Napa River Water, Algal and Bio-assessment Collection

And

Analysis Final Report

By

Charley Dewberry

For

Institute for Conservation Advocacy Research and Education

Chris Malan

Executive Director

2021-2022

Executive Summary

During 2021, ICARE (Institute of Conservation, Advocacy, Research, and Education) collected 29 macro-invertebrate and algae samples at 26 sites within the Napa basin following the California State Protocol for collection. The macro-invertebrates were analyzed given a well-established protocol. The macro-invertebrates were identified by Biological Associates (Bob Wisseman). An Index of Biological Integrity (IBI) was constructed for the 29 samples. The following metric were used in the construction of the IBI: total taxa, total taxa of Ephemeroptera, Plecoptera, and Trichoptera, percent of the top three taxa, number of intolerant taxa, number of Plecoptera taxa, number of predator taxa, and percent of semi-voltine taxa. The score included a range of values from the minimum of seven to the maximum of thirty-five. The average score for all the sites during 2021 was 19.5.

Simultaneously, a major element of this project was to collect the samples and analyze them in 2021 using the California Stream Condition Index (CSCI) protocol. As previously stated, the samples were analyzed into their taxonomic categories by Biological Associates (Bob Wisseman) a certified laboratory for the state of California. The CSCI results were provided by Kristina Yoshida of the California Water Board. The results are given in (Appendix Table 1). These results are included in the State of California database (SWAMP). The CSCI calculated a continuous index that is arbitrarily divided into four categories: Likely Intact, Possibly Altered, Likely Altered, and Very Likely Altered. Five of the samples were in the Likely Intact category. Four were in the Possibly Altered category. Eight were in the Likely Altered category. Eleven were in the Altered category.

How does the CSCI index compare with the IBI that ICARE developed? A direct comparison is not possible as the ICARE protocol does not similarly classify the scores into four categories, rather it uses a quantitative comparison. The most straight forward comparison is a comparison of the correlation between the actual scores of the two protocols. The scores for the ICARE IBI are also found in Appendix Table 1. The resulting correlation is 0.866, which is high. Both protocols yield similar results.

In addition, ICARE sampled macro-invertebrates in the Napa watershed from 2000-2006 minus the year 2005. In each year, approximately 30 samples were taken. In order to facilitate comparisons to the 2021 surveys, several standardization steps were taken: first, the taxonomic changes were examined to see if they would result in changes in IBI scores; second, all sample IBI scores from 2000-2006 were recalculated using the IBI developed for 2021 as the standard. The average results from each of the years were as follows: 2000-26.9; 2001-25.6; 2002-19.2; 2003-17.8; 2004-24.1; 2006-18.8; 2021-19.5.
In addition, the CSCI was calculated for the samples collected in the Napa basin from 2000 to 2006, except 2005. Appendix Table 2 lists the median CSCI score of the Napa sites for each year with the average ICARE IBI for the same years. In addition, the CSCI scores for 2000-2006 were graphed using a Box-Whisker Plot (Appendix Figure 1). The years graphed are 2000-2004, 2006, and 2021. The correlation between the CSCI scores and the ICARE IBI was 0.7877. This is a high correlation, but not as high as for the 2021 analysis alone.

The algae samples were collected at the same sites as the macro-invertebrate samples and taxonomic analysis was completed by the California State University San Marcos lab. The current recommended procedure developed by the State of California for the analysis of the algal information is as follows: It is recommended that diatoms be used and the information quantified using the Algae Stream Condition Index (D_ASCI)(Theroux et al. 2020). Using this method, sixteen samples from fourteen sites scored as Likely Intact (> 0.94). Five sites scored as Very Likely Altered (< 0.75) and six samples from five sites scored as Likely Altered (0.76- 0.86).

A comparison of the macro-invertebrate IBI with the Algal (ASCI) showed that these two methods of determining the health of the Napa basin yielded significantly different results. The correlation between the two was only 0.28 at each of the 29 sites. This is a low correlation. Little can be concluded from this with only one year of information, especially given it was an unusual year. (More on this later.)

Also in 2021, at each site, the current State of California physical habitat protocol (IPI) was used to characterize the habitat at the sample sites. The protocol has changed significantly from the one used in the early 2000's. The IPI was developed from the same EMAP protocol as the CSCI. The IPI index of the 2021 sample sites classified all but two sites as Largely Intact. Two exceptional sites were classified as Possibly Altered. In order to compare the 2021 habitat scores with ICARE's earlier habitat surveys, the 2021 survey information was used to translate the habitat scores as best as possible to the earlier physical metrics. The majority of habitat characteristics could be captured, but with varying degree of confidence. The information in the 2021 surveys was significantly different from that of the 2000-2006 surveys.

A comparison was made between the IPI and the ICARE habitat scoring for 2021. The correlation between the two surveys was only 0.52, suggesting that the two methods evaluated the physical habitat quite differently. Is one a better measure than the other? One significant observation is that the CSCI index indicated that only five of the 26 sites were classified as Likely Intact while the IPI indicated at 24 of the 26 sites were Likely Intact. These results suggest that the site characteristics have little to do with the CSCI index. In fact, the correlation between the CSCI index and IPI index for 2021 in the Napa basin was 0.02, essentially zero. These results suggest that the site characteristics are not a factor determining the macro-invertebrate community metrics. The conclusion would have to be that the driver of the metrics for the biological community are the whole-basin features not the physical habitat at the site. By contrast, the ICARE transformation of the physical habitat information correlated 0.42 with the CSCI index at the sample sites. The ICARE scoring suggested that both the site physical characteristics and the whole basin features were affecting the CSCI scores.

The habitat and IBI scores have little meaning by themselves. For example, the fact that the average IBI score for 2021 was 19.5 has little meaning by itself. In order to interpret the IBI scores, we need to understand context both during the current year and for the period of record. Part of the context is the flow regime for the water year (October 1- September 30). In this case, we used the USGS stream gage information for Napa River for the period 2000-2022 to characterize the flow regime for each year.

The IBI average of 19.5 for 2021 was the third lowest average score of the seven years of survey. The water year (October, 2020 - September 30, 2021) had the lowest peak flow of the entire 22 years of record by a lot: the highest flow during the year was only 89 cfs. By contrast, the highest peak flows for the 22 year record were 29,200 cfs in 2006 and 19,100 in 2003.

The years with the highest scores were the first two years (2000 and 2001). The lowest two years were 2003 and 2006: years with the highest peak flows observed during the 22 years of record. The water year 2020-2021 was one of the most unusual years on record. The high flow was only 89 cfs as there were no major storms during the winter period. The effect of such an unusual event can only be determined within the context of examining several adjacent years. Unusual years are important reference points in the long-term record, but they by themselves are difficult to evaluate. So, it is difficult to compare the 2021 survey with the earlier surveys.

Also the effects of the fires are difficult to evaluate because there were no samples taken between 2006 and 2017. Taking all this into account, it appears that the health of the Napa Basin is somewhat reduced from the first samples in the early 2000's. Certainly the droughts, floods, and fires have stressed the health of the basin. The effects of management activities such as increased water withdrawal and development have also stressed the health of the basin. In the final analysis, it is likely that the health of the basin is slightly reduced from what it was in the early 2000's, but it difficult to evaluate how much is due to natural factors verses human factors. First, the water year 2021 was so unusual it cannot easily be compared to the earlier samples. Second, to separate the natural from the human effects direct analysis of the human factors such as water withdrawal from streams and groundwater and the extent of development would need to be examined directly.

Introduction

In 1999, Chris Malan initiated a study using macro-invertebrates to determine the health of the Napa basin. At that time, no systematic survey of the health of the Napa Basin had been completed. She hired Dr. Charley Dewberry who had worked with Jim Karr, who had developed the Index of Biological Integrity (IBI) for that purpose (e.g. Karr and Chu 1997). Also at the same time, the State of California was developing an IBI protocol. During the initial development of this project, we worked closely with Jim Harrington, who headed the development of the State's protocol. The initial phase of the project covers the time-frame 2000-2006. Approximately thirty samples were collected during each year, with the exception of 2005 when no samples were collected.

During 2021, ICARE (Institute of Conservation, Advocacy, Research, and Education) collected macro-invertebrate and algae samples at 29 sites within the Napa basin following the current California State Protocol of Collection. The samples were collected in May-June 2021. The macro-invertebrates were analyzed given a well-established protocol. They were identified by Biological Associates (Bob Wisseman). An Index of Biological Integrity (IBI) was constructed for the 29 samples. An IBI can be a powerful tool for analyzing the response of biological communities to annual physical changes as well as management activities within a basin (Karr and Chu 1997). One of its strengths can be the capacity to separate natural effects of floods, drought, and wildfire from long-term changes in the management of the basin. It can be an excellent tool for tracking the long-term trajectory of the health of basins.

Simultaneously, a major element of this project was to collect the samples and analyze them in 2021 using the California Stream Condition Index (CSCI) protocol. While the State of California, started with a similar IBI protocol that we used for the Napa basin in 2000, California

revised its protocol a number of times. The current protocol utilizes the basic well-established framework (EPA's- Environmental Monitoring and Assessment program-EMAP) (Olson and Hawkins 2012) and modified certain elements of the EMAP protocols (Ode 2007). The result is the California Stream Condition Index (Boyle 2020). The framework uses physical and climatic elements to establish the context for predicting what macro-invertebrate community metrics would be expected. The model predicts the reference condition and then compares the predicted results from the model to what is actually observed at the site. The CSCI results were provided by Kristina Yoshida of the California Water Board.

In addition, algal samples were collected at the 29 sites at the same time as the macroinvertebrate samples. The algal samples were taxonomically identified by California State University-San Marcos. Scores were calculated using the Algae Stream Condition Index (ASCI). The State of California recommends focusing on diatoms. We used the D_ASCI index calculated by the state.

The current State of California physical habitat protocol was used to characterize the habitat at each site. Unfortunately, the current protocol has changes significantly from the one used at the beginning of this project in 2000. We attempted to use the 2021 information to reconstruct scores compatible with the earlier survey in order to try to compare the results of the physical habitat surveys.

The objectives of this report are as follows:

1) Report the results from the 2021 surveys of macro-invertebrates, algae, and physical habitat scores.
2) Compare these results to the phase one (2000-2006) surveys.
3) Determine the trajectory of the health of Napa basin from 2000 to 2021.

The Napa Basin

The Napa basin is part of the North Bay of the San Francisco Estuary. The Napa River enters the estuary on the upstream portion of San Pablo Bay. The Napa River and its tributaries are all within Napa County (Figure 1).

Methods

In 2021, 29 samples were collected from sites which had been sampled in phase one (2000-2006). It was a requirement for this project that all sites had to be in the SWAMP/CEDEN database. The sampling scheme was a stratified random survey similar to that of phase one (2000-2006). Each year, six reference sites were sampled: Mill, Ritchie, Redwood reserve, Rector, and two mainstem sites. The rest of the streams were selected randomly. The specific survey sites were in the same location as previous samples.

Macro-invertebrates

The macro-invertebrates were collected following the State of California protocol. The crew chief of each survey crew completed the state training for collection of the surveys. The samples were analyzed by Biological Associates (Bob Wisseman) a laboratory certified by the State of California. In order to compare the samples from 2021 with those collected in phase one, the taxonomic changes from 2006 to 2020 were examined to see if it would result in change in IBI scoring. No changes were observed in scoring with the update in taxonomic identification.

An Index of Biological Integrity (IBI) was constructed for the 29 samples collected in 2021. The following metric were used in the construction of the IBI: total taxa, total taxa of Ephemeroptera, Plecoptera, and Trichoptera, percent of the top three taxa, number of intolerant taxa, number of Plecoptera taxa, number of predator taxa, and percent of semi-voltine taxa. The score included a range of values from the minimum of seven to the maximum of thirty-five.

A major advantages of the IBI analytical tool over a statistical method of analysis is that the IBI avoids the issue of so many variables within the physical stream system being highly correlated with each other as are the biological responses of the macro invertebrate community to the physical changes. The high degree of interconnectedness is the basic assumption undergirding an IBI. The same interconnectedness is a liability for most statistical methods. Also, outliers are viewed as sites of particular interest in the analysis.

ICARE sampled macro-invertebrates in the Napa watershed from 2000-2006 with the exception of 2005. In each year, approximately 30 samples were taken. In order to facilitate comparisons to the 2021 surveys, several standardization steps were taken: first, the taxonomic changes were examined to determine if they would result in changes in IBI scores; second, all sample IBI scores from 2000-2006 were recalculated using the IBI from 2021 to establish a standard.

Simultaneously, the macro-invertebrate information was analyzed using the CSCI protocol. The CSCI model was run by the state of California and the results were provided by Kristina Yoshida of the California Water Board The CSCI calculated a continuous index that is arbitrarily divided into four categories: Likely Intact, Possibly Altered, Likely Altered, and Very Likely Altered

Algae Samples

The algae samples were collected at the same sites as the macro-invertebrate samples and taxonomic analysis was completed by the California State University San Marcos Lab. The current recommended procedure developed by the State of California for the analysis of the algal information is as follows: It is recommended that diatoms be used and the information quantified using the Algae Stream Condition Index (D_ASCI) (Theroux et al. 2020). We followed the State's recommendation.

Physical Habitat Protocol

In 2021, at each site the current State of California physical habitat protocol was used to characterize the habitat. The physical habitat information is then input into an EMAP style algorithm. The result are the scores for the IPI. The IPI is a continuous variable that are then classed into the following arbitrary categories: <0.70 Very Likely Altered; 0.71-0.83 Likely Altered; 0.84-0.93 Possibly Altered; >0.94 Likely Intact (Rehn et al. 2018).

In order to compare the 2021 habitat scores with earlier habitat surveys, the current survey information was used to calculate the habitat scores comparable as possible with the earlier protocol. The majority of habitat characteristics could be captured with varying degree of confidence. Eight features were chosen that most closely compared to the physical habitat protocol used during the early 2000's: epifaunal substrate, embeddedness, velocity/depth regime, sediment deposition, channel alternation, frequency of riffles, bank stability, vegetative protection, and riparian vegetation. Three features of these features from the Additional Habitat

Characterization Section were the same as the protocol from the earlier years: epifaunal substrate, sediment deposition, and channel alternation. The analysis of the other five features was quantified by computing the averages computed from all eleven transects. The average embeddedness was calculated from the eleven transects and scored the same as the protocol from the early 2000's. Bank stability was calculated from the bank stability portion of the protocol by the following: eroded=1; vulnerable=3; stable=5. Vegetative cover was calculated by summing the scores of the first four features from the riparian vegetation section of the protocol. The totals were standardized to obtain a maximum score of 20 for the feature. Features were then compiled to obtain a maximum score of 160 for the site. Two variables used in the earlier protocol could not be estimated: channel flow status and frequency of riffles.

Results

Macro-Invertebrates

The CSCI index for each site is given in Appendix Table 1. Five of the sites were classed as Likely Intact; 4 of the sites were classified as Possibly Altered; 8 of the sites were classified as Likely Altered; and 11 sites were classed as Very Likely Altered.

The following metric were used in the construction of the ICARE IBI for 2021: total taxa, total taxa of Ephemeroptera, Plecoptera, and Trichoptera, percent of the top three taxa, number of intolerant taxa, number of Plecoptera taxa, number of predator taxa, and percent of semi-voltine taxa. The score included a range of values from the minimum of seven to the maximum of 35. The average score for all the sites during 2021 was 19.5 (Table 1).

The CSCI scores for the ICARE samples from 2000-2006 were computed and provided by Kristina Yostida of the California Water Board. The average median scores for each year are tabulated in Appendix Table 2. Also a Box-Wisker Plot was constructed from the information (Appendix Figure 1). The median averages for each year is as follows: 2000-0.872; 2001-0.7915; 2002-0.717; 2003-0.646; 2004-0.794; 2006-0.79; and 2021-0.666.

The ICARE IBI scores from the earlier surveys were recalculated using the IBI protocol for 2021. The results are presented in Tables 2-7.

The average results from each of the years were as follows: 2000-26.9; 2001-25.6; 2002-19.2; 2003-17.8; 2004-24.1; 2006-18.8 (Table 8). There appears to be no clear pattern to the annual results. For example, the first two years had the highest averages. This suggests that the general trajectory of the survey is downward. However, 2003 and 2006 were lower than expected given the other years of sampling and the average score from 2004 was the third highest. Also, the average score in 2021 was 19.5, which is below the average of all scores throughout the survey period.

Physical Habitat Surveys

In 2021, at each site the State of California physical habitat protocol was used to calculate the quality of the physical habitat (IPI). Two sites were classified as Possibly Altered. All the rest were classified as Likely Intact.

The ICARE habitat scores from 2000-2006 are listed in Table 4. In years 2000-2004, the maximum score was 200. In 2006, the physical habitat protocol changed and the maximum score was increased.

Algal Samples

The results of the algae analysis are given in Table 5 as (D_ASCI- Diatom; Algae Stream condition Index). The range of value was from 0.58 in the mainstem of the Napa River to 1.28 in Soda Creek. The average score for all 29 sites surveyed in 2021 was 0.94.

Discussion

Macro-invertebrates

How does the CSCI index compare with the IBI that ICARE used? A direct comparison is not possible as the ICARE protocol does not similarly classify the scores into four categories; rather, it uses a quantitative comparison. The most straight forward comparison is a comparison of the correlation between the scores of the two protocols. The scores for the ICARE IBI are also given in Appendix Table 1. The resulting correlation is 0.866, which is a high correlation. Both protocols yield similar results. In addition, the CSCI was calculated for the samples collected in the Napa basin from 2000 to 2006, except 2005. Appendix Table 2 lists the median CSCI score of the Napa sites for each year with the average ICARE IBI for the same years. In addition, the CSCI scores for 2000-2006 were graphed using a Box-Whisker Plot (Appendix Figure 1). The years graphed are 2000-2004, 2006, and 2021. The correlation between the CSCI scores and the ICARE IBI was 0.7877. This is a high correlation, but not as high as for 2021 alone.

Is one protocol preferred to the other? I would contend it depends on the questions asked, methodological assumptions, and the scale that is of interest. The CSCI is a standardized sampling method, aimed at a regional scoring, that can be easily compared across the mountain west based on the EMAP logic. It is a valuable protocol for certain questions. On the down-side, it is a complicated protocol that necessitates GIS skills ARCGIS not just ARCMAP; these are

expensive licenses, and several key parts of the algorithm are a “black box”, i.e. they are not readily apparent what calculations they are making and what the assumptions are. The metrics entered into the protocol are set. They cannot be altered or the standardization is lost. This method is limited to a small number of highly skilled computer operators. I cannot run the CSCI because of the high cost of the license to do so. This is not an open and transparent protocol. as a result. The ICARE IBI is a simple protocol that can be calculated by anyone with little more than a pencil and paper. It is also more open to exploration. We used some different macro-invertebrate metrics than the CSCI because it seemed more appropriate for the questions we were asking. Lastly, it is a more open and transparent protocol. In the end, both are highly correlated and it is an open question which is more accurate.

The purpose of collecting the macro-invertebrates is to track the health of the Napa basin. However, macro-invertebrate scores have little meaning by themselves. What does it mean that the average ICARE IBI score for 2021 was 19.5 or what is the meaning of the pattern of the IBI annual scores from 2000 to 2021? There are a number of methods that could be used to interpret the survey results. We have chosen to take an insight from medicine to select our interpretive method. In medicine, there are two areas that have different goals and methods. Both are necessary for medicine to function properly. One is the research side, which investigates general principles using scientific methods. The other is the general practice side, which emphasizes diagnosing the health of particular patients. Diagnosing a patient is an art that takes skill. The doctor must take the available information and his/her experience and create a narrative for the patient. What counts is the trajectory of the health of a patient over time. Medical doctors, with rare exception, are on one side of medicine or the other. It is realized that these two sides of medicine require different skill sets. We have taken the general practice approach to interpret the

information. The major goal is to understand the pattern of annual scores in this particular basin from 2000-2021.

In order to interpret the IBI scores, we need to understand context both during the current year for the period of record, and we need to know the trajectory of land management within the basin (discussed in the habitat section). In this case, we used the USGS stream gage information for Napa River for the period 2000-2022 to characterize the flow regime for each year. One of the most important contexts for understanding the samples is the flow regime (Table 9).

The narrative is the most important part of the analysis. The IBI average of 19.5 for 2021 was the second lowest average score of the seven years of survey. The water year (October, 2020 - September 30, 2021) had the lowest peak flow of the entire 22 years of record (2000-2021) by a lot: the highest flow during the year was only 89 cfs. By contrast, the highest peak flows for the 22 year record were 29,200 cfs in 2006 and 19,100 in 2003. Also, the Napa River was dry near the mouth on June 1, 2022. During the 22 years of record, the Napa River only went dry two other times (2014 and 2015). In fact, the Napa River was also dry on May 1, 2021, an event that only occurred in one other year (2015) during the 22 years of record. Therefore, it is clear that 2021 was an unusually dry year, which was at least partially responsible for the lower than average IBI score for the year. In addition, the previous year water year 2020 was also a dry year. The low flow on June 1, 2020 was 3.2 cfs, the lowest flow on that date recorded during the 22 years of record. (This was only exceeded by the two previously mentioned years when the Napa River was dry on June 1.) The 2021 scores also reflect the impacts of wildfires in 2017 and 2020 that occurred in the Napa basin. However, with no samples collected since 2006, it is not possible to directly analyze the effect of the fires.

During the period 2000-2006 of sampling, the lowest average IBI scores were in 2003 and 2006. These two years had the highest peak flow events for the entire 22 years of record. It is quite likely that the low averages for these two years were primarily the result of these major storms. The water year 2004, which had a high score, had a near average flow regime. The peak flow was only 11,100 cfs - not large enough to create major channel scouring and the low-flows were near average for the period of record. Therefore, 2004 was an average year, unlike 2003 and 2006, with their floods which scoured stream channels, thereby greatly resetting the macro-invertebrate community. Also, 2004 was unlike 2021, which was characterized by no major high flow events and extremely low-flows during the entire water year.

Clearly, the flow regime has a significant effect on the macro-invertebrate community in a given year. There must be a significant number of years of consecutive sampling to establish the relationship between the flow regime and the macro-invertebrate community. The six years of sampling in the early 2000's has established the context for understanding the meaning of biological sampling in subsequent years.

Sampling during the 2021 water year was also significantly important for understanding the response of the Napa macro-invertebrate community to a flow regime during the water year with no major storms and extremely low-flows entering summer months. In addition, the previous water year (2020), also had a very small peak-flow event and had a lower than average stream-flow entering the summer months. These two extremely low water years had a significant effect on the macro-invertebrate community in Napa streams. Having information in 2021 will be vitally important in the long-term for understanding the response of the Napa macro-invertebrate communities to droughts. However, as the single measure since 2006, it is less useful as reliable index of the response of the Napa basin during average conditions.

Also in the period between 2006 and 2021, two significant wildfires that burned a significant portion of the Napa Basin occurred in 2017 and 2020. Wildfires burn with a very complex pattern; some areas burn extremely hot while other areas are skipped. The effects of wildfire on stream communities are best seen in the response of the biological communities. The different response of the macro-invertebrate communities to wildfire can be seen by comparing Mill Creek with Ritchie Creek (Table 10). The streams are adjacent, of similar size, and both are largely in a state park. Both streams are considered reference streams with little effects due to management activities. In all years without high peak flows, both streams had the maximum score of 35 with the exception of Mill Creek in 2000. In 2000, Mill missed the maximum score by one parameter -- the percent of the top three dominant taxa. It was close to a maximum score. These two streams do not show the declining trajectory of IBI scores seen in the basin as a whole. Both streams show a decline in years with high peak flows. (Mill was not sampled in 2003). Both streams also had a maximum score in 2004, indicating that the effects of major storm events only had an impact during the current water year. In 2021, Mill had a score of 33 (again only one parameter was below the maximum score and it was close), while Ritchie had a score of 23. Mill was little affected by the unusual water years of 2020 and 2021 and the wildfires. Ritchie was highly impacted. Since both basins are adjacent, with similar land use, it suggests that the difference between them biologically is due to the different effects of the fires.

These two reference sites do not show a general decline in the trajectory of the response of their macro-invertebrate communities over time. This indicates that these reference streams are resilient enough to buffer their biological communities from unusual water years, while other basins in less than healthy condition are not.

In theory, taxa richness and therefore IBI scores should be the highest in the mainstem of the Napa River under natural conditions (Vannote et al. 1980). As the stream canopy begins to open up, with an increase in stream width, the result is a great increase in habitat diversity and increased algal production in the stream. The mainstem Napa River scores in every year were the lowest in each sample year. This is not an unexpected result. It is often the case that cumulative effects of basin management activities show up first near the mouth of the major stream basin. The mainstem Napa River is highly degraded from a healthy condition.

In summary, the overall trajectory of the health of the Napa River is likely a slight, downward trend. The major difficulty is that the 2021 samples occurred in a very unusual year and it is not clear the effect of this water year on the macro-invertebrate community. Had the water year been average, the results would have been clearer. The lowest scores occurred in years with the highest peak streamflow, suggesting that floods exert a strong influence on the health of the macro-invertebrate community. The majority of the reference sites did not show decline from 2000-2021, indicating that they are highly resilient to the changes of the last two decades. The exception was Ritchie Creek, where the IBI scores declined significantly in 2021, likely due to the wildfire that occurred a couple years previous.

Algae Samples

Using the method developed by the State of California, sixteen samples from fourteen sites scored as Likely Intact (> 0.94). Five sites scored as Very Likely Altered (< 0.75) and six samples from five sites scored as Likely Altered (0.76- 0.86). It is difficult to develop a narrative for the algal samples from one year of sampling and sampling during a very rare water year, as previously discussed.

A comparison of the macro-invertebrate IBI with the Algal (ASCI) showed that these two methods of determining the health of the Napa basin yield significantly different results. The correlation between the two was only 0.28 at each of the 29 sites. This is a low correlation. There are a number of possible explanations for why the macro-invertebrates and algae information do not correlate with each other: First, these two biological communities are capturing different system attributes. The algae sampling is focused on the primary production within the stream system. The macro-invertebrates are affected not just by the algal primary production but also by the organic material coming into the stream system from the terrestrial portion of the watershed. In most tributary streams such as those in Napa, the terrestrial component may make up to 90% of the organic matter driving the stream system. The fact that the macro-invertebrates do not correlate well with primary production (algae) is not a surprise. Second, the response of algae and macro-invertebrates may be quite different in a water year with no major storms. For the algae in a year with no stream scour events, it may lead to the development of an unusual algal community. For the macro-invertebrates, major storm events lead to major community changes; years with no scour events probably affect the community much less.

Habitat Protocol

Also in 2021, at each site, the current State of California physical habitat protocol (IPI) was used to characterize the habitat at the sample sites. The IPI was developed from the same EMAP protocol as the CSCI (Rehn et al. 2018). The IPI index of the 2021 sample sites classified all but two sites as Largely Intact. Two exceptional sites were classified as Possibly Altered.

In order to compare the 2021 habitat scores with ICARE's earlier habitat surveys, the 2021 survey information was used to translate the habitat scores as best as possible to the earlier

physical metrics. The majority of habitat characteristics could be captured, but with varying degree of confidence. The information in the 2021 surveys was significantly different from that of the 2000-2006 surveys.

A comparison was made between the IPI and the ICARE habitat scoring for 2021. The correlation between the two surveys was only 0.52 (Appendix Table 3), suggesting that the two methods evaluated the physical habitat quite differently. Is one a better measure than the other? One significant observation is that the CSCI index indicated that only five of the 26 sites were classified as Likely Intact while the IPI indicated at 24 of the 26 sites were Likely Intact. These results suggest that the site characteristics have little to do with the CSCI index. In fact, the correlation between the CSCI index and IPI index for 2021 in the Napa basin was 0.02, essentially zero. These results suggest that the site characteristics are not a factor determining the macro-invertebrate community metrics. The conclusion would have to be that the driver of the metrics for the biological community are the whole-basin features, not the physical habitat at the site. By contrast, the ICARE transformation of the physical habitat information correlated 0.42 with the CSCI index at the sample sites. The ICARE scoring suggested that both the site physical characteristics and the whole basin features were affecting the CSCI scores.

The habitat protocol has been modified from 2006 to 2021. During the early period (2000-2006), the protocol was centered around scoring from 0-20 for ten habitat parameters. The range of values therefore was from 0-200. In 2006, the habitat protocol was modified, thereby increasing the maximum possible score. During the ensuing period the habitat worksheet has changed significantly. The process now centers on characterizing 11 transects, spaced 10 m apart, through the entire 150 m of stream channel sampled. Only a few specific scoring rubrics are provided for the habitat parameters. Anytime there is a change in protocol, it makes

comparisons of habitat information from previous years more difficult. It is the case that the new protocol provides more accurate and precise information on the slope of the stream channel and certain physical parameters by measuring them at 11 transects along the sample reach; however, it is questionable if the gain in accuracy and precision improves the narrative. First, the new parameters need to be standardized with the old parameters. This adds a layer of complexity. Second, the new protocol greatly increases the time to sample each site, increases the time of analysis, and greatly increases the costs. It makes additional sampling less likely and the more sampling is what improves the narrative the most. In this particular case, it is questionable if the increase in the accuracy and precision of the stream channel slope can improve the narrative. The correlation between the stream slope and total taxa richness, the major driver of an IBI, is only 0.5, which is weak. The IBI graphic analysis of these two variables suggest there is a difference between low gradient and high gradient streams, but with the exception of the lowest three slopes, stream slope appears to be a poor predictor of total taxa richness (Figure 2). The habitat form also includes identifying the stream as the high gradient vs. low gradient stream. It is unlikely that the time to measure the stream gradient is of greater value than the simple observation of high or low stream gradient.

Therefore, stream channel slope does not appear to be a direct parameter that affects the relationship between the physical habitat and the IBI characterization of the macro invertebrate community. Yet we know that stream channel slope is an important habitat feature. It is intimately connected to a number of channel features including: substrate size, embeddedness, and quantity of riffles and pools. In the Napa Basin, low-gradient streams are also often bordered with agriculture or urban uses, while steeper slopes are often forested hill slopes. It is quite likely that the differences are at least partially due to the management differences within the basins. But

with the current physical habitat characterization, we cannot speak to that. All the physical habitat characteristics are site specific. (One is to look adjacent to the stream to see if the general condition is native vegetation, agriculture, or suburban/ urban.) This is hardly a characterization of the basin.

An IBI is a powerful tool for synthesizing the effects at a site and for synthesizing the effects of the overall basin condition and management, but in order to investigate the basin effects, the IBI needs measures that clearly capture the real effects of management activities on the landscape (Karr and Chu 1997). Major factors would include: ground-water and surface-water withdrawal within each basin, percent of the basin in the following management regimes: natural vegetation, agriculture, or suburban/urban, and in particular management activities on steep slopes that deliver sediment to stream channels. Without these measures, an IBI cannot directly separate human management related from natural variation.

To conclude this section, I would like to make a comment. The trajectory of the development of the habitat characterization is wrong. It is assumed that more precise and accurate measurement of stream features will yield more accurate relationships that give us a better understanding of the dynamics of the biological communities in the Napa basin. That is not necessarily true. These more accurate measures take far more time to collect, far more time to analyze, and are exponentially more expensive. Also, their relationship to macro-invertebrate community metrics is not clear. The goal of the protocol should be a quick and efficient protocol that gives the most important basic information. It also means that sampling is cheaper and can occur more often. Instead of this new protocol, imagine if additional samples had been collected in 2017 before the first wildfire or 2019 the last year with a normal water year or 2020 before the second wildfire. These samples would greatly improve the narrative. Also, with all the increase

in complexity of the information gathered at a site, the most important characteristic is not measured directly, i.e. stream connectivity.

In the 1980's, the primary author invited over twenty of the leading stream ecologists to write a "white paper" for the U.S. Congress. The most important measure of the health of streams was identified as stream connectivity, that is, the relationship to the stream channel to its floodplain. This measure is most important in both steep hillslope streams and in low-gradient unconfined valley floor streams. It is more important in the low-gradient unconstrained stream channels, but even in confined hillslope streams, it is an important measure. A stream that is connected to its floodplain in a low-gradient unconfined reach will often have a braided channel and if the water comes up a foot or so, it will spread over its floodplain. As degradation progresses, the steam channel will begin to incise into the valley floor. The result is a steep bank that separates the stream channel from the floodplain. As the stream channel incises into the valley floor, it also lowers the water table and reduces the amount of water stored in the valley floor. The mainstem Napa River is a case in point. The highly incised "disconnected" stream channel in every year had the lowest IBI scores. The IPI for the mainstem Napa River site was 0.96 which is Likely Intact, the highest habitat category.

While this effort attempts to standardize the two protocols, the results do not have a high level of confidence because of the different ways of quantifying the habitat features.

Summary

From 2000 to 2021, approximately 30 biological samples per year were collected during seven years from the Napa basin: 2000, 2001, 2002, 2003, 2004, 2006, and 2021. This report

covers the physical, algal, and macro-invertebrate samples. The ICARE and CSCI index of the macro-invertebrate community correlated well with each other. The average ICARE IBI or CSCI scores for the Napa basin as a whole have declined slightly from 2000 to 2021. The year 2021 was a highly unusual year and it is difficult to determine the impacts of the unusual year on trend of the CSCI scores. This suggests that the health of the basin has likely declined a little over the twenty-year period. In the years preceding 2021, extensive wildfires also burned in the Napa basin. While the overall IBI scores have declined over the period, the scores in several reference sites have not declined over that period. This suggests that healthy basins have a high level of resilience against the effects of droughts and wildfire. All Napa sites, including the reference sites, experienced declines in IBI scores during the two major flood years (2003 and 2006). Mill Creek did not show the effects of wildfire while the adjacent Ritchie Creek was highly affected by the wildfires.

The algal index was collected only in 2021, which was a very unusual year. The algal index did not correlate well with the CSCI index. The correlation was only 0.28. It is difficult to comment with only one year of sampling and it being a highly unusual year.

The physical habitat survey protocol has significantly changed from the early 2000's to 2021. In 2000, both groups were using the same habitat protocol. By 2021, the State of California had moved to an EMAP framework. The transformation of the 2021 physical information into the old protocol was difficult and the two protocols only correlated with each other at 0.52. The IPI only correlated with the CSCI at 0.02, which is essentially 0. The transformed ICARE protocol correlated with the CSCI at 0.42.

An IBI or CSCI are both powerful analytical tools which can be effective at tracking the health the health of a basin and the risks to the health of the aquatic system. The years of

sampling suggest that the Napa basin has slightly declined in health from 2000 to 2021. This is not a surprise, given the two extensive wildfires that occurred in the basin in the last five years. With only one year of information, no evaluation could be made about the algae protocol. The correlation between the algal and the macro-invertebrate protocols were only 0.28, which is low. The habitat index (IPI) is problematic. It's correlation with the CSCI is 0.02, which is essentially zero.

Literature Cited:

Boyle,T.R. et al. 2020. *Instructions for Calculating Bioassessment Indices and other Tools for Evaluating Wadeable Streams in California: The California Stream Condition Index (CSCI), Algal Stream Condition Index (ASCI), and the Index of Physical Integrity (IPI).* SWAMP-SOP-2020-0001

Karr, J.R. and E.W. Chu. 1997. *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively*. EPA 235-R97-001. University of Washington, Seattle.

Ode, P.R. 2007. Standard operating procedures for collecting benthic macroinvertebrate samples and associated chemical and physical data for ambient bioassessment in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP-001.

Olson, J.R. and C.P. Hawkins. 2012. Predicting natural base-flow stream water chemistry in the western United States. Water Resources Research 48: W02504

Rehn, A.C., Raphael D. Mazor, Peter R. Ode. 2018. *An Index to Measure the Quality of Physical Habitat in California Wadeable Streams*. SWAMP Technical Memorandum SWAMP- TM-2018-0005

Theroux et al. 2020. *Predictive biological indices for algae populations in diverse stream environments.* Ecological Indicators.

Vannote et al. 1980. The River Continuum Concept. Canadian Journal of Fisheries and Aquatic Science 37:130-137.

Acknowledgments:

Institute for Conservation Advocacy Research and Education; Chris Malan; manager and sponsor of the project and major funder

San Francisco Bay Regional Water Quality Control Board/SFBRWQCB/Kristina Yoshida; collaborative partner; In-Kind contribution

SFBRWQCB; Kevin Lunde; collaborative partner; In-Kind contribution

Napa County Wildlife Conservation Commission; funder

T**he Giles W. and Elise G. Mead Foundation;** Parry Mead Murray; funder

Figure 1. Sample sites in Napa Basin 2021.

Figure 1B. List of sample sites in the Napa Basin 2021

1.Bear Creek
2.Bell Creek
3. Dry Creek
4. Dry Creek 2
5. Garnett Creek
6. Heath creek
7. Huichica Creek
8. Marie Creek
9. Mill Creek
10. Milliken Creek
11. Milliken Creek 2
12. Moore Creek
13. Murphy Creek
14.Napa Creek
15. Napa River
16. Napa River 2
17. Rector Creek
18. Redwood Creek
19. redwood Creek 2
20. Redwood Creek 3
21. Salvador Creek
22. Soda Creek
23. Sulphur Creek
24. York Creek
25 Ritchie Creek

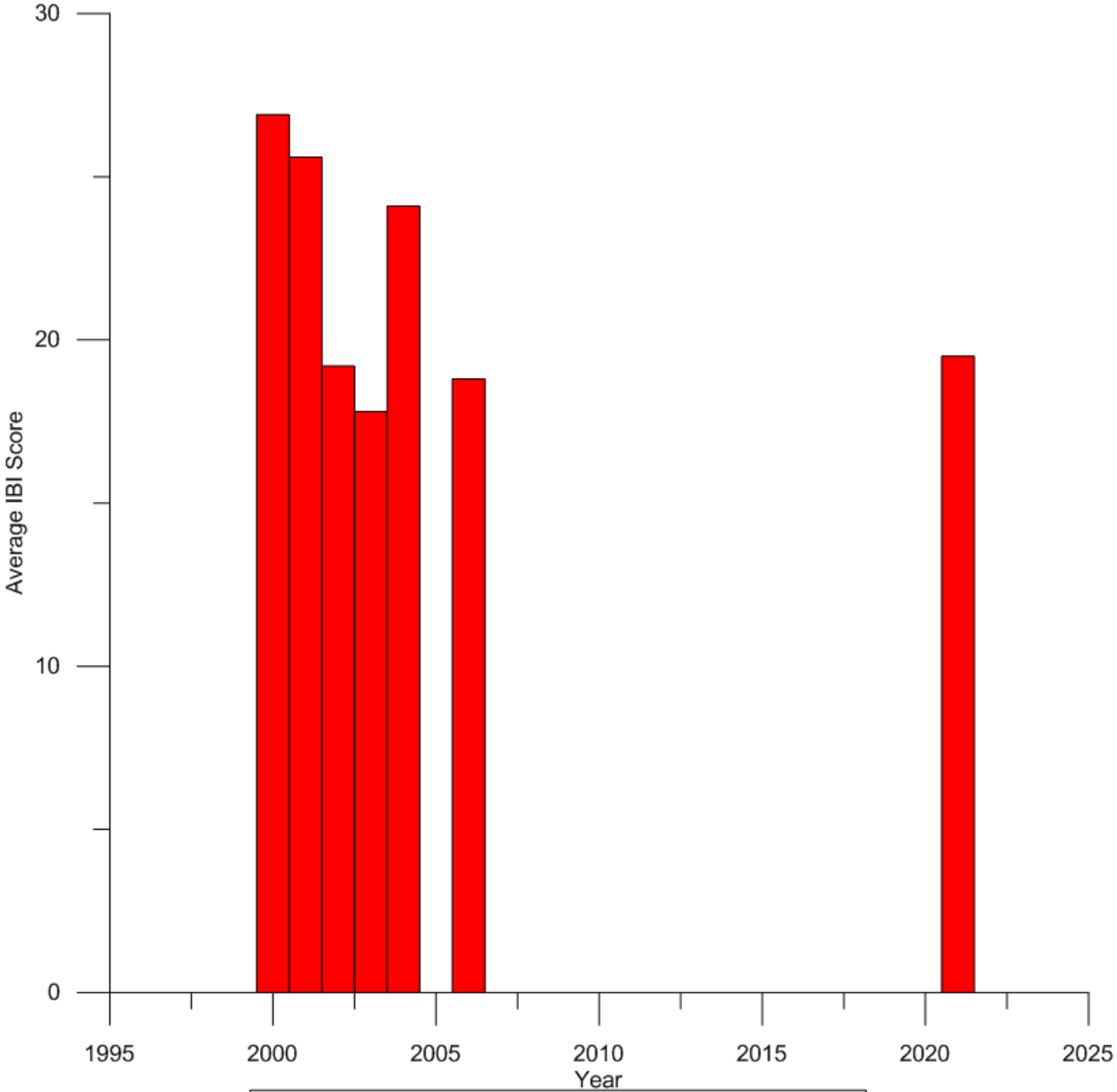


Figure 2. Average IBI Scores From Napa Basin (2000-2006)

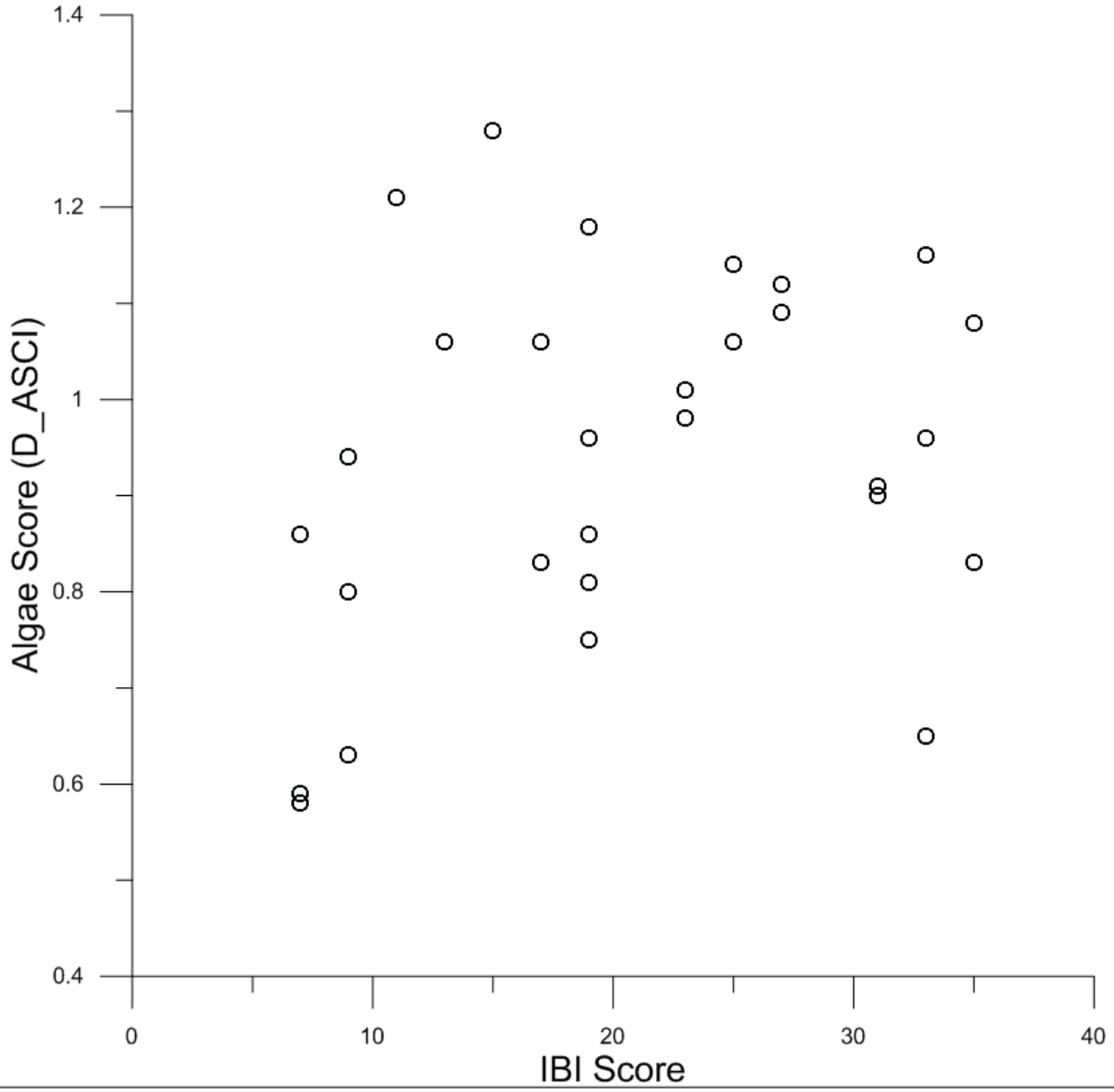


Figure 3. Comparison of Algae Scores with IBI Scores from Napa Basin (2021)

Table 1. 2021 Napa IBI Scores

Attribute	Bear	Bell	Dry	Dry	Garnett	Heath	Huichica	Marie
Total Taxa	5	3	3	5	1	5	1	1
EPT	5	5	5	5	1	5	1	3
Top 3	5	3	1	5	1	5	1	3
Intol	5	3	3	3	1	5	3	3
Plecopt	3	3	5	5	1	5	1	3
Pred	3	5	5	5	1	5	1	3
semi-vol	5	3	5	5	1	3	3	3
Total	31	25	27	33	7	33	11	19
Sum		566						
total		29						
Avg		19.51724						

Mill	Mill	Milli	Milli	Moore	Murphy	Napa Crk	Napa R	Napa R
5	5	5	3	3	1	3	1	1
5	3	3	3	3	3	3	1	1
5	5	5	3	1	3	5	1	3
5	3	3	5	5	3	1	1	1
3	3	1	5	1	1	1	1	1
5	3	1	3	3	1	1	1	1
5	5	1	3	3	5	3	1	1
			5					
33	27	19	25	19	17	17	7	9

Rector	Redwd re	Redwod	Redwd	Ritchie	Ritchie	Salvador	Soda	Sulphur
5	1	1	5	3	3	1	3	3
5	1	1	5	3	3	1	1	3
5	1	3	5	5	3	1	3	3
5	1	1	5	3	5	1	1	3
5	1	1	5	3	3	1	1	3
5	1	1	5	3	3	1	5	3
5	3	1	5	3	3	1	1	1
35	9	9	35	23	23	7	15	19

Sulphur	Tulucay	York
3	1	5
3	1	5
1	1	5
3	3	5
5	3	5
3	3	3
1	1	3
19	13	31

Table 2. 2000 Napa IBI Scores

Attribute	Bear	Bell	Brown V	Carneros	Chiles	Cyrus	Dry	Upper Dry
Total Taxa	5	5	1	1	5	3	5	5
EPT	5	5	3	3	5	3	5	5
Top 3	3	3	5	1	1	1	3	3
Intol	5	5	3	3	5	3	5	5
Plecopt	5	5	3	3	5	5	5	5
Pred	5	5	1	1	5	3	5	5
semi-vol	5	5	3	3	5	1	5	5
Total	33	33	19	15	31	19	33	33
Sum	887							
total	33							
Avg	26.87879							

Dry	Fagan	Fir	Garnett	Heath	Hopper	Huichica	Lorette	Mill
3	1	5	3	5	5	3	5	5
5	1	5	5	5	5	3	5	5
1	3	3	1	5	1	3	5	3
3	1	3	3	5	1	3	5	3
5	1	5	5	5	5	3	5	5
3	1	5	3	3	3	3	5	5
3	3	5	3	5	3	3	5	5
23	11	31	23	33	23	21	35	31

Milliken	Moore	Murphy	Napa Cal	Pickle	Rector	Redwood	L. Redwd	Ritchie
5	5	5	1	5	5	5	5	5
3	5	5	3	5	5	5	5	5
3	3	3	1	3	5	5	1	5
3	3	5	1	5	5	3	5	5
3	5	5	3	5	5	5	5	5
3	5	3	1	5	5	5	3	5
3	5	3	1	5	5	5	5	5
23	31	29	11	33	35	33	29	35

Soda	Spencer	Sulphur	Suscol	Tulucay	Wing	York
3	5	5	3	3	5	3
5	5	5	3	3	5	5
3	5	1	1	1	3	3
3	3	3	3	3	5	3
5	5	5	3	3	5	5
5	3	5	3	1	5	5
3	5	3	3	3	5	3
27	31	27	19	17	33	27

Table 3. 2001 Napa IBI Scores

Attribute	Amer Can	Bear	Brown V	Carneros	Chiles	Conn	Cyrus	Diam Mtn
Total Taxa	1	5	1	1	5	3	3	5
EPT	3	5	3	3	5	3	5	5
Top 3	1	3	1	3	3	5	3	5
Intol	1	5	1	1	5	3	3	5
Plecopt	1	5	3	3	5	3	5	5
Pred	1	5	3	3	5	1	5	5
semi-vol	1	5	3	1	5	5	3	5
Total	9	33	15	15	33	23	27	35
Sum		793						
total		31						
Avg		25.58065						

Dry	Dry	Garnett	Jericho	Marie	Mill	Milliken	Moore	Murphy
5	5	1	5	3	5	5	5	1
5	5	3	5	3	5	5	5	1
1	1	3	3	1	5	3	5	1
5	5	3	5	3	5	3	5	1
5	5	3	5	3	5	3	5	3
5	5	1	5	3	5	3	5	5
5	3	3	3	3	5	5	5	3
31	29	17	31	19	35	27	35	15

Napa Cal	Pickle	Rector	L. Redwd	Redwood	Redwd re	Ritchie	Salvador	Seggas
3	3	5	5	5	5	5	1	5
3	5	5	5	5	5	5	1	5
1	3	5	1	5	5	5	1	5
1	5	5	3	5	5	5	1	5
3	5	5	3	3	5	5	1	5
3	5	5	3	5	5	5	1	5
3	3	5	3	5	3	5	5	5
17	29	35	23	35	33	35	11	35

Soda	Spencer	Sulphur	Tulucay	York
3	3	5	5	1
3	1	5	5	3
1	1	3	3	3
1	1	5	1	3
5	3	5	5	3
3	3	5	3	5
1	3	5	3	3
17	15	33	25	21

Table 4. 2002 Napa IBI Scores

Attribute	Amer Can	Bell	Blossum	Brown V	Canon	Chiles	Congress	Conn
Total Taxa	1	5	1	1	1	1	1	1
EPT	1	3	3	1	1	5	1	1
Top 3	1	5	1	1	1	5	1	1
Intol	1	1	3	1	1	3	1	1
Plecopt	1	3	3	1	1	5	1	1
Pred	1	1	3	1	3	3	1	1
semi-vol	1	3	3	1	1	1	1	3
Total	7	21	17	7	9	23	7	9
Sum		768						
total		40						
Avg		19.2						

Cyrus	Diam Mtn	Dry	Fagan	Hopper	Huichica	Jericho	Kimball	Kreuse
1	5	5	1	3	1	3	1	3
1	5	5	3	5	1	3	3	1
1	5	1	1	3	1	1	3	3
1	5	3	1	5	1	3	1	1
3	5	5	1	5	1	5	3	1
1	5	5	3	5	1	5	3	1
1	5	5	3	3	1	1	1	3
9	35	29	13	29	7	21	15	13

Marie	Mill	Milliken	Milli 2	Milli 3	Milli 4	Milli 5	Montgom	Moore
1	5	1	5	1	3	1	1	5
1	5	3	5	5	5	3	3	5
1	5	1	1	1	1	1	3	5
1	5	1	3	5	1	3	3	3
1	5	1	5	5	5	3	3	5
1	5	1	5	3	5	1	3	5
5	5	1	5	3	1	1	3	3
11	35	9	29	23	21	13	19	31

Napa Cal	Napa po	Nash	Rector	Redwd re	Ritchie	Sage	Salvador	Seggas
1	1	5	5	1	5	5	1	5
3	3	5	5	3	5	5	1	5
1	1	5	1	1	5	1	1	3
1	1	5	5	1	5	5	1	5
3	1	5	5	3	5	5	1	5
1	1	5	3	1	5	5	1	5
1	1	5	5	1	5	5	1	5
	0							
11	9	35	29	11	35	31	7	33

Soda	Sulphur	Suscol	Tulucay	York
3	3	3	1	3
5	5	3	1	3
3	1	3	3	1
3	3	1	1	3
5	5	3	3	5
5	3	5	1	5
5	3	3	1	1
29	23	21	11	21

Table 5. 2003 Napa IBI Scores

Attribute	Amer Can	Bell	Blossum	Canon	Chiles	Congress	Conn	Cyrus
Total Taxa	1	3	1	1	3	1	1	5
EPT	1	3	1	3	5	1	1	5
Top 3	1	1	1	3	1	1	1	3
Intol	1	5	5	5	5	1	3	5
Plecopt	1	3	3	5	3	1	1	5
Pred	1	5	1	5	3	1	1	5
semi-vol	3	3	1	3	3	3	1	5
Total	9	23	13	25	23	9	9	33
Sum		604						
total		34						
Avg		17.76471						

Diam Mtn	Dry	Dutch H	Fagan	Garnett	Hopper	Jamison	Jamison	Kimball
3	3	1	3	1	3	1	1	1
5	5	1	3	3	3	1	1	1
1	1	5	1	1	3	1	1	1
5	5	5	5	5	5	3	3	3
5	5	1	5	5	5	3	1	1
5	5	1	5	3	3	3	1	1
1	3	3	3	1	5	3	3	3
25	27		25		27	15	11	11

Kreuse	Marie	Napa Cal	Napa po	Pickle	Rector	Redwd re	Ritchie	Sage	
5	3	1	1	1	1	1	5	5	
5	3	3	3	3	1	3	5	5	
3	1	1	1	1	3	1	1	1	
5	5	5	3	5	3	5	5	5	
5	3	3	1	5	1	5	5	5	
5	3	1	1	5	1	1	3	5	
3	3	1	3	5	5	3	3	5	
			0						
31	21	15	13	25	15	19	27	31	

Salvador	Sarco	Simmons	Soda	Spencer	Sulphur	Walsh	York
1	1	1	3	1	3	1	5
1	5	1	3	1	5	1	5
1	1	1	1	1	1	1	3
1	5	3	5	5	5	3	5
1	5	1	5	3	5	1	5
1	5	1	3	1	3	1	5
3	3	5	1	3	3	1	5
9	25		21		25	9	33

Table 6. 2004 Napa IBI Scores

Attribute	Amer Can	Bell	Brown V	Carneros	Carn 2	Chiles	Congress	Conn
Total Taxa	1	5	3	1	3	5	1	1
EPT	1	5	3	1	3	5	1	1
Top 3	1	5	5	1	1	1	1	1
Intol	1	5	5	5	5	5	3	3
Plecopt	1	5	3	3	3	5	1	1
Pred	1	5	5	1	3	3	1	1
semi-vol	5	5	5	3	3	3	3	5
Total	11	35	29	15	21	27	11	13
Sum		845						
total		35						
Avg		24.14286						

Cyrus	Diam Mtn	Dry	Heath	Hopper	Huichica	Jamison	Jericho	Kimball
5	3	5	5	1	1	1	5	1
5	5	5	5	1	3	1	5	3
3	3	5	5	1	1	3	5	1
5	5	5	5	3	5	3	5	5
5	3	5	5	1	1	3	5	1
5	5	5	5	1	1	1	5	1
5	3	3	5	3	1	5	5	3
33	27	33	35	11	13	17	35	15

Kreuse	Marie	Mill	Milli	Napa Cal	Napa po	Pickle	Rector	Redwd re
5	5	5	1	1	1	1	5	5
5	5	5	3	3	3	3	5	5
3	3	5	1	1	1	1	5	5
5	5	5	5	5	5	5	5	5
5	3	5	1	3	3	5	5	5
5	5	5	1	1	1	3	5	5
5	5	5	1	1	3	3	5	5
					0			
33	31	35	13	15	17	21	35	35

Ritchie	Sage	Salvador	Sarco	Sarco 2	Suscol	Suscol	Walsh	York
5	5	1	3	5	3	3	1	5
5	5	1	3	5	5	5	1	5
5	3	1	3	3	3	3	1	5
5	5	1	5	5	5	5	3	5
5	5	1	3	5	3	3	1	5
5	5	1	3	5	5	5	1	5
5	5	3	3	5	1	3	1	5
35	33	9	23	33	25	27	9	35

Table 7. 2006 Napa IBI Scores

Attribute	Bear	Bell	Dry	Dry	Hopper	Jericho	Kimball	Kreuse
Total Taxa		3		3	1	3	1	1
EPT		5		5	3	5	3	1
Top 3		1		3	1	1	3	3
Intol		5		5	5	5	5	5
Plecopt		5		5	3	5	3	1
Pred		5		5	5	5	5	1
semi-vol		3		3	3	3	3	5
Total		27		29	21	27	23	17
Sum		549						
total		30						
Avg		18.3						

Marie	Mill	Milli	Moore	Murphy	Napa Crk	Napa R	Pickle	Redwd re
1	1	1	3	3	1	1	3	5
3	5	1	5	5	3	3	3	5
1	1	1	1	3	3	1	3	3
5	5	3	5	5	5	3	5	5
3	5	1	5	3	3	3	5	5
3	1	1	3	3	1	1	5	5
3	5	3	3	3	3	1	5	5
						0		
19	23	11	25	25	19	13	29	33

Redwod	Ritchie	Ritchie	Sage	Sarco	Suscol	Suscol	York
3	5	5	3	5	1	1	3
5	5	5	5	5	3	3	5
1	1	1	1	3	3	3	1
5	5	5	5	5	5	5	5
5	5	5	5	5	3	3	3
1	5	5	1	5	3	1	3
5	5	5	5	5	3	3	3
25	31	31	25	33	21	19	23

Table 8. Physical Habitat Scores Napa 2021

Factor	Bear	Bell	Dry	Dry	Garnett	Heath	Huichica
Epifaunal	19	15	16	12	16	18	14
Embedded	18	18	18	19	18	18	19
Sediment	15	15	18	15	11	17	15
Channel Alt	16	20	20	19	10	18	19
Bank Stab	18	20	20	20	20	20	14
Veg. Protect	14	12	15	14	15	13	10
Riparian	20	19	19	20	14	19	18
Freq of stream Hab	18	14	16	17	14	19	19
Total	138	133	142	136	118	142	128

Marie	Mill	Milliken	Milliken 2	Moore	Murphy	Napa Crk	Napa R	Rector
14	18	19	18	17	4	15	2	20
19	18	20	19	17	18	18	20	19
18	15	20	18	18	16	17	4	20
9	18	20	20	17	1	12	9	20
15	15	20	20	18	19	20	13	20
13	15	13	13	14	9	13	15	12
19	19	20	19	17	15	13	17	20
18	19	18	16	17	17	13	14	15
125	137	150	143	135	99	121	94	146

Redw res	Redw Br	Redw L	Ritchie	Salvador	Soda	Sulphur	Tulucay	York
19	10	8	20	11	16	10	17	14
18	19	15	16	11	13	17	13	13
16	7	12	17	13	17	10	10	10
20	13	17	19	13	15	17	18	10
18	20	12	20	14	20	20	12	14
13	13	13	14	13	13	13	10	9
19	17	17	19	16	18	18	16	18
16	16	17	14	19	11	17	18	16
139	115	111	139	110	123	122	114	104

Table 9. Habitat Scores 2000-2006

Site	2000	2001	2002	2003	2004	2006
American Canyon		110	102	97	108	
Bear	94	168				
Bell	134		133	143	169	244
Blossum			114	131		
Brown Valley	80	86	89		112	115
Canon			76	142		
Carneros	111	107			122	134
Chiles	155	152	144	156	138	209
Congress Valley			80	93	85	135
Conn		144	106	149	135	210
Cyrus	149	144	151	143	179	
Diamond Mtn		160	154	152	174	178
Dry	160	124			148	
Upper Dry	170	180	171	184		
Dutch Henry				119		
Fagan	96		116	123		
Fir	184					
Garnett	142	148		117		
Heath	180	166			184	
Hopper	107		137		104	209
Huichica	94		127		179	
Jamison				99	75	
Jericho		170	129		154	212
Kimball			131	169	162	204
Kreuse			110	181	150	151
Lorette	187					
Maria		149	80	138	165	178
Mill	148	155	174		170	233
Milliken	100	179	154		161	167
Montgomery			154			
Moore	141	147	152			189
Murphy	161	131				176
Napa Crk						144
Napa R		148	137		134	
Napa	129		139			
Nash			149			
Pickle	100	113		158	149	184
Rector	166	186	161	140	170	
Redwood	170	181			180	
Redwood		178				
l. Redwood	150	148	150	145		224
Ritchie	158	172	174	145	175	208
Sage			134	175	169	234
Salvador		135	121	104	112	
Sarco				172	178	210
Segassia		169	176			

Simmons				178		
Soda	139	144	150	167		
Spencer	174	152		184		
Sulphur	126	159	149	138		
Suscol	123		148		127	175
Tulucay	121	162	119			
Walsh				72	96	
Wing	150					
York	124	111		152	163	200
york trib			129			

Sum	Average
417	104
262	131
579	145
245	123
367	92
218	109
340	113
745	149
258	86
534	107
766	153
640	160
432	144
705	176
119	119
335	112
184	184
407	136
530	116
348	116
400	133
174	87
453	151
462	154
441	147
187	187
532	133
647	162
594	149
154	154
440	147
292	146
0	144
548	137
139	139
149	149
520	130
823	165
531	177
178	178
593	148
824	165
478	159
472	118
350	175
345	173

178	178
600	150
510	170
572	143
398	133
402	134
168	84
150	150
550	138
129	129

Table 10. BMI vs AMI from Napa Basin 2021

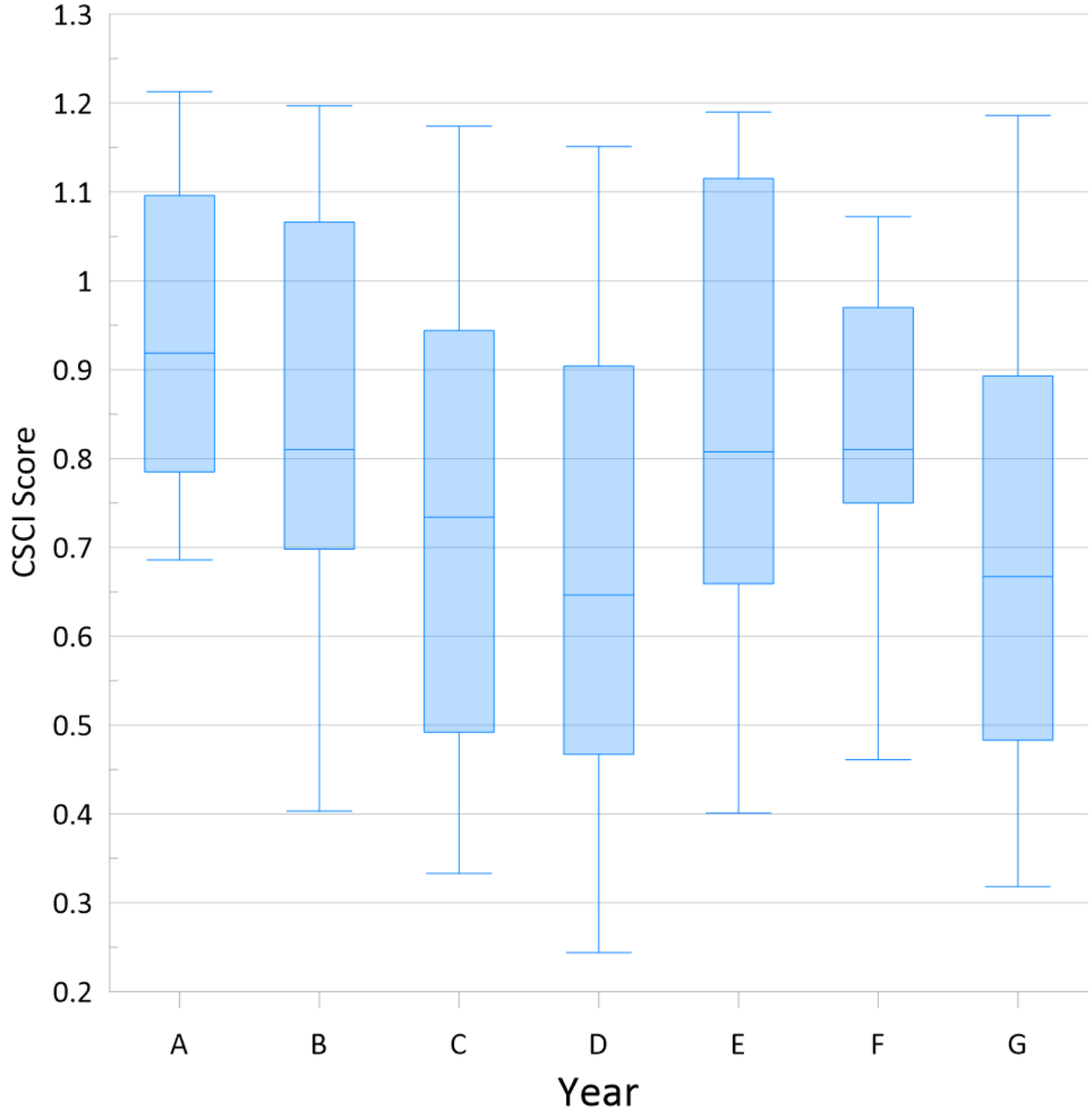
Site	BMI	Algae
Bear	31	0.91
Bell	25	1.14
Dry1	27	1.12
Dry 2	33	0.96
Garnett	7	0.86
Heath	33	0.65
Huichica	11	1.21
Marie	19	1.18
Mill1	33	1.15
Mill2	27	1.09
Milliken1	19	0.96
Milliken2	25	1.06
Moore	19	0.75
Murphy	17	1.06
Napa C	17	0.83
Napa R1	7	0.59
Napa R2	9	0.63
Rector	35	0.83
Redwood1	9	0.8
Redwood2	9	0.94
Redwood3	35	1.08
Ritchie1	23	1.01
Ritchie2	23	0.98
Salvador	7	0.58
Soda	15	1.28
Sulphur	19	0.86
Suphur	19	0.81
Tulucay	13	1.06
York	31	0.9

Table 11. Napa River Streamflow (USGS) 2000-2021

Year	Peakflow	Date	Flow May 1	Flow June 1
2000	7,140	14-Feb	54	19
2001	4,300	5-Mar	31	9.5
2002	9,810	2-Jan	34	16
2003	19,000	16-Dec	581	69
2004	12,200	18-Feb	37	16
2005	6,080	22-Mar	84	114
2006	29,000	31-Dec	243	59
2007	1,870	11-Feb	23	16
2008	8,030	4-Jan	21	13.3
2009	6,600	22-Feb	19.8	15.3
2010	6,450	20-Jan	152	65.4
2011	11,800	20-Mar	101	52.7
2012	5,710	14-Mar	102	24.3
2013	13,100	23-Dec	12.5	8.9
2014	3,070	9-Feb	33	0
2015	10,400	14-Dec	0	0
2016	7,380	6-Mar	49.6	16.8
2017	15,900	8-Jan	135	39.2
2018	4,580	22-Mar	35.5	15.6
2019	16,500	27-Feb	104	72.8
2020	820	8-Dec	11	3.8
2021	86	2-Feb	0	0
2022	8,550	24-Oct	15.6	6.4

Table 12. IBI Comparison of Mill and Ritchie Creeks

Year	Mill	Ritchie
2000	31	35
2001	35	35
2002	35	35
2003	None	27
2004	35	35
2006	23	31
2021	33	23



Appendix Figure 1.

Site	CSCI	ICARE IBI
Bear	0.956	31
Bell	0.76	25
Dry	0.86	27
Dry	1.039	33
Garnett	0.318	7
Heath	0.893	33
Huichica	0.467	11
Marie	0.667	19
Mill	0.893	33
Milliken	0.606	19
Milliken	0.932	25
Moore	0.71	19
Murphy	0.713	17
Napa Crk	0.48	17
Napa R	0.346	7
Rector	1.186	35
Redwood	0.483	9
Redwood	0.503	9
Redwood	1.105	35
Ritchie	0.643	23
Salvador	0.389	7
Soda	0.531	35
Sulphur	0.665	19
Tulucay	0.536	13
York	0.823	31

Site	CSCI	IPI	ICARE IBI
Bear	0.956	1.22	133
Bell	0.76	1.15	138
Dry	0.86	1.2	142
Dry	1.039	1.19	136
Garnett	0.318	1.21	118
Heath	0.893	1.22	142
Huichica	0.467	1.05	128
Marie	0.667	1.16	125
Mill	0.893	1.2	137
Milliken	0.606	1.21	150
Milliken	0.932	1.15	143
Moore	0.71	1.18	135
Murphy	0.713	0.89	99
Napa Crk	0.48	1.21	121
Napa R	0.346	0.96	94
Rector	1.186	1.04	146
Redwood	0.483	1.09	139
Redwood	0.503	1.2	115
Redwood	1.105	1.15	111
Ritchie	0.643	1.11	135
Salvador	0.389	1.23	110
Soda	0.531	1.12	123
Sulphur	0.665	1.12	122
Tulucay	0.536	1.07	114
York	0.823	0.85	104

Year	med CSCI	Avg IBI
2000	0.872	26.88
2001	0.7915	25.58
2002	0.717	19.2
2003	0.646	17.76
2004	0.794	24.14
2006	0.79	18.3
2021	0.666	19.52