Turbid Water Zooplankton and Drift Invertebrate Population Measurement Equipment

The quantitative and qualitative solution to detecting, counting and identifying zooplankton and drift invertebrate food sources available to critical fish species targeted for recovery and protection in river and estuary systems requires a high degree of flexibility, adaptation, scientific understanding and ability in comparative methodology, test calibration, results assessment, and trend recognition on the part of technicians in the field and lab. In the case of such dynamically changing, non-standard or specialized environments, with different features around so many bends and significant seasonal effected variation, like the San Joaquin Valley Watershed, for the sake of legitimate data, results and conclusions, testing chosen to be performed in particular locations based on the characteristics of those locations and should be the consistently employed method over a set number of years in those particular locations, as well as cross-compared to information gathered through other methods of measurement. While no certainty is assured, probability can be approached.

In approaching the process of finding a solution regarding calculation, my first thought was toward “off the shelf” technology, which is already easily available and commonly employed. The methods and equipment are sound, but require adjustment in order to be applicable to the watershed. The large nets and capture buckets typically used in oceanic studies of zooplankton and drift invertebrates are commonly known by those in this field. You can likely picture them in your mind at this time. They are on occasion used not only vertically but also horizontally. However, they may be a bit of an excessive or ill-fitting measurement, when applied to the watershed. Depth or lack thereof, surface area, varying substrates, varying velocities, turbidity, and calibration would need to be accounted for in deriving dependable measurements and conclusions as well. Those same factors would need to be consideration in adjusting light versus dark bottle tests, in addition to, phosphate and ammonia measurements. The answer, which is a method in this case, could be calibrated to deliver better understood results based on data points informing better calibration after measurement relationships are studied, for more accurate and precise conclusions,. For a very short duration (even despite their weaknesses) older, odd or ill-fitting oceanic methods could still be adapted in order to proof newer, better fitting or improved methods. The oceanic methods would establish a base understanding for adapted watershed methods, portion or parts of the watershed, the watershed as a sum, and the watershed as a synergy. Moreover, with the simplicity of the tests, force multipliers in the form of educational system participation and internships could result in substantial cost savings.

Please refer to figure 1. This is a redesigned apparatus which would allow for the administration of numerous aforementioned tests within a watershed rather than an oceanic environment. In calibrating the sampling methods with their own mathematical assessments of the base line food availability to fish in the watershed, it is important that initial studies are conducted in portions or parts of the watershed that offer the least variation of conditions from a traditional oceanic assessment. In other words, the zooplankton and drift invertebrates nets and capture buckets, light versus dark bottle tests, microscopic grid counting assessments, and phosphate & ammonia tests could be used on a deeper, lake-like portion of the watershed a minimal number of times. Those data points, results and conclusion from the oceanic study equipment could be compared to those from the similar, size-adjusted watershed study equipment in order to develop and check the mathematical assessment foundations for the new equipment’s use in the rest of the watershed. Of course, in using the new equipment to measure the rest of the watershed, additional consideration and adjustment for the other more difficult variables and constraints will need to be accounted for in sample collection method and mathematical assessment. During the early calibration test, while comparing oceanic equipment to the watershed equipment, the newer equipment’s sample arm box was used in a vertical manner, such will not always be the case.

As an example, in taking a capture and filtration based measurement in a broad, shallow river portion of the watershed, the velocity of the water should be measured to determine the length of time that the capture and filter vessels should be open and exposed to the flow. Water velocity can be measured a number of ways. For one, the OTT Hydromet Pro Water Flow Meter could be a time saver. In this situation, multiple filter containers can be evenly spaced along the body of the sample arm box which would allow for duplication to confirm data and results for that particular location. As a second example, after the capture and filtration vessels are removed from the sample arm box, light and dark as well as mobility water vessels could be put in. The vessels or containers are interchangeable within the sample arm box. Multiple water samples could be taken along the surface of the water for development and study at a lab. In the two immediately aforementioned examples, the design of the sampling equipment lent itself to horizontal use.

Whether in vertical or horizontal use, the exposure time, water velocity and movement of the collecting sample arm box, as well as the distance and level in water must be considered in order to get the actual flora and fauna quantitative and qualitative measurements under water in each gallon, in each liter, per cubic inch, per cubic foot along with on top of the water in each square inch, square foot, square centimeter or square meter of surface. If a capture and filtration assessment is made of a particular location on several different occasions, and water velocity is not calculated to a uniform 1 of the particular unit of water measured to have passed through the filter chamber, then the outcome would be incorrect. If sample X were taken with 3 gallons of water having passed through the filter, then its biological count would have to be divided by 3 in order to find the values for 1 gallon. If sample Y were taken with 4 gallons of water having passed through the filter, then its biological count would need to be divided by 4 in order to get to 1 gallon’s values or biological count. For the sake of this hypothetical, if the following sample Z is calculated down to its biological sample values for 1 gallon that would be correct as well. While capture and filtration may not occur at a set or consistent rate, for short duration sampling it may be considered a given. In this hypothetical, gallons were selected not as a prescription but only simply for the sake of illustration of principles, other units of measurement can be used. The values for samples X, Y, and Z could be used to find an average in understanding productivity and availability. Over time, additional measurements and calculations could be performed to find total amounts of estimated food availability during greater measured set period. The mental image of a lifeguard cleaning out pool skimmer baskets every morning before opening the facility comes to mind.

While velocity or the lack of velocity as well as variations in substrates and shallow depth can be accounted for by adjusting the process of sampling or calculation, turbidity’s effects on accurate and precise assessment is a difficulty not easily solved. Turbidity’s effect on the availability of food is hard to assess as well. While reducing visibility, turbidity could accompany smaller, usual, or even large supplies of food. To note, the appearance of turbidity often reflects other events that affect or can accompany the levels of zooplankton and drift invertebrates, such as farming run off that may or may not be high in phosphates and ammonia, soil erosion from construction, excessively saturated flood planes draining into various waterways, algae blooms, and more. Each event or condition affects, accompanies, or reflects types and levels of productivity in its own way. With that understanding and California’s typically arid weather considered, it is recommended that the water tests discussed in this report thus far should be carried out on days with stable weather and less water turbidity in order to establish a dependable, under most common circumstances or usual conditions, base line assessment of the watershed’s productivity and the availability of zooplankton and drift invertebrate food sources. As well, with consideration for survival necessity and other human productive endeavors, in some cases simply having the ability to make measurements might require better timed sampling or temporary stoppage of activities causing turbidity just long enough to allow the water to become measurable, but that could possibly not provide for the measurement of actual typical conditions, productivity, and availability. With this understood, there may be a number of methods still worth developing for quantifying availability of zooplankton and drift invertebrates in turbid waters.

The first option considered was the application of the improved watershed sample arm box and various vessels arranged and secured therein, of course adjusted by maximum technician discretion in the method applied on site, nonetheless documented in particulars on forms yet to be developed. The validity of the tests would fluctuate in accord with experience and conditions. Still, over time and with duplication, wrong data can be excluded. The idea of using auxiliary, uniform weight, disposable, coffee maker size, filters in the sample arm box vessels to determine biomass collected was also contemplated. The filters could be studied for particular zooplankton and drift invertebrates and compared by weight change as well. Then, the question was asked, as to what size in microns are the majority of non-biological particles that cause turbidity as opposed to the size in microns through millimeters of the zooplankton and drift invertebrates that are the focus of relevant study would be. It occurred that the three types of sample vessels could produce largely or mostly viable samples from turbid water in addition to another set of data points if employed with supplemental insert filters varying in micron size. Insert or supplemental filters could aid the separation of samples taken into distinct test focus larger organisms as opposed to smaller particulate studied in relation. Those filters have been included in Figure 1. as well. Additionally, rudimentary centrifuges could offer the ability to separate the remaining turbid water from solids. In the remaining water sample, various types of gases (including oxygen and carbon dioxide), elements (metals, phosphates, nitrates, ammonia, and more), and compounds (including complex hydrocarbons) as well as their levels could be measured with hand held meters commonly found on the market. Upon the removal of the water, the slightly wet solids sample could be studied for microscopic life and ratios there of. Both quantitative and qualitative genetic testing could be performed and extrapolated from. More over, unfiltered and unmodified samples could likewise be microscopically studied on a tradition grid assessment. The sample vessels being more right sized and closable with screw top lips would allow for better transport to and study in the lab.

With the amount of information available from collected materials, it might be possible for singular departments to work in conjunction with other agencies and bureaus in order to reduce the costs of study. These possibilities became apparent when some thought was given to the nitrate tests administered by the EPA in the Shenandoah watershed. More over, the effects of nitrates, among many other pollutants, have been studied so greatly that changes in productivity of particular areas and the watershed in general can be projected as well. Proving those projections, with aquatic and species terrain considered, would allow for more adjustments in study of cascade effects and feedback on the watershed’s productivity. Over time projections would gain more validity.

Until proven otherwise, turbidity must still be considered an obstacle to legitimate measurement and assessment. However, some thought was also given to the “behavior” of the organisms studied, flood planes, rain cycles, and waterways small through large. Please refer to Figure 2. at this time. While serious caution may be found in hesitation from the collection of excessive samples due to possible negative impact, the value of productivity, and web balance, there is a reason why entomologists use large white nets, traps and lights at night to study rain forests. While such net studies could be undertaken on the banks of the watershed and projections regarding reproductive potential could be made with respect for available food in the water, such is an indirect measurement. For a direct measurement, several trough style collection nets or traps with different sized meshes between 1 to 20 mm, illuminated with cyalume rope lighting when necessary could be used to take very shallow but very broad samples to be counted with consideration for the amount of water and even surface area that passed through in a given period of time. The trough nets, made from clear or white nylon, would be useful even in turbid water, as their filter size could be directed more toward zooplankton and drift invertebrates larger in size, while allowing the opaque water to simply pass through. Such nets do not necessarily need to be suspended on bright light ropes held on each bank, but could also be held and used by a pole from one bank. My recommendation is that the nets be made 12 inches by 12 inches by 6 inches for the purposes of easier formulas. Seeing an increase in studied organisms after or during a rain might not be a surprise. If such levels could be deduced to reflect consistent increases with a particular type of weather or season would still have to be studied. As a matter of process, care should be taken to close off the net and store it in a container so that the sample does not get destroyed, damaged, depleted, or contaminated on the way to a counting and evaluation station. As well, some method for rinsing the net’s content into a sample container might be another option, a much better option, thus allowing for more samples to be taken with fewer nets.

In this age of information technology, some thought should be given to the development of a program that could recognize and count zooplankton and drift invertebrates. The technology might actually be cost effective now, if not soon. Please refer to Figure 3. The concept of a one cubic foot or one gallon cube Plexiglas water sample container, on which a high resolution web camera could be focused, with the purpose of feeding into a program that counts discolorations, dots and small moving organisms, as well as changes in overall tint for a given period of time could be possible with clearer water but not turbid water. The time spent allowing turbid water to settle in that tank could affect the outcome, possibly changing measurable level of zooplankton and drift invertebrates. As well, the employment of an adapted Sherman tank periscope connected to a webcam monitoring an underwater cyalume lit background to count the same points in the field on site would have the same constraints regarding clarity. However, while the two aforementioned applications of technology could be further developed for limited or discretionary use, I am not convinced that they would be successful and they are bulky.

Please refer to Figure 4. Use of a web cameras and laptops in the field might not be necessary, as SD card cameras have become smaller and better. SD cameras are getting so small and so good that they can fit inside of watches, pens, smoke alarms, and more, even while showing distinct facial features in video that can run from 8 to 24 hours in duration. More over SD card cameras, much like game camera mounted on trees, can be left in the field for prolonged periods of time. If the SD card cameras are waterproof and put inside an additionally water proofed housing that has an appropriately shaped lens, they could be placed in the field. There might be a number of configurations that would allow the measurement of zooplankton and drift invertebrates with a degree of legitimacy. My first thought was toward a well lit sphere shaped container. Consider it an underwater or truly waterproof game camera. My second thought was toward putting the camera or cameras in an anchoring stake itself. Still, the use of skates or anchors is not recommended. The best idea came from the use of a long waterproof tube shaped container that would be held to a flat, heavy, broad peace of steel and would not only allow water to run around or over it, but could be towed in the right manner. In order to tow it, two holes could be drilled and cable or rope clipped in evenly. It is versatile and could be deployed horizontally or vertically, in addition to stationary or in motion. More over, on returning to the field technicians could find the device using a GPS chip or locating beacon. Then, the memory cards and batteries could be switched, and the video could be uploaded through Wi-Fi, or simply brought into a lab, for counting and assessment. While battery and memory technology has come a long way, in the event that the cameras used have build in batteries and memory, then the entire camera array tray could be switch for continued deployment. At the lab or a counting substation the array tray could be recharged and uploaded. Having additional cameras available might be a benefit in an emergency situation.

Please refer to Figure 5. Suspecting that turbidity might still be a difficulty, even with technology applied, consider it might be possible to perform the same counting and recognition task if the water sample were thinned into a column and the tint or color of the water was used as the calibrated standard that was monitored for changes by a program. Again, with an inexpensive water proof camera a sluice or chute could be video recorded on site. In the field, the narrowed column view concept lends itself to adaptation for measurement, horizontally, vertically, stationary, in motion as well.

Please refer to Figure 6. In the event that the computer is unable to tell the difference between organisms to be measured and identified as opposed to debris, an alternative simpler program could be developed which would keep track of the number of times a human being touched a computer screen with a stylus or light pen in recognition of a generally desired organism and even possibly specific identification during the viewing of a video brought back from the field. It would be fun, just like wack-a-mole or dance revolution. That last option for counting would be able to be checked, proofed, or duplicated by additional lower paid staff, viewing the same video, with the same task. That might not only add greater degrees of accuracy and precision, allowing for more employment of T values, but also save expense associated with gathering too many additional samples from the field. However, when considering the facial recognition and population monitoring software that is employed in policing these days, it might not be so difficult to develop similar programs for environmental applications. After the initial development and acquisition, the technology would pay for itself in a short time though savings in labor and fuel.

In conclusion, there are a number of possible methods and tools which could be developed to offer better assessment of zooplankton and drift invertebrates available in turbid waters as well as other waters of the watershed studied. While I tend to hold that simple equipment requires much less repair, and others may lean toward more advance technology, the solution is likely a combination and balance of both. The most promising seems to be the Tubular Camera Array, Water Column Sluice, and Zooplankton and Drift Invertebrates Recognition or Tap Recognition Counting Programs. While I could assemble the first two, the programming is out of my field of expertise. None the less, there are companies that specialize in that type of software. I could research to find a suitable match to the task at hand. Thank you for the opportunity to contribute.