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BIOLOGICAL ASSESSMENT:

**THE IMPACT OF FLUCTUATING FLOWS FROM GLEN CANYON DAM ON
WINTERING BALD EAGLES ALONG THE COLORADO RIVER IN GRAND
CANYON NATIONAL PARK AND GLEN CANYON NATIONAL RECREATION
AREA**

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SPECIES ACCOUNT

Background Information

The Bald Eagle (Haliaeetus leucocephalus) is presently listed as endangered by the U.S. Fish and Wildlife Service and legally protected under the Endangered Species Act of 1973. Most populations of Bald Eagles have steadily increased in numbers since 1972 because of the banning of DDT (Gerrard and Bortolotti 1988), and as many as 80,000 eagles are currently estimated to exist in North America (Stalmaster 1987). Up to 20,000 of these eagles overwinter in the contiguous 48 states. Approximately 200 Bald Eagles overwinter in Arizona, which is near the southern edge of the species' range (Grubb et al. 1989). However, the population estimate of wintering eagles in Arizona was based on surveys done in the early 1980s; contemporary statewide surveys for wintering eagles have not been performed, but would probably indicate a somewhat larger population.

Wintering Bald Eagles are present along the Colorado River below Glen Canyon Dam in Grand Canyon National Park and Glen Canyon National Recreation Area from November through March each year (Fig. 1). Peak eagle abundance is in late February, when helicopter surveys of the river corridor identified at least 23 eagles between the dam and the confluence of the Little Colorado River in 1991 (122 km; Brown and Stevens 1991).

Bald Eagles in the river corridor tend to concentrate during late winter at and near the confluence of Nankoweap Creek, 108 km downstream of the dam, because of the abundance and accessibility of spawning rainbow trout (*Oncorhynchus mykiss*) in the creek. Up to 1,500 spawning trout may be present in the lowermost 1 km of the creek during the peak spawn in late February (Brown et al. 1989). Up to 26 eagles/day were present at the confluence of Nankoweap Creek during the last week of February 1990, representing the largest sustained concentration of wintering Bald Eagles in Arizona (Fig. 2; Brown and Stevens 1991). This represented approximately 13% of the known population of wintering eagles in Arizona, but only a tiny fraction of the population of wintering eagles in western North America.

The true number of Bald Eagles making use of the Nankoweap site each winter is probably greater than these figures indicate, because individual eagles were apparently moving into and out of the area as dictated by their innate migratory urge. Figure 2 indicates substantial changes in numbers of eagles present/day throughout 1990 and 1991. Since eagles were not marked or banded during the studies of 1990-91, the only valid estimate of the size of the concentration was the number of individual eagles observed simultaneously on the peak day. Moreover, eagle abundance between years may vary substantially because of changes in prey abundance and possibly also because of levels of

human disturbance or regionwide climatic patterns that would influence eagle migration strategies.

The winter concentration of Bald Eagles at and near the confluence of Nankoweap Creek is a recent occurrence, for no such concentration could have existed prior to the construction of Glen Canyon Dam in 1963 due to a lack of concentrated food resources (Brown et al. 1989). The existing eagle concentration has developed because trout were introduced, flourished in the cold, clear water released by the dam, and then began spawning in large numbers in Nankoweap Creek. Eagles were first observed frequenting the Nankoweap area in winter during the early 1980s, and had increased to as many as 18/day in late February 1988 (Brown et al. 1989). The combination of abundant prey and the remote location of Nankoweap suggests that the eagle concentration could continue to increase in size, similar to the increase exhibited by the Bald Eagle concentration in Glacier National Park (McClelland 1973), provided that trout abundance is maintained and **human disturbance in the Nankoweap area is not excessive** (Brown and Stevens 1991).

The Nankoweap area, with its historically-sizeable trout spawn, represents an important stopover feeding and resting site for spring migrant Bald Eagles moving northward to their breeding areas. Age structure of the eagle concentration varies within and among years, but immature and subadult eagles were significantly more abundant than adults at peak concentrations in both 1990 and 1991. Immature and subadult eagles were present at Nankoweap in significantly greater proportions than they were in the adjacent Colorado River corridor, demonstrating that younger age classes concentrate near more abundant food sources. Since young eagles appear to be food-limited in winter and often cannot consume enough to meet their daily energy requirements (Stalmaster 1983), especially during their

instead of the river.

Bald Eagles exhibited flow-dependent spatial foraging patterns at and near the confluence of Nankoweap Creek and the Colorado River during 1990 and 1991 (Brown and Stevens 1991). As river flows increased, the proportion of eagle foraging attempts in the creek increased from 50% to 100%. Within the creek, proportionally more foraging attempts occurred > 50 m upcreek during high river flows, but this flow-dependent shift in foraging patterns did not influence foraging success rates.

In contrast, the proportion of eagle foraging attempts in river, shore, and isolated pool habitats declined with increasing flows. This spatial foraging pattern resulted from the relative stability of Nankoweap Creek as foraging habitat and the relative instability of river, shore, and isolated pool foraging habitats. Reasons for this pattern were that 1) prey on shore (carriion) or in isolated pools (left by fluctuating flows from the dam) were inundated and washed away by the river at higher flows, and 2) the difficulty of foraging in the river apparently increased at higher flow levels. This caused eagles to shift their foraging activity to a less difficult foraging habitat.

If this pattern of eagle foraging behavior documented at Nankoweap is exhibited by all eagles in the river corridor, as is likely, then eagles downstream of the dam may temporarily experience reduced opportunities to forage or a reduction in foraging success at the highest river flows. This potential temporary disadvantage for foraging eagles would diminish as flows decreased.

Trout stranded in shallow, isolated pools along the riverbank created by fluctuating flows from Glen Canyon Dam constituted 11.5% and 18.7%, respectively, of all prey items captured by Bald Eagles at Nankoweap in 1990 and 1991. This represented a moderate,

beneficial contribution to the eagle energetic budget. This contribution increased in 1991, a year of low prey abundance in Nankoweap Creek. However, the ultimate importance of this contribution can only be put into perspective by use of an energetics simulation model for Bald Eagles, such as that developed by Stalmaster (1983). The opportunistic nature of foraging by Bald Eagles suggests, but does not prove, that eagles might compensate for a lack of prey in isolated pools by foraging in other habitats if river flows during the 1990 and 1991 study had not exhibited fluctuations.

Data Gaps

Eagle prey consumption and foraging ecology relative to their daily energy requirements are poorly understood. Most importantly, the proportion of prey obtained from isolated pools needs to be evaluated with respect to its contribution to eagle caloric needs. Completion of an eagle energetics simulation model, similar to that developed by Stalmaster (1983), would adequately evaluate the contribution of isolated pools, and therefore fluctuating flows, to the overall eagle energetic budget.

Eagle foraging ecology at and near Nankoweap Creek has been thoroughly documented, but these findings have had to be extrapolated to the river corridor as a whole. If these extrapolations are to be used as the basis for dam management in the future, then further studies of eagle foraging ecology in the river corridor away from the concentrated food resources at Nankoweap Creek should be undertaken. These studies should address hunting methods, attack methods, foraging success, and use of different foraging habitats (as defined by Brown and Stevens 1991) by river flow level. Information on eagle foraging ecology along the river away from Nankoweap will be useful to management if the trout

spawn at Nankoweap consistently fails to occur, forcing eagles to rely entirely on riverine food resources.

IMPACT ASSESSMENT

Fluctuating flows from Glen Canyon Dam or the operation of the dam have short-term, direct impacts on the behavior, foraging ecology, and food intake of wintering Bald Eagles downstream of the dam. These influences are manifested through the dam's control over eagle foraging habitat and prey base. Dam operations also have the potential for long-term, indirect influences on Bald Eagles through changes in riverine aquatic productivity that would be passed up the food chain to Bald Eagles. However, the influence of indirect impacts of this nature is unknown. These direct and indirect influences are summarized in Table 1.

Eagle spatial foraging patterns at and near the confluence of Nankoweap Creek were dependent on fluctuating flows from the dam, but these flow-dependent shifts in foraging patterns did not influence eagle foraging success. Therefore, the effect of fluctuating flows on Bald Eagle foraging behavior is a neutral influence.

The highest river flows may temporarily reduce eagle foraging opportunities or cause a decline in eagle foraging success, but this potential negative influence of fluctuating flows diminishes as flows decrease. The quantitative effect of temporary high river flows is unknown, but is probably negligible under conditions of daily fluctuating flows. Steady, high river flows with no fluctuations could negatively influence wintering Bald Eagles in the river corridor. In contrast, low river flows (temporary or sustained) appear to have no

negative influence on eagle foraging behavior or prey consumption.

The proportion of prey captured by Bald Eagles from isolated pools left by fluctuating flows could be an important component of the eagles' overall energetic budget if the eagle concentration at Nankoweap were existing at, slightly below, or slightly above energetic equilibrium. If the eagles at Nankoweap exhibited a strong energetic surplus (i.e. they were gorging to put on fat prior to the rigors of migration), then prey from isolated pools would not be critical. Without the results of an energetics simulation model (Stalmaster 1983), an evaluation of these possibilities is impossible. Therefore, prey from isolated pools can only be described as a moderate, beneficial influence of fluctuating flows from the dam.

Furthermore, the opportunistic nature of Bald Eagle foraging suggests that eagles may be able compensate for a loss of prey from isolated pools by foraging in the creek. This form of compensation would only be possible if spawning trout were present in the creek.

The largest point of impact of fluctuating flows on wintering Bald Eagles is at the mouth of Nankoweap Creek and in the lowermost 50 m of the creek. Since 78% and 67%, respectively, of all eagle foraging attempts in 1990 and 1991 occurred in this area (Brown and Stevens 1991), this was the focal point of eagle foraging activity. All four foraging habitats were contained in this area (creek, river, isolated pool, shore), but most foraging attempts took place in the creek.

Wintering Bald Eagles are opportunistic foragers and would probably attempt to compensate for any decline in prey abundance in Nankoweap Creek by foraging in other areas. However, a sustained eagle concentration at Nankoweap would not occur during a year when the trout spawn in Nankoweap Creek failed to materialize. Under this scenario, eagles would still be present in the river corridor, but probably in reduced numbers

compared to a year (1990) when trout in Nankoweap Creek were abundant. The long-term effects of a 1-year failure of the trout spawn on the eagle concentration at Nankoweap are unknown, but **the eagle concentration would probably continue to occur in any year in which trout were abundant in the creek.**

The presence of Glen Canyon Dam and its historical operation have created conditions beneficial to wintering and migrating Bald Eagles. The Colorado River below Glen Canyon Dam would probably not be able to support the number of wintering and migrating eagles it does without the influence of Glen Canyon Dam and the subsequent introduction of rainbow trout (Brown et al. 1989).

EVALUATION OF FLOW ALTERNATIVES ON BALD EAGLES

Seven alternatives for possible future water releases from Glen Canyon Dam have been identified. These alternatives, and their potential influence on wintering Bald Eagles, are discussed below.

1. **Year-round steady flows.** Prey stranded in isolated pools would no longer be available to eagles. Neutral influence on eagle spatial foraging patterns. Overall influence: unknown but probably neutral.
2. **Seasonally-adjusted steady flows.** Prey stranded in isolated pools would no longer be available to eagles. Neutral influence on eagle spatial foraging patterns. Overall influence: unknown but probably neutral.
3. **Existing monthly volume steady flows.** Prey stranded in isolated pools would largely be unavailable to eagles. Neutral influence on eagle spatial foraging patterns. Overall influence: unknown but probably neutral.

4. **Low fluctuating flows.** Prey from isolated pools would still be available. Neutral influence on eagle spatial foraging patterns. The temporary negative influence of higher flows that would reduce foraging opportunities or success in the river corridor away from Nankoweap would not occur. Overall influence: neutral to moderately beneficial.
5. **Moderate fluctuating flows.** Prey from isolated pools would still be available. Neutral influence on eagle spatial foraging patterns. Overall influence: neutral to moderately beneficial.
6. **High fluctuating flows.** Prey from isolated pools would still be available. Neutral influence on eagle spatial foraging patterns. Highest flows would temporarily reduce eagle foraging opportunities or success in the river corridor away from Nankoweap. Overall influence: neutral to moderately beneficial.
7. **No action (Existing limits).** The 1990-1991 research of Brown and Stevens (1991) addressed this alternative. All the influences discussed in Impact Assessment above will apply. Current operations have a neutral influence on eagle spatial foraging patterns; a moderately positive influence on eagle food intake; and a potentially negative influence on eagle foraging opportunities and success in the river corridor away from Nankoweap at the highest flows released by the dam. Overall influence: neutral to moderately beneficial.

In summary, little information exists that would allow a quantitative evaluation of the first six alternatives. In most likelihood, none of the above seven alternatives would strongly influence in either a positive or negative sense the continued existence of Bald Eagles in the

river corridor or of the eagle concentration at Nankoweap.

CONCLUSIONS

1. Fluctuating flows from Glen Canyon Dam have a neutral influence on eagle foraging behavior and spatial foraging patterns.
2. Fluctuating flows have a moderately positive influence on eagle prey consumption because of prey stranded in isolated pools.
3. Eagle in the river corridor that are not near Nankoweap Creek may temporarily experience reduced opportunities to forage or foraging success at the highest flow levels experienced during fluctuating flows. High steady flows from the dam could negatively impact eagle foraging opportunities or foraging success in the river corridor, but further research on this topic is necessary if this possibility is to form the basis for dam operation in the future.
4. The concentration of wintering Bald Eagles will almost certainly continue to occur at Nankoweap Creek provided that: 1) the availability of spawning trout in Nankoweap Creek is maintained, and 2) increasing levels of human disturbance in the Nankoweap area during the peak eagle concentration do not preclude the use of this unique area by eagles.

DETERMINATION OF EFFECT

The current operation of Glen Canyon Dam directly influences the behavior, foraging ecology, and food consumption of wintering and migrating Bald Eagles. These influences are neutral or moderately beneficial in nature, with the exception of the potential for high flows to temporarily reduce eagle foraging opportunities or foraging success in the river. For this reason, the project under consideration may not detrimentally effect the continued existence of wintering and migrating Bald Eagles along the river between Glen Canyon Dam and the Grand Wash Cliffs.

COMMENTS AND RECOMMENDATIONS

An annual monitoring program designed to assess the size of the Bald Eagle concentration at Nankoweap Creek should be developed. The management and scientific goals of the monitoring program would be to: 1) determine if an eagle concentration occurred during the monitoring period, 2) determine the size and age class distribution of the eagle concentration, and the timing of the peak concentration; and 3) document the relative abundance of trout in Nankoweap Creek and the relative abundance of other fish-eating predators that may become habituated to the trout spawn. Monitoring of the eagle concentration from the rim on the Navajo Reservation by means of powerful spotting scopes should take place from 22 February to 3 March of each year. Further details of the proposed monitoring program are discussed by Brown and Stevens (1991).

Bald Eagles have not been known to nest along the Colorado River in Glen and Grand canyons (Brown et al. 1987). However, the possibility exists that they may colonize the river corridor as a nesting species as a result of habitat changes brought about by the

construction and operation of Glen Canyon Dam. Recent summer sightings of a pair of adult Bald Eagles near Nankoweap Creek (pers. comm., Richard L. Glinski, Arizona Game and Fish Dept.) lend credence to this hypothesis. Further evidence of the consistent presence of adult eagles along the river corridor after March should be vigorously investigated to determine if Bald Eagles have begun to nest in Grand Canyon. The discovery of an active Bald Eagle nest along the river could have substantial implications for dam management.

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FIGURE CAPTIONS

- Figure 1. Numbers of wintering and migrating Bald Eagles detected during helicopter surveys of the Colorado River corridor from Glen Canyon Dam to the Little Colorado River confluence in the winter of 1990-91.
- Figure 2. The abundance of wintering and migrating Bald Eagles in 1990 and 1991 at the confluence of Nankoweap Creek and the Colorado River.

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Table 1. Summary of direct and indirect influences of the operation of Glen Canyon Dam on wintering Bald Eagles along the Colorado River in Grand Canyon.

Type of Influence	Effect of Influence
<u>Short-term direct Influences on:</u>	
1. Changes in spatial foraging patterns and behavior caused by fluctuating flows	Neutral
2. Prey captured from isolated pools left by fluctuating flows	Moderately positive
3. Foraging opportunities or success in the river away from Nankoweap at highest fluctuating flows	Negative (extent unknown)
<u>Long-term indirect Influence on:</u>	
4. Changes in aquatic productivity	Unknown
