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Factors Affecting Humpback Chub Population Dynamics in Grand Canyon

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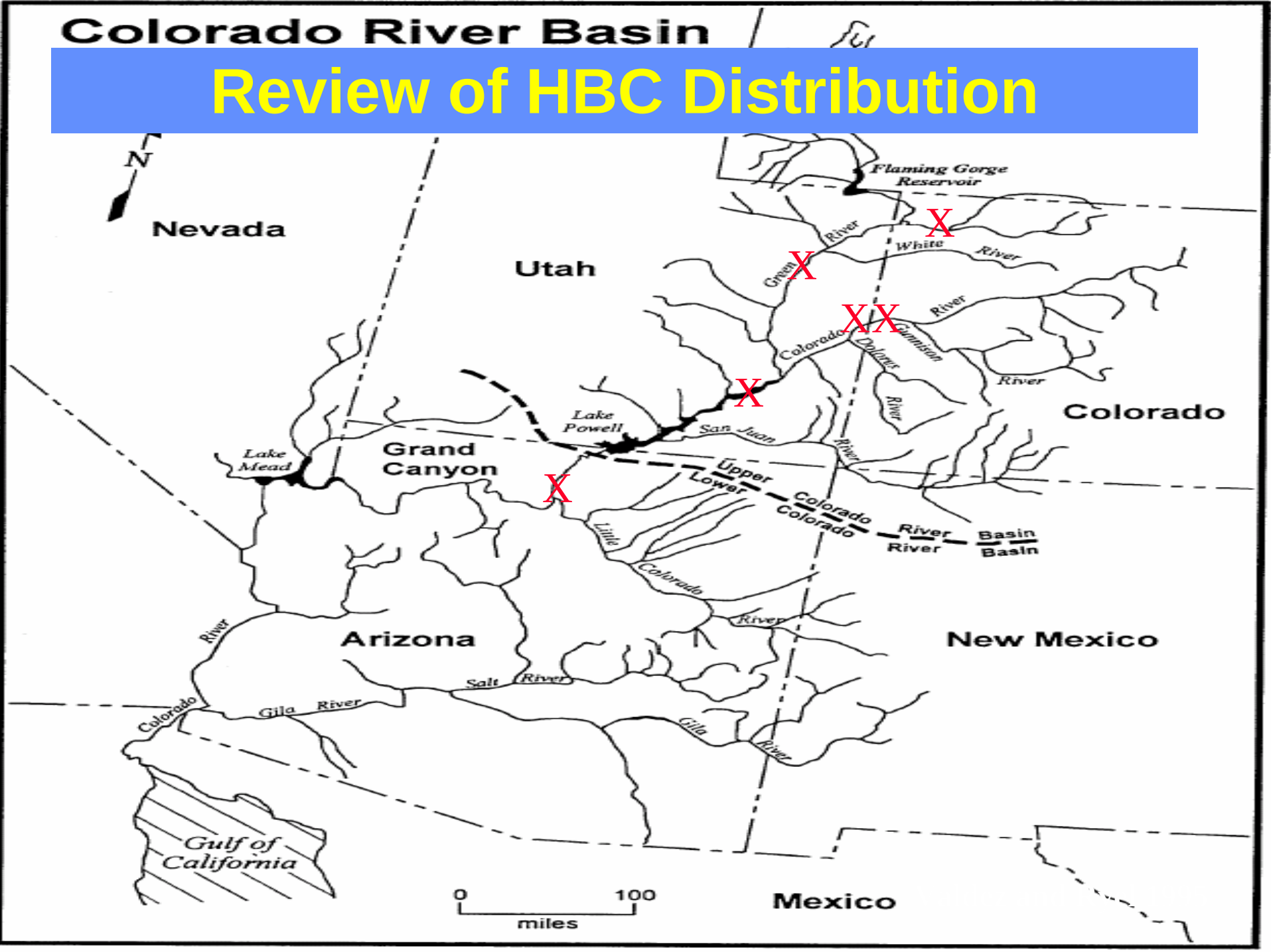
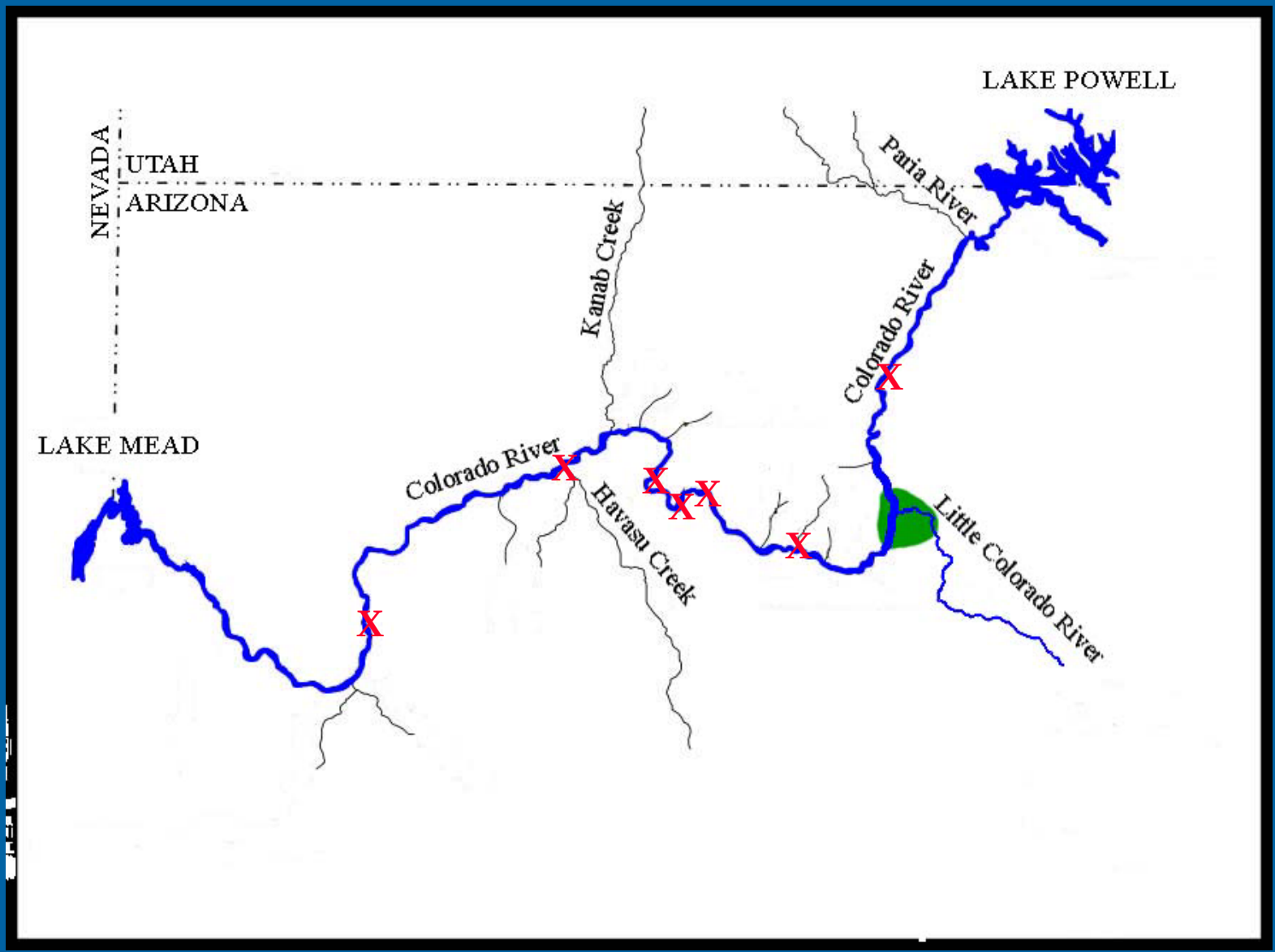

Colorado River Basin
Review of HBC Distribution
N
Nevada
Utah
Colorado
Arizona
New Mexico
Mexico
Flaming Gorge Reservoir
Green River
White River
Colorado River
Gunnison River
Dolores River
San Juan River
Lake Powell
Lake Mead
Grand Canyon
Upper Colorado River Basin
Lower Colorado River Basin
Little Colorado River
Salt River
Gila River
Gulf of California
0
100
miles

Humpback Chub Distribution in Grand Canyon



Little Movement Among Aggregations

Tag-Recapture Matrix (Pit Data 989-2000)

Aggregations other than the LCR likely supported by LCR population emigrants (strongly suspected)

30MI	Lees Ferry to 30 Mile aggregation
LCR	In Little Colorado River
LCRIN	Little Colorado River Inflow (rm 57-68.5)
UGG	"Upper Granite Gorge" (rm 70 - 92.3)
BAC	In Bright Angel Creek
SHM	In Shinumo Creek
SHMIN	Shinumo Creek Inflow (rm 108 - 109)
STEPH-CONQ	Stephen - Conquistador Aisle (rm 114 -125)
MGG	Middle Granite Gorge (rm 125 -129)
KAN	In Kanab Creek
KANIN	Kanab Creek inflow (rm 142 -143.5)
HAV	In Havasu Creek
HAVIN	Havasu Creek inflow (rm 155 - 157)
BLOHAV	Below Havasu Creek

		Recapture Location														
Tag Location	Total Tagged	30MI	LCR	LCRIN	UGG	BAC	SHM	SHMIN	STEPH-CONQ	MGG	KAN	KANIN	HAV	HAVIN	BLOHAV	Total Recaptured
30MI	34	16	1	0	0	0	0	0	0	0	0	0	0	0	0	17
LCR	11779	1	**12032**	**766**	3	0	0	0	0	0	0	1	2	0	0	12805
LCRIN	1158	0	**883**	**257**	0	0	0	0	1	1	0	0	1	0	0	1143
UGG	43	0	2	0	2	0	0	0	0	1	0	0	0	0	0	5
BAC	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHM	18	0	0	0	0	0	2	1	0	0	0	0	0	0	0	3
SHMIN	47	0	0	0	0	0	0	15	0	0	0	0	0	0	0	15
STEPH-CONQ	32	0	0	0	0	0	0	0	3	1	0	0	0	0	0	4
MGG	181	0	0	0	0	0	0	1	1	75	0	0	0	0	0	77
KAN	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KANIN	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HAV	42	0	1	0	0	0	0	0	0	1	0	0	13	1	0	16
HAVIN	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLOHAV	8	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
Total	13354	17	12919	1023	5	0	2	17	5	79	0	1	16	1	4	14089

RED is Downstream Movement
YELLOW is Upstream Movement
Grey is "no movement"

Why are there still HBC in the LCR?

- Little Colorado River
  - Perennial spring fed river throughout lower ~21km
  - Baseflow ~250 cfs, 21° C at blue spring, high salinity
  - Occasional intense flooding associated with runoff and monsoons
  - Few cold water non-natives.
  - Warm water non-natives.
  - Asian Tapeworm
- Colorado River
  - Cold, hypolimnial releases from Glen Canyon Dam
  - Water temperature too cold for successful reproduction of humpback chub.
  - Few warm water non-natives
  - Cold water non-natives

Distribution and Life History Attributes of the LCR HBC Population

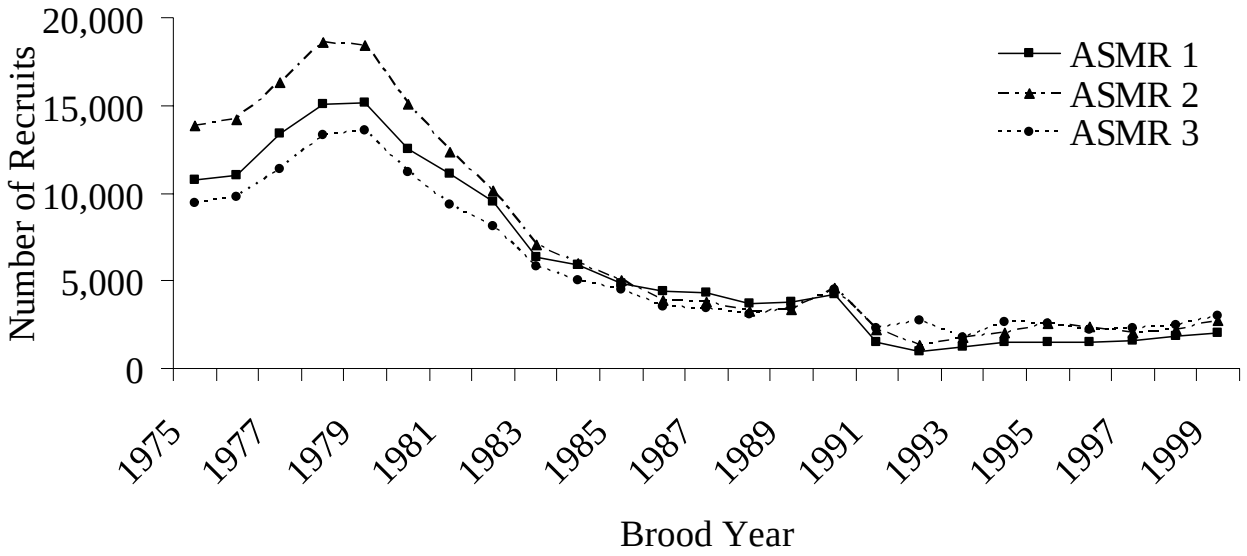
- Distribution
  - Lower 14.9 km in LCR
  - RM 56 – 65.5 in Mainstem (8 km upstream and 11 km downstream from confluence).
- All life stages found in LCR.
- Predominantly HBC >200 mm found in mainstem.
- YOY and Juveniles found in mainstem following LCR freshets (Spring & late Summer).

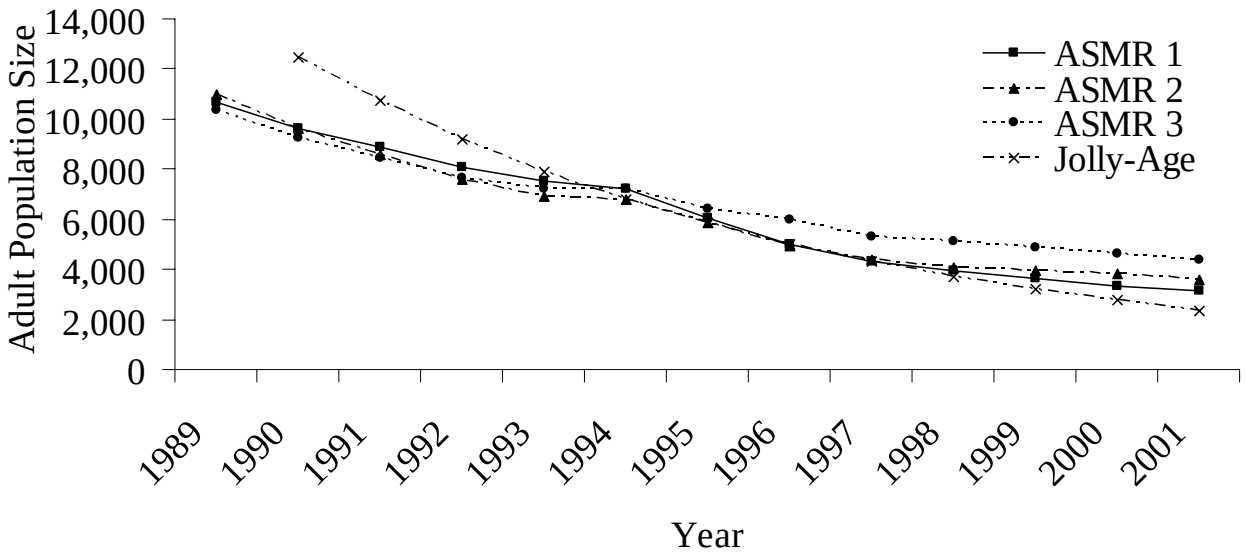
Distribution and Life History Attributes of the LCR HBC Population

- Spawning Migration
  - Adults stage near confluence February- March
  - Enter LCR March – April
  - Return to Mainstem April – July
  - Unknown migration cues
- YOY initially captured in LCR
  - May - July

Stock Assessment Results

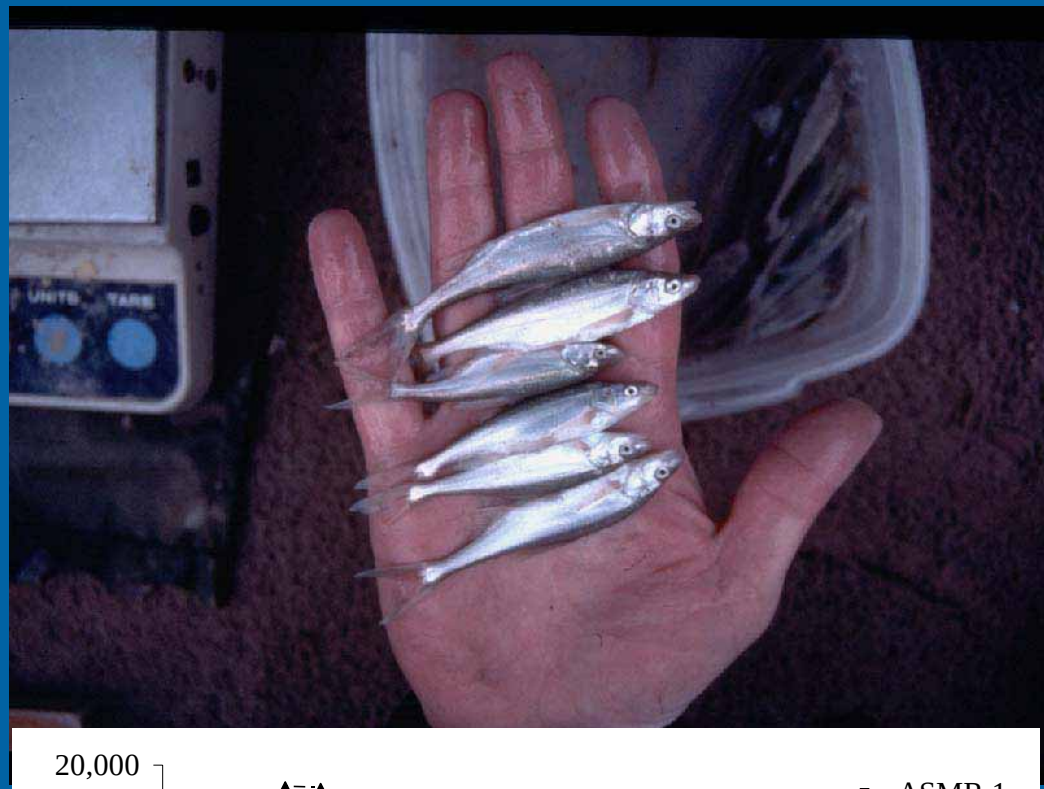
Little Colorado River Humpback Chub Population

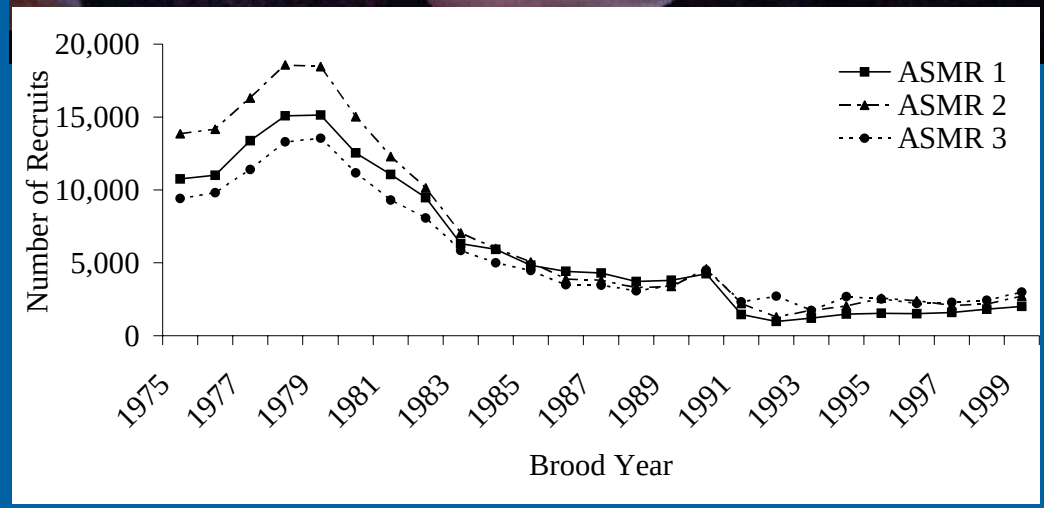




Decline in adult HBC seems to be a result of low recruitment

- Assessment Uncertainty
  - Recruitment estimates before 1989 based on observed size (age) structure observed in the late 1980s.
  - Error in age assignment results in a “smeared” or running average characterization of recruitment strength, particularly prior to 1989.
  - Patterns observed in recruitment time series subject of much speculation. Decline of 1992 year class temporally correlated with lots of changes. Bottom line… correlations and speculations not grounded in good science.



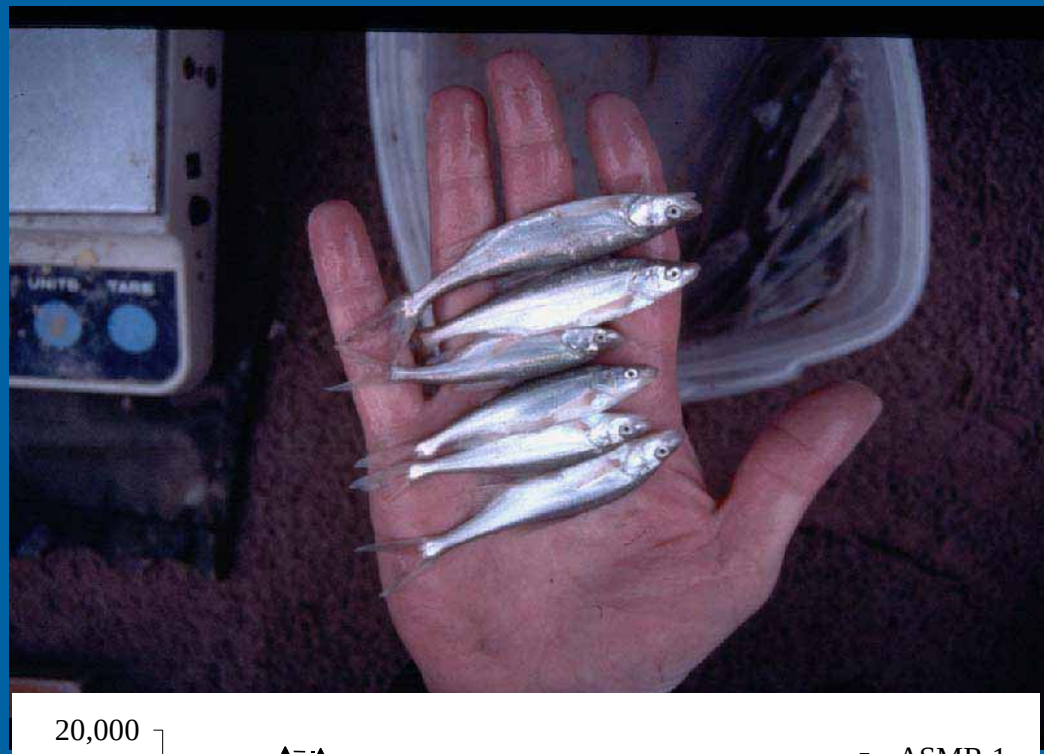


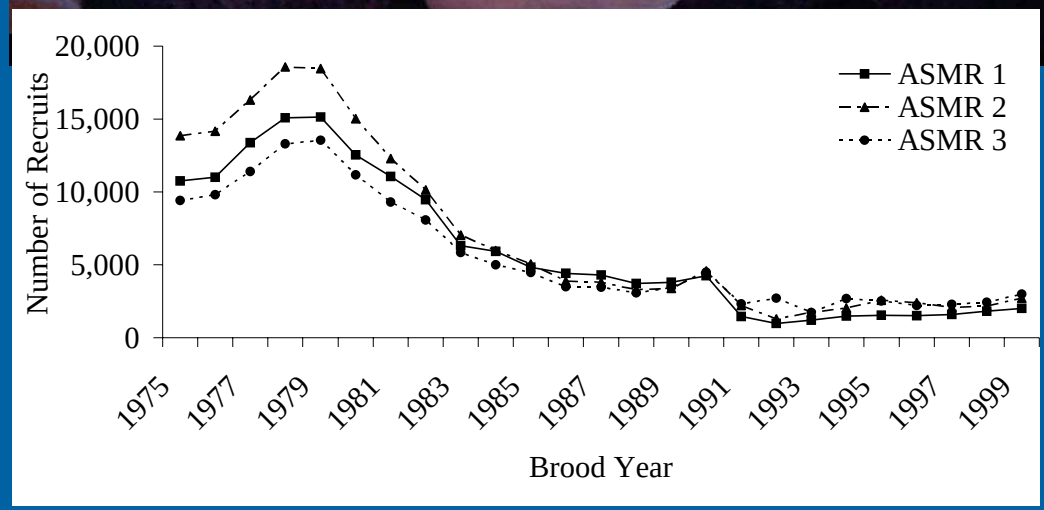
What do we know or suspect about recruitment dynamics of this population?

- Successful spawning occurs in the Little Colorado River (known)
- Most successful rearing occurs in the Little Colorado River (suspect-known)
- Juvenile fish migrate to the mainstem Colorado associated with freshet events in the LCR (known)
- Juvenile fish under some size (suspect ~ 100mm -200mm) have very poor survival in the mainstem Colorado. Therefore, majority of recruitment is from fish that remain in the LCR until reaching some critical size

What do we know or suspect about recruitment dynamics of this population?

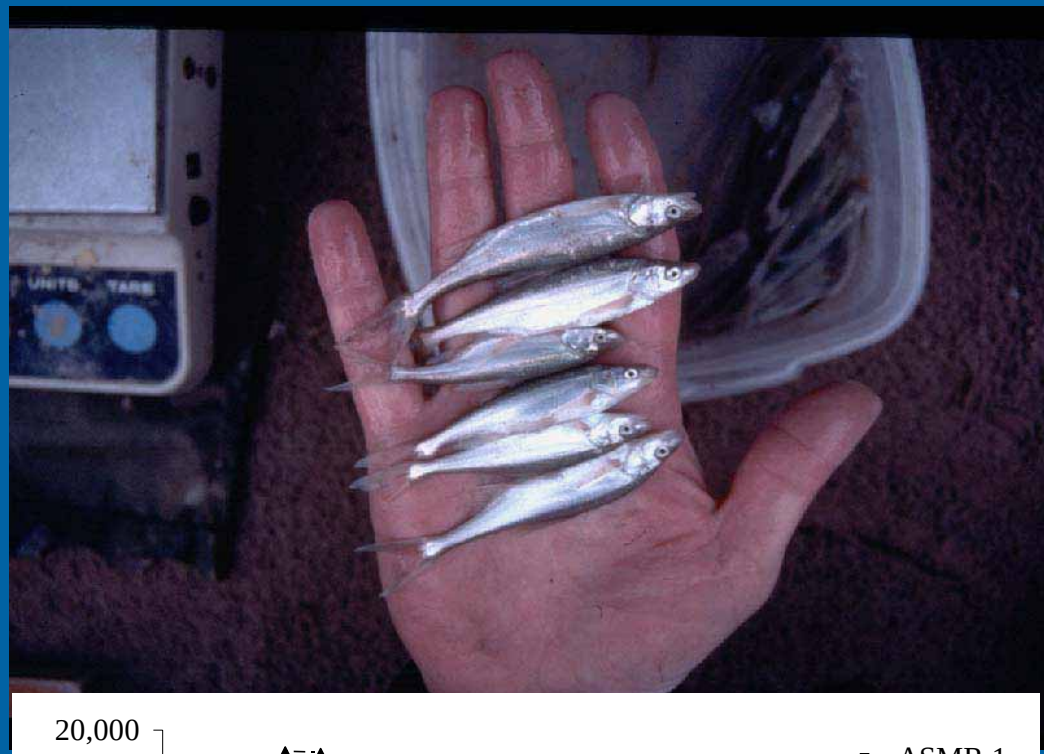
- Factors inhibiting successful recruitment in the LCR include:
  - Low productivity (known)
  - Asian Tapeworm (known) Paper available: Cole et al 2004
  - Competition/predation with native and non-native fish (Suspect)
  - Flooding and displacement out of the LCR (known)
  - Water Quality?
    - Not monitored (unknown)

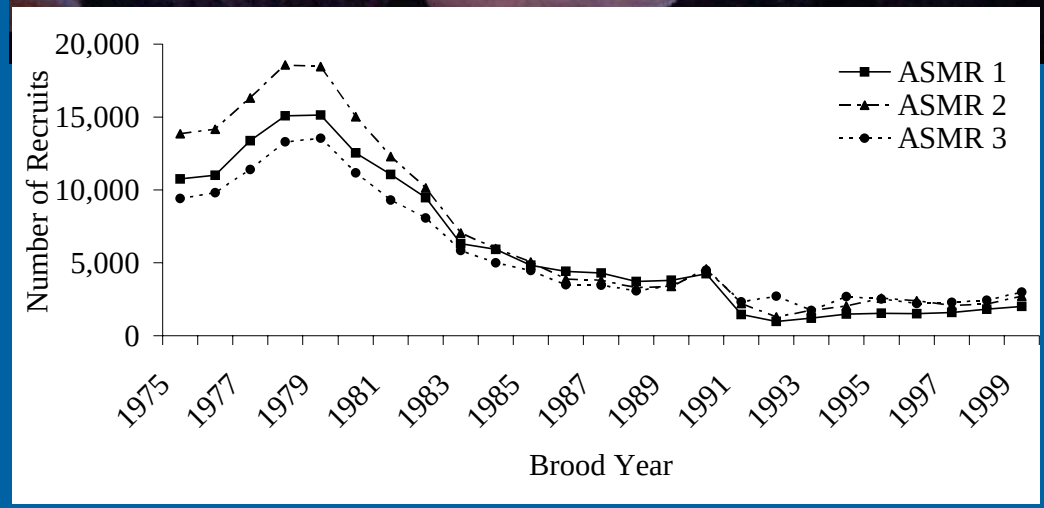




What do we know or suspect about recruitment dynamics of this population?

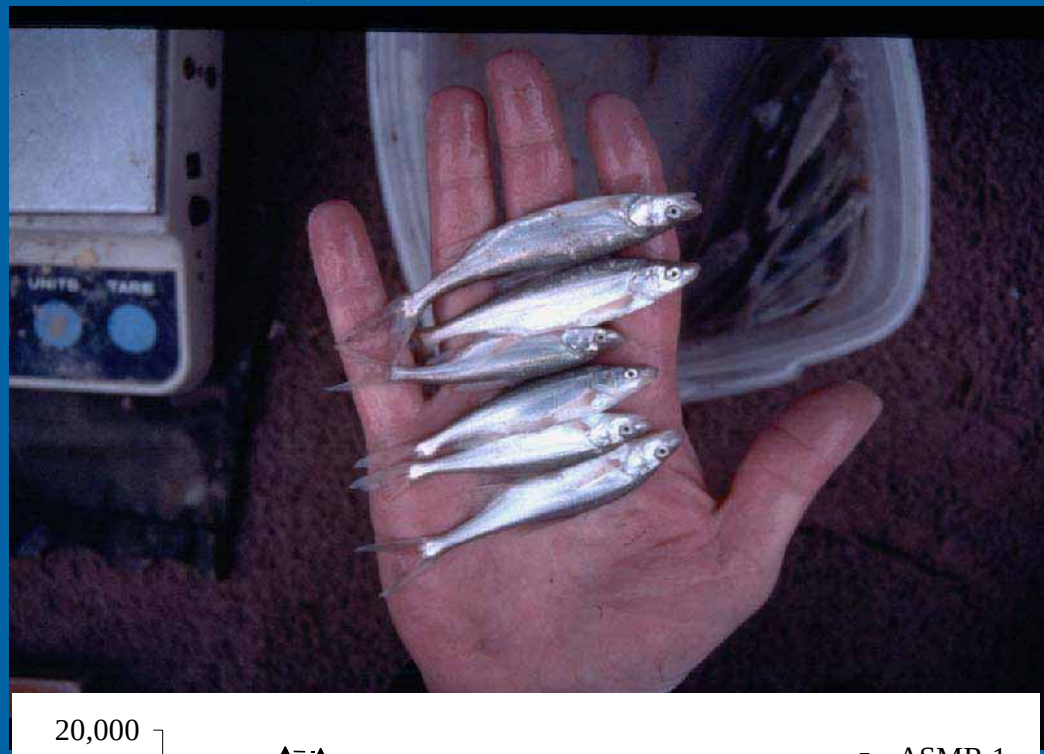
- Recruitment levels evident in the mid to late 1990's may represent rearing capacity of the LCR (SUSPECTED)
- With no additional suitable rearing area (e.g. mainstem Colorado), recruitment level may persist at or below late 1990's average (SUSPECTED)

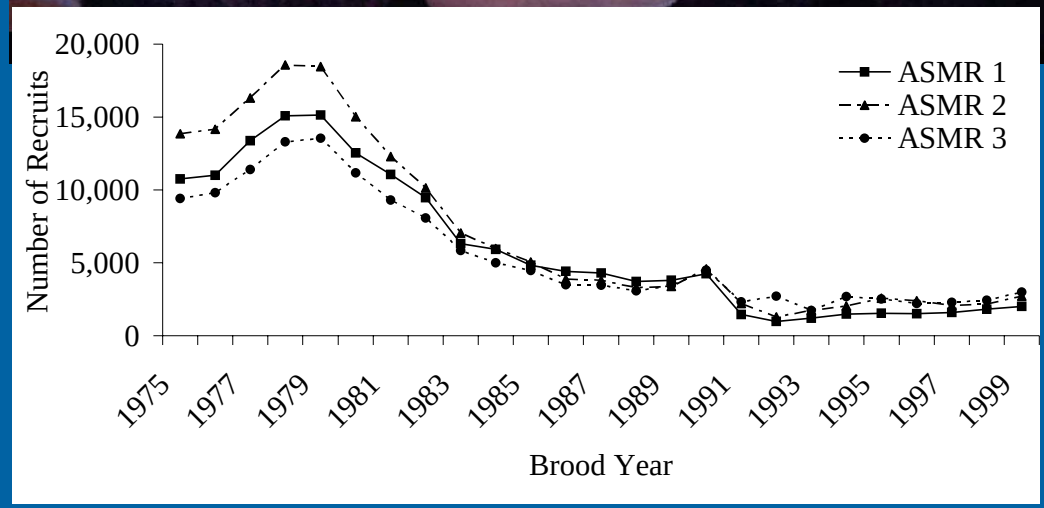




Why do juvenile fish find the mainstem Colorado poor rearing habitat?

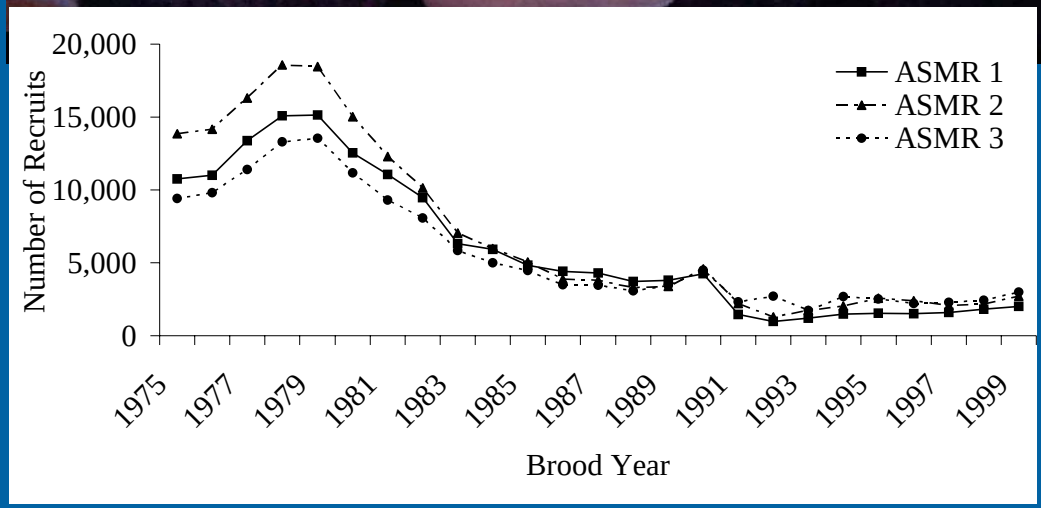
- Temperature
  - Poor growth (known)
  - Cold shock (suspected-known)
- Food
  - Likely better resources in the mainstem than in the LCR, adults seem to gain condition better in the mainstem. (unknown)
- Dam Operations
  - (e.g. fluctuating flows) destabilizing near-shore habitat? No adequate test yet performed (unknown to suspected).





Why do juvenile fish find the mainstem Colorado poor rearing habitat?

- Non-native fish
  - predation/competition (suspected)
- Lack of turbidity
  - Increase in autotrophic production (known)
  - Increase in efficiency of sight predators (known)
- Lack of quality nearshore rearing habitat
  - Do backwater habitats support a large fraction of successful mainstem rearing (unknown)
- Complex interactions among above factors
  - E.g., cold temperature and slow growth, increased predation



What other factors potentially affect HBC population dynamics

- Capture and handling of fish for monitoring and research
  - Capture, handling, tagging of fish has been shown to lower individual fitness in a variety of ways (growth, condition, behavior; KNOWN).
  - Investigation of these factors will do little to understand how handling affects vital population rates (mortality and recruitment)
  - KEY QUESTION: How do current or proposed monitoring programs affect population vital rates? (UNKNOWN)
    - This is an extremely difficult research question.
    - Past research in this area usually utilizes captive fish and is only useful in providing insight into changes in fish health as a function handling, not vital rates.
    - Mortality is essentially impossible to fully address with captive fish as it is certainly underestimated.
    - Recruitment is inferred through changes in fecundity.
    - Simple assessments of condition factor will only serve to validate what we already know.

What other factors potentially affect HBC population dynamics

- Capture and handling of fish for monitoring and research
  - Ultimately, managers must grapple with some unavoidable facts relative to estimating population abundance with mark-recapture studies:
    - Handling causes fish stress and can ultimately lead to diminished health and death.
    - High precision and low bias in mark-recapture assessments of abundance is directly related to proportion of the population handled.
    - Bottom line 1… Increases in accuracy and precision of mark-recapture based stock assessment programs necessarily come with an increased risk of depressing vital rates.
    - Bottom line 2… Monitoring and research should strive to utilize least invasive technologies available. E.g., hoopnets vs trammel nets as possible, remote pit tag antenna, acoustic camera

What other factors potentially affect HBC population dynamics

- **Recreation in the Lower Little Colorado River**
  - **Difficult to believe that recreation activities affect humpback chub population dynamics positively**
  - **However, no evidence to suggest that recreation activities affect humpback chub population dynamics negatively**
- **Limiting humpback chub emigration from the LCR**
  - **Ponding Hypothesis (untested and unknown)**
  - **Potentially beneficial if rearing capacity is not exceeded**
- **BHBF**
  - Evidence from 2004 suggests that BHBF ***MAY*** (given caveats described in the March AMWG Meeting update) adversely affect juvenile humpback chub in the mainstem Colorado at the time of the BHBF.

Where do we go from here?

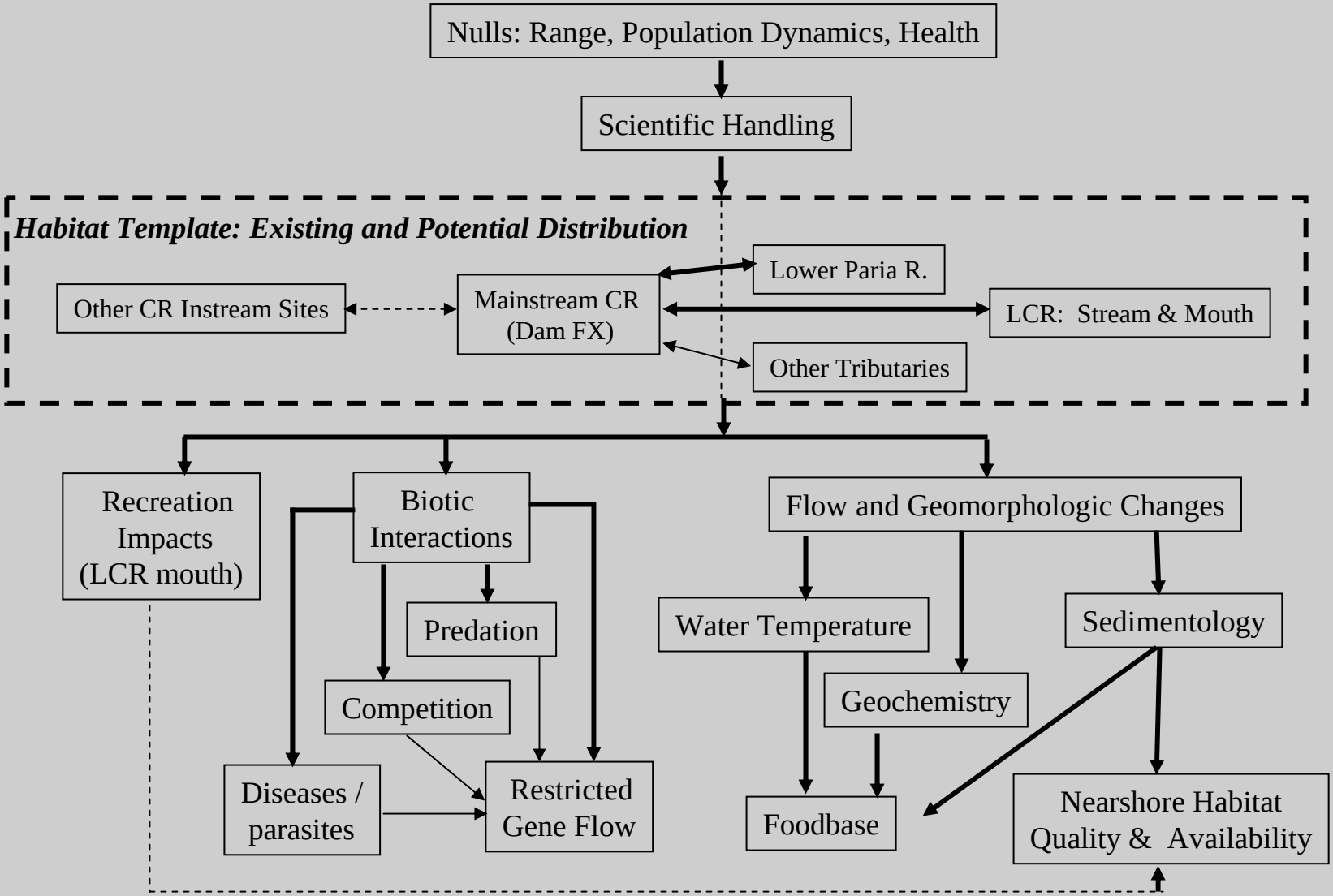


Fig. 3: Logical tree of hypothetical interactions that account for humpback chub (HBC) population status. Each box should be considered in relation to the various life stages of HBC.

Which factors can we test with experimentation?

- LCR
  - Low productivity (known)
    - Likely not possible to manipulate
  - Asian Tapeworm (known)
    - Likely not possible to manipulate
    - Advice from parasitologist suggests that attempting to treat captured fish will be ineffective given high probability of subsequent infection. However, need to hear about recent AGFD research.
  - Competition/predation with native and non-native fish (Suspect)
    - Attempts thus far suggest large scale mechanical removal in the LCR will be problematic (bycatch of HBC with most effective gear). However, further consideration is warranted.

Which factors can we test with experimentation?

- LCR
  - Displacement out of the LCR (known)
    - Experimentation with various methods to keep juvenile fish in the LCR is reasonable to consider.
    - Potential Problems:
      - Inadvertently exceeding rearing capacity and causing density dependent increases in mortality (more is not always better)
      - Possibly restricting migration opportunities for larger fish
- Mainstem Colorado River
  - Temperature
    - Implementation of a TCD would allow experimentation
    - Potential Problems:
      - Irreversible changes in fish community structure or aquatic foodbase.
      - Establishment of new parasites or diseases
      - Others that you have already heard about
    - Recent bioenergetics modeling by Petersen and Paukert (in press) suggests desirable changes in interactions between HBC and RBT assuming adequate food resources

Which factors can we test with experimentation?

- Mainstem Colorado River
  - Dam Operations
    - Given the focus of this program on the operation of GCD, it makes sense to experiment with operations
    - We should learn from the uncertainty we are currently experiencing and plan experiments with operations that are of adequate duration and contrast to facilitate learning
  - Non-native fish
    - Mechanical removal treatments should be planned in the context of well designed experiments
  - Lack of turbidity
    - Turbidity augmentation experiments should be carefully considered given the possibility to adversely affect lower trophic level productivity. A better understanding of productivity is required through improved foodbase research and monitoring.

Which factors can we test with experimentation?

- **Mainstem Colorado River**
  - **Lack of quality nearshore rearing habitat**
    - **Understanding the contribution of backwater habitats to overall mainstem rearing and recruitment is a fundamental uncertainty in this program.**
    - **It is not clear that we can affect the abundance and distribution of backwaters through management actions**
  - **Complex interactions among above factors**
    - **Only through well designed experiments can we hope to account for interactions and environmental variability in response variables (e.g., HBC recruitment)**