An evidence-based approach to developing environmental flow needs for Great Lakes tributaries in New York

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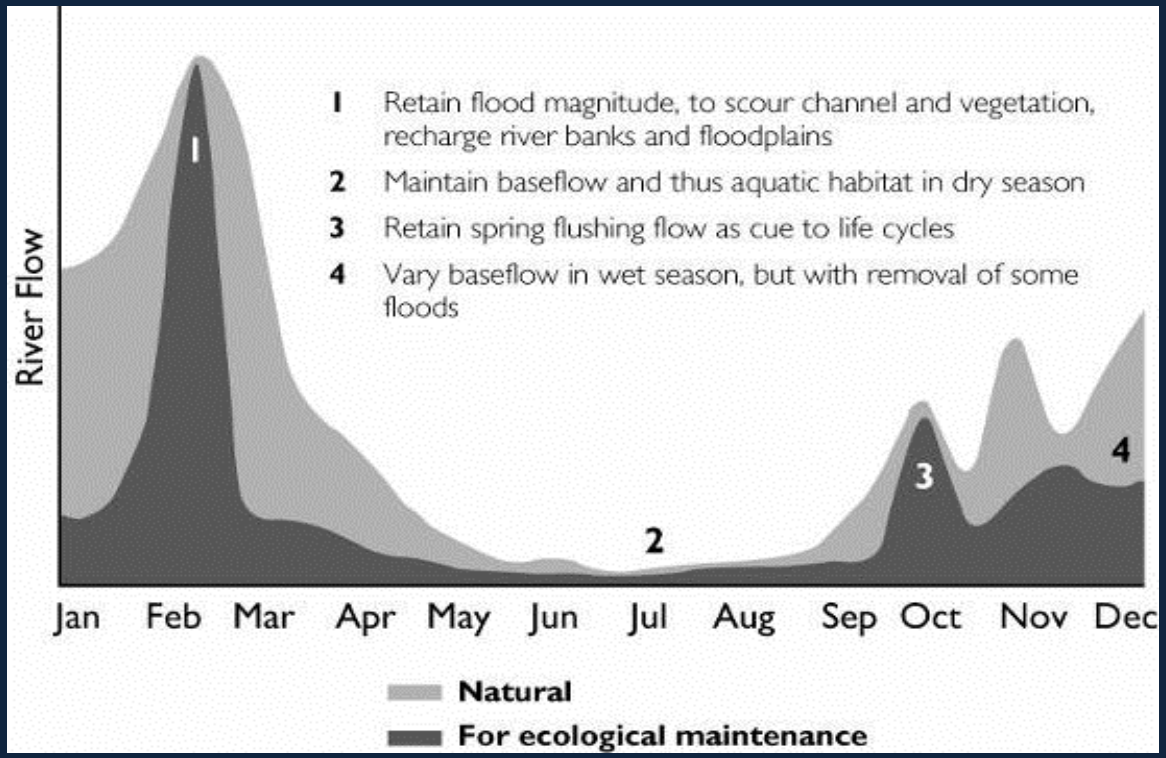
- **Need:**
  - Meet obligations of the GREAT LAKES COMPACT
  - Inform development of NYSDEC FLOW POLICY

- **Objective**: develop science-based flow recommendations based on existing information that are useful to water managers.

Environmental Flows

The flow of water in a natural river or lake that sustains healthy ecosystems **AND** the goods and services that humans derive from them.



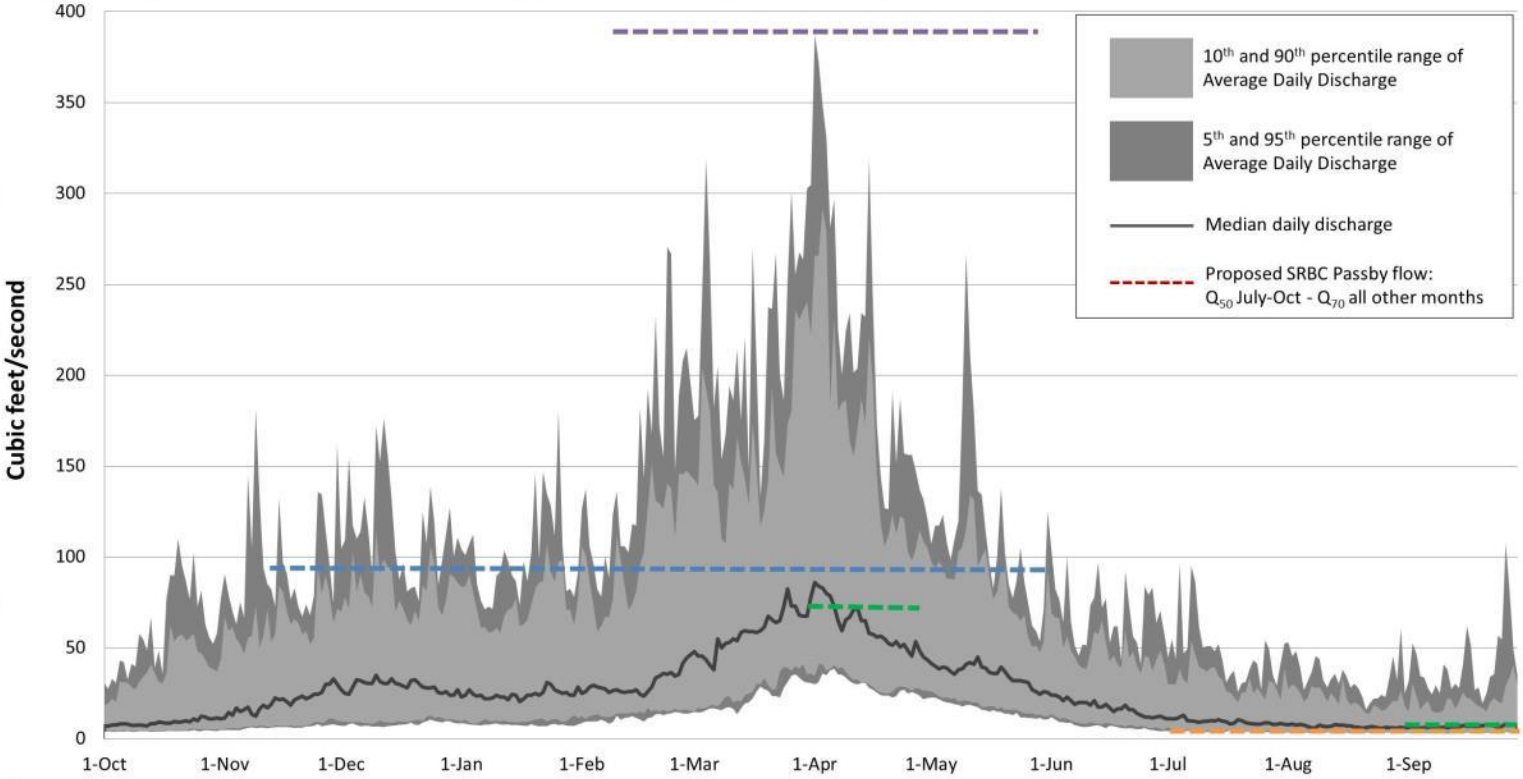
Headwater/Creek, cool, low to moderate gradient: (36 sq. mi.)

Flood (2 yr rec) ----
525 – 1020 cfs

High flow (≥ Q10) --
Discharge > 86 cfs
9 events/year
2 days/event

Seasonality (monthly median) ----
April: 61 cfs
Sept: 6.4 cfs

Low Flow (≤ Q90) --
Discharge < 5.4 cfs
5 events/year
4 days/event



SRBC proposed monthly passby flow	8.8	11	19	17	20	41	44	27	12	9.5	6.8	6.6

Cold headwater fish	Trout	Spawning; Egg and Larval Development; Juvenile Growth; Adult Growth
	Sculpin	Juvenile Survival; Spawning
Riffle obligate fish	Longnose dace	Spawning; Larval Development
	Fantail darter	Juvenile Growth; Spawning; Larval Development; Juvenile Growth
Riffle associate fish	White sucker	Spawning; Egg hatch/Larval Drift; Juvenile/Adult Growth
	Brook Lamprey	Spawning
Nest builders fish	Creek chub	Nesting; Juvenile Growth
	Rock Bass	Nesting; Juvenile Growth
Anadromous sport fish	Fall run	Adults in-migrate and spawn; Egg Incubation/Overwintering Juveniles; Smolt out-migrate; Fry Emergence; Juvenile Growth
	Spring run	Adults in-migrate (Sept.-Dec.); Peak spawining (Mar.-Apr.); Smolts out-migrate; Fry Emergence; Juvenile Growth
Riverine mussels		Brooding; Glochidia release; Spawning
Facultative riverine mussels		Spawning; Brooding; Glochidia release; Brooding
Lentic mussels		Brooding; Glochidia release; Spawning; Brooding

FLOW-ECOLOGY HYPOTHESES describe *who* (species or guild) is affected by *what* (flow component), *when* (month or season), *where* (habitat), and *how* (hypothesized ecological response).

During the spring and early summer, a decrease in median flow will limit recruitment of riffle associate fishes by decreasing the amount of riffle habitat and spawning area available.

Forty (40) FLOW-ECOLOGY HYPOTHESES describe *who* (species or guild) is affected by *what* (flow component), *when* (month or season), *where* (habitat), and *how* (hypothesized ecological response).

EXAMPLE FISH HYPOTHESES

H1 ● During the **spring**, a decrease in the magnitude and/or duration of the peak flow event will extend the timing of riffle associate and anadromous sportfish (rainbow) **spawning runs**, reduce access to **spawning habitats**, and expose migrating fish to increased predation.

H2 ● During the **spring** (March-mid-May, riffle associates and spring spawning salmonids require high flows at the correct temperature to **cue spawning migrations**. A change in timing of the peak flow event will disrupt spawning cues, restrict access to suitable **spawning habitat**, and lower recruitment.

H2 ● During the **spring and early summer**, a decrease in median flow will decrease the amount of riffle habitat and **spawning area** available and limit recruitment of riffle associate fishes.

Forty (40) FLOW-ECOLOGY HYPOTHESES describe *who* (species or guild) is affected by *what* (flow component), *when* (month or season), *where* (habitat), and *how* (hypothesized ecological response).

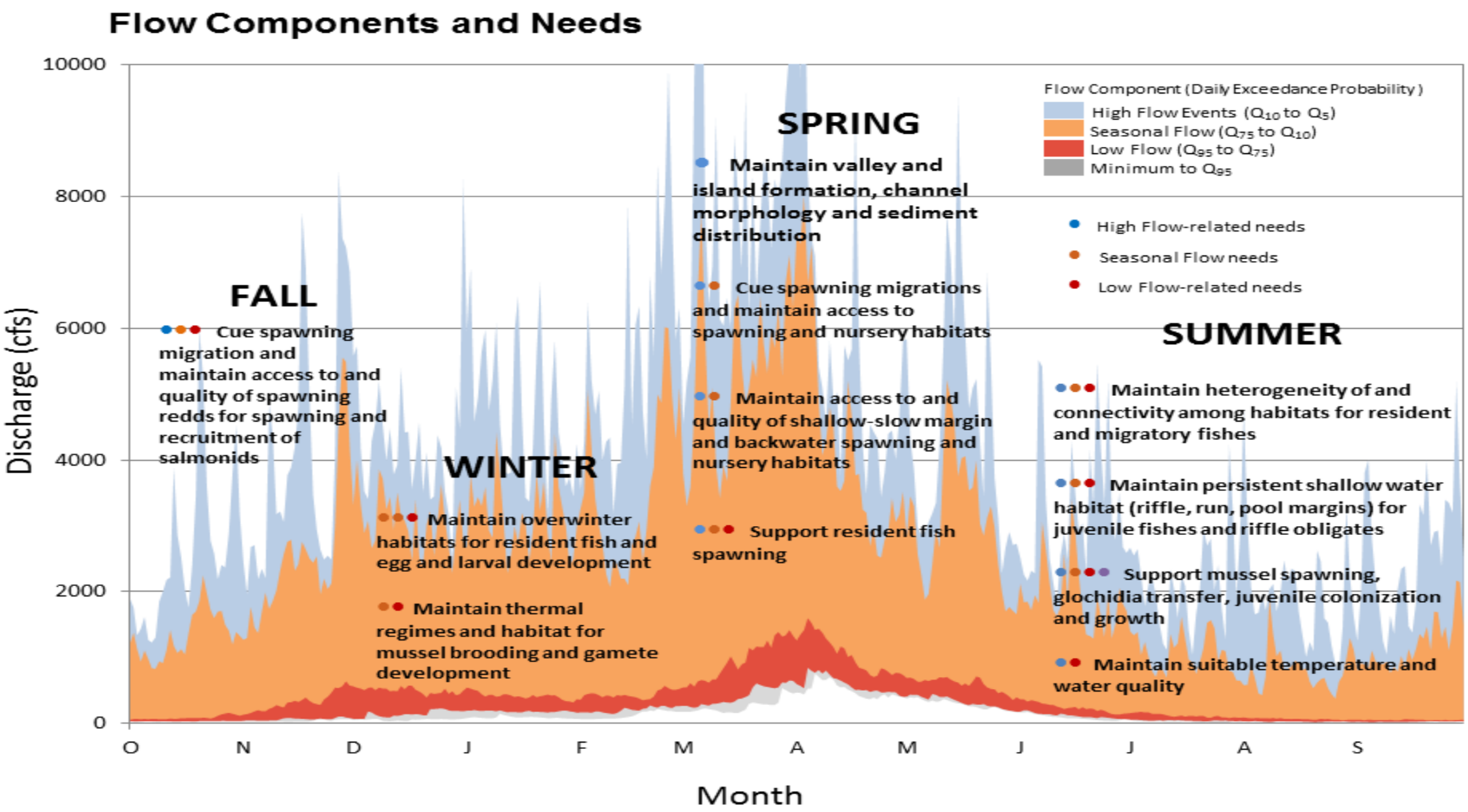
Hypotheses are consolidated into FLOW NEEDS (11)

EXAMPLE FLOW NEED FOR FISH

Cue spawning migration and maintain access to suitable spawning and nursery habitats

Support for Flow Needs is assessed through Weight-of-Evidence from the literature.

Hypotheses were consolidated into 11 Flow Needs



SEARCH STRING EXAMPLES

(fall* or autumn* or september or october or november)

(winter* or spring* or november or december or january or february or march or april* or may* or june* or ice*)

(spring* or march or april* or may* or june*)

(sumr

("max

bankf

(seasc

(base

((base

(fish*

(((bro

("brov

semot

(esoci

(spaw

("yeai

(spaw

((egg*

(shall

("ancl

((egg*

((wetl

(spaw

(temp

((shal

((peri

(grow

((larv

(riff*

((larva* or juven* or "age 0" or YOY) AND (surviv* or mortal*))

105 Different Search Strings

For each search string we recieved anywhere from 1 to over 10,000 hits in the Web of Knowledge Search Engine

We extracted 272 pieces of information related to our hypotheses from 221 RELEVANT papers

Flow-Ecology Hypotheses are consolidated into Flow Needs and literature support is assessed through Causal Criteria Analysis.

Freshwater Science (JNABS), 2012, 31(1): 5-21

Study design	Weight
BACI	4
Gradient response model	3
Before vs. after (no reference/control)	2
Reference/control vs. impact (no before)	2
After impact only or Observational data	1

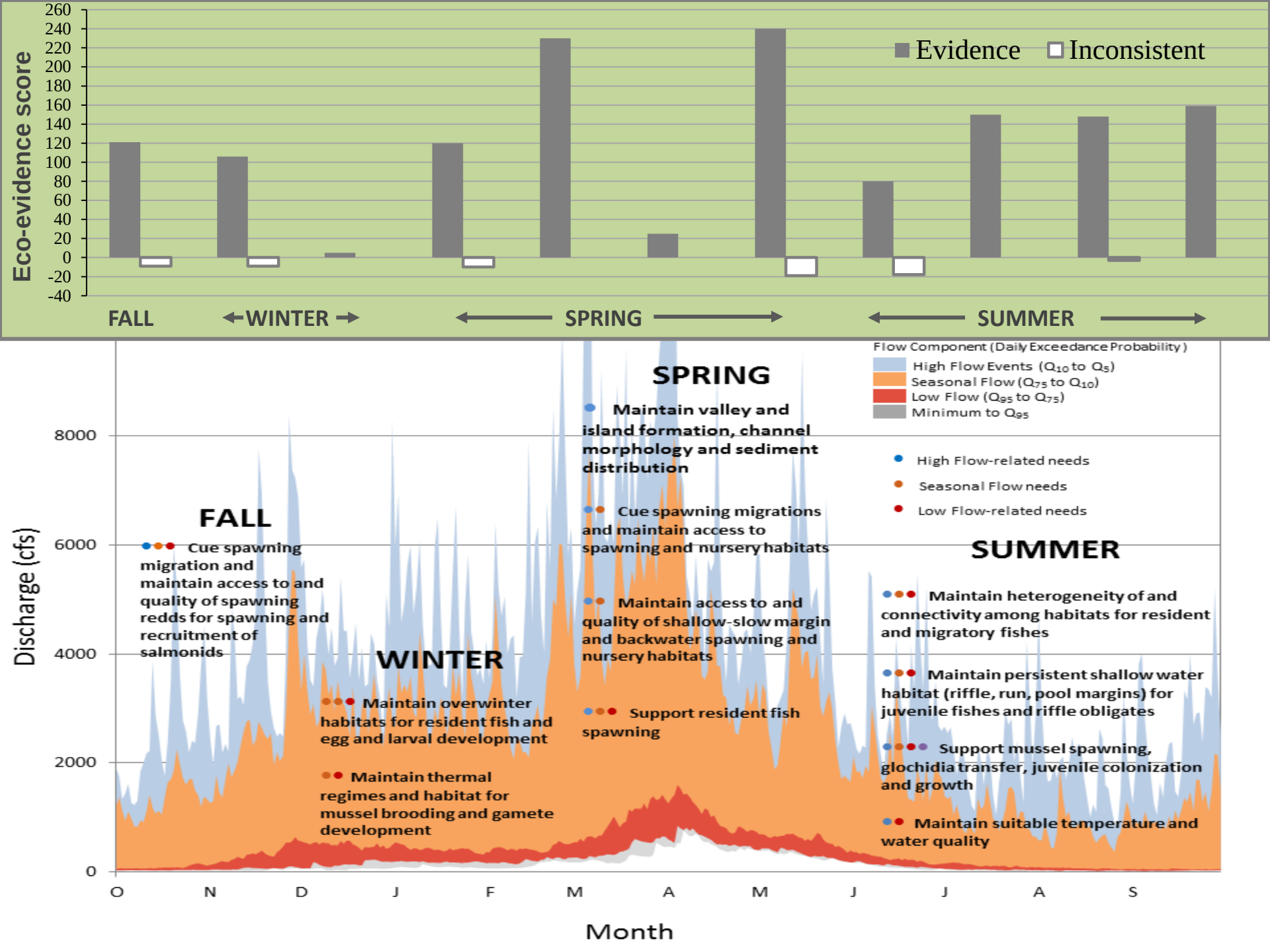
Control sites	Weight	Impact sites	Weight	Gradient design sites	Weight
0	0	1	0	<4	0
1	2	2	2	4	2
> 1	3	> 2	3	5	4
				> 5	6

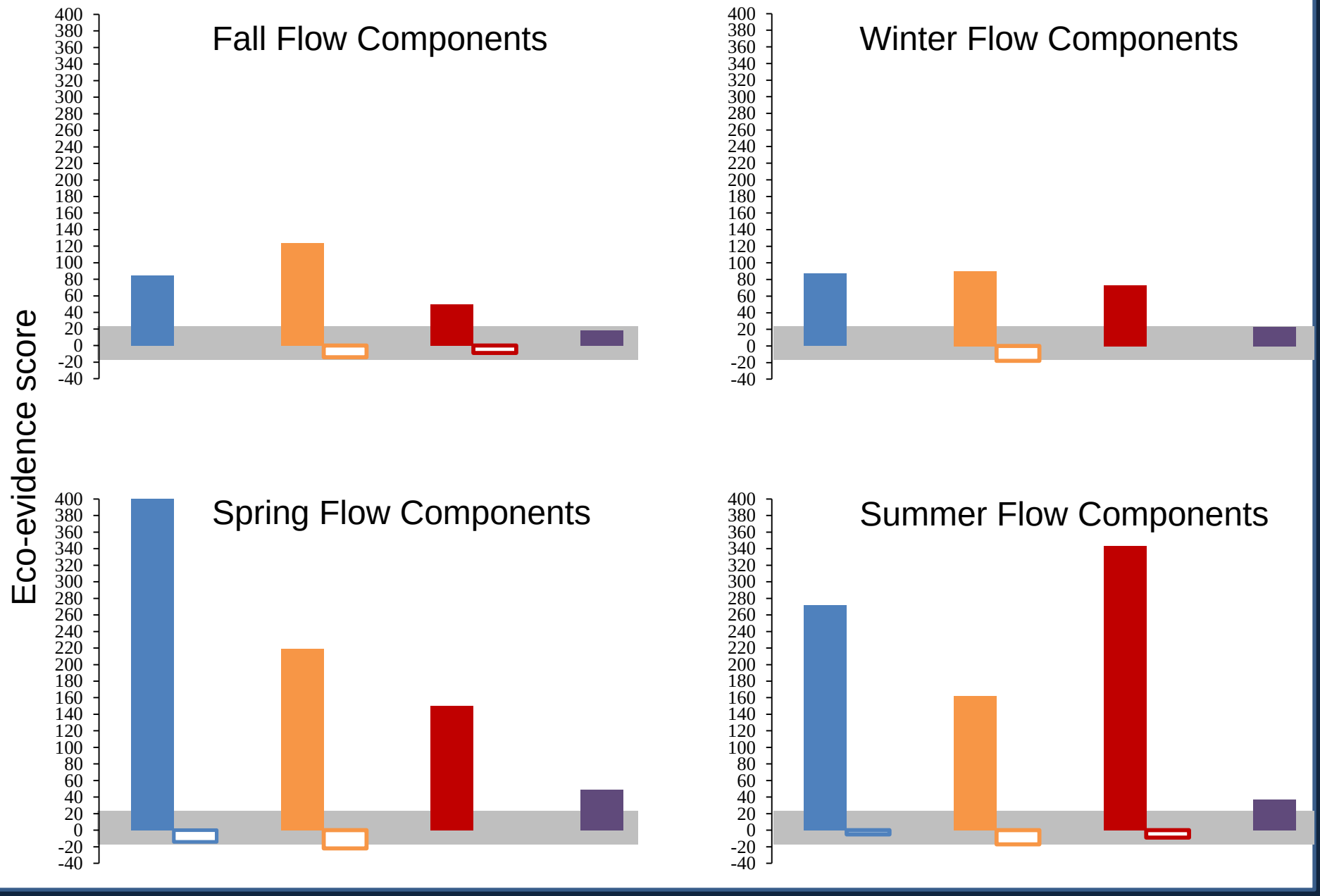
2 + 6 = 8

Flow-Ecology Hypotheses are consolidated into Flow Needs and literature support is assessed through Causal Criteria Analysis.

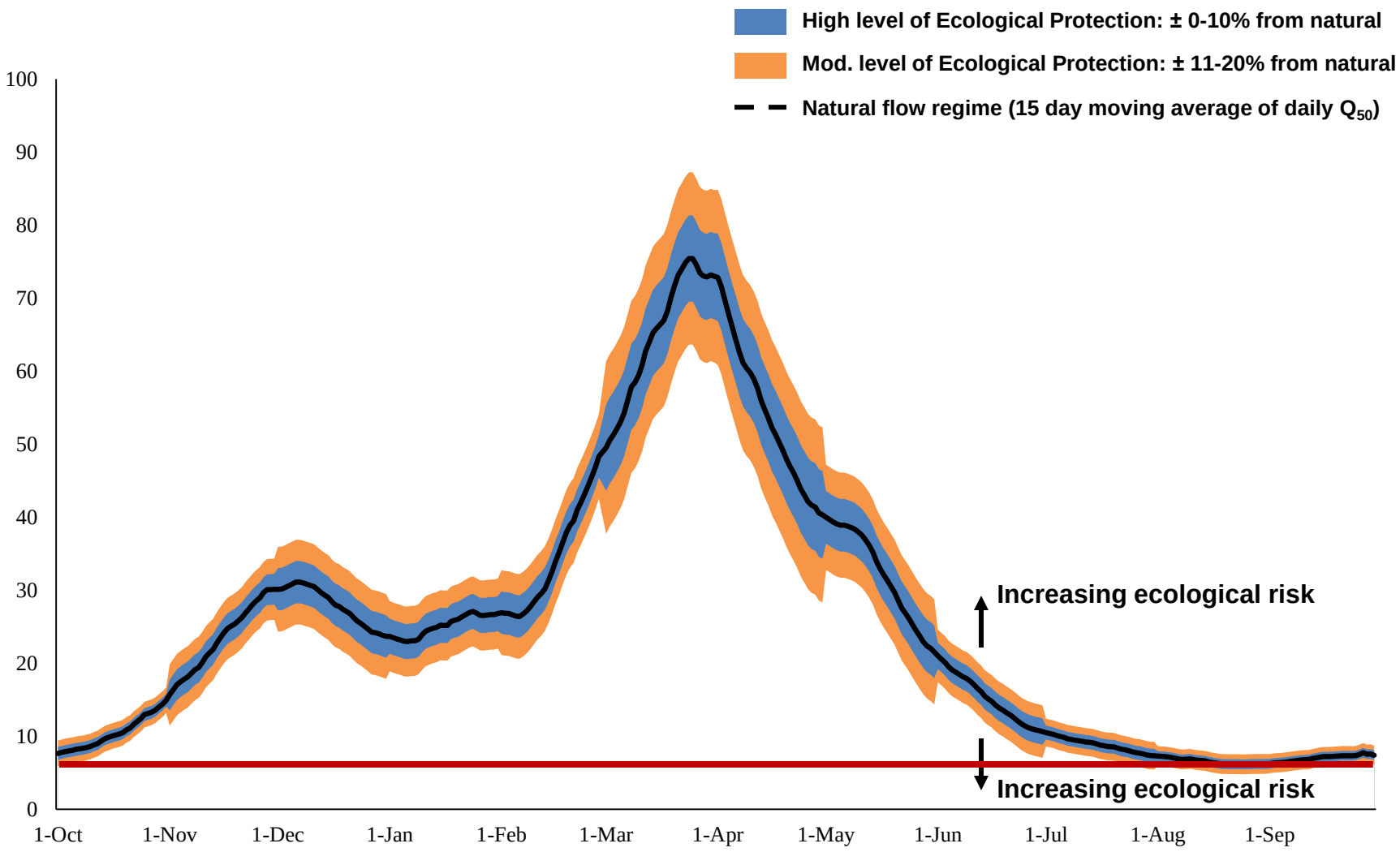
Flow Need:
Cue spawning migration and maintain access to spawning habitat during the spring

	Summed evidence weights	
Hypotheses	**Evidence**	**Not consistent**
GL-F11	**15**	**0**
GL-F13	**48**	**9**
GL-F15a	**57**	**1**
Total	**120**	**10**

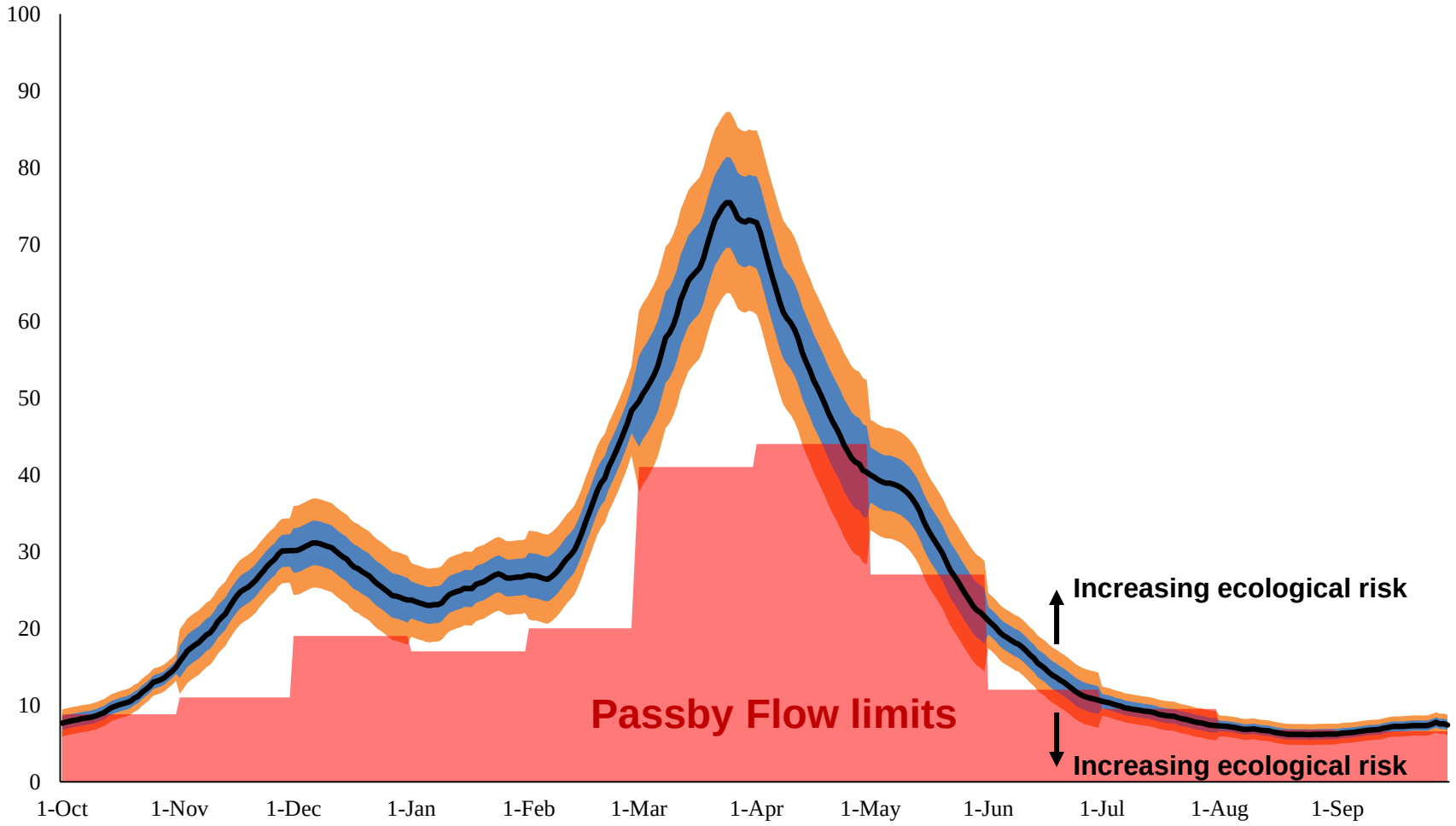

Eco-evidence score
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
Evidence
Inconsistent
FALL
WINTER
SPRING
SUMMER
Discharge (cfs)
8000
6000
4000
2000
0
O
N
D
J
F
M
A
M
J
J
A
S
Month
Flow Component (Daily Exceedance Probability)
High Flow Events (Q_{10} to Q_5)
Seasonal Flow (Q_{75} to Q_{10})
Low Flow (Q_{95} to Q_{75})
Minimum to Q_{95}
High Flow-related needs
Seasonal Flow needs
Low Flow-related needs
FALL
Cue spawning migration and maintain access to and quality of spawning redds for spawning and recruitment of salmonids
WINTER
Maintain overwinter habitats for resident fish and egg and larval development
Maintain thermal regimes and habitat for mussel brooding and gamete development
SPRING
Maintain valley and island formation, channel morphology and sediment distribution
Cue spawning migrations and maintain access to spawning and nursery habitats
Maintain access to and quality of shallow-slow margin and backwater spawning and nursery habitats
Support resident fish spawning
SUMMER
Maintain heterogeneity of and connectivity among habitats for resident and migratory fishes
Maintain persistent shallow water habitat (riffle, run, pool margins) for juvenile fishes and riffle obligates
Support mussel spawning, glochidia transfer, juvenile colonization and growth
Maintain suitable temperature and water quality


Eco-evidence score
Fall Flow Components
Winter Flow Components
Spring Flow Components
Summer Flow Components
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40

Going from Flow Needs to Recommendations

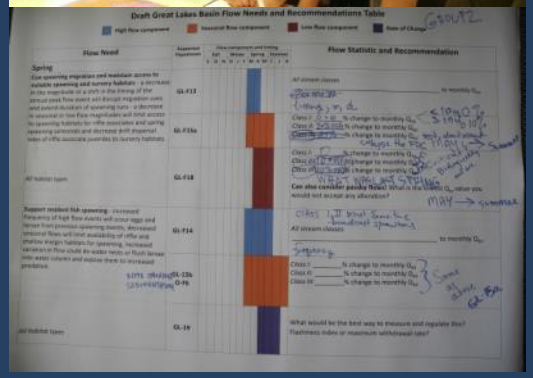


Going from Flow Needs to Recommendations



Going from Flow Needs to Recommendations

Expert Elicitation (Dec 2012)



Change to the median (Seasonal Flow)

- 10% change reduced brook trout relative abundance by 33%
- 10% change reduced fluvial fish relative abundance by 9%
- 5-25% change reduced benthic invertivores by 15%
- 20% change reduced fluvial fish relative abundance by 17%

Low Flow Impacts

- Q_{77} Loss of riffle habitat
- Q_{80} Reduced riffle and pool habitat, brook trout population size and body condition, increased competition among riffle obligates
- Q_{85} Dewatered margin habitats exposed mussels

Draft Recommendations

Technical Review

Final Recommendations

Take Home Points

1. We utilized regional expert knowledge to develop ecosystem flow needs.
2. We synthesized existing information in a transparent format using the weight of evidence approach to support flow needs.
3. We are using this information combined with expert input to develop recommendations in support of NY State Flow Policy.

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