An integrated population model for estimating the relative effects of natural and anthropogenic factors on a threatened population of steelhead

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Casey Ruff & Eric Beamer (Skagit River System Cooperative)

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RECOVERY OPTIONS FOR STEELHEAD?

Life-cycle models are used extensively to predict effects of recovery actions

Common approach

Pre-process raw data based upon chosen model

~~Common~~ Approach

~~Pre-process raw data based upon chosen model~~

Choose model based upon raw data

Maunder & Punt (2013) *Fish Res*

INTEGRATED POPULATION MODEL

A hierarchical framework

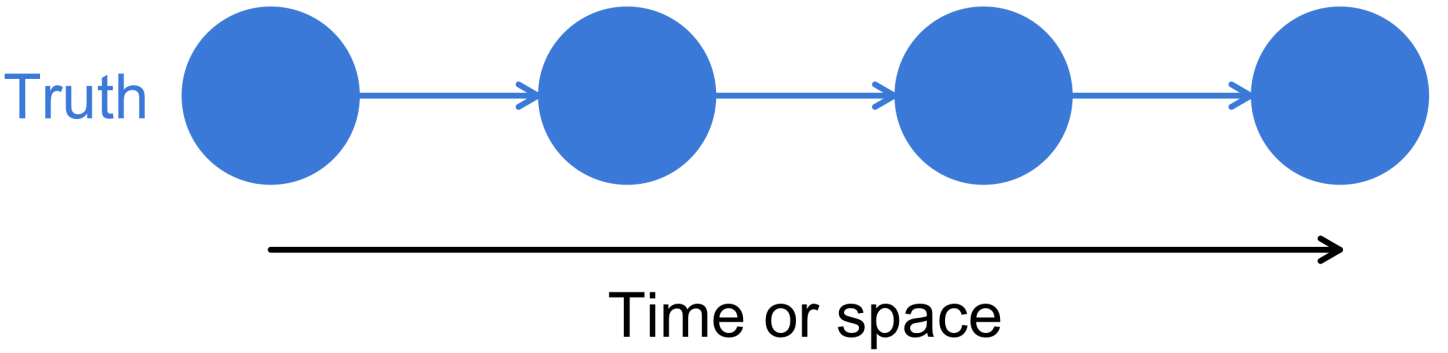
that allows for the joint modeling

of different data types

IPMs have 2 general parts

Part 1: State model

Describes the true state of nature over time or space



States of nature might be

Animal location

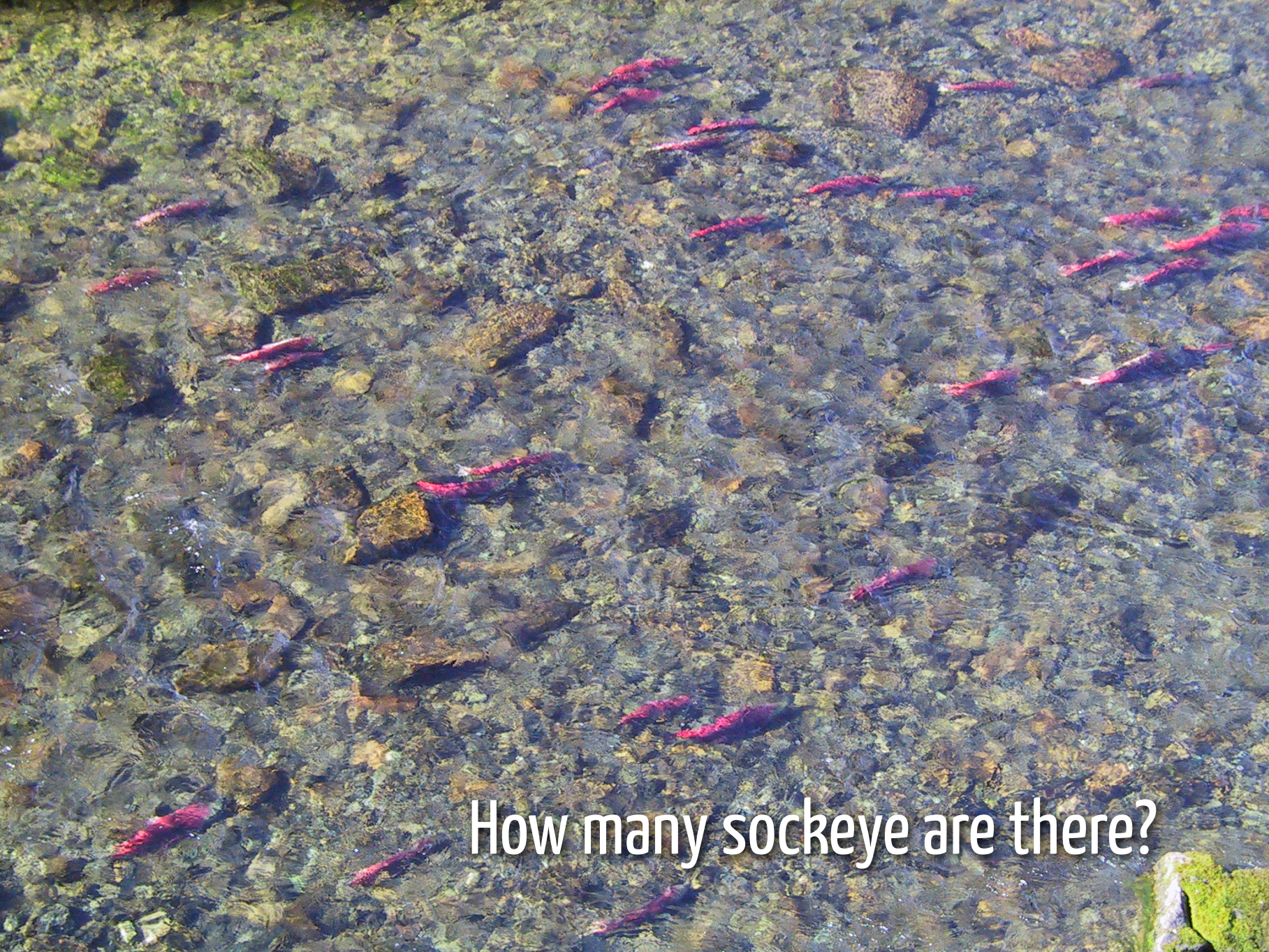
Species density

Age structure

Reproductive status


Revealing the true state requires observations

Observing nature can be easy


How many sockeye are there?

Observing nature can also be hard


How many mayflies are there?

Part 2: Observation model

Data = Truth ± Errors

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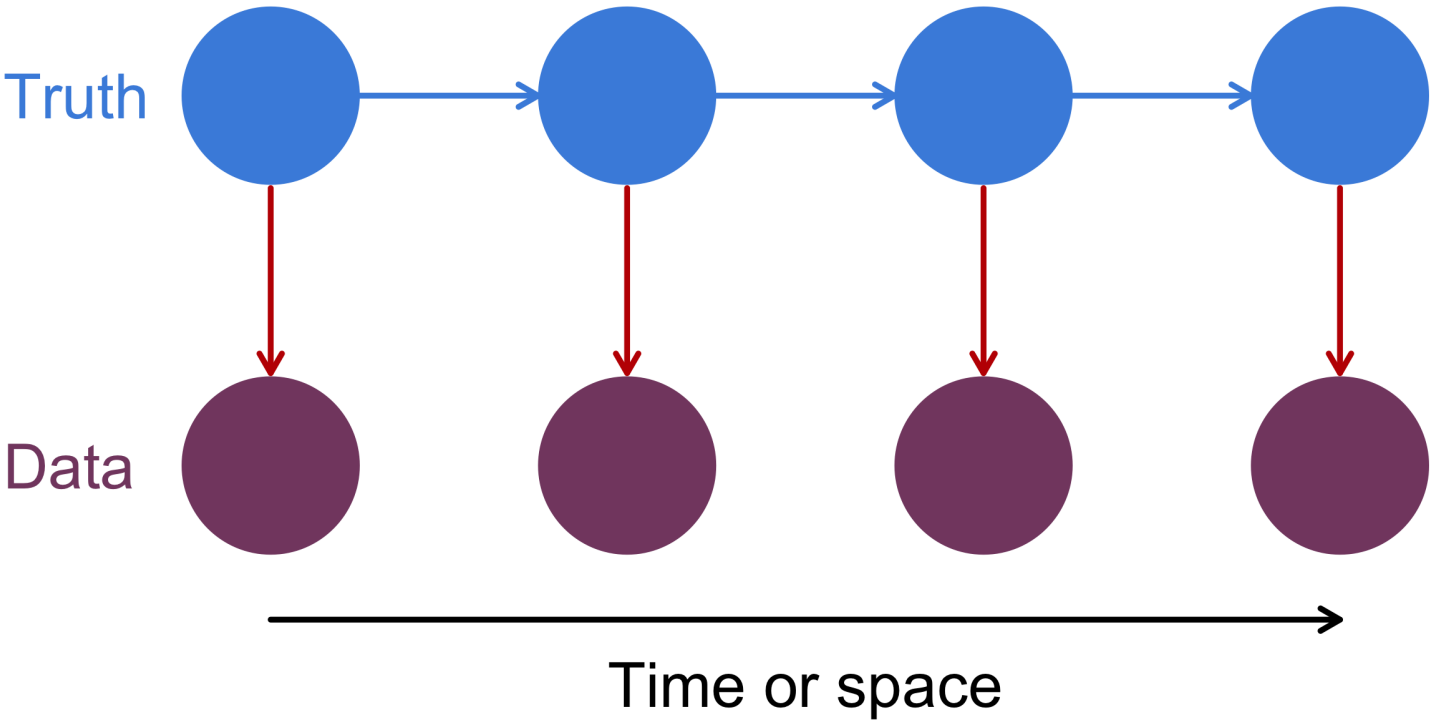
Data = Truth ± Errors



OK, but why bother?

Advantages

1. Can combine many different data types

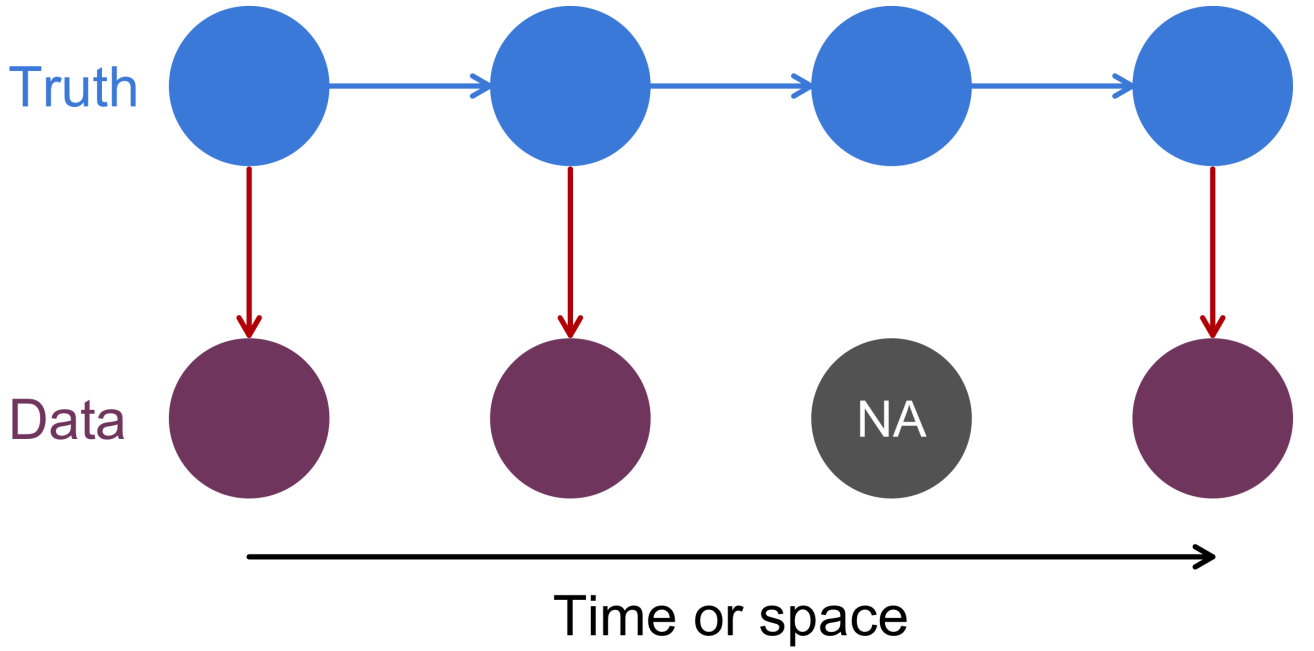
Changes in observers or sensors

Varying survey locations & effort

Direct & remote sampling

Advantages

2. Missing data are easily accommodated



Advantages

3. Improved accuracy & precision

Article | OPEN | Published: 08 February 2016

Joint estimation over multiple individuals improves behavioural state inference from animal movement data

Ian Jonsen

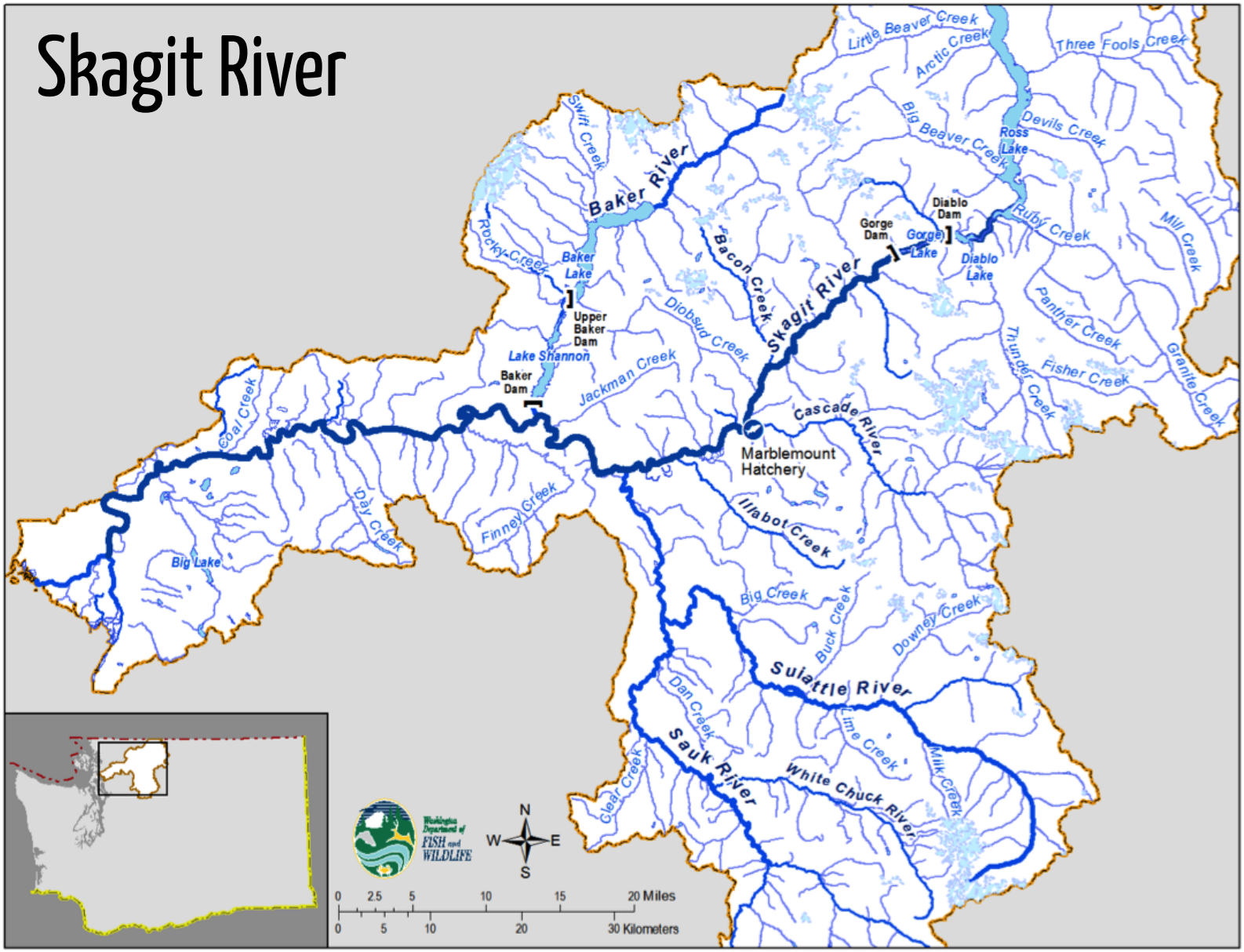
Scientific Reports **6**, Article number: 20625 (2016) | Download Citation

Advantages

4. Data-poor benefit from data-rich


SNAKE
OIL

Skagit River



Characterize uncertainty between

1) spawners and recruits

2) productivity and environmental conditions

Skagit River steelhead data

Escapement, harvest & age composition

Skagit River steelhead data

Escapement, harvest & age composition

Environmental data

Hatchery releases, flows, ocean conditions

Skagit River steelhead data

Escapement, harvest & age composition

Environmental data

Hatchery releases, flows, ocean conditions

1978-2018

Integrated population model

State model

Recruits = f(Spawners, Hatchery fish, Flows, Ocean)

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State model

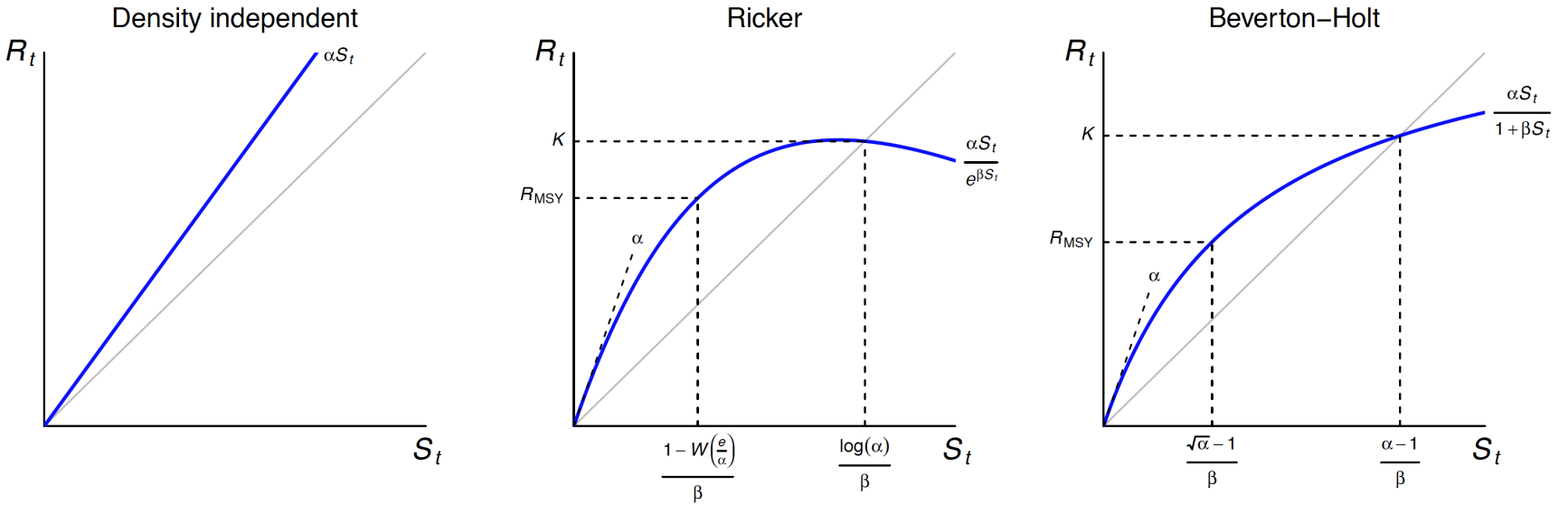
Recruits = f(Spawners, Hatchery fish, Flows, Ocean)

Observation models

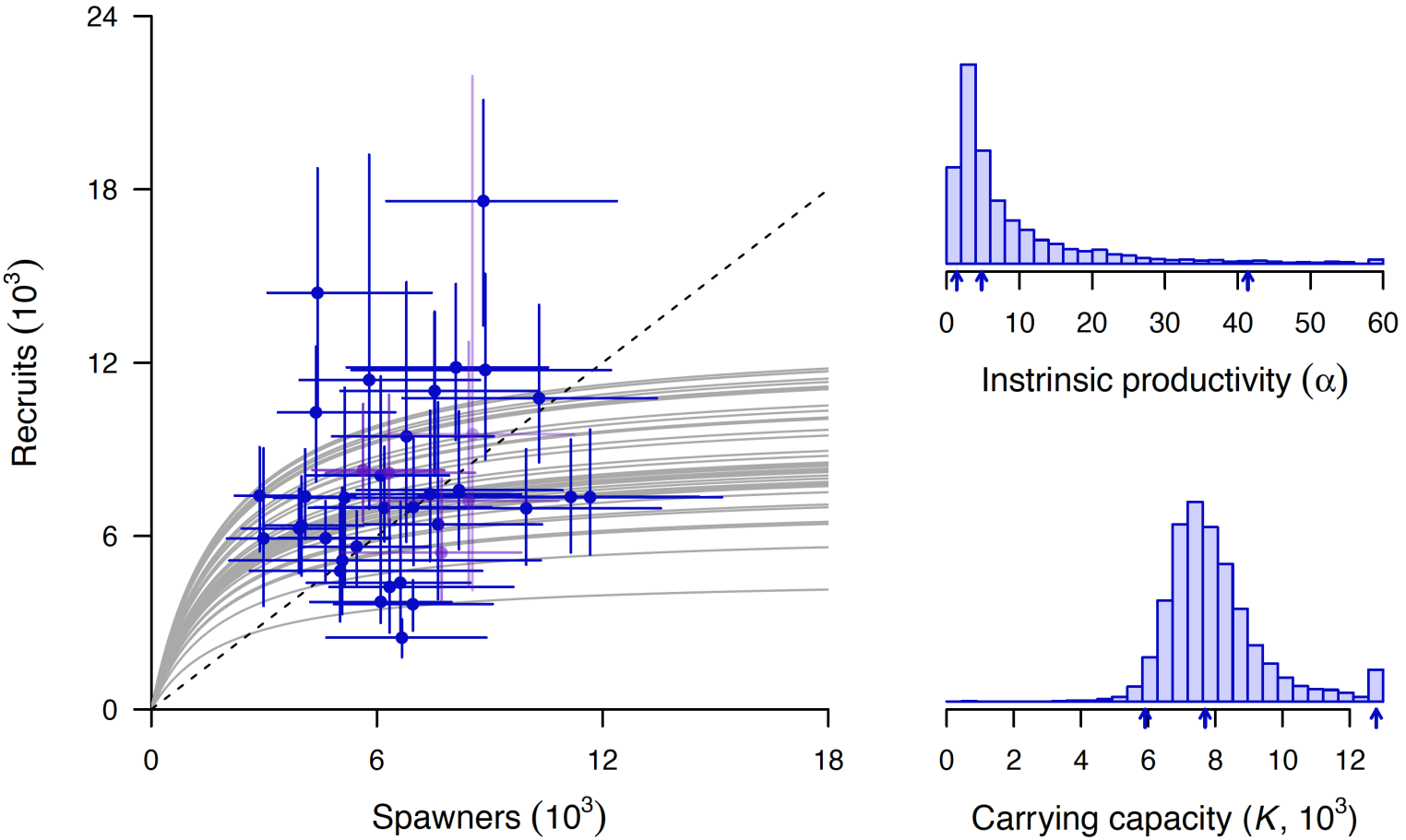
Spawners = g(Spawners, Harvest)

Ages = h(Recruits)

Possible spawner-recruit relationships

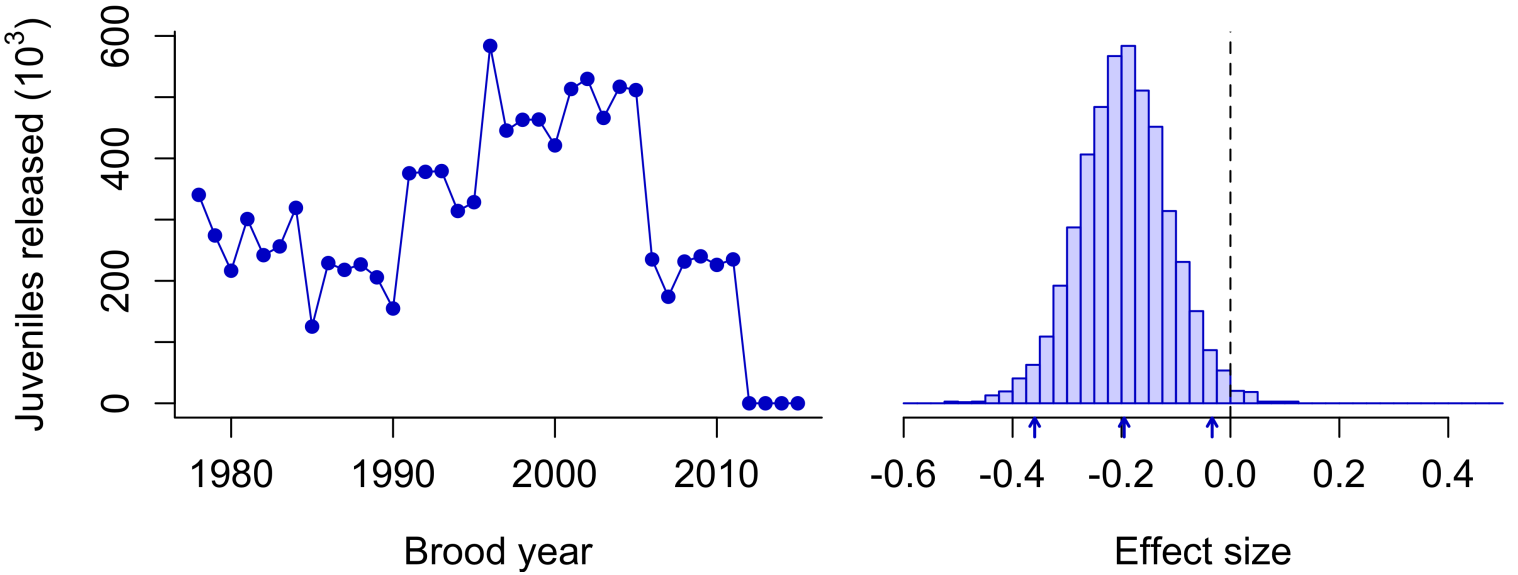


Real parent-offspring relationship



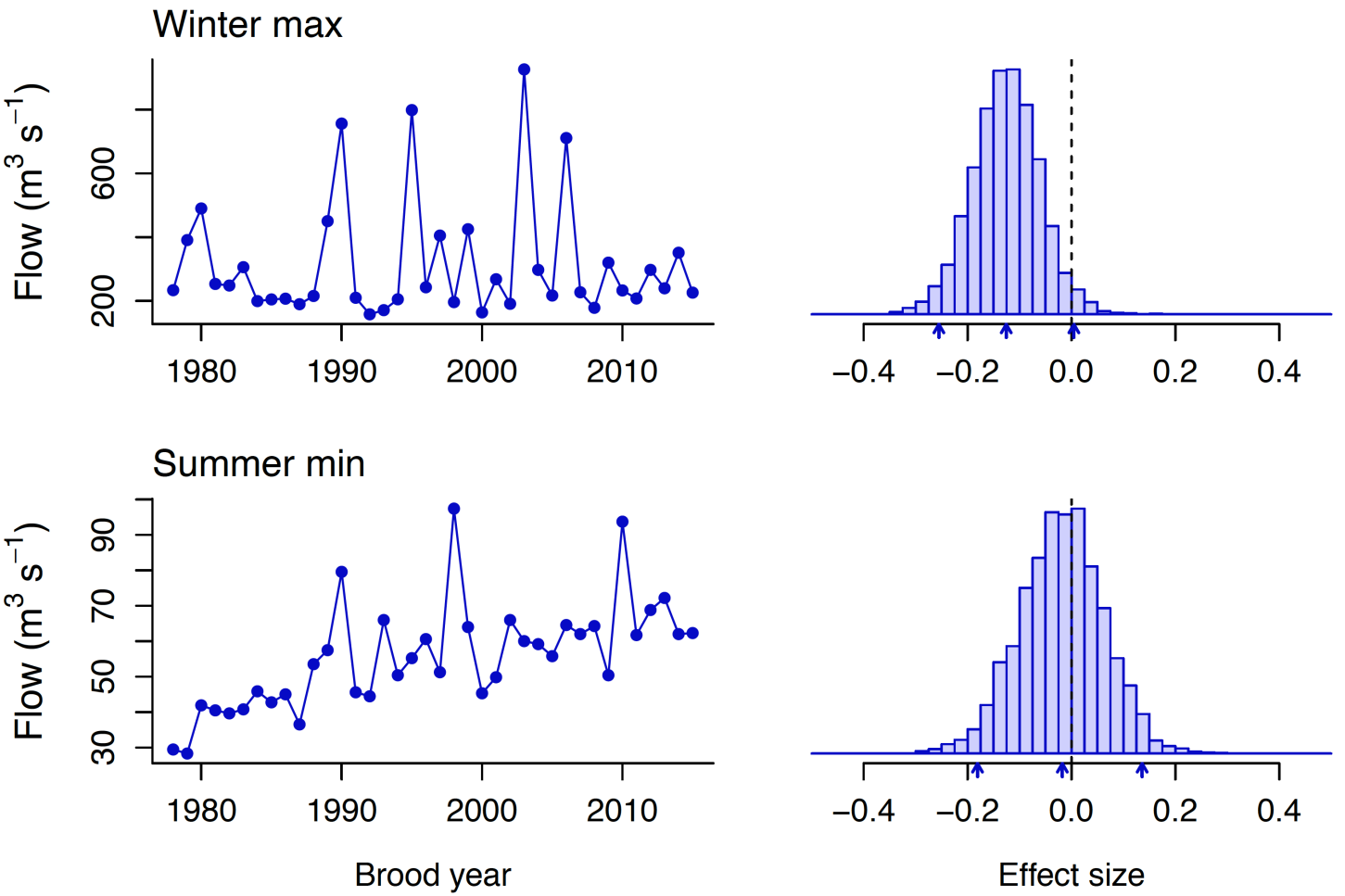
Scheuerell et al. (2021)

Hatchery effect on productivity



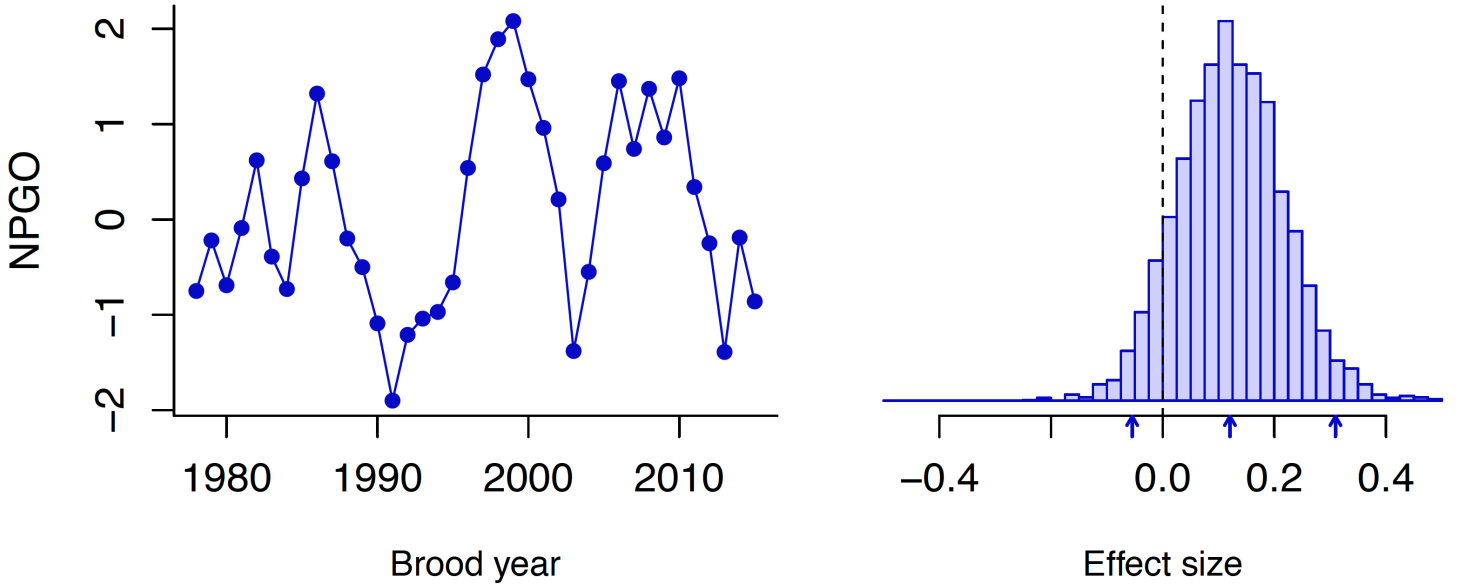
Scheuerell et al. (2021)

Flow effects on productivity



Scheuerell et al. (2021)

NPGO effect on productivity



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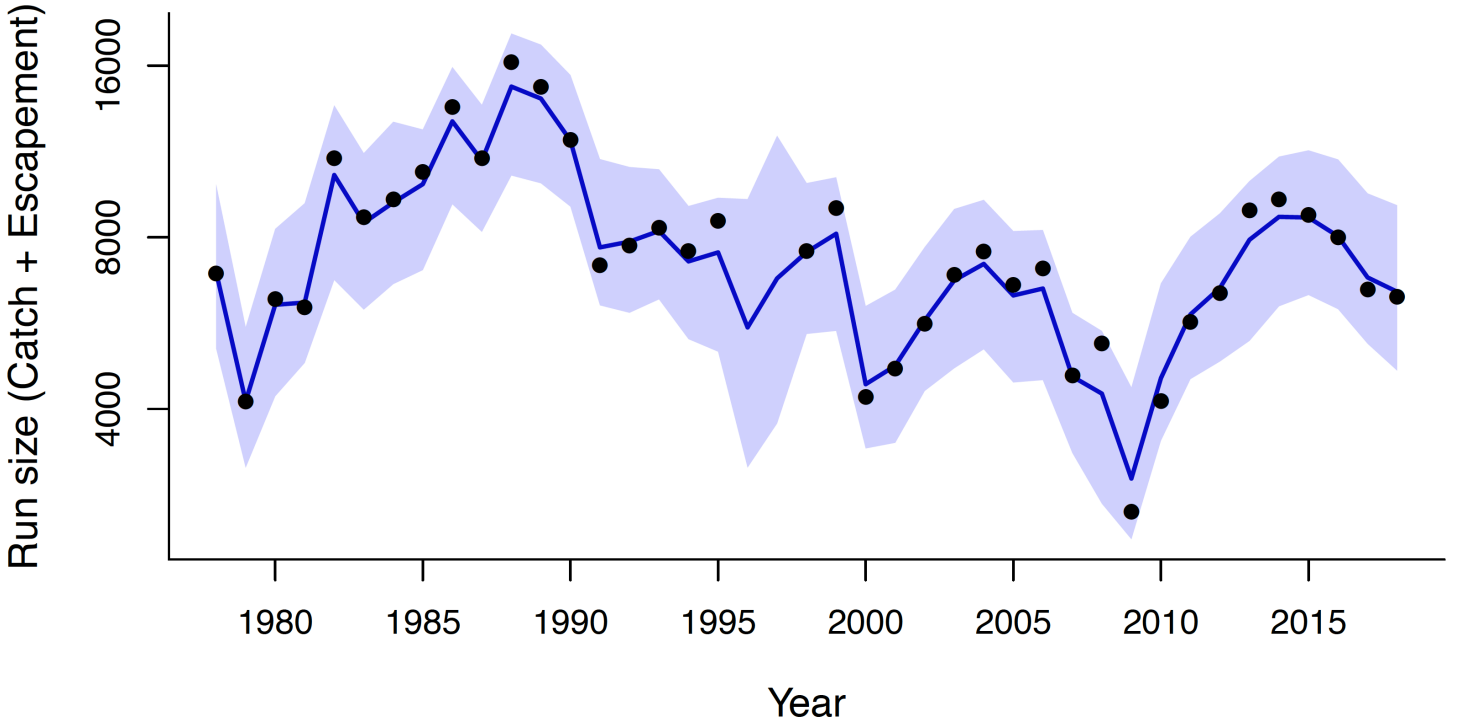
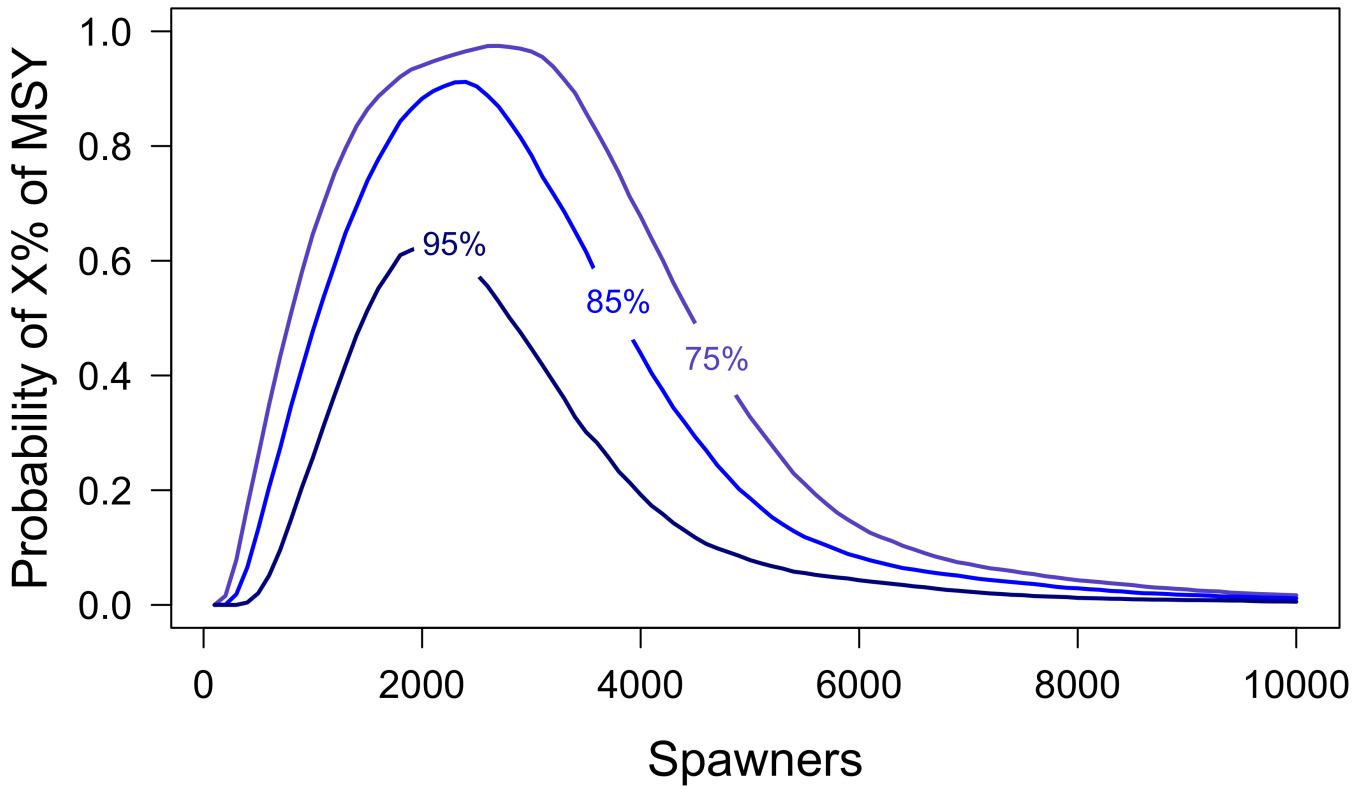
Catch + escapement over time



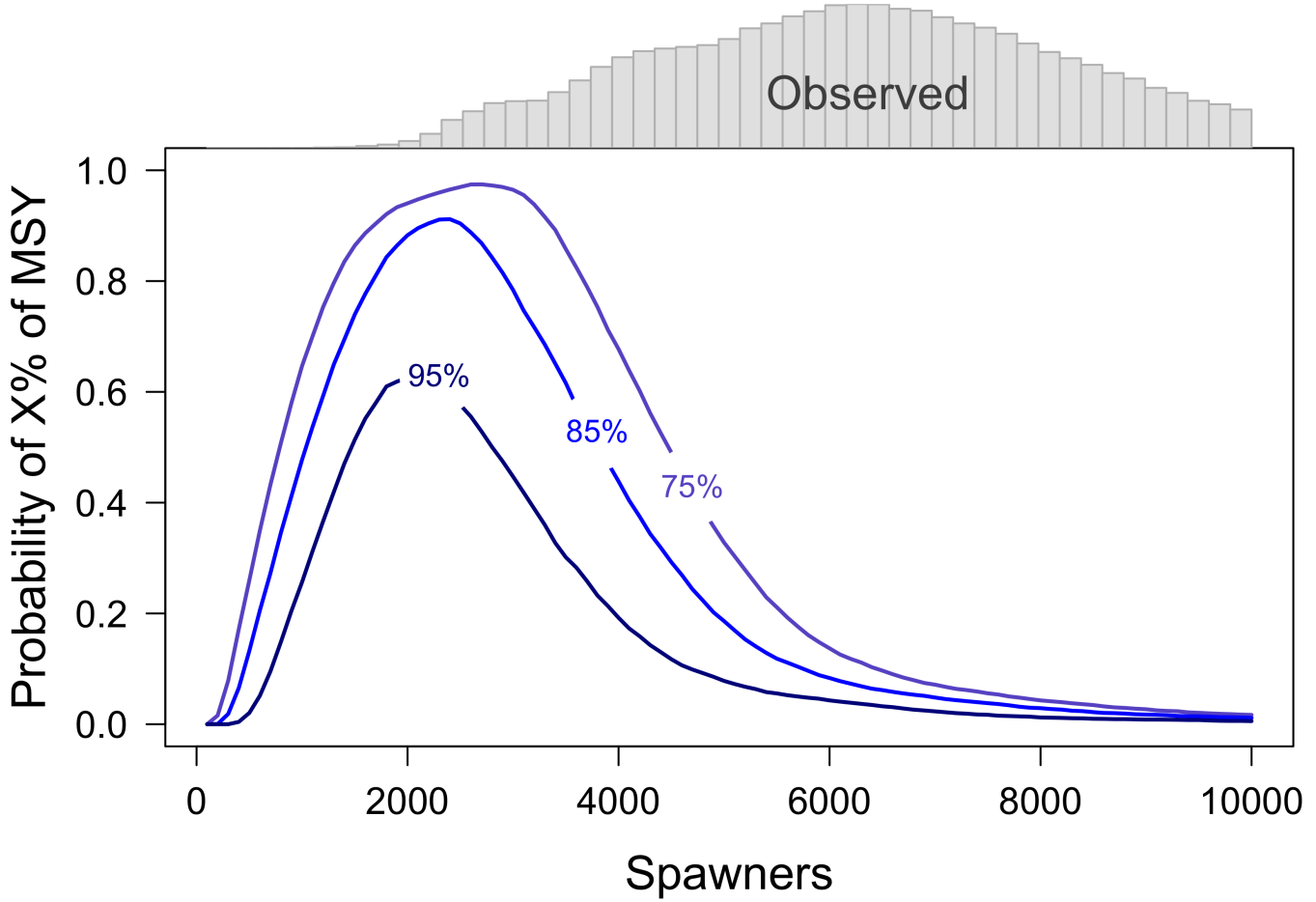
Scheuerell et al. (2021)

Optimal escapement for targeting MSY



Scheuerell et al. (2021)

Co-management is conservation minded



Scheuerell et al. (2021)

In summary

Evidence for density-dependent survival, combined with loss of juvenile rearing habitat, suggests habitat restoration could be beneficial

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Winter maximum flows appear more important than summer minimum flows

Ocean conditions are indeed important

Trade-offs exist between providing harvest opportunities via hatchery production & achieving wild steelhead recovery goals

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RESEARCH ARTICLE

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Open science

https://github.com/mdscheuerell/steelhead_IPM

Slide deck

https://github.com/mdscheuerell/pcsmm

Image sources

M Caulkin: *20th Century Fox*
Carnival: *Frank Kovalchek (2010)*
Robin Hood: *John Escott*
Snake oil: *The Register*