
List of Key Species

1. Sacramento River fall-run chinook salmon
2. San Joaquin River fall-run chinook salmon
3. Late fall-run chinook salmon
4. Winter-run chinook salmon
5. Spring-run chinook salmon
6. Steelhead trout
7. American shad
8. Green and white sturgeon
9. Striped bass
10. Sacramento Splittail
11. Delta smelt
12. Longfin smelt

What additional species would you include (e.g., largemouth bass, invertebrates)? Why?

What species would you delete? Why?

Fisheries Assessment Variables by Life Stage:
Sacramento River Fall-Run Chinook Salmon

- I. Adult Migration and Spawning (Riverine Habitat)
 - A. Temperature Survival Relationship for Adult Salmon
 - B. Temperature Survival Relationship for Pre-Spawn Eggs
 - C. Flow Survival Relationship for Adult Migration
 - D. Barrier Survival Relationship for Adult Migration
 - E. Flow Habitat Relationship for Spawning Success
 - F. Spawning Gravel Availability
 - G. Spawning Dispersal
 - H. Pollutant Mortality Relationships
 - I. Sport Fishing Mortality
 - J. Effects of Hatchery Fish Competition for Spawning Habitat
 - K. Stock Recruitment Relationships

- II. Incubation and Emergence (Riverine Habitat)
 - A. Temperature Survival Relationship for Eggs and Larvae
 - B. Flow Habitat Relationship for Incubation Success (e.g., scour, redd dewatering, water circulation)
 - C. Spawning Gravel Quality (e.g., effects on dissolved oxygen, emergence)
 - D. Pollutant Mortality Relationships
 - E. Predation and Disease Mortality Relationships

- III. Fry and Juvenile Rearing and Migration (Riverine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Habitat Relationship for Rearing Success (cover, food, stranding)
 - C. Flow Transport Relationship for Out-Migration Success
 - D. Diversion Mortality Relationship
 - E. Dam Passage Mortality Relationship
 - F. In-River Rearing Habitat Availability
 - G. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - H. Flood Bypass Habitat Availability and Stranding Losses
 - I. Predation, Competition, and Disease Relationships to Survival
 - J. Pollutant Mortality Relationships
 - K. Effects of Hatchery Fish Competition for Rearing Habitat

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- IV. Fry and Juvenile Rearing and Migration (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Out-Migration Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition for Rearing Habitat

 - V. Juvenile and Adult Rearing (Ocean Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)
 - B. Commercial Fishing Mortality
 - C. Sport Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assessment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
San Joaquin River Fall-Run Chinook Salmon

- I. Adult Migration and Spawning (Riverine Habitat)
 - A. Temperature Survival Relationship for Adult Salmon
 - B. Temperature Survival Relationship for Pre-Spawn Eggs
 - C. Flow Survival Relationship for Adult Migration
 - D. Barrier Survival Relationship for Adult Migration
 - E. Flow Habitat Relationship for Spawning Success
 - F. Spawning Gravel Availability
 - G. Spawning Dispersal
 - H. Pollutant Mortality Relationships
 - I. Sport Fishing Mortality
 - J. Effects of Hatchery Fish Competition for Spawning Habitat
 - K. Stock Recruitment Relationships

- II. Incubation and Emergence (Riverine Habitat)
 - A. Temperature Survival Relationship for Eggs and Larvae
 - B. Flow Habitat Relationship for Incubation Success (e.g., scour, redd dewatering, water circulation)
 - C. Spawning Gravel Quality (e.g., effects on dissolved oxygen, emergence)
 - D. Pollutant Mortality Relationships
 - E. Predation and Disease Mortality Relationships

- III. Fry and Juvenile Rearing and Migration (Riverine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Habitat Relationship for Rearing Success (cover, food, stranding)
 - C. Flow Transport Relationship for Out-Migration Success
 - D. Diversion Mortality Relationship
 - E. Dam Passage Mortality Relationship
 - F. In-River Rearing Habitat Availability
 - G. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - H. Flood Bypass Habitat Availability and Stranding Losses
 - I. Predation, Competition, and Disease Relationships to Survival
 - J. Pollutant Mortality Relationships
 - K. Effects of Hatchery Fish Competition for Rearing Habitat

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- IV. Fry and Juvenile Rearing and Migration (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Out-Migration Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition for Rearing Habitat

 - V. Juvenile and Adult Rearing (Ocean Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)
 - B. Commercial Fishing Mortality
 - C. Sport Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assessment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Late Fall-Run Chinook Salmon

- I. Adult Migration and Spawning (Riverine Habitat)
 - A. Temperature Survival Relationship for Adult Salmon
 - B. Temperature Survival Relationship for Pre-Spawn Eggs
 - C. Flow Survival Relationship for Adult Migration
 - D. Barrier Survival Relationship for Adult Migration
 - E. Flow Habitat Relationship for Spawning Success
 - F. Spawning Gravel Availability
 - G. Spawning Dispersal
 - H. Pollutant Mortality Relationships
 - I. Sport Fishing Mortality
 - J. Effects of Hatchery Fish Competition for Spawning Habitat
 - K. Stock Recruitment Relationships

- II. Incubation and Emergence (Riverine Habitat)
 - A. Temperature Survival Relationship for Eggs and Larvae
 - B. Flow Habitat Relationship for Incubation Success (e.g., scour, redd dewatering, water circulation)
 - C. Spawning Gravel Quality (e.g., effects on dissolved oxygen, emergence)
 - D. Pollutant Mortality Relationships
 - E. Predation and Disease Mortality Relationships

- III. Fry and Juvenile Rearing and Migration (Riverine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Habitat Relationship for Rearing Success (cover, food, stranding)
 - C. Flow Transport Relationship for Out-Migration Success
 - D. Diversion Mortality Relationship
 - E. Dam Passage Mortality Relationship
 - F. In-River Rearing Habitat Availability
 - G. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - H. Flood Bypass Habitat Availability and Stranding Losses
 - I. Predation, Competition, and Disease Relationships to Survival
 - J. Pollutant Mortality Relationships
 - K. Effects of Hatchery Fish Competition for Rearing Habitat

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- IV. Fry and Juvenile Rearing and Migration (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Out-Migration Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition for Rearing Habitat

 - V. Juvenile and Adult Rearing (Ocean Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)
 - B. Commercial Fishing Mortality
 - C. Sport Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assessment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Winter-Run Chinook Salmon

- I. Adult Migration and Spawning (Riverine Habitat)
 - A. Temperature Survival Relationship for Adult Salmon
 - B. Temperature Survival Relationship for Pre-Spawn Eggs
 - C. Flow Survival Relationship for Adult Migration
 - D. Barrier Survival Relationship for Adult Migration
 - E. Flow Habitat Relationship for Spawning Success
 - F. Spawning Gravel Availability
 - G. Spawning Dispersal
 - H. Pollutant Mortality Relationships
 - I. Sport Fishing Mortality
 - J. Effects of Hatchery Fish Competition for Spawning Habitat
 - K. Stock Recruitment Relationships

- II. Incubation and Emergence (Riverine Habitat)
 - A. Temperature Survival Relationship for Eggs and Larvae
 - B. Flow Habitat Relationship for Incubation Success (e.g., scour, redd dewatering, water circulation)
 - C. Spawning Gravel Quality (e.g., effects on dissolved oxygen, emergence)
 - D. Pollutant Mortality Relationships
 - E. Predation and Disease Mortality Relationships

- III. Fry and Juvenile Rearing and Migration (Riverine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Habitat Relationship for Rearing Success (cover, food, stranding)
 - C. Flow Transport Relationship for Out-Migration Success
 - D. Diversion Mortality Relationship
 - E. Dam Passage Mortality Relationship
 - F. In-River Rearing Habitat Availability
 - G. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - H. Flood Bypass Habitat Availability and Stranding Losses
 - I. Predation, Competition, and Disease Relationships to Survival
 - J. Pollutant Mortality Relationships
 - K. Effects of Hatchery Fish Competition for Rearing Habitat

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- IV. Fry and Juvenile Rearing and Migration (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Out-Migration Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition for Rearing Habitat

 - V. Juvenile and Adult Rearing (Ocean Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)
 - B. Commercial Fishing Mortality
 - C. Sport Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assessment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Spring-Run Chinook Salmon

- I. Adult Migration and Spawning (Riverine Habitat)
 - A. Temperature Survival Relationship for Adult Salmon
 - B. Temperature Survival Relationship for Pre-Spawn Eggs
 - C. Flow Survival Relationship for Adult Migration
 - D. Barrier Survival Relationship for Adult Migration
 - E. Flow Habitat Relationship for Spawning Success
 - F. Spawning Gravel Availability
 - G. Spawning Dispersal
 - H. Pollutant Mortality Relationships
 - I. Sport Fishing Mortality
 - J. Effects of Hatchery Fish Competition for Spawning Habitat
 - K. Stock Recruitment Relationships

- II. Incubation and Emergence (Riverine Habitat)
 - A. Temperature Survival Relationship for Eggs and Larvae
 - B. Flow Habitat Relationship for Incubation Success (e.g., scour, redd dewatering, water circulation)
 - C. Spawning Gravel Quality (e.g., effects on dissolved oxygen, emergence)
 - D. Pollutant Mortality Relationships
 - E. Predation and Disease Mortality Relationships

- III. Fry and Juvenile Rearing and Migration (Riverine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Habitat Relationship for Rearing Success (cover, food, stranding)
 - C. Flow Transport Relationship for Out-Migration Success
 - D. Diversion Mortality Relationship
 - E. Dam Passage Mortality Relationship
 - F. In-River Rearing Habitat Availability
 - G. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - H. Flood Bypass Habitat Availability and Stranding Losses
 - I. Predation, Competition, and Disease Relationships to Survival
 - J. Pollutant Mortality Relationships
 - K. Effects of Hatchery Fish Competition for Rearing Habitat

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- IV. Fry and Juvenile Rearing and Migration (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Out-Migration Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition for Rearing Habitat

 - V. Juvenile and Adult Rearing (Ocean Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)
 - B. Commercial Fishing Mortality
 - C. Sport Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assesment variables which you would recommend CALFED not use for this species? Why?

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- IV. Fry and Juvenile Rearing and Migration (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Out-Migration Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition for Rearing Habitat

 - V. Juvenile and Adult Rearing (Ocean-Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)
 - B. Commercial Fishing Mortality
 - C. Sport Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assesment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Steelhead Trout

- I. Adult Migration and Spawning (Riverine Habitat)
 - A. Temperature Survival Relationship for Adult Salmon
 - B. Temperature Survival Relationship for Pre-Spawn Eggs
 - C. Flow Survival Relationship for Adult Migration
 - D. Barrier Survival Relationship for Adult Migration
 - E. Flow Habitat Relationship for Spawning Success
 - F. Spawning Gravel Availability
 - G. Spawning Dispersal
 - H. Pollutant Mortality Relationships
 - I. Sport Fishing Mortality
 - J. Effects of Hatchery Fish Competition for Spawning Habitat
 - K. Stock Recruitment Relationships

- II. Incubation and Emergence (Riverine Habitat)
 - A. Temperature Survival Relationship for Eggs and Larvae
 - B. Flow Habitat Relationship for Incubation Success (e.g., scour, redd dewatering, water circulation)
 - C. Spawning Gravel Quality (e.g., effects on dissolved oxygen, emergence)
 - D. Pollutant Mortality Relationships
 - E. Predation and Disease Mortality Relationships

- III. Fry and Juvenile Rearing and Migration (Riverine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Habitat Relationship for Rearing Success (cover, food, stranding)
 - C. Flow Transport Relationship for Out-Migration Success
 - D. Diversion Mortality Relationship
 - E. Dam Passage Mortality Relationship
 - F. In-River Rearing Habitat Availability
 - G. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - H. Flood Bypass Habitat Availability and Stranding Losses
 - I. Predation, Competition, and Disease Relationships to Survival
 - J. Pollutant Mortality Relationships
 - K. Effects of Hatchery Fish Competition for Rearing Habitat

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- IV. Fry and Juvenile Rearing and Migration (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Out-Migration Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition for Rearing Habitat

 - V. Juvenile and Adult Rearing (Ocean Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)
 - B. Commercial Fishing Mortality
 - C. Sport Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assesment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
American Shad

- I. Adult Migration and Spawning (Riverine and Delta Habitat)
 - A. Temperature Survival Relationship for Spawning Success
 - B. Flow Survival Relationship for Adult Migration
 - C. Barrier Survival Relationship for Adult Migration
 - D. Flow Habitat Relationship for Spawning Success
 - E. Spawning Habitat Availability
 - F. Salinity Effects on Spawning Success
 - G. Pollutant Mortality Relationship
 - H. Sport Fishing Mortality
 - I. Stock Recruitment Relationships

- II. Incubation (Riverine and Delta Habitat)
 - A. Temperature Survival Relationship
 - B. River Flow Survival Relationship
 - C. Delta Flow Survival Relationship
 - D. Diversion Mortality Relationship
 - E. Lower San Joaquin River TDS Survival Relationship
 - F. Pollutant Mortality Relationship
 - G. Predation and Disease Relationships to Survival

- III. Larval and Juvenile (YOY) Rearing (Riverine and Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Rearing Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. In-River Rearing Habitat Availability
 - F. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - G. Delta Rearing Habitat Availability
 - H. Predation, Competition, and Disease Relationships to Survival
 - I. Pollutant Mortality Relationships

- V. Juvenile and Adult Rearing (Ocean Habitat)
 - A. Natural Mortality Rate (based on water temperature, ocean upwelling)

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assessment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Green and White Sturgeon

- I. Adult Migration and Spawning (Riverine Habitat)
 - A. Temperature Survival Relationship for Adult Sturgeon
 - B. Flow Survival Relationship for Adult Migration
 - C. Barrier Survival Relationship for Adult Migration
 - D. Flow Habitat Relationship for Spawning Success
 - E. Spawning Habitat Availability
 - F. Pollutant Mortality Relationships
 - G. Sport Fishing Mortality
 - H. Stock Recruitment Relationships

- II. Incubation, Emergence, and Larval Distribution (Riverine Habitat)
 - A. Temperature Survival Relationship for Eggs and Larvae
 - B. Flow Habitat Relationship for Incubation Success (e.g., water circulation)
 - C. Spawning Substrate Quality (e.g., effects on dissolved oxygen, emergence)
 - D. Flow Transport Relationship for Rearing Success
 - E. Diversion Mortality Relationship
 - F. Pollutant Mortality Relationships
 - G. Predation and Disease Mortality Relationships

- III. Juvenile Rearing and Migration (Riverine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Habitat Relationship for Rearing Success (cover, food, stranding)
 - C. Flow Transport Relationship for Out-Migration Success
 - D. Diversion Mortality Relationship
 - E. Dam Passage Mortality Relationship
 - F. In-River Rearing Habitat Availability
 - G. Riparian and Shaded Riverine Aquatic (SRA) Habitat Availability
 - H. Flood Bypass Habitat Availability and Stranding Losses
 - I. Predation, Competition, and Disease Relationships to Survival
 - J. Pollutant Mortality Relationships

- IV. Juvenile and Adult Rearing (Delta, Estuarine, and Ocean Habitat)
 - A. Diversion Mortality Relationship
 - B. Delta Rearing Habitat Availability
 - C. Suisun Bay Rearing Habitat Availability
 - D. Predation, Competition, and Disease Relationships to Survival
 - E. Pollutant Mortality Relationships
 - F. Fishing Mortality (Sport and Poaching)

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assessment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Striped Bass

- I. Adult Migration and Spawning (Riverine and Delta Habitat)
 - A. Temperature Survival Relationship for Spawning Success
 - B. Flow Relationship for Adult Migration
 - C. Flow Habitat Relationship for Spawning Success
 - D. Spawning Habitat Availability
 - E. Ocean Salinity Effects on Spawning Success
 - F. San Joaquin River Salinity Effects on Spawning Success
 - G. Pollutant Mortality Relationship
 - H. Sport Fishing Mortality
 - I. Stock Recruitment Relationships

- II. Incubation (Riverine and Delta Habitats)
 - A. Temperature Survival Relationship
 - B. Sacramento River Flow Survival Relationship
 - C. Lower San Joaquin River Flow Survival Relationship
 - D. Diversion Mortality Relationship
 - E. Lower San Joaquin River TDS Survival Relationship
 - F. Pollutant Mortality Relationship
 - G. Predation and Disease Relationships to Survival

- III. Larval and Juvenile (YOY) Rearing (Delta Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Rearing Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Suisun Bay Rearing Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships
 - I. Effects of Hatchery Fish Competition and Predation

- IV. Juvenile (1 to 3 years old) and Adult Rearing (Delta, Estuarine, and Ocean Habitats)
 - A. Diversion Mortality Relationship
 - B. Delta Rearing Habitat Availability
 - C. Suisun Bay Rearing Habitat Availability
 - D. Predation, Competition, and Disease Relationships to Survival
 - E. Pollutant Mortality Relationships
 - F. Effects of Hatchery Fish Competition and Predation
 - G. Fishing Mortality (Sport and Poaching)

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assesment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Sacramento Splittail

- I. Adult Migration and Spawning (Riverine and Delta Habitat)
 - A. Temperature Survival Relationship for Spawning Success
 - B. Flow Relationship for Adult Migration
 - C. Flow Habitat Relationship for Spawning Success
 - D. Spawning Habitat Availability
 - E. Pollutant Mortality Relationship
 - F. Sport Fishing Mortality
 - G. Stock Recruitment Relationships

- II. Incubation (Riverine and Delta Habitats)
 - A. Temperature Survival Relationship
 - B. Flow Survival Relationships (e.g., dewatering)
 - C. Pollutant Mortality Relationship
 - D. Predation and Disease Relationships to Survival

- III. Larval and Juvenile (YOY) Rearing (Riverine and Delta Habitats)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Rearing Success
 - C. Flow Survival Relationships (e.g., stranding)
 - D. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - E. Diversion Mortality Relationship
 - F. Rearing Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships

- IV. Juvenile (1 to 3 years old) and Adult Rearing (Delta and Estuarine Habitats)
 - A. Diversion Mortality Relationship
 - B. Delta Rearing Habitat Availability
 - C. Suisun Bay Rearing Habitat Availability
 - D. Predation, Competition, and Disease Relationships to Survival
 - E. Pollutant Mortality Relationships
 - G. Fishing Mortality

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assesment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Delta Smelt

- I. Adult Migration and Spawning (Delta and Suisun Bay Habitat)
 - A. Temperature Survival Relationship for Spawning Success
 - B. Flow Relationship for Adult Migration
 - C. Flow Habitat Relationship for Spawning Success
 - D. Spawning Habitat Availability
 - E. Ocean Salinity Effects on Spawning Success
 - F. San Joaquin River Salinity Effects on Spawning Success
 - G. Pollutant Mortality Relationship
 - H. Stock Recruitment Relationships

- II. Incubation (Delta and Suisun Bay Habitats)
 - A. Temperature Survival Relationship
 - B. Pollutant Mortality Relationship
 - C. Predation and Disease Relationships to Survival

- III. Larval and Juvenile Rearing (Delta and Suisun Bay Habitats)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Rearing Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Delta Rearing Habitat Availability
 - F. Suisun Bay Rearing Habitat Availability
 - G. Predation, Competition, and Disease Relationships to Survival
 - H. Pollutant Mortality Relationships

- IV. Juvenile and Adult Rearing (Delta and Suisun Bay Habitats)
 - A. Diversion Mortality Relationship
 - B. Delta Rearing Habitat Availability
 - C. Suisun Bay Rearing Habitat Availability
 - D. Predation, Competition, and Disease Relationships to Survival
 - E. Pollutant Mortality Relationships

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assessment variables which you would recommend CALFED not use for this species? Why?

Fisheries Assessment Variables by Life Stage:
Longfin Smelt

- I. Adult Migration and Spawning (Delta and Suisun Bay Habitat)
 - A. Temperature Survival Relationship for Spawning Success
 - B. Flow Relationship for Adult Migration
 - C. Flow Habitat Relationship for Spawning Success
 - D. Spawning Habitat Availability
 - E. Ocean Salinity Effects on Spawning Success
 - F. San Joaquin River Salinity Effects on Spawning Success
 - G. Pollutant Mortality Relationship
 - H. Stock Recruitment Relationships

- II. Incubation (Delta and Suisun Bay Habitats)
 - A. Temperature Survival Relationship
 - B. Pollutant Mortality Relationship
 - C. Predation and Disease Relationships to Survival

- III. Larval and Juvenile Rearing (Estuarine Habitat)
 - A. Temperature Survival Relationship
 - B. Flow Transport Relationship for Rearing Success
 - C. Pathway and Barrier Survival Relationships (e.g., DCC and Old River)
 - D. Diversion Mortality Relationship
 - E. Rearing Habitat Availability
 - F. Predation, Competition, and Disease Relationships to Survival
 - G. Pollutant Mortality Relationships

- IV. Juvenile and Adult Rearing (Estuarine Habitat)
 - A. Diversion Mortality Relationship
 - B. Rearing Habitat Availability
 - C. Predation, Competition, and Disease Relationships to Survival
 - D. Pollutant Mortality Relationships

What life stages would include or delete? Why?

Can you recommend any additional assessment variables for this species? If so, what are they?

Are there any proposed assesment variables which you would recommend CALFED not use for this species? Why?

EXAMPLES OF ASSESSMENT METHODS

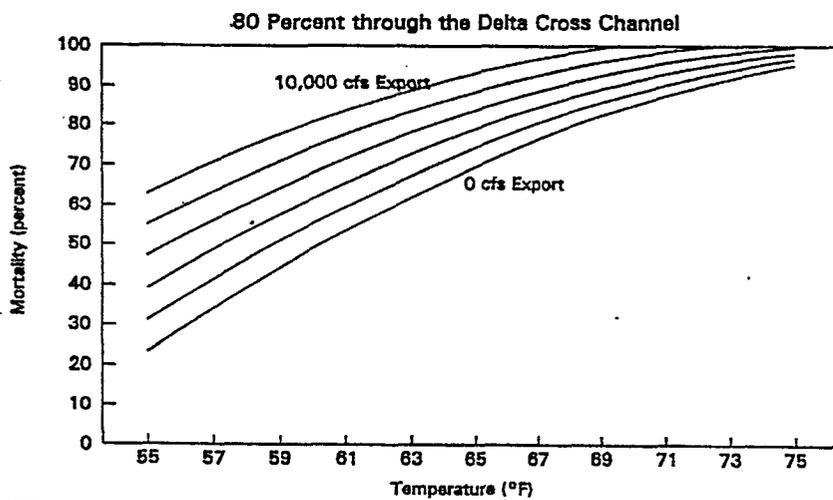
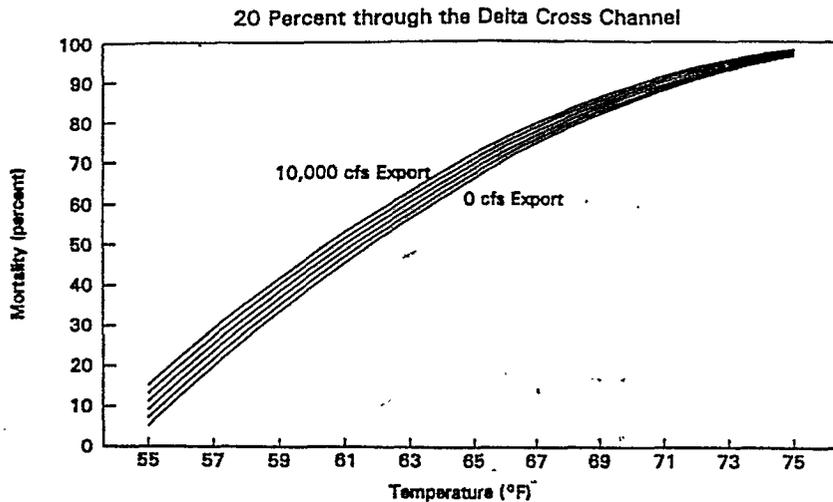
Species/Life Stage: Sacramento River Fall-Run Chinook Salmon / Fry and Juvenile Rearing and Migration (Delta Habitat)

Assessment Variable: Pathway and Barrier Survival Relationships (also includes Temperature Survival and Diversion Mortality Relationships)

Assessment Method: USFWS model for estimating mortality of fall-run chinook salmon smolts in the Sacramento-San Joaquin Delta.

Application to CALFED: CALFED actions may affect salmon smolt survival through changes to Sacramento River inflow and water temperature, the distribution of flow across the Delta, and Delta diversions. The mortality index could be used to compare mortality of salmon smolts among alternatives with variable flow and diversion patterns.

Description: The model uses analytical relationships developed by the USFWS from tag release-return studies conducted under variable inflow, export, and water temperature conditions. The analytical relationship developed from the tag-return data is depicted in the figure below. Mortality of salmon smolt that migrate through the Delta is a function of flow, Delta Cross Channel operations, export rate, and Sacramento River water temperature.



SOURCE: Kjelson et al. (1989).

PREDICTED SACRAMENTO RIVER CHINOOK SALMON SMOLT MORTALITY THROUGH THE DELTA VERSUS SACRAMENTO RIVER WATER TEMPERATURE AND DELTA EXPORT PUMPING RATES

Reference: Kjelson, M.A., S. Greene, and P. Brandes. 1989.

Input Data: Channel flow, water temperature, export rates, and Delta Cross Channel gate operations.

Modifications necessary for CALFED use: Although modifications to the model are not required with the existing Delta facilities and channel configuration, controversy regarding model validity should be clearly identified and, if possible, resolved. Potential changes to Delta channel barriers and diversion location under the CALFED alternatives may limit model usefulness.

Species/Life Stage: Fall-Run Chinook Salmon / Adult Migration and Spawning (Riverine Habitat)

Assessment Variable: Flow Habitat Relationship for Spawning Success (and Spawning Habitat Availability)

Assessment Method: Flow Habitat Relationship for Fall-Run Chinook Salmon in the Lower American River

Application to CALFED: CALFED actions may result in changes to the flow below Nimbus Dam on the American River that could affect depth, velocity, and spawning habitat availability for fall-run chinook salmon.

Description: The analytical relationship depicted in the figure below depicts the relationship of spawning habitat as a function of river flow based on IFIM studies. An index of spawning habitat can be calculated.

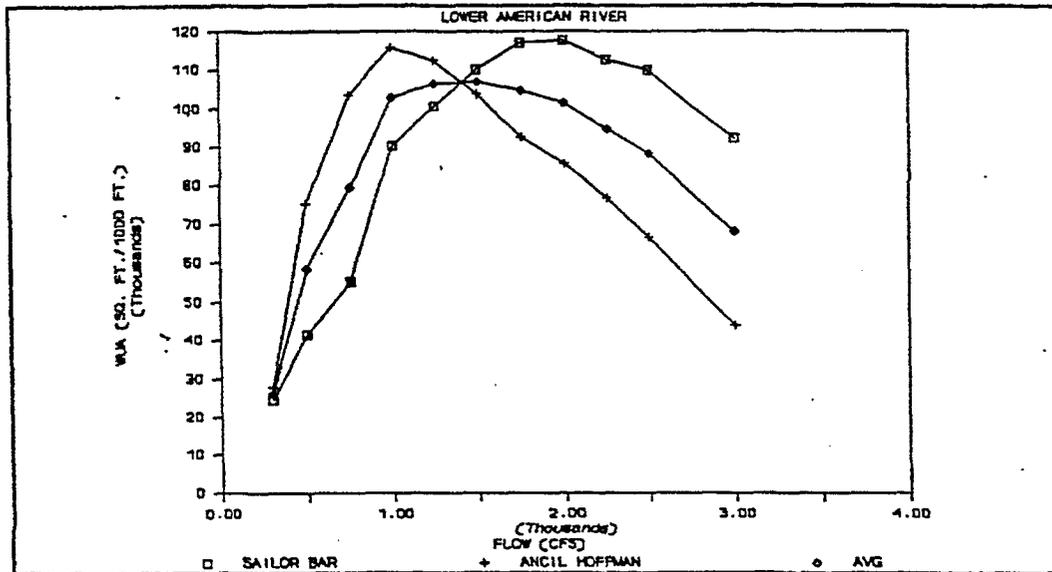


Figure 15. Relationships between flow and spawning habitat in Lower American River (from USFWS 1985).

Reference: BioSystems Analysis, Inc. 1989. Chinook salmon population model for the Sacramento River Basin - Version CPOP-2. Submitted to California Department of Fish and Game, Sacramento, California.

Input Data: River flow, flow-habitat relationship.

Modifications necessary for CALFED use: Although modifications to the model are not required with the existing river morphology, controversy regarding model validity should be clearly identified and, if possible, resolved. Potential changes spawning habitat (e.g., spawning gravel restoration) under the CALFED alternatives may alter model usefulness.

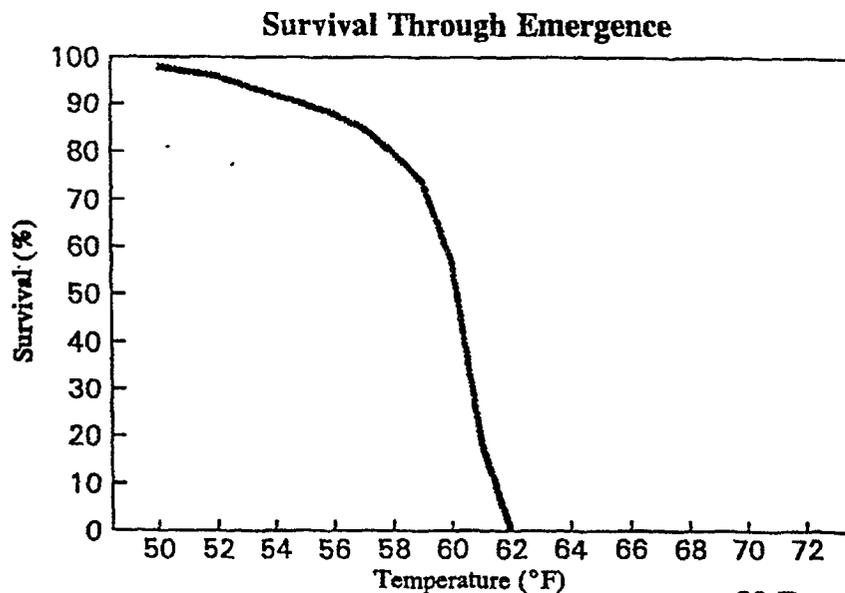
Species/Life Stage: Fall-Run Chinook Salmon / Incubation and Emergence (Riverine Habitat)

Assessment Variable: Temperature Survival Relationship for Eggs and Larvae

Assessment Method: Water Temperature Survival Relationship

Application to CALFED: CALFED actions may include changes to the flow below Keswick Dam in the upper Sacramento River, changes in Shasta Reservoir storage, and changes in operations of the water temperature control structure that could affect water temperature and the survival of eggs and larvae of fall-run chinook salmon.

Description: Survival is calculated using the relationship shown in the figure below that depicts survival through emergence as a function of water temperature. Incubation survival is based on simulated water temperatures in the river below Keswick Dam.



Reference: Brett, J. R., W. C. Clarke, and J. E. Shelbourn. 1982. Experiments on thermal requirements for growth and food conversion efficiency of juvenile salmon *Oncorhynchus tshawytscha*. (Canadian Technical Report of Fisheries and Aquatic Sciences No. 1027.) Department of Fisheries and Ocean, Fisheries Research Branch, Pacific Biological Station. Nanaimo, B.C., Canada.

Input Data: Simulated water temperature and temperature-survival relationship.

Modifications necessary for CALFED use: Modifications to the temperature survival model are not required. Changes in the existing river morphology (e.g., channel shape, riparian restoration), however, would require adjustments to the model used to simulate water temperature.

Questions for Discussion (Continued)

3. *How important is linkage of relationships? Why?*

Can it be done in the time frame for the CALFED Program?

4. *Should we integrate qualitative and quantitative analysis? How would this be accomplished?*
