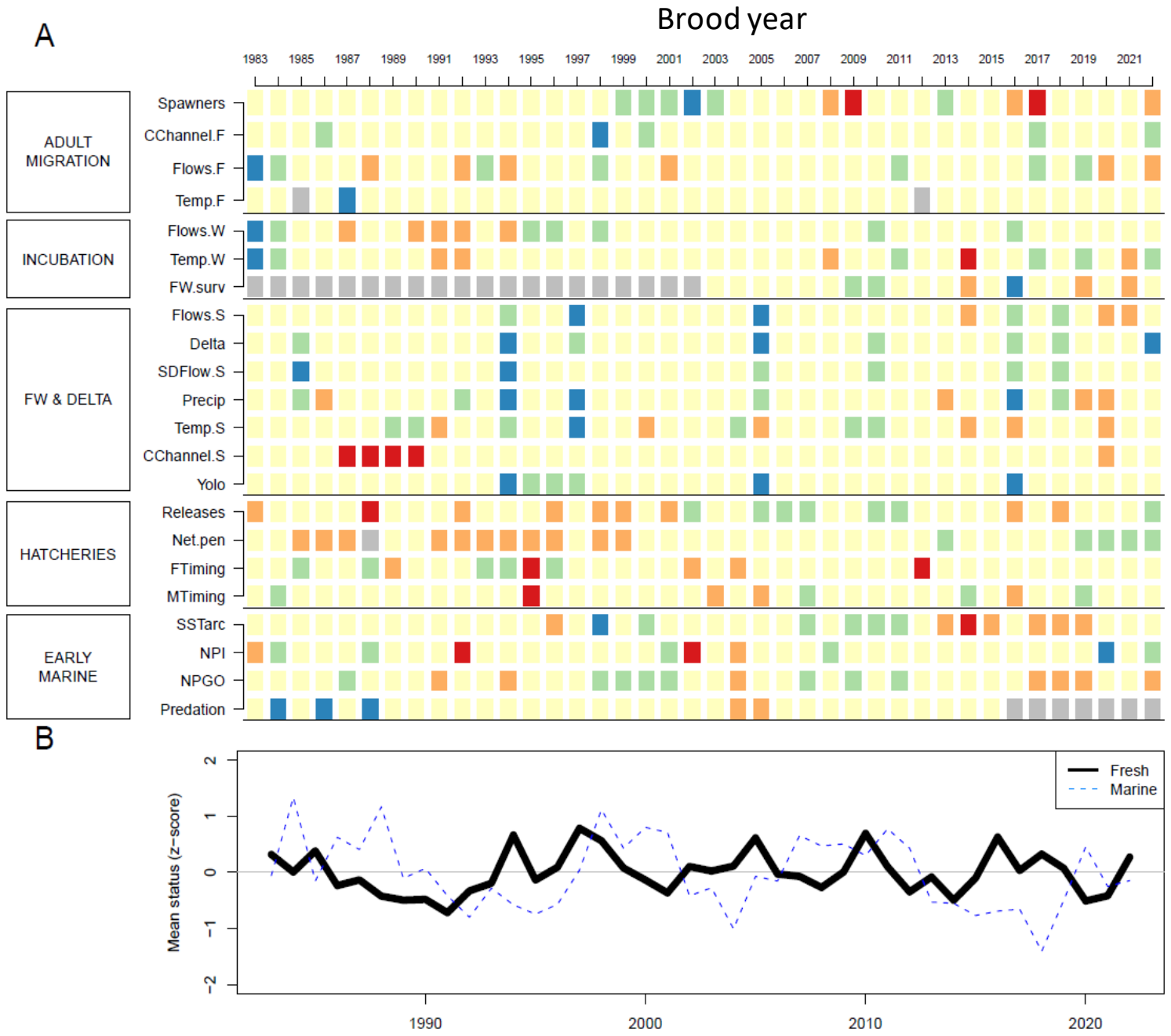
- Multiple life stages
- Multiple indicators within life stages
- Often defined by specific seasonal time periods
- Predicted direction of effect of the indicator on productivity
- Summarized by indicator and as freshwater and marine averages



Sacramento River Fall-Run Chinook indicators

Are indicators useful predictors?

- Associated with SRFC the way we expect
- Predictive of changes in productivity



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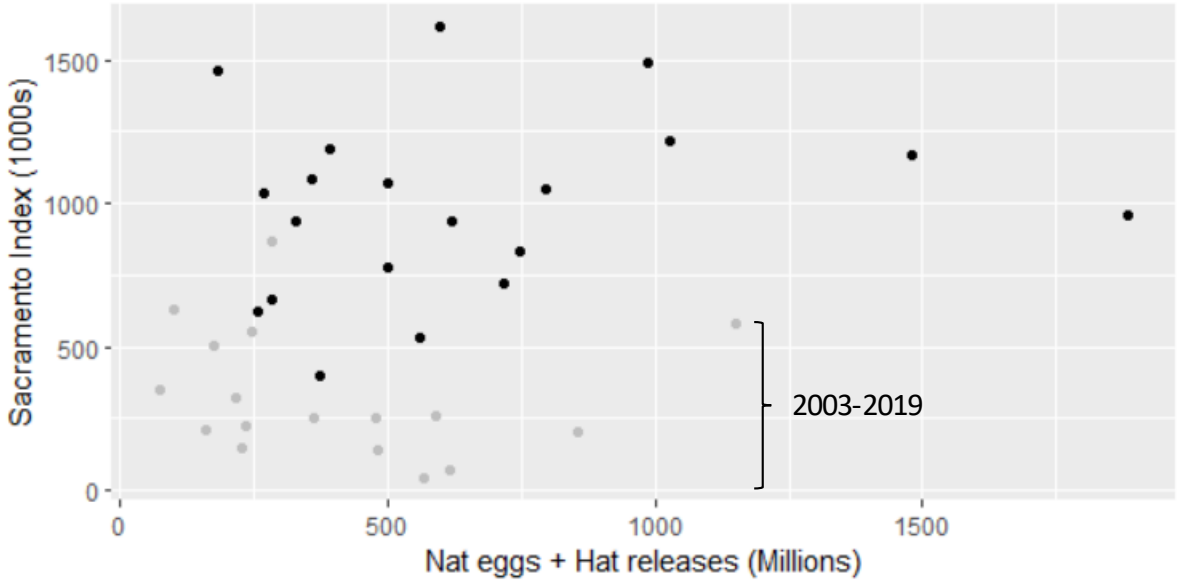
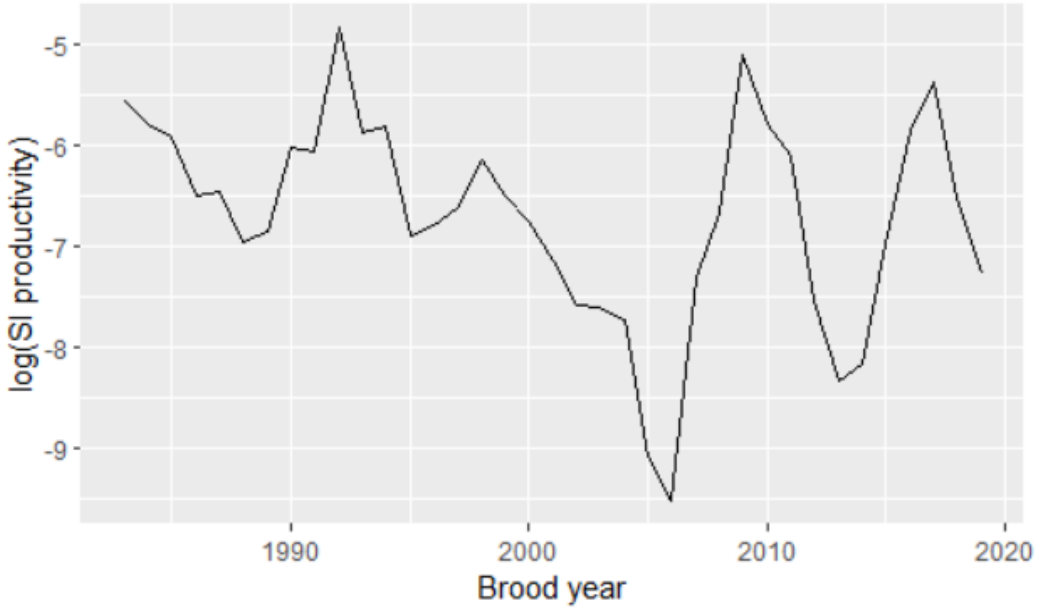
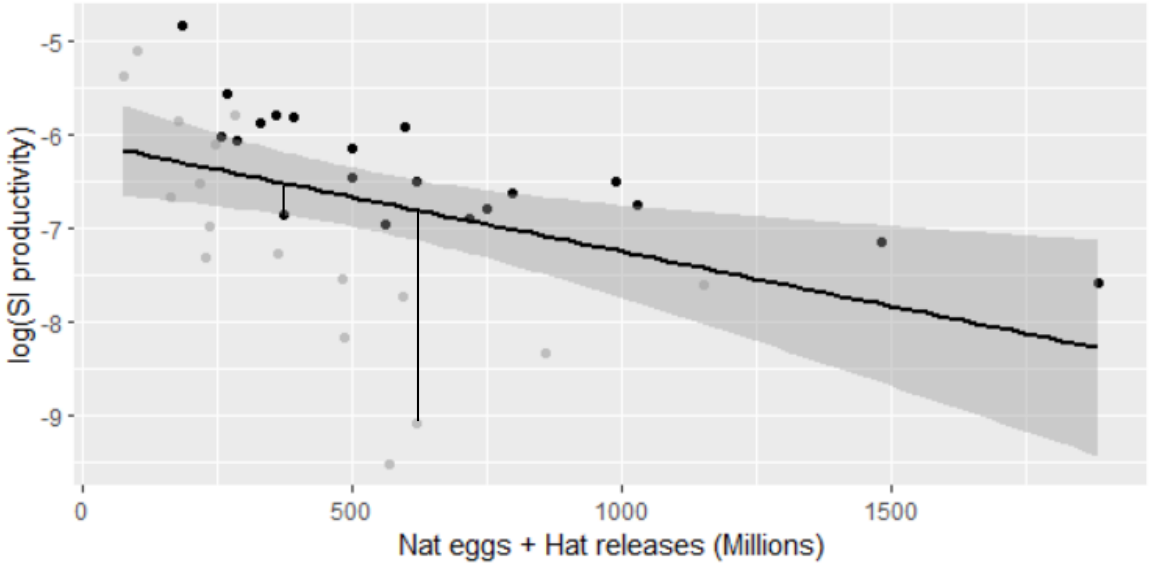
An index of SRFC productivity for testing indicators

- Compare Sacramento Index with estimate of natural egg production + hatchery releases, lagged 3 years
- (Multiple assumptions with this approach)
- Decline in SI after 2003, associated with lower productivity and greater temporal variability
- Use recruitment deviations to correlate with indicators

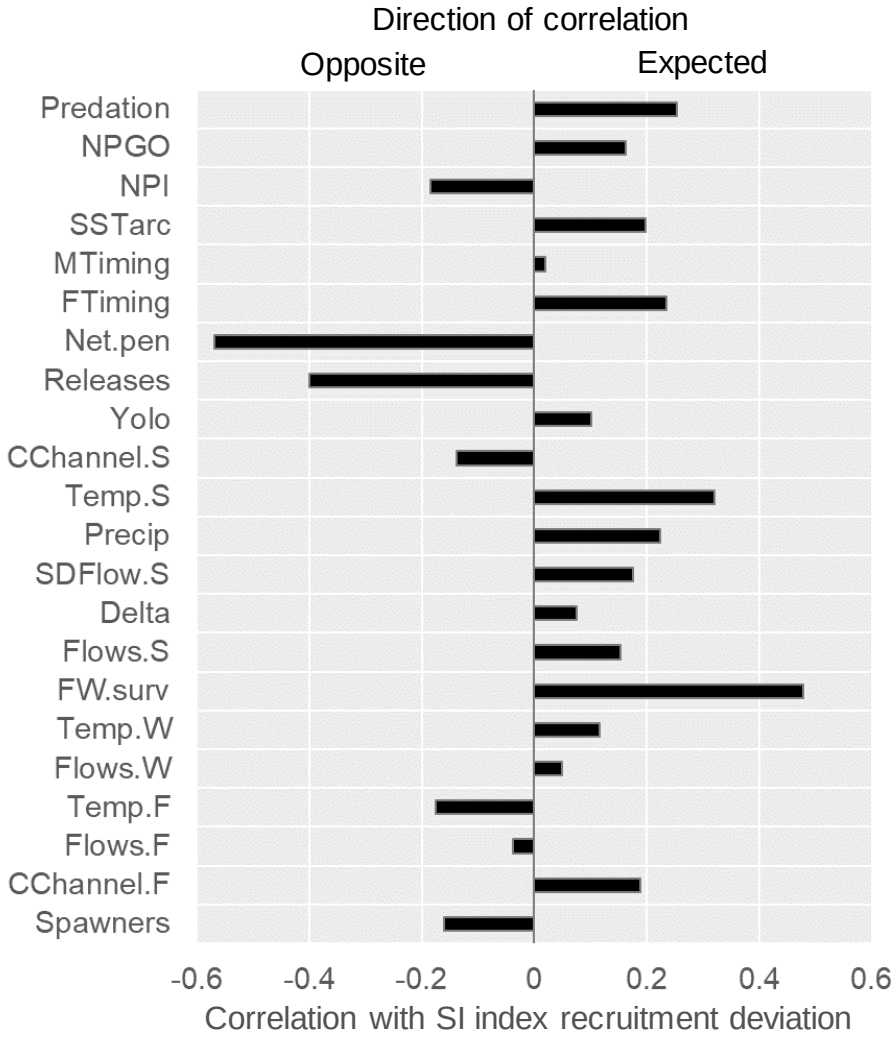


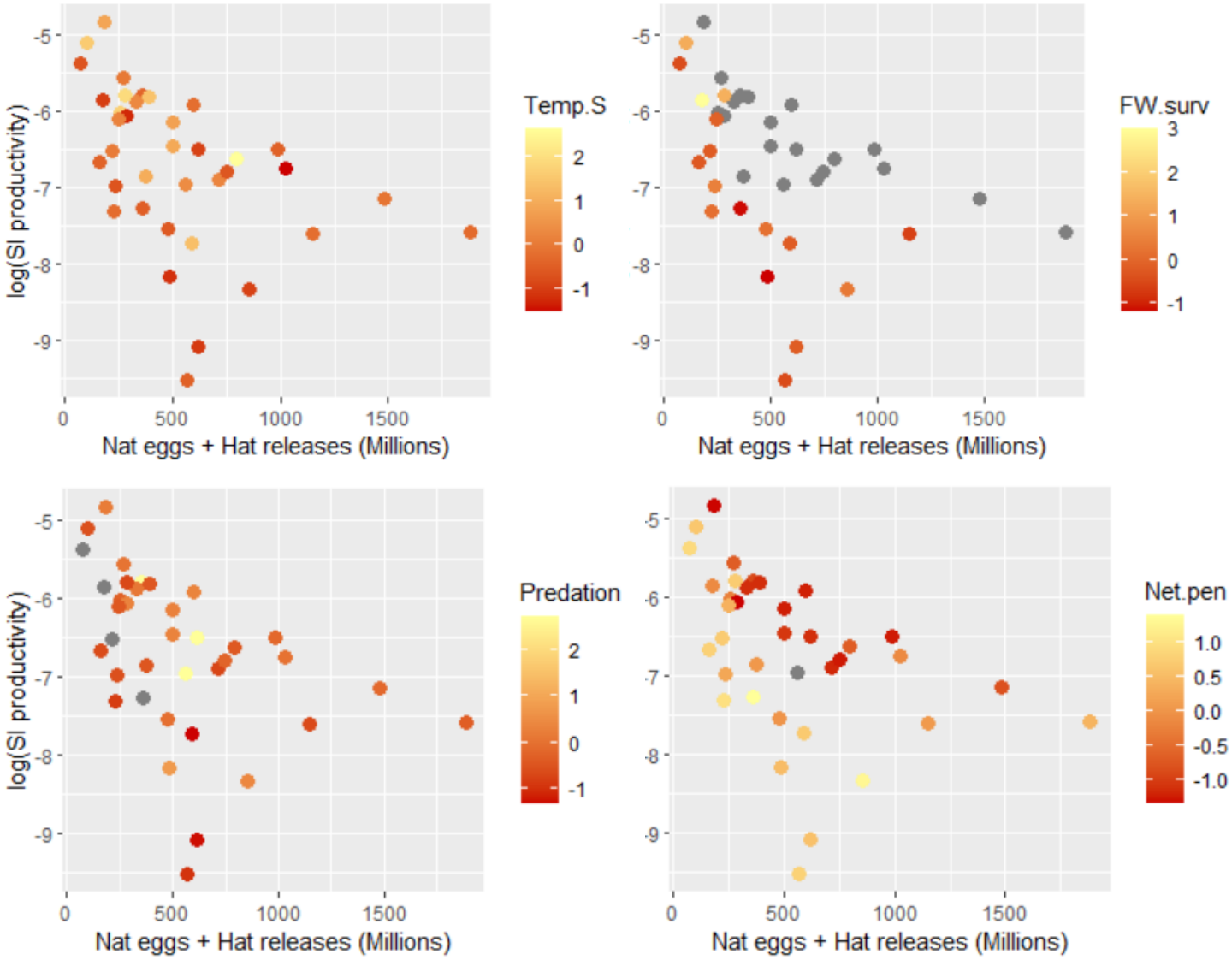




Correlations between indicators and recruitment deviations

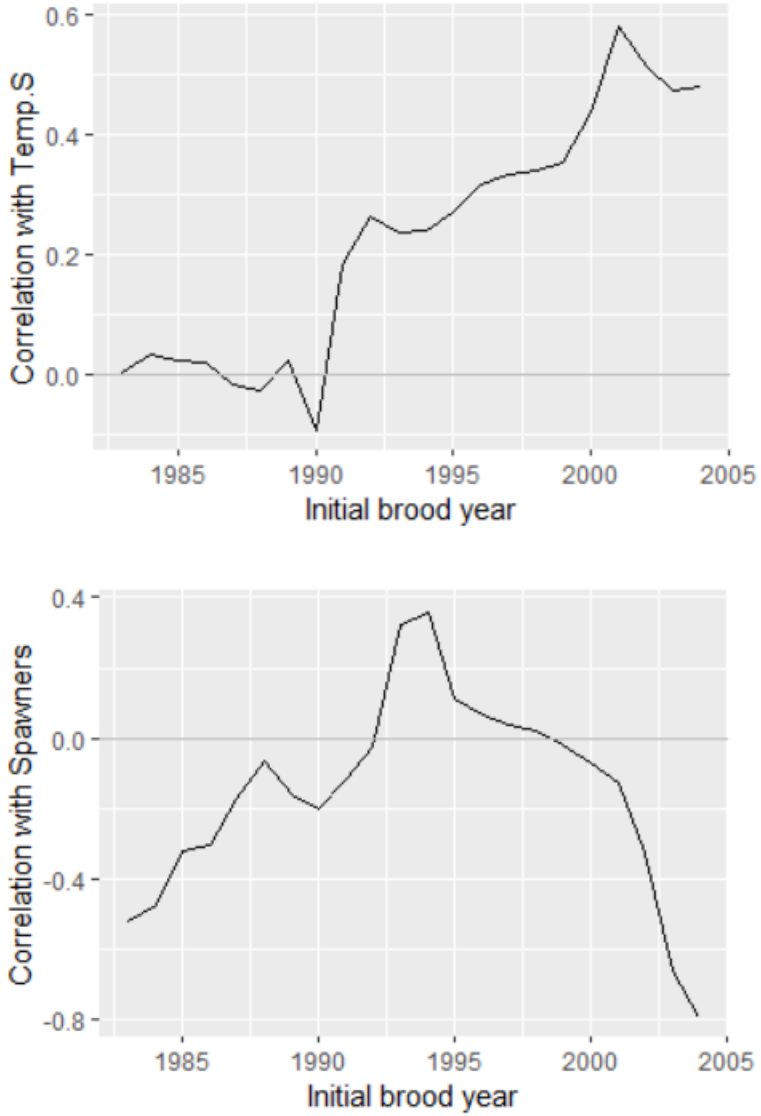
- Most correlations in expected direction
- Net.pen - best indicator of recruitment deviation
- FW.surv – explains variation in later years

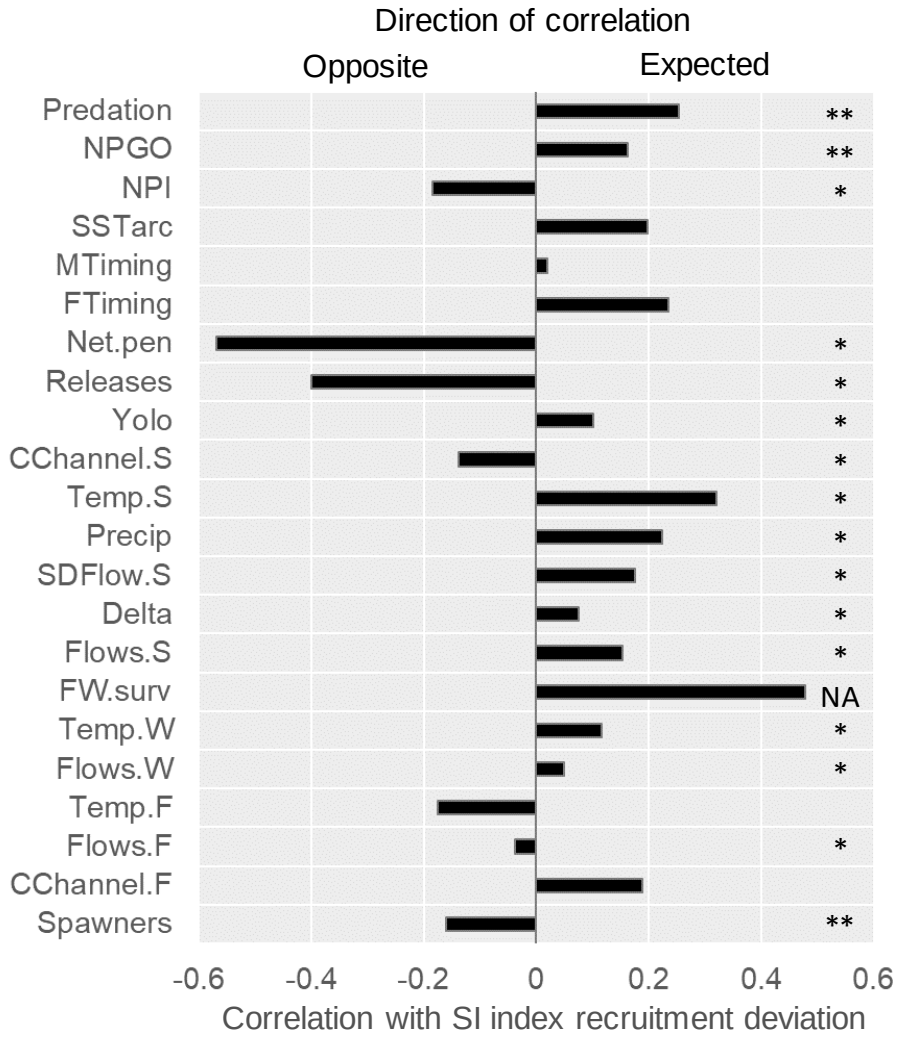




Evidence for nonstationarity

- Nonstationarity: Change in the correlation between two variables over time
- Compared 15-year running correlations between each indicator and SI productivity index recruitment deviations
- Strong evidence for nonstationarity in many indicators
- Change in strength and sign of some correlations warrants continued tracking of indicator suite





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Qualitative indicator-based assessment

Content for these two columns to be provided during stock assessment development and review.

	Environmental/ecosystem considerations	**Assessment model-related uncertainty considerations**	**Population dynamics considerations**
Level 1: Above or better than normal	Some indicators show the system supporting greater abundance or increased habitat area.	Below-average uncertainty/very few unresolved issues in assessment, no or few data conflicts.	Stock trends are above normal for the stock; recent recruitment is above normal range.
Level 2: Normal	No apparent environmental/ecosystem concerns.	Typical to moderately increased uncertainty/minor unresolved issues or data conflicts in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.
Level 3: Substantially increased concerns	Some indicators show adverse signals but the pattern is not consistent across all indicators.	Substantially increased assessment uncertainty/ unresolved issues, or data conflicts.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.
Level 4: Major Concern	Most indicators showing consistent adverse signals a) across the same trophic level, and/or b) up or down trophic levels (i.e., predators and prey of stock).	Major problems with the stock assessment, poor fits to data, major data conflicts, high level of uncertainty, strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.

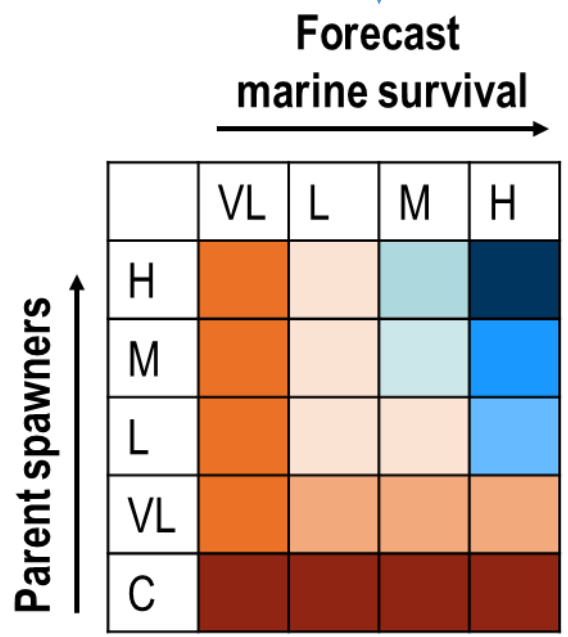
EWG, 2023 (September BB)

Quantitative indicator-based reference points

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) Allowable Total Fishery Impact Rate		
		Low (<0.0009)	**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%

Multiple marine ecosystem indicators



Conclusions

- Strong evidence for environmentally driven changes in productivity
- Good evidence for environmental variation in potential conservation objectives
- Opportunity for indicator approaches to inform assessments qualitatively if not quantitatively
- Lots of potential to develop analyses (and data inputs) further, should more refinement be desired