State of California
Department of Fish and Wildlife

M e m o r a n d u m

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Subject: Trends in Angling Effort, Catch, and Harvest of American Shad, and Implications for Regulations in the Sacramento Basin Sport Fishery

The purpose of this memorandum is to provide an update on subject fishery, and to assess the adequacy of current regulations for maintaining the sustainability and quality of the fishery.

Background

Current California fishing regulations allow for the take of 25 American Shad (shad) per day per licensed angler. The shad fishery is monitored for targeted angler effort, catch, and retention rates by the Central Valley Angler Survey (CVAS). According to CVAS data, the shad fishery ranks as the sixth most popular fishery in Central Valley anadromous waters (by targeted angler hours). Anglers spend, on average, 151,000 hours per year fishing for shad in Central Valley rivers and the catch per unit effort (CPUE) for shad is 0.6 shad per angler hour.

In recent survey years, CVAS staff have observed a trend in increasing shad effort and an apparent increase in shad harvest. The data collected had not been analyzed until now to verify whether this trend in increasing effort and harvest was in fact occurring. The purpose of the current analysis is to evaluate the American Shad fishery in the Central Valley and determine if the population appears to be reaching over exploitation levels. The specific questions addressed by this analysis are as follows: Has angling effort targeting shad increased since previous iterations of the CVAS; Has catch per unit effort increased since previous iterations of the CVAS; How if at all has shad harvest changed since previous iterations of the CVAS; Has angler retention of shad increased since previous iterations of the CVAS; Have male and female shad fork length (sizes) changed since previous iterations of the CVAS.

Angling Effort Targeting American Shad

The CVAS collect data on the shad fishery in the Sacramento, American, Yuba and Feather rivers every month in years 2008 through 2015. Older data dating back to 1991-1994 and 1998-2002 collected during previous iterations of the CVAS were also used in this analysis. Angling effort, reported as the number of angler hours targeting shad has increased since the early 1990's (Figure 1). However, the increase in

angling effort between the first iteration of the project (study years 1991-1994) and the current iteration (2008-2015) is not significant (ANOVA p=0.1670). There was a significant decline in angling effort targeting shad during the second iteration of the project (study period 1998-2002). The angling effort during this period was marginally significantly less than that of the first study period (p=0.051) and was significantly less than the effort observed in the current study period (p=0.002). A regression analysis of angling effort over the current iteration of the CVAS indicated that angling effort is not significantly increasing (p=0.2836).

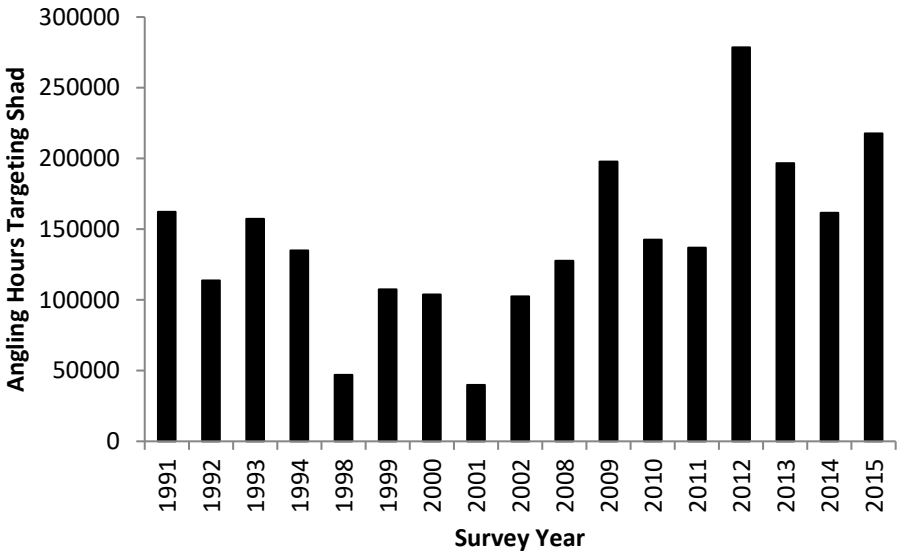

Figure 1. Angling effort targeting American Shad in the Central Valley, California.

Catch

Angler catch is defined as the number of fish kept plus the number of fish released. As angling effort and harvest have increased, angling catch has also increased (Figure 2). Shad catch has significantly increased from study periods 1 and 2 to the current study period 3 (p=0.008).

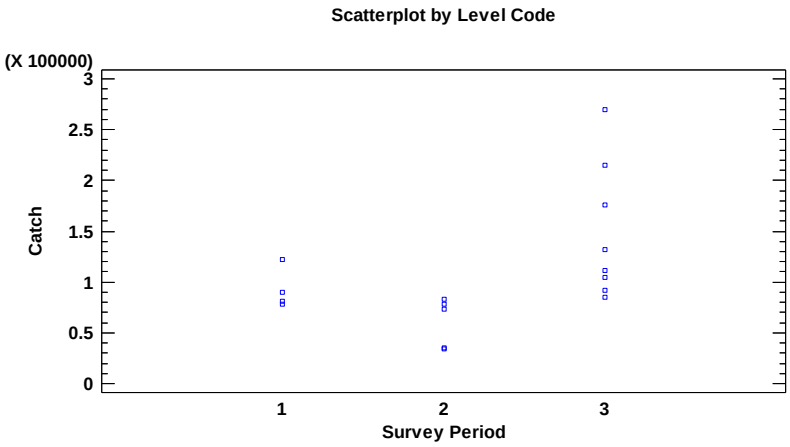

Figure 2. American Shad catch over time. Survey period denotes which CVAS iteration the data comes from. Survey Period 1 = 1991-1994, 2= 1998-2002, 3=2008-2015.

Harvest

Shad harvest has a significant relationship with angling effort ($p<0.001$), with shad harvest increasing exponentially with increased angling effort (Figure 3). As a result, harvest of shad has also significantly increased since the early 1990's ($p=0.010$, Figure 4).

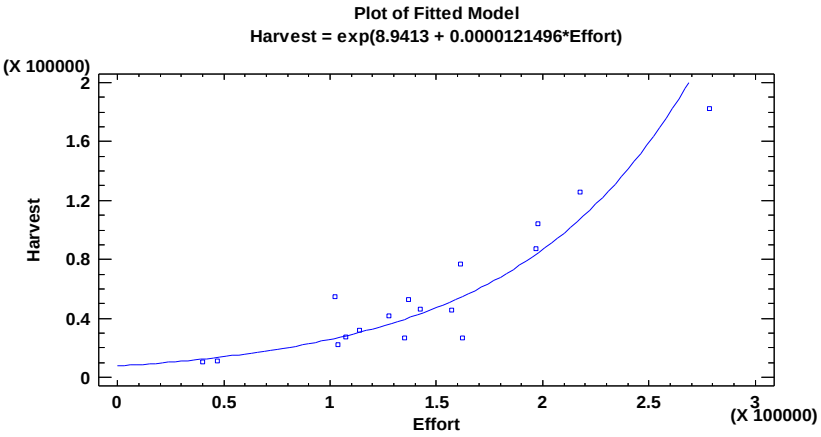

Figure 3. The relationship between angling effort for American Shad and the number of shad harvested is exponential and highly significant.

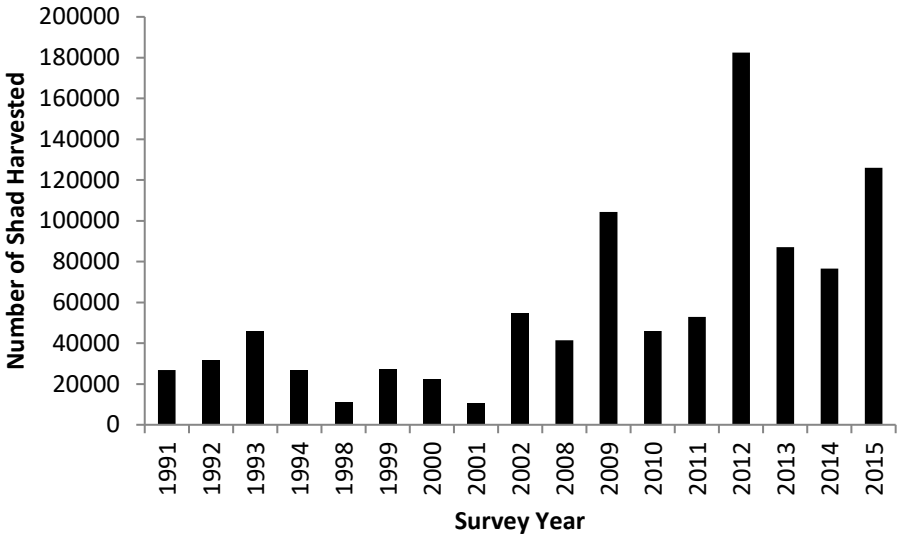

Figure 4. The estimated number of American Shad harvested by survey year.

A regression analysis of the data showed that retention of shad has also significantly increased (p=0.001) with each iteration of the project. The average retention rate from the 1991-1994 survey was 35%, the average retention rate from 1998-2002 was 39% and the current iteration of the CVAS (2008-2015) has a retention rate of 60% (Figure 5). Anglers report reasons for retention as primarily consumption and secondarily as bait.

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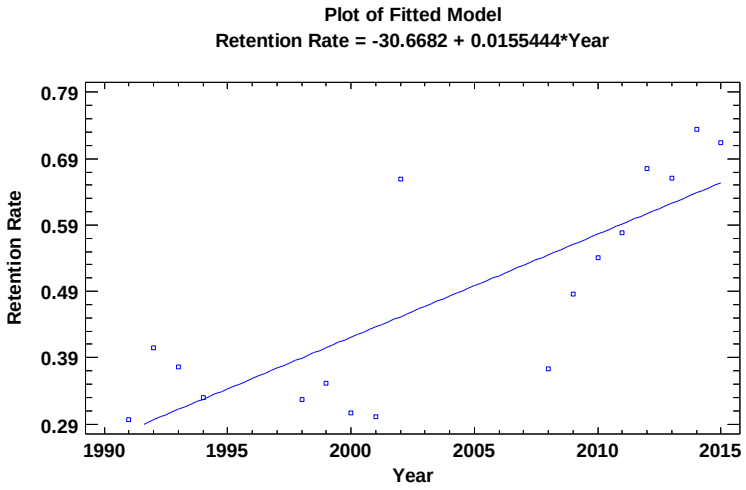

Figure 5. Retention rates of American Shad have significantly increased since the early 1990's.

Reason for concern

With increasing angler effort and harvest of shad, there is concern over whether the population is being overexploited. One indication that the population is declining would be if catch per unit effort (CPUE) was declining over time. Catch per unit effort is the number of fish caught (or harvested in this instance) per unit of effort (angler hours) expended. If effort was increasing and CPUE was decreasing, than the implication may be that the shad population is not keeping up with demand. A regression of CPUE on survey year, as well as an Analysis of Variance (ANOVA), indicated that CPUE was not significantly changing over time (Regression p= 0.2333)(ANOVA p=0.2996) (Figure 6). Average CPUE by study period (1991-1194, 1998-2002, 2008-2015) were as follows: 0.66 shad/hour, 0.77 shad/hour, and 0.79 shad/ hour respectfully.

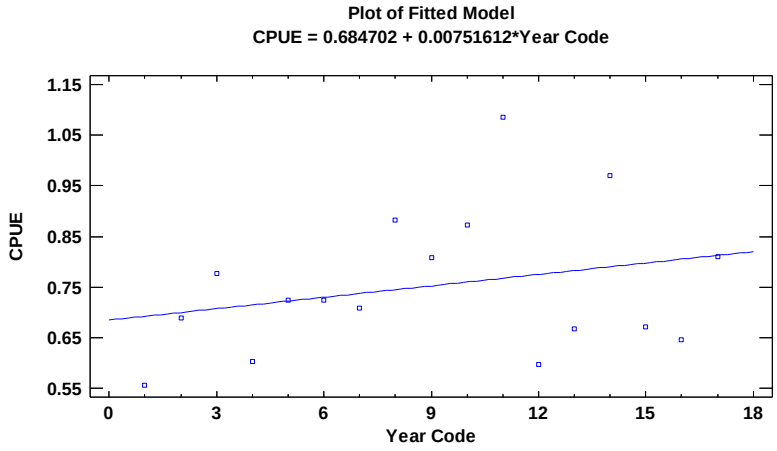

Figure 6. Regression of catch per unit effort (CPUE) on survey year indicated that CPUE was not declining.

A maximum sustainable yield (MSY) curve was also constructed to determine if catch was declining with increased effort, which would indicate that the shad population was being overexploited. The curve indicated that catch was still increasing with effort and was not yet reaching a plateau, much less declining (Figure 7).

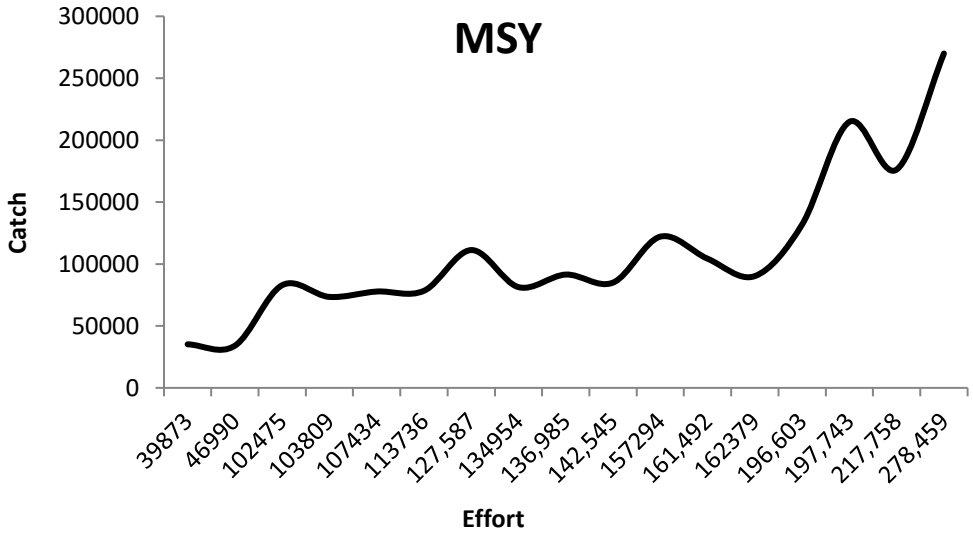

Figure 7. Maximum sustainable yield curve (MSY) indicating that the American Shad population has not yet reached over exploitation levels.

Composition of the catch

The current iteration of the CVAS collects data on shad size (fork length [FL] in millimeters) and sex from the observed catch. During the peak of the shad run, the CVAS collects these biological data on a subsample of 30 shad per survey area per day. Length and sex data were available from previous studies and from previous iterations of the CVAS for time periods 1975-1978, 1991-1992, and 2007-2016. Average fork lengths for each sex were analyzed to determine if shad observed in the harvest were smaller in more recent years than in previous decades (Figure 8). Average size of female shad captured from 1975 to 1992 was 459.2 mm FL, and was 405.5 mm FL for males during this same time period. Between 2007 and 2016, average size of female shad was 402.4 mm FL and for males was 360.4 mm FL.

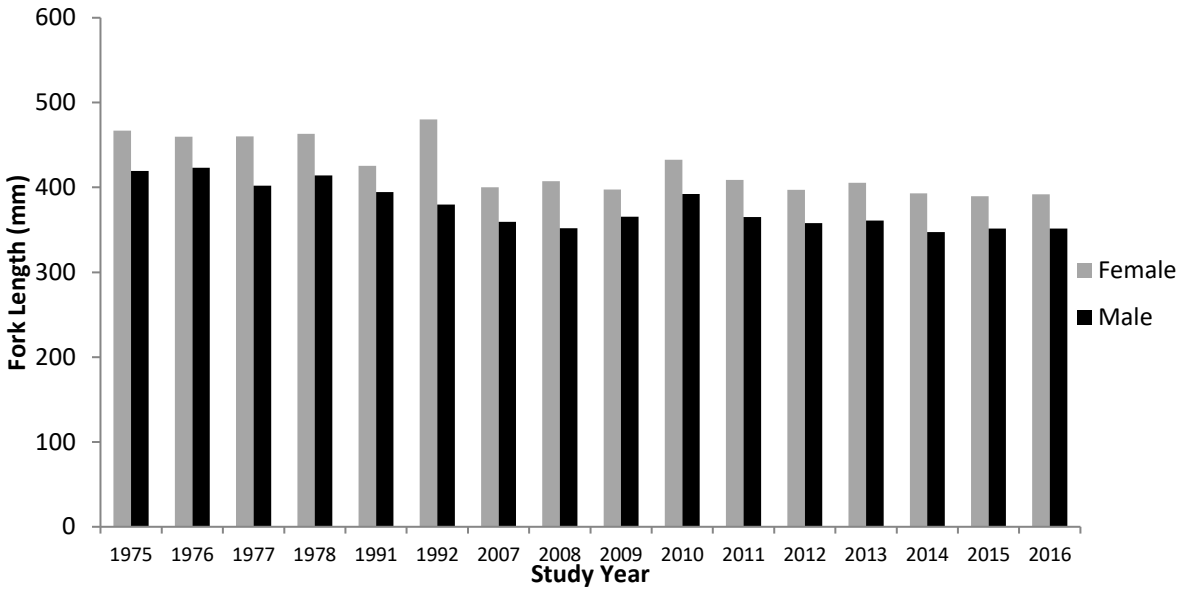

Figure 8. Average size in millimeters of the American Shad catch as observed by the CVAS and previous studies.

Female shad are significantly larger than male shad ($p<0.0001$) in all study periods analyzed. American Shad harvested during the current iteration of CVAS are significantly smaller than shad harvested in previous iterations ($p<0.0001$). A declining trend in shad size was observed in both sexes, females ($p<0.0001$) and males ($p<0.0001$).

Summary and Recommendations

American Shad are an introduced species that has a high economic and recreational value to Central Valley anglers. Data collected from the CVAS reports that the shad fishery consistently ranks in the top 10 fisheries in Central Valley anadromous waters and has a retention rate that currently is exceeding 60%. Because the fishery is experiencing increasing catch and retention rates, as well as has a liberal bag limit of 25 shad per day per licensed angler, an analysis of the sustainability of the fishery was warranted.

At first inspection, it appeared that the current shad fishery was abundant and thriving. These conclusions were made based on the facts that although angling catch and retention were increasing, CPUE was not significantly changing over time. A maximum sustainable yield curve also indicated that the catch had not yet reached overexploitation levels. When the composition of the catch was analyzed, it was discovered that the average size of both male and female shad had significantly declined since previous studies on shad harvest had been conducted (1975-1978, 1991-1992).

A decrease in fish size can have significant impacts on fecundity. Because fecundity is directly proportional to shad size and weight (Leggett 1969, Leggett et al. 1978), a decline in fish would have the implication that less juvenile shad were being produced. Although shad are prolific spawners, high fecundity is important because the egg survival rate is low at just one in 100,000 eggs surviving to become spawning adults (Leggett 1977). A decline in fish size could also signal that the number of repeat spawning shad are also declining.

Previous work conducted by Wixom (1981) focused on spawner age structure and repeat spawning occurrences in the Central Valley. According to his report, repeat spawning events ranged from 27.7% for females and 33.3% for males, and age at first maturity was three or four for males and four or five for females. With retention rates increasing and average fish size decreasing, it is a logical conclusion that the age structure of the catch is now primarily comprised of virgin spawners and the number of older (and larger) repeat spawners has declined. Scale analysis on more current shad catches needs to be conducted to determine the age composition of the catch as well as determine if repeat spawning events have declined due to increased retention of shad.

A notable trend observed in the shad fishery was retention for the specific purpose of roe consumption. While there are always anglers who keep shad for the purpose of consumption, there has appeared to be a shift in the angling demographic that is harvesting shad instead of releasing them. A subset of these later anglers were questioned as to their purpose for retention, a vast majority of their responses were associated with either personal roe consumption or for the purpose of gifting the fish to a friend. Although it is unclear if there is a “black market” for whole shad, or even shad roe, it is clear that there is an increasing interest in the consumption of these fish.

If the trend of increasing harvest of American Shad continues, the fishery may begin to decline due to reductions in annual spawners. As a precautionary measure, a reduction in the bag limit of 25 shad per day per licensed angler should be considered. Reductions in liberal bag limits, such as the one for shad, have been shown to increase the observed size of the catch in fisheries such as Bluegill (Rypel 2015). A reduction in the daily bag limit of shad may produce similar results. A change in daily bag limit may also help bolster the effects that the drought has had on larval shad survival. In 2015, the Fall Mid-Water Trawl conducted by the CDFW reported the lowest numbers of larval American Shad in the history of the survey. An increase in first year and repeat spawners may help buffer the effects of low juvenile survival that has been observed during drought years, as well as enhance the size and quality of American Shad in the sport fishery in subsequent years.

Literature Cited

Leggett, W.C. 1969. Studies on the reproductive biology of the American shad (*Alosa sapidissima*, Wilson). A comparison of populations from four rivers of the Atlantic seabord. PhD. Thesis, McGill Univ., Montreal, Que. 125 p.

Leggett, W.C. 1977. Density dependence, density independence, and recruitment in the American Shad (Alosa sapidissima) population of the Connecticut River. Proceedings of the Conference on Assessing the Effects of Power-Plant-Induced Mortality on Fish Populations, p. 3-17.

Leggett, W.C., and J.E. Carscadden. 1978. Latitudinal variation in reproductive characteristics of American Shad (*Alosa sapidissima*): evidence for population specific life history strategies in fish. Journal of the Fisheries Research Board of Canada 35 (11); https://doi.org/10.1139/f78-230.

Rypel, A. 2015. Effects of a reduced daily bag limit on Bluegill size structure in Wisconsin lakes. North American Journal of Fisheries Management 35: 388-397.

Wixom, L. 1981. Age and spawning history of American shad (*Alosa sapidissima*) in central California, 1975-1978. California Department of Fish and Game Anadromous Fishes Branch Administrative Report 81(3). 37 p.