Use of Icy Waters Arctic Char for freshwater aquaculture in Nepal

AGR1110 - Introduction to Agri-food Systems
University of Guelph
Prof. Raizada

By: Nicholas Clement

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1. Introduction

This paper will explore the use of Canadian bred Arctic char in fresh coldwater aquaculture focused in the High Mountain region of Nepal (see figure 1). Eyed eggs will be transported to Nepal from Icy Waters Arctic Char in Yellowknife, Yukon, Canada in order to develop extensive methods of aquaculture integrated with subsistence farming in this region. Although there are no previous accounts of Arctic char use in Nepal their is a precedence for the introduction of fresh coldwater exotic species as several trout species have been introduced primarily for subsistence and recreational/sport fishing (Petr, 2002).

There are several advantages associated with using Arctic char outlined by Summerfelt et al. (2004) which include survival at colder water temperatures feeding successfully between 0-16 *C exhibiting maximum growth between 12-15 *C. In addition Arctic char have a unique ability to prosper at higher densities when compared with other aquaculture species allowing opportunity for increased production in relatively small areas. Aquaculture using salmonids such as Arctic char, salmon, and trout produce the highest feed conversion ratios of any husbandry system approaching 1:1 around 1.2-1.3 whereas the second most efficient feed conversion takes place in chicken approaching 2:1 at approximately 1.7-.1.8 (Owen Skipper-Horton, personal statement November 5, 2014).

Icy Waters Arctic Char's aquaculture facilities in Yellowknife are fully integrated allowing for complete control over fish life cycle and they produce 150 MT/year of Arctic char in addition to seasonal sale of eggs and fish stock (Arctic Rose Inc., 2011). Their

facilities strive to produce zero waste acting as a large filter for the surrounding watershed. They make use of drum filters, settling ponds and wetlands in order to remove effluent and particulate matter before returning the water to natural wetlands downstream. Their Arctic char fish eggs available biannually in May/June and November/December are a result of over 20 years of continued research and development (Troutlodge, n.d.). This research has involved selection for upper temperature tolerance, increased growth, disease resistance, and all female populations important for juvenile development (Arctic Rose Inc., 2011). They are grown without antibiotics, which may be inaccessible to some Nepalese farmers, and are a good source of protein as well as healthy Omega-3 fatty acids (Troutlodge, n.d.). Despite their success they have experienced failures with start-up operations in Ireland and the United States which the president, John Rose, attributes to immature marketplaces and technical issues in addition to a lack of focus on social licenses for water and resource use as well as being respectful and investing in the local community. He believes many of these challenges may be overcome by furthering a collaborative industry-wide approach to improve the Arctic char industry in Canada.

2. Market

According to Gurung (2012) fish production in Nepal is far below the market as per capita fish production in 2010 was only 1.8 kg. In the densely populated Kathmandu Valley roughly 99% of fresh fin fish sold is imported from India and other countries (Gurung, 2012). Approximately 3,000 metric tons of fresh fish was imported to Nepal in 2009 and considering all forms of fish (canned, dried, marine and other high value

products) Nepal spent about 1.5 billion Nepalese rupees, equal to $20.5 million dollars US, in 2009 (Gurung, 2012). Consumers in Nepal prefer fish that are fresh and healthy and recognize that Nepalese fish are superior in quality and freshness compared with fish from India (Berbamini, 2006). Traditionally seafood dishes such as ghonghi snails have been considered a highly nutritious delicacy with many benefits including being offered as a protein supplement for pregnant women, providing immunity to malaria, helping to heal broken bones and clearing bowels among indigenous and rural poor indicating a cultural recognition of the high dietary value placed in protein rich seafood (Kumbha, 2013). These findings indicate that the market for fresh fish in Nepal is already well established and continuing to grow.

3. Benefits to Canada

The methods suggested to develop aquaculture using Arctic char in Nepal should be largely extensive as opposed to intensive. Such Extensive methods can be development along with seasonal markets should be accessible to rural farmers who may be able to use an existing pond to generate supplemental income as they require little capital investment as well as less time commitment when compared with intensive production (Alberta Department of Agriculture and Rural Development, 2006). Similar methods could be implemented in order to improve food security in Canadian north. The parallels between Nepalese and Canadian aquaculture production using Arctic char could prove to be valuable for research and development of this industry in both countries. This also provides the opportunity for Canada to be viewed as a world leader in aquaculture genetics as well as improving the reputation of Canadian businesses abroad in regards to

sustainability and cooperation with local populations. In fact, a project proposal on this subject, albeit using more intensive methods than suggested here, was put forward by Dr. Vanderburg (n.d.) from the University of Laval in Quebec. In this proposal he suggests that to in order to address issues such as transportation costs of food and contamination of food supplies land-based production of Arctic char using a recirculation system integrated with greenhouse based aquaponic fruit and vegetable production should be implemented. This method should be given proper consideration once the aquaculture industry in Nepal is better established as currently the recirculation method of production may prove to be too costly for Nepalese farmers as the filters, pumps and oxygenation equipment would amount to a large initial investment. The less capital intensive method of using available outdoor resources and gravity-fed water circulation is suggested in this proposal although integration with fruit and vegetable production is a priority and will be discussed in greater detail later in this proposal.

Although Icy Waters Arctic Char have been chosen as the subject of this proposal their are other producers of Arctic char strains in Canada. Although the commercial availability of these strains of Arctic char eggs has not been verified to date a brief overview of other potential producers will be presented.

Coastal Zones Research Institute headed by Claude Pelletier have been developing a strain of Arctic char referred to as the “Fraser Strain” at the Aquarium and Marine Center in Shippagan, New Brunswick since 1996 (***ref final report). The strain where originally collected from the Labrador Fraser River in the 1980s and are noted for having a very low level of inbreeding, early maturation and 75% increased weight gain compared to the first generation, although production of all female populations in still in progress.

In addition computer software which may be of value was created allowing for hatchery management in order to evaluate and control inbreeding and minimize loss of genetic diversity.

Pisciculture des Monts de Bellechasse Inc. operated by Mr. Moïse Cantin in Quebec produces Arctic charr hybrids for the egg market and although the majority of his production in focused on brook and rainbow trout he is an expert in egg production and sterilization, production of all female stocks as well as photoperiod manipulation.

It should also be noted that Arctic char are bred and produced at the Alma Aquaculture Research Station near Elmira in Ontario operated by Guelph University and although this facility is also fully integrate char this station is focused primarily on research as opposed to commercial production (**ref). It should be noted that this research may be a valuable resource for use in production of Arctic char.

4. Transport and Distribution

Their are currently 13 Fishery Development Centers in Nepal with four being dedicated to the development of coldwater fish species, Trisuli Development Center, Pokhara Development Center, Godawary Development Center and Kulelekhani Fisheries Development Center (Petr, 1999). The eyed Icy Waters fish eggs will be transported from Yellowknife Canada to any suitable development centers in Nepal. As the eggs are relatively light, small and durable transportation costs will be minimized considering the distance they must travel. Salmonoid eggs are easily transportable at the proper stage of development referred to as “eyed” due to the development of small black dots in the center of each egg. During a guided tour of the Alma aquaculture research station

operated by Guelph University the tour guide explained that eyed eggs can be transported on ice for extended periods without risk of spoiling (personal statement, ate****). Icy Waters has previously been successful transported their fish eggs to four different continents indicating that arrangement of long distance transportation will not be an obstacle. The fish eggs could be transported by plane from Yellowknife to Kathmandu in 30-45 hours without incurring great expense due to their relatively small size and weight. To give a rough estimate a commercial flight for one passenger from Yellowknife to Kathmandu costs around $1,000 Canadian.

The local distribution of fingerlings, or small young fish, will be organized through the coldwater fishery development centers. In addition the strategic planing for financing will be based on a the model of popular dairy co-operatives in developing countries. Karki (2005) outlines three principals that define a cooperative. The first being that the persons who use the co-operative own and finance it. Secondly, that those who use the co-operative have control of it. Finally, that any benefits accumulated by the co-operative are distributed based on use to it's users. In addition, as a developing country the strategic plan for coldwater aquaculture co-operative in Nepal will be to reduce the cost of production, increase production, create internal improvement in local communities, and provide quality service to the consumer by means of trained and educated manpower and e-commerce (Karki, 2005).

5. Integrated Aquaculture within Agricultural Irrigation

The many benefits of integration of aquaculture with agriculture irrigation in Nepal are discussed by Gurung (2012) who states it will help alleviate pressures caused by

issues relating to food security and climate change. As irrigation provides water for crop production which does not come directly from rainfall Gurung (2012) argues that it has great potential for increasing agricultural production. Gurung (2012) continues stating that small-scale multiple-use water systems and irrigation are likely to reduce poverty where physical and financial infrastructure have not been developed, such as in Nepal where only 33% of cultivable agricultural lands have access to irrigation. In a study by Cohen (1996) it was indeed found that Integrated Aquaculture within Agricultural Irrigation (IAAI) is able to increase land productivity by allowing fish to supply available nutrients in order to maximize agricultural production using scare land resources. Capturing water within the landscape is particularly important in Nepal due to the intensity of the monsoon season when over 90-100 days 85% of the rainfall occurs leaving only 15% throughout the rest of the year (Gurung, 2012).

An example of high altitude sustainable farming integrated with extensive aquaculture is provided by Holzer (2004) in his book describing the establishment of a pond system using terraced ponds located at elevations between 1000-1500 of meters in Salzburg, Austria (see photo 2). In this system the land is terraced using machinery in order to create a connected pond system that makes use of the steep gradient for gravity based transport (Holzer, 2004). The ponds are connected to one another using above ground streams for water oxygenation as well as underground pipes which are bent at an right angle allowing them to be opened or closed manually. This allows the ponds to be emptied or filled as desired greatly facilitating fish harvest as well as upkeep and repair of ponds. Although the initial investment for such a system would require transport of machinery for landscaping to relatively remote locations provided proper management

these pond systems could remain functional for many generations given adequate research and development. In this case the capacity of the roads described by ***** in the High Mountain regions for movement of landscaping machinery must be first accessed.

6. Geography and Hydrology in Nepal

According to a study referenced by Petr (1999) about 3% of Nepal's total surface area could be available for fish production amounting to 500,000 ha of water surface. Approximately 98% of this total available water surface area is divided equally between paddy fields and lakes, rivers and reservoirs. Nepalese rivers can be divided into two major groups: rain-red rivers, and glacier melt or snow plus rain fed rivers. The fluctuation of discharge is particularly high in rain-fed rivers where shorter rivers may be seasonal, drying up from time to time (Petr, 1999). Therefore the more reliable source of fresh water will be from the glacier melt or snow plus rain fed rivers which will have lower water temperatures in the High Mountain regions as a result of relative proximity to snow and glaciers sources.

Petr (1999) states that although coldwater species in Nepal may tolerate a wide range of water temperatures the majority live between 10-20 °C, significantly higher temperatures than those to which Arctic char are adapted from 0-16 °C. As the energy required for heating of water close from near 0°C to 10-20°C in order to support the majority of coldwater species in these areas would not be feasible without use of a recirculation filtration system with heating as outlined by Summerfelt (2004).

7. Current coldwater species

In coldwater lake regions (see figure 2) capture fishery is predominant. Although cage culture has increased in select lakes most of the coldwater capture fishery is subsistence related, the fish being consumed shortly after being caught (Petr, 1999). On the southern slopes of Himalayas in Nepal there are two river zones; the rhithron which has a high concentration of dissolved oxygen, fast current and turbulent water upstream and the potamon downstream with higher water temperature, lower dissolved oxygen content and lower current velocity (Petr, 1999). Arctic Char would be more suited to the lower water temperatures of the rhithron zone. Fish fauna in the rhithron include the indigenous *cyprinid schizothoracines* as well as the introduced brown trout but because in the winter larges numbers of cyprinid schizothoracines migrate to the potamon zone to avoid extremely low water temperatures there is no clear distinction between the two zones. In fact, some species from the potamon region enter the rhithron for spawning. At high altitudes rivers and streams have low fish production and therefore are of little importance for commercial fisheries although useful at a subsistence level. Brown trout are sometimes stocked in rivers and streams for recreational and sport fishing. This exotic fish has in fact successfully established self-sustaining populations in some streams.

8. Conclusion

Nepal's aquaculture industry began in the 1940s when pond culture using Indian carps was introduced (FAO, 2006). This type of carp polyculture remains the most popular and viable method for aquaculture production accounting for over 90% of total production (FAO, 2006). This pond production system is used in the Terai plains region which is the location of 94% of these fish ponds (FAO, 2006). Enclosures fish culture in

lakes and reservoirs, cage fish culture as well as rice-fish culture are popular production systems although with limited expansion (FAO, 2006). The use of Icy Waters Arctic char integrated with subsistence farming could expand the current aquaculture industry to the High Mountain regions of Nepal and create new opportunities for Nepalese farmers in this region to diversify their subsistence or commercial farming.

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[credit for figure 2: Major rivers of Nepal major rivers of Nepal and figure 3: Himalayan river system]

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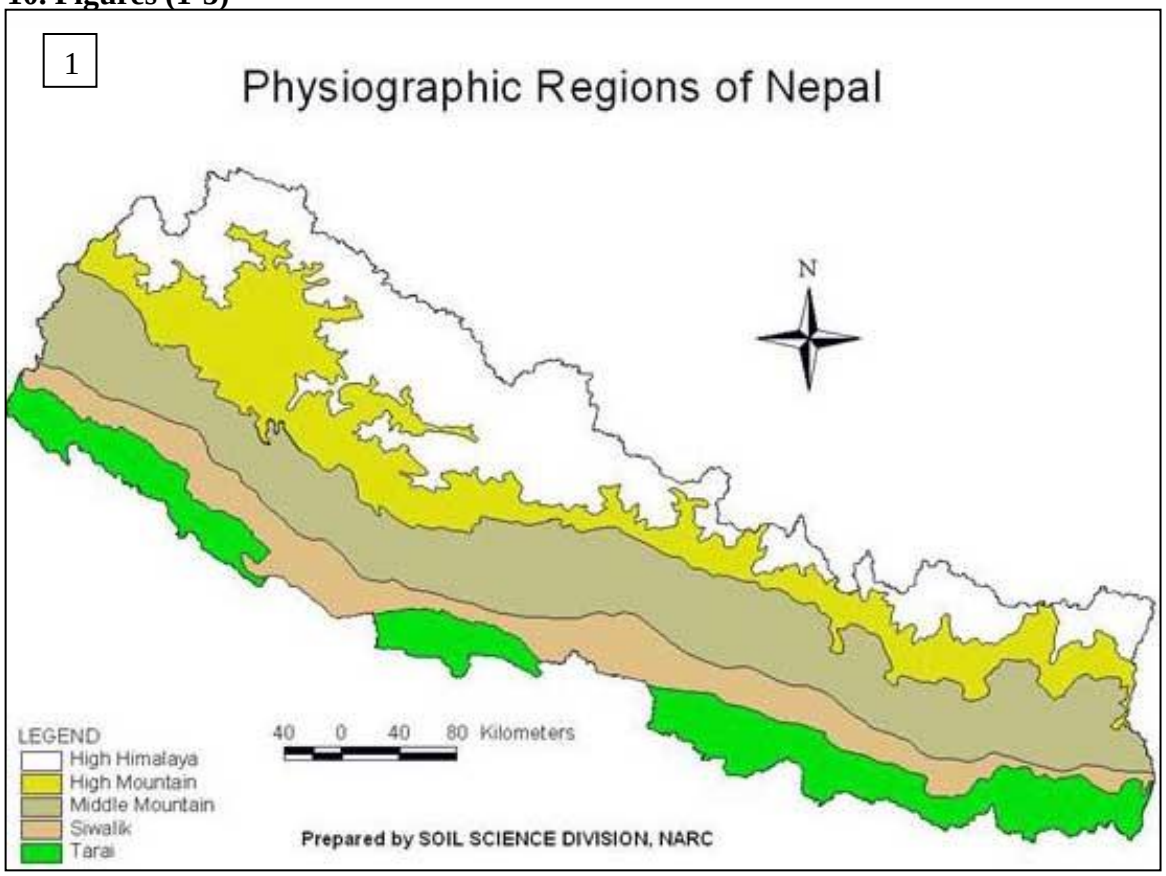
10. Figures (1-5)



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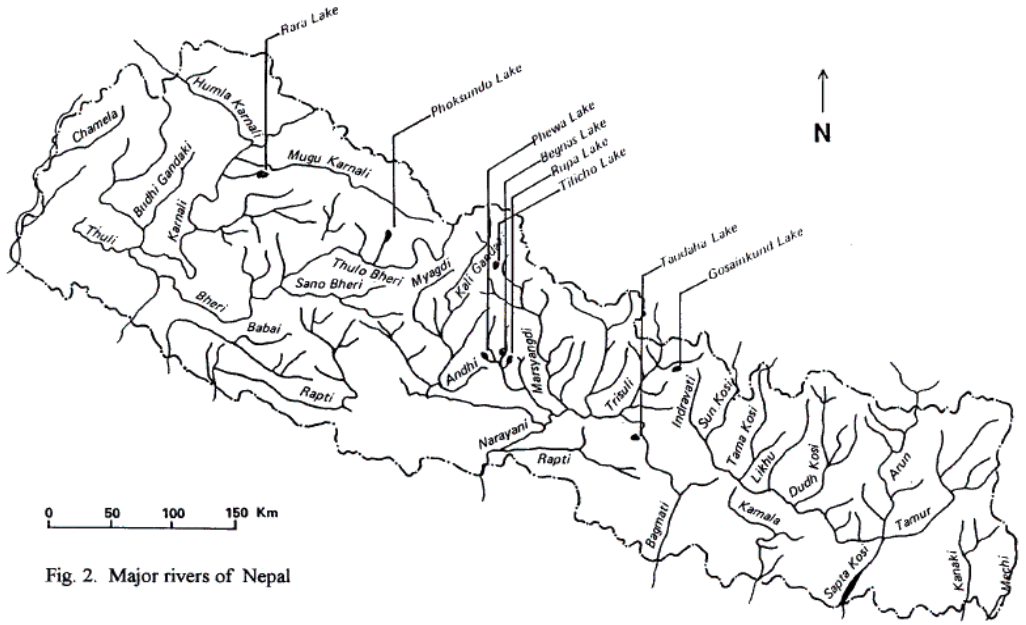

Fig. 2. Major rivers of Nepal

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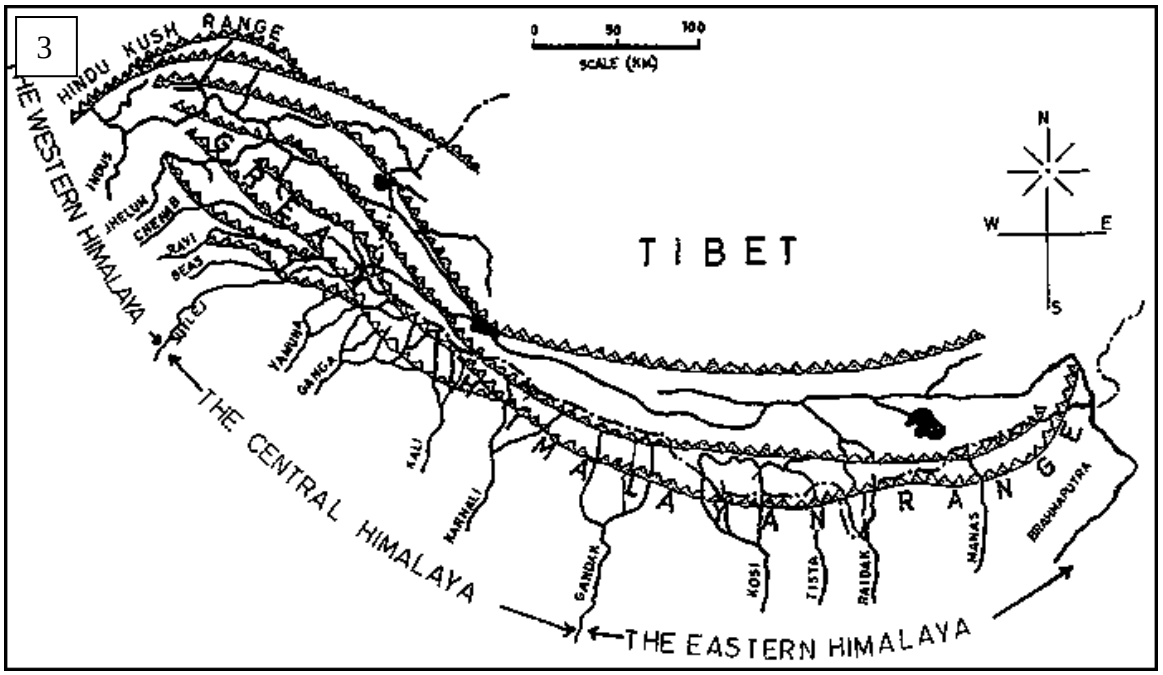

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