# Chapter One: Dams, Dam Removals and Fisheries

A dam may be constructed for a variety of reasons. Flood control, water supply, irrigation, waste disposal, water power and electricity production, fire and farm ponds and flat-water recreation are all possible reasons that a dam can be a beneficial structure (Heinz Center, 2002). Whenever a dam is constructed, however, the watershed in which the structure is built will forever be changed. Fisheries especially are affected by the construction of dams.

## Dams and Fisheries

A wealth of effects can occur to a fishery when a dam is built. Concerns include changes in the movement and amounts of sediments in the river, stream channel alterations and water levels, water temperature and quality (Born et al., 1998; American Rivers et al., 1999; Costenbader, 1998). Downstream ecological effects also occur after a dam is built, and these can be especially harmful for the fishery downstream of the structure. Dams change the flow of water, sediments and nutrients downstream (Ligon et al., 1995). Changes in one or a combination of these three riverine features can have a dramatic effect on the downstream fishery.

Changes in the flow of water downstream could be beneficial for one fish species, while terribly detrimental to another. If water flows are reduced, this may result in increased water temperatures, and the amount of oxygen in the river may decrease (Breder, 1927). This inverse relationship between temperature and the amount of oxygen in the water can result in a dramatic decline in populations of some fish species, while at the same time providing a more favorable ecosystem for others. Coldwater fish species, such as trout and salmon, need cooler, more oxygenated water conditions than other fish species

(Breder, 1927). The construction of a dam can therefore have a domino effect from water flow all the way to oxygen levels in the river. Pejchar and Warner (2001) note that good water quality for coldwater species is correlated with cool water temperature, and high amounts of dissolved oxygen and nutrients.

Nutrient and sediment flow are factors that can clearly affect the downstream fishery. Decreased nutrients and sediments flowing down river reduce the amount of food for consumption for the fish species which live downstream of the dam. If a dam significantly lowers the amount of available nutrients for these fish, populations will dwindle.

Perhaps one of the most widely acknowledged and publicized effects of dam construction is the blockage of upstream migrations of anadromous fish species (fish species which live in salt water, but breed in fresh). The degradation of habitat for migratory fish species is especially of concern for coastal areas of the United States (Pejchar and Warner, 2001).

Anadromous fish species include Atlantic, Chinook and Sockeye salmon, shad, steelhead trout, sturgeon and striped bass, to name a few (www.noaa.gov). Construction of a dam immediately alters the amount of spawning habitat an anadromous fish has access to. The Kennebec River is a clear example of decreased spawning habitat due to dam construction. The Edwards Dam closed off river habitat to Atlantic salmon, striped bass, smelt and shad, among others. The Edwards Dam will be discussed in more depth later in this chapter, and in chapters to come.

Case studies have also concluded that dams lead to decreased anadromous fish populations (Moyle, 1994; Whitelaw and Macmullan, 2002; Pejchar and Warner, 2001). The Glines Canyon Dam in the Elwha River has resulted in a reduced population of Chinook salmon to 25% of their size in the 1800s (Lewis, 1991). Without access to suitable spawning habitat, anadromous fish species are unable to lay eggs, thus resulting in decreased populations. Anadromous fish species are also highly vulnerable to the turbines of hydropower dams, resulting in injury or death before reaching spawning habitat (Lewis, 1991).

The effects dams have on rivers and the fisheries of those rivers are huge. Once a dam is built, the fishery is forever changed. The cases presented above illustrate the potential negative impacts a dam may have to a fishery, but it should be noted that sometimes the flat-water recreational fishery opportunities created by dams are also of value (Heinz Center, 2002). The habitat which is detrimental to cold water species (warmer temperatures, less dissolved oxygen) can be suitable for warm water species such as small and largemouth bass.

Given the possible damaging affects a dam can cause to a fishery, it is conceivable to wonder whether the removal of the dam may result in an improved fishery. When the public, environmental organizations or any stakeholder raises concern over the possible detrimental affects a dam has incurred upon a river ecosystem and the environment, it may be plausible that the dam be removed. As a result, dam removal decisions have arisen across the United States. As Costenbader (1998) puts it, “the onetime world leader in building hydropower projects, now may become the leader in removing them.” The next section details a dam removal decision making methodology.

Dam Removal Decision Making

In light of all the affects a dam may bring to a fishery, dam removal proposals periodically arise. Since every dam removal decision is very unique; it would be impossible to create a standardized formula for all dam removal decisions (Pejchar and Warner, 2001). The H. John Heinz Center for Science, Economics and the Environment has written and published a decision making guide, which details dam removal decision making methodology (2002).

The methodology focuses on the premise that better decision making will follow if the process is "logical, defensible, and organized," (Heinz Center, 2002: 4). The decision making process presented is a step-by-step procedure:

- Define Goals and Objectives
- Identify Major Issues of Concern
- Collect and Assess Data
- Decision Making: Remove Dam or Leave in Place
- Data Collection, Assessment and Monitoring

Dam removal decision making concerns can arise in a variety of areas. They may be environmental, legal, safety, social, economic or management concerns (Heinz Center, 2002). This thesis is focused on dam removals and fisheries; therefore, the step-by-step procedure presented above will be centered around fisheries.

A clear definition of goals and objectives for the removal must be made at the beginning of the dam removal process. As mentioned above, dams oftentimes create flat-water reservoirs which provide recreational fishing opportunities for fish which some anglers find very valuable. Those anglers who value this flat-water fishing might argue against removal.

In contrast, those anglers who value fishing opportunities on un-dammed rivers (for anadromous and/or coldwater fish species) higher than flat-water opportunities, would define a goal of removal to be a restoration to the river ecosystem that existed before the dam was built. These anglers would argue that removal of the dam could lead to enhanced recreational fishing opportunities downstream and/or upstream. Again, as each dam removal decision is site-specific, the effect of removal to the up and downstream fishery can vary.

An identification of the major issues of concern follows the first step. Issues of concern presented by those in favor of removal may differ significantly from those opposed to removal. Concerns related to fisheries involve a comparison of the present fishery to that fishery which would arise were the dam removed. This issue is also economic, as the value of the fishery that may be created from removal could prove to be greater than that of the current fishery. Determining the 'value' of a fishery can be a very difficult and controversial endeavor. The report at hand is just this; a valuation of the Kennebec River recreational fishery. Economic valuation theory is presented in the following chapter.

A period of data collection and assessment follows. Ideally, all data relating to the ecological concerns detailed above should be collected. Information on past dam removals on comparable rivers may also be helpful in the dam removal decision making process. If valuation data is available, it should be included in this step of the process. Economic data concerning the benefits and costs of removal should be collected and compared. Fishery valuation estimates would then be a part of the benefits included in the benefit-cost analysis. Also, the value of the flat-water fishery that would be lost due to removal would be included in the costs of this analysis. Data may also take the form of individual or public opinion. Therefore, personal statements as well as public debates or hearings should also be considered.

After an appropriately timed period of data collection and assessment, the ultimate decision of whether or not to remove the dam is made. Following the decision is a period of continued data collection, assessment and monitoring. This final step should be undertaken in cases where the dam is removed, and where it is not. Data collection and monitoring in forms similar to those taken in the third step of the process is done, as well as continued monitoring of the dam site. Monitoring is necessary to "evaluate whether the goals and objectives of dam removal are met" (Heinz Center, 2002: 95). It also provides a way to assess the predicted results of removal.

Dam removal decisions which follow this methodology should prove to be well informed and effective. Not all dam removal decisions follow this exact procedure. The following section details a number of case studies of dam removals, and their effect on the fisheries of the rivers in which the dams were removed.

## Dam Removals and Fisheries

Dam removals have taken place across the country. Reasons for removal may not always be related to fishery concerns, but there is little to dispute the fact that the removal of a dam can lead to improved fisheries and recreational fishing opportunities. As mentioned above, when a dam is removed, the improvement to one certain type of recreational fishing opportunity may be due to the deterioration, or even loss, of another. As different anglers prefer different fishing opportunities, what one angler labels an 'improvement' may indeed be a 'deterioration' to another.

In 1960, the Jackson Street Dam was built on Bear Creek in Medford, Oregon for water diversion purposes. The construction of the dam resulted in a barrier to migratory fish as well as lost stream habitat and water quality concerns (American Rivers et al., 1999). Because the Jackson Street Dam was used for diversion purposes, an alternative dam had to be made prior to removal. After the new, less-damaging alternative was constructed, the dam was removed in 1998, allowing steelhead, Chinook and Coho salmon to move freely up and downstream. The removal of Jackson Street Dam was especially significant, as it was the first concrete dam to be removed in the state of Oregon, as well as the first dam to allow up and downstream travel to Coho salmon, which were then classified as threatened species (American Rivers et al., 1999).

Removal of the Woolen Mills Dam along the Milwaukee River in Wisconsin resulted in improved river habitat, enhanced fisheries potential, as well as improved biotic integrity (Kanehl et al, 1997). The river also saw decreased populations of the non-native and detrimental carp, while experiencing increased numbers of smallmouth bass (Doyle et al., 2005).

Another successful dam removal occurred along the Clyde River in Vermont. Built in 1957, Newport Dam No. 11 blocked landlocked Atlantic salmon travel between the river and Lake Memphremagog. Before the dam was built, the river was a world-renowned Atlantic salmon fishery (American Rivers et al., 1999). The Federal Energy Regulatory Commission's (FERC) relicensing procedures adopted in the 1980s, combined with a breach of the dam in 1994 led to a Citizen's plan to reinforce the dam. This plan was eventually appealed through the efforts of local conservation groups and the EPA, and in 1996 the FERC recommended removal of the dam. In August of 1996, Newport Dam No. 11 was removed, opening up waters to Atlantic salmon once again, as well as trout, and other species of salmon (American Rivers et al., 1999: 33-6).

Built in the late 1700's, the Grist Mill Dam provided mechanical power for a mill located along the Souadabascook Stream in Hampden, Maine (American Rivers et al., 1999). Later converted into a hydroelectric facility, the dam was the first upstream blockade for migratory fish traveling from the Atlantic Ocean. Souadabascook Stream is a tributary of the Penobscot River, which holds populations of Atlantic salmon, sea-run brook trout, American shad, smelt and alewives. When the dam was sold to a private owner in the mid-1990's, it was in a state that required extensive repair. Then in 1998, the dam was sold to the Facilitators Improving Salmonid Habitat (FISH) for one dollar, with the understanding that the dam would then be removed (American Rivers et al., 1999). Removal of the Grist Mill Dam opened up three miles of migratory fish habitat as well as creating improved recreational opportunities. The removal also restored historic fishing waters of the Penobscot Nation Indians.

Not all dam removals are so successful, however. When the dam removal methodology is not followed, and the relevant and necessary data is not collected, removals can have negative consequences. When the Fort Edward Dam was removed from the Hudson River, upstream of Albany, New York in

1973, several tons of sediments containing toxic amounts of PCBs (polychlorinated biphenyls) were sent down river (American Rivers et al., 1999). Not only was down-river water quality decimated, but navigation along the river was adversely affected, as well as fish and wildlife, flood control and public health. To top it off, the state of New York closed the Hudson River for fishing in 1976, which wiped out a $40 million striped bass fishery (American Rivers et al., 1999). The removal of the Fort Edward Dam is a key case study in which incomplete data collection resulted in disaster.

The Daguerre Dam on the Yuba River was built in 1906 to serve as a basin for mining debris. The dam now no longer serves this purpose, as the dam has been completely filled with debris. It also blocks 40% of the salmon and steelhead which historically migrated up-river to spawn (Pejchar and Warner, 2001). Twenty four kilometers up river from the Daguerre is the Englebright Dam, which serves as another upstream obstacle for the migrating fish that do pass the Daguerre. A California Ecosystem Restoration Program Plan considered and recommended removal of the two dams. Removal of these two dams could be immensely beneficial for the migrating fish species, as spawning habitat could nearly quadruple (Pejchar and Warner, 2001).

Returning to the dam removal methodology described previously, sometimes a benefit-cost analysis of the removal is undertaken. When done, included in the benefits should be a valuation of the fishery that will arise once the dam is removed. This is not always the case though. Determining the value of a fishery can prove to be a difficult venture. Difficulty and accuracy issues arise in the valuation of fisheries, and this is why fishery valuations are not commonly conducted; valuations of fisheries to be created from dam removals are especially uncommon.

Removal of Edwards Dam from the Kennebec River in Augusta, Maine is an example of one of the few cases where a valuation of the fishery to be created from removal was conducted, and used in the benefit-cost analysis of removal. A contingent valuation and travel-cost method survey was conducted by Boyle et al. (1991) to investigate the economic benefits that would accrue from the fishery if the dam was removed. The results from this study eventually led to removal of the dam in 1999. Removal of the dam opened up seventeen miles of river spawning habitat to Atlantic salmon, striped bass, shad and smelt, among other species. The focus of the study at hand is on this removal and on the post-removal fishery. The history of the Edwards Dam and its removal will be discussed in greater detail later in this thesis.

The effects dams have on fisheries are staggering. They can significantly degrade one type of fishery, while at the same time greatly improving another. They can also lead to dramatic changes in river ecology. The effects of dams on fisheries have been discussed in this chapter, as well as a dam removal decision making methodology. This methodology is not always followed exactly (or in part), but dam removals occur nonetheless. Many of these dam removals have resulted in greatly improved fisheries and river ecosystems; some have not. Several dam removal case studies have been presented, along with a special case where the value of the fishery to be created from removal was used in a benefit-cost analysis that eventually led to removal. The valuation theory used in this last case will be discussed in the following chapter.