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SURVEY OF PISCIVOROUS BIRDS OF THE NECHAKO AND STUART RIVERS, B.C.

by

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ABSTRACT

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Counts and observations of birds within the Nechako and Stuart rivers were made as part of the Department of Fisheries and Oceans commitment to examine the potential impacts of reduced flows and altered temperatures on predation of juvenile chinook salmon (*Oncorhynchus tshawytscha*) prior to water diversion. Birds were observed and counted from a drifting boat on 4 surveys of 241 km of river. These 4 surveys were completed between May and October 1991, prior to completion of Kemano II, a water diversion project. A simple feeding model that incorporated information from the relevant literature, actual field counts and observations of birds, and fish prey distribution from earlier studies was developed to rank the potential impact of each bird species on juvenile chinook salmon.

Common mergansers (*Mergus merganser*, 55%) and belted kingfishers (*Ceryle alcyon*, 13%) accounted for the majority of the piscivorous birds identified on the Nechako River. Other piscivorous bird species identified were: mew gull (*Larus canus*), black tern (*Chlidonias niger*), osprey (*Pandion haliaetus*), red-necked grebe (*Podiceps grisegena*), common loon (*Gavia immer*), great blue heron (*Ardea herodias*) and bald eagle (*Haliaeetus leucocephalus*). We estimated that common mergansers and belted kingfishers would account for the majority of the juvenile chinook consumed by birds (91% and 8%, respectively). Common mergansers had the greatest potential for consuming chinook salmon fry in May-June when broods were actively feeding along the shallow river margins where chinook fry were most abundant. Common mergansers could have consumed approximately 40% of the total chinook fry which emerged within the Nechako River in 1991.

Résumé

Brown, T.G., L. Rzen, and E. White. 1995 Survey of piscivorous birds of the Nechako and Stuart Rivers, B.C. Can. Manus. Rep. Fish. Aquat. Sci. 2285: 26p.

Le ministère des Pêches et des Océans a pris des engagements relatifs à l'examen des répercussions possibles d'une réduction des débits et de changements de la température sur la prédation exercée sur le saumon quinnat juvénile (*Oncorhynchus tshawytscha*) avant le détournement des eaux. Nous avons donc procédé à des observations et à des dénombrements d'oiseaux sur les rivières Nechako et Stuart. Nous avons effectué quatre expéditions à bord d'une embarcation laissée à la dérive pour un total de 241 km franchis au fil de l'eau. Les expéditions ont eu lieu à différents moments entre mai et octobre 1991, avant que soit terminé le project Kemano II de déviation du cours d'eau. Nous avons eu recours à un modèle simple d'alimentation qui incorporait des renseignements tirés de la documentation, les résultats de dénombrements et des observations d'oiseaux que nous avions faits et de données sur la distribution du poisson qui sert de proie, tirées d'études antérieures. Ce modèle nous a permis de classer l'impact potentiel de chaque espèce aviaire sur les populations de quinnat juvénile.

Le grand bec-scie (*Mergus merganser*, 55%) et le martin-pêcheur d'Amérique (*Ceryle alcyon* 13%) formaient la majorité des oiseaux observés sur la Nechako. Nous avons aussi observé les espèces suivantes: le goéland cendré (*Larus canus*), la grifette noire (*Chilidonias niger*), le balbuzard (*Pandion haliaetus*), le grèbe jougris (*Podiceps grisegena*), le huart à collier (*Gavia immer*), le grand héron (*Ardea herodias*), et le pygargue à tête blanche (*Haliaeetus leucocephalus*). Nous avons estimé que le grand bec-scie et le martin-pêcheur d'Amérique seralent à l'origine de la majeure partie des quinnats consommés par les oiseaux (91% et 8%, respectivement). Le grand bec-scie est l'espèce qui présentair le plus grand potentiel pour se nourrir des alevins de quinnat en mai-juin alors que les couvées se nourrissaient activement, à proximité des rives où l'eau est peu profonde et où les alevins de quinnat sont les plus abondants. Cet oiseau aurait pu consommer environ 40% de tous les alevins qui auralent émergé dans la rivière Nechako en 1991.

INTRODUCTION

With respect to the Kemano Completion Project, an agreement was reached between the federal government, the provincial government and Alcan Aluminium Ltd. on September 14, 1987. Terms of the agreement included a commitment by the Department of Fisheries and Oceans (DFO), on behalf of the federal government, to conduct applied research projects on specific areas of concern. One area of concern was the potential impact of reduced flows and altered temperatures on predation of juvenile chinook salmon (*Oncorhynchus tshawytscha*) in the Nechako River. This study was carried out in partial fulfilment of DFO's commitment to that applied research program and specifically examines the potential of various bird species to consume juvenile chinook salmon. An excellent description of the Kemano Completion Project and of the Nechako River is given by Mundie and Bell-Irving (1986).

This report summarizes data collected on piscivorous birds during 1991 for the Nechako and Stuart rivers, and reviews relevant literature on the bird species observed (Appendix I). Information collected during this study was incorporated into a simple feeding model which ranks the potential impact of each bird species on the juvenile chinook salmon population prior to alteration of the Nechako River's hydrologic regime by the Kemano Completion Project.

Various sources of information were used to assess each bird species ability to meet the criteria necessary to be considered a significant predator of juvenile chinook salmon in the Nechako River. The main emphasis of field data collection was to establish the abundance, distribution and residence of the potential bird predators of juvenile chinook salmon. Literature sources provided information on bird feeding behaviour, ration requirements, and prey size selection (Appendix I). A companion study on juvenile chinook distribution and abundance (Brown et al. 1994) provided information on juvenile chinook salmon availability. A bird species was considered to be a potentially significant predator of juvenile chinook salmon only if:

1) the bird species was relatively abundant,
2) individual birds were of a large enough size to catch and consume fish,
3) a high percentage of bird diet was fish,
4) it ate fish within a size range that included juvenile chinook salmon,
5) it fed in habitat occupied by juvenile chinook salmon.

JUVENILE CHINOOK AVAILABILITY

The availability of juvenile chinook to feeding birds was a major consideration during development of the feeding model. Relative abundance of juvenile chinook along the margins of the Nechako River was highly variable, being dependent upon time of day (day or night), section of river, and season (Brown et al. 1994). Birds are visual predators and fish utilizing shallow water along the margins of the river during the day would be most vulnerable to bird predation. In May-June for a short 30 to 40 day period within the Upper Nechako (above Fort Fraser), Lower Nechako (Fort Fraser to confluence of Stuart River), and Stuart River; juvenile chinook respectively represented 14%, 34% and 20% of the fish present along the margins of the rivers during the day (Brown et al. 1994). Later in the season juvenile chinook represented less than 1% of the fish present (Brown et al. 1994). From May to October 1991, juvenile chinook represented 11% of the river margin fish community (Brown et al. 1994). These results are consistent with earlier findings (Lister et al. 1981; Nechako River Project 1987; Russell et al. 1983) that as the season progressed the number of chinook found along the river margins declined dramatically because juvenile chinook emigrated downstream or occupied positions progressively further from shore. In 1991 juvenile chinook averaged 1.0 g (46 mm) in late May and 8.0 g (90 mm) in September (Brown et al. 1994). Thus, birds feeding along the river margins

in spring (May-June) would encounter a high proportion of small chinook fry, whereas birds feeding along the river margins later in the year (July-October) would rarely encounter the larger chinook juveniles.

METHODS

Counts and observations of larger birds on the Nechako and Stuart rivers were made by two persons in an inflatable kayak while slowly drifting downstream. Special emphasis was placed on identifying and counting piscivorous birds likely to be present within the study area (Bruce 1991). Four drifts of the Nechako and Stuart rivers covered a total distance of 980 km (Figure 1). Drifts were initiated on the Nechako River at Cheslatta Falls and ended at the confluence of the Stuart River, 190 km down-river. Drifts on the Stuart River were initiated approximately 10 km below Stuart Lake and ended at Sturgeon Point 55 km downstream. Where the rivers branched into more than one channel, only the main channel was followed, however the channels on either side of small islands were examined. The majority of the total channel length of the Nechako River (> 95% including side-channels) was covered during each drift.

The four drifts were made from May 9, 1991 to October 11, 1991 (Table 1) during daylight and a total of 257 hours of observations by a two person team was completed. Level of river discharge (Figure 2) influenced the speed of the drifting kayak and occasional stops along the river margin for ancillary data collection (i.e., behaviourial observations and examination of minor channels) increased the duration of the drifts. Field notes were entered into a computer database. Recorded information included; date, time, species, count, and location. Sex, age, and notes on feeding behaviour were also recorded where appropriate and location and status of bald eagle and osprey nests were noted (Table 2). The locations of each bird or nest on the two rivers were estimated to within 100 m from laminated maps. Hand held binoculars were used to observe birds from a distance and Peterson (1974) was used as a field guide to species identification.

Common mergansers with flightless broods fled downstream in advance of the kayak and were herded for considerable distances, creating confusion and uncertainty in counts. We attempted to reduce duplication of brood counts when broods fled downstream by not recording a brood of a similar size if it were sighted within the next 5 km.

Two methods of estimating the total number of chinook salmon fry which emerged in 1991 could be employed. The first method uses the 1990 spawning escapement and sex ratio of recovered carcasses as well as assumed fecundity and egg to fry survival rates. In 1990, the Nechako River above the Stuart River confluence supported an estimated 1519 female chinook salmon (escapement of 2642 chinook salmon of which 57.5% were females; unpublished data from Fisheries and Oceans). If we assume a fecundity rate of 5000 eggs/female and an egg to fry survival rate of 30% (Groot and Margolis 1991), then an initial population of 2,278,500 chinook fry would have been present within the Nechako River during 1991. The second method of estimating the total number of chinook fry is more direct and relies on a May estimate of fry abundance along the margins of the Nechako River. In mid-May 1991, chinook fry estimates of 5 fry/m of Nechako River margin were recorded (Brown et al. 1994) and we assumed this would represent a reasonable estimate of chinook fry density for the entire river during early May. The 190 km of Nechako River has 380,000 m of river margin and would therefore contain 1,900,000 chinook fry. The two methods yield similar estimates of total chinook fry emergence for the Nechako River, however both methods required assumptions to be made. A 1991 population of 2,000,000 chinook fry was used in later calculations and is a compromise between these two estimates.

A simple feeding model was used to estimate consumption of juvenile chinook salmon by piscivorous birds (Table 5). The estimation of total number of bird days (TBD) for each bird species was the product of the number of days between each census and the average number of birds sighted for those census. TBD for each census period was summed to obtain seasonal totals. In estimating TBD, only Nechako River bird counts were used. Migrating common mergansers (when identified) were excluded from the TBD calculation.

Percentage of fish in the diet of each bird species (%Fish in Table 5) was obtained from the literature (Appendix I). Estimation of the percentage of fish which would be represented by juvenile chinook salmon (%Chin in Table 5) required integrating information on bird feeding behaviour from the literature, information obtained from Brown et al. (1994) on relative chinook abundance in various habitats during different seasons, and our observations on bird distribution and feeding behaviour. We assumed that birds would select chinook juveniles in proportion to their numerical abundance. Brown et al. (1994) found juvenile chinook size distribution to be similar to that of the total fish assemblage and concluded that size selectivity for or against chinook juveniles was unlikely. Average daily ration per bird (Ration in Table 5) was obtained from the literature or estimated from the average bird weight for that species when no information on ration was available (Appendix I).

RESULTS

1. Common Merganser (*Mergus merganser*)

Common mergansers were the most abundant piscivorous bird species (Table 3, Figure 3) accounting for 55% of counts on the Nechako River and 68% of those on the Stuart River. May counts were the highest due in part to, two large flocks of migrating mergansers noted on the Stuart River, one of the flocks contained 136 birds and the other flock numbered 69 birds. Merganser counts were lowest in August when females with broods were flightless, secretive and actively avoided the drifting kayak. High water levels between the July count and the August count (Figure 2) may have reduced the numbers of mergansers residing on the Nechako River above the Stuart River confluence.

Migrating common merganser added slightly to counts made on the Nechako River. One concentration of 62 common mergansers (30 birds at 31.9 km and 32 birds at 32.8 km below Cheslatta Falls) was noted on the Nechako River and this was in October 1991. In autumn it was difficult to identify which birds were resident and which were migrants. No large flocks were sighted and the sex of the mergansers in autumn is difficult to distinguish. During the two previous drifts June-July and August, 35 and 37 birds respectively were sighted at the same location. Thus, for estimating TBD for the feeding model, we have deducted 30 birds from our October common merganser census on the Nechako River.

We estimated that on the Upper Nechako River (above Fort Fraser), common mergansers (adults and young) accounted for 5,430 total bird days in spring (May-June), when chinook fry were most abundant along the river margins (Brown et al. 1994) and 12,057 total bird days through the remainder of the year. On the Lower Nechako River (below Fort Fraser), common mergansers accounted for 4625 total bird days in spring and 12,472 through the remainder of the year.

On the Stuart River, 8,954 total bird days were attributed to common mergansers. This figure is likely a gross over-estimate of total bird days for common mergansers on the Stuart River because counts included large numbers of spring and fall migrants that reside on the river for only a few days. This argument is supported by the large size of the flocks in spring

and the lack of resident merganser broods in summer (only 1 sighted). This indicates the birds sighted were not nesting on the river.

The ratio of female mergansers to male mergansers changed dramatically during the summer. In May slightly more male mergansers were sighted than females (Figure 4c). The ratio of female to male mergansers in the Nechako River was 1:1.3 while in the Stuart River the ratio was 1:2.5. The high relative number of males in the Stuart River is an indication that the large flocks of birds noted in May were predominantly migrating males. Males have been reported to leave the nesting areas while adult females are rearing broods (Bellrose 1978; Wood 1985; Erskine 1971). In July the ratio of females to males was 9.8:1 as the females remained on the two rivers after the males had left. Plumage of males and females is similar in late summer (Erskine 1971) and sex of the adult mergansers was indistinguishable at that time.

Common mergansers were unevenly distributed on the Nechako River (Figure 4a) and Stuart River during periods of migration. In spring and autumn more adult mergansers utilized the Nechako River above Vanderhoof than below it. In May the Nechako River above Vanderhoof yielded 1.0 adults/km of river, while below Vanderhoof 0.5 adults/km were counted. In October 1.6 adults/km were recorded above Vanderhoof, while 0.3 adults/km were counted below Vanderhoof. The river below Vanderhoof is wider, deeper, slower and more turbid than the river above Vanderhoof. The Stuart River had the highest densities of migrating common mergansers in May (4.3 adults/km of river) but, densities were lower in October (0.6 adults/km of river).

The number and distribution of merganser broods on the Nechako River changed from July to August 1991 (Figure 4b). A period of high water occurred during late July and August (Figure 2) when water was released from the Skins Lake Spillway to lower water temperature in the Nechako River for Stuart River sockeye salmon (*Oncorhynchus nerka*) migrating through the Nechako. In early July 1991, twenty broods were counted on the Nechako River, or 1 brood/9.5 km, (1 brood for every 8 km above Fort Fraser, and above Vanderhoof, and 1 brood for every 23 km below Vanderhoof). This result is comparable to a count of 18 common merganser broods in July 1982 (Envirocon 1984). In August 10 broods were recorded on the Nechako River. One brood was sighted below Vanderhoof and 6 of the 10 broods were located in the upper 35 km of the Nechako River. Brood size was similar during the two periods (8.2 young/brood in May, and 7.7 young/brood in August). Thus, during the period of high water, the total number of broods was reduced by half while the concentration of broods in the upper reaches of the Nechako River increased. Only 1 brood was sighted on the 55 km of the Stuart River.

Densities of 1 brood/9.5 km for the Nechako River and 1 brood/55 km for the Stuart River are lower than values reported in the literature (Foreman 1972; Munro and Clemens 1937; Wood 1985). It is likely that our counts of broods are underestimations of actual densities due to problems associated with merganser census on large rivers (see methods) and our count of broods must be considered a minimum number.

Group endeavours by common mergansers foraging along the shallow river margins was a behaviourial pattern we observed (Table 4) and was also well documented in the literature (Appendix I). The rushing behaviour by brood members appeared to be synchronized and took place in water less than 30 cm deep and within 4 m of shore. Sightings of solitary mergansers were rare. We observed solitary individuals foraging in deeper water on two occasions in October.

The diet of common mergansers feeding on the Nechako River was not examined in this study. It is suspected that during spring (May-June) mergansers (especially the young) have the potential to consume large

quantities of small (45 to 50 mm, approximately 1.0 g) chinook fry, as the mergansers foraged in shallow margin habitat occupied by chinook fry (Brown et al. 1994). Mergansers continued to forage predominately along the river margins later in the season (July-October) when larger chinook juveniles (50 to 90 mm, approximately 4.0 g), occupied deeper water and would have been less available. The mean fork-length and shape of the fork-length distribution of juvenile chinook salmon in spring was similar to that of the entire fish community occupying the river margins (Brown et al. 1994). Thus, juvenile chinook salmon would not be preferentially selected for or against on the basis of size.

2. **Belted Kingfisher** (*Ceryle alcyon*)

On the Nechako River, the number of belted kingfishers remained relatively constant from May to October (Figure 5a). They were distributed relatively evenly from Cheslatta Falls to the confluence of the Stuart River (Figure 6a). Belted kingfishers are territorial (White 1953) and the uniform distribution would be a reflection of this behaviour. Belted kingfishers represented 13% of the piscivorous birds sighted on the Nechako River and 14% sighted on the Stuart River (Figure 3).

The density of belted kingfishers on the Nechako and Stuart rivers is well below that noted in the literature (Alexander 1979; Elson 1962; White 1953). In July a density of 0.35 adults/km for the Nechako River and a density of 0.30 adults/km for the Stuart River was estimated based on direct sightings only. Our density estimates should be considered minimum values. It is likely that our counts of belted kingfishers are lower than the actual numbers utilizing the rivers, as some birds are missed during a census.

Adult belted kingfishers represented 9831 total bird days however, young birds in the nest must be considered. Belted kingfishers fledge between 2 to 7 young/year (assumed average of 4 young/year) and rear them over a 30 to 35 day period (Campbell et al. 1990). If we assume that each adult belted kingfisher sighted in July, represented a nest, then we can estimate a total of 9380 days of rearing (4 young * 67 adults in July * 35 days). Thus, belted kingfishers on the Nechako River represented 19,211 total bird days.

Belted kingfishers were observed hovering and diving for fish throughout the summer on the Nechako River (Table 4). Fish captured were of a size and shape comparable to juvenile chinook salmon however, the species of prey could not be confirmed. Unlike the common mergansers, belted kingfishers were noted fishing in deeper water, well removed from the river margins. It is questionable if kingfishers would remove many chinook from the river margins in spring (April-June) as chinook at that time are smaller (40-50 mm) than the preferred prey size indicated in the literature.

3. **Black Tern** (*Chlidonias niger*)

The duration of residence and the distribution of black terns was very limited. Black terns were never very numerous and were seen only on the Nechako River (Table 3). The count of black terns on the Nechako River peaked in July at 66 (Figure 5b) and during the remainder of the year 11 more sightings were recorded. Black terns utilized the Nechako River from 115 km to 180 km below Cheslatta Falls (Figure 6b) and were most abundant below Vanderhoof. This section of the river is predominately wide, deep, slow flowing, and river margins were often covered with marsh vegetation.

We observed black terns making shallow dips to the water surface and on three occasions they successfully captured small fish of between 5 to 7 cm in length (Table 4). The species of fish prey could not be ascertained however, juvenile salmon would be within that size range during July.

4. **Osprey** (*Pandion haliaetus*)

Osprey were sighted during all four drifts however, the majority of sightings were made during July and August (Figure 5b), when they were raising their young. Osprey were sighted throughout the entire length of the Nechako River (Figure 5b) with the majority of the sightings (30/52) below Vanderhoof. One active osprey nest was recorded 6 km below the bridge over the Nechako River at Vanderhoof (Figure 1). On the Stuart River, 5 osprey were sighted during the four drifts (3 in July and 2 in Aug/91), and we suspected an active osprey nest was located approximately 28 km below Stuart Lake (Table 2).

The two fish captured by osprey during this study (Table 4) were large (17 to 25 cm), but unidentifiable. It is unlikely that salmon juveniles (less than 10 cm in length) would be preyed upon by osprey.

5. **Gulls** (*Larus sp.*)

Mew gulls represented 7.9% of the piscivorous birds sighted on the Nechako River and 2.7% on the Stuart River (Table 3; Figure 3). The number of mew gulls counted on the Nechako and Stuart rivers (Figure 5b) peaked in July at 52, declined to 7 in August, and increased to 54 in October. The highest concentrations of mew gulls (Figure 6c) were at Fort Fraser (80 to 90 km below Cheslatta Falls) and at Vanderhoof (140 to 150 km below Cheslatta Falls). Seventy percent of the mew gulls sighted were within 10 km of these two towns.

Mew gulls were never observed actively fishing on the river, but they were often observed flying 20 to 30 m above it. In October the gulls were observed feeding on adult chinook carcasses (Table 4). The concentration of mew gulls near human habitation for most of the year suggests the gulls were relying on terrestrial food sources rather than those found in the river (Appendix I).

6. **Red-Necked Grebe** (*Podiceps grisegena*)

Sightings of red-necked grebes on the Nechako and Stuart rivers were rare (Table 3). The highest count of red-necked grebes was in August (7 sighted), and a total of 11 grebes on the Nechako River and 3 grebes on the Stuart River were sighted on the four drifts. All sightings were made at the widest locations on the two rivers (Figure 7a).

In October one red-necked grebe was noted diving and feeding on the Stuart River however, food items were unidentifiable (Table 4). Their feeding habits as reported in the literature (Appendix I) combined with their low numbers suggest its unlikely that red-necked grebes consumed more than an occasional chinook juvenile.

7. **Common Loon** (*Gavia immer*)

A total of 10 common loons were sighted on the Nechako and Stuart rivers during the course of this study. Eight were sighted on the Nechako River in May and July of 1991 (Table 3). Common loons had a distribution similar to that of red-necked grebes (Figure 7a). They also occupied the widest, slowest sections of the two rivers.

Species of fish prey consumed on the Nechako River by common loons could not be verified. It is unlikely loons would consume many chinook juveniles, as the loons were few in number and foraged in deeper water while chinook fry were inhabiting the river margins.

4. **Great Blue Heron** (*Ardea herodias*)

Eight great blue herons were sighted on the Nechako River in August and two were sighted in October. The birds were distributed from 65 to 165 km below Cheslatta Falls (Figure 7c). Although great blue herons were seen wading along the margins of the river, no prey items were ever observed being eaten. The low numbers of great blue heron sighted on the Nechako River, location of fishing (river margins), and time of year when present (after July when chinook juveniles had vacated the river margins) makes it unlikely that they consumed many juvenile salmon.

5. **Bald Eagle** (*Haliaeetus leucocephalus*)

Bald eagles were usually very visible, often seen soaring high above the river. Counts made over a ten day period are doomed to continuously recount the same birds as they can easily cover a greater distance than can be drifted in an inflatable boat in one day. The highest count of bald eagles on the Nechako River was in July, when 57 were sighted (Table 3). A total of 14 eagle nests were seen along the banks of the Nechako River (Table 2). Our counts were lower than counts made in July 1982, when 103 eagles and 23 nests were sighted on the Nechako River above the Stuart River Confluence (Envirocon, 1984).

DISCUSSION

The common merganser was the only piscivorous bird with the potential to consume significant numbers of juvenile chinook salmon in the Nechako River (Table 5,6) under the current water discharge regime. Concentrated feeding activity by common merganser broods along the margins of the Nechako River in spring when chinook fry are small, but abundant, was considered to be the single greatest threat to juvenile chinook by avian predators. Common mergansers were relatively abundant, predominately piscivorous, fed in habitat occupied by juvenile chinook, and consumed fish of a size similar to juvenile chinook salmon. This finding is consistent with those of researchers studying salmonid predation on other rivers (White 1957; Erskine 1972; Elson 1962; Wood 1986).

Based on a simple model of bird feeding (Table 5,6) we estimated that common mergansers consumed 91% (88% May-June, 3% July-Oct) of the juvenile chinook taken by birds during 1991. Common mergansers had the potential to consume 40% of the estimated juvenile chinook salmon present in the Nechako River during 1991, (797,000 fry consumed/2,000,000 fry total; Table 6).

It is conceivable that common mergansers may not have selected the smaller (<2 g) chinook in relative proportion to their numbers. Although, juvenile chinook had a mean size and size distribution similar to that of the fish community occupying the river margins, mergansers may have selected the few juvenile northern squawfish (*Ptychocheilus oregonensis*), juvenile common suckers (*Catostomus commersoni*), juvenile mountain whitefish (*Prosopium williamsoni*), and redside shiners (*Richardsonius balteatus*) that also occupied the river margins and were larger than the juvenile chinook salmon Brown et al. 1994). Thus, our estimate of May-June juvenile chinook consumption by common mergansers (Table 5,6) could be high. An accurate assessment of common merganser diets for the Nechako River during May-June when fry are small and abundant along the river margins as well as later in the year when the larger chinook juveniles occupy deeper water is required to produce a more accurate estimate of total consumption of chinook fry by common mergansers.

We viewed the belted kingfisher to be less of a threat to the juvenile chinook population than the common merganser. Belted kingfishers were relatively abundant, are predominately piscivorous, fed in habitat occupied

by juvenile chinook and did consume fish of a size similar to juvenile chinook. However, belted kingfishers were less abundant than common mergansers, were smaller in size and required a lower daily ration, tended to select fish slightly larger than juvenile chinook, and were noted to feed further from shore where the ratio of chinook to other fish species would be lower. In 1991 we estimated that belted kingfishers had the potential to consume 8% of the chinook juveniles eaten by piscivorous birds and 3% (67,400 fry consumed/2,000,000 fry total) of the estimated juvenile chinook salmon present in the Nechako River (Table 5,6). Although kingfishers took less juvenile chinook than common mergansers, they would likely have consumed the larger chinook juveniles later in the season (assumption based on their size preference) and this may constitute one of the factors operating unfavourably on chinook production. An accurate assessment of belted kingfisher diets for the Nechako River is required to produce a more accurate estimate of total consumption of chinook fry by kingfishers.

In 1991, the other piscivorous birds were not considered a threat to the chinook population of the Nechako River. They were either small, few in number, consumed only a small portion of their diet as fish, did not feed in areas where juvenile chinook were high in numbers, or selected fish much larger than juvenile chinook. All other avian predators combined consumed less than 1% of the juvenile chinook salmon taken by birds in the Nechako River (Table 5,6) and less than 1% (10,034 fry consumed/2,000,000 fry total; Table 6) of the estimated, juvenile chinook salmon present in the Nechako River.

It is possible our estimates of chinook consumption by birds has been underestimated. Common merganser and belted kingfisher densities recorded on the Nechako River were lower than those reported in the literature. The total number of bird days for each bird species used in the model to calculate consumption were minimum values as they were based on the actual number of birds counted rather than on estimated numbers. In the future, more surveys during the year combined with individual brood identification of common mergansers (Wood, 1984) would help in estimating common merganser abundance. Detailed surveys within reference sections of river would enable us to calibrate our drift counts with more accurate estimates of kingfisher abundance.

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REFERENCES

Alexander, G. R. 1979. Predators of fish in coldwater streams. Pages 153-170. *In* R. H. Stroud and H. Clepper (ed.) Predator-prey systems in fisheries management. Sport Fishing Institute. Washington. D.C. 504p.

Bellrose, F.C. 1978. Ducks, geese and swans of North America. 2nd ed. Stackpole Books, Harrisburg, PA.

Brown, T.G., E. White, D. Kelly, L. Rzen, and J. Rutten. 1994. Availability of juvenile chinook salmon to predators along the margins of the Nechako and Stuart rivers, B.C. Can. MS. Rep. Fish. Aquat. Sci. 2245: 43p.

Bruce, J.A. 1991. Review of literature on competitive and predator-prey interactions with juvenile salmonids in the context of reduced stream flows. Report to Department of Fisheries and Oceans, West Vancouver, B.C. 60p + app.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, H.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990. The Birds of British Columbia: Volume II. The Royal British Columbia Museum, Victoria, British Columbia. 636p.

Farreker, R.G. 1985. Habitat suitability index models:least tern. U.S. Fish and Wildlife Service, Fort Collins, Co. Biological Report 82(10.103). 29p.

Hunt, E.H. 1979. Nesting biology and development of young in Ontario black terns. Canadian Field-Naturalist 93(3): 276-281.

Lacroix, P.F. 1962. Predator-prey relationships between fish-eating birds and Atlantic salmon. Bull. Fish. Res. Board Can. 133. 87p.

Marmocon Ltd. 1984. Pages 158-164 (Tables 3.8,3.10,3.13) *in* Wildlife Resources of the Nechako River system - Baseline Information. Aluminum Company of Canada, Ltd. Kemano Completion Hydroelectric Development. Environmental Studies. Vol 10/Section B.

Mattsson, M.O.G. 1986. Fish delivery, production of young, and nest density of Osprey (*Pandion haliatus*) in southwest Sweden. Can. J. Zool. 64: 1961-1965.

McKinne, A.J. 1971. Growth and annual cycles in weights, plumages and reproductive organs of goosanders in Eastern Canada. Ibis, 113: 42-58.

McKinne, A. J. 1972. Populations, movements and seasonal distribution of mergansers. Can. Wildl. Serv. Ser. No. 17: 35p.

Mortman, L.D. 1976. Observations of common mergansers broods in Northwestern California. Calif. Fish and Game 62(3): 207-212.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life Histories. UBC Press. Vancouver. 564p.

Godin, J.J. 1977. A great blue heron preying on shiner perch in deep water. Canadian Field-Naturalist 91(3): 88-91.

Haley, D. (editor). 1984. Page 152 *in* Seabirds of eastern North Pacific and Arctic waters. Pacific Search Press, Seattle, Washington. 214p.

Imer, R.S. (editor). 1962. Handbook of North American birds. Vol I. Yale University Press, New Haven. 576p.

Mace, P.M. 1983. Bird predation on juvenile salmonids in the Big Qualicum Estuary, Vancouver Island. Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1176.

Miller, S.W. and J.S. Barclay. 1973. Predation in warm water reservoirs by wintering common mergansers. Proc. Annu. Conf. Southeast. Assoc. State Game Fish Comm. 27: 243-252.

Mudge, G.P. and P.N. Ferns. 1982. The feeding ecology of five species of gulls (Aves: Larini) in the inner Bristol Channel. J. Zool., Lond. 197: 497-510.

Mundie, J.H. and R. Bell-Irving. 1986. Predictability of the consequences of the Kemano Hydroelectric Proposal for natural salmon populations. Canadian Water Resources Journal 11: 14-25.

Munro, J.A. and W.A. Clemens. 1932. Food of the American Merganser, (*Mergus Merganser Americanus*) in British Columbia a preliminary paper. The Canadian Field-Naturalist. Vol XLVI: 166-168.

Munro, J.A. and W.A. Clemens. 1937. The American Merganser in British Columbia and its relation to the fish population. Bul. Biol. Board Canada, No. 55, 50p.

Nechako River Project. 1987. Studies of juvenile chinook salmon in the Nechako River, British Columbia - 1985 and 1986. Can. Ms. Rep. Fish. Aquat. Sci., 1954: vii + 152p.

Nels, H.B. 1981. Familiar birds of the Northwest. Portland Audubon Society. Portland, Oregon. 192p.

Palmer, R.S. (editor). 1962. Handbook of North American birds. Vol. I. Yale University Press, New Haven. 576p.

Peterson, R.T. 1974. A Field Guide to Western Birds. Houghton Mifflin Company, Boston. 309p.

Rad, O. 1980. Breeding distribution and habitat selection of red-breasted mergansers in freshwater in western Norway. Wildfowl, 31: 53-56.

Reimchen. T.E., and S. Douglas. 1980. Observation of loons (*Gavia immer* and *G. stellata*) at a bog lake on the Queen Charlotte Islands. Canadian Field-Naturalist 94(4): 398-404.

Reimchen. T.E., and S. Douglas. 1984. Seasonal and diurnal abundance of aquatic birds on the Drizzle Lake Reserve. Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 98(1): 22-28.

Peterson, A. 1986. Habitat suitability index models: bald eagle (breeding season). U.S. Fish and Wildlife Service, Fort Collins, Co. Biological Report 82(10.126). 25p.

Prose, B.L. 1985. Habitat suitability index models: belted kingfisher. U.S. Fish and Wildlife Service, Fort Collins, Co. Biological Report 82(10.87). 22p.

Short, H.L. 1984. Habitat suitability index models:western grebe. U.S. Fish and Wildlife Service, Fort Collins, Co. Biological Report FWS/OBS-82/10.69. 20p.

Short, H.L. and R.J. Cooper 1984. Habitat suitability index models: great blue heron. U.S. Fish and Wildlife Service, Fort Collins, Co. Biological Report 82(10.99) 23p.

Slayer, J.C. II, and K.F. Langer. 1940. The food and habitats of the American merganser during winter in Michigan, considered in relation to fish management. J. Wildlife Management 4(2): 186-219.

Swenson, J.E. 1978. Prey and foraging behaviour of ospreys on Yellowstone Lake, Wyoming. J. Wildl. Manage. 42(1):87-90.

Timken, C.L. and B.W. Anderson. 1969. Food habits of common mergansers in the northcentral United States. J. Wildl. Manage. 33(1):87-91.

Van Daele, L.J. and H.A. Van Daele. 1982. Factors affecting the productivity of ospreys nesting in West-Central Idaho. Condor 84:292-299.

Vana-Miller, S.L. 1987. Habitat suitability index models: osprey. U.S. Fish and Wildlife Service, Fort Collins, Co. Biological Report 82(10.154) 46p.

White, H.C. 1936. The food of kingfishers and mergansers on the Margaree River, Nova Scotia. J. Biol. Board Can. 2: 299-309.

White, H.C. 1953. The eastern belted kingfisher in the maritime provinces. Bull. Fish. Res. Board Can. 97. 44p.

White, H.C. 1957. Food and natural history of mergansers on salmon waters in the maritime provinces of Canada. Fish. Res. Board Can. Bull. No. 116. 63p.

Wood, C.C. 1984. Foraging behaviour of common mergansers (*Mergus merganser*) and their dispersion in relation to the availability of juvenile pacific salmon. Ph.D. thesis, University of British Columbia, Vancouver, B.C. 307p.

Wood, C.C. 1985. Aggregative response of common mergansers (*Mergus merganser*): predicting flock size and abundance on Vancouver Island salmon streams. Can. J. Fish. Aquat. Sci. 42: 1259-1271.

Wood C.C. 1986. Dispersion of common merganser (*Mergus merganser*) breeding pairs in relation to the availability of juvenile Pacific salmon in Vancouver Island streams. Can. J. Zool. 64: 756-765.

Wood, C.C. 1987. Predation of juvenile Pacific salmon by the common merganser (*Mergus merganser*) on eastern Vancouver Island. II: Predation of stream-resident juvenile salmon by merganser broods. Can. J. Fish. Aquat. Sci. 44: 950-959.

Wood, C.C. and C.M. Hand. 1985. Food-searching behaviour of the common merganser (*Mergus merganser*) I: Functional responses to prey and predator density. Can. J. Zool. 63: 1260-1270.

Table 1. Sampling dates and sampling effort during 1991.

RIVER	SAMPLING PERIOD	DAYS	HOURS
Mechako	May 9 - May 17	9	53.9
Mechako	June 28 - July 6	8	49.7
Mechako	Aug 10 - Aug 17	8	50.9
Mechako	Oct 3 - Oct 13	9	53.0
Stuart	May 23	1	13.1
Stuart	July 3	1	9.5
Stuart	Aug 18	1	13.4
Stuart	Oct 10 - Oct 11	2	13.3

Table 2. Location of bald eagle and osprey nests during 1991.

River	Species	Distance (km)	occupied
Mechako	bald eagle	6.0 below Cheslatta falls	yes
Mechako	bald eagle	18.1	
Mechako	bald eagle	18.4	
Mechako	bald eagle	28.0	
Mechako	bald eagle	67.1	yes
Mechako	bald eagle	73.5	
Mechako	bald eagle	84.5	
Mechako	bald eagle	114.0	
Mechako	bald eagle	119.8	
Mechako	bald eagle	125.5	
Mechako	bald eagle	127.9	
Mechako	bald eagle	146.9	
Mechako	osprey	148.0	yes
Mechako	bald eagle	148.4	
Mechako	bald eagle	153.0	
Mechako	bald eagle	159.0	
Mechako	bald eagle	165.4	yes
Stuart	osprey	28.6 below Stuart lake	yes

Table 3. Bird counts from the Nechako (190 km) and Stuart (55 km) rivers during: May 9-23, Jun 28-Jul 6, Aug 10-18, and Oct 3-13.

Species	Nechako				Stuart			
	May	Jul	Aug	Oct	May	Jul	Aug	Oct
Belted Kingfisher	41	67	48	22	21	16	16	6
Common Loon	2	6	0	0	0	1	1	0
Common Merganser	155	242	94	246	238	3	7	34
Great Blue Heron	0	0	8	2	0	0	0	0
Mew Gull	2	52	6	45	1	0	1	9
Osprey	5	18	27	2	0	3	2	0
Red Necked Grebe	1	0	7	3	0	0	0	3
Black Tern	1	66	8	2	0	0	0	0
Teal sp.	0	0	38	50	7	0	2	24
Mallard	161	27	94	2178	167	8	10	9
Bufflehead	5	0	0	0	10	0	0	1
Goldeneye sp.	29	48	1	0	2	0	0	0
Scoter	5	0	0	0	0	0	0	0
Scaup sp.	25	0	0	0	5	0	0	0
Ring-Necked Duck	2	0	0	0	0	0	0	0
Widgeon	5	0	0	18	0	0	0	0
Unidentified Duck	102	10	29	781	105	0	2	109
Pintail	0	0	2	0	0	0	0	0
Canada Goose	35	8	115	4366	9	0	2	49
Trumpeter Swan	2	0	0	2	3	0	0	0
Greater Yellowlegs	0	27	0	0	3	0	0	0
Lesser Yellowlegs	4	5	0	24	2	0	0	1
Unidentified Hawk	10	0	4	1	4	0	1	0
American Kestrel	1	0	0	0	0	0	0	0
Bald Eagle	20	57	27	56	1	6	22	22

[illegible] 4. Behaviourial observations of piscivorous birds recorded during 1991 on [illegible]ako and Stuart rivers.

Species	Number of Observations	Description
[illegible]erganser	3 Broods 2 Individuals	Three broods (20 to 30 birds each) were observed fishing along river margins (<15 cm depth). In October two solitary adults were observed fishing in deeper water. No fish catches were noted.
[illegible]fisher	4	Observed from May to October, hovering and diving for fish. Two fish were captured (10-15 cm) of which one was a possible salmonid.
[illegible] Tern	5	A total of 19 terns were observed fishing along river margins in May and July. The birds flew approximately 4 meters above the river and made shallow dips to the water surface. Three silvery fish (non-salmonids) were captured (5-7 cm).
[illegible]sprey	4	Numerous Osprey were observed, but only four dives were recorded. Birds dove mid-river and two dives were successful. Fish captured were not identified, but were not chinook as they were too large (17-25 cm).
[illegible] Gull	2	Mew gulls were never observed fishing. In October, birds fed on dead adult salmon.
Grebe	1	Observed diving and feeding in wide, slow and deep section of Stuart River. Catch was unidentifiable.
[illegible] Heron	1	Observed wading and stalking along the river margins. Substrate consisted of cobbles and current was slow. No catch noted.
Loon	1	Observed foraging and diving in wide, slow and deep section of Stuart River.

Table 5. Feeding model to estimate the number of juvenile chinook salmon consumed by piscivorous birds on the Nechako River in 1991. Where; TBD = total number of bird days, %fish = percent fish in diet, %chin = percentage of fish which would be chinook, Ration = estimated average daily ration/bird, WT = total weight of all chinook (TBD * Ration * %fish * %chin), fish = average weight of a chinook, Chinook = number of chinook consumed (Wt/fish).

Species	TBD	%fish	%chin	Ration (g)	Wt (g)	fish (g)	chinook
Merganser Adults Upper (May-June)	3,628	100	14	400	203,140	1.0	203,140
Merganser Young Upper (May-June)	1,802	95	14	200	47,940	1.0	47,940
Merganser Adults Lower (May-June)	3,126	100	34	400	425,136	1.0	425,136
Merganser Young Lower (May-June)	1,499	95	34	200	96,803	1.0	96,803
Merganser Adults Upper (July-Oct)	7,004	100	1	400	28,014	4.0	7,004
Merganser Young Upper (July-Oct)	5,053	95	1	200	9,600	2.0	4,800
Merganser Adults Lower (July-Oct)	10,007	100	1	400	40,028	4.0	10,007
Merganser Young Lower (July-Oct)	2,465	95	1	200	4,684	2.0	2,342
Kingfisher adults	9,831	100	9	156	138,020	4.0	34,505
Kingfisher young	9,380	100	9	156	131,695	4.0	32,924
Common loon	323	80	9	1,400	32,558	4.0	8,140
Black tern	3,333	13	9	30	1,170	2.5	468
Red-necked grebe	500	10	9	350	1575	4.0	394
Great blue heron	478	72	1	1,200	4,130	4.0	1,032
Osprey	2,364		0				0
Bald eagle	6,636		0				0
Mew gull	4,345		0				0
Total							874,6340

[illegible] Estimated percentages of juvenile chinook salmon consumed by [illegible] birds on the Nechako river in 1991.

Bird Grouping	Number of chinook	Percentage of Bird consumption	Percentage of 2,000,000 fry
[illegible] - May to June 30	773,019	88%	39%
[illegible] - July 1 to Oct	24,152	3%	1%
[illegible]	67,429	8%	3%
[illegible]	10,034	1%	1%
Total	874,634		44%

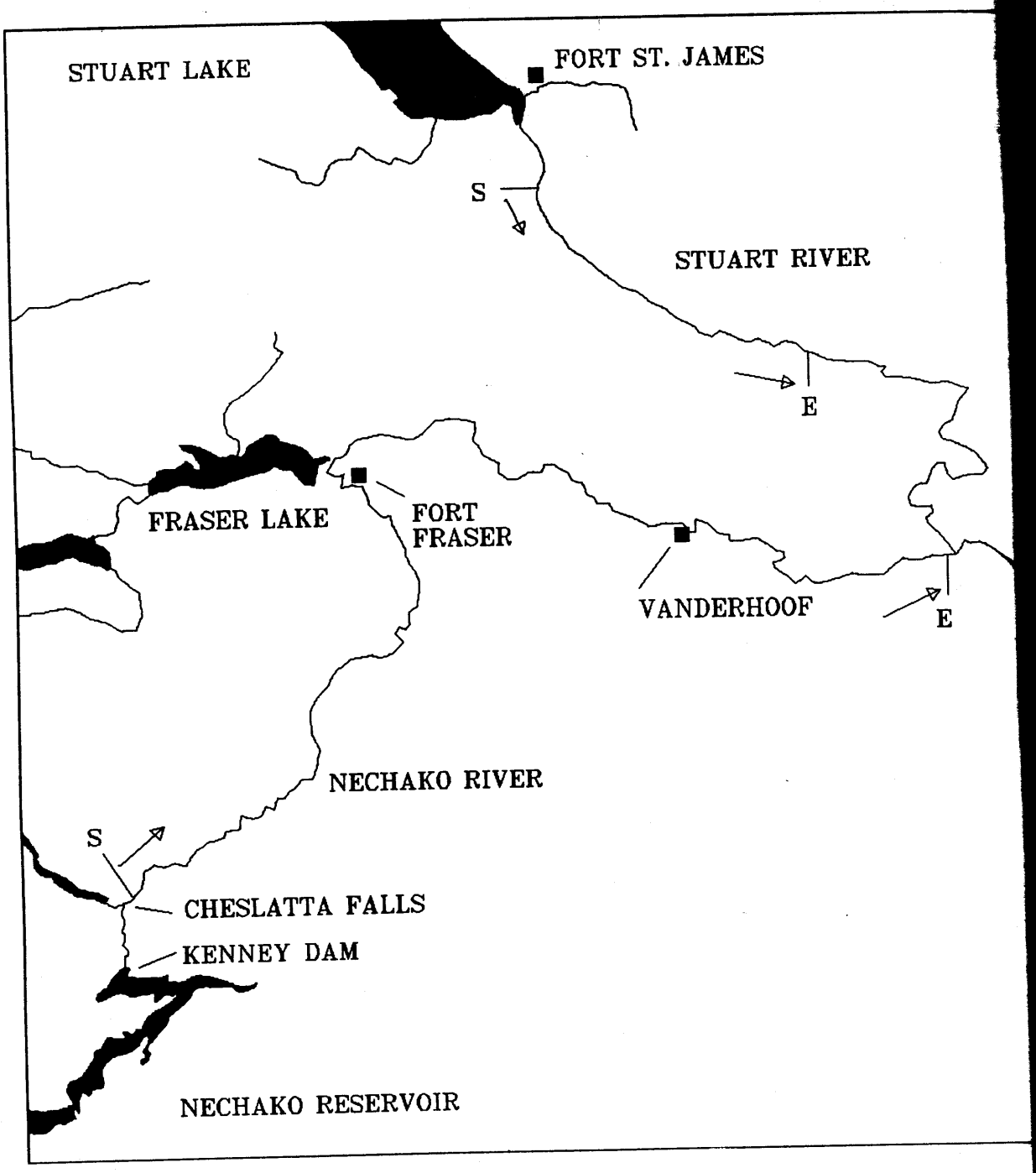


Figure 1. Map of Nechako and Stuart rivers identifying portio of the two rivers in which birds were enumerated.

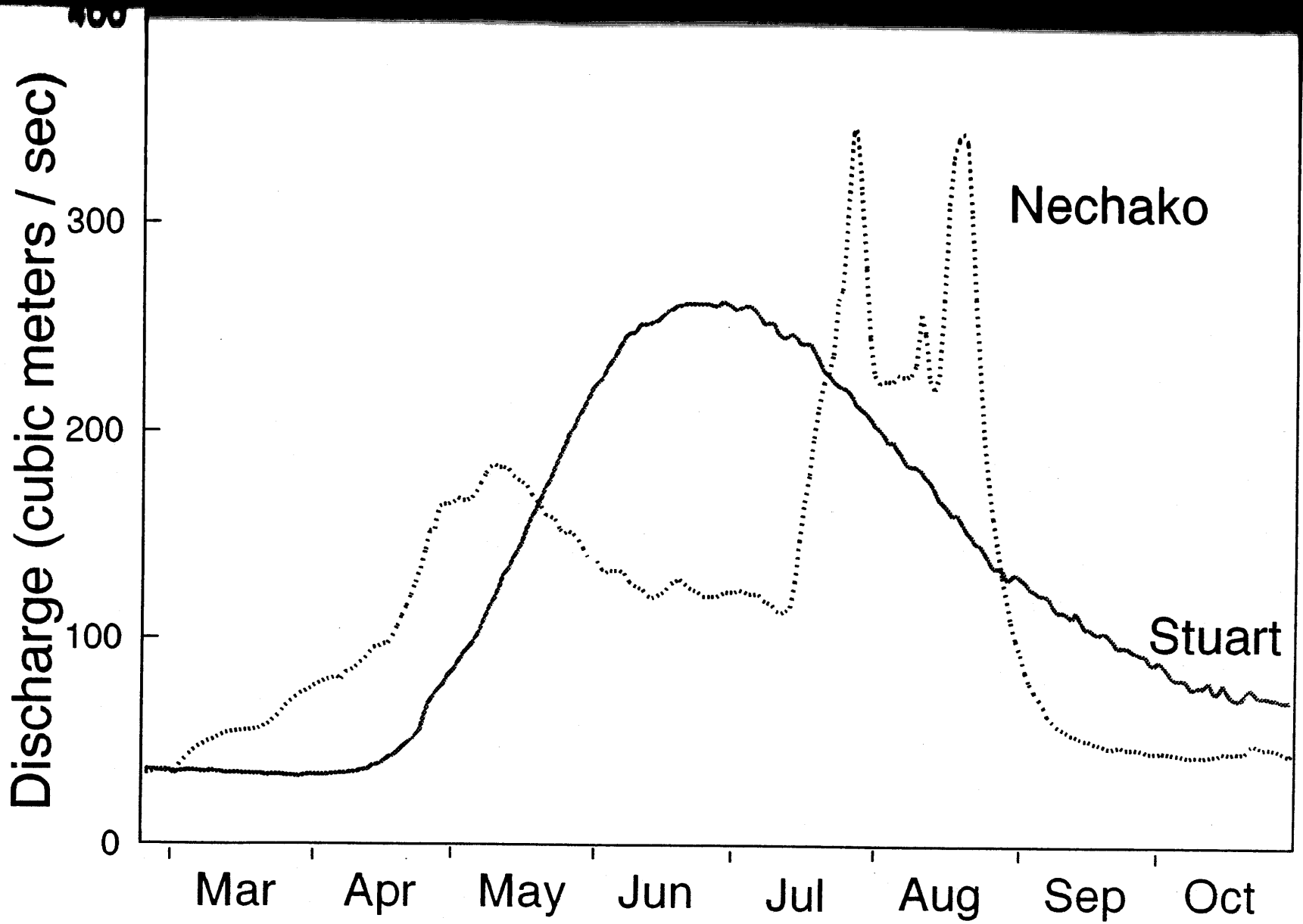


Figure 2. Nechako and Stuart river discharges (m^3/sec) for 1991. Nechako River discharge was recorded at Vanderhoof and Stuart River discharge was recorded below Fort St. James.

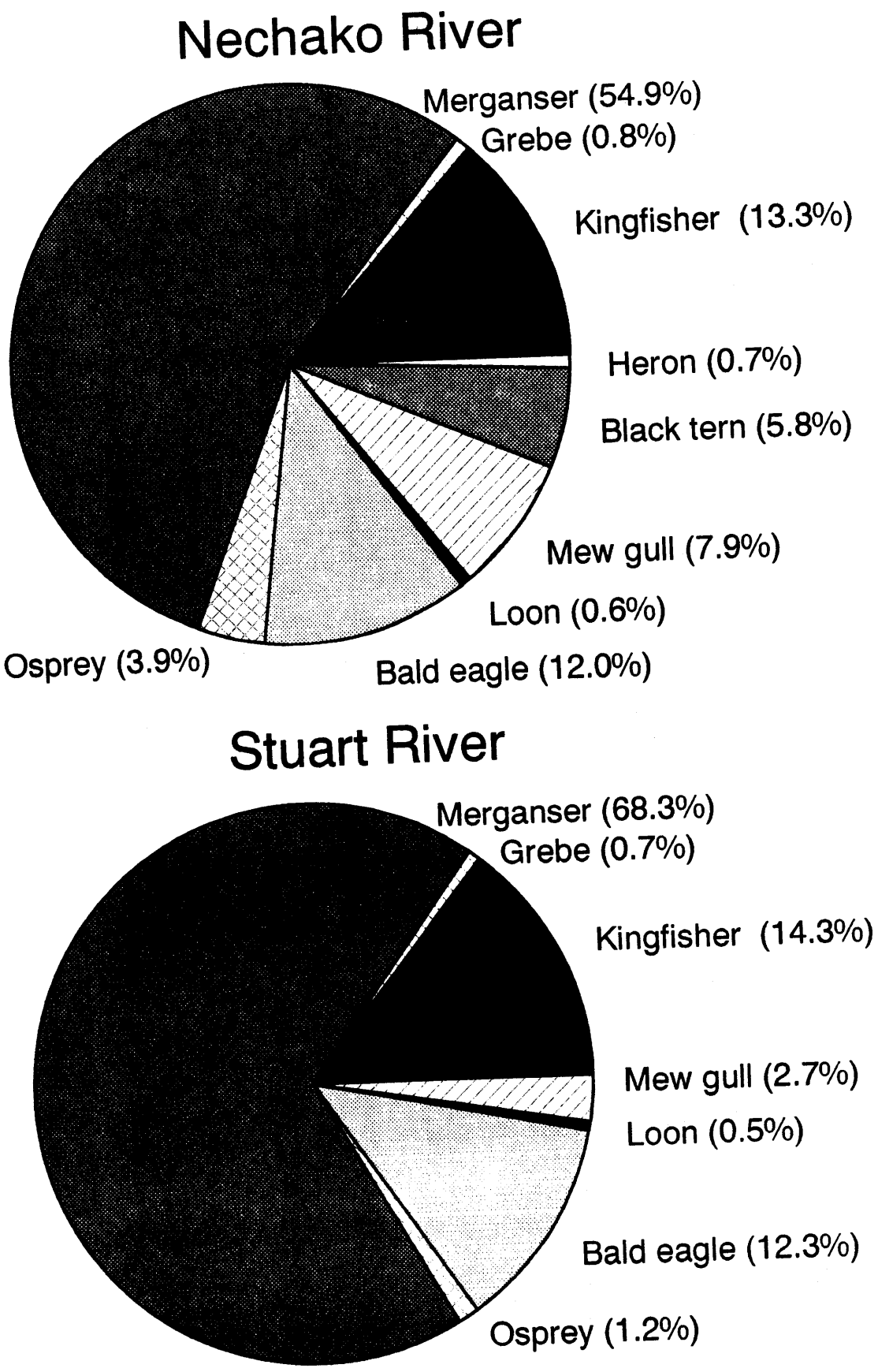
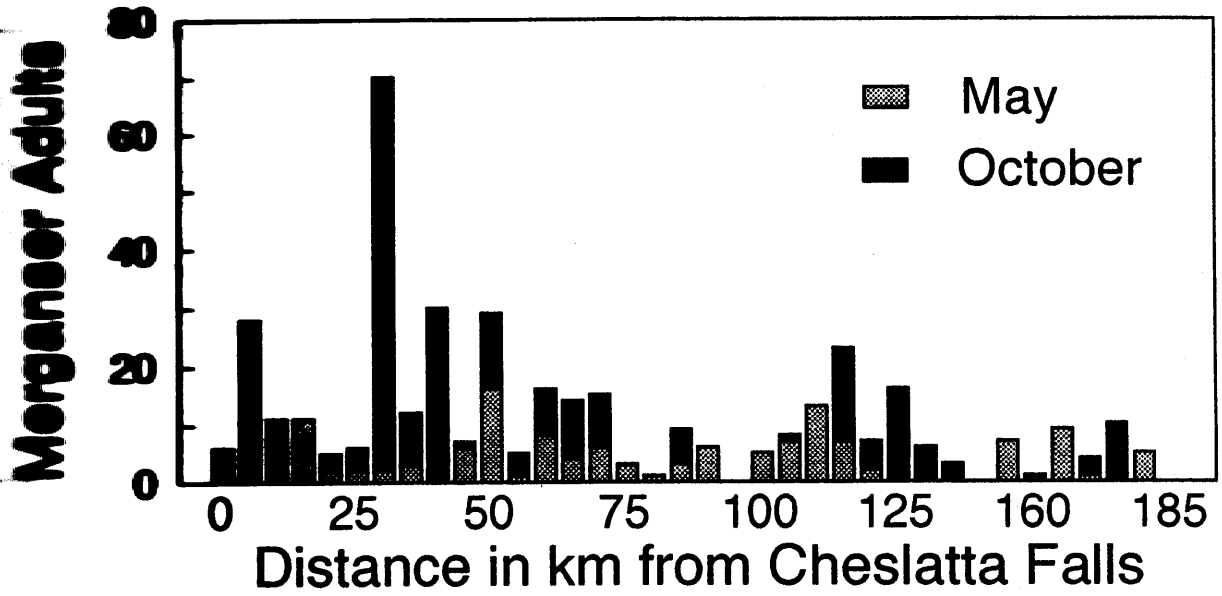
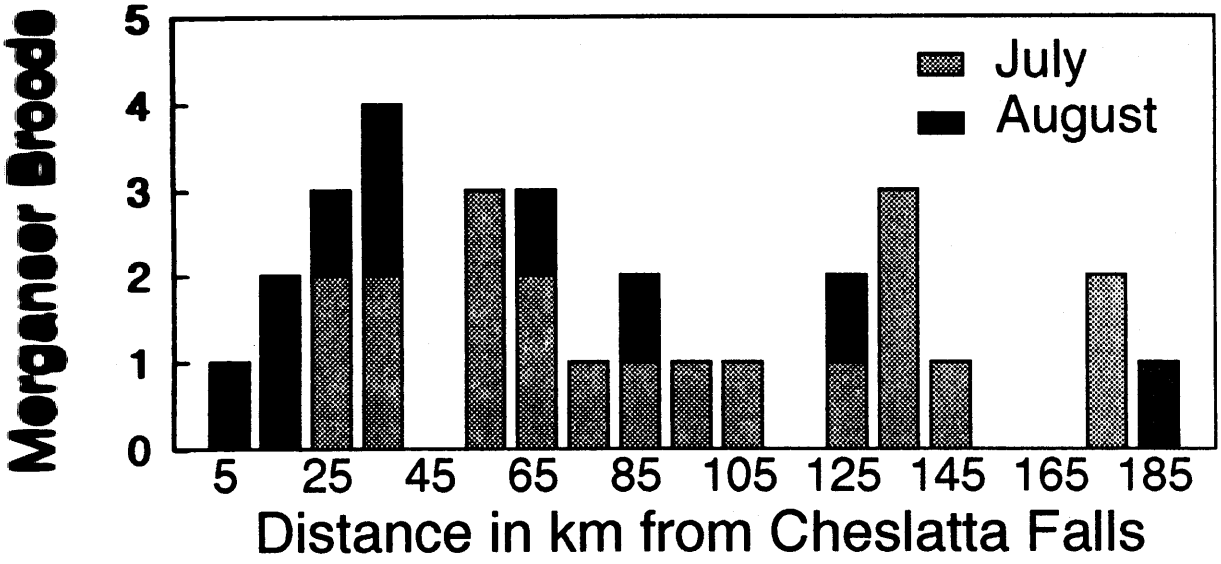


Figure 3. Relative abundance of piscivorous birds on the Nechako and Stuart rivers from May 9 to October 31/91.





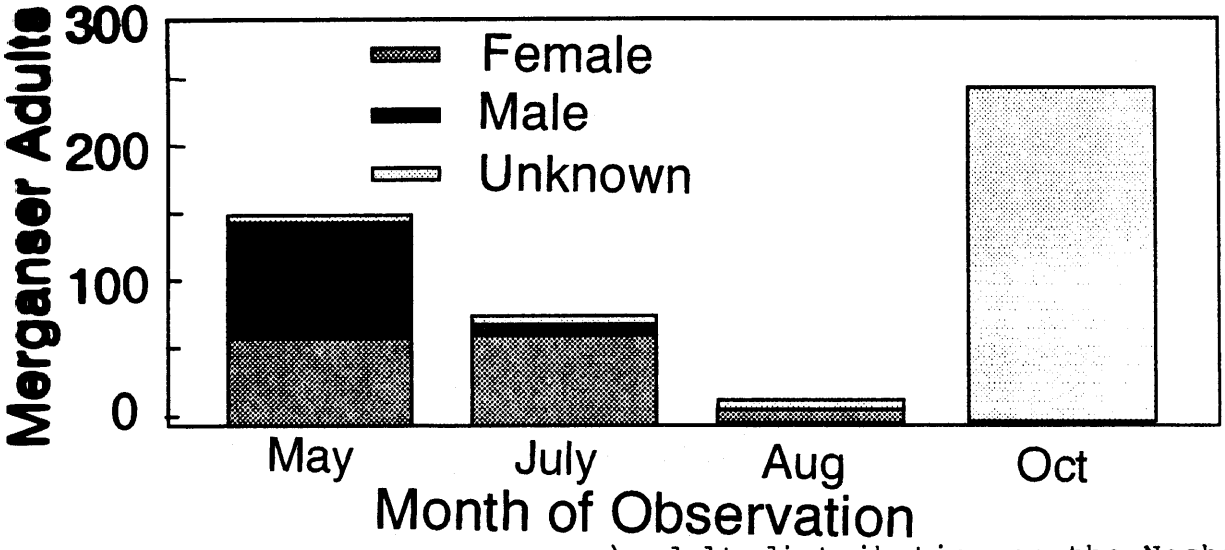


Figure 4. Common mergansers; a) adult distribution on the Nechako River (during migration), b) brood distribution on the Nechako River, and c) merganser sex ratios on the Nechako and Stuart rivers.

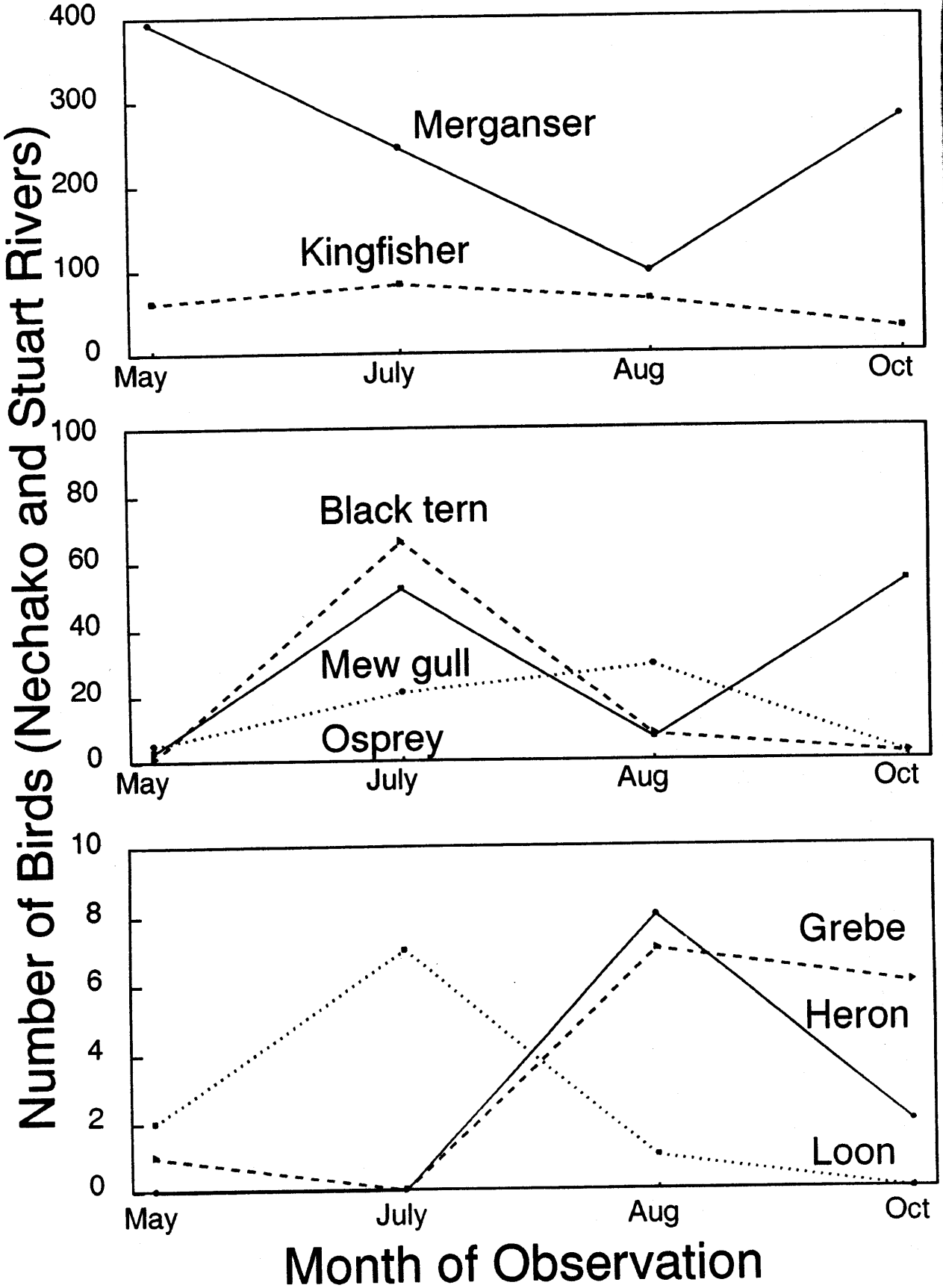


Figure 5. Number of each species of bird counted during 4 sampli periods; a) common merganser and belted kingfisher, b) gull, black tern, and osprey, and c) red-necked grebe, great blue heron, and common loon.

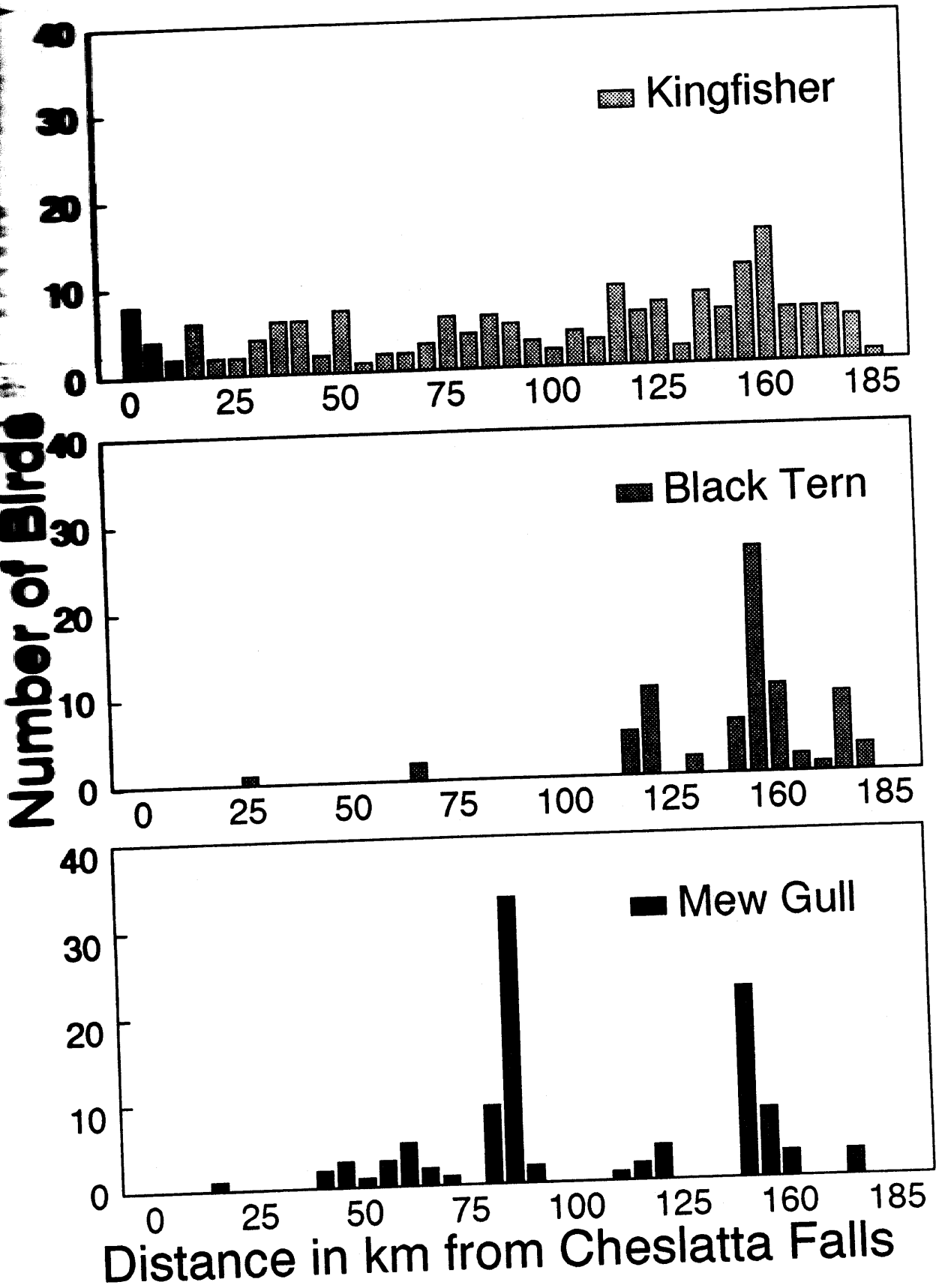


Figure 6. Distribution of birds on the Nechako River; a) belted kingfisher, b) black tern, and c) mew gull.

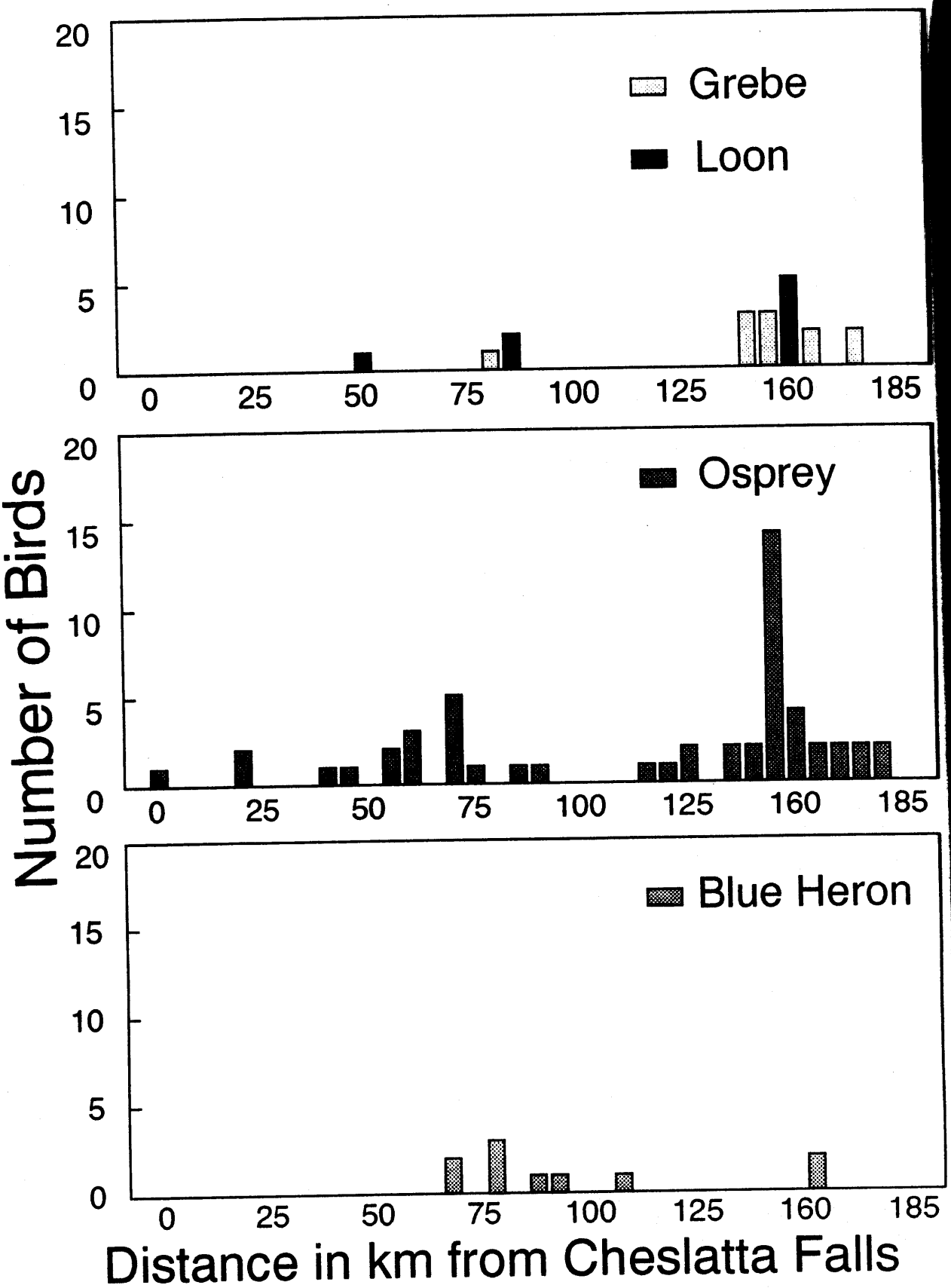


Figure 7. Distribution of birds on the Nechako River; a) red-nec grebe and common loon, b) osprey, and c) great blue heron.

APPENDIX I REVIEW OF LITERATURE

[redacted] mergansers (*Mergus merganser*), because of their abundance, piscivorous [redacted] and possible preference for salmonids were considered to be the greatest [redacted] threat to juvenile chinook salmon in the Nechako river. Common mergansers [redacted] been considered capable of substantially reducing salmonid populations in [redacted]ter such that predator removal programs were initiated on several eastern [redacted] rivers (White 1957; Erskine 1972; Elson 1962). Wood (1986) concluded [redacted] an aggregative response by mergansers could negatively impact wild salmon [redacted] in Vancouver Island rivers where hatchery fish were also released.

[redacted]sities of common mergansers are usually greater than 1 brood/10 km of [redacted]. Foreman (1972) recorded 1 brood/5.6 km in the Klamath and Trinity rivers [redacted] California. Munro and Clemens (1937) found 1 brood/8 km (10 broods in 49 [redacted] in the Cowichan River and 1 brood/4 km (2 broods in 5 miles) in the Tlell [redacted] on Graham Island, British Columbia. A rough recalculation of Wood's (1985) [redacted]ces from 8 Vancouver Island streams (1 km above tidal influence) yielded [redacted]/1.3 km on systems with salmon producing facilities (enhanced systems) and [redacted]/2.1 km on natural systems.

[redacted]on mergansers have the potential of consuming great numbers of juvenile [redacted]ids; 42% of their diet on the Pollett River were juvenile Atlantic salmon [redacted] 1962) and they may have consumed more salmon relative to their abundance [redacted] other fish species. Wood (1987) used a value of 50% of consumption by [redacted] as an estimate of coho fry in the diet of common mergansers on eastern [redacted]ver Island streams and speculated that this was an underestimate. Other [redacted]s have indicated that non-salmonids comprise the majority of a merganser's [redacted] where salmon are less abundant than other prey (87% coarse fish; Timken and [redacted]son 1969). After reviewing studies of merganser diets, Wood (1987) [redacted]cluded that mergansers ate whatever fish was locally most abundant, however [redacted] productive salmonid-rearing waters, juvenile salmonids were usually the [redacted]nant prey species. An adult merganser requires an average daily ration of [redacted] 400 g for growth and maintenance (Wood and Hand 1985), while a juvenile [redacted]red approximately 1/2 of an adult ration (Elson 1962) or 200 g/day.

[redacted]unro and Clemens (1937) recorded the stomach contents of 70 mergansers from [redacted] interior of British Columbia. They found the major identifiable fish prey [redacted]ecies to consist of "coarse fish" which they designated as suckers, chub, [redacted]fish, shiners and sculpins (no latin names were given). They identified [redacted]ansers as mainly a predator feeding upon all species of shallow water rearing [redacted] and stated that there was a correlation between shallow water habitat and [redacted]anser feeding habits. The lack of juvenile chinook in the merganser stomachs [redacted] analyzed would be expected because of the season and location of sampling. [redacted]y 3 of 70 mergansers were taken during the period February to August (chinook [redacted]enile are abundant along the river margins in May and June and scarce at [redacted]er times; Brown et al. 1994) and the 3 June samples were from Okanagan Lake [redacted]unro and Clemens 1932) which lacks rearing chinook. Thus, the Munro and [redacted]emens (1937) interior merganser stomachs were very unlikely to contain juvenile [redacted]nook.

Common mergansers (adults and young) consumed fish over a wide range of sizes [redacted] cm to 36 cm) but most authors considered fish of between 5 cm and 20 cm to be [redacted]thin the optimum size range of fish selected by adult mergansers. Wood and [redacted]d (1985) reported that common mergansers preferred larger juvenile coho salmon [redacted]lts averaging 43 g) over small coho salmon fry (averaging 2.3 g). Slayer and [redacted]ger (1940) speculated that there was a "preference by the merganser for fish [redacted] other food items of the larger sizes." In Michigan, fish caught by [redacted]rgansers averaged "a little under six inches in length" and one merganser

gullet contained a 14.25 inch, 15 ounce brown trout (Slayer and Lagler 1940). Larger ducklings and adults do not ordinarily take fish under 5 cm (White 1957). Fish recovered from 43 common mergansers stomachs had a maximum length of 185 mm and a mean length of 125 mm (Miller and Barclay 1973). Alexander (1979) reported that mergansers ate more trout between 6 to 9 inches in length than any other size category or species when compared to what existed in the population. White (1957) noted that very young common merganser ducklings consumed insects but switched to small fish (some as small as 20 mm) within 10 to 12 days of feeding. Rad (1980) reported that the food of red-breasted mergansers (*Mergus serrator*) ducklings during the first days after hatching consisted in part of larvae of water insects, but within days fish constituted the main part of their food.

Group foraging in shallow water by common merganser broods has been observed in many studies (Munro and Clemens 1937; Salyer and Lager 1940; Foreman 1976; Wood and Hand 1985). Wood and Hand (1985), however, found no evidence that mergansers foraging in groups captured more prey than those foraging alone. Rad (1980) concluded that merganser ducklings required an abundance of easily accessible small fishes in shallow water.

Belted kingfishers (*Ceryle alcyon*) are primarily fish eaters but can take a diversity of different food items such as crustacea, insects, and frogs (White 1953). Elson (1962) noted that the diet of belted kingfishers consisted of 13% Atlantic salmon (*Salmo salar*) however, they consumed more suckers and minnows than salmon, relative to their abundance. White (1953) indicated that juvenile Atlantic salmon represented 87% of the belted kingfisher's diet in a good salmon-rearing area and White (1936) reported that kingfishers feeding young can remove 50 salmonid fingerlings per day at fish hatcheries. Fish swimming near the surface or in shallow water are the primary food of belted kingfishers and they generally catch the prey that are most available (Prose 1985). White (1953) speculated that the majority of fish are taken from the "top 2 ft. of water". Elson (1962) speculated that the type of habitat fished by belted kingfishers (upper 2 ft of water column) may in part reflect the lower catches of juvenile salmon relative to salmonid abundance.

The number of belted kingfishers estimated along streams and rivers often exceeds 1/km. Alexander (1979) estimated 1.5 adults/km on Michigan streams during summer and calculations based on Elson's data (1962) for an experimental section of the Pollett River yield 10 birds/km. White (1953) estimated 1 nest/mile or approximately 1.2 adults/km.

Prose (1985) summarized prey size information from various authors and reported maximum prey sizes of 10.2 cm, 12.7 cm and 10.2 cm; mean prey sizes of 9.2 cm and 7.6 cm; and prey size ranges of 2.5 - 17.8 cm and 4 - 14 cm. Alexander (1979) reported that kingfishers ate small 2 to 5 inch (5 - 13 cm) trout. White (1936) estimated captive pre-flight kingfishers ate 0.344 lb per day (0.156 kg) or 40 fish of 6 cm in length. Elson (1962) used 24 fish per day as an estimate of fish consumption, as length of fish captured by wild kingfishers averaged approximately 7 cm.

Black terns (*Chlidonias niger*) feed fish to their young (Haley 1984). One of the parents brings small items (insects) to the nest, while the other brings mainly fish to the nest (Dunn 1979). Exact age of fledging was undetermined, but was estimated at 19 days by Dunn (1979). Dunn (1979) reported that minnows represented 13% of the food items fed to black tern chicks and Cuthbert (1954: cited in Dunn 1979) reported that 5% were minnows and 94% were insects. The length of fish captured by the least tern (*Sterna antillarum*), a slightly larger tern, ranged from 2.5 - 7.5 cm, 5 - 8 cm, and 4 - 9 cm; and 84% of fish eaten were < 5 cm long (authors listed by; Carreker 1985). If we assume that a bird eats between 1/3 to 1/2 of its body weight daily (Elson 1962) and an adult black

[illegible] an average weight of 63 g (Dunn 1979), then the daily ration of an adult [illegible] would be approximately 30 g.

[illegible] (*Pandion haliaetus*) feed entirely upon fish (Nels 1981) and size of [illegible] captured are generally large. Eriksson (1986) reported that an average of [illegible] were delivered to a osprey nest per day and the total weight for those 5 [illegible] was 514 grams. In Yellowstone Lake and River, cutthroat trout comprised 93% [illegible] diet with fish between 25 to 35 cm being preferred (Swenson 1978). Major [illegible] prey include: suckers (*Catostomus* sp.), mountain whitefish (*Prosopium* [illegible]), chub species (*Mylocheilus* sp.), rainbow trout (*Oncorhynchus* [illegible]), common carp (*Cyprinus carpio*), crappie species (*Pomoxis* sp.), bullhead [illegible] (*Ictalurus* sp.), and northern squawfish (*Ptychocheilus oregonensis*), [illegible]-Miller 1987). Fish prey captured by osprey in West-Central Idaho reflected [illegible] availability and fish in the 11 to 30 cm range constituted 89% of the diet [illegible] and Daele 1982).

Although only mew gulls (*Larus canus*) were seen during our survey, herring [illegible] (*Larus argentatus*) and Bonaparte's gull (*Larus philadelphia*) have been [illegible] within the Nechako River system (Bruce 1991; Campbell et al. 1990). [illegible]parte's gull is an efficient predator on salmonid fry. Mace (1983) [illegible]lated that Bonaparte's gull accounted for 8.3 to 9.9% of the total take of [illegible] fry released from the Qualicum River Hatchery, Vancouver Island (more [illegible] any other piscivorous bird). Food provided indirectly by man is clearly of [illegible] importance to other gull species (Mudge and Ferns 1982). Mudge and Ferns [illegible] reported that herring gulls dominated refuse sites (75% of feeding counts) [illegible] mew gulls were most numerous in fields (94% of feeding counts).

The diet of red-necked grebes is not well known, especially their diet while [illegible]ding on interior lakes, rivers, and marshes (Campbell et al. 1990). Red-[illegible] grebes (*Podiceps grisegena*) consume fish, insects, tadpoles, crustaceans [illegible] molluscs (Palmer 1962). Small fish (no salmonids were noted) represented 56% [illegible] the stomach contents of 46 birds taken on the west coast, while fish were [illegible]sidered "a minor item" of birds feeding on interior lakes and marshes (Palmer [illegible]962). In the West Kootenay region of British Columbia during the first week of [illegible]ir life young red-necked grebes consumed significant numbers of Odonata [illegible]dragonfly) larvae, but fish (non-salmonids) soon became an important diet item [illegible]Campbell et al. 1990). Fish captured by the closely related western grebe [illegible]*Aechmophorus occidentalis*) "averaged about 27 to 88 mm (about 1 to 3 1/2 inches) [illegible] length" (Short 1984).

The male red-necked grebe weights 1113 gm (average from Alaska in July, [illegible]mer 1962) and the female is slightly lighter (945 gm). For the purposes of [illegible]delling predation of fish by birds, the lack of accurate diet information for [illegible]d-necked grebes on rivers such as the Nechako River requires us to [illegible]nservatively assume a grebe will consume 350 g/day of which 10% would be fish.

Common loons (*Gavia immer*) can consume large quantities of fish, especially [illegible] lakes were they can account for 59% of the total fish consumed by piscivorous [illegible]irds (Reimchen and Douglas 1984), but the majority of the prey may be coarse [illegible]fish such as sticklebacks (Reimchen and Douglas 1980). Approximately 80% of [illegible]eir freshwater diet consisted of fish, other items eaten included crustaceans, [illegible]and vegetable matter (Palmer 1962). Prey size for loons in Drizzle Lake in [illegible]October was estimated to be between 50 - 70 mm (Reimchen and Douglas 1980). If [illegible]one assumes a bird consumes 1/3 to 1/2 its weight in food per day (Elson 1962) [illegible]and a common loon weighs between 2.9 to 3.8 kg (Palmer 1962), then each common [illegible]oon could eat approximately 1.4 kg per day.

Great blue herons (*Ardea herodias*) are excellent predators on small fish [illegible]Godin 1976) and approximately 72% of their diet consisted of fish (Palmer 1962). [illegible]Alexander (1979) reported that herons consumed 13% of the annual trout production

in a Michigan stream. The great blue heron ate fish from 3 to 13 inches (7.5 - 33 cm) long, but seemed to select 7 to 12 inch (18 - 30 cm) trout (Alexander 1979). If we assume that a bird will consume 1/2 to 1/3 its weight daily (Elson 1962) and an adult great blue heron weights approximately 3.0 kg (Palmer 1962), then an estimated daily ration would be 1.3 kg. Great blue herons will feed anywhere they can locate prey but the primary feeding activity is fishing in shallow water, usually less than 50 cm deep (Short and Cooper 1985).

Bald eagles (*Haliaeetus leucocephalus*) are not considered a threat to juvenile chinook salmon. They are primarily fish eaters and may take "larger fish idling on the surface" (Nels 1981). However, they mostly consume dead or dying fish on the shore or harass osprey and other birds for their prey (Nels 1981). Summarizing the diet of bald eagles from various authors, Peterson (1986) reported fish as comprising 77% of diet in interior Maine, 90% of diet in north-central Minnesota, 51% of breeding season diet in San Juan Islands (Washington), and 67% in one ecosystem of Yellowstone National Park. Bald eagle prey selection may be determined largely by availability, as birds accounted for 68% of their diet in a different ecosystem of Yellowstone National Park (Peterson 1986). In Oregon, bald eagles fed on 16 species of fish, 46 species of birds, 20 species of mammals, and 2 invertebrate species (Peterson 1986).