**Green Sturgeon - DRAFT**

**BDCP Logic Chains for Covered Fish Species**

***Note to Reviewer:***

*The following presents a draft set of BDCP biological objectives for green 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.*

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# Global Goal

Attain self-sustaining populations of green sturgeon that will persist indefinitely and to support future proposed de-listing criteria. (Note: There currently is not a Recovery Plan for Southern DPS green sturgeon which would include detail of de-listing criteria.)

# Global Objectives

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

# Stressors/Limiting Factors

The following stressors/limiting factors were adapted from Israel and Klimley (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 Delta inflow and outflow 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** | Entrainment | Entrainment at project and non-project facilities |
| **5** | Illegal harvest | Effects of poaching. |
| **6** | Habitat loss and modification | Changes in the extent, access to, and or quality of in-Delta habitat. |
| **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. |
| **Stressors Not Addressed by BDCP** | | |
| **9** | Invasive species | Effects of non-native species through predation and competition. |

### Stressor #1: Altered Flows

Current flow management may inhibit the return of green sturgeon to the Sacramento River and Bay-Delta estuary by restricting seasonal flow necessary as cues for spawning and emigration of juveniles (Israel and Klimley 2008).

**BDCP Objective #1**

Determine through targeted studies and 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.

(Note: Since sufficient flows are not defined, a targeted study is needed to determine the flow. In this case, flow may be related to characteristics like duration, rate of change, magnitude, frequency, and timing).

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| **Relation to Global Objectives** | Improving migration success will:   * Increase productivity * Increase abundance |
| **Indicators** | Green sturgeon age class abundance |
| **Location** | * Sacramento River (at Rio Vista) * Feather River * Upper Sacramento River |
| **Attribute** | \_\_\_\_(year class) river cohort index of abundance (tbd and may include eggs, larvae and young of year).  Season: flows in April, May, June during Wet and AN years |
| **Quantity or State** | Positive trajectory in the abundance of river cohort index towards recovery. Sustainable population level thereafter. |
| **Time Frame** | Within five (5) above normal or wet water years..  *Note: This number (5) was determined by reviewing histogram of flows in Sacramento River by water year type*. |

### Stressor #2: Passage Impediments/Barriers

Barriers such as the Fremont and Lisbon weirs are presumed passage impediments for green sturgeon. This may prevent or delay adult green sturgeon from reaching their spawning areas. Reduced access to spawning areas may limit egg survival, since adults would reach optimal spawning habitats later in the season when water temperatures may be suboptimal, and this stressor may therefore influences the population abundance.

**BDCP Objective #2**

Improve upstream fish passage success for adults through the Fremont Weir and other operational gates/barriers.

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| **Relation to Global Objective** | Elimination of barriers to passage will have positive effects on productivity. |
| **Indicator** | Upstream and downstream passage |
| **Location** | Fremont Weir  Other operable gates and barriers |
| **Attribute** | * migration rate * migration 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)

Water quality is likely a limiting factor during early life history stages of green sturgeon (Israel and Klimley 2008). Green 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 green sturgeon (Israel and Klimley 2008).

It is possible that low levels of dissolved oxygen result in chronic stress in young green sturgeon (Lankford et al. 2003), which forage in subtidal and intertidal Delta habitats (Israel and Klimley 2008) and presumably also the Stockton Deep Water Ship Channel.

Juvenile green sturgeon occupy the Delta year round and may be exposed to increased water temperatures in the late 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).

(Note: Since this is a marine migrant species, their exposure to contaminants in the Delta might have a minimal effect.)

**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 green sturgeon. Based upon the results of these studies, reduce levels of these constituents below the chronic threshold effects levels for green sturgeon. Maintain the level of Se below the chronic threshold.
2. Dissolved Oxygen - Provide dissolved oxygen levels above the threshold effects levels for green sturgeon. Conduct a focused study to determine DO tolerances for young-of-year juveniles, spawning adults, and post-spawning adults (Israel and Klimley 2008).
3. Temperature – Maintain water temperatures in key rearing areas below threshold effects levels for green sturgeon.

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| **Relation to Global Objective** | Improvements in key water quality parameters will positively effect:   * Abundance * Productivity * Distribution |
| **Indicator** | Water quality parameters. |
| **Location** | BDCP Planning Area with site specific monitoring locations in the ROA’s. |
| **Attribute** | * Decreasing concentration in bioindicator species (clams) for the near term and fish tissue concentration in the long-term of;   + selenium   + mercury (seasonal floodplain or intertidal habitat)   Concentration in environment (soil, water etc) of   * + - 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).  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 sturgeon (Israel et al 2009).  DO: Maintain dissolved oxygen levels at greater than 60% of air saturation during April to October for sturgeon eggs, embryos, and larvae in the upper and middle rivers. Additional research is needed to determine DO tolerances for young-of-year juveniles, spawning adults, and post-spawning adults (Israel and Klimley 2008).  Temperature: <17oC during April to October for sturgeon eggs, embryos, and larvae in the upper and middle rivers. 15-19oC during August to March for young-of-year juveniles. 15-19oC year-round in the Delta for juveniles. |
| **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

Poaching for sturgeon seems to be a threat in the Sacramento River, and green sturgeon may be illegally harvested in these operations (Israel and Klimley 2008). Manager’s understanding for the effect of fishing-associated mortality on green sturgeon is low and the predictability of this stressor is little (Israel and Klimley 2008). Sturgeon that concentrate behind the Fremont Weir during periods of high flow are subject to heavy illegal fishing pressure or become stranded behind the flashboards when high flood flows recede (M. Marshall, pers. comm.). *This is not what the DWR surveys of the Fremont Weir show.*

*(note: are there records of stranding, or accumulation of green sturgeon at the Fremont Weir.)*

*Note: It is currently illegal to possess a green sturgeon in California. LC members have not heard that poaching is a problem for the green sturgeon population. This is a low magnitude stressor.*

**BDCP Objective #4**

Determine through targeted studies the significance of poaching to the population and based upon study results, reduce poaching of adult green sturgeon in the Planning Area.

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| **Relation to Global Objectives** | Reducing poaching will likely increase abundance and productivity |
| **Indicator** | Number of wardens in key sturgeon fishing locations within the Planning Area. |
| **Location** | Planning Area |
| **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

Channelization of the estuary has likely negatively impacted the amount of subtidal and intertidal habitat available for green sturgeon foraging (Israel and Klimley 2008). These habitats have been lost along the river corridor and San Pablo and Suisun bays, where subadult and adult green sturgeon are commonly found (Israel and Klimley 2008). These estuarine habitats are important for growth during the juvenile, coastal migrant, and adults life stages (Israel and Klimley 2008).

**BDCP Objective #5**

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

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| **Relation to Global Objectives** | Increasing the extent of, access to, and availability of suitable rearing habitat will improve the productivity of green sturgeon. |
| **Indicator** | Tidal habitat |
| **Location** | BDCP Planning Area (especially the western and northern and Suisun ROA’s) |
| **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: <17oC during April to October for sturgeon eggs, embryos, and larvae in the upper and middle rivers. 15-19oC during August to March for young-of-year juveniles. 15-19oC year-round in the Delta for juveniles.  Turbidity: Additional research is needed to determine preferred turbidity ranges for green sturgeon (Israel and Klimley 2008). Once study is completed, maintain the turbidity ranges referenced therein.  DO: Maintain dissolved oxygen levels at greater than 60% of air saturation during April to October for sturgeon eggs, embryos, and larvae in the upper and middle rivers. Additional research is needed to determine DO tolerances for young-of-year juveniles, spawning adults, and post-spawning adults (Israel and Klimley 2008). |
| **Time Frame** | ELT and LLT steps/milestones for restoration of western, northern and Suisun ROA’s. |

### Stressor #6: Entrainment

Entrainment, or loss of life due to water pump, canal, or dam operations can be a problem for almost every life stage of green sturgeon- larvae, juveniles, subadults, and adults (Israel and Klimley 2008). Entrainment may significantly reduce the number of adults in the Sacramento River returning to the sea after spawning (Richard Corwin, Pers. Comm.). The overall impact of entrainment on fish populations is typically unknown (Moyle and Israel 2005), however there is enough descriptive information to predict where green sturgeon may be entrained (Israel and Klimley 2008).

**BDCP Objective #6**

Reduce entrainment of juvenile green sturgeon.

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| **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 green sturgeon population.   Below normal (or drier) water year type:   * Entrainment mortality rate ≤ \_\_% of total green 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:

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

Lankford, S.E., Adams, T.E., and Cech, J.J. (2003). Time of day and water temperature modify the physiological stress response in green sturgeon, Acipenser medirostris. Comparative Biochemistry and Physiology A **135**: 291-302.

Marshall, M. (Supervisory Fish Biologist, USFWS, Stockton, California), Conversation with Rick Wilder about fish stranding at Fremont Weir, February 9, 2007.

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. 483-501.

# Attachment 1: Objective Worksheet

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| **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? |