Project Report

Study of the advance and scientific fish sampling techniques and their assessment for the application in Nepalese conditions

By

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The Project Report

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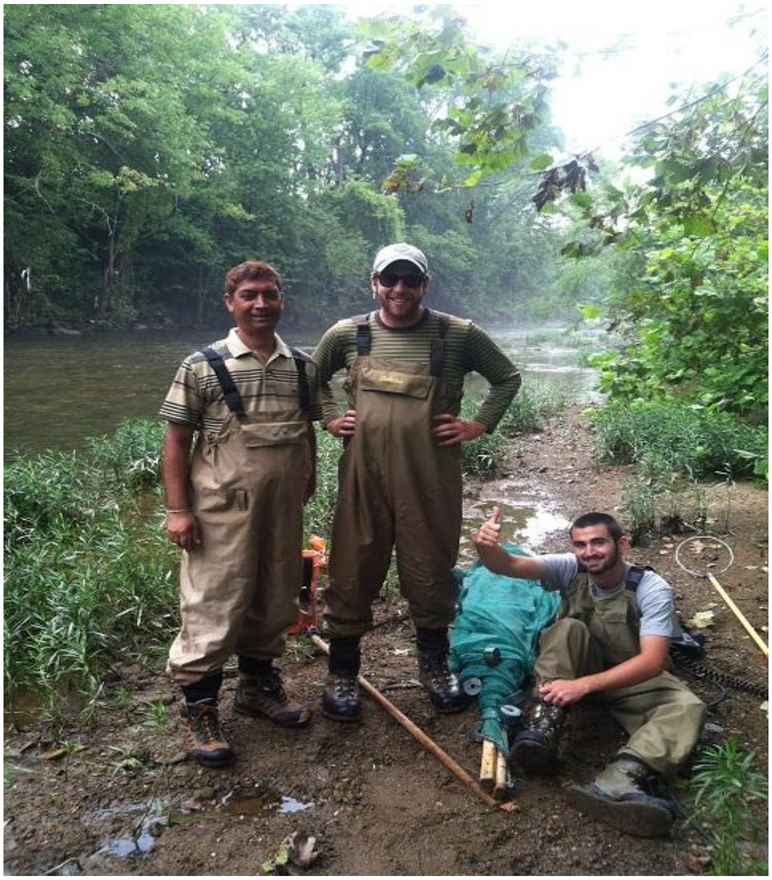
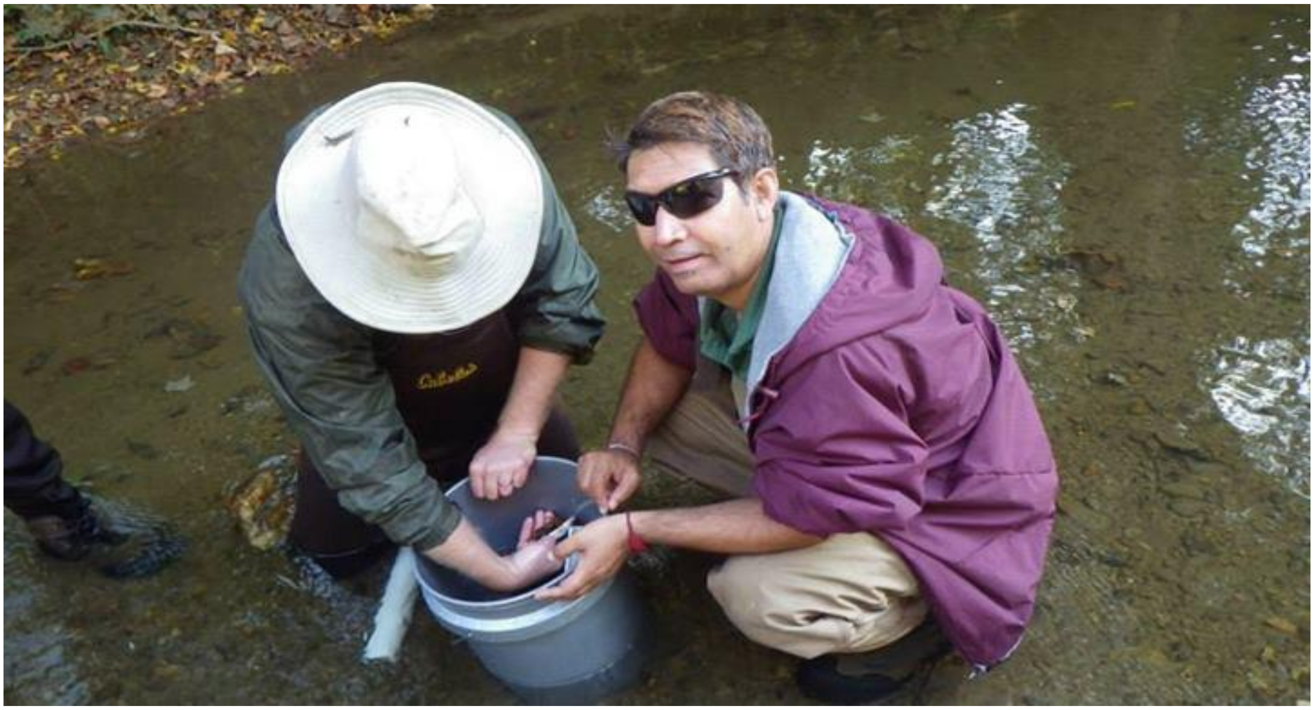


All Set to Start Fish Sampling in Roanoke River



Counting and Sorting Fish species

Introduction

A post-doctoral research work on the '**Study of the advance and scientific fish sampling techniques and their assessment for the application in Nepalese conditions'** was granted by the Fulbright Commission, USA to be carried out in the Department of Fish and Wildlife Conservation of Virginia Polytechnic Institute and State University (Virginia Tech) under the supervision of Prof. Paul Angermeier. Subsequently, observation and learning of the standard scientific methods were realized by getting involved in a number of field based activities as well as in the laboratories and working places.

Standard sampling methods are fundamental in any field of scientific study as this leads to proper documentation and recording, meaningful interpretations and comparisons, and further applications such as monitoring, modeling, management and development. Accordingly, the field of fish and river ecology too has progressed and developed tremendously in the countries and regions where there is a history of the practice of scientific sampling methods. The United States is perhaps the best example in this regard as it could also be seen through its rate of innovations in the techniques; the number of publications and the quality of the work of the scholars involved; the volume and accuracy of information and records; and success in monitoring, conservation and management. Thus, the knowledge acquired and the skills learned in the U.S. have the potential of assisting contributions of the highest order, wherever it is applied. This project, seeking collaboration between the United States and Nepal in the field of fish/river ecology has the potential to yield far reaching and highly desirable consequences.

Nepal is one of the poorest and least developed countries, which is not making desirable progress mainly because of the lack of internal capacity, that includes institutions and individuals, to manage its rich natural resources. Despite the small size, Nepal is known for its huge water resources and inherent fisheries too as they complement each other. Nepal's inland water resource include natural waters such as rivers, lakes and reservoirs, village ponds, marginal swamps and irrigated paddy fields. Out of this, the network of rivers and streams, which are more than 6000 in number alone covers around 395000ha of surface (Khanal, 2001).

Among these, rivers and its tributaries are the most abundant of the natural water bodies, the sum of its length measures more than 4500 km. Therefore, sampling Nepalese rivers by applying scientific methods require enormous resources that include skilled manpower, instruments, funds and time. In addition, the heterogeneity in origin, morphology, water quality, velocity and discharge of Nepalese rivers and streams clearly indicates the complexity in sampling, which asks for multiple scientific methods to produce the results acceptable to national and global information base.

Diversity of the fish fauna in Nepal is very high as it could be easily expected from the range of variations of the conditions of rivers and streams arising from the complexities of its site, geography and climate. The formation of Hindu-Kush Himalaya is believed to be due to the union of Palearctic and Oriental Plate and hence, Nepal, which is situated on the lap of Himalayas consists the components of biodiversity of both the tectonic plates. The last taxonomic revision of the fish fauna of the country documents a total of 182 species belonging to 93 genera under 31 families and 11 orders (Shrestha, 2001). However, the total diversity of fisheries as mentioned must be a crude estimate, as there are very few records or evidence of extensive samplings and using scientific techniques and tools.

Under estimation of the total fish diversity in Nepal is also indicated by the reporting of new varieties of fish every year. As already mentioned, the samplings of all the 6000 thousand rivers and streams and that too divided into different climatic zones and habitat conditions would definitely take a long course with the current state of human resources, techniques, tools and funds. And, this is just for primary information of the country's fisheries resource such as species number, distribution, population etc. The current project tries to address this situation by training and exposing an academic to advanced scientific methods and tools of fish samplings so that the skills and information thereafter are disseminated to the students through the university in Nepal to develop a stock of capable human resource.

There is limited information on ecological and population characteristics of fish species, such as region and altitude of occurrence, habitat preference, temperature range, maximum length and weight, feeding habit, life history and a crude status of many of the fish species, available. The fish species list from some of Nepal's rivers has been developed by various authors such as Rajbanshi (1982) Talwar and Jhingran (1991) Shrestha (1990 and 1994), Shrestha (1999), Swar (2001), Rajbanshi (2001) and Shrestha (2001). However, there are only few instances to show the application of the scientific methods in fish sampling in the process of the development of the lists mentioned above, and many times they are also based on secondary information.

The application of scientific methods to gather firsthand information regarding the Nepalese fisheries resource gathered momentum with the work of Jha and his team (2006, 2006 and 2012) in selected rivers of Nepal. The primary information, thus collected, has already been widely utilized by academics, researchers, students and many stakeholders including IUCN (2010). Though their work is in progress, soon it was realized that due to the heterogeneity of the river systems of Nepal, the sampling gears and the skills the team was using were inadequate to sample all the rivers and streams for fish.

In this background, it has become a necessity for a person involved in fisheries research in Nepal be trained and exposed in various advanced scientific methods of samplings and data management in a country where there is a long history of such practices. The United States, obviously is the best place to observe and acquire skills in this sector because of its developed academia and institutions, advanced technology and equipment, and quality and number of the scientific publications. Therefore, a proposal to study and observe 'the state of art' in fisheries research in US, as a Post-Doctoral work for 6 months was submitted to the Fulbright Commission on behalf of myself, which was subsequently selected for funding.

Prof. Paul Angermeier from the Department of Fish and Wildlife Conservation was involved in this process ever since he unconditionally accepted the role as a Host Supervisor in this project, and this is the primary reason why Virginia Polytechnic Institute and State University (Virginia Tech) was selected as the institution for this project. Its reputation and the presence of prominent academic human resources in the Department too, made the selection easy. Thus, this project aims to establish a continuity and enhance the efficiency regarding fish based studies of Nepal's water resources with the learning of required appropriate techniques from the institutions and experts from the United States.

Historically, Nepal's fisheries resource has served as livelihood for some typical communities but its potential to develop into commercial value has never been realized. This is generally attributed to the lack of investments, however, business interest increases if there is technical knowledge that guarantees profit. In the meantime, widespread illegal and lethal fishing methods such as poisoning and high voltage fishing has already depleted the country's fisheries resources such that many species have been included in the IUCN threatened list (IUCN 2010). To address all these issues, a complete quantitative account of the fish attributes and its scientific information in all the water bodies is a basic requirement.

This proposal was therefore, accepted by the Fulbright program to support the primary aim to enhance individual's capacity to undertake fish sampling work and to acquire knowledge and information of the fish diversity in the U.S., so that on return one can implement new techniques and apply new knowledge to one of the world's most unique territories for the protection and conservation of this global common resource, as well as to uplift livelihoods by optimum utilization of Nepal's fisheries resource. Accordingly, the Visiting Scholar from Nepal have been engaged in number of activities related to this sector such as, participating in diverse fish sampling methods, conferences (American Fisheries Society 2013) and seminars, talk and discussions, and meetings with academicians, technicians, policy makers and businessmen.

Objectives

This project has two categories of objectives, which it aims to accomplish. The broader and general one covers a much larger timeframe than 6 months, where it aims to establish an exemplary collaboration between scholars in the U.S. using the world's most advanced technology and scholars in Nepal using almost non-existing technology, so as to uplift the capability of the latter and help its society to develop and prosper. Clearly, this objective would be an ongoing process, which is expected when the academics and scientists of different countries and culture interact together.

Another long term objective of this project is to involve scientists in the advancement and propagation of science, knowledge and technology, and to use, conserve and manage natural resources such as water and biodiversity, which truly are global commons. As the scientist involved in this project is associated with the university, the propagation and dissemination of knowledge and skill, again would be an ongoing process and would continue producing capable human resources. Thus, here too the extension of goals of this project is much larger than the specified time frame of 6 months.

The third grand and long lasting objective is the establishment of friendly and congenial relationship between the two countries at personal level, which emerges out of the opportunity of cultural exchanges that this project provides to the scholar of Nepal and to the US citizens. This helps propagate feelings of goodwill, tolerance, and coexistence between the cultures and states, so important in the modern world, which is surrounded by conflicts of all types. Therefore, this project which brings two entirely different cultures together has the component of Global Peace that continues to produce fruitful results, irrespective of time.

However, there are also some smaller but important tasks to be completed within the 6 months' time frame of this project. Therefore, along with those broad objectives mentioned above, the following are the specific objectives of this project which will be achieved within the prescribed time of six months:

1. To observe and learn as many fish and water sampling techniques as possible by taking part in sampling field trips organized by the host institutions.
2. To be taught and mentored in data management and its analysis related to fish sampling and fish ecology.
3. To exchange experiences with the host partners that may lead to enhancement of knowledge and techniques in sampling and data analysis.

4. To establish long term mutual partnership and collaborations between the institutions and scholars of the involved institutions.

Methodology

This project is a collaboration between a Fulbright Senior Scholar from Nepal and Prof. Paul L Angermeier, Virginia Tech, College of Natural Resources and Environment. Therefore, it is also an interaction and exchanges between the faculties of Department of Fish and Wildlife Conservation of Virginia Tech and the Department of Environmental Science and Engineering of Kathmandu University. The specific objectives as mentioned above would be achieved within six months' time by using the following methods:

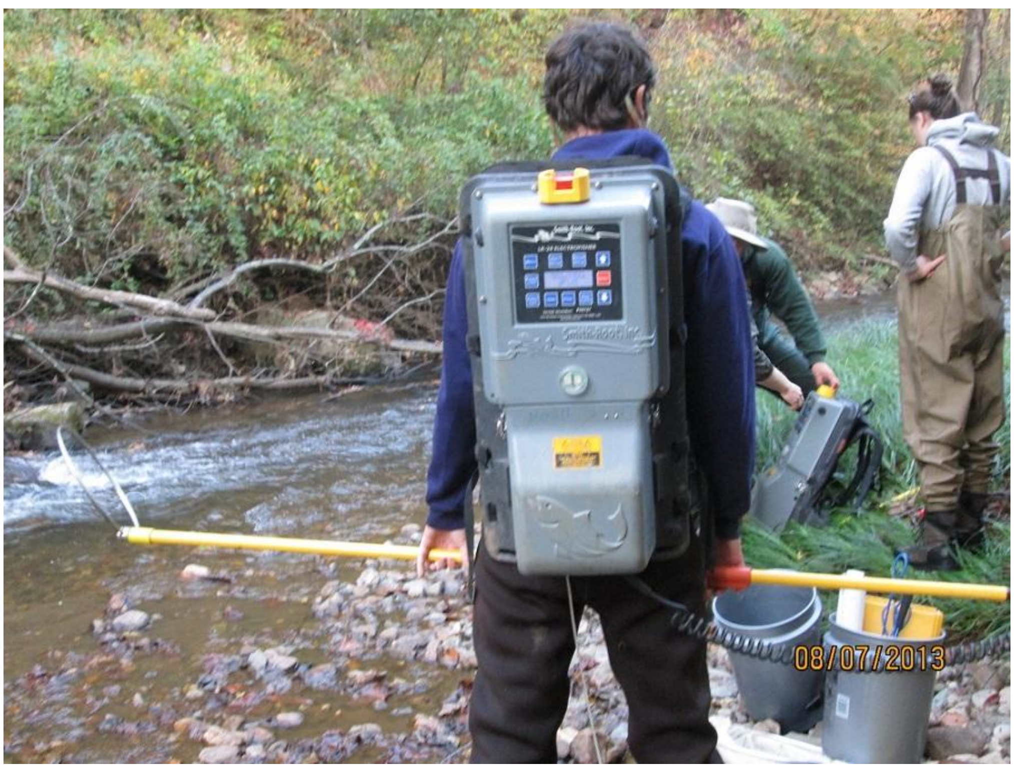
1. Direct participation in the fieldwork, laboratories, seminars and conferences conducted by host partner and their collaborators. According to the general plan the U.S. partners in the Department of Fish and Wildlife Conservation such as the host supervisor Paul L. Angermeier, Brian Murphy, Donald Orth, Eric Hallerman Emmanuel Frimpong, Leandro Castello and their associates were consulted in fieldwork selection and worked according to their suggestions and schedules. The main thrust here was to learn techniques applicable in Nepalese water to generate the basic information. The fish based basic information includes information of species assemblage, distribution, abundance, diversity, taxonomy, population dynamics, status, morphometry, life-cycle, habitat and ecology. Therefore, several field trips to rivers and streams were made to accompany the colleagues in the Department, who were involved in many of the above mentioned fish base projects. Various scientific sampling techniques and instruments such as electrofishing, seining, gill-nets, flow meter, various probes to measure water quality parameters, length and weight measuring devices, transects etc. were observed and handled during those field trips.

   A field based practical class of the undergraduate program of the Department was also observed. Here, in addition to the observation and participation of the scientific fish sampling techniques, the teaching and learning process between students and instructors too was keenly viewed. The various technique and tools that are in use in laboratories to study biology, ecology, population, taxonomy, phylogeny and physiology of fish by students, technicians and faculties were also taken note of by directly interacting with people in work.

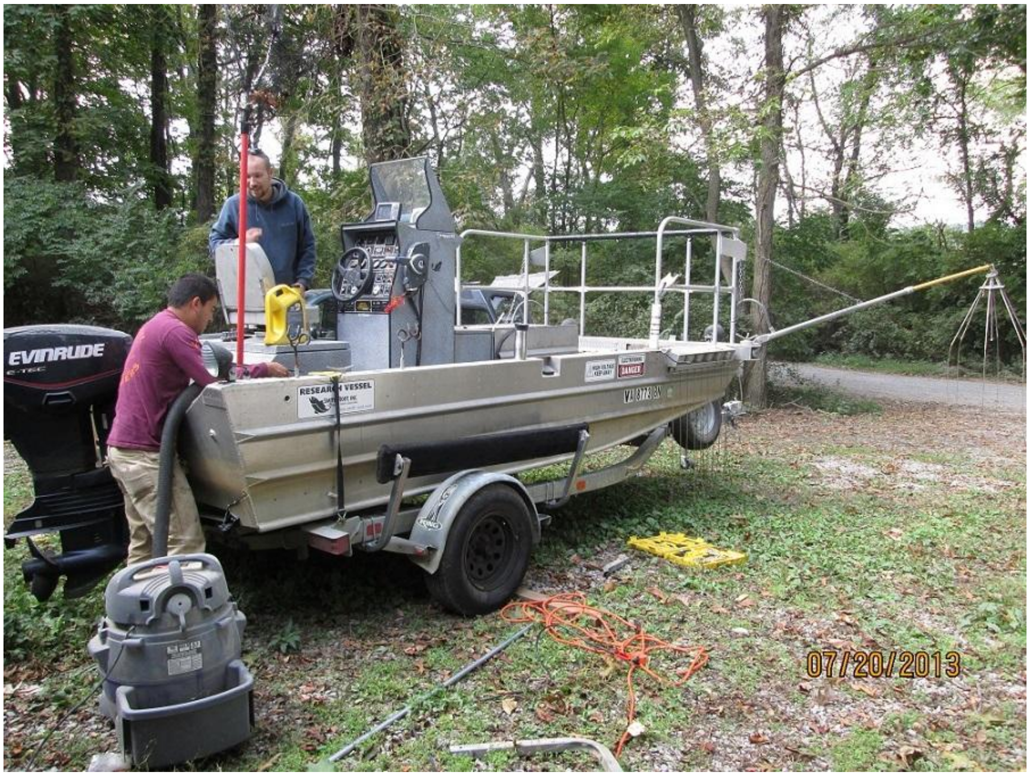
The small scale Natural History Museum setup inside the Department was also studied for the techniques to keep records, tools and chemicals to enhance the preservation, its use in class and references, and its maintenance and management. The office of Virginia Department of Game and Inland Fisheries at Blacksburg was also visited to interact with their fishery biologists and technicians. Also their tools and equipment used in the overall maintenance and monitoring of the aquatic resources of Virginia were observed and studied.

The Annual Conference of the American Fisheries Society was attended, in which the state of the art of fisheries research in North America was observed and understood. There was a big input not only of the academic matter related to the field, but also the chance of interacting with business people producing and selling wide varieties of fishing implements including fishing gears, traps, nets and rods, tags, apparel, and other scientific instruments associated with fish and water research and experiments.

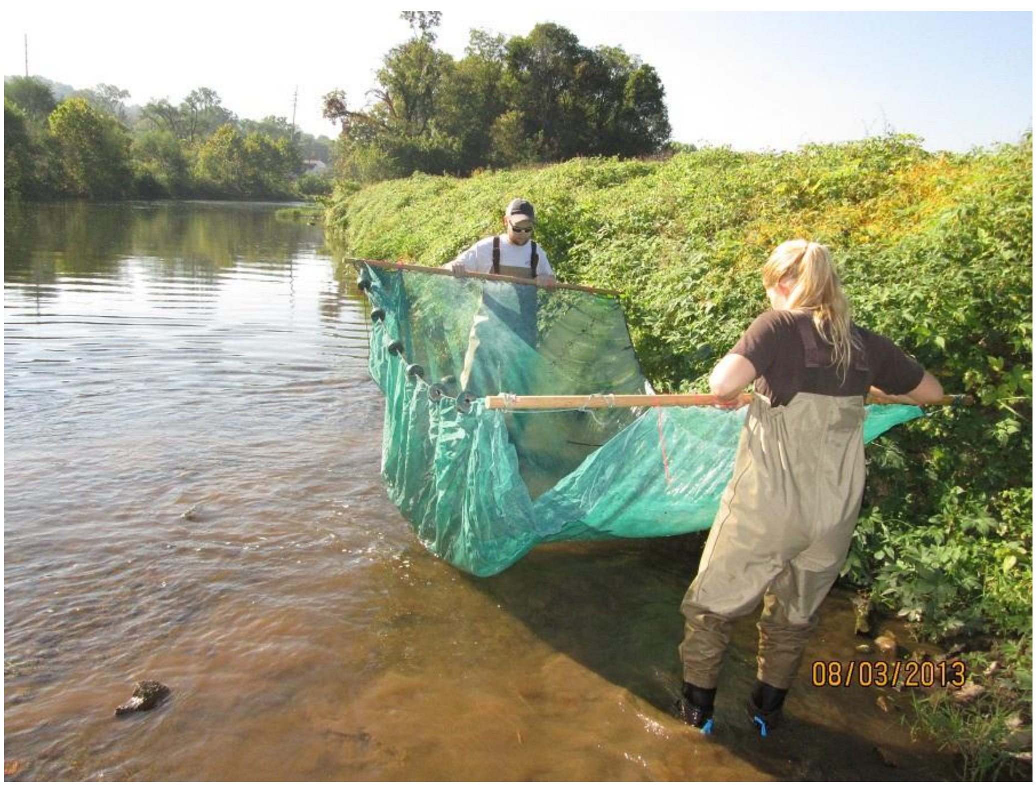
Relevant keys, protocols and literatures associated with all the above mentioned tasks were surveyed and reviewed with the help of the Department, Library and internet accessibility.



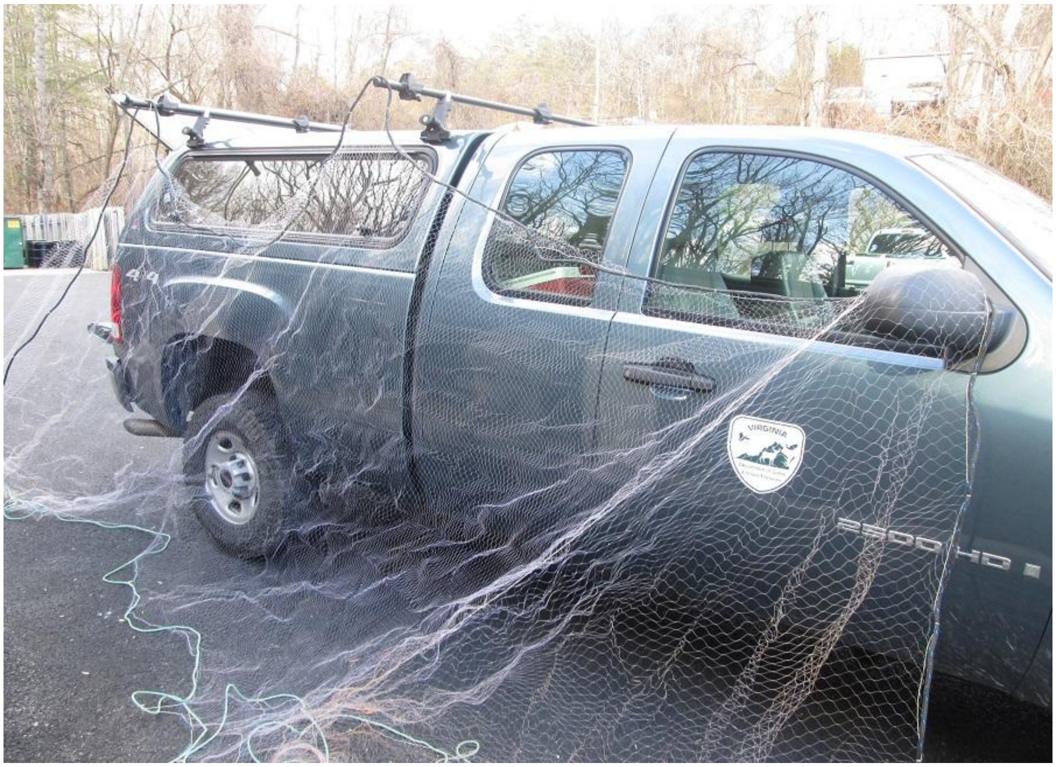
All Set for Battery Run Electro-Fishing



Maintenance of Boat-Mounted Electro-Fishing Gear



Seining Net



Multi-size Mesh Gillnet

2. Data management techniques and analysis were observed for diverse fish based projects ongoing in the Department. In the first step, how the various types of data recorded in the protocols during field samplings are entered and copied in a computer program such as XL spreadsheet were studied. In the second step, how the data are further processed and analyzed using various tests and software to produce meaningful results and their interpretations was studied. The various software revisited and put to basic use included SAS, JMP, Minitab, Matlab, ArcGIS and R.

3. Regarding the sharing of culture and experience between the partners, the chance to meet and interact with many people and institutions has been fully worked on and utilized. Everyone in the Department, including Faculties, Ph.D and MS Scholars and Administrators were contacted frequently to meet and thereby shared the contents of environment and culture with one another. Many of the dissertation defenses by the students and scholars were also attended, as they not only provided the academic inputs, but also provided the chance for interactions during question answer sessions and after defense treats.

   The participation in the American Fisheries Society's Conference in Little Rock, Arkansas, as mentioned before, not only provided exposure to the state of art of fisheries research in the entire Continent, but also provided an opportunity to interact with diverse people with different cultures. Many of those contacts are continuing and functional, and thus has a potential for future exchanges. Besides, the rich history and architecture of the city was observed, various museums were visited and many local people with different walks of life were mutually entertained. On the sideline of the conference, interaction with business communities dealing with fishing implements was done to buildup rapport for future business.

A Departmental Seminar was given regarding the state of the fisheries/river research in Nepal so as to exchange information about conditions in Nepal and also to get feedback from the faculties and scholars. Likewise, a talk was also given to the Virginia Tech Fresher about the environment and academia in general, and the situation mentioned in the book, The Little Princes, by Connor Grennan, in particular. In addition, a Fulbright Enrichment Seminar, with the title, Old to New West: The Role of Land in Shaping the American Story, was attended in Tulsa, Oklahoma. During the seminar, interaction between Fulbright Scholars from different countries and cultures was given a top priority, but listening to the academics, experts and locals was not less significant. The conservation and management practices on the Great Prairies, where the wild population of Bison is thriving, was the highlight, and was observed keenly.

Discussion

Field trips associated with a of number of diverse projects such as, 'Assessing Impacts of the Roanoke River Flood Reduction Project', 'Impacts of Dams on Little River Fish fauna', Sampling of Young of the Year Roanoke Log Perch in Roanoke River', 'Selective and Qualitative Sampling of Rock and Roanoke Bass for the Study of their Status', 'A meristic and morphometric assessment of Roanoke bass, rock bass, and their hybrids', ' Study of Rock Bass for genetic variation', etc. were participated in so as to acquire first hand field knowledge of the fish sampling practiced in the institutions in US. In addition, a field practical for the Undergraduate Program in the Department of Fish and Wildlife Conservation too was attended to see various fishing implements in use.

Methodologies of field samplings and protocols to record the information for all of the field trips attended were studied and understood before and during the samplings. Related literatures on the methodologies applied were also studied in detail (Schreck and Moyle 1990; Paller 1995; Simonson and Lyons 1995; Angermeier and Smogor 1995; Bowen and Freeman 1998; Furse et al. 2006; Bonar et al. 2009; Holtrop et al. 2010; Liefferinge et al. 2010; Price and Peterson 2010; Hubert et al. 2012; Zale et al. 2012). These literatures describe the application of different sampling tools in different conditions, according to the goals and objectives of the study, however, the methods should be standard and consistent.

In all the projects mentioned above the fish sampling was the integral part, though various other physical, chemical and substrate base characters too were measured and recorded. The most common technique applied to sample fish was electric shocking, but some samplings were done without using electric current such as seine and gill-nets. The most common equipment for the electro-shocking of fish for sampling were backpack electrofishing gear for wadeable streams and boat-mounted electrofishing gear for the non-wadeable water bodies, together with the intermediate form, the barge. Though, there are negative impacts (Nielsen 1998) of electrofishing on fish populations in terms of mortality, injury and unknown long term effects, it has become the most essential methods in fisheries research.

When compared with the backpack electrofishing gear that are in use in Nepal for scientific fish samplings, the gears in use in US showed some differences, though the principle and purpose is the same. In Nepal most of the gears are built and assembled in Europe and run by gas, but in US, the gears are exclusively made in the country and commonly charged by a battery. Also, interesting to note was the manufacturer, Smith-Root (http://www.smith-root.com), which supplies the maximum number of these sampling units and was allowed to specialize in efficiency and safety because of its market.

The commonly used back-pack electro-fishing gear in the US was found to possess several advantages over the similar gears that are in use in Nepal. The first clear advantage is that these gears are lighter and are designed for much more robust use, as when the device is lighter, it can be held and used for a longer time and for a longer stretch. The Europe made gears that are in use in Nepal too are designed to make it bearable on one's back and built to last long, but they are still heavier and designed sophisticatedly, and thus, exhaust the user physically very fast and also draw mental attention on its operation and maintenance continuously.

The second advantage in US made back-pack gears is that they have a digital display and have more control over its output by the users. This is a very prominent advantage, as the output has to be controlled for efficient and precise samplings demanded by the objectives of the research in different conditions such as temperature, conductivity, depth, target species, mortality etc. On the other hand, the gears in use in Nepal have none or limited control over the output of the voltage, amperage and power from the generator. Therefore, the US made gear allows more freedom and accuracy in adjustment of the output that leads to efficient sampling as well as helps in the safety of the operators.

The third difference between the two is in the fuel type. The US made gears normally use a specially designed rechargeable battery as a source of energy, while the European made gears used in Nepal burns gas. It is generally said that the gas operated gears generate more power and hence captures more fish compared to battery powered generator. However, Smith-Root manufactured gear that uses a special kind of batteries produces as much power, volt or ampere as is produced by gas operated gears. In addition to that, it minimizes costs, space and hazards compared to traditional European gear.

Another prominent difference between the two gears is in the type of current the unit generates. The gears in use in US generates either DC or Pulse DC as an electric field, but never an AC current. While in Nepal the electrofishing gears produce either AC or DC, but never a Pulse DC. It is generally accepted that the AC current is more lethal and leads to more mortality of the sampled fish, while Pulse DC is regarded as the least hazardous to the fish population (Nielsen 1998; Beaumont et al. 2002). However, the personal experience in the field sampling in different rivers and streams in Virginia, US suggest that the mortality of fish species is not less than in the fish samplings done in Nepal, using either AC or DC current, suggesting that these currents may be as good if applied carefully (Schneider 1992).

There are not many other differences in the equipment in use between the countries, but there still are some in the operation and safety procedures. In most of the samplings in US, standardization of the 'space' takes place as there would be predefined stretches of the streams and rivers with well-constructed transects. Then the data is recorded and computed into abundance, density, frequency, richness and various other population and diversity indices as required by the research. However, In Nepal the sampling 'time' is standardize for similar outcomes, though the width and stretch length of the streams sampled are also recorded for reference (Jha 2009).

In some of the samplings in US, the downstream wading in the stream was also noticed, especially when a big seine was used to fetch the shocked fish instead of the traditional dip nets (Roberts et al. 2013). This is in contrast with the technique used in Nepal, where wading has been always upstream and shocked fish collected by the dip nets. However, the technique could be adapted according to the objectives of the research and stream conditions, as the main work is to capture either all shocked fish or some selected species.

The barge and boat-mounted electrofishing too are very common in the fish sampling in American institutions, especially in the river conditions where wading is difficult or not possible. Because of these, all water bodies here have been studied for aquatic diversity. However, in Nepal, there are no instances of the use of this equipment and hence our larger rivers and lakes, where wading method is not possible, remain inadequately studied. It may not be still in use for foreseeable future because of its cost and technical knowledge needed for its application.

Another aspect given more priority during sampling in American institutions is the concern of safety to the sampling teams (Bonar and Wayne 2002). Since, during electrofishing lethal amount of electric current is in use, all the members need to be properly insulated and also provided with life jackets in deeper water bodies. The wading boots used in US seem lighter and made of waterproof synthetic material coated internally with rubber and hence provide greater ease while wading. However, the boots used in Nepal are heavier, all rubber and add difficulty during wading. Practically though, it was found that many times the boots are leaking and thus, makes the clothes of the team wet, heavier and hazardous, which is remarkably common in the both countries.

In addition to the application of the electricity in fish sampling, other tools such as hydro-acoustics, seine, gill-nets, hooks, long lines and other minor nets and traps are used extensively in fish-based research in the US and Europe (Kushlan 1981; Rudstam et al. 1984; Wilson et al. 2011; Emmrich et al. 2010 and 2012; MacPherson 2012; Wayne 2012). These fishing elements are also in use in Nepal, but not by academic institutions for research purpose. Mostly, they are used by subsistence and commercial fishing communities, sport fishing and by the related Government Departments. Therefore, no standardization of the methods are seen in the use of those fishing implements and hence, if ever they are used for research purpose, it's all qualitative. However, there is a great potential for use of the alternative gears in Nepal if the methods are standardized since many of them are less costly and could be manufactured indigenously.

The field base observation and information in US are normally backed-up by laboratory works that involve the use of preservatives and museums, dissections and anatomy and tissues and genetics. The first two works are also in practice in Nepal to some extent, but the third one is almost non-existent, and even if there are provisions now, it is too costly to implement. The genetic level research increases the accuracy of all fish-based data and is essential in the study of phylogeny, taxonomy, distribution, population, and aquaculture, which are all basic to higher and wider level of fisheries research. Fisheries scientists in Nepal need to incorporate genetics at the molecular level to increase the authenticity of the data for wider use.

Other equipment used in the field to measure and record various water and fish base characteristics, such as multi-functional probes, tags, cameras, flow-measuring meter, weighing machines, length measuring tool, preservatives, tapes, protocols, etc. have been found to be not much different in the fisheries research in the US. Researchers in Nepal too are using the latest variants of these tools. However, one thing to note is the use of the equipment suitable for quick and robust use are common in US compared to Nepalese work, where many times tools that are either too sophisticated, or too difficult, are in use.

In addition to the application of advanced and standard methods in research in Nepal, other important aspects are to compare different techniques to adopt the most suitable methods as per its condition and need, and to document information of fisheries resources in a scientific way so that it can be used and compared internationally. Therefore, the use of different sampling tools in terms of its efficiency, merit and need were discussed among the experts and academics and the related literature were also extensively reviewed. There are many experts and researchers, whose works are mainly concerned with improving the safety, efficiency and utility of the gears, so that the best outcome could result (Zachary and Freeman 1998; Cao et al. 2002; Dolan and Miranda 2003; Diekmann et al. 2005; SFCC 2007; Hitt and Angermeier 2008; Reid et al. 2009; Pont 2009; Habera et al. 2010; Reynolds and Harlan 2011; Meyer and High 2011).

Finally, the tools and literature concerned with simple and basic information regarding water and fisheries resources were studied in detail so that the scientific gathering of the information in Nepal can be worked upon and could be utilized by the international community as these resources truly are the global commons. Here the fish species diversity, richness, composition, population, abundance and density, biology and ecology, development of biotic indexes, impacts of various disturbances, and the conservation and monitoring of the resources were studied extensively (Karr 1981; Angermeier et al. 2000; McCormick et al. 2001; Smogor and Angermeier 2001; Daniels et al. 2002; Blocksom 2003; Angermeier and Davideanu 2004; Hughes et al. 2004; Bramblett et al. 2005; Hering et al. 2006; Stoddard et al. 2006 and 2008; Whittier 2007; Sickle 2010; Aparicio et al. 2011; Launois et al. 2011; Hitt and Angermeier 2011).

Development and application of fish-based biological indexes (IBI) is a widespread practice in the developed world as in the process it documents and analyses multitude of information such as habit and habitat of the species, biological and ecological traits, population dynamics, distribution and status, health and integrity, and even modelling, climate change and forecast that are essential for the conservation and monitoring of the species (Hughes and Gammon 1987; Ligon et al. 1995; Lucas and Baras 2000; Chan

2001; Freeman et al. 2001; Morgan and Cushman 2005; Frimpong and Angermeier 2009; Villamagna 2009; Barbour et al. 2010; Benejam et al 2010; Hawkins et al. 2010; Sarkar et al. 2010; Geist 2011; Hermoso et al. 2011; Nislow et al 2011; Birk et al. 2012; Gorney et al. 2012; Kelly et al. 2012; Schaefer et al. 2012; Argillier et al. 2013; Peoples and Frimpong 2013; Verberk et al. 2013). The fisheries research in Nepal should follow this trend of development as there are numerous, issues and factors automatically studied and incorporated.

The various software used in the field of fisheries research were also studied and tried to learn, the scientific way to keep data, important statistical analysis of the data and the art of modelling and predicting the trends that help in the conservation, monitoring and policy making. The software and programs most commonly used in US were, XL, SAS, JMP, Minitab, Matlab, ArcGIS and R, even though there exists numerous others. These, are enough to analyze complex statistical problems and also produce desired results, models and trends. Fisheries research in Nepal too utilizes these tools, but needs to specialize and explore more within this framework.

The literature related to data analysis, modelling and future trends in the use of computer and statistics were also searched and reviewed. The data used in such technical evaluations come either from accurate test experiments or from the long term records, which the US has facilities all over the country. There are many issues related to water and fisheries resources covered by such tools and techniques (Bain et al. 1988; Oberdorff 2001; Olden and Jackson 2002; Rashleigh et al. 2005; Rose and Sable 2009; Gozlan 2010; Grossman et al. 2010; Snelder and Lamouroux 2010; Davey 2011; Elith et al. 2011; Garcia et al. 2011; Kulhanek et al. 2011; Maunder 2011; Strecker et al 2011; Tetzlaff et al. 2011; de Mello et al. 2012; Hitt and Roberts 2012; Rolls et al. 2012; Henriques-Silva et al. 2013;).

Nepal has very scant information regarding the vast natural resources and that too is mostly qualitative. Hence a detailed analysis of long term data and subsequent results and models are difficult to generate. However, with academic, technical and financial support from the developed and rich nations, such as the US, just like in this project, scientific records of the information and their publication would be started.

Finally, the more extensive and meaningful engagement of faculties, students, scientists and experts between the two countries are extremely important, as was provided by this project, for many reasons. There would be a direct transfer of knowledge and techniques from more advanced countries to the less advanced countries like Nepal. There would also be the exposure and acquaintance to the advanced equipment and tools. And most importantly, the exchange of cultures between the countries creates a more conducive environment for the future engagements to realize mutual benefits.

This project has given ample opportunities for the exchange of socio-cultural aspects of two countries through the conference, enrichment seminars, lectures and talk. The National Conference of American Fisheries Society provided the mutual exchanges of ideas between hundreds of professionals and academicians not only from the US, but from all over the American continent. Many of such personal and institutional exchanges have a potential to grow into concrete collaborations between two countries in the field of fisheries and water resources, which are two important natural resources of the world.

Similarly, participation in the Global Enrichment Seminar organized by the Fulbright Commission has also provided opportunities of exchange of views and ideas between number of countries including the locals, as well as Native Americans. It was also a valuable chance to observe American National Park with Great Prairie and the wild buffalo in the wild, and the heritage and system of indigenous people of America. These contacts and experience have truly enriched the participants with experience that highlights the American values of diversity, freedom and tolerance. Surely, these values will dominate in all decision making and way of life of all the participants coming from different corners of the world.

The engagement in the own host university, The Virginia Polytechnic Institute and State University, Blacksburg has been most useful and rewarding. According to the objective of this project, it was possible to establish a permanent link between the College of Natural Resources and Environment, Department of Fish and Wildlife Conservation, faculties, students and the academia of Nepal because of the generous cooperation from all the personnel concerned. The host supervisor, Prof. Paul L. Angermeier has been instrumental in the achievement of all the objectives of this project by facilitating all required aspects and actions, besides direct inputs from his specialized field. A lecture, given to the Undergraduate Students of Virginia Tech, would also surely makes an impact in the future for the mutual benefit of the countries.

The interactions with New River Community College, Blacksburg Middle School, Hospitals, Hotels, Church groups, Businessmen, other professionals and local people at the family level, have been very exciting and rewarding to the scholar engaged in this project and his family. The entire family has learned the society and culture of the US and has left a deep imprint in the mind. As expected, similar imprints must have also been passed to American people and institutions. The effect of these exchanges would certainly play role in shaping the mind for more conducive environment while engaging with different cultures.

Recommendations

1. As this project is a direct cooperation between two countries, there are benefits which are clear and certain. Therefore, the possibility of more such projects should be explored by all concerned so that more mutual benefits could be reaped

2. The areas of Global Concern, such as the current project, attracts international attention and hence the countries are more willing to get engaged in joint projects. This kind of joint project should be extended to all such fields of international importance.

3. The pool of information and level of research in the area of Fisheries is huge and advanced in the US, while it is low and scant in the country like Nepal. Therefore, more projects that explores information of the natural resource and enhance the research capability of the country like Nepal should be worked out and materialize.

4. The equipment and tools used in the field of fisheries, the main concern of this project, is certainly more advanced than are used in the country like Nepal. Therefore, the chance of exposure and learning of these tools should be given to more people on regular basis so that it creates a pool of experts in the country like Nepal.

5. The advanced equipment and tool, which are in use in developed countries cost much and are usually not affordable by the people and institutions of countries like Nepal. Therefore, suitable mechanisms to transfer such devices as a grant or reduced price should be worked out by all parties.

6. To secure permanent or long term mutual benefits of the exchanges, collaborations at Departmental or individual level have to continue in an uninterrupted manner.

7. A follow up mechanism to see the success of the projects, as this one, should be made by the engagement of all the parties concerned, The Fulbright Commission, Host Institute in the US (Virginia Tech in this regard) and the engaging partner (Kathmandu University in this regard).

8. The mutual exchange of scholars at a family level should be facilitated as this has more profound effect on the exchange of socio-cultural dimension of the participating countries.

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