2007 Field Season Summary for the Adult Sturgeon Population Study

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Nov. 16, 2007

The adult sturgeon population study conducted by the California Department of Fish and Game (CDFG) has been ongoing intermittently since 1967. Presented here is a summary of the 2007 field season. This mark-recapture project is designed to understand and monitor the population dynamics of white sturgeon (*Acipenser transmontanus*) and green sturgeon (*Acipenser medirostris*), with the ultimate goal being to provide the tools to inform science-based resource management decisions. These tools include relative and absolute abundance, harvest rate, overall mortality rate, individual growth rates, and large-scale movement/migration patterns. To this end, our objective during the tagging study was to capture, tag, measure, and release in good condition as many sturgeon as possible and to document previously tagged individuals. Secondary objectives this season included collaborating with other researchers investigating various aspects of sturgeon biology, collecting baseline biological data for leopard sharks and California halibut, evaluating new methods for reducing marine mammal interactions, and evaluating the use of injected Passive Integrated Transponder (PIT) tags in sturgeon.

Methods

Adult sturgeon were captured using trammel nets deployed from two research vessels (*New Alosa* and *Striper II*) in San Pablo Bay and Suisun Bay from August 2 to October 25, 2007. The 2007 tagging season saw a shift in fishing effort from primarily in San Pablo Bay to primarily in Suisun Bay, with the *Striper II* fishing exclusively in Suisun Bay and the *New Alosa* fishing approximately 50% in each bay. This shift was a strategic move to increase the number of sturgeon tagged relative to 2006 and was based on data from trials conducted during the 2006 season. Additionally, the 2007 season included two major alterations to our sampling methodology designed to decrease interactions with marine mammals. These changes included shortening the amount of net in the water from primarily 200 fathoms (366 m) to primarily 100 fathoms (183 m) and decreasing the net soak time (the amount of time between the completion of the net set to the beginning of the net retrieve) from about 45 minutes to about 30 minutes per set.

The *New Alosa* is a 42 foot West Coast-style combination-type fishing vessel with a 610 hp Volvo engine capable of cruising at 17 knots, and the *Striper II* is a 32 foot Southeast Alaska-style gillnetting vessel with a 6-V 53 Detroit Diesel engine capable of 7.5 knots. For the 2007 season, the *New Alosa* was berthed at the Vallejo Marina and the *Striper II* was berthed in the Martinez Marina, irrespective of bay fished. Each vessel had a standard crew of four people including a boat operator, a deckhand, and two scientific aides. Both vessels were equipped with one 200 fathom (366 m) trammel net, one hydraulic net reel, one resuscitation tub, and one tagging station. Typically, the boat operator ran the boat, operated the net hydraulics, and extracted fish from the net upon retrieval; the deckhand tended the net during deployment, and assisted the boat operator with removing fish and debris from the net upon retrieval; the scientific aides measured and tagged sturgeon, recorded bycatch, collected biological data/samples, and assisted with other boat duties as needed.

The trammel nets consisted of two 100 fathom sections separated by approximately 20 meters of rope to facilitate the deployment of either a 100 fathom net set or a 200 fathom net set. Each of these 100 fathom sections was comprised of four contiguous 25 fathom (45.7 m) long by 2 fathom (3.7 m) deep sections of net. Each 25 fathom net section was made up of a gillnet panel between two panels of trammel net. The gillnet was an Alaska salmon-style webbing made up of multi-strand monofilament twist, and the trammel net was made up of three multi-strand twisted nylon braids. The diagonal mesh size of the gillnets varied by 25 fathom net section (either 6, 7, or 8 inch mesh), with one 100 fathom net section being assembled in the following order: 8”, 7”, 6”, 8”.

The decision of where to set the net was based on avoiding known snags, the observation of jumping sturgeon, and the knowledge and experience of the boat operator. The net was deployed across the prevailing current or wind (whichever was stronger) and took approximately five minutes to set. Once deployed, the net was carefully monitored during the drift to detect snags, tangles, and marine mammal interactions, as well as to avoid conflicts with other vessels, channel markers, and other hazards. The nets were set as many times as possible (usually 4-5, but up to 7) in a given workday, and soaked for approximately 30 minutes from the end of the set to the beginning of the retrieval. The data collected for each net set included the time of the start and end of the net set/retrieve, the latitude-longitude of the start and end of the net set/retrieve, the water temperature, the number of pinnipeds patrolling and raiding the net, any vessel interactions, and the weather (based on the Beaufort scale). The decision to set a full 200 fathom net and/or to leave the net in the water longer than 30 minutes was made based on the abundance of bycatch and/or sturgeon in earlier sets, the presence of marine mammals in the area, and the weather conditions. Our goal was to maximize the number of sturgeon caught while minimizing interactions with marine mammals and minimizing stress to sturgeon and bycatch by keeping the maximum amount of time any part of the net was in the water to less than 70 minutes.

Upon being brought onboard the vessel, each sturgeon was immediately removed from the net and carefully placed in the tagging cradle. During net sets where the amount of sturgeon caught exceeded the ability of the tagging crew to process them in a timely manner, sturgeon were placed in a plastic tub filled with water pumped from the bay. Sturgeon were then processed out of the tub instead of directly from the net. Upon being placed in the tagging cradle, sturgeon were checked for old tags or evidence of a shed or clipped tag, had their total length measured (to the nearest cm), tagged or retagged with a disk tag based on the size of the fish and the presence/condition of an old tag, injected with a PIT tag, had biological samples taken as applicable, subjectively assessed for overall condition/stress level (good, fair, or poor), and then released as quickly as possible. Fish too large to place in the cradle (approx. > 180 cm) were processed on the deck of the vessel, with length measurements being taken using a retractable metal measuring tape. Sturgeon which exhibited an unusually high level of stress and/or trauma (e.g. lack of “gilling”, lack of vigor, or severe bleeding) were placed in the plastic holding tub for resuscitation and released as soon as their condition improved.

Disc-dangler (Petersen) tags were inserted into all white sturgeon between 100 cm and 168 cm in total length (legal size 117-168 cm). Some sturgeon less than 100 cm were disc tagged early in the 2007 tagging season, but this practice was reviewed and halted after the recapture of a 2006 tagged sturgeon with a large wound from overgrowing the tag. Disk tags were placed in the flesh just below the base of the dorsal fin, midway between the anterior and posterior ends of the fin. Each disk tag offers a reward of $20, $50, or $100 to anyone who returns it to CDFG. When previously tagged fish were recaptured, their tag numbers were recorded and the fish were retagged only if the old tags were too tight or loose or had caused sores to form on the fish. Captured sturgeon that had obviously been tagged at one time but in which the tag was no longer present (i.e. wire sticking out of the fish below the dorsal fin) were recorded as having a “shed tag” and were retagged and released. Sturgeon that did not have a tag or wires present but exhibited open sores or scars at the location of tagging were counted as “possibly shed tags”.

Every sturgeon captured was implanted with a Crystal Tag® RFID-PIT tag. Sturgeon were scanned with a handheld scanner unit prior to implantation to ensure there were no pre-existing tags. PIT tags were then injected intramuscularly posterior to the base of the skull (1-3 cm) and left of the spinal column (1-2 cm) at a depth of 0.5-1 cm. The tag was then read with the scanner to ensure proper function and to record the unique eight digit identification number. Small sturgeon (< 60 cm) were implanted as shallowly as feasible (often < 0.5 cm) to minimize the chance of injury to the fish.

Biological samples were collected on certain fish for research collaborators. Fin samples (< 1 cm^2) were taken from the dorsal or pectoral fin on most sturgeon irrespective of size. Gill samples (1-2 mm of 5-6 filaments on the outer raker) were taken on a limited basis from a subset of white sturgeon caught (90 – 117 cm in length). All samples were stored in ethanol and paired with the fish’s PIT tag identification number for later analysis.

Bycatch species were documented, measured (California halibut, leopard shark, and Chinook salmon), sexed (leopard shark), and released as quickly as possible. All marine mammals (Pacific harbor seals and California sea lions) within 50 meters of the net were recorded, and any instance of a marine mammal predating fish captured in the net was also recorded.

Results

During the three months of this study, we performed 332 net sets (321x100 fathom sets and 11x200 fathom sets) over the course of 82 boat-days with a total of 278 hours of fishing time (25077 net-fathom-hours). The average fishing time (the amount of time from the beginning of the net deployment to the completion of the net retrieval) of each net set was 53 minutes, and crews averaged 4 net sets per day. A total of 889 white sturgeon and 17 green sturgeon were captured. Of the white sturgeon captured, 849 were measured and implanted with PIT tags, 29 were untagged and had length estimated (usually because they escaped while being brought aboard the boat), and 11 were recaptured sturgeon previously tagged. The length distribution of measured white sturgeon was 394 sublegal sized (< 117 cm), 395 legal sized (117 – 168 cm), and 60 oversized (> 168 cm). In addition to being implanted with PIT tags, a total of 688 white sturgeon were given disk tags, with 303 being of sublegal size (< 117 cm) and 385 being of legal size (117 – 168 cm).

Much of the fishing effort was focused on Suisun Bay in 2007 (Figure 1), with only 26% of net-fathom-hours being in San Pablo Bay and the remainder (74%) being in Suisun Bay.

Thus, most of the white sturgeon caught (93%) were located in Suisun Bay. Of the green sturgeon captured, 71% (12) were caught in Suisun Bay.

Figure 1: Locations of Net Sets

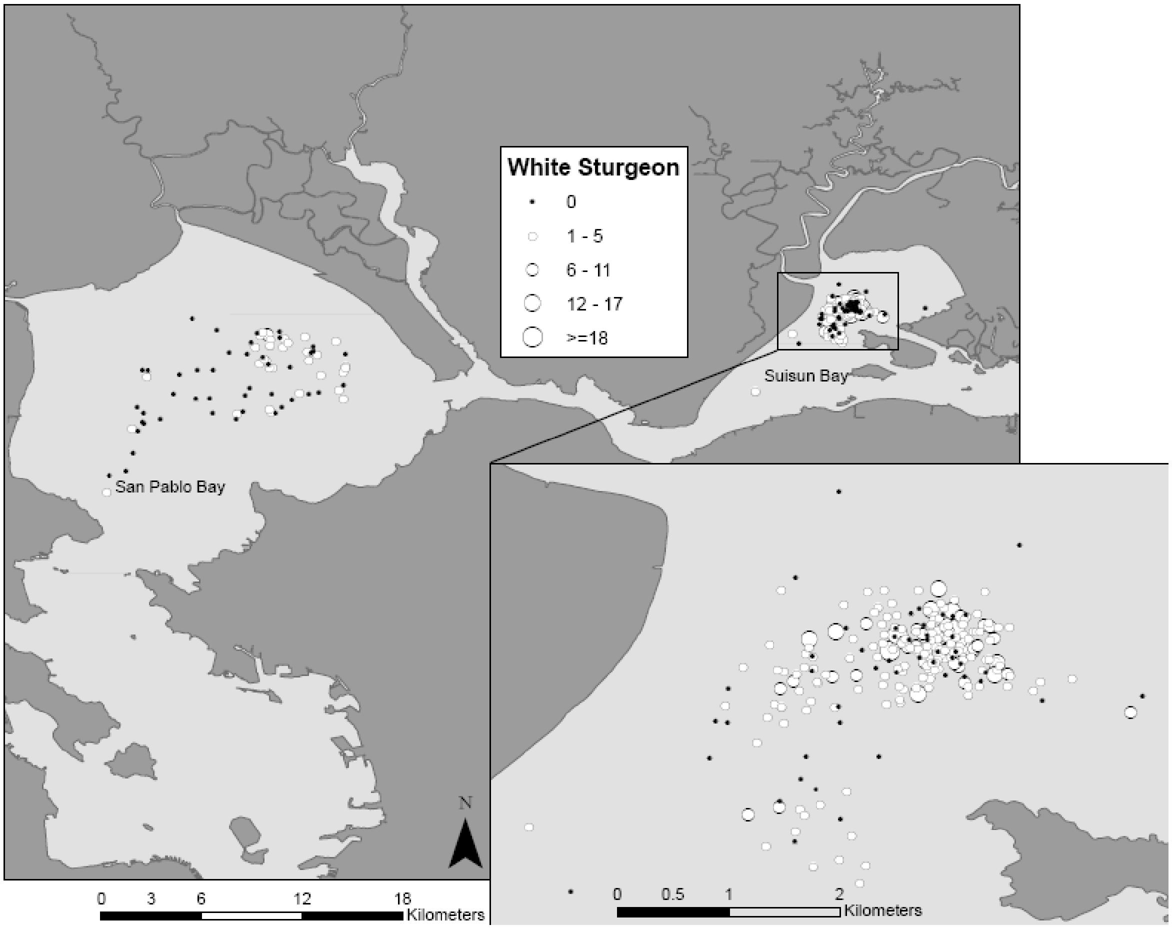

Figure 1: Map of location of net sets during the 2007 tagging season. Note that the size of the symbol is proportional to the catch of that net set, and black dots indicate sets where no sturgeon were caught.

We recaptured 11 white sturgeon in 2007, including 2 fish that had evidence of shed tags and 9 fish that were previously tagged and had retained their tags. Of the previously tagged sturgeon, 4 fish were tagged during the 2006 season and 1 fish was tagged during the 1993 season. Additionally, we had no "true" in-season recaptures, as defined for statistical purposes (i.e. assuming random mixing in the population) as a sturgeon being recaptured greater than 30 days from the initial tagging date but within the 2007 tagging season. We also did not recapture any previously tagged green sturgeon.

Of all the white sturgeon captured, approximately 94% were released in good condition and 6% were released in fair condition. Only one fish was released in poor condition. For green sturgeon, 88% were released in good condition and the remaining 12% were released in fair condition. The only capture related sturgeon deaths reported during the 2007 tagging season were due to one California sea lion killing 2 (possibly 3) adult white sturgeon in one day on San Pablo Bay.

The number of sturgeon caught was dependent upon the amount of fishing effort to catch them (e.g. number of boats, length of nets, amount of soak time for the nets). Thus, the Catch Per Unit Effort (CPUE) was calculated in order to standardize comparisons among boats and net sets. Catch was calculated as the sum of all newly-tagged fish, recaptured fish, and untagged fish brought to the boat. The unit of effort was 100 net-fathom-hours, which was equivalent to a net 100 fathoms long fished for 1 hour. Effort was calculated by weighting the soak time (the amount of time between the end of the net set and the beginning of the net retrieve) by 100% and the amount of time for the net deployment and the net retrieval by 50% (assuming a steady rate of deployment/retrieval). Overall, CPUE during the 2007 season for white sturgeon was 3.93 fish per 100 net-fathom-hours, though this varied significantly by net set, boat, and day. The CPUE was greater than 10 fish per 100 net-fathom-hours for 6 of 82 boat-days, with a maximum CPUE of 20.4 fish per 100 net-fathom-hours (Figure 2). These exceptionally high days appear to occur randomly throughout the three months of sampling, and they do not appear to correlate well with the CPUE on adjacent days or with the success of the other boat on the same day. The CPUE time series (Figure 2) does not appear to show any strong temporal autocorrelation, though some periodicity may be present, possibly due to tidal influences. Overall, CPUE for white sturgeon was substantially higher in September compared to August and October (Figure 3).

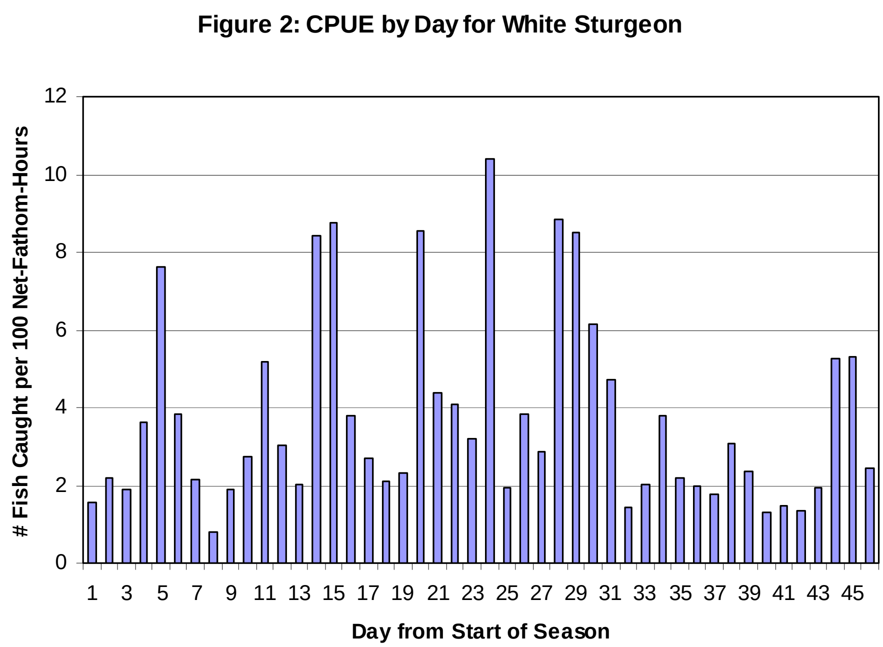

Figure 2: Average daily CPUE (i.e. both boats combined) by day from the start of the season. August = days 1 – 16, September = days 17 – 31, October = days 32 – 46. Data are for white sturgeon.

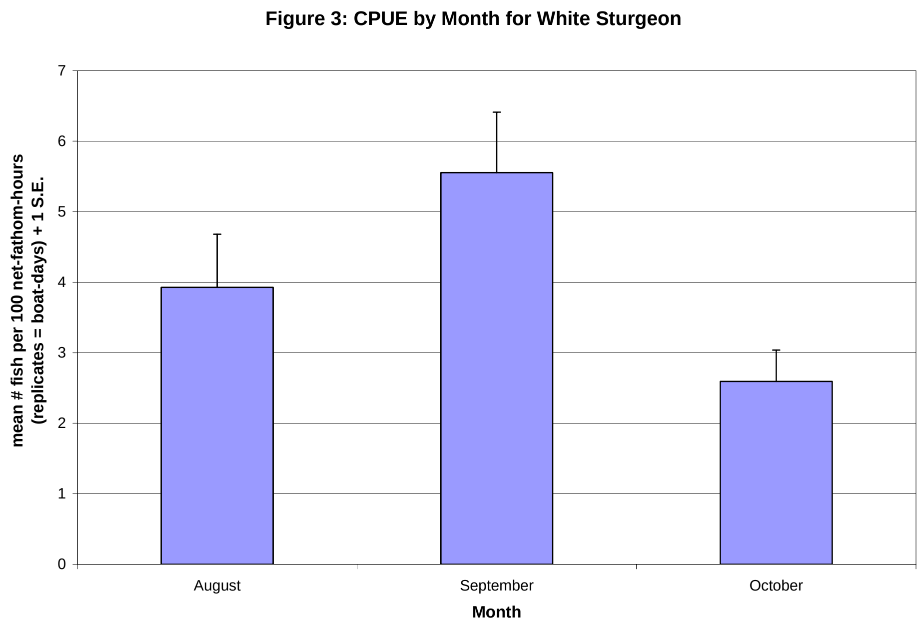

Figure 3: Monthly CPUE for white sturgeon during the 2007 tagging season.

A total of 889 white sturgeon were measured and the resulting length frequency distribution was unimodal, with the peak being between 101 and 110 cm total length (Figure 4). Most of the fish were close to or slightly smaller than the minimum legal size of 117 cm, indicating that a large cohort of fish is nearing entry into the recreational fishery. So few green sturgeon were captured and measured (16) that a meaningful interpretation of the size frequency distribution was not possible (figure not shown).

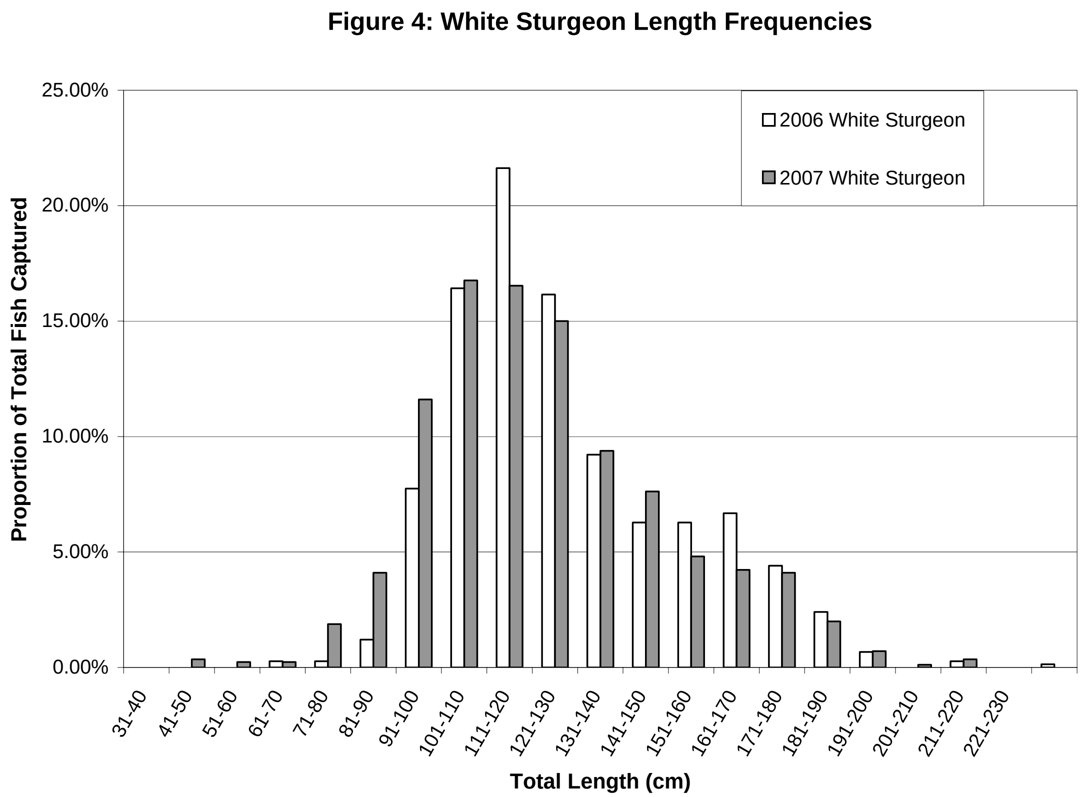

Figure 4: Length frequency distribution for all white sturgeon measured. Y-axis is the percent of total fish caught per year within the specific length range. The 2006 tagging season length frequency distribution is placed next to the 2007 distribution for comparison.

Bycatch during sturgeon tagging was primarily comprised of California bat rays (46% of total bycatch). Secondarily, starry flounder and Chinook salmon both made up 13% of total bycatch, followed in decreasing abundance by California halibut (7.6%), leopard sharks (6.9%), striped bass (4.1%), diamond turbot (3.5%), and seven-gill sharks (3.3%; Figure 5). The remaining four species of bycatch (Pacific harbor seal, white sea bass, spiny dogfish, and brown smooth hounds) totaled less than 2% of the total. All species of bycatch were released unharmed in most instances. The exceptions were Chinook salmon, and secondarily striped bass, that were killed by California sea lions and Pacific harbor seals while in the nets (n = 27). We measured the fork length for 43 California halibut, and 70% of these were between 50 and 60 cm in length. Leopard sharks were also measured (n = 39, mean TL = 119; Figure 6) and sexed (59% female, 41% male). In general, bycatch was severely reduced in 2007 (1068 instances in 2006 and 578 in 2007). Of the 578 untargeted individuals caught, only 21% were captured in Suisun Bay.

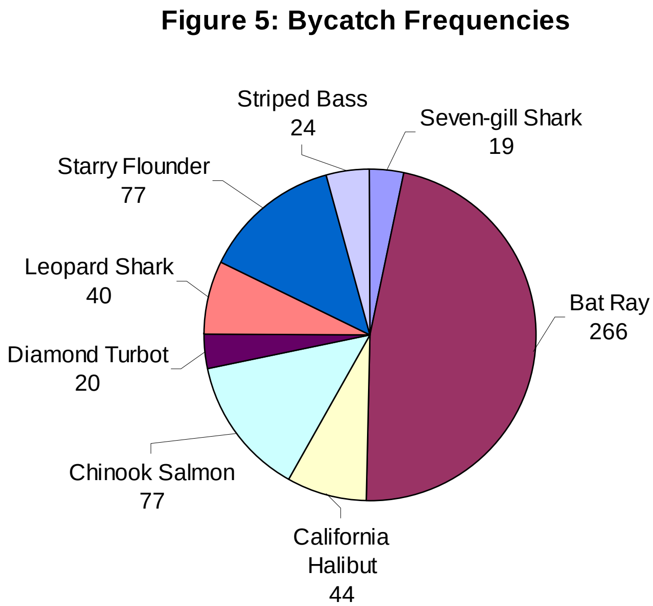

Figure 5: Total bycatch from sturgeon tagging operations during the 2007 season, with the number of individuals caught after the species common name.

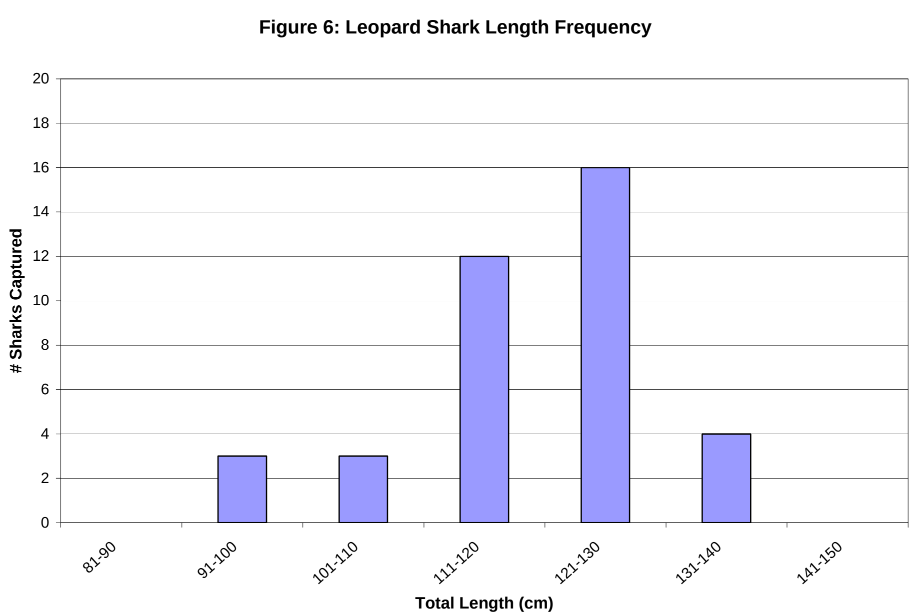

Figure 6: Length frequency distribution of leopard sharks captured during the 2007 tagging season. All sharks caught in San Pablo Bay. Legal size > 91 cm.

Discussion

The population metrics derived from the data collected this season will be calculated and presented detail in a future publication. Therefore, in the following discussion we briefly summarize and put into context the important findings from this season.

While sampling effort decreased by 36% (measured by total net-fathom-hours) compared with the 2006 sturgeon season, total catch of white sturgeon increased by 10% (82 fish). Thus, CPUE for total white sturgeon captured increased from 1.95 fish per 100 net-fathom-hours in 2006 to 3.93 in 2007. However, the CPUE calculated for 2007 is not directly comparable to 2006 (or previous years) because of the significant deviation from the typical sampling area (San Pablo Bay) to Suisun Bay. The increase in the CPUE for white sturgeon in 2007 was due in large part to the shift of our operations to Suisun Bay. Despite the dramatic increase in overall CPUE from 2006, the CPUE for legal-sized fish (a metric used for comparisons with historical data) in 2007 was nevertheless below the historical average (Figure 7). This metric, however, is also confounded by the periodic decrease in the legal slot limit for white sturgeon since the inception of the project.

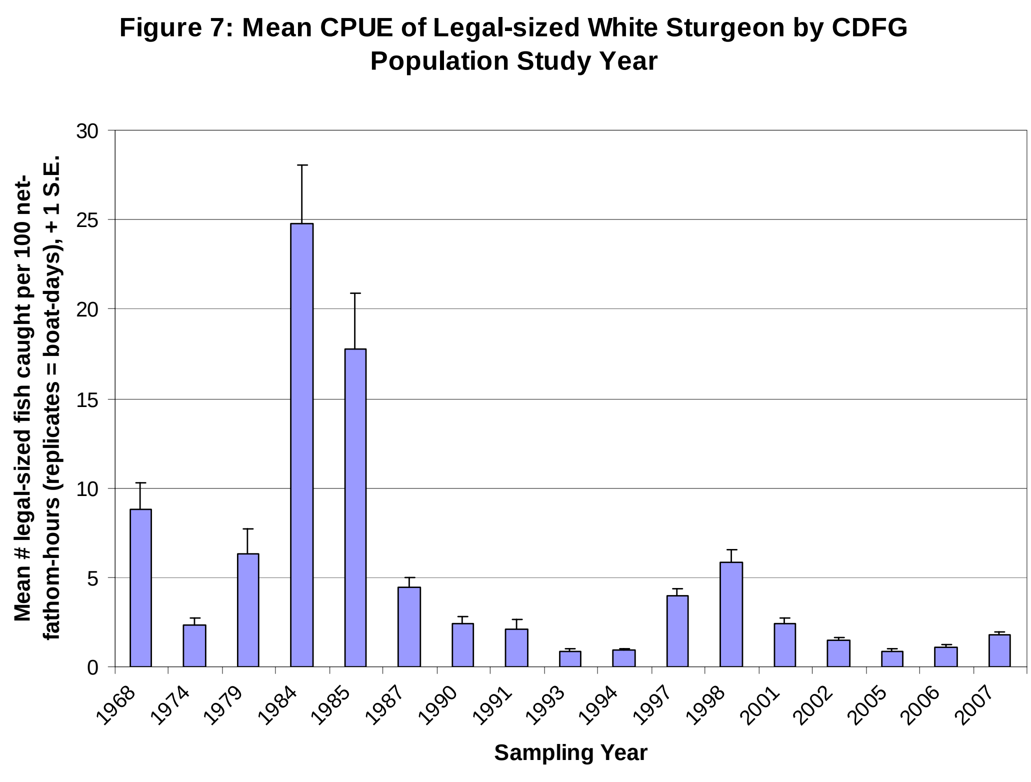

Figure 7: Mean daily CPUE for legal-sized white sturgeon for each sampling year.

Our shift of operations to primarily being focused in Suisun Bay was apparently successful. Our CPUE and total number of sturgeon caught not only increased over the previous year, but 93% of sturgeon captured came from Suisun Bay, where only 74% of the fishing effort was conducted. Another benefit to this shift in location was the drastic decrease of bycatch species with saltwater affinities (e.g., bat rays, leopard sharks) compared with previous years. The reduction in Chinook salmon bycatch from 2006 to 2007 was probably due, in large part, to the minimal salmon run in fall of 2007 (CDFG, personal communication), rather than a shift of operations to Suisun Bay or other protocol modifications (e.g., shorter net soak time, shorter net length). The *Striper II* clearly excelled in Suisun Bay with its shallow draft, low windage factor, and minimal freeboard. If future operations call for two vessels to sample in Suisun Bay, then an alternative to the *New Alosa* could be considered.

The 2007 sturgeon season saw a slight drop in the number of fish recaptured from previous years compared with 2006 (11 vs. 15, respectively). However, the rate of recapture was still higher than in 2005, where only one sturgeon was recaptured. In 2007, 4 fish tagged during the 2006 tagging season were recaptured, with a mean growth rate of 7.9 cm/yr. Additionally, one white sturgeon was captured with a tag implanted in 1993. This individual grew by 66 cm, which corresponded to a growth rate of 4.7 cm/yr. Unfortunately, many of the recaptured fish showed signs of injury from the implanted disk tags (open wounds, bleeding, and abscesses). In the future, alternative tag designs will be explored and double-tagging experiments will be conducted. Tagging options currently proposed include anchor, dart, and spaghetti tags.

The number of white sturgeon measured in 2007 was large enough to allow for the construction of a robust length frequency distribution, and this distribution shifted slightly to the right (larger total length) compared with 2006 (Figure 4), consistent with the growth of individuals. The cohort from the mid-1990s continued to move into the legal-sized slot limit (117 – 168 cm), with the highest number of fish being caught in the 110 – 119 cm range. However, the issue of net mesh size selectivity for different size classes complicates the interpretation of the length frequency data for our sample (i.e. statistical) population relative to the actual biological population. This issue will be analyzed in depth using data from previous years and reported in a future publication.

In 2007, we also began implementation of a PIT tagging program to 1) inconspicuously mark sublegal and oversized white sturgeon and all green sturgeon to prevent confusion with anglers, and 2) rigorously determine the rate of disk tag shedding through double tagging with PIT tags. While there are no results yet of recaptured PIT tagged fish, the implementation of the tagging went smoothly and successfully.

San Francisco Bay-Delta green sturgeon were officially listed by the federal government as a Threatened Species in 2006. As in the 2006 tagging season, we began sampling in August (one month earlier than in pre-2006 seasons) to better gather baseline population data for this species. However, unlike 2006, most green sturgeon were caught at the end of the tagging season as opposed to the beginning. Thus, 4 green sturgeon were caught in August, 4 in September, and 9 in October. We do not have an explanation for this shift, and there did not appear to be any correlation between total length and month of capture. Additionally, the limited number of green sturgeon captured in 2007 (17, compared with 28 in 2006) made meaningful interpretations of length frequency data impossible. However, it appeared that the majority (56%) of green sturgeon in Suisun and San Pablo Bays during our sampling period are juveniles (80-110 cm; Figure 4).

Biological data continued to be gathered for certain bycatch species (leopard sharks and California halibut) in 2007. Because of the increased sampling in the more inland, brackish water environment of Suisun Bay, fewer leopard sharks were captured than in 2006. However, enough sharks were sampled to construct a meaningful histogram (Figure 6). A length frequency distribution for California halibut was also created (figure not shown) and was indicative of a young adult population (if our nets sampled the entire population effectively), as California halibut mature at 23 – 43 cm depending on sex (Kucas and Hassler 1986). The cost for opportunistically collecting data on bycatch species is negligible, though these opportunities may decrease if our fishing efforts continue to shift toward Suisun Bay. Regardless, these data may be useful as a baseline for fisheries managers, and we plan to continue data collection.

California sea lions and Pacific harbor seals continued to pose a threat to fish entangled in our nets during 2007, particularly Chinook salmon and striped bass. Deterrent methods adopted for the 2007 season included shortening the net length from 200 fathoms to 100 fathoms and decreasing the soak time of the net from 45 minutes to 30 minutes. These methods may have played a role in our reduced salmon bycatch, and thus instances of pinnipeds raiding the nets, but the switch of fishing efforts to Suisun Bay and the minimal salmon run during 2007 (Pacific Fishery Management Council 2007) confounds this conclusion. Additionally, the 2007 field crew witnessed the first instance in the 50 year history of the project of a California sea lion killing and consuming an adult white sturgeon caught in our nets. This behavior has already become common with California and Steller sea lions in the Columbia River system (Brown pers comm.), and has been witnessed by numerous recreational anglers in the San Francisco Bay-Delta (personal communication). If the events in the Columbia River system are an indication, this behavioral shift in prey selection to include white sturgeon may prove highly troublesome in the future for the operation of this study, as well as for the entire white sturgeon population in the San Francisco Bay-Delta.

Acknowledgments

We would like to thank our boat operators Ken Flowers and Mike Silva, our deckhands Brian Delano and Galen Tigan, and all of our research assistants, including Andrea Drauch, Veronica Mullen, Katie Smith, Alyssa Stark, Emily Stevens, Angela Villanueva, and Travis Walker. We greatly appreciate their dedication and hard work.

References

Brown, Robin. Marine mammal biologist with the Oregon Department of Fish and Wildlife. Personal communication.

Kucas, S.T., T.J. Hassler. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest) -- California Halibut. U.S. Fish and Wildlife Service Biol. Rep. 82(11.44) pp 8

Pacific Fishery Management Council website, November 2007.