5.7 FISH RESOURCES

The analysis of the effects of the alternatives on fish resources was accomplished using the results of eight models. These models predicted young fish production in the lakes, coldwater fish habitat in the lakes, coldwater fish habitat in river reaches, warmwater fish habitat in river reaches, physical habitat for native river fish in river reaches, connectivity of the river to low-lying lands along much of the Lower River, spring spawning cue along the Lower River, and shallow water habitat along the Lower River. Several technical reports document the development of these models for assessing reservoir and riverine fishes, the model assumptions, and the data produced by the model runs (Corps, 1994j; Corps, 1994k; Corps, 1994l; Corps, 1994m; Corps, 1994n). In addition, supplemental information was recently published on riverine fishes (Corps, 1998f; Corps, 1998g). Information on the basic modeling techniques for each of the models are described in the corresponding discussions of the effects defined by model results in this section of Chapter 5.

5.7.1 Young Fish Production in Mainstem Lakes

The young-of-year fish production index uses annual hydrologic data to model fish productivity. It was developed through a process of correlating annual catch data for various species to hydrologic variables such as lake levels, inflows, and amount of shore area. For further detail, see Volume 7A: Environmental Studies, from the 1994 Missouri River Master Water Control Manual Review and Update Study. The values presented in the following discussion are useful as an indicator of the relative effects of the different alternatives. For example, if an alternative results in a young-of-year index value that is 2 percent higher than that of the CWCP, this indicates the potential for a slight increase in annual fish production under that alternative. Table 5.7-1 and Figures 5.7-1 through 5.7-4 present the data from the young fish production model, commonly referred to as the "young-of-year model."

Figure 5.7-1 graphically shows that four of the alternatives are closely grouped together between 2.00 and 2.04 units, a difference of 4 hundredths. The remaining alternatives are more closely related and are grouped between 2.10 and 2.12 units, a difference of only 0.02.

The average annual total relative index value for the CWCP is 2.00, the lowest of the alternatives. Both the CWCP and MLDDA alternatives have a balanced intrasystem regulation; however, the MLDDA decreases the system's base of flood control storage by 2 MAF. This decrease in the base of flood control storage is slightly more beneficial to total young fish production in the mainstem lakes compared to the CWCP, with an average annual value increase of only 1 hundredth. The ARNRC and MRBA alternatives equally benefit the average annual values compared to the CWCP (value increase of 4 hundredths), even though they both have an unbalanced intrasystem regulation and greater conservation but different criteria for additional spring/summer releases. Delaying flood storage evacuation to the Lower River until mid-September combined with increased conservation of water in the lakes during droughts, as with the MODC alternative, results in the greatest benefit in total young fish production. This alternative also has a spring rise from Fort Peck Dam on the average of about every 3 years, water conditions allowing. The total average annual value of the MODC alternative is 12 hundredths, or 6.0 percent, greater than the CWCP. The BIOP and FWS30 alternatives have a spring rise and decreasing summer flows out of Gavins Point Dam with the same level of conservation in droughts as the MRBA and MODC alternatives,

Table 5.7-1. Average annual young fish production in the mainstem lakes (relative index), 1898 to 1997.

Alternative	Total	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Lake Sharpe	Lake Francis Case	Lewis & Clark Lake
CWCP	**2.00**	0.55	0.46	0.40	0.23	0.20	0.16
MLDDA	**2.01**	0.53	0.48	0.42	0.23	0.19	0.16
ARNRC	**2.04**	0.51	0.49	0.39	0.17	0.27	0.20
MRBA	**2.04**	0.58	0.45	0.41	0.22	0.20	0.18
MODC	**2.12**	0.55	0.49	0.43	0.22	0.21	0.21
BIOP	**2.10**	0.52	0.51	0.40	0.21	0.26	0.20
FWS30	**2.11**	0.52	0.51	0.41	0.21	0.26	0.20

which is also more beneficial for total young fish production than the CWCP. These two alternatives also have a spring rise out of Fort Peck Dam. Average annual values with these alternatives increase 10 and 11 hundredths, respectively.

The major difference between the CWCP and the MLDDA alternative is that the MLDDA alternative reduces the system's base of flood control storage from 57.1 to 55.1 MAF. Compared to the other alternatives, the increase in total average annual young fish production value is the lowest under the MLDDA alternative, a 1 hundredth, or 0.5 percent, increase over that of the CWCP. A 2-MAF decrease in the base of flood control storage decreases young fish production values in Fort Peck Lake by 3.6 percent and in Lake Francis Case by 5.0 percent. It increases the values in Lake Sakakawea by 4.3 percent and Lake Oahe by 5.0 percent. There is no change in young fish production values from the CWCP in Lake Sharpe or Lewis and Clark Lake. Compared to the other alternatives, the MLDDA alternative is the only one that actually reduces young fish production values in Lake Francis Case and maintains the CWCP value in Lewis and Clark Lake. Aside from the MODC alternative, the MLDDA alternative provides the second largest increase (5.0 percent) in young fish production value in Lake Oahe.

The ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season, unlike the CWCP. From Gavins Point Dam, there is a spring release increase of 15 kcfs and a lower summer release of 18 kcfs after the spring release. Compared to the other alternatives, the increase in total average annual young fish production value is among the lowest under the ARNRC alternative, a 4 hundredths or 2.0 percent increase over that of the CWCP. Two factors generally account for improved fish production values at Fort Peck Lake: an unbalanced intrasystem regulation and an increase in conservation in the upper three lakes. Two other factors generally account for reduced young fish production values, however: a spring rise from the lake and from Gavins Point Dam, both occurring with ARNRC alternative. Consequently, the ARNRC alternative decreases young fish production values within this lake the most (4 hundredths or 7.3 percent compared to the CWCP values) when compared to the other alternatives. In addition, the ARNRC alternative shows the greatest decrease in values in both Lake Oahe (2.5 percent) and Lake Sharpe (26.1 percent). Lake Sakakawea, Lake Francis Case, and Lewis and Clark Lake all experience an increase in young fish production values under the ARNRC alternative (6.5, 35.0, and 25.0 percent, respectively).

Although the ARNRC alternative has an unbalanced intrasystem regulation and an increase in conservation similar to the MRBA alternative, a major difference between these two alternatives is in the MRBA alternative's maintenance of a year-round steady flow, as with the CWCP. Spring rises are not included in the MRBA alternative. That steady flow combined with an unbalanced intrasystem regulation benefits young fish production in Fort Peck Lake and, when compared to the other alternatives, the MRBA alternative is the only one that provides a benefit, or increase in young fish production value, within this lake. The MRBA alternative also increases young fish production values in Lake Oahe by 1 hundredth, or 2.5 percent, and in Lewis and Clark Lake by 2 hundredths, or 12.5 percent; however, it decreases this value in Lake Sakakawea by 2.2 percent and Lake Sharpe by 4.3 percent. Compared to the other alternatives, the MRBA alternative is the only one that reduces young fish production values in Lake Sakakawea. There is no change in value from the CWCP in Lake Francis Case under this alternative.

The MRBA and MODC alternatives both maintain a year-round steady flow, have an unbalanced intrasystem regulation, and increase conservation in the upper three lakes; however, the MODC alternative has an extended flat release from Gavins Point Dam and a spring rise out of Fort Peck Dam. Compared to the other alternatives, the increase in total average annual young fish production value is among the highest under the MODC alternative, a 12 hundredths or 6.0 percent increase over that of the CWCP. A variation in the flat release from Gavins Point Dam results in different changes in young fish production values in all of the lakes except Lake Sharpe, where the value would be reduced by 1 hundredth, or 4.3 percent, which is the same as with the MRBA alternative. In Fort Peck Lake, the MODC alternative has the same benefit to young fish production as the CWCP. Compared to the other alternatives, it is the only one that provides this benefit to this lake. Maintaining lower flows for a longer period in the summer on the Lower River is most beneficial to young fish production in the remaining lakes. Values are increased over the CWCP in Lake Sakakawea (6.5 percent), Lake Oahe (7.5 percent), Lake Francis Case (5.0 percent), and Lewis and Clark Lake (31.3 percent). Compared to the other alternatives, the MODC alternative provides the greatest value increase over the CWCP in both Lake Oahe and Lewis and Clark Lake and the smallest value increase in Lake Francis Case.

The BIOP and FWS30 alternatives also have most of the components of the MRBA and MODC alternatives; however, there is variation in the additional spring/summer release criteria compared to the CWCP. Compared to the other alternatives, the increase in total average annual young fish production value is among the highest under the BIOP and FWS30 alternatives, a 5.0 and 5.5 percent increase over that of the CWCP, respectively. These two alternatives reduce young fish production values in Fort Peck Lake by 3 hundredths, or 5.5 percent, and in Lake Sharpe by 2 hundredths, or 8.7 percent. The greatest increase in young fish production values over the CWCP in Lake Sakakawea occurs under both the BIOP and FWS30 alternatives, with which there is a 10.9 percent increase in value. The BIOP alternative maintains the same level of young fish production in Lake Oahe as the CWCP, while the FWS30 alternative increases this value by 1 hundredth. In Lake Francis Case and Lewis and Clark Lake, young fish production values are increased under these alternatives by 30.0 and 25.0 percent, respectively. These results are similar to those of the ARNRC alternative.

The annual values for young fish production in the mainstem lakes for the submitted alternatives are shown on Figures 5.7-2 through 5.7-4. Generally, the submitted alternatives all show similar results during the full period of analysis as relative index values vary between 1 and almost 4 units. The years that show the greatest decrease in young fish production values are 1930, 1934, 1960, the late 1980s, and the early 1990s. These years are all during one of the three major drought periods. In very general terms, a close relationship exists between the annual average release from Gavins Point Dam and the annual fish production values. The greatest index value (between 3.50 and 4.00 units) occurs in 1986.

5.7.2 Coldwater Fish Habitat in Mainstem Lakes

The minimum coldwater fish habitat volume available from July through October in the upper three Mainstem Reservoir System lakes was estimated for each year of the 100-year simulation period. Modeling of the changes in this habitat was based on extensive water quality modeling of differing conditions in terms of lake levels, inflows to and outflows from the lakes, and ambient air conditions (warm year, cold year, etc.).

Regressions of the results of the water quality model runs were conducted to get equations to use for the Master Manual environmental impact model. Data files on the average ambient conditions for each year had to be included in the impact model, and data on inflows, outflows, and lake levels from the Daily Routing Model for each alternative simulation are used to compute changes in the volume of coldwater habitat in the lakes modeled. Table 5.7-2 and Figure 5.7-5 present the average annual values for the 100-year period of analysis for the upper three lakes. Even though Lake Francis Case was modeled, data for this lake are not included because the average annual values are essentially zero.

The CWCP provides 9.88 MAF of coldwater fish habitat on an annual basis. This total volume at the sites analyzed is distributed among Fort Peck Lake (36.3 percent), Lake Sakakawea (28.3 percent), and Lake Oahe (35.4 percent). As shown in Figure 5.7-5, the CWCP and MLDDA alternatives are closely grouped together between 9.62 and 9.88 MAF, a difference of 0.26 MAF. The remaining alternatives range between 10.17 and 10.76 MAF, a difference of 0.59 MAF.

The 2-MAF decrease in the base of flood control storage under the MLDDA alternative results in a decrease in total coldwater fish habitat for all three of the upper lakes, and it provides the least amount of total habitat of all the alternatives (3.0 percent less habitat than the CWCP). The MLDDA alternative decreases coldwater fish habitat by 2.2 and 2.1 percent in Fort Peck Lake and Lake Sakakawea, respectively, and by 3.2 percent in Lake Oahe. The alternative with the greatest increase in total average annual coldwater fish habitat is the ARNRC alternative. Under this alternative, total habitat increases as the existing balanced system of intrasystem regulation is modified, drought conservation levels are increased, and additional spring/summer releases mimic the natural flow of the river. This alternative has the highest level of drought conservation, which is the primary factor for the increased values over those of the CWCP.

Compared to the CWCP, the ARNRC alternative provides a 9.0 percent increase in total coldwater fish habitat. It increases coldwater fish habitat by1.9 percent in Fort Peck Lake and by 12.1 and 13.8 percent in Lake

Table 5.7-2. Average annual coldwater fish habitat in the mainstem lakes (MAF).

	1898 to 1997			
Alternative	**Total**	**Fort Peck Lake**	**Lake Sakakawea**	**Lake Oahe**
CWCP	**9.88**	3.59	2.81	3.47
MLDDA	**9.62**	3.51	2.75	3.36
ARNRC	**10.76**	3.66	3.15	3.95
MRBA	**10.17**	3.76	2.75	3.66
MODC	**10.42**	3.78	2.97	3.67
BIOP	**10.55**	3.75	2.90	3.90
FWS30	**10.57**	3.77	2.93	3.87

Sakakawea and Lake Oahe, respectively. These changes are likely due to the increased amount of water stored in the upper three lakes during the droughts, which results from the increased drought conservation measures of this alternative. This alternative also permits no flood storage evacuation in most of the years, which allows the lakes to stay higher through the summer period and maintain coldwater fish habitat values at a higher level.

The CWCP and MRBA alternatives maintain a year-round steady flow; however, the MRBA alternative has an unbalanced intrasystem regulation and increased conservation in the upper three lakes. As a result, the MRBA alternative yields a 4.7 and 5.5 percent increase in coldwater fish habitat in Fort Peck Lake and Lake Oahe, respectively, and a 2.1 percent decrease in habitat in Lake Sakakawea.

The MODC alternative also includes conservation measures similar to the MRBA alternative; however, it delays the start of system flood storage evacuation from late August to mid-September in many years. This change results in slightly more coldwater habitat in the lakes than the MRBA alternative. It results in a 5.3 percent increase in coldwater fish habitat in Fort Peck Lake and a 5.7 and 5.8 percent increase in habitat in Lake Oahe and Lake Sakakawea, respectively.

The BIOP and FWS30 alternatives both increase the amount of total coldwater fish habitat in all three lakes; however, the greatest amount of habitat increase occurs in Lake Oahe, where there is an 12.4 percent increase under the BIOP alternative and an 11.5 percent increase under the FWS30 alternative. These alternatives have the same conservation measures as the MRBA and MODC alternatives; however, the combination of the spring rise and summer low flow in the BIOP and FWS30 alternatives results in less outflow from the lakes by the time the low flow ends. This means that the lakes are slightly higher in the latter part of the summer and early fall, which results in more coldwater habitat for fish.

The annual values of total reservoir coldwater fish habitat for the submitted alternatives are shown in Figures 5.7-6 through 5.7-8. The 1930 to 1941 drought period yields the least amount of total coldwater fish habitat for all the submitted alternatives. The alternative that has the most habitat during this period is the ARNRC alternative because it has the greatest drought conservation measures of the submitted alternatives. During the other two major droughts, there is another reduction in habitat; however, these droughts were less severe in terms of amount of lake drawdown and duration than the earlier drought period. Other than during these three periods, annual coldwater fish habitat is fairly stable during the 100-year period of analysis.

5.7.3 Coldwater Fish Habitat in River Reaches

The number of miles of coldwater fish habitat downstream from Fort Peck and Garrison Dams was computed for the months of April through September. Two factors were used to determine the amount of habitat for coldwater fish species: the amount of water released from the upstream dam and water temperature. Generally, higher lake levels and higher releases result in more miles of coldwater habitat below the dams. Differences in the amount of this habitat for the submitted alternatives are discussed in this section. Annual values were computed and then averaged to compute a single value for each of the two reaches. Table 5.7-3 and Figure 5.7-9 present the combined, or total, value for the two reaches. Table 5.7-3 also presents the value for each reach over the 100-year period of analysis.

Table 5.7-3. Average annual coldwater fish habitat in the river reaches (miles).

	1898 to 1997		
Alternative	**Total**	**Fort Peck**	**Garrison**
CWCP	**183.6**	140.2	43.4
MLDDA	**182.4**	141.2	41.2
ARNRC	**198.1**	153.5	44.7
MRBA	**186.8**	142.3	44.5
MODC	**187.9**	143.8	44.1
BIOP	**197.2**	153.6	43.6
FWS30	**195.8**	152.6	43.2

The CWCP provides 183.6 miles of coldwater fish habitat in the two coldwater river reaches of the Mainstem Reservoir System on an annual basis. This total volume at the sites analyzed is distributed among the river reaches below Fort Peck Dam (76.4 percent) and Garrison Dam (23.6 percent).

Figure 5.7-9 shows that four of the submitted alternatives are closely grouped together between 182.4 and 187.9 miles, a difference of 5.5 miles. The remaining three alternatives range between 195.8 and 198.1 miles, a difference of only 2.3 miles. These latter three alternatives all have spring rises out of Gavins Point Dam, followed by lower summer releases.

Compared to the CWCP, the 2-MAF decrease in the base of flood control storage under the MLDDA alternative creates a small amount of additional coldwater fish habitat (0.7 percent increase) below the Fort Peck Dam and reduces this habitat by 5.1 percent below Garrison Dam. The MLDDA alternative has the lowest total average annual value of coldwater fish habitat for the 100-year period of analysis when the values for the two reaches are combined.

Of the submitted alternatives, the ARNRC alternative has the highest total value for coldwater fish habitat in the two combined reaches. Modifying dam operations for high water levels in the spring and low levels in the summer provides a 9.5 and 3.0 increase in the amount of coldwater fish habitat below the Fort Peck and Garrison Dams, respectively. Increased drought conservation under this alternative also means that the releases during the droughts may be colder and may help increase the number of miles of coldwater fish habitat on an average annual basis.

Compared to the CWCP, it is apparent that the MRBA's unbalanced intrasystem regulation and increased conservation in the upper three lakes creates an increase in coldwater fish habitat below both Fort Peck and Garrison Dams. Under this alternative, the greatest percentage increase (2.5 percent) over the CWCP occurs below Garrison Dam while slightly higher habitat values (1.5 percent) occur below Fort Peck Dam. The MODC alternative results are opposite of the MRBA alternative since slightly higher habitat values (1.6 percent) occur below Garrison Dam and a greater amount of habitat (2.6 percent more than the CWCP) occurs below Fort Peck Dam.

Both the BIOP and FWS30 alternatives increase spring releases from Fort Peck Dam and subsequently create more coldwater fish habitat below this dam than the CWCP. The BIOP alternative creates 9.5 percent more habitat while the FWS30 alternative creates 8.8 percent more habitat than the CWCP. The impact model does not recognize that much of the spring rise will be obtained from the surface of the lake and run down the spillway. Consequently, the actual miles of coldwater habitat should diminish for these alternatives as well as the ARNRC and MODC alternatives.

Figures 5.7-10 through 5.7-10 graphically depict the annual values for total coldwater river fish habitat for the submitted alternatives. Generally, all of the alternatives maintain an average 200 miles of habitat during the full period of analysis. Habitat is reduced to between 100 and 150 miles during the 1930 to 1941 drought and continues into the early 1940s; however, the ARNRC, BIOP, and FWS30 alternatives maintain higher habitat values during this period than the remaining alternatives. These three alternatives also maintain higher habitat levels during the other two major droughts, with little drop in value compared to the other four alternatives.

5.7.4 Warmwater Fish Habitat in River Reaches

The number of miles of warmwater river fish habitat downstream from Fort Peck, Garrison, and Fort Randall Dams in each month from April through August was estimated using another fish habitat model. In general, the amount of warmwater habitat is expected to be lower for an alternative that has higher amounts of water in storage over the period of analysis and has higher releases. This is the opposite of the effects described for coldwater fish habitat. The following compares the effects on warmwater fish habitat of the submitted alternatives. Table 5.7-4 and Figure 5.7-13 present the average annual warmwater river fish habitat for the 100-year period of analysis. The total value shown on the table is the sum of all three reaches, with the reach downstream from Fort Peck Dam providing more than 60 percent of the habitat.

The CWCP provides 52.9 miles of warmwater fish habitat in the river reaches of the Mainstem Reservoir System on an annual basis. This total volume at the sites analyzed is distributed among the river reaches below Fort Peck Dam (62.0 percent), Garrison Dam (11.5 percent), and Fort Randall Dam (26.3 percent).

Figure 5.7-13 shows that three of the submitted alternatives are closely grouped together between 44.2 and 45.6 miles, a difference of only 1.4 miles. The remaining four alternatives range between 48.1 and 52.9 miles, a difference of 4.8 miles.

A balanced intrasystem regulation and 2-MAF reduction in the base of flood control storage, as with the MLDDA alternative, and an unbalanced intrasystem regulation and spring rise followed by a lower summer flow that mimics the natural flow, as with the ARNRC alternative, generally decrease the amount of warmwater fish habitat downstream of the three dams. The alternative with the greatest amount of total average annual warmwater fish habitat, aside from the CWCP, is the MLDDA alternative; however, it provides 2.8 percent less habitat than the CWCP. The MLDDA alternative reduces warmwater fish habitat by as much as 8.2 percent below Garrison Dam. Reduction in habitat also occurs below Fort Peck Dam (0.9 percent) and Forst Randall Dam (4.3 percent). The ARNRC alternative provides the least amount of total habitat of all the alternatives. Compared to the CWCP, the ARNRC alternative causes and 18.6 percent reduction in habitat below Fort Peck Dam and a 15.1 percent reduction in habitat below Fort Randall Dam.

The unbalanced intrasystem regulation and increased conservation in the upper three lakes under the MRBA alternative results in an overall decrease in fish habitat in the reaches below Fort Peck, Garrison, and Fort Randall Dams. Compared to the CWCP, the MRBA alternative shows the greatest percent decreases in habitat downstream of Fort Peck and Fort Randall Dams, where there is a 10.4 and 8.6 percent reduction in habitat, respectively. The warmwater fish habitat downstream of Garrison Dam is reduced by 1.6 percent.

Compared to the CWCP, the MDOC alternative provides mixed results for the three downstream locations. Warmwater fish habitat is reduced in the river reaches downstream of Fort Peck and Fort Randall Dams (8.2 and 5.8 percent less habitat, respectively), and it is increased downstream of Garrison Dam (14.8 percent).

The BIOP and FWS30 alternatives would increase the spring rise and decrease summer flows. Compared to the CWCP, an additional spring/ summer release decreases the amount of warmwater

Table 5.7-4. Average annual warmwater fish habitat in the river reaches (miles).

	1898 to 1997			
Alternative	**Total**	**Fort Peck**	**Garrison**	**Fort Randall**
CWCP	**52.9**	32.8	6.1	13.9
MLDDA	**51.4**	32.5	5.6	13.3
ARNRC	**44.2**	26.7	5.7	11.8
MRBA	**48.1**	29.4	6.0	12.7
MODC	**50.2**	30.1	7.0	13.1
BIOP	**44.9**	27.3	6.6	10.9
FWS30	**45.6**	28.4	6.5	10.7

fish habitat in the river reaches below Fort Peck and Fort Randall Dams and increases this habitat in the river reach below Garrison Dam. The greatest percentage reduction (23.0 percent) in warmwater habitat occurs under the FWS30 alternative downstream of Fort Randall Dam. Compared to the CWCP, the BIOP and FWS30 alternatives respectively create 8.2 and 6.5 percent more warmwater fish habitat, respectively, downstream of Garrison Dam.

As shown on Figures 5.7-14 through 5.7-16, there is an overall increase in warmwater fish habitat during the 1930 to 1941 drought. Of the fish models analyzed thus far, the warmwater fish habitat model is the only one that has shown an overall benefit in habitat during this period. The CWCP and MLDDA alternative show the greatest benefit during this 13-year drought. The ARNRC, MRBA, and MODC alternatives show the least amount of benefit.

5.7.5 Physical Habitat for Native River Fish

Native river fish habitat values were computed for the river reaches downstream from four of the dams and for five subreaches on the Lower River downstream from Sioux City. An index value (correlation coefficient) was computed for each month based on how closely the velocity and/or depth distributions for a given river reach match the "natural" flow conditions based on pre-Mainstem Reservoir System channel conditions. In April, May, and June, the habitat value is dependent on the potential for overbank flooding for each reach. The index can range between 0 and 1.0 with a value of 1.0 assigned to a perfect match. The values for each of the 12 months are summed to compute an annual index value for each reach and can be as high as 12.0. A total annual value is computed by combining the values from the nine reaches. Average annual values are the means for the individual and total reaches. This section discusses the physical habitat index values for native river fish that were computed for the submitted alternatives. The total and individual reach average annual values are presented in Table 5.7-5, and the total value only is presented in Figure 5.7-17.

As shown in Figure 5.7-17, all of the alternatives are closely grouped together between 81.5 and 83.2 units, a difference of 1.7 units. The total relative index value for the CWCP is the lowest of the submitted alternatives. The ROR alternative represents unregulated releases from the dams and has a total average annual index value of 90.49. Compared to the CWCP, the ROR alternative provides 11.1 percent higher value for total physical habitat for native fish.

The balanced intrasystem regulation and 2-MAF reduction in the base of flood control storage under the MLDDA alternative slightly increase physical habitat values below Fort Peck, Garrison, and Fort Randall Dams and within the Nebraska City and St. Joseph reaches.

With the ARNRC alternative, several factors affect the total average annual values for physical habitat for native river fish: an unbalanced intrasystem regulation, greater conservation in the upper three reservoirs, and changes in the spring and summer releases that mimic the Missouri River's natural flow. These factors result in the greater index values for total average annual physical habitat compared to the other alternatives (2.1 percent more than the CWCP). The ARNRC alternative provides higher values than the CWCP in the river reaches below Fort Peck and Garrison Dams and the five subreaches on the Lower River downstream from Sioux City.

Table 5.7-5. Average annual physical habitat for native river fish in nine river reaches (relative index).

	1898 to 1997									
Alternative	**Total**	**Fort Peck**	**Garrison**	**Fort Randall**	**Gavins Point**	**Sioux City**	**Nebraska City**	**St. Joseph**	**Kansas City**	**Boonville**
CWCP	**81.46**	9.03	7.86	8.56	9.30	10.22	7.98	7.93	10.03	10.55
MLDDA	**81.53**	9.06	7.91	8.57	9.30	10.18	8.00	7.94	10.03	10.54
ARNRC	**83.17**	9.49	8.03	8.44	9.20	10.27	8.46	8.30	10.28	10.70
MRBA	**81.67**	9.09	7.95	8.50	9.24	10.23	8.06	8.00	10.04	10.55
MODC	**81.76**	9.14	7.85	8.55	9.28	10.23	8.11	8.01	10.04	10.56
BIOP	**81.95**	9.18	7.82	8.45	9.35	10.08	8.19	8.16	10.10	10.63
FWS30	**82.48**	9.20	7.81	8.46	9.36	10.18	8.31	8.27	10.20	10.69

The MRBA alternative shows a 0.3 percent higher index value than the CWCP. Slight increases in habitat values occur below the Fort Peck and Garrison Dams and in the four of the five subreaches of the Lower River downstream from Sioux City. The Boonville subreach habitat value is the same as the value for the CWCP. Results are similar for the MODC alternative except at Boonville, where this alternative would provide a 0.1 percent increase in habitat value over the CWCP, and below Garrison Dam, where it would provide a slightly lower value.

Increasing drought conservation and the spring rise and decreasing summer flows, as with the BIOP and FWS30 alternatives, are also more beneficial for total physical habitat for native river fish than the CWCP. Index values are higher than the CWCP downstream of Fort Peck and Gavins Point Dams and lower below Garrison and Fort Randall Dams. Four of the five subreaches in the Lower River downstream from Sioux City would have higher values under the BIOP and FWS30 alternatives, whereas the Sioux City subreach would have lower index values.

The annual values of total river fish physical habitat for the submitted alternatives are shown on Figures 5.7-18 through 5.7-20. In general, the relative index values remain between 80.0 and 85.0 units during the full period of analysis. During the early 1920s and mid-1950s, the relative index values increase for all alternatives to about 87.0 units, whereas values decrease to about 77.0 units during 1913 and 1979.

5.7.6 Missouri River Connectivity to Low-Lying Lands during the Spring Rise

As stated in the November 2000 USFWS BiOp, “Floodplain connectivity refers to the seasonal flooding of areas adjacent to the river. The spring flood pulse often provides connectivity between the floodplain to the river. For native river fish like the pallid sturgeon, this floodplain connectivity, especially during May/June, provided spawning areas for forage species, increased phytoplankton production, and redistributed carbon to the river” (USFWS, 2000). This carbon, in the form of detritus scoured off of the floodplain, settled out in the shallow water areas along the river where the microscopic biota grew. As the pallid sturgeon hatched, the larval fish would float down the river until they were able to float into the shallow water areas. There they would reside during their fragile first months of life.

The physical habitat model discussed in the previous subsections on fish impacts acknowledges this important component for the growth of the young-of-year pallid sturgeon. The model requires over-bank flooding to get high index values in April, May, and June. This is the period when organic matter needs to be flushed into the river to provide biota in shallow water areas with a food source so that the larval pallid sturgeon have adequate food after spawning. Examination of the physical habitat output files for these 3 months shows very low index values, which means that river flows were generally lower than necessary for overbank flooding. To better understand how much floodplain connectivity may be occurring along the Lower River from Sioux City to the mouth, the Corps undertook an analysis. As a first step in the analysis, the Corps estimated the acreage and elevation of the low-lying lands (areas adjacent to oxbow lakes and chutes) that could be inundated by high river flows. The elevations were then converted to river stages for the output nodes of the DRM hydrologic model to determine when the spring rises were inundating these areas. The months of May and June, the period when the spring rise was modeled in most of the DRM simulation runs, were checked to see how many acres were flooded for a varying number of days for the alternatives being analyzed. All six of the alternatives submitted for consideration were analyzed with this model of connectivity.

The graphical results of the analyses of connectivity are duration plots of acres inundated versus percent of the time. Duration plots were developed for inundation for at least 2 days up to over 10 days. As the number of days is increased, the amount of acres inundated diminishes, and the curves slide to the lower left on the plots. The duration plot of the 2-day analysis is shown as Figure 5.7-21. This figure shows that the various alternatives provide similar duration plots of connectivity, with the number of acres of connectivity for 2 days sometime during May or June, increasing as the amount of spring rise increases (e.g., BIOP acres [17.5-kcfs rise] are less than FWS20 acres [30-kcfs rise]). This figure also includes the duration plot for the ROR alternative to provide a perspective for how often these low-lying lands would have been inundated for 2 days with no flow control. This flow scenario has considerably higher values across the entire range of the plot from near zero percent to near 100 percent.

Table 5.7-6 presents the total values for the 25th percentile (lower quartile) from Figure 5.7-21 with a breakdown among the reaches making up the total reach from Sioux City to the mouth of the Missouri River. The 25th percentile was selected for presentation in the RDEIS because the alternatives were designed to have spring rises about one-third of the time, and the 25th percentile falls within the range when spring rises may be affecting the amount of connectivity. The total values are also shown in Figure 5.7-22.

The CWCP provides a total of 3,282 acres of connectivity. The greatest share of this connectivity, 39.8 and 23.4 percent, respectively, is provided in the Hermann and upstream Boonville reaches. The remaining acres are fairly evenly divided among the five other reaches, with the Nebraska City reach having the lowest amount at only 4.1 percent.

Figure 5.7-22 shows the 25th percentile acres of connectivity for the submitted alternatives, the ROR scenario, and the CWCP. The CWCP and the MLDDA, MRBA, and MODC alternatives result in the lowest acres. They are clustered in a range of only 14 acres. The BIOP alternative has about 120 acres more than the lowest group. The ARNRC and FWS30 alternatives have about 140 acres more than the BIOP alternative. This grouping is essentially by amount of spring rise. What is not apparent from the description of the ARNRC alternative is that it moves considerably more water than the 15-kcfs spring rise it includes because very little extra water is released in most years above the summer low-flow flat release of 18 kcfs. This requires that water be moved earlier in the year to ensure that the extra water in flood storage can be evacuated at a relatively safe rate in the fall months. This mode of operation makes this alternative perform like an alternative with a higher spring rise, such as the FWS30 alternative. Finally, the ROR scenario, which has no inflow control (uncontrolled releases from Gavins Point Dam), has the highest value at 646 acres higher than the CWCP and almost 400 acres more than the higher spring rise alternatives.

The MLDDA alternative provides an additional 2 MAF of flood control storage than the CWCP. In most years, this alternative has releases from Gavins Point Dam very similar to the CWCP; therefore, it has a connectivity value for the 25th percentile that is only 0.4 percent less than that for the CWCP.

The ARNRC alternative has a 15-kcfs spring rise that appears to be even greater than specified, as discussed above. (Review of the data plots of Gavins Point releases supports this conclusion.) The 25th percentile value for the ARNRC alternative is 7.3 percent higher than that of the CWCP. The greatest share of the increase occurs in the two reaches analyzed that are closest to Gavins Point Dam: Sioux City (43.8 percent increase for this reach) and Omaha (49.4 percent increase). All of the other reaches have either a change of less than 1 percent or a slight negative change.

The MRBA alternative has no spring rise and no summer low flow period. Without a forced spring rise in most years, it provides essentially the same connectivity as the CWCP. There is some variation in the reaches, but the changes are in the range of a 3.0 percent increase to a 1.5 percent decrease. The Kansas City reach is the one that most often decreases, which is the case for the MRBA alternative.

The MODC alternative is essentially the same on the Lower River as the MRBA alternative except that the flood storage evacuation is delayed until mid-September in many years. It has essentially the same value as the MRBA alternative (when

Table 5.7-6. Missouri River connectivity to low-lying lands for 2 days from mid-May to mid-June.

	(Acres for the 25th percentile)						
	CWCP	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Sioux City	249	251	358	257	251	310	359
Omaha	270	270	403	267	273	311	399
Nebraska City	136	136	137	137	137	137	137
St. Joseph	287	287	287	287	287	287	287
Kansas City	265	251	262	261	261	271	273
Boonville	768	768	768	768	768	768	768
Hermann	1,307	1,307	1,307	1,307	1,307	1,307	1,307
Total	**3,282**	**3,270**	**3,523**	**3,284**	**3,284**	**3,390**	**3,529**

rounded), that is a 0.1 percent increase over the CWCP. Changes in the individual reaches range from an increase of 1.1 percent to a decrease of 1.5 percent.

The BIOP alternative has a spring rise of 17.5 kcfs, which provides greater connectivity along the Lower River than the CWCP. It provides an increase of 3.3 percent. As with the ARNRC alternative, the greatest increases are in the Sioux City (24.5 percent) and the Omaha (15.0 percent) reaches. The changes in the other reaches range from 0 to 2.1 percent compared to the CWCP values.

A 30-kcfs spring rise is the primary component of the FWS30 alternative affecting its connectivity to the low-lying areas along the Lower River. Its 25th percentile value is 7.5 percent higher than the CWCP. Again, the greatest changes occur in the two reaches closest to Gavins Point Dam: Sioux City (44.1 percent) and Omaha (47.7 percent). Two of the next three downstream reaches have changes of 0.7 percent (St. Joseph) and 2.8 percent (Kansas City).

The model was not set up to provide year-to-year values for acres of connectivity. If it had, the results would have shown considerable fluctuation throughout the 100-year period of analysis because the forced spring rises from Gavins Point Dam would have increased connectivity in the upstream reaches. The downstream reaches would have also shown considerable year-to-year variability as the flows on the lower reaches fluctuated with tributary inflows in the spring.

5.7.7 Shallow Water Habitat along the Lower River

In its November 2000 BiOp (USFWS, 2000), the USFWS states that shallow water habitat has value to all life stages of native big river fish and other river organisms. As stated in the introductory remarks of the connectivity analysis discussion, shallow water habitat is especially important during the first few months of the life of the larval pallid sturgeon, an endangered species. The Corps and USFWS agreed during the formal consultation for, and the review of, the BiOp, that 20 to 30 acres of shallow water habitat per mile may provide the habitat necessary for initial recovery of the pallid sturgeon. This part of the fish section of the RDEIS focuses on the amount of shallow water habitat occurring in the Lower River for the CWCP and the alternatives submitted for Corps consideration.

The analysis of existing habitat under the various alternatives was conducted using data obtained for the physical habitat model. As part of the development of that model, cross sections were taken at a representative subreach of seven reaches of the Lower River and hydraulically modeled. These data provided a basis for determining the amount of habitat fitting into a variety of depth and velocity classes for each of the seven reaches (habitat per mile times reach length). Shallow water habitat for the purpose of this analysis is that habitat that is up to 5 feet deep with a velocity no greater than 2.5 feet per second. The amount of habitat in each depth and velocity class could be determined based on the amount of flow in each river reach. Using these relationships, the Corps developed a model that would provide duration plots of the acres of habitat per mile in each reach for any timeframe of interest.

Generally, the Corps looked at individual months; however, the lowest flows for two of the submitted alternatives occur from mid-July to mid-August. Data were computed for this period for the seven Lower River reaches. Figure 5.7-23 is one of the resulting plots for the submitted alternatives. Integration of the area under the duration curve leads to the average daily value per mile for shallow water habitat for each reach. Table 5.7-7 presents these data for all seven subreaches modeled for the CWCP and submitted alternatives.

Using these acres per mile, the total acreage available in each reach of the Lower River from Sioux City to the Osage River (River Mile 130) can be computed. The data for the five reaches are presented in Table 5.7-8 on a reach and total basis (data combined using data from two locations for the Sioux City to Omaha reach). Figure 5.7-24 shows the total acres for the five reaches from Sioux City to the Osage River for each of the submitted alternatives, the CWCP, and the run-of-river (ROR) alternative (no control of system inflows by the Mainstem Reservoir System). Data are not presented for the reach downstream from Gavins Point Dam because there is already adequate habitat (63.8 acres per mile for the CWCP) in this reach.

The CWCP provides 3,717 acres of shallow water habitat for the five reaches. The greater share of this habitat is provided between the Grand and Osage Rivers in the central part of the State of Missouri: 2,193 acres, or 59.0 percent of the total. The Nebraska City to Kansas City reach provides 25.0 percent of the total, and the other three reaches provide only 16.0 percent of the total, with the Sioux City to Omaha reach providing about half of that.

Table 5.7-7. Expected daily shallow water habitat for representative subreaches for river fish (acre per mile).

Reach	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Gavins Point	63.8	63.5	71.7	63.1	62.1	72.0	72.4
Sioux City	2.2	2.4	8.0	2.3	2.3	5.8	5.9
Omaha	1.9	2.1	7.1	2.0	2.0	5.1	5.2
Nebraska City	4.5	4.6	6.9	4.6	4.6	6.0	6.0
St. Joseph	4.8	5.0	9.6	5.1	5.1	7.9	7.9
Kansas City	1.4	1.4	1.7	1.4	1.3	1.7	1.8
Boonville	18.3	18.3	18.9	18.2	18.0	18.7	18.8

Figure 5.7-24 shows that the total acreage varies among the CWCP, submitted alternatives, and the ROR scenario. These can be divided up into four groupings. The lowest grouping has four alternatives: the CWCP and the MODC, MRBA, and MLDDA alternatives. The values range from 3,712 to 3,776, a difference of 64 acres. The ROR scenario is in the second lowest group by itself at 4,061 acres, about 100 acres more than the middle value of the lowest group. Next come the two alternatives submitted by the USFWS for consideration. These two alternatives have values just above 4,900 acres, which is about 1,200 acres more than the lowest group. Finally, the ARNRC alternative has almost 5,600 acres, which is about 1,900 acres more than the lowest group.

The MLDDA alternative provides an additional 2 MAF of flood control storage as its primary difference from the CWCP; therefore, it generally has similar summer flows to that of the CWCP. As expected, it also has similar total shallow water habitat, at 3,776 acres as presented in Table 5.7-8. This total represents a 1.6 percent increase in shallow water habitat in the mid-July to mid-August timeframe. There is some variation among the reaches. The three reaches between Sioux City and Kansas City have increased habitat ranging from an increase of 2.8 percent in the middle of the three reaches to an increase of 7.8 percent in the Sioux City to Omaha reach. In contrast, the Kansas City to Grand River reach decreases by 3.7 percent.

An 18-kcfs release from Gavins Point Dam in the summer with greater limits on evacuation of water from flood storage in the summer result in the highest shallow water habitat values of the submitted alternatives. The 5,587 acres represents a 50.3 percent increase in habitat over the CWCP. A 265 percent increase in the Sioux City to Omaha reach is by far the greatest percentage increase. Three of the other reaches increase by from 21.8 to 99.5 percent, and the Grand River to Osage River reach increases by only 3.2 percent.

The MRBA alternative also has summer flows very similar to the CWCP; therefore, it has only a 1.3 percent increase in habitat compared to the CWCP. The increases range from 2.9 to 5.6 percent for the three upstream reaches. The two lower river reaches decrease by 0.3 and 4.3 percent.

The MODC alternative also has summer flows in the mid-July to mid-August timeframe similar to those of the CWCP; therefore, it has habitat values similar to the CWCP. Total habitat decreases by only 0.1 percent; however, the losses are downstream from Kansas City only, ranging from 1.7 percent to 10.2 percent. The gains in the three upstream reaches range from 1.7 to 4.4 percent increases.

Table 5.7-8. Expected daily shallow water habitat available during mid-July to mid-August (acres).

Reach	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30	ROR
Sioux City to Omaha	288	311	1,051	304	294	758	771	479
Omaha to Nebraska City	144	148	221	148	146	191	191	165
Nebraska City to Kansas City	929	966	1,852	971	970	1,513	1,526	1,187
Kansas City to Grand River	164	158	200	157	148	196	204	144
Grand River to Osage River	2,193	2,193	2,263	2,187	2,155	2,248	2,256	2,086
Total	**3,717**	**3,776**	**5,587**	**3,767**	**3,712**	**4,906**	**4,949**	**4,061**

The BIOP alternative has lower summer Gavins Point releases than the CWCP. The 25/21 split season has a release of 21 kcfs during the mid-July to mid-August timeframe. This results in lower flows throughout the Lower River, which is reflected in the increased shallow water habitat of this alternative. It has 32.0 percent more habitat, which increases in all of the five reaches downstream from Sioux City. The increases range from a low of 2.5 percent for the most downstream reach to a high of 163 percent in the reach between Sioux City and Omaha.

The FWS30 alternative also has the 25/21-split summer release from Gavins Point Dam. An increase in habitat similar to the BIOP alternative occurs, as anticipated. The total increase is 33.1 percent with increases in all five reaches. Similar to the BIOP alternative, the increases range from 2.9 percent in the most downstream reach to a high of 168 percent in the Sioux City to Omaha reach.

Because the modeling process results in a duration plot, there are no annual data to plot. The summer low flow remains about the same throughout the period of analysis, which runs from 1898 to 1997. There are habitat decreases when evacuation of flood storage becomes necessary. Review of the duration plot, Figure 5.7-25, confirms that there must be periods of high flows because there are noticeably lower values at least 10 percent of the time.

An important point to note regarding the amount of habitat that exists per mile in the reaches from Sioux City to the Osage River is the following: with the exception of the Grand River to Osage River reach, habitat acreage is well below the minimum of 20 acres per mile that the Corps and USFWS agreed upon for the pallid sturgeon. Even though there are some significant increases in shallow water habitat (as discussed above and shown in Figures 5.7-23 and 5.7-25), the gains provided by release changes alone are not enough to provide the minimum 20 acres per mile. Because of this, the USFWS included in its BiOp RPA the recommendation for the Corps to construct additional shallow water habitat.

5.7.8 Spawning Cue for the Lower River

The November 2000 USFWS BiOp RPA recommends a spring rise release from Gavins Point Dam to provide, among other biologically important functions, a spawning cue for native river fish, especially the endangered pallid sturgeon. The RPA specifies a modified annual release pattern that has a spring rise above the full navigation service releases of 15 to 20 kcfs. The peak period for this release is 2 weeks. The total duration for this release is 4 weeks, including the periods before and after the peaks, when the release is gradually increased and decreased. Discussions between USFWS and Corps staff determined that the spawning cue requirements of the pallid sturgeon are basically unknown at this time.

In an e-mail sent to the Corps on January 22, 2001, the USFWS requested the Corps to conduct some hydrologic analyses. This set of analyses included a spring rise analysis. The USFWS requested, "For gage sites downstream of Gavins Point, document spring rise spawning cues. Rises should be defined as increases of discharge of at least 20 percent above the mean discharge prevailing for the preceding 15 days, during the period May to July. The rise should take place over three days or less" (USFWS, 2000). The USFWS provided no information on what duration of rise to analyze. This lack of information supported the general understanding between the Corps and USFWS staffs that the required spawning cue is basically unknown at this point in time. Corps staff understood that the aforementioned criteria were hypothetical, and they did not have supporting data, analysis, and documentation of associated spawning success. A discussion of the analysis conducted for evaluating a spawning cue follows.

A model was developed that would access the daily flow data for each DRM location from Gavins Point Dam to the mouth. A running average of the daily flows for the previous 15 days was conducted using the data starting on May 1 and ending on June 30 of each year. (The likelihood of spawning cues after June 30 is low, so it was not checked.) The flows for May 1, 2 and 3 were checked to determine if the flows over this 3-day period exceeded the prior 15-day average by at least 20 percent. If the flows on one of the days met the 20 percent increase, the model would continue to check the daily average flow until it dropped to less than 20 percent of the flows for the 15 days prior to May 1. The model would continue a day-by-day check of the prior 15 days, compute an average, and count the number of days the flows continued to be at least 20 percent above that prior 15-day average. This continued up to June 30.

In some years there were some short periods and some longer periods. The model recorded the longest period in terms of days. The longest period was recorded for each year, and when the 100 years of data were analyzed. The 100 annual values were sorted from highest to lowest with the highest value assigned a 1 (for equaled or exceeded 1 percent of the time) and the lowest value assigned a 100 (for equaled or exceeded 100 percent of the time). A plot of these data is called a duration plot, and Figure 5.7-26 is an example of such a plot for the Sioux City gage. This figure shows the duration plots for the CWCP at all of the gage locations in the DRM simulation output files for the Lower River from Sioux City downstream. A similar plot was completed for the six submitted alternatives.

Another set of curves was developed for the ROR scenario (no control of inflows to the mainstem of the Missouri River). Sets of curves can be compiled for each gage location using this first set of curves, as shown on Figure 5.7-27. This second set of curves, one for each gage location in the DRM, provides the spawning cues for a full range of days. For example, to determine how often a 20 percent increase in flow occurred for a total of 21 consecutive days, one would go to the point where the 21-day line crosses the duration curves. Next one would slide down and read off the percent of time from the bottom axis of the graph for each curve. In the case of the CWCP curve on the figure, this point is located at 7 percent of the time. Similarly, it is 28 percent of the time for the ARNRC alternative.

Because the USFWS did not specify a length for the spawning cue, one was selected for analysis based on the spring rise recommended in the BiOp RPA. The total rise occurs over a 28-day period. If it takes 3 days to go up 20 percent, there will also be 3 days at the end of the spring rise where the releases will drop below the 20 percent value. This means that the spawning cue lasted 22 days (28 minus 6). Based on this basic consideration, a 3 week, or 21-day, length was evaluated for the spawning cue. Figure 5.7-28 shows a plot of the resulting data for all of the gage locations included in the DRM. The curves shown on this plot would shift upward for shorter lengths of spawning cues, and vice versa.

Figure 5.7-28 shows that the CWCP, the submitted alternatives, and the ROR scenario have spawning cues that occur for differing amounts of time. The values are presented in Table 5.7-9. For example, the Sioux City line on the plot shows that the percent of time increases for the CWCP in a downstream direction with a 21-day spawning cue occurring 7 percent of the time at Sioux City and a maximum of 38 percent of the time at Hermann. The values for Sioux City vary from alternative to alternative. For example, the ARNRC alternative with its 15-kcfs spring rise raises the value to 27 percent for Sioux City. The FWS30 alternative with its 30-kcfs spring rise has the highest values, ranging from 38 percent at St. Joseph to 48 percent at Gavins Point Dam.

Generally, for the reaches Kansas City upstream, the values are higher as the spring rise included in the alternative is higher. Downstream from Kansas City, however, the value for the percent of the time the spawning cue occurred remains relatively constant, with the values ranging from 37 to 42 percent of the time at Hermann, and 33 to 40 percent of the time at Boonville. A spring rise of 30 kcfs was required to make the percent change by more than 2 percent for the two lowest gage locations. The ROR scenario has more spawning cues because the uncontrolled flows were historically much higher than the modeled spring rises, with the percent values ranging from high on the reaches closest to Sioux City (78 or 79 percent) to the lowest value occurring at Hermann (54 percent).

Table 5.7-9. Percent of years with a 21-day spawning cue at Lower River gaging stations.

	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30	ROR
Gavins Point Dam	18	20	33	23	23	35	48	78
Sioux City	7	11	27	15	11	32	44	79
Omaha	7	9	30	16	12	32	46	79
Nebraska City	10	12	26	15	13	31	43	68
St. Joseph	17	19	24	19	21	26	38	63
Kansas City	33	31	42	35	33	39	44	62
Boonville	33	33	33	33	33	34	40	62
Hermann	38	38	37	39	38	38	42	54

5.7.9 Fish Resources for Tribal Reservations

Young-of-Year Lake Fish Production

Table 5.7-10 presents the relative index of average annual young fish production of the alternatives for seven Tribal Reservations along the mainstem lakes during the full period from 1898 to 1997. For a discussion of how the young fish index value was calculated, see Section 5.7.1.

The total index value for average annual young fish production associated with these Reservations is 1.65 for the CWCP. All of the submitted alternatives result in a increase in total young fish production values over the CWCP: the MLDDA alternative by 1.2 percent, the ARNRC alternative by 8.5 percent, the MRBA alternative by 0.4 percent, the MODC alternative by 7.3 percent, the BIOP alternative by 11.5 percent, and the FWS30 alternative by 12.1 percent.

Under the CWCP, the average annual index value for young fish production for the Fort Berthold Reservation (on Lake Sakakawea) is 0.46. Five of the submitted alternatives increase young fish production index values compared to the CWCP. The BIOP and FWS30 alternatives both provide the greatest percentage increase over the CWCP (10.9 percent). The ARNRC and MODC alternatives both result in a 6.5 percent increase in young fish production index values, while the MLDDA alternative provides a 4.3 percent increase. The MRBA alternative is the only submitted alternative that decreases the young fish production index value from the CWCP (2.2 percent).

The CWCP provides a young fish production index value of 0.40 within the Standing Rock Reservation and the Cheyenne River Reservation, both of which are located on Lake Oahe. The BIOP alternative does not result in an index value change over the CWCP. Under the ARNRC alternative, the index value within these Reservations decreases by 2.5 percent. The remaining four submitted alternatives all provide an index value increase. The MODC alternative provides the greatest percentage increase (7.5 percent), while the MRBA and FWS30 alternatives both result in the smallest percentage increase (2.5 percent). The MLDDA alternative yields a 5.0 percent increase in young fish production index value over the CWCP.

Within the Lower Brule Reservation and the Crow Creek Reservation, on the lower portion of Lake Oahe, the CWCP provides an index value of 0.43 for young fish production. The MODC alternative does not result in a change in young fish production index values over the CWCP. The BIOP and FWS30 alternatives both provide an index value increase of 9.3 percent. The ARNRC alternative also provides an index value increase over the CWCP, but only by 2.3 percent. The MLDDA and MRBA alternatives both result in a 2.3 percent decrease in index values.

The CWCP yields a young fish production index value of 0.20 within Yankton Reservation, on Lake Francis Case. There is an index value increase under the ARNRC alternative (34.5 percent), the FWS30 alternative (29.9 percent), and the BIOP alternative (29.5 percent). The MODC alternative also provides an index value increase, but it is a much smaller value than the previously mentioned alternatives (5.4 percent). The MRBA and MLDDA alternatives both decrease the index value (1.3 and 5.2 percent, respectively).

Under the CWCP, the index value for young fish production for the Santee Reservation (on Lewis and Clark Lake) is 0.16. Compared to the CWCP, five of the submitted alternatives increase the young fish production index value for this Reservation. The MLDDA alternative does not

Table 5.7-10. Average annual young fish production in the mainstem lakes for seven Reservations (relative index).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Berthold	0.46	0.48	0.49	0.45	0.49	0.51	0.51
Standing Rock and Cheyenne River	0.40	0.42	0.39	0.41	0.43	0.40	0.41
Lower Brule and Crow Creek	0.43	0.42	0.44	0.42	0.43	0.47	0.47
Yankton	0.20	0.19	0.27	0.20	0.21	0.26	0.26
Santee	0.16	0.16	0.20	0.18	0.21	0.20	0.20
Total	**1.65**	**1.67**	**1.79**	**1.66**	**1.77**	**1.84**	**1.85**

result in a change in value from the CWCP. The MRBA alternative provides a 12.5 percent index value increase, while the ARNRC, BIOP, and FWS30 alternatives all provide a 25.0 percent increase. The MODC alternative results in the largest percentage index value increase over the CWCP (31.3 percent).

Coldwater Fish Habitat in Lakes

Table 5.7-11 presents the average annual volume of coldwater fish habitat (in MAF) for each alternative for three Tribal Reservations along the mainstem lakes during the full period from 1898 to 1997.

The total volume associated with the Fort Berthold, Standing Rock, and Cheyenne River Reservations is 6.28 MAF for the CWCP. Compared to the CWCP, only one of the submitted alternatives, the MLDDA alternative, decreases total coldwater fish habitat in the upper two mainstem lakes (decrease of 2.7 percent). The remaining five submitted alternatives all increase coldwater fish habitat: the ARNRC alternative by 13.1 percent, the BIOP and FWS30 alternatives by 8.3 percent, the MODC alternative by 5.7 percent, and the MRBA alternative by 2.1 percent.

The CWCP provides 2.81 MAF of coldwater fish habitat for the Fort Berthold Reservation, which is located on Lake Sakakawea. The ARNRC alternative provides the greatest increase (12.1 percent) in coldwater fish habitat over the CWCP within this Reservation. The MODC, FWS30, and BIOP alternatives increase habitat by 5.7, 4.3, and 3.2 percent, respectively. The MLDDA and MRBA alternatives both decrease coldwater fish habitat for the Fort Berthold Reservation by 2.1 percent.

For the Standing Rock Reservation and the Cheyenne River Reservation on Lake Oahe, the CWCP provides 3.47 MAF of coldwater fish habitat. One alternative, the MLDDA alternative, decreases coldwater fish habitat (3.2 percent), while the ARNRC, BIOP, and FWS30 alternatives all increase habitat by 13.8, 12.4, and 11.5 percent, respectively. The MRBA alternative also increases coldwater fish habitat within the Standing Rock and Cheyenne River Reservations, but by a smaller amount (5.5 percent).

Coldwater Fish Habitat in the River

Table 5.7-12 presents the miles of average annual coldwater habitat of the alternatives for the Fort Peck Reservation during the full period from 1898 to 1997. The Fort Peck Reservation is located downstream of Fort Peck Dam.

The CWCP provides 140.2 miles of coldwater fish habitat for the Fort Peck Reservation. According to the model, the greatest increase in coldwater fish habitat for the Fort Peck Reservation is under the BIOP alternative, under which there is a 9.5 percent increase over the habitat for the CWCP. The model also shows that the ARNRC and FWS30 alternatives increase habitat by 9.4 and 8.9 percent, respectively. Lesser increases occur under the MODC alternative (2.6 percent), the MRBA alternative (1.5 percent), and the MLDDA alternative (0.7 percent). The average annual values should actually be lower for the four

Table 5.7-11. Average annual coldwater fish habitat for three Reservations along the mainstem lakes (MAF).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Berthold	2.81	2.75	3.15	2.75	2.97	2.90	2.93
Standing Rock and Cheyenne River	3.47	3.36	3.95	3.66	3.67	3.90	3.87
Total	**6.28**	**6.11**	**7.10**	**6.41**	**6.64**	**6.80**	**6.80**

Table 5.7-12. Average annual coldwater fish habitat for the Fort Peck Reservation (miles).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	140.2	141.2	153.5	142.3	143.8	153.6	152.6

alternatives that have a spring rise out of Fort Peck Dam—the ARNRC, MODC, BIOP, and FWS30 alternatives—because warmwater will be discharged from the spillway to benefit native river fish in this reach. Unfortunately, the coldwater model does not know that a portion of the flow will come from the spillway.

Warmwater Fish Habitat in the River

Table 5.7-13 presents the miles of average annual warmwater habitat of the alternatives for Tribal Reservations along two river reaches during the full period from 1898 to 1997. The Reservations analyzed include the Fort Peck Reservation, located downstream of Fort Peck Dam, and the Yankton Reservation and Ponca Tribal Land, located downstream of Fort Randall Dam.

The CWCP provides an average 32.8 miles of warmwater fish habitat downstream from the Fort Peck Reservation. Compared to the CWCP, all of the submitted alternatives decrease warmwater fish habitat for this Reservation. The MLDDA and MODC alternatives reduce habitat by 0.9 and 8.3 percent, respectively. The MRBA alternative reduces habitat by 10.6 percent. The greatest decreases in warmwater fish habitat occur under the ARNRC alternative (18.6 percent), the BIOP alternative (16.8 percent), and the FWS30 alternative (13.4 percent). The same basic model generates both the warmwater habitat data and the coldwater habitat data. Data for the Fort Peck reach are not accurate because of the warmwater release over the Fort Peck Dam spillway in a portion of the period modeled. The number of warmwater habitat miles should be greater in some years for the four alternatives with the Fort Peck spring rise: the ARNRC, MODC, BIOP, and FWS30 alternatives. Overall, one could anticipate that the average annual number of miles would decline relative to the CWCP values, but not by as much as the table and narrative indicate.

Under the CWCP, the Yankton Reservation and Ponca Tribal Lands show 13.9 miles of warmwater fish habitat; however, all of the other submitted alternatives decrease warmwater fish habitat for the Yankton Reservation and Ponca Tribal Lands compared to the CWCP. The MLDDA, MODC, and MRBA alternatives reduce habitat by 4.6, 5.9, and 8.5 percent, respectively. The greatest decreases in habitat occur under the ARNRC, BIOP, and FWS30 alternatives; these reductions are 15.2, 21.5, and 23.3 percent, respectively.

Physical Habitat for Native Fish

Table 5.7-14 presents the average annual physical habitat index values of the alternatives for seven Tribal Reservations during the full period from 1898 to 1997. The Reservations analyzed include Fort Peck Reservation, downstream of Fort Peck Dam; Yankton Reservation and Ponca Tribal Lands, which are downstream of Fort Randall Dam; and Winnebago Reservation, Omaha Reservation, Iowa Reservation, and Sac and Fox Reservation, all of which are downstream of Gavins Point Dam. For a discussion of how the physical habitat index was calculated see Section 5.7.5.

An index value was computed for each month based on how closely the velocity and/or depth distributions for a given river reach match the "natural" flow conditions based on pre-Mainstem Reservoir System channel conditions. The index can range from 0 to 1.0 with 1.0 indicating a perfect match. The values for each of the 12 months are summed to compute an annual index for each reservation or group of reservations in that reach. The annual index can range as high as 12.0. The total annual index is computed by combining the values from all the reservations.

Total index values for average annual physical habitat associated with these Reservations is 35.74 for the CWCP. All of the other alternatives result

Table 5.7-13. Average annual warmwater fish habitat for Reservations for the river reaches downstream from Fort Peck and Fort Randall Dams (miles).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	32.8	32.5	26.7	29.4	30.1	27.3	28.4
Yankton and Ponca Tribal Lands	13.9	13.3	11.8	12.7	13.1	10.9	10.7
Total	**46.8**	**45.8**	**38.5**	**42.1**	**43.2**	**38.2**	**39.1**

Table 5.7-14. Average annual physical habitat values for native river fish impact on Reservations (index).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	9.03	9.06	9.49	90.9	9.14	9.18	9.20
Yankton and Ponca	8.56	8.57	8.44	8.50	8.55	8.45	8.46
Winnebago and Omaha	10.22	10.18	10.27	10.23	10.23	10.08	10.18
Iowa and Sac and Fox	7.93	7.94	8.30	8.00	8.01	8.16	8.27
Total	**35.74**	**35.75**	**36.50**	**35.82**	**35.93**	**35.87**	**36.11**

in an increase in total physical habitat values over the CWCP: the MLDDA alternative by 0.1 percent, the ARNRC alternative by 2.1 percent, the MRBA alternative by 0.2 percent, the MODC alternative by 0.5 percent, the BIOP alternative by 0.4 percent, and the FWS30 alternative by 1.0 percent.

Under the CWCP, the average annual index value for physical habitat for the Fort Peck Reservation is 9.03. For this Reservation, all of the other alternatives increase the physical habitat index values over the CWCP. The greatest increase in physical habitat index values occurs under the ARNRC alternative (5.1 percent). The remaining submitted alternatives provide smaller percentage increases over the CWCP: the MLDDA alternative by 0.3 percent, the MRBA alternative by 0.7 percent, the MODC alternative by 1.2 percent, the BIOP alternative by 1.7 percent, and the FWS30 alternative by 1.9 percent.

The CWCP yields an index value of 8.56 for physical habitat for native river fish for the Yankton Reservation and Ponca Tribal Lands. Five of the submitted alternatives decrease physical habitat values from the value of the CWCP. While the MLDDA alternative increases the index value by 0.1 percent, the MODC alternative decreases the index value by 0.1 percent. The remaining submitted alternatives all decrease the physical habitat index value: the MRBA alternative by 0.7 percent, the FWS30 alternative by 1.2 percent, the BIOP alternative by 1.3 percent, and the ARNRC alternative by 1.4 percent.

The CWCP provides a physical habitat index value 1for native river fish of 10.22 for the reach adjacent to the Winnebago Reservation and Omaha Reservation. The ARNRC alternative increases (0.5 percent) the physical habitat value as do both the MRBA and MODC alternatives (0.1 percent). Both the MLDDA alternative and FWS30 alternative decrease physical habitat values by 0.4 percent, while the BIOP alternative decreases habitat values by 1.4 percent.

For the Iowa Reservation and the Sac and Fox Reservation, the CWCP shows a 7.93 index value for native river fish physical habitat. All of the submitted alternatives provide an increase in physical habitat index values over the CWCP. The MLDDA alternative provides the smallest percentage increase over the CWCP, 0.1 percent, and the MRBA and MODC alternatives increase habitat values by 0.9 and 1.0 percent, respectively. The FWS30 and ARNRC alternatives provide the greatest percentage increase (4.3 and 4.7 percent, respectively). The BIOP alternative provides a 2.9 percent value increase over the CWCP.

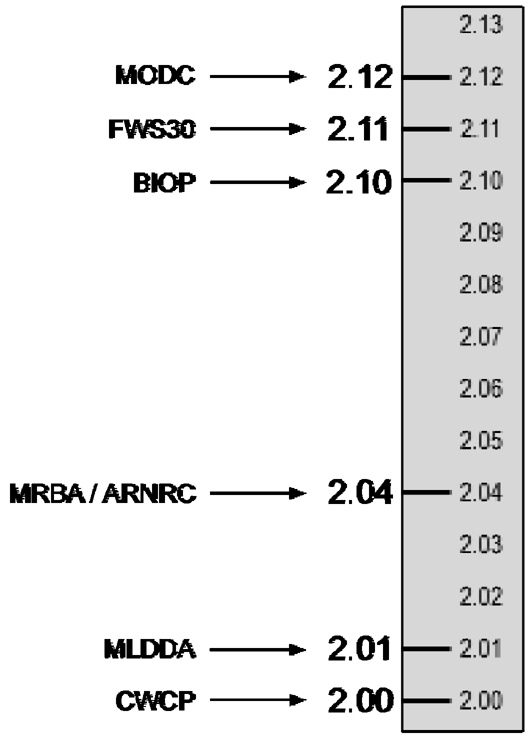

Figure 5.7-1. Average annual young fish production index values for submitted alternatives.

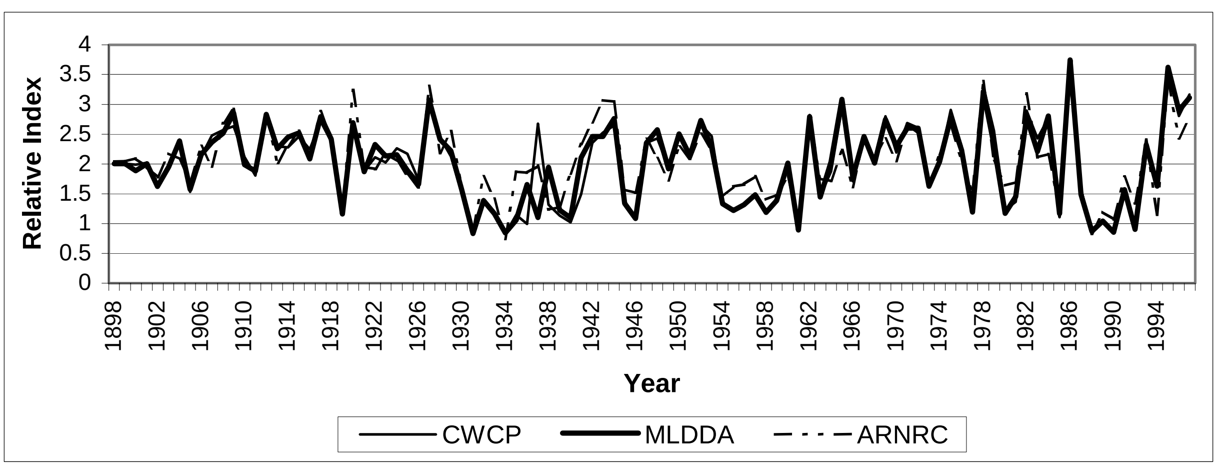

Figure 5.7-2. Average annual values for young fish production in mainstem lakes for alternatives CWCP, MLDDA, and ARNRC.

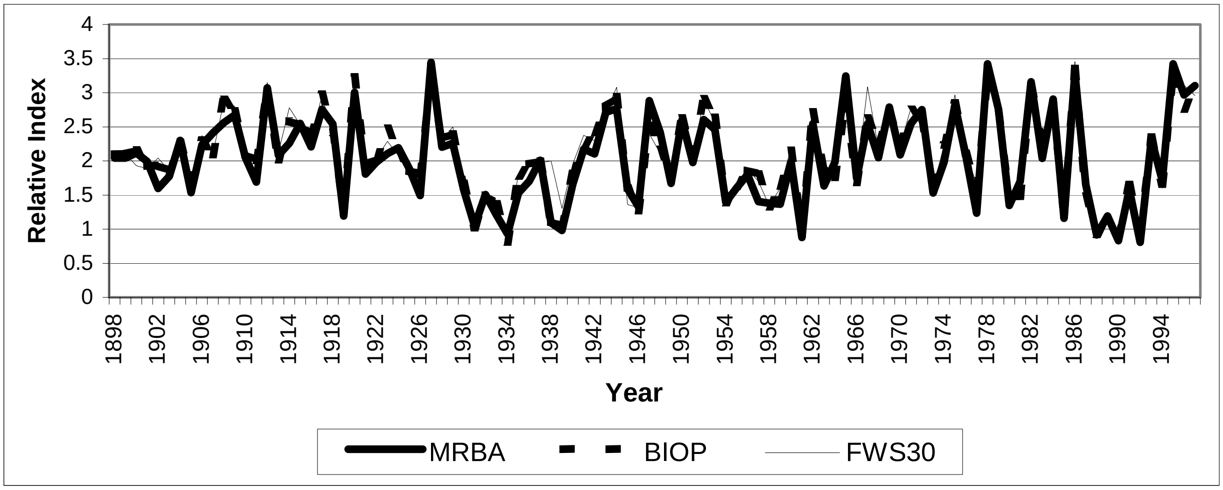

Figure 5.7-3. Average annual values for young fish production in mainstem lakes for alternatives MRBA, BIOP, and FWS30.

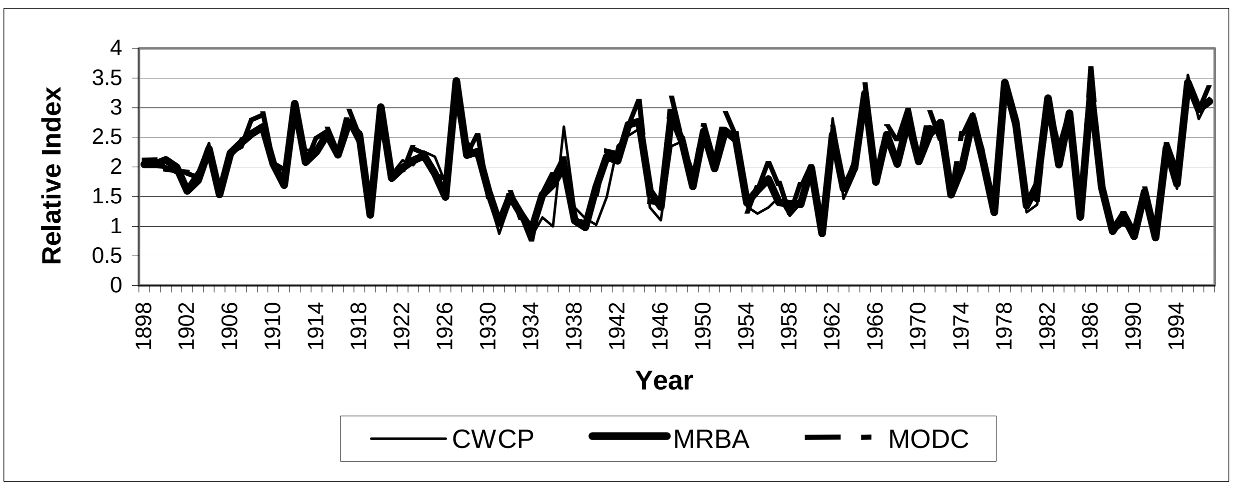

Figure 5.7-4. Average annual values for young fish production in mainstem lakes for alternatives CWCP, MRBA, and MODC.

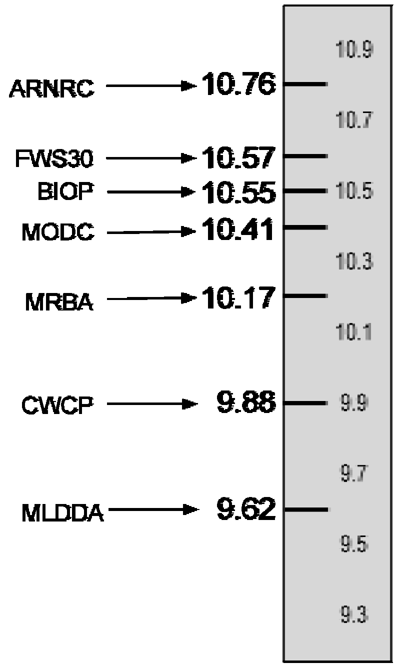

Figure 5.7-5. Average annual coldwater fish habitat in mainstem lakes for submitted alternatives (MAF).

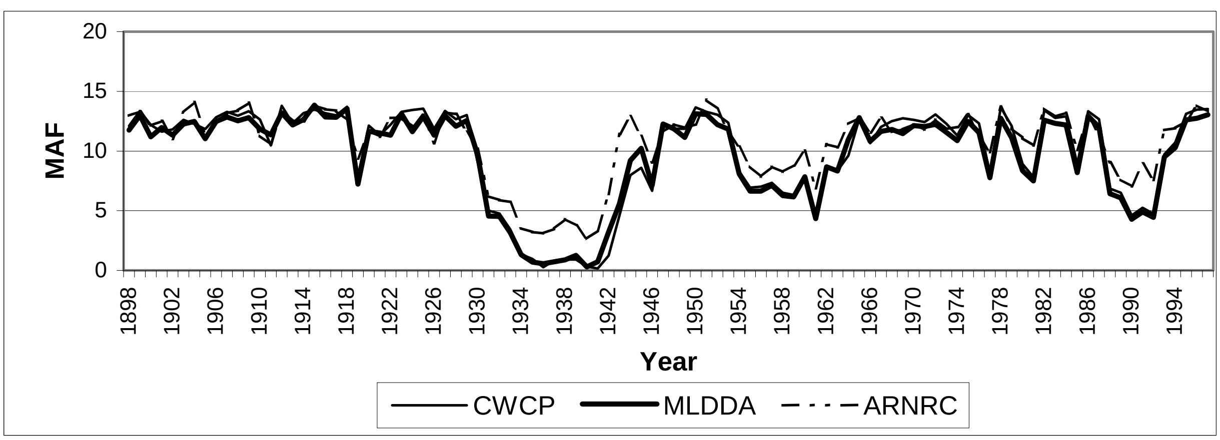

Figure 5.7-6. Average annual coldwater fish habitat in mainstem lakes for alternatives CWCP, MLDDA, and ARNRC.

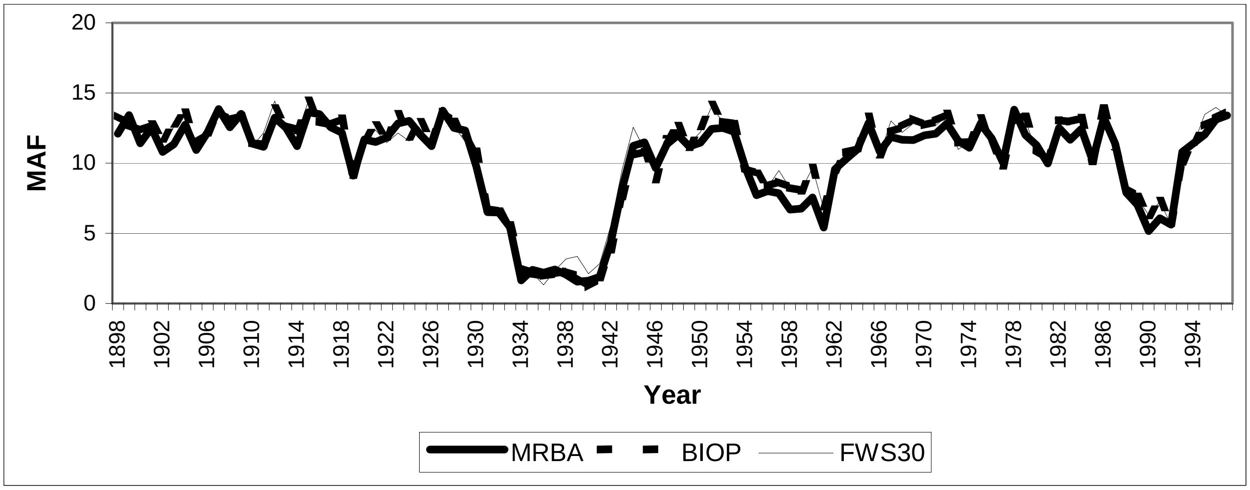

Figure 5.7-7. Average annual coldwater fish habitat in mainstem lakes for alternatives MRBA, BIOP, and FWS30.

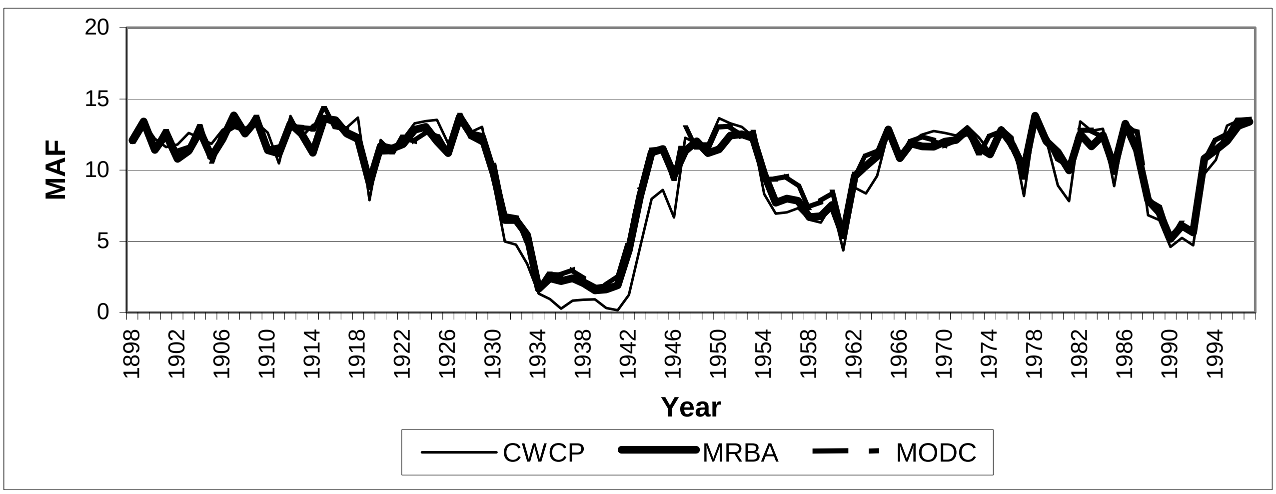

Figure 5.7-8. Average annual coldwater fish habitat in mainstem lakes for alternatives CWCP, MRBA, and MODC.

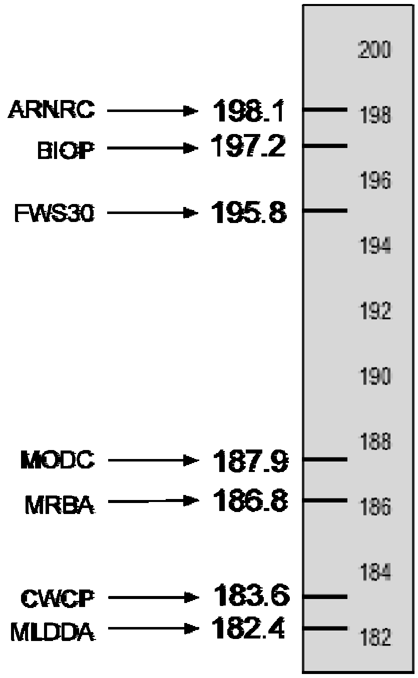

Figure 5.7-9. Average annual coldwater fish habitat in river reaches for submitted alternatives (miles).

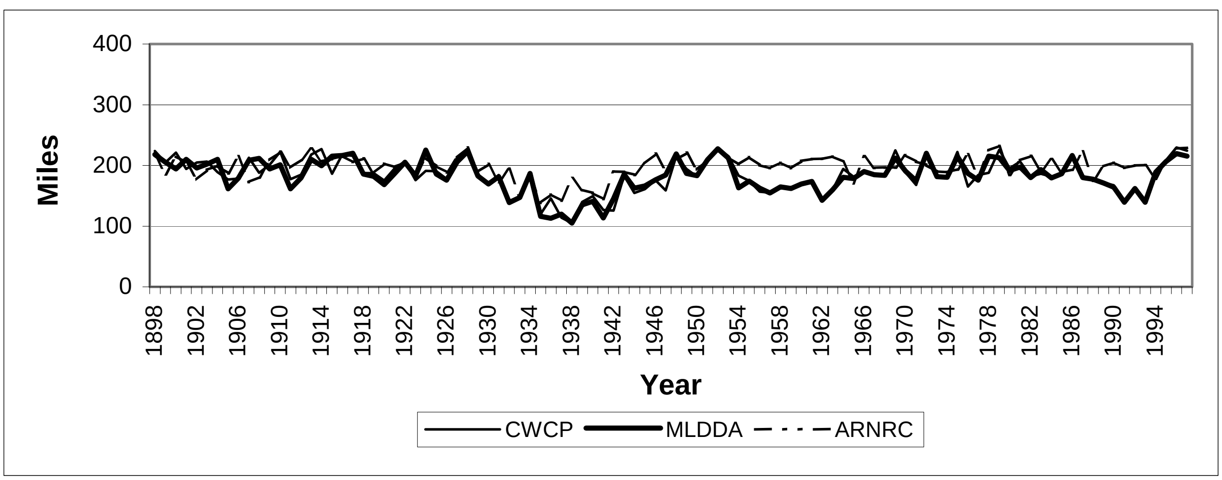

Figure 5.7-10. Average annual coldwater fish habitat in river reaches for alternatives CWCP, MLDDA, and ARNRC.

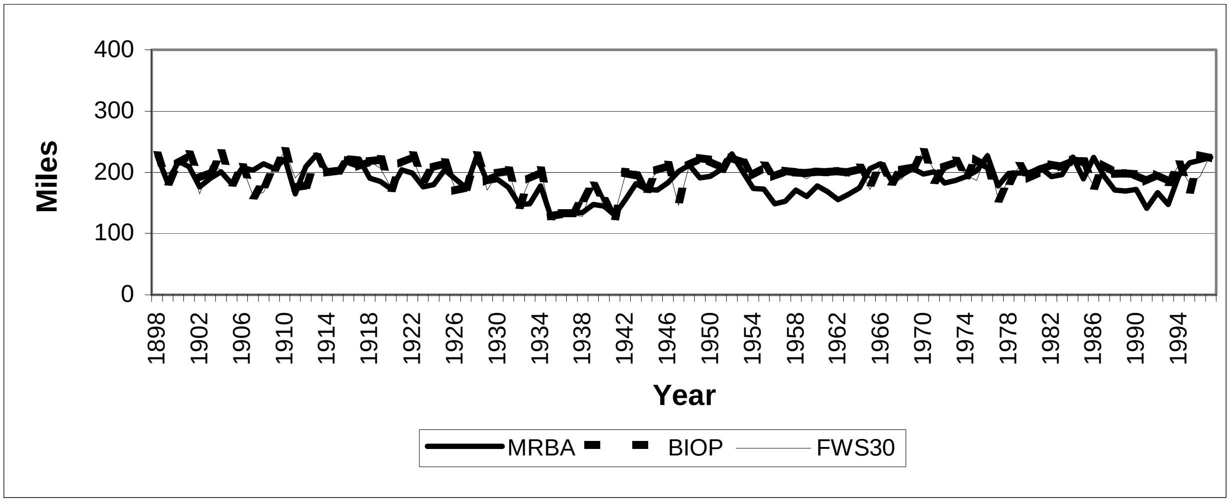

Figure 5.7-11. Average annual coldwater fish habitat in river reaches for alternatives MRBA, BIOP, and FWS30.

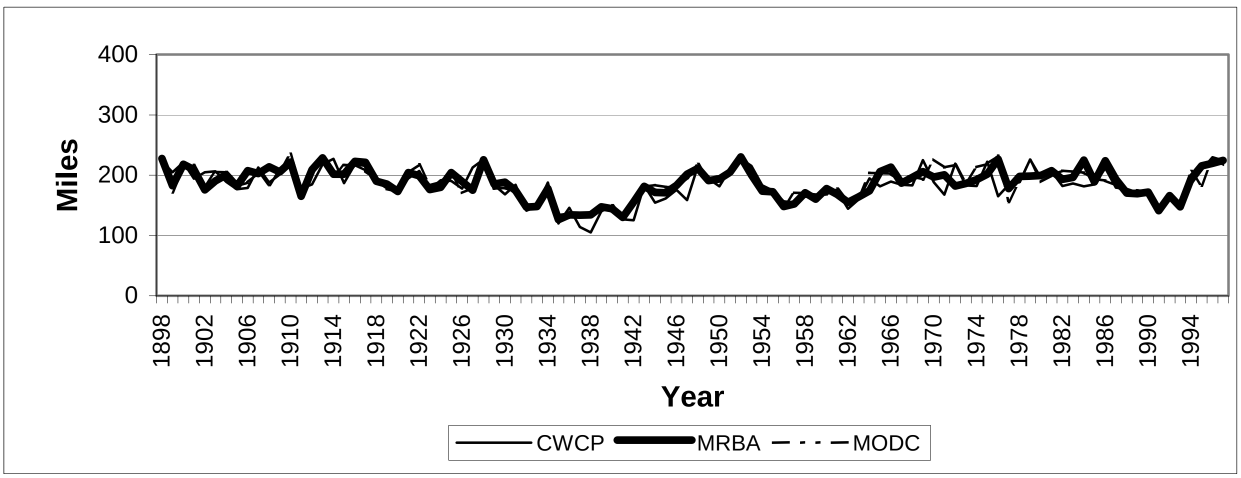

Figure 5.7-12. Average annual coldwater fish habitat in river reaches for alternatives CWCP, MRBA, and MODC.

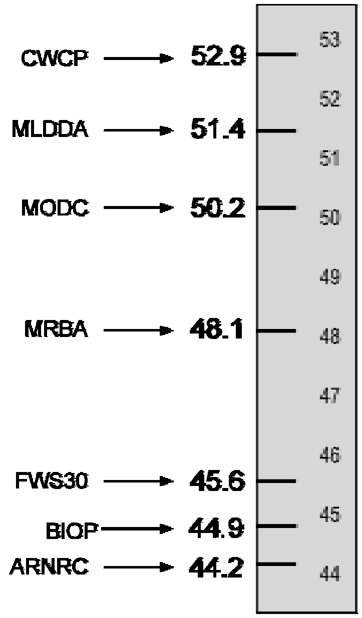

Figure 5.7-13. Average annual warmwater fish habitat in river reaches for submitted alternatives (miles).

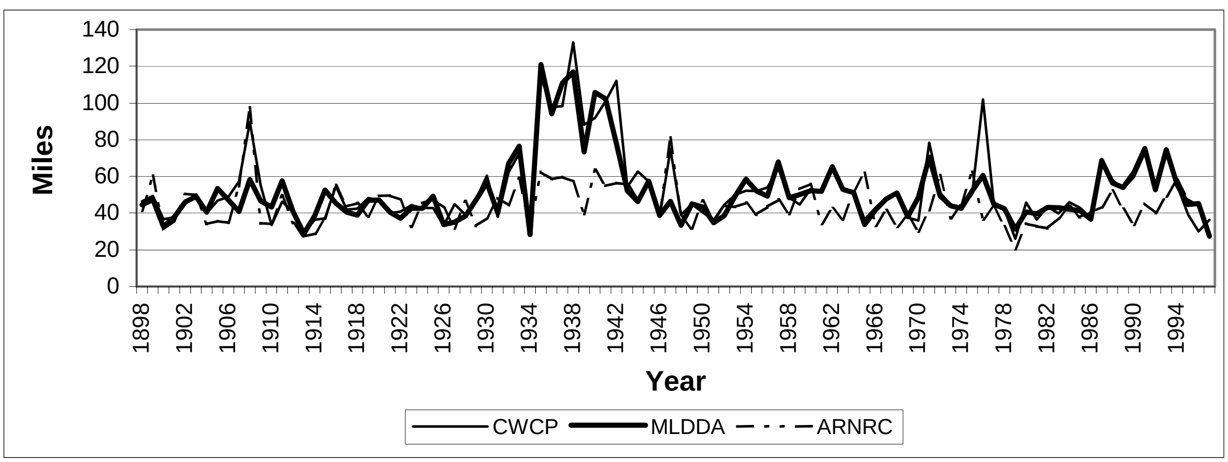

Figure 5.7-14. Average annual warmwater fish habitat in river reaches for alternatives CWCP, MLDDA, and ARNRC.

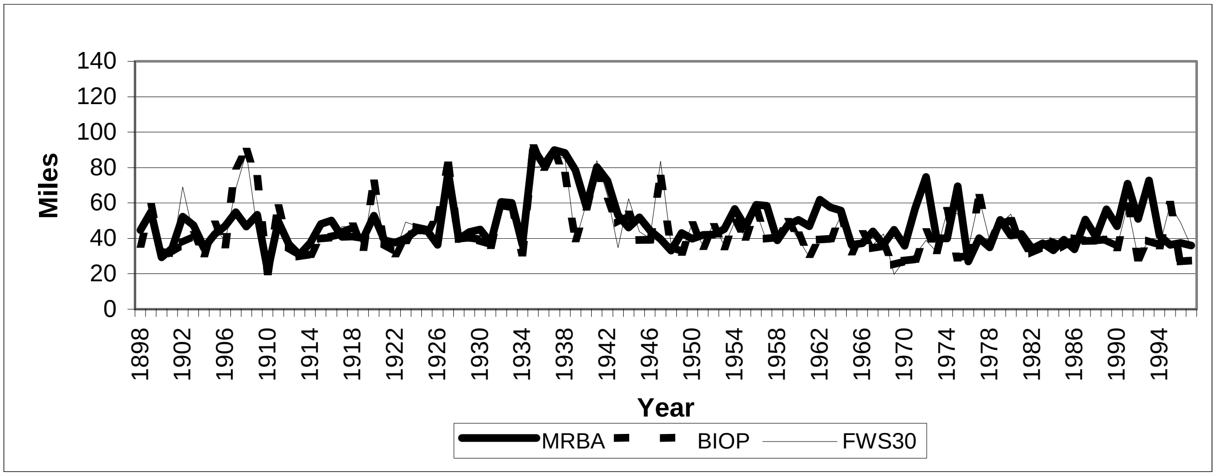

Figure 5.7-15. Average annual warmwater fish habitat in river reaches for alternatives MRBA, BIOP, and FWS30.

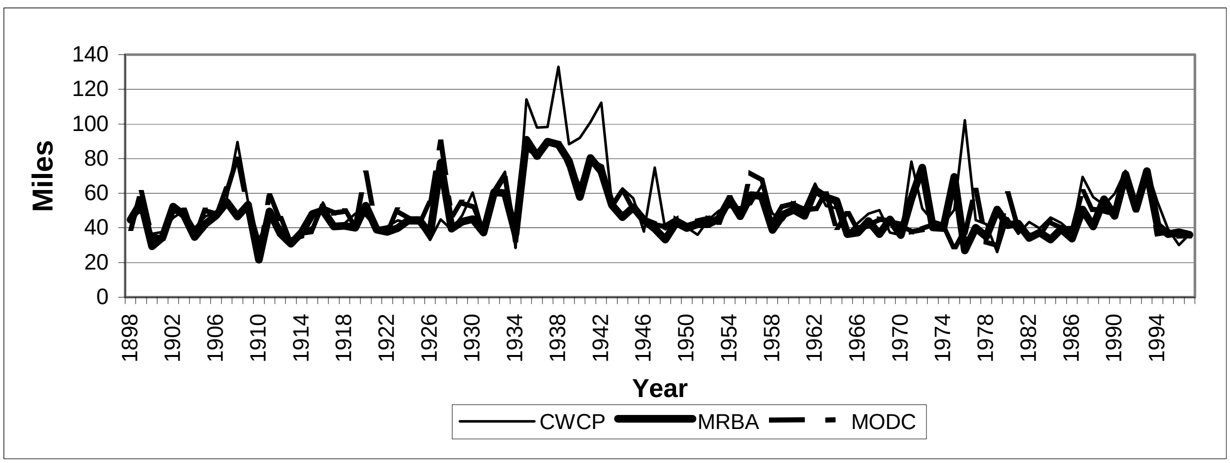

Figure 5.7-16. Average annual warmwater fish habitat in river reaches for alternatives CWCP, MRBA, and MODC.

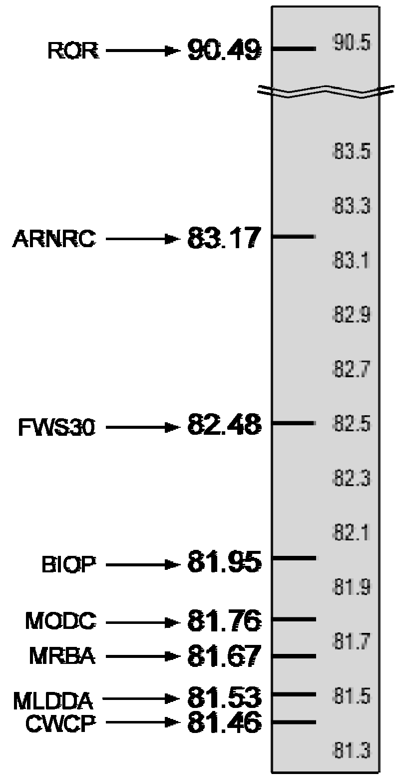

Figure 5.7-17. Average annual river fish physical habitat for submitted alternatives (miles).

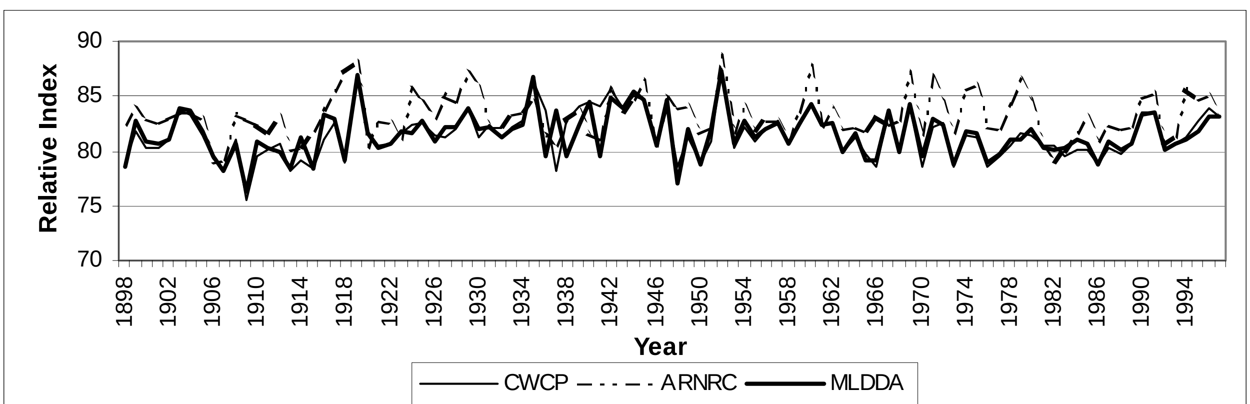

Figure 5.7-18. Average annual values for river fish physical habitat for alternatives CWCP, ARNRC, and MLDDA.

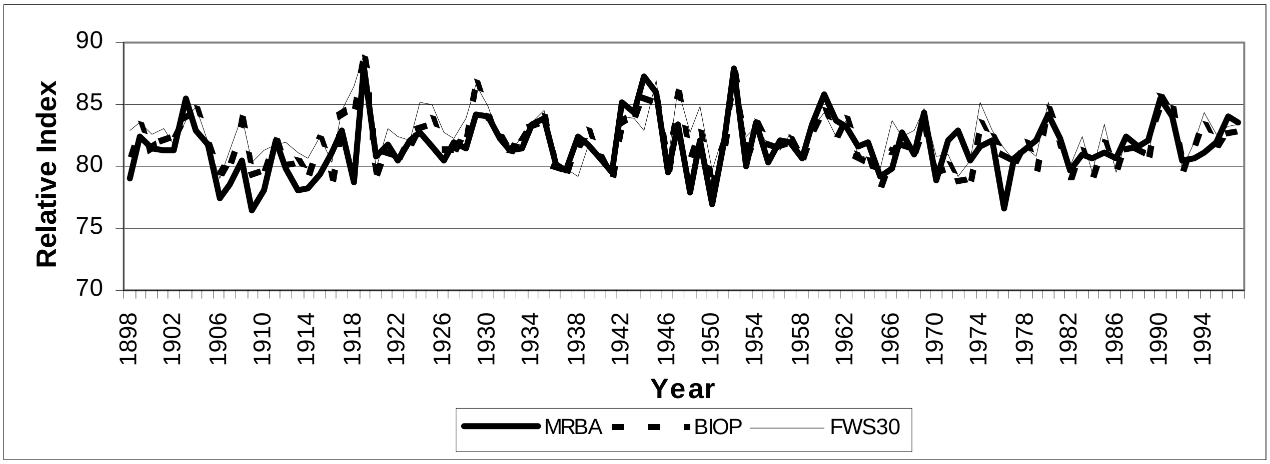

Figure 5.7-19. Average annual values for river fish physical habitat for alternatives MRBA, BIOP, and FWS30.

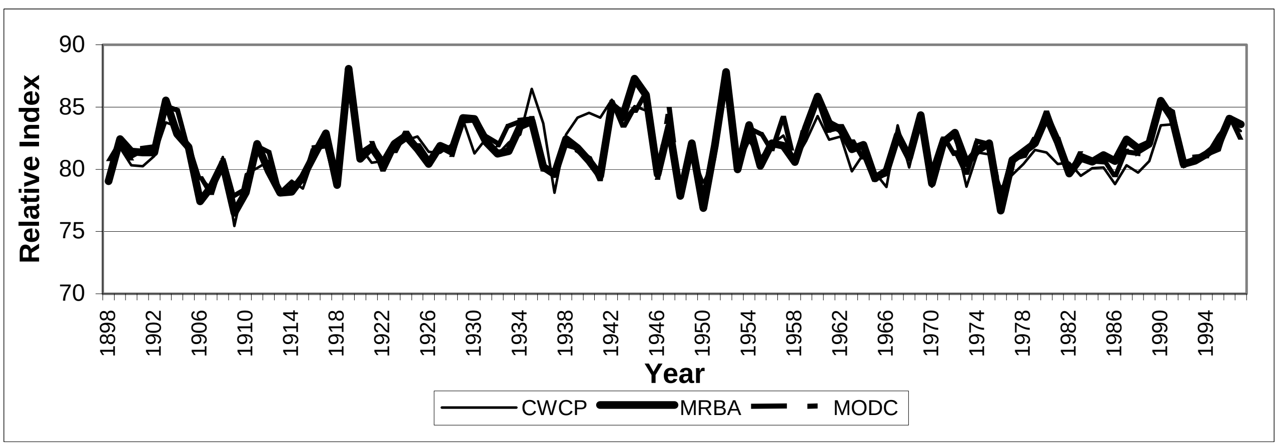

Figure 5.7-20. Average annual values for river fish physical habitat for alternatives CWCP, MRBA, and MODC.

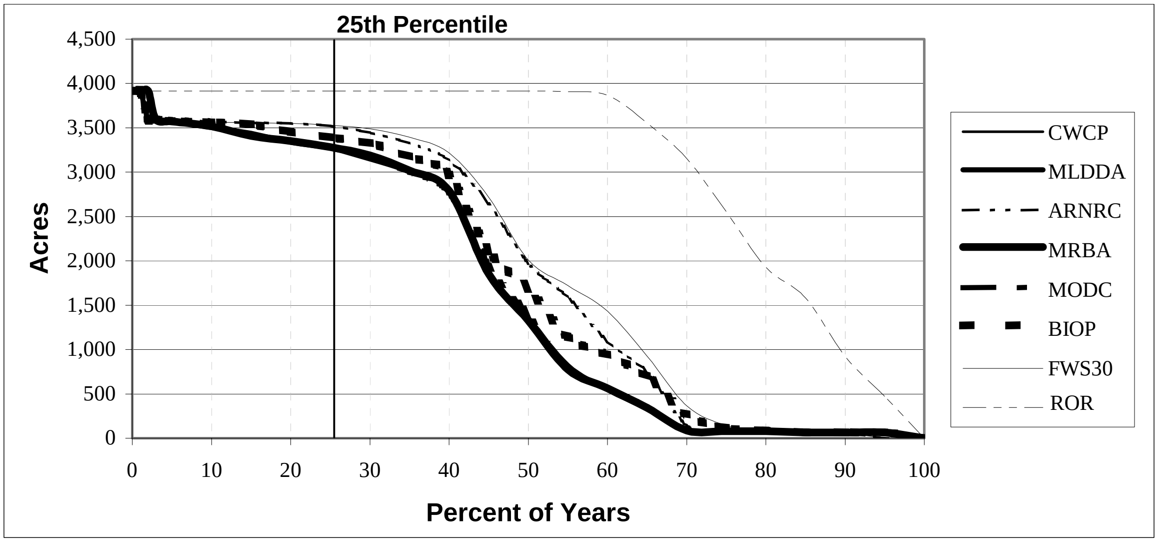

Figure 5.7-21. Acres of connectivity for 2 days during May and June.

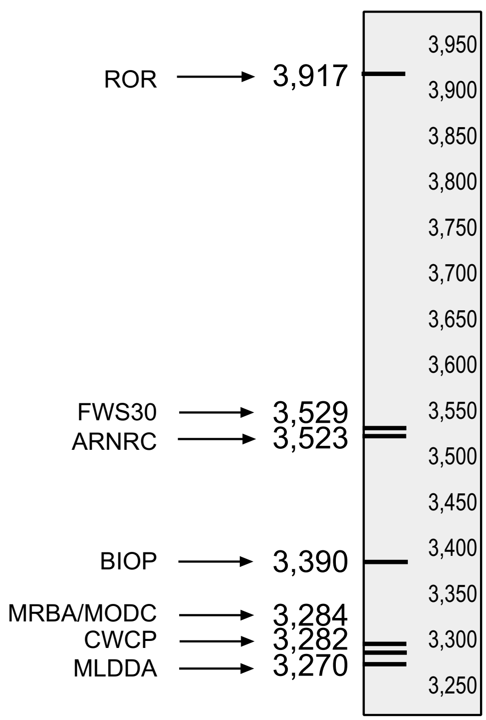

Figure 5.7-22. Acres of connectivity for 2 days in May and June (25th percentile).

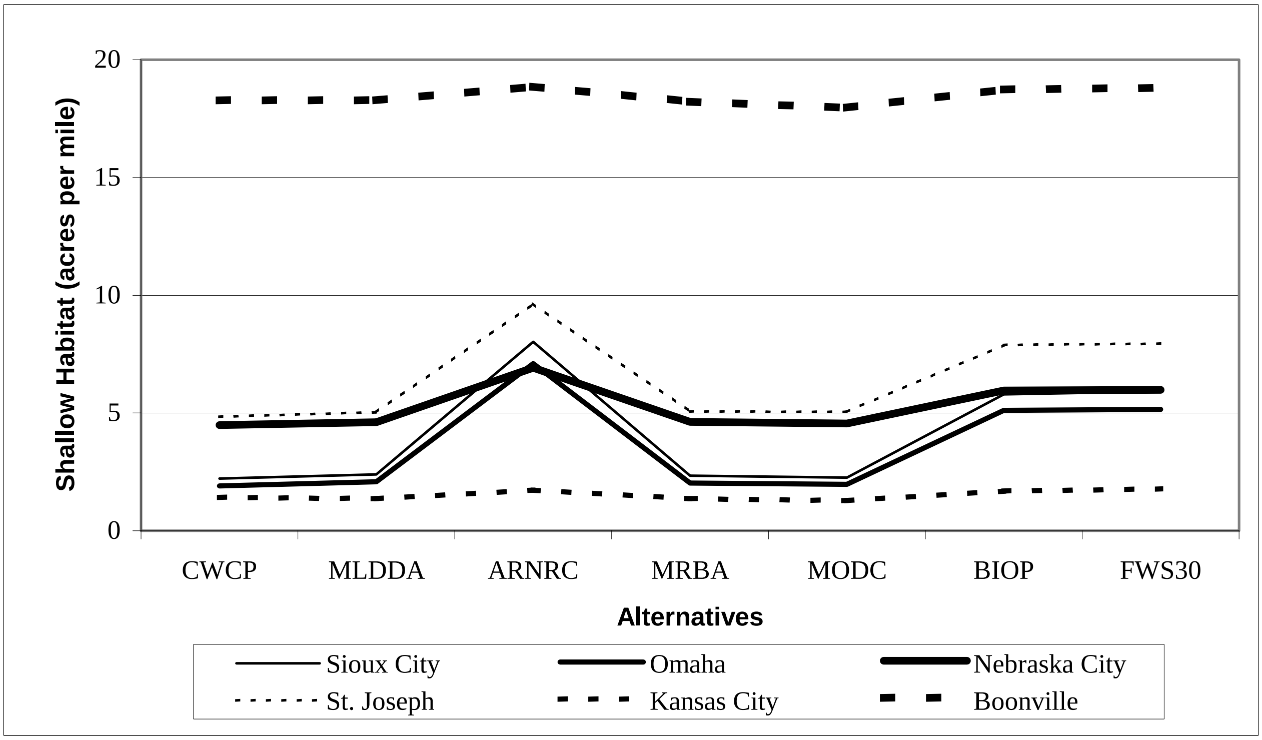

Figure 5.7-23. Expected daily shallow water habitat for river fish.

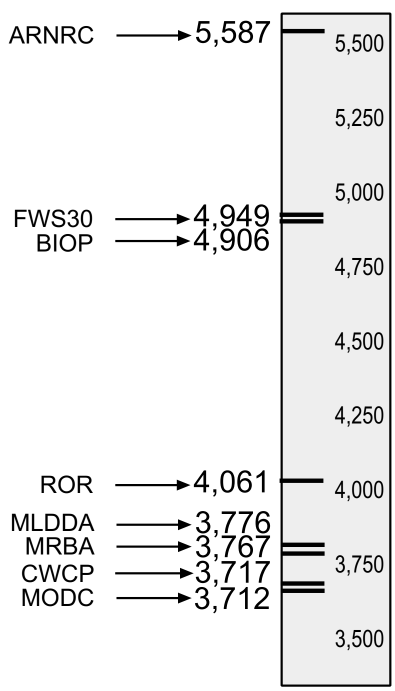

Figure 5.7-24. Total expected daily shallow water habitat available during mid-July to mid-August for submitted alternatives and ROR (acres).

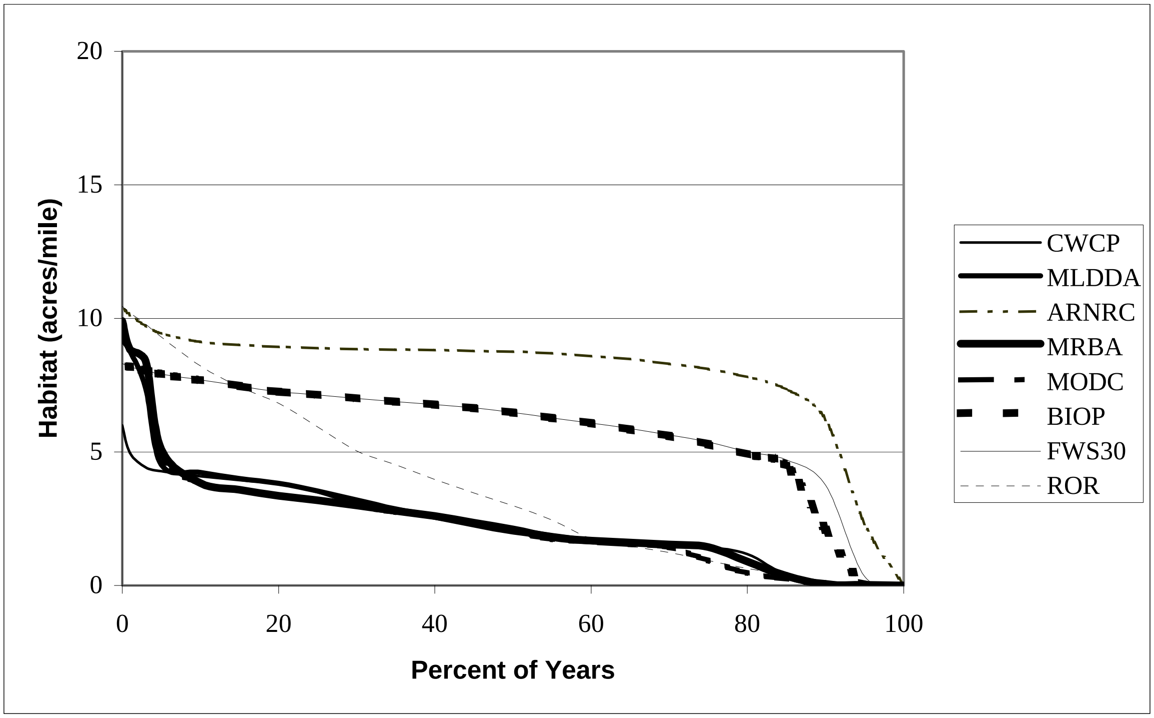

Figure 5.7-25. Duration plot of shallow water habitat during the mid-July to mid-August period - Sioux City reach.

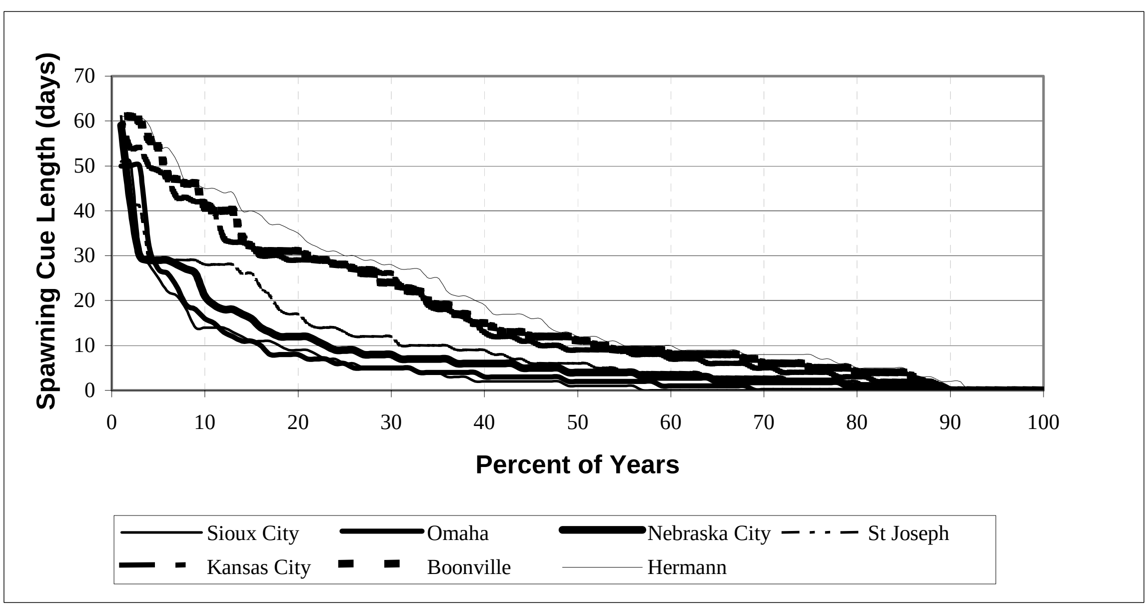

Figure 5.7-26. Duration plot of spawning cue length during May and June for the CWCP.

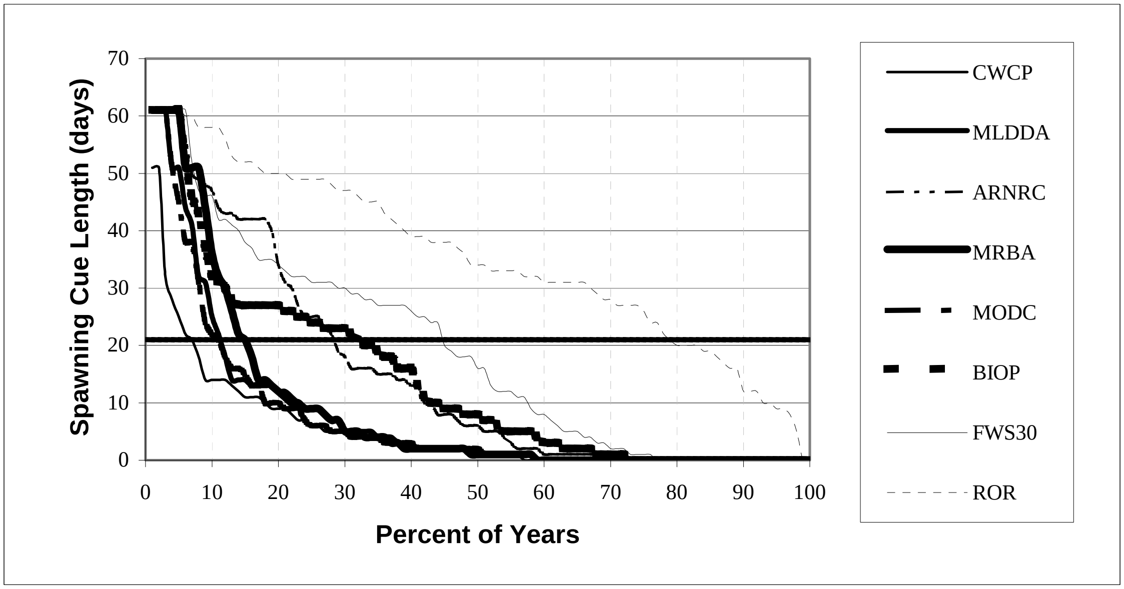

Figure 5.7-27. Duration plot of spawning cue length during May and June at Sioux City.

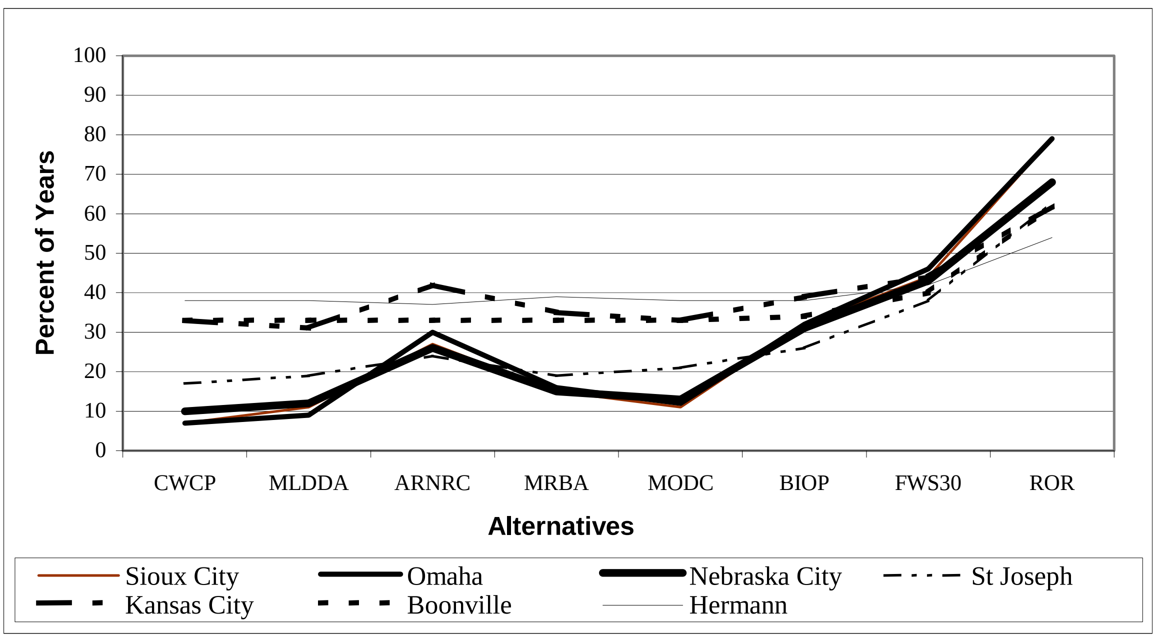

Figure 5.7-28. Percent of years with a 21-day spawning cue at Lower River gaging locations.

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