**White Sturgeon - DRAFT**

**BDCP Logic Chains for Covered Fish Species**

***Note to Reviewer:***

*The following presents a draft set of BDCP biological objectives for white sturgeon. Per the recommendations of the independent science review panel, the objectives have been structured to address specific stressors as identified in existing documents such as existing recovery plans, biological opinions, and/or DRERIP life history conceptual models. A standardized table is used for each objective to provide specificity regarding the objective. Terms used in the table such as “Indicator” and “Attribute” are defined in Attachment 1. Additional components of the logic chain such as expected outcomes, conservation measures, and monitoring metrics are not presented herein. However, portions of the objective table are specifically intended to provide information relevant for these additional components. Efforts to link specific species objectives to broader natural community objectives and ecosystem objectives will be conducted once the species objectives have been reviewed and finalized.*

***Disclaimers:***

1. *Some of the objectives presented herein are hypothetical. These objectives are introduced to stimulate further discussion.*
2. *The Global Goals and Global Objectives presented below are not BDCP goals and objectives. BDCP will contribute to the achievement of these global goals and objectives.*

**Table of Contents**

[Global Goal 2](#_Toc277095160)

[Global Objective 2](#_Toc277095161)

[Stressors/Limiting Factors 2](#_Toc277095162)

[Stressor #1: Altered Flows 4](#_Toc277095163)

[Stressor #2: Passage Impediments/Barriers 5](#_Toc277095164)

[Stressor #3: Water Quality (Toxics, D.O. and Temperature) 5](#_Toc277095165)

[Stressor #4: Illegal Harvest 7](#_Toc277095166)

[Stressor #5: Habitat Loss and Modification 8](#_Toc277095167)

[Stressor #6: Entrainment 9](#_Toc277095168)

[Stressor #7: Dredging 10](#_Toc277095169)

[References 11](#_Toc277095170)

[Attachment 1 Objective Worksheet 12](#_Toc277095171)

# Global Goal

There currently is not a Recovery Plan for the white sturgeon because it is not listed under the California or Federal ESA. The logic chain recommends the following text as a global goal: Maintain self-sustaining populations of white sturgeon that will persist indefinitely. (reference: logic chain workshop October 2010)

# Global Objective

Implement actions known to benefit white sturgeon, to minimize threats to their existence, and improve understanding of them in order to maintain their abundance and distribution. (*reference: logic chain workshop October 2010*)

(Note: An additional objective could be to avoid listing of this species

# Stressors/Limiting Factors

The following stressors/limiting factors were adapted from Israel et. al.(2008) and SAIC (2009). Not all of the stressors listed below are proposed to be addressed by BDCP.

|  |  |  |
| --- | --- | --- |
| ***ID*** | ***Stressor*** | ***Summary Description*** |
| **Stressors Addressed by BDCP** | | |
| **1** | Altered flows | Modifications to river and Delta flow rates and hydrodynamics resulting in deviations from historic migration patterns. |
| **2** | Passage impediments/barriers | Landscape features and water operation facilities within the Planning Area that reduce or eliminate access to key habitats. |
| **3** | Water Quality  (Toxics, D.O. and Temperature) | Water quality conditions affecting migration, growth rate, and reproductive success. |
| **4** | Illegal harvest | Effects of poaching. |
| **5** | Habitat loss and modification | Changes in the extent, access to, and or quality of in-Delta habitat. |
| **6** | Entrainment | Entrainment at project and non-project facilities. |
| **7** | Predation | Predation losses, including effects of structures and habitat alterations that promote predators. |
| **8** | Dredging | Disturbance of benthos and associated direct and indirect effects. (Note: Construction of facilities may require dredging. Suisun Marsh Plan also includes dredging. Even though this is a short duration, it is a low magnitude stressor that should be included) |
| **Stressors Not Addressed by BDCP** | | |
| **9** | Invasive species | Effects of non-native species on predation and competition.  (Note: For sturgeon, clams are the non-native species of most concern). |

### Stressor #1: Altered Flows

Operational changes in river flow have led to significant ecological changes that influence white sturgeon at multiple life history stages (Israel et. al, 2008). River flows influence white sturgeon spawning, habitat availability, and prey resources. River flows have been shown to be related to YOY abundance (Kohlhorst et al, 1991). Spawning adults may be delayed in reaching spawning grounds in the early winter due to misleading water flows through the south and central delta, and fish headed up the San Joaquin River may be confused due to the shifted Sacramento River flows entering the south delta via the DCC (Israel et. al., 2008).

The dispersal of larval white sturgeon is dependent on high spring river flows (Israel et. al., 2008). Reduced seasonal flows or flows mismatched ecologically with sensitive early life stages may reduce dispersal of these life stages when they are most vulnerable to predation (Israel et. al., 2008). Flow reductions may serve to reduce or eliminate YOY survival even if spawning is successful (Israel et. al., 2008). Outflow influences YOY, juvenile, and adult white sturgeon bay and delta habitats by influencing salinity (Israel et.al, 2008).

(Note: There is likely two populations of white sturgeon: a Sacramento population and a San Joaquin population. It is possible that fish that cannot spawn in the SJR do spawn in the Sacramento River. This issue may need to be resolved. This logic chain may need to be more specific about which population it is talking about. Distribution is key. Provide sufficient outflow of good YOY abundance. Provide outflow to support multiple cohorts of white sturgeon (i.e. multiple age classes within a 20 year period. Sturgeon require April, May, June flows of 30,000 cfs.) Outflow & abundance Relationship that Kolhorst built in 1990’s linear equation year class index strength in the “Bay Study”.

**BDCP Objective #1**

Provide sufficient flows (at Rio Vista/Verona) during above normal and wet water year types for larval and YOY production (age class) such that there is a self-sustaining reproductive population.

(Notes: Need enough adults to take advantage of the good conditions and reproduce. S. Unger reviewed the DRERIP models and the Kolhorst citations and she will follow-up here)

|  |  |
| --- | --- |
| **Relation to Global Objectives** | Improving migration success will:   * Increase the distribution of adult white sturgeon |
| **Indicators** | juvenile migration and larval dispersal patterns see the “Bay Study by DFG/IEP” |
| **Location** | * Sacramento River (at Rio Vista) * San Joaquin River |
| **Attribute** | * Average daily flows |
| **Quantity or State** | \_\_% increase in larval and juvenile white sturgeon in the Central Delta.  \_\_% improvement in migration success. |
| **Time Frame** | TBD |

### Stressor #2: Passage Impediments/Barriers

The Fremont Weir is a documented barrier to white sturgeon (Z. Matica, Department of Water Resources, pers. comm.).

~~The effect of Delta Cross Channel (DCC) operations are not known; they are open when juvenile and post-spawn white sturgeon are outmigrating through the lower Sacramento River headed to the Delta (Israel 2008). This periodicity suggests that juvenile and post-spawn green sturgeon likely are redirected by these operations when tides are forcing flows into the interior delta routes, which may delay migrations, expose fish to adverse conditions, or influence growth and survival (Israel 2008).~~

**BDCP Objective #2**

Improve upstream fish passage success for adults through the Fremont and Lisbon weirs and other operational gates.

|  |  |
| --- | --- |
| **Relation to Global Objective** | Elimination of barriers to passage will have positive effects on:   * Productivity |
| **Indicator** | Migration rate |
| **Location** | Fremont Weir  Lisbon Weir  Other gates and barriers |
| **Attribute** | * Immigration rate * Immigration success |
| **Quantity or State** | Confirmed passage of green sturgeon past barriers in the Planning Area. |
| **Time Frame** | Immediately following passage construction/implementation. |

### Stressor #3: Water Quality (Toxics, D.O. and Temperature)

White sturgeon are long-lived, bottom-feeding fish at the top of the benthic food web, and are bioaccumulators of contaminants (Israel et.al, 2008). White sturgeon growth, fecundity, and egg size are likely negatively affected by contaminants which persist for a long time in the environment like selenium and mercury (Israel and Klimley 2008). Pollutants like endrocrine disruptors and pyrethroids, may also have effects on juvenile white sturgeon (Israel and Klimley 2008).

Low levels of dissolved oxygen result in reduced oxygen consumption rates, swimming abilities, and growth in white sturgeon (Crocker and Cech 1997, Cech et al. 1984). White sturgeon forage in subtidal and intertidal habitats in the western and southern Delta, where low dissolved oxygen can occur seasonally (Israel et. al, 2008). The Stockton Deep Water Ship Channel may also limit the distribution of white sturgeon in the summer and fall due to low dissolved oxygen levels.

Juvenile sturgeon occupy the Delta year round and may be exposed to increased water temperatures in the Delta during the late spring, summer, and early fall due to the loss of riparian shading and by thermal inputs from municipal, industrial, and agricultural discharges (Israel and Klimley 2008).

**BDCP Objective #3**

1. Toxics - Initiate and complete focused studies to determine the chronic threshold level of ammonia, organophosphate, pyrethroid pesticides and copper in the Delta for white sturgeon. Based upon the results of these studies, reduce levels of these constituents below the chronic threshold effects levels for white sturgeon. Reduce levels of Se to below the chronic threshold in Suisun Marsh and western Delta ROAs that are essential foraging habitats for white sturgeon
2. Dissolved Oxygen - Provide dissolved oxygen levels above the threshold effects levels for white sturgeon. Conduct a focused study to determine DO tolerances for pre-spawning adults, spawners, and mature adults (Israel, Drauch, and Gringas 2009.)
3. Temperature – Maintain water temperatures in key rearing areas below threshold effects levels for white sturgeon.

|  |  |
| --- | --- |
| **Relation to Global Objective** | Improvements in key water quality parameters will positively effect:   * Abundance * Productivity * Distribution |
| **Indicator** | Water quality parameters. |
| **Location** | BDCP Planning Area  Stockton Deep Water Ship Channel |
| **Attribute** | * Decreasing concentration in bioindicator species (clams) for;   + selenium   + mercury   + pyrethroids, * Dissolved oxygen levels (mg/L) * Water temperatures (°C) |
| **Quantity or State** | Reduce or maintain concentrations of the water quality parameters below the chronic threshold values (determined by science) as listed below:  Selenium: Levels of dietary Se consumed should not exceed 20 microg Se/g. If levels of dietary Se consumed exceed 10 microg Se/g then more frequent monitoring and other measures may apply (i.e. 10 microg Se/g is a “yellow-light) (Tashjian et al. 2006  Other Toxics: Additional research is needed to determine toxicity thresholds for green and white sturgeon (Israel et al 2009).  DO: Maintain dissolved oxygen levels at greater than 10 ppm during February to May for sturgeon eggs and embryos in the lower rivers. Greater than 80 mmHg for feeding larvae and juveniles in the lower river and Delta. Additional research is needed to determine DO tolerances for pre-spawning adults, spawners, and mature adults (Israel, Drauch, and Gringas 2009.)  Temperature: <16oC during February to June for sturgeon eggs, embryos, and feeding larvae in the lower rivers. <20oC for juveniles in the lower rivers and Delta year-round. <20oC year-round in the lower river and river for pre-spawning adults, spawners, and mature adults . |
| **Time Frame** | Near-term (clam concentration) and long-term (fish tissue concentration). Note, when measuring concentration of toxics in sturgeon, samples may be needed approximately once every five years. |

### Stressor #4: Illegal Harvest

As with most other sturgeon species, the life history characteristics of white sturgeon (e.g., late maturing, infrequent spawning) in concert with cyclic recruitment in the Sacramento River population make them susceptible to overexploitation, and the additional annual mortality due to harvest by sport anglers over and above natural mortality rates cannot be dismissed as a potential limiting factor of the white sturgeon population (Israel et.al., 2008).

When the weirs on the Yolo and Sutter bypasses are impassable, white sturgeon on their way to the spawning grounds are often stranded, leaving them vulnerable to poaching they are rescued (Z. Matica, Department of Water Resources, pers. comm.).

**BDCP Objective #4**

Reduce poaching of adult white sturgeon in the Planning Area.

|  |  |
| --- | --- |
| **Relation to Global Objectives** | Eliminating poaching will increase abundance |
| **Indicator** | Number of wardens in key sturgeon fishing locations within the Planning Area |
| **Location** | Entire Planning Area (i.e. Central Valley) |
| **Attribute** | Number of wardens in key sturgeon fishing locations within the Planning Area.  Season: the time of year that sturgeon fishing occurs (i.e. spring and summer for green and summer and fall for white sturgeon). |
| **Quantity or State** | Increased warden presence |
| **Time Frame** | Immediately |

### Stressor #5: Habitat Loss and Modification

In the Bay-Delta, channelization has likely had a negative impact on the amount of intertidal habitat available for juvenile and adult foraging, these areas are presumably important to juvenile growth and reproductive maturation of adults (Israel et al, 2008). Invasive plant species in the Bay-Delta have reduced the quality of shallow water habitats available for juveniles and adults, while increasing habitat for non-native predatory species (Israel et al, 2008).

(Note: Tidal marsh allocanthous support of clams and other macro-crustaceans contribute to the prey base of sturgeon.)

**BDCP Objective #5**

Improve rearing habitat for white sturgeon. Conduct focused study of turbidity requirements for sturgeon eggs, embryos, larvae, and juveniles in order to define suitable incubation and rearing habitat for this parameter.

|  |  |
| --- | --- |
| **Relation to Global Objectives** | Increasing the extent of, access to and availability of suitable rearing habitat will improve the productivity of white sturgeon. |
| **Indicator** | Sub- and intertidal habitat |
| **Location** | BDCP Planning Area |
| **Attribute** | Extent and quality of sub-and intertidal habitat with suitable temperatures, turbidity, and DO. |
| **Quantity or State** | Increase in acreage of rearing habitat where optimal temperature, turbidity and DO levels are maintained as listed below:  Temperature: <16oC during February to June for sturgeon eggs, embryos, and feeding larvae in the lower rivers. <20oC for juveniles in the lower rivers and Delta year-round. <20oC year-round in the lower river and river for pre-spawning adults, spawners, and mature adults .  Turbidity: Additional research is needed to determine preferred turbidity ranges for white sturgeon (Israel, Drauch, and Gringas 2009). Once study is completed, maintain the turbidity ranges referenced therein.  DO: Maintain dissolved oxygen levels at greater than 10 ppm during February to May for sturgeon eggs and embryos in the lower rivers. Greater than 80 mmHg for feeding larvae and juveniles in the lower river and Delta. Additional research is needed to determine DO tolerances for pre-spawning adults, spawners, and mature adults (Israel, Drauch, and Gringas 2009). |
| **Time Frame** | Not specified. Assume ELT and LLT steps/milestones for restoration of western, northern and Suisun ROA’s. |

### Stressor #6: Entrainment

White sturgeon entrainment from agricultural operations, power plants, and the state and federal water project facilities causes direct mortality for migrating larvae, juvenile, and adult white sturgeon, though the magnitude of these stressors varies for life stages and location (Israel et. al, 2008). The overall impact of entrainment of fish populations is typically unknown (Moyle and Israel 2005), however there is enough descriptive information to predict where white sturgeon may be entrained (Israel and Klimley 2008).

(Note: Entrainment is a low magnitude stressor for sturgeon, currently. This should be addressed during real-time operations)

**BDCP Objective #6**

Reduce entrainment of juvenile white sturgeon.

|  |  |
| --- | --- |
| **Relation to Global Objective** | Reducing direct and indirect mortality associated with entrainment and salvage will have positive effects on:   * Abundance * Productivity |
| **Indicator** | Entrainment numbers and mortality rates. |
| **Location** | Power plants and water diversions within BDCP planning area. |
| **Attribute** | Entrainment rates   * Mortality * Occurrence |
| **Quantity or State** | Normal (or wetter) water year type:   * Entrainment rate ≤ \_\_% of total white sturgeon population.   Below normal (or drier) water year type:   * Entrainment mortality rate ≤ \_\_% of total white sturgeon population. |
| **Time Frame** | Within 10 years of permit issuance and maintained annually thereafter. |

### Stressor #7: Dredging

**BDCP Objective #7**

Minimize the effects of dredging on sturgeon.

# References

Cech, J.J., S.J. Mitchell, and T.E. Wragg. (1984). Comparative growth of juvenile white sturgeon and striped bass: effects of temperature and hypoxia. Estuaries 7:12-18.

Crocker, C.E. and J.J.Cech Jr. (1997). Effects of environmental hypoxia on oxygen consumption rate and swimming activity in juvenile white sturgeon, Acipenser transmontanus, in relation to temperature and life intervals. Environmental Biology of Fishes 50:383-289.

Isreal J., Drauch A., and Gingras M. (2009). Life History Conceptual Model for White Sturgeon  *(Acipenser transmontanus).* Reviewed.

Isreal, J.A. and Klimley A.P. (2008). Life History Conceptual Model for North American Green Sturgeon (Acipenser medirostris). December 27, 2008. Reviewed.

Moyle, P.B., and Israel, J.A. (2005). Untested assumptions: effectiveness of screening diversions for conservation of fish populations. Fisheries **30**(5): 20-+.

Science Applications International Corporation [SAIC]. (2009). Bay Delta Conservation Plan – Draft Document. Appendix A-X pp. 502-515.

# Attachment 1 Objective Worksheet

|  |  |
| --- | --- |
| **Relation to Global Objective** | How will the stressor-level objective contribute to achieving the global objective? |
| **Indicator** | What will be measured?  Species, habitat, ecological process, physical condition… |
| **Location** | Where will it be achieved? |
| **Attribute** | What aspect of the indicator will be measured?  Population size, density, cover, presence/absence, reproductive rate… |
| **Quantity or State** | What measurable condition or change is expected?  Increase, decrease, maintain or limit negative impact?  *Quantity*: 500 individuals, 20% cover, 30% increase …  *Quality*: Weed-free, all life stages present, cover class 4… |
| **Time Frame** | When will this be achieved? |