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The Impact of *Mysis*-induced Food Web Alterations on the Salmonid Sport Fishery in Flathead Lake, Northwestern Montana

Preproposal

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Flathead Lake is the largest natural lake in the Western United States. Its pristine water and quality fisheries are important contributors to the otherwise depressed economy of Northwestern Montana. The principal fish species sought after by anglers in Flathead is the introduced kokanee salmon, which comprises 80 to 90 percent of the sport fish catch. More than a quarter of a million kokanee are harvested annually, and, in addition, annual congregations of spawning kokanee in Glacier National Park provide an important food source for bald eagles which in turn draw thousands of tourists. Montana Department of Fish Wildlife and Parks (FWP) reports that a healthy kokannee fishery may be worth at least eight million dollars annually to the local economy. Other important fish species include Westslope Cutthroat, Bull and Lake Trout, and a number of coregonids. Bull and Lake Trout provide a trophy fishery and rely heavily on kokanee as forage.

In recent years there have been dramatic fluctuations and a general decline in the kokanee population of Flathead Lake. Extensive research by FWP determined that increased water level fluctuations in spawning areas due to an increased use of local hydropower for peaking (vs baseload) requirements are principally responsible. New discharge regulations were instituted to aleviate these problems but a new and potentially more serious threat may more than negate positive improvements seen and projected as a result of the new water regulatiuons.

A rapidly increasing population of Mysis relicta, the oppossum shrimp, is now established in Flathead Lake. Mysis apparently migrated downstream from some other Lakes in the basin where it had been introduced in unsuccessful efforts to improve the fisheries in those lakes. Mysis is considered a potent threat to kokanee in Flathead Lake because it has been implicated in the decline or elimination of kokanee fisheries in other lakes where it had been introduced, (e.g. Lakes Pend Oreille, Idaho, and Tahoe, California-Nevada). Introduced Mysis populations apparently can change the community structure of the benthos, phytoplankton, zooplankton, and fish communities, in short the entire food web of the lake; and this change is often particularly detrimental to planktivorous fish. In the particular case of Flathead Lake, we have documented already the loss of some formerly abundant zooplankton species, including Daphnia longiremis, and the decline of Daphnia thorata. In Lake Pend Oreille the loss of Daphnia thorata occurred during the establishment of Mysis and the subsequent kokanee decline. FWP stomach anaylsis data indicates that Daphnia thorata is the single most important food species for Flathead Lake kokanee during the warm season when most kokanee growth occurs. Mysis are excellent forage, but kokanee don't feed heavily on them because kokanee are daytime surface feeders while Mysis migrate to the bottom during the day.

The objective of our proposed work is to document and quantify the entire food chain of Flathead Lake leading up to the salmonids --both before and after the introduction of Mysis-- and to investigate new management possibilities based on the changes in the food web. In particular, we will investigate the feasibility of certain new management options, such as encouraging the native Westslope Cutthroat and Bull Trout, while investigating which options are realistic for maintaining kokanee.

Most fisheries studies have focused on the theoretical or actual population dynamics of a particular sport species. While often providing useful information, this approach may fall far short of providing the data necessary for a complete understanding of a particular problem, especially when the fish are responding to perturbations in the entire ecosystem. For example, a conventional concept applied to the study and management of kokanee populations is that kokanee respond to an increase in their own density through a compensatory decrease in average size of the individuals in the population. There are documented cases of this relationship in the literature, and size even has been used as a relative measure of population density. The use of this relationship, however, assumes a nearly constant carrying capacity of the environment. Application of this idea to a suddenly stunted kokanee population without an independent assessment of year class strength and age composition, as well as estimates of the lower trophic levels, might lead one to believe that the population density had recently increased beyond a desireable level. This sort of analysis, which is still being undertaken in lakes with new Mysis populations, is quite misleading where an independent factor is causing a rapid decrease in the carrying capacity. An ecosytem approach combined with more traditional population approaches would detect the reduction in available food to the kokanee and much more clearly point to the mechanism of change.

We will use an ecosystem approach for studying the food web of Flathead Lake and its relation to the dominant sport fisheries. Because Flathead is a deep lake, processes in the pelagic zone dominate the food web. Therefore we will concentrate our efforts on the pelagic zone and on the energy flow from the phytoplankton to the fish via the zooplankton. We will emphasize the effects of Mysis on primary and secondary production, energy flow and efficiency, and on describing the Mysis-altered food web.

We plan 3 basic approaches to describing and quantifying the impacts of Mysis establishment:

1. We will use the extensive existing data base to construct a quantitative flow diagram to describe Flathead Lake food web dynamics before alteration by the addition of Mysis. We will then compare this diagram to one which we will construct from field data that we propose to gather during this study. Part of the data base that we will examine are the growth patterns found in fish otiliths from before and after the establishment of Mysis in Flathead Lake.

2. We propose to run experiments (probably in medium-sized limnocorrals) designed to duplicate the processes (e.g. predation rates, selectivities, efficiencies, etc) which have been important in bringing about the Mysis-induced changes in the food web. With these experiments we will attempt to create miniature physical and biological models of the real system and its processes as well as derive process rates and efficiencies for use in computer simulation modelling. We would be joined in these experiments by Dr. Andrew L. Sheldon who would specialize

in the feeding of larval and juvenile fishes on the zooplankton communities.

3. We will then synthesize the results of both 1. and 2. in a simulation model of the Flathead food web. Many parts of this model already exist.

Flathead Lake is an ideal location for these studies because of:

1. the extensive limnological facilities and field gear available at the Flathead Lake Biological Station (FLBS) and at FWP.

2. the timing; *Mysis* is still in the exponential growth phase of initial population expansion in Flathead Lake, and changes are still occurring now.

3. the potential for dovetailing with ongoing and recently completed research on: a) preliminary *Mysis*-zooplankton-fish interactions in the lake. b) *Mysis*-zooplankton interactions. c) zooplankton-phytoplankton-nutrient interactions. d) *Mysis* population dynamics in Flathead Lake.

4. The existence of an extensive historical data base including:

   a. FLBS data on primary productivity, zooplankton and phytoplankton abundance, water chemistry, and physical data for Flathead Lake from 1977 to the present.

   b. FWP data on fish population dynamics, zooplankton, and fish food habits.

   c. a detailed data set on Flathead Lake zooplankton abundance and distribution from a doctoral thesis done during the 1970's (well before *Mysis* establishment).

   d. archived zooplankton and fish samples which are available for further lab analysis.

5. We have an extensive computer model which is currently directed primarily at water and nutrient budgets; the proposed study will contribute to this model (and vice versa) by providing understanding of the higher level trophic interactions in Flathead Lake. Refinements to the model that would result from the proposed study should improve the effectiveness of the model as a useful tool for resource managers to use in their management efforts in Flathead Lake.

In conclusion, we would like to continue, expand and integrate our present studies to accomplish the objectives outlined above. While *Mysis*-induced change has been documented for aspects of the food web in other lakes, no one has yet conducted a comprehensive evaluation of *Mysis*-induced change at all trophic levels in a lake. Such an analysis would be of value to limnologists in increasing the understanding of lake system function and structure, and of immense value to fisheries managers attempting to deal with the altered Flathead system (and others). Armed with a increased understanding of the altered trophic dynamics and trophic structure managers will be better equipped to make appropriate decisions for future management of the Flathead Lake fisheries. Finally, if enough is learned about the food web dynamics and the response of the salmonids, it should be possible, through management techniques, to encourage the native sport fishes as well as recommend measures to aleviate impacts to the kokanee fishery.