Ecology of the Wintering Bald Eagles on the Skagit River, Washington

by

Christopher Walter Servheen

A thesis submitted in partial fulfillment

of the requirements for the degree of

Master of Science

University of Washington

1975

Approved by David Ahammond
(Chairperson of Supervisory Committee)

Program Authorized to Offer Degree Forest Resources

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Signature Christyl Sutherland

Date 18 Sept. 1975

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And finally, I am thankful for the privilege of spending two winters in close association with one of the most magnificent raptors in the world.

This thesis is dedicated with deepest appreciation to Dr. Bart O'Gara of the Montana Cooperative Wildlife Research Unit who taught me so much and whose wise counsel never steered me wrong.

He clasps the craig with crooked hands;
Close to the sun in lonely lands,
Ring'd with the azure world, he stands.

The wrinkled sea beneath him crawls;
He watches from his mountain walls,
And like a thunderbolt he falls.

Tennyson

INTRODUCTION

The Bald Eagle usually inhabits areas close to water and is found along sea coasts, lake shores and rivers. It formerly was found throughout the North American continent, but the population has been declining ever since the arrival of the white man. This long-term decline was due mainly to habitat destruction and the shooting of the birds themselves. Since the 1940's, there has been an accelerated decline in the Bald Eagle population in the continental U.S. (Broley 1951, 1958; Sprunt 1969; Sprunt, et al. 1973) and in some areas of Canada (Grier 1974; Weekes 1974). This recent decline has been much more rapid than the previous long-term decline and has been attributed to several factors: (1) habitat elimination and the loss of solitude at nesting areas due to the increased use of such areas by man; (2) pesticide contamination of food sources leading to a disruption of eagle reproductive physiology; and (3) the continued shooting and poisoning of eagles by irresponsible persons.

The Bald Eagle has been divided into two subspecies: the northern Bald Eagle (*Haliaeetus leucocephalus alascensis*) and the southern or Florida Bald Eagle (*H. l. leucocephalus*) (A.O.U. Check-list 1957). The northern subspecies is found in northwestern North America (Brown and Amadon 1969) and the Bald Eagles wintering on the Skagit River are members of this subspecies.

REVIEW OF THE LITERATURE

Some aspects of the life history of the Bald Eagle have been intensively studied while others have received little attention. There are numerous published accounts of the nesting and productivity of the Bald Eagle. These include Herrick in Ohio (1924a, 1924b, 1924c, 1924d, 1932a, 1932b); Ganier in Tennessee (1932); Howell (1937, 1941, 1949, 1954, 1958, 1962, 1968), Broley (1947, 1950, 1951, 1952) and Howell and Heinzman (1967) in Florida; Smith in Maryland (1936); Hensel and Troyer (1964), Troyer and Hensel (1965), Robards and King (1967) and Corr (1974) in Alaska; Retfalvi in Washington (1965); Grier (1974) and Weekes (1974) in Ontario; and Gerrard (1974) and Whitfield, et al. (1974) in Saskatchewan. Data on the life history of the Bald Eagle has been published by Dixon (1909), Brooks (1922), Herrick (1933, 1935), Bent (1937), Murie (1940), Imler and Kalmbach (1955), Kalmbach, et al. (1964), Grewe (1966) and Snow (1973).

Our knowledge of Bald Eagle winter biology however, is limited. Imler (1934, 1937) in Kansas was the first to describe a winter roost of Bald Eagles where lagomorphs were a major food source. Musselman (1949) was the first to report large numbers of eagles wintering on the Mississippi River. Fawks (1961) has been coordinating counts on the Mississippi for many years and his work has demonstrated the importance of this area as a wintering site. Winter concentrations have also been reported by Van Den Akker (1954), Halloran (1959) and Johnson (1961) in Oklahoma; Larson and Abbott (1962) in Chesapeake Bay; Swisher (1964) in Utah; and Jonkel (1965) in South Dakota.

Little published information is available on the winter ecology of the Bald Eagle along the Washington, British Columbia and Alaska coasts where

most of the Bald Eagles in North America occur. Robards (1966) worked on capture and handling techniques on the Chilkat River in southeast Alaska. Hancock (1964) describes wintering eagles in the southern Gulf Islands of British Columbia. His work deals with seasonal movements, density and food habits. Brooks (1922) briefly noted abundance and habits of eagles in coastal British Columbia. Munro (1938) describes food habits and hunting methods of a group of eagles in the late winter and early spring on the Queen Charlotte Islands, off the coast of British Columbia.

The first intensive research on a wintering population was by Southern (1963, 1964) on the Mississippi River in northwestern Illinois. Immature eagles were the first to arrive and were found in larger numbers in the southern half of Illinois. Live gizzard shad (*Dorosoma cepedianum*) was the primary food source. The population fluctuated with the abundance of shad and ice conditions on the river. Most eagles roosted singly or in small groups usually several miles from their morning feeding sites. Eagles arrived in the area in mid-November and all had departed by 6 April. Southern developed a preliminary scheme for aging subadult eagles by plumage characteristics. He also color-marked eagles and was the first to use biotelemetry techniques in Bald Eagle research.

Edwards (1969) studied a wintering population of Bald and Golden eagles in the arid valleys of western Utah. He found the principal prey of both eagle species to be jackrabbits (*Lepus californicus*) and that the eagles preferred to kill their own prey. Bald Eagles roosted together up to 15 miles from their feeding sites. These wintering Bald Eagles arrived in the area in mid-November and were gone by mid-April.

Shea (1973) studied the winter Bald Eagle aggregation at Glacier National Park in Montana. These eagles gather in response to the spawning of kokanee salmon (*Oncorhynchus nerka kennerlyi*) in the Flathead River. Most eagles roosted together. Eagles began arriving in mid-October and were gone by mid-December.

My study, then, is one of only four intensive studies that have been done on wintering Bald Eagles. No previous studies have been done on wintering Bald Eagles consuming salmon in the Pacific Northwest.

OBJECTIVES OF THIS STUDY

(1) Determine the temporal and spatial distribution of the wintering Bald Eagle population that concentrates on the Skagit River between Rockport and Newhalem.

(2) Determine the critical habitat needs of the wintering population and the relation between these needs and human activity.

(3) Determine the effects of food supply, weather, river level fluctuation and human activity on the local distribution and movement of the winter population.

(4) Record the age structure of the population in an effort to determine if there is differential migration between age classes.

(5) Quantify the availability, utilization and distribution of the eagle food source.

(6) Study the relationship between roosting activity, food supply and other environmental variables.

LOCATION AND DESCRIPTION OF THE STUDY AREA

The study area is located in northwestern Washington where it encompases parts of both Skagit and Whatcom counties (Figures 1 and 2). The principal study area consists of the Skagit River valley from Rockport east and north to Newhalem, a distance of approximately 26 river miles (Figures 3 through 9). The study area lies approximately 70 miles east of Puget Sound and approximately 100 road miles northeast of Seattle.

The Skagit River is the largest western drainage in northwestern Washington. It flows south and west through the North Cascade Range and bisects North Cascades National Park. It is impounded above Newhalem by Gorge Dam, Diablo Dam and Ross Dam, all of which are owned and operated by Seattle City Light Company. Ross Lake, at 1620 feet above sea level, is the largest impoundment, extending approximately 20 miles to the Canadian border in the Ross Lake National Recreation Area. This recreation area begins just east of Bacon Creek and includes the Skagit valley from this point to the Canadian border.

The Skagit valley is two to three miles wide in the Rockport area and narrows to less than one mile in width around Newhalem. The valley has steep sides and a U-shaped form typical of a glaciated valley. The most recent glaciation occurred within the past 20,000 years (McKee 1972). The valley has a low gradient rising from 205 feet above sea level at Rockport to 401 feet above sea level at Newhalem. A thick cover of glacial sediment covers the valley floor throughout the study area (McKee 1972).

Water quality in the Skagit is high. The Skagit and all its tributaries above Burlington are rated Class AA, Extraordinary under criteria established

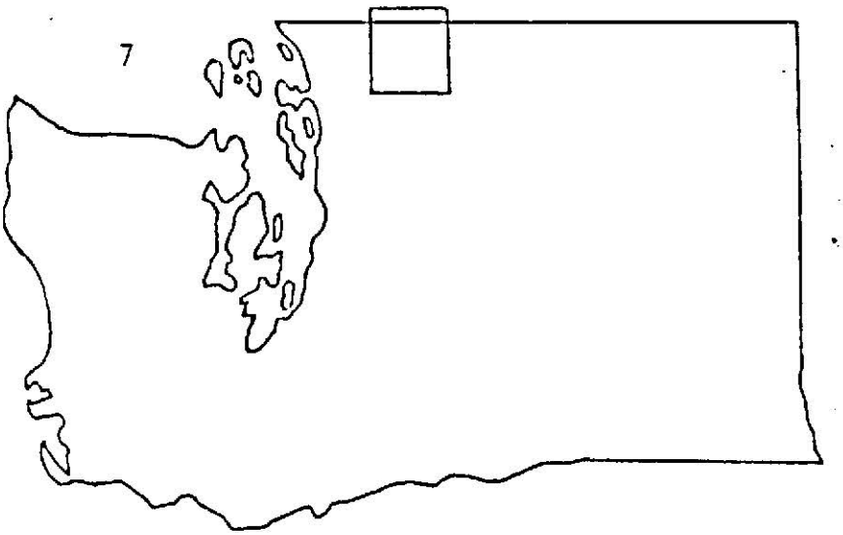


Figure 1. The state of Washington showing the location of the area outlined in Figure 2.

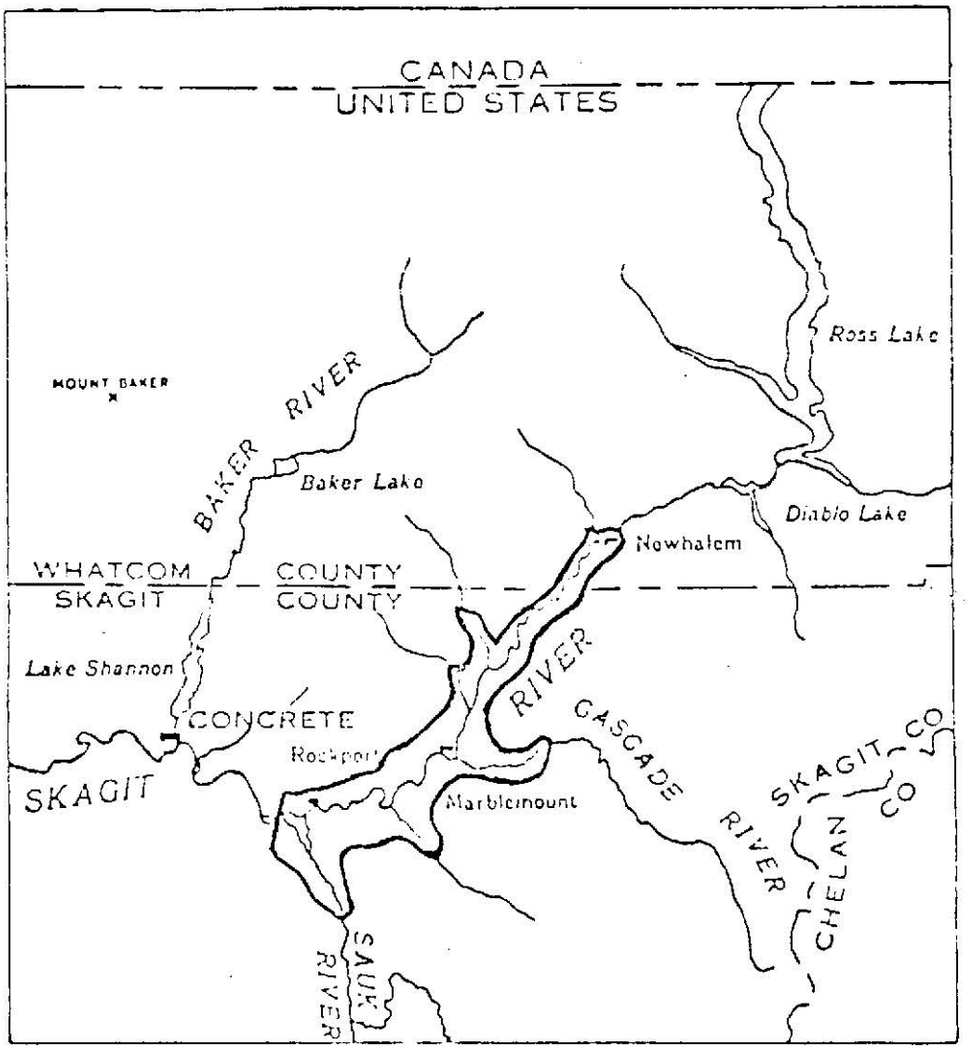
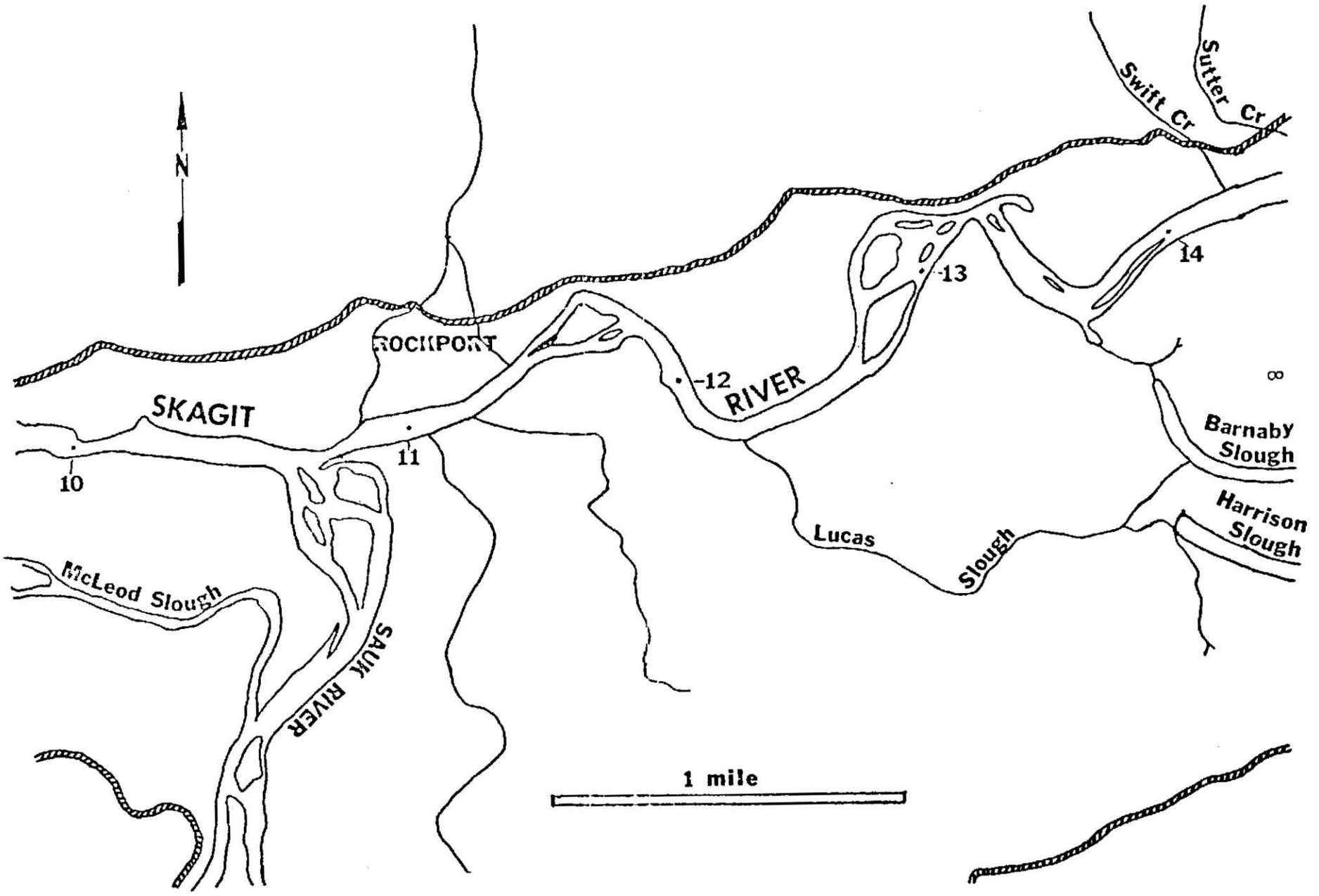
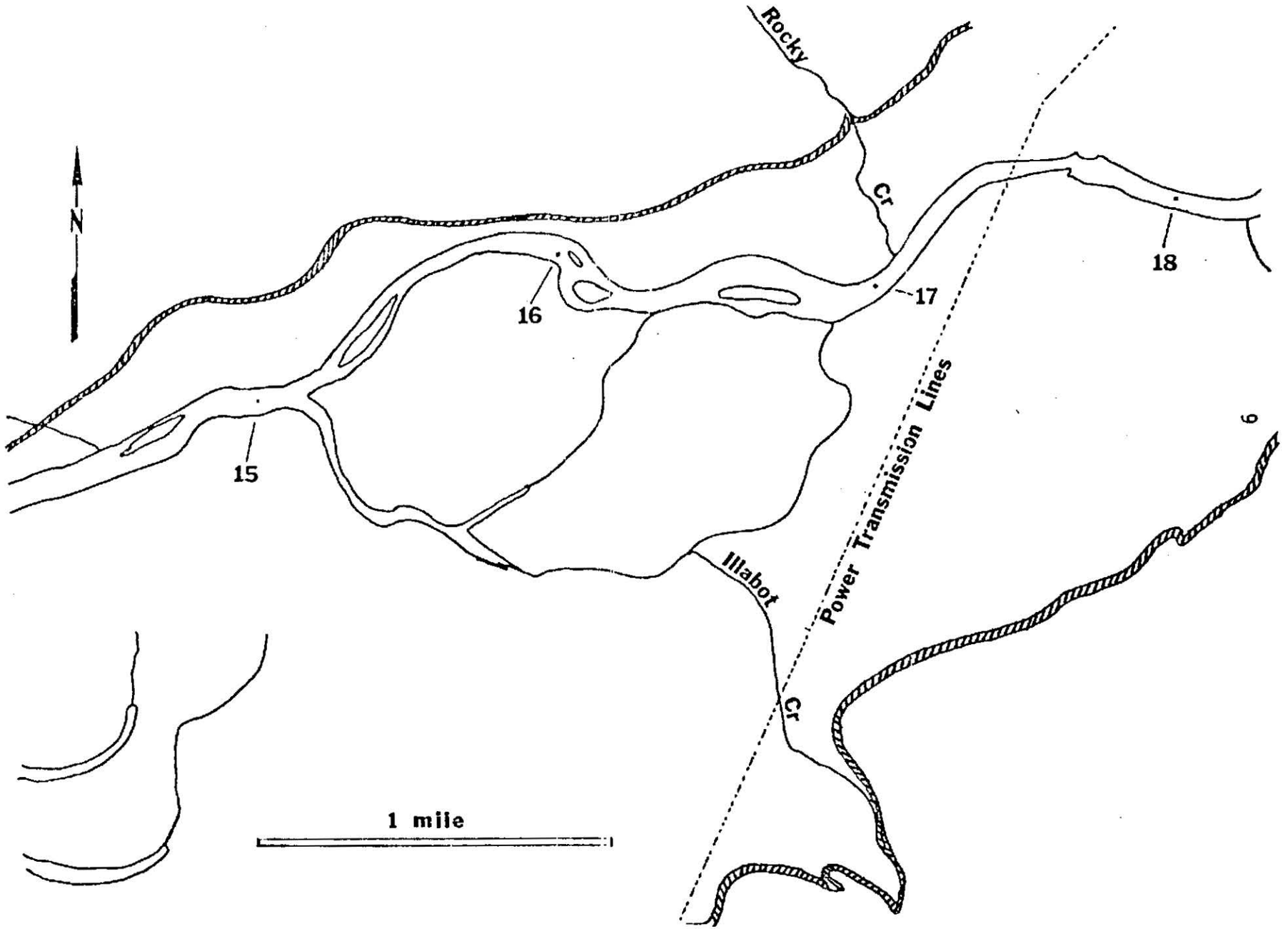


Figure 2. The primary study area outlined between Rockport and Newhlalem.

Figures 3 through 9. Detail of the Skagit valley from Rockport to Newhalem. The ═══ line indicates the margin of the valley floor by USGS mapped contour lines. Numbers indicate distance in river miles.


N
Swift Cr
Sutter Cr
ROCKPORT
SKAGIT
RIVER
10
11
12
13
14
Barnaby Slough
Harrison Slough
Lucas Slough
McLeod Slough
SAUK RIVER
1 mile


Rocky
Cr
N
16
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18
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Power Transmission Lines
6
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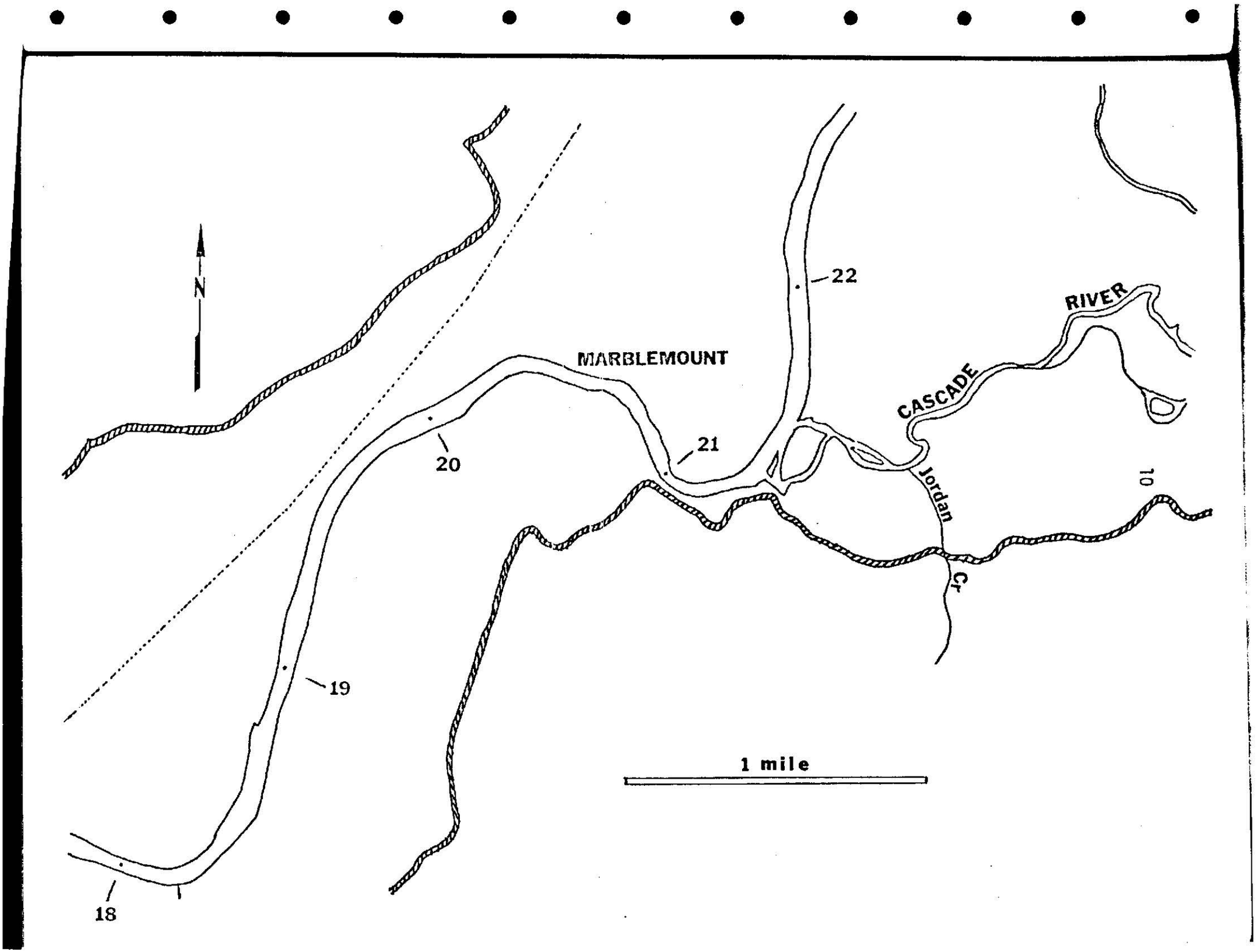
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MARBLEMOUNT
CASCADE
RIVER
Jordan
Cr
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18
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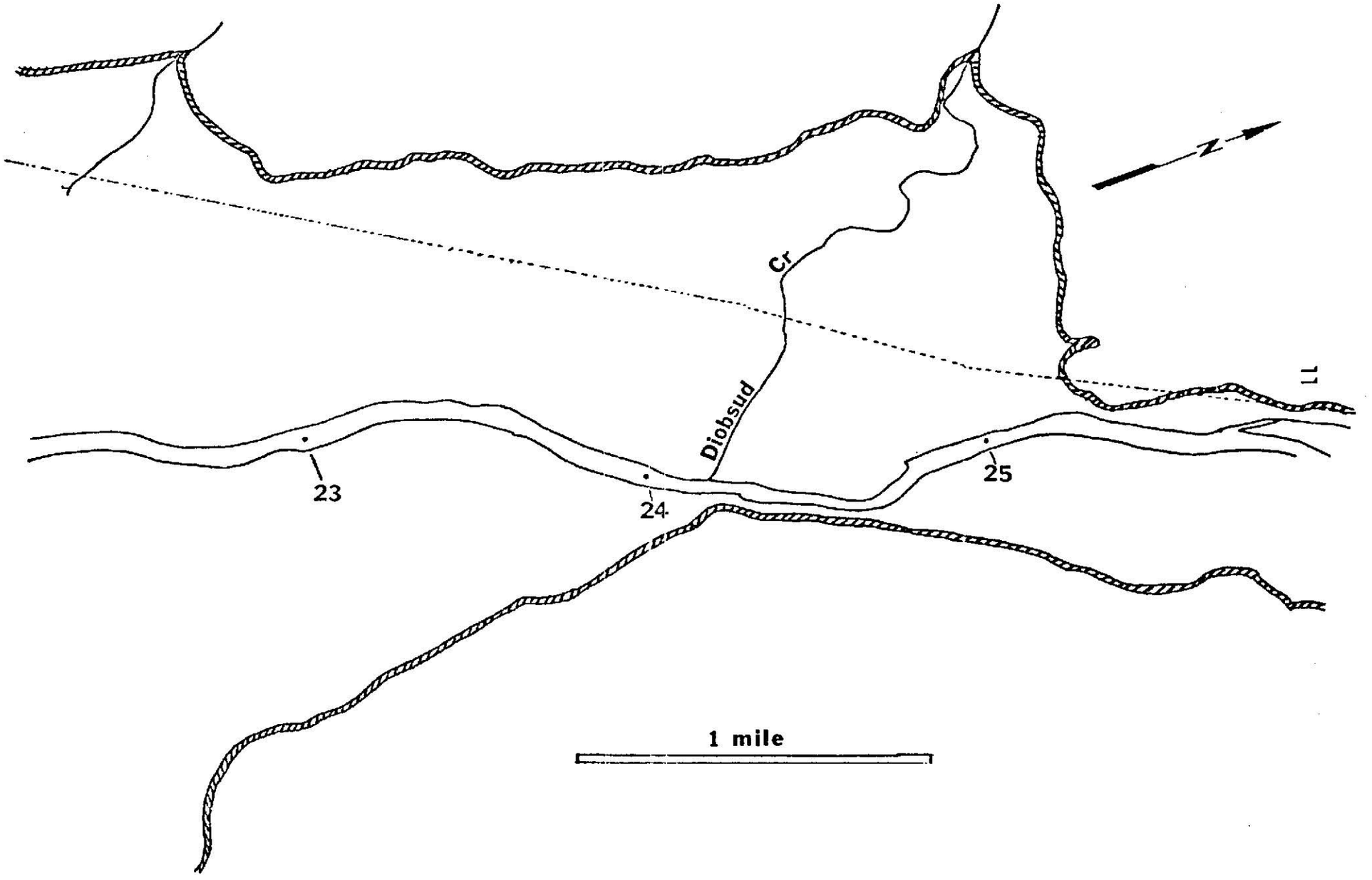
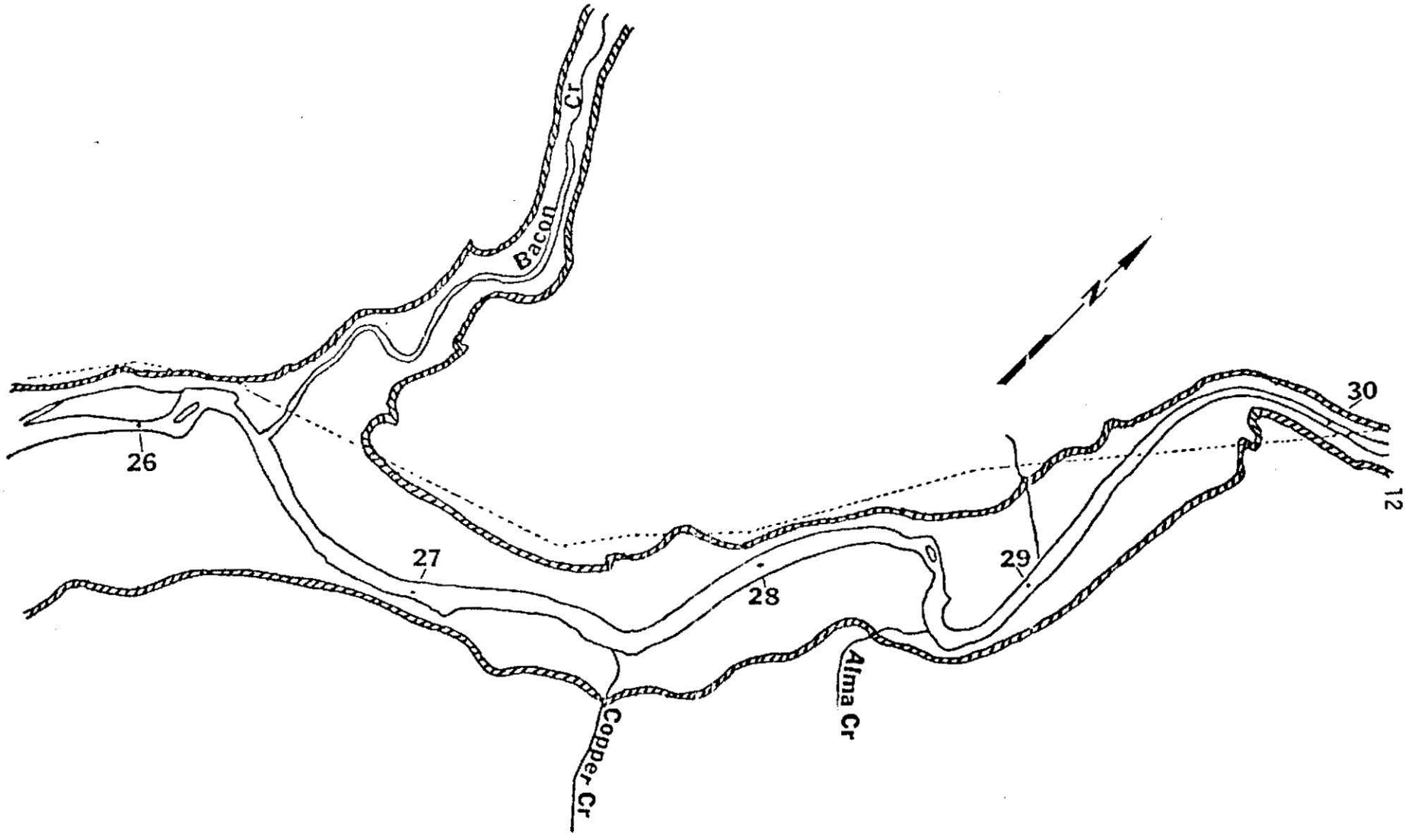
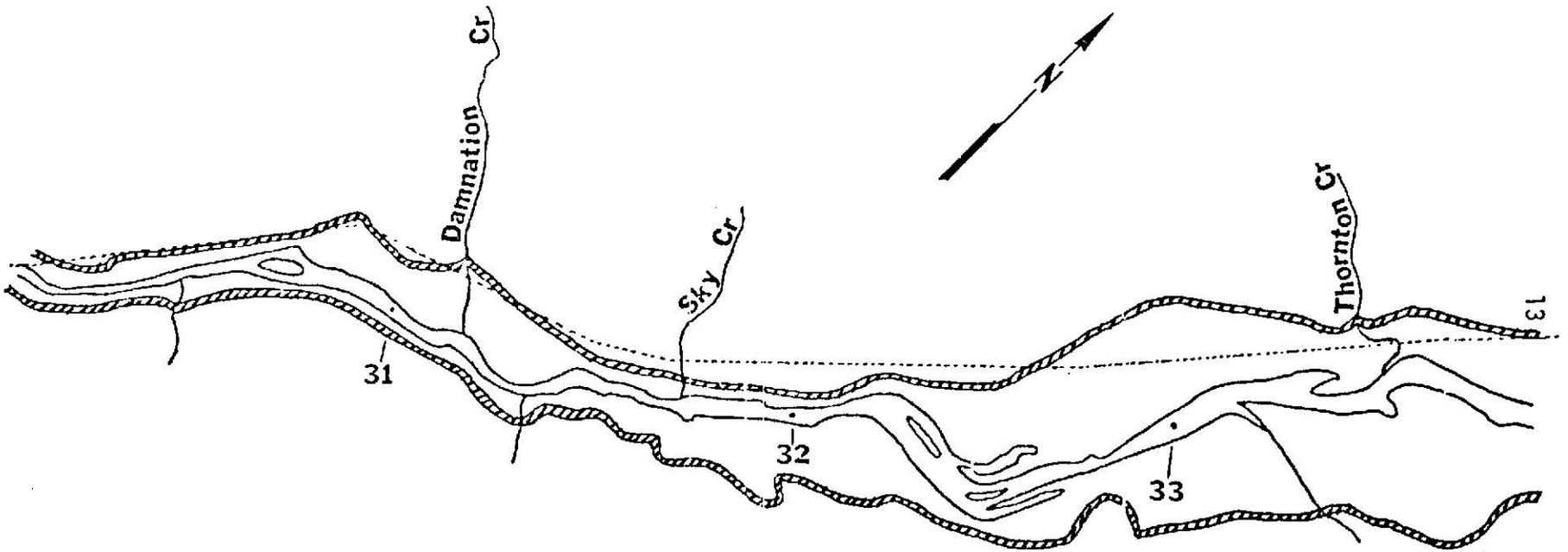
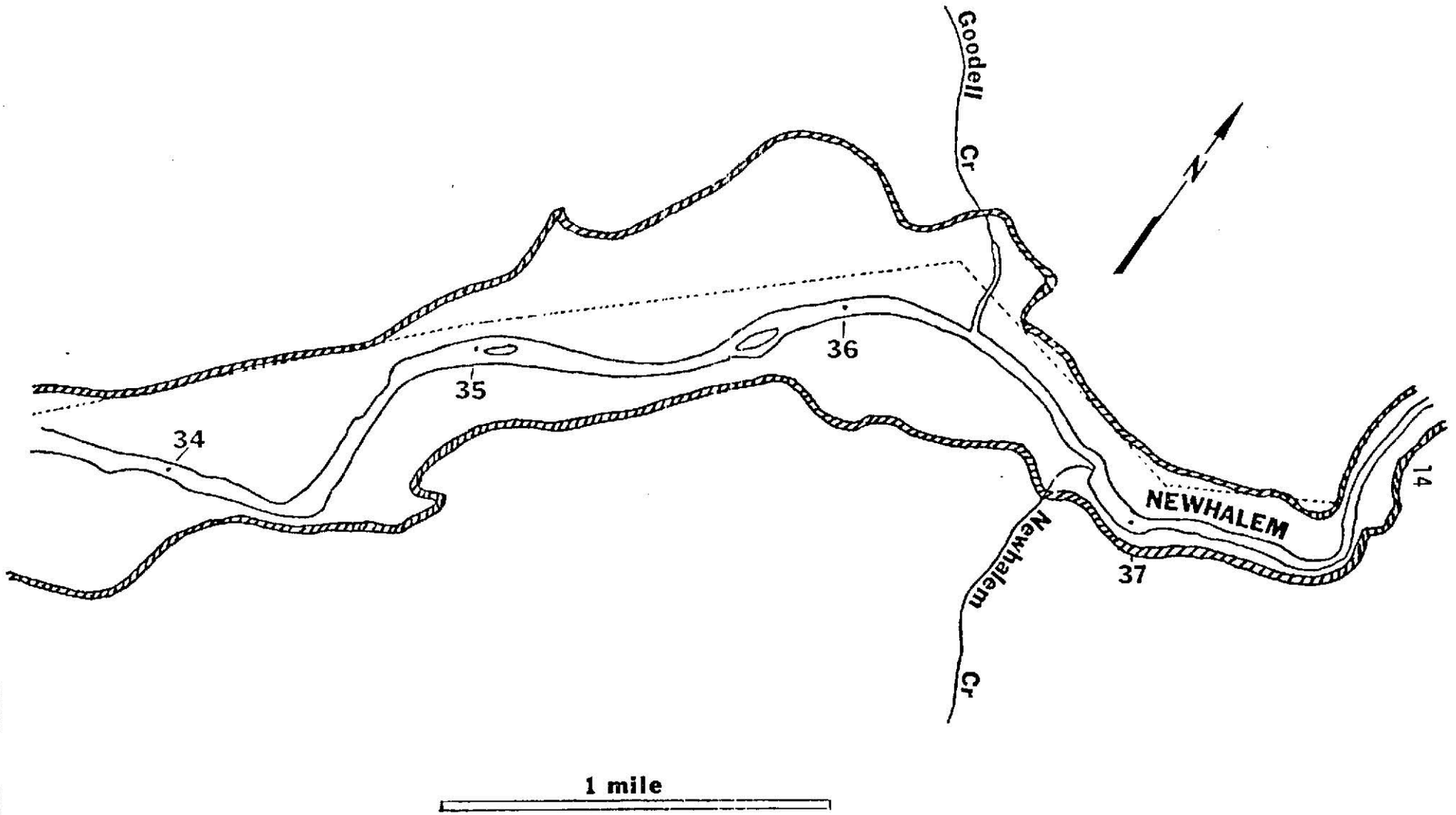
21
22
1 mile


N
Cr
Diobsud
23
24
25
1 mile


Bacon Cr
N
30
26
27
28
29
12
Alma Cr
Copper Cr
1 mile


Damnation Cr
Sky Cr
Thornton Cr
N
31
32
33
13
1 mile


Goodell Cr
N
34
35
36
37
NEWHALEM
14
Newhalem Cr
1 mile

by the Federal Water Pollution Control Act of 1956 (Puget Sound Task Force of the Pacific Northwest River Basins Committee 1970).

The river in the study area averages 50 to 75 yards wide. Water turbidity is low except during periods of extreme water flow. The river averages 4 to 6 feet in depth. The river bottom is composed mostly of large rocks with small gravel and sand comprising the shoreline and the gravel bars. Many gravel bars are found both as islands and as shoreline areas. These gravel bars are most common from mile 12.0 to 16.5. Driftwood snags are deposited on the gravel bars during periods of high water. Water fluctuations during the winter period are due to rapid snow melt often combined with warm rains, and to changing flow rates at the hydroelectric dams.

The average monthly temperatures and precipitation are summarized in Tables 1 and 2. The study area has a wet, mild maritime climate and can be classified in the Humid Climate Zone according to Thornthwaite (1941). The average annual precipitation at the U.S. Weather Station at Concrete is 65.21 inches and at Newhalem is 78.22 inches (National Oceanographic and Atmospheric Administration, Environmental Data Service, published records). Summers are fairly dry, contributing only 6% to 9% of the total precipitation. More than 64% of the precipitation falls between 1 November and 1 April. Most of the winter precipitation is in the form of rain and wet snow.

The study area in the winter is characterized by heavy cloud cover. Fog and low stratus clouds are common and the steep sides of the valley are often obscured in clouds.

TABLE 1

AVERAGE MONTHLY TEMPERATURES IN DEGREES FAHRENHEIT [1]

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
NEWHALEM	33.8	37.5	42.0	49.5	56.4	60.4	65.5	65.1	60.7	51.6	41.9	36.9
CONCRETE	36.7	40.1	44.5	51.3	57.3	61.1	65.4	65.2	61.2	53.3	43.7	39.2

TABLE 2

AVERAGE MONTHLY PRECIPITATION IN INCHES [1]

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL MEAN
NEWHALEM	10.88	8.77	6.45	4.75	3.94	2.70	1.50	1.76	4.14	8.96	11.04	13.33	78.22
CONCRETE	8.80	7.03	6.76	4.12	2.87	2.75	1.30	1.50	3.57	7.03	9.10	10.38	65.21

[1] National Oceanographic and Atmospheric Administration, Environmental Data Service, published records.

Vegetation

The valley floor within the study area can be placed in the Western Hemlock (*Tsuga heterophylla*) life zone (Franklin and Dyrness 1973). Trees found along the river include western hemlock (*Tsuga heterophylla*), douglas fir (*Pseudotsuga menziesii*), pacific silver fir (*Abies amabilis*), grand fir (*Abies grandis*), western red cedar (*Thuja plicata*), northern black cottonwood (*Populus trichocarpa*), white birch (*Betula papyrifera*), red alder (*Alnus rubra*), black hawthorne (*Crataegus douglasii*), and broadleaf maple (*Acer macrophyllum*). Shrubs found include salal (*Gaultheria shallon*), oregon grape (*Mahonia nervosa*) and black raspberry (*Rubus leucodermis*). Common ferns in the area include sword fern (*Polystichum minitum*) and bracken fern (*Pteridium aquilinum pubescens*).

The lower elevations of the Skagit valley were extensively logged from approximately 1913 to 1935 (Fred Martin, local rancher, pers. comm.). There are currently few tracts of the magnificent climax forest remaining today. Huge stumps of the cedar and fir trees that once comprised the original forest are still a prominent feature of the valley. Much of the valley is in second and third growth timber and is now being actively managed by timber companies. Land development has increased with the establishment of North Cascades National Park and the completion of the north cross-state highway up the Skagit valley and over the Cascade crest.

Fisheries

Five species of salmon spawn in the Skagit River. These include chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), sockeye (*O. nerka*), chum (*O. keta*) and pink (*O. gorbuscha*) (R. Orrell, State Fisheries Dept. Biol., pers. comm.). All the salmon die after spawning.

Steelhead, the anadromous form of rainbow trout (*Salmo gairdneri*), also ascend the Skagit to spawn. The steelhead do not all die after spawning. The steelhead support an active sport fishery in the river during the winter.

Plate I. The Skagit valley at mile 13.5 looking south showing the feeding bar and the large broadleaf maple trees (*Acer macrophyllum*) used as perching sites on the south side of the river.

Plate II. A group of eagles on the feeding bar at mile 13.4. Several salmon carcasses can be seen in the photograph.

METHODS AND PROCEDURES

The study was initiated in the autumn of 1973. During the autumn of 1973 field work was started in mid-September and two to three days were spent in the study area per week. From 3 January 1974 to 19 March 1974, and from 11 December 1974 to 11 March 1975, I conducted research full time while I lived in Marblemount. During this time I usually spent 6 days per week in the field. During the two years of this study I spent over 960 hours observing eagles, counting salmon and censusing the eagle population.

Censusing

A total of 63 censuses of the study area were made in the winter of 1973-74 and a total of 55 censuses were made during 1974-75. I conducted censuses by car to avoid disturbing the eagles. The census route was 39 miles and covered the north and south sides of the river from Rockport to Marblemount, and the north side of the river from Marblemount to Newhalem. Through experience, I found that counts by boat were unreliable and disturbed the eagles. Eagles could not be aged from the boat due to lack of a stable base for the spotting scope.

I placed all eagles seen on each census into one of six age classes on the basis of plumage characteristics according to my own observations and Southern's (1964, 1967). I also recorded the activity, perch height, type of perch tree and crop condition of each eagle. Activity was divided into 26 categories and perch height into 4 categories as seen in Table 3. The type of perch tree was recorded as coniferous, deciduous or dead snag. Eagles having a noticeable bulge in the crop area were recorded as having a crop and were assumed to have recently eaten. If an eagle could be observed

TABLE 3. Activity codes and perch height codes used during this study.

ACTIVITY	PERCH HEIGHT
00 No data	00 No data
01 Perched in tree	01 Bottom one-third
02 Feeding on bar	02 Half way
03 Feeding in water	03 Top one-third
04 Feeding in tree	04 Top
05 Standing on shore	
06 Perched and preening	
07 Perched, wings drooped	
08 Perched, vocalizing	
09 Perched sleeping	
10 Perched on driftwood	
11 Standing, preening	
12 Standing, wings drooped	
13 Flying, flapping	
14 Flying, gliding	
15 Flying, soaring alone by ridge	
16 Flying, soaring in group by ridge	
17 Flying, soaring alone in valley	
18 Flying, soaring in group in valley	
19 Carrying food	
20 Attacking other eagles	
21 Defending fish	
22 Watching fish in river from tree	
23 Attacking live fish	
24 Attacking waterfowl	
25 Standing in water	

with the spotting scope and no bulge was seen in the crop area it was recorded as having no crop. All eagles that were not easily observed to determine crop condition were classified as unknown and were not included in the data analysis. Plumage characteristics and crop condition were recorded by observation with a 15-45 power spotting scope.

During the 1974-75 season I recorded all census data on fortran coding forms. This information was processed on the Control Data 6400 computer at the University of Washington. Chi Square Tests were used on cross-tabulations of data using an SPSS program format.

Observations

Much of the observation time was devoted to watching feeding activity on the gravel bars on the river. Some feeding activity was photographed at 32 frames per second on 16 mm motion picture film for reference and for detailed examination of behavior. I also devoted time to observing roosting and soaring behavior.

Food Quantification

I counted and classified the dead salmon on measured transects of shoreline. The type of data sheet used on these transects is shown in Figure 10. I classified salmon according to their accessibility to the eagles, their position on the shore, and the amount of flesh consumed on each fish. I classified salmon on the major feeding area on the north shore from mile 13.3 to 13.8 at regular intervals throughout the winter of 1974-75. In order to minimize disturbance to the eagles, I carried out salmon counts at night with the aid of flashlights.

Figure 10. The form sheet used to record and classify dead salmon on the shore of the river. Percentages represent the amount of each fish consumed.

DISTANCE (IN METERS) _____ DATE _____ TIME _____

LOCATION _____

ACCESSIBLE			INACCESSIBLE
WATER		SHORE	
SUBMERGED	EXPOSED		
0% _____	0% _____	0% _____	0% _____
Eyes Only _____	Eyes Only _____	Eyes Only _____	Eyes Only _____
10% _____	10% _____	10% _____	10% _____
50% _____	50% _____	50% _____	50% _____
100% _____	100% _____	100% _____	100% _____
Total _____	Total _____	Total _____	Total _____

GRAND TOTAL: _____

BIRDS FEEDING IN AREA:

RESULTS AND DISCUSSION

Population Dynamics

Bald Eagles are found in the study area only during the winter months. The nearest eagle nest is located approximately 23 miles west of Rockport by Day Creek on the Skagit River. I have been unable to locate any historical records of Bald Eagles nesting in the study area.

Bald Eagles have traditionally used the study area as a wintering site. Fred Martin (pers. com.), a local rancher, states that there were "hundreds" of eagles wintering in the area of his ranch at mile 15.5 in the early part of this century. No quantifiable data are available concerning eagle numbers before the construction of the dams above Newhalem in 1924. It is possible that the present winter eagle distribution is partially a result of the impoundment of the upper river and the subsequent destruction of the migratory fish population that spawned in the upper river.

The variations in the censuses in Figures 11 and 12 are due to the effect of different weather and river level conditions on the activity of the eagles. These day-to-day variations do not represent actual changes in the population of the area. In order to develop a seasonal trend curve of the population, each season was divided into 8 day intervals. The mean and range for all the counts in each interval were plotted (Figures 13 and 14).

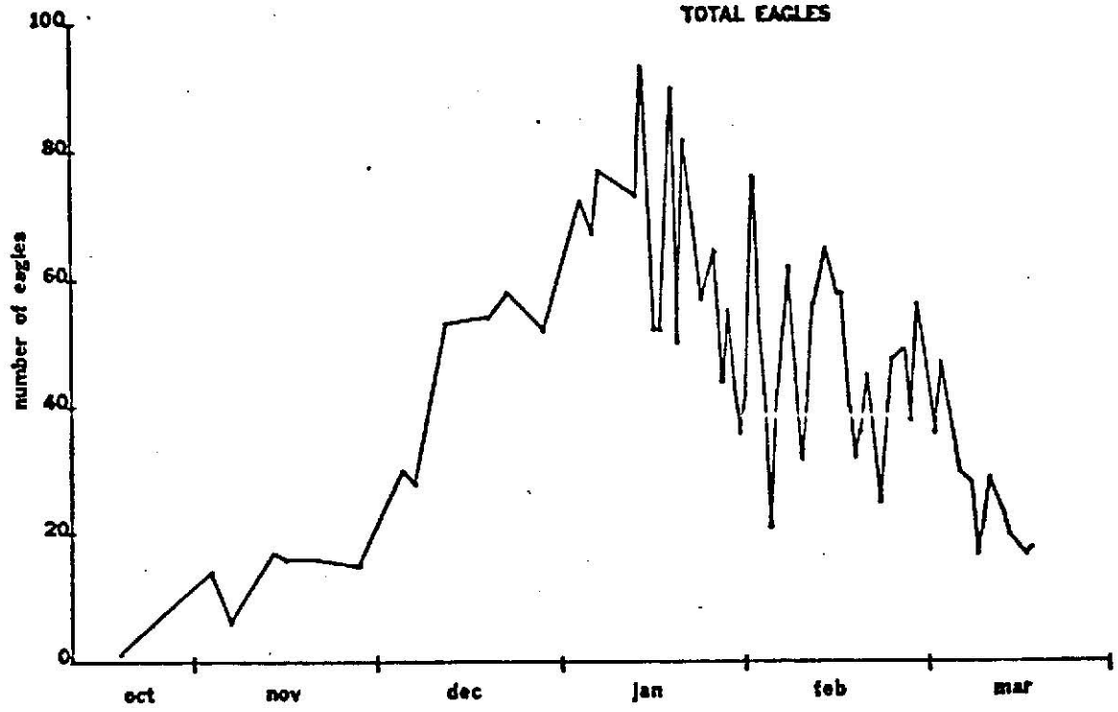
Seasonal Fluctuation

The first eagles to arrive in the study area were seen in mid-October in both years. The population remained relatively stable at less than 20 birds through November. During the first two weeks of December in both years there was a dramatic increase in the population. In the 1973-74

Figure 11. Total number of eagles, Rockport to Newhalem, 18 October through 15 March 1973-1974.

Figure 12. Total number of eagles, Rockport to Newhalem, 18 October through 15 March 1974-1975.

1973-74
ROCKPORT TO NEWHALEM
TOTAL EAGLES



1974-75
ROCKPORT TO NEWHALEM
TOTAL EAGLES

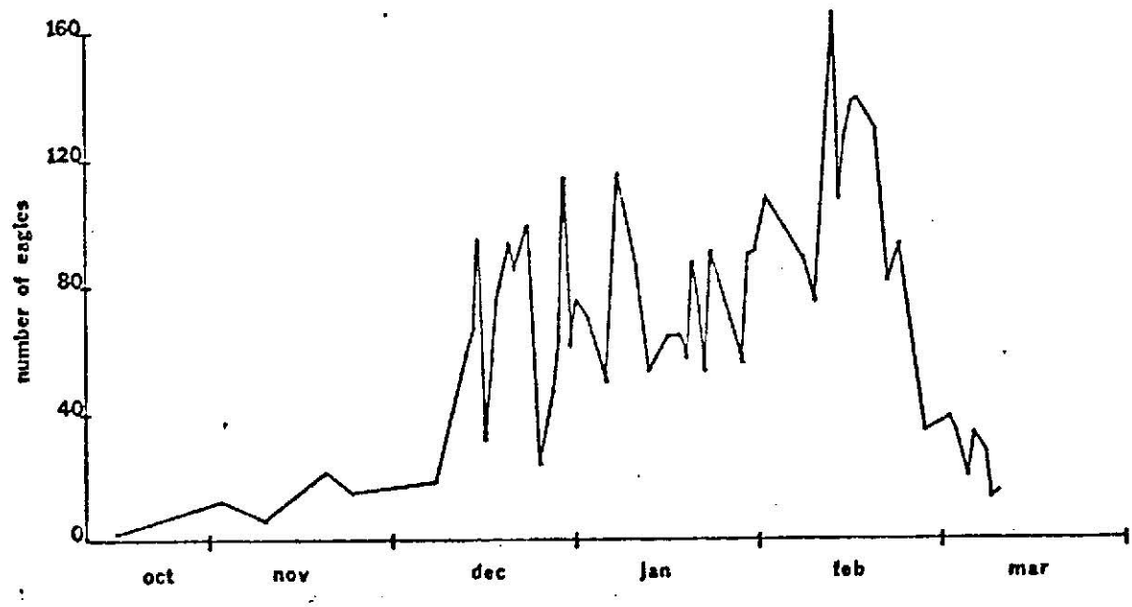
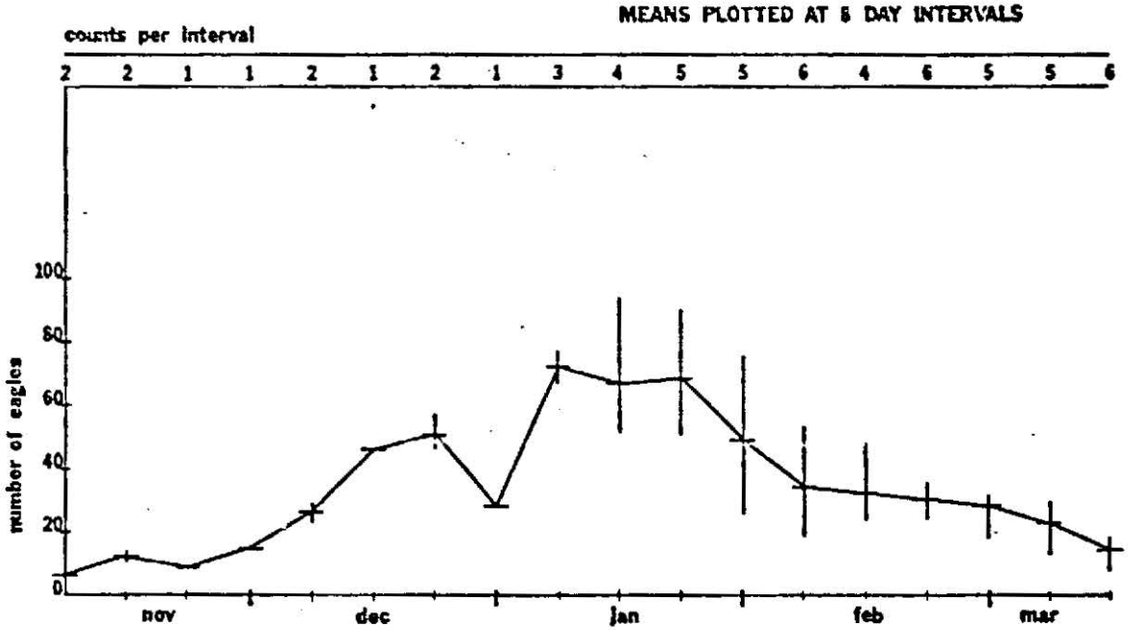


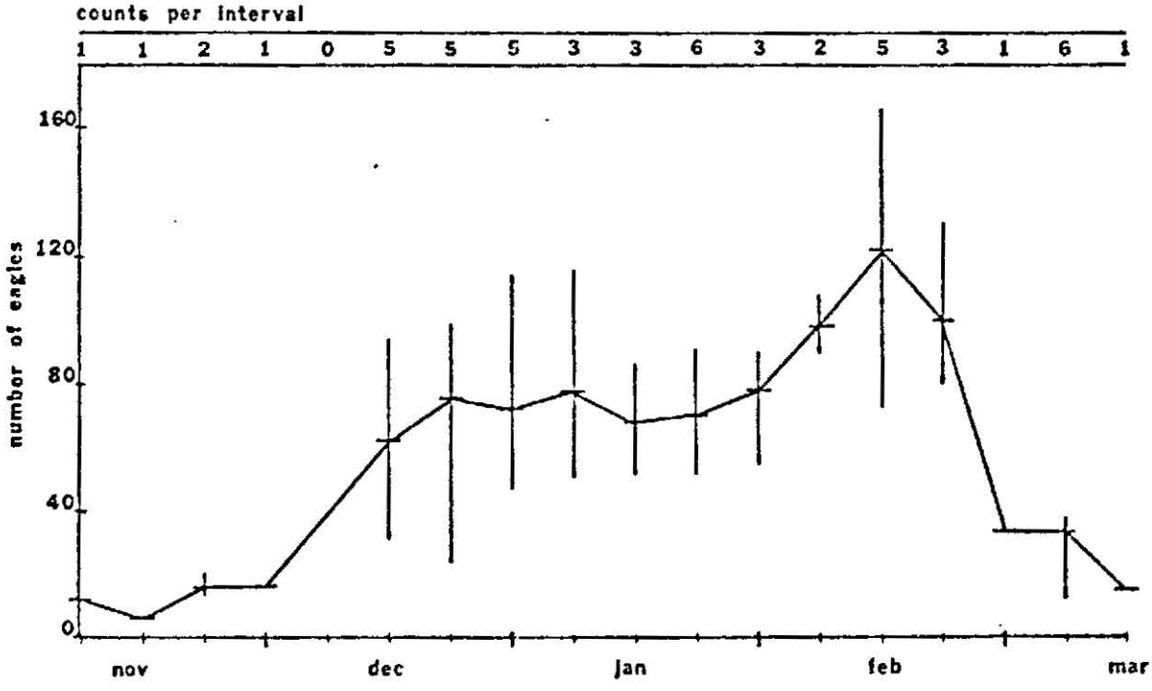
Figure 13. Total number of eagles, Rockport to Newhalem, 7 November through 15 March 1973-1974. Means plotted at 8 day intervals. Vertical lines at each interval indicate the range for that interval.

Figure 14. Total number of eagles, Rockport to Newhalem, 7 November through 15 March 1974-1975. Means plotted at 8 day intervals. Vertical lines at each interval indicate the range for that interval.

1973-74
ROCKPORT TO NEWHALEM
TOTAL EAGLES
MEANS PLOTTED AT 8 DAY INTERVALS



1974-75
ROCKPORT TO NEWHALEM
TOTAL EAGLES
MEANS PLOTTED AT 8 DAY INTERVALS



season, the population increased slightly in the second week in January and remained stable for three weeks until the first week in February. In 1974-75 the population remained stable from the third week in December through the first week in February. The increase in the population that occurred in mid-February 1975 was in sharp contrast to the situation in mid-February of the previous season when the population was declining and had been doing so for four successive weeks. In 1973-74 the population decline was gradual, lasting over a seven week period, while in 1974-75 the population decline began five weeks later and lasted only four weeks. The peak population in 1973-74 was 93 eagles on 13 January, while the peak in 1974-75 was 165 eagles on 12 February.

The startling difference in the population curves after the third week in January may be a result of a different food supply situation during the two years. This will be discussed later.

Timing of the arrival and departure of the Skagit population is very similar to that of the population of Gulf Islands, British Columbia (Hancock 1964) and the Mississippi River population (Southern 1964) (Table 4). The arrival time of the Skagit population is similar to that of the Glacier Park eagles (Shea 1973), while the departure time is similar to that of the Utah population (Edwards 1969).

TABLE 4. Arrival, peak population and departure times of wintering Bald Eagle populations.

	Arrive	Peak	Depart
Glacier Park Montana (Shea 1973)	Early-mid Oct.	Nov. 10-12	Late Nov.-Dec.
Utah (Edwards 1969)	Late Nov.-Dec.	1st week Feb.	Late March
Mississippi River, Illinois (Southern 1964)	Late Oct.	1st week Feb.	Late March
Gulf Is., B.C. (Hancock 1964)	Mid-Oct.	Mid-Feb.	Late March
Skagit River, Washington	Late Oct.	Mid-Feb.	Late March

The similarity of the seasonal movements in widely distributed populations (Table 4) is intriguing. It may indicate that local factors, such as weather, play a minor role in determining the overall migratory timing of the eagles in the fall and spring. I suspect that the spring movements are primarily controlled by proximate factors (Lack 1954, p. 5), perhaps photoperiod. I would expect subadults, being non-breeders, to be less sensitive to photoperiod in the spring and more responsive to local factors (e.g. food supply) in the wintering area. Southern (1963) has found that adults move north before subadults but this is the only area in which this has been found.

Factors Influencing Eagle Movements and Aggregations

A combination of factors controls the distribution and movements of Bald Eagles during the winter. Winter eagle distribution becomes condensed due to

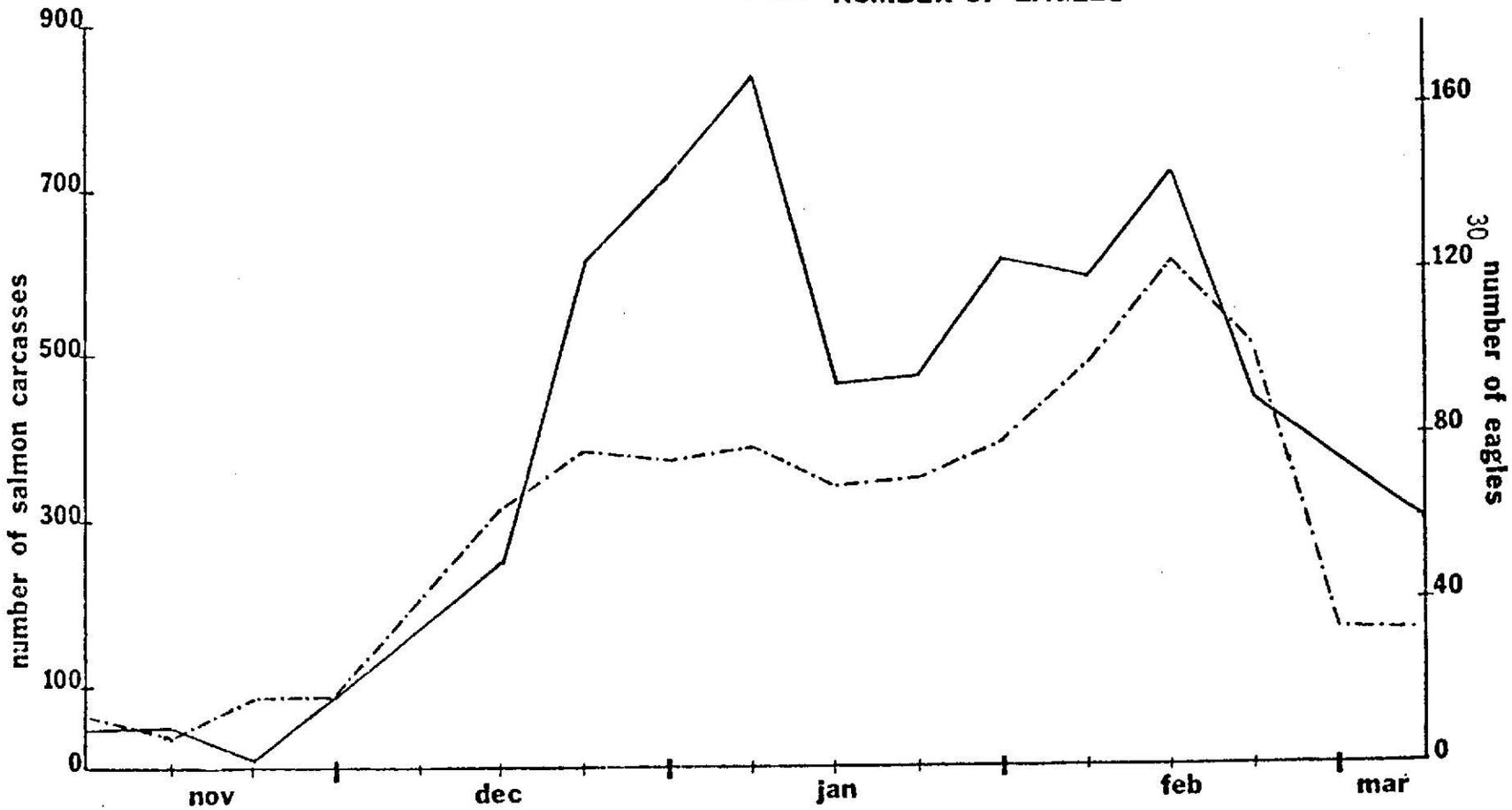
climatic conditions which cause reduction in the amount of available habitat. Winter climatic conditions are important for the Bald Eagle which is generally associated with aquatic sources of food that can be eliminated by freezing temperatures. The formation of eagle aggregations within this reduced habitat is related to the availability of food. Food availability also governs the movements of the eagles within the compressed winter habitat. The close relationship between eagle numbers and food availability on the Skagit demonstrates the importance of food supply on the formation of winter aggregations (Figure 15). The eagle aggregations on the Chilkat River (Robards 1966) and at Glacier Park (Shea 1973) are also related to food availability.

The tendency of Bald Eagles to aggregate at concentrated food sources results in their tendency for nomadic movements during the winter. The presence of hundreds or even thousands (Robards 1966) of eagles in one area will rapidly deplete a food source causing the population to disperse and move in mid-winter. A well documented example of this is the Glacier Park population which disperses in the last week of November when the salmon are depleted. The Glacier Park population dispersal occurs one week before the arrival of the eagle aggregation in Utah (Edwards 1969), approximately 950 kilometers south of Glacier Park. This suggests that the same eagles comprise both populations and they move from one area to the other in mid-winter each year. The same type of aggregation-dispersal-aggregation system may also occur on the southeast Alaska, British Columbia and Washington coasts. More data are needed to verify this hypothesis.

The tendency of Bald Eagles to aggregate during the winter to exploit concentrated food sources presents an interesting aspect of social evolution.

Figure 15. Salmon carcass availability at mile 13.3 to 13.8 north shore in relation to total eagle numbers from Rockport to Newhalem 7 November through 7 March 1974-1975. Means of salmon carcass numbers and total eagle numbers at weekly intervals.

MILE 13.3 TO 13.8 NORTH SHORE
SALMON AVAILABILITY
IN RELATION TO EAGLE NUMBERS 1974-75
MEANS AT WEEKLY INTERVALS
—— TOTAL SALMON CARCASSES
-·-· NUMBER OF EAGLES



It is possible that the Bald Eagle has evolved a social system which enables it to more efficiently utilize concentrated food sources. Such a social system could minimize intraspecific combat over food and thereby maximize food utilization and minimize energy loss. Also, such a system would be advantageous to such a large, well-armed predator in order to minimize injuries that could be the results of intraspecific combat. More data are needed on the possibilities of a social system in wintering Bald Eagles and its evolutionary significance.

Plumage Characteristics of Subadult Bald Eagles

In order to determine the age structure of the Skagit Bald Eagle population I had to use an aging method that was both accurate and applicable to field conditions. This section presents my efforts to develop such a system based on the work of Southern (1964, 1967) and my own observations with captive and wild eagles.

The plumage of subadult Bald Eagles is variable from year to year. Bent (1937) was the first to attempt to describe these variations. However, he had insufficient data to permit an accurate description of the age classes. Based on observation of a single bird, Crandall (1941) gave a brief and incomplete description of plumage changes.

Confusion about the amount of variation in individual subadults was still present in 1961 when Fawks postulated that observing the movements of what he called "odd colored" subadults could provide information on the seasonal movements of eagles on the Mississippi River. Southern (1964) made the first serious attempt to group subadults into yearly age classes. In a later paper, Southern (1967) verified some of his earlier conclusions about plumages, but also noted some individuals which did not fit his initial scheme. The result

of Southern's work was a working classification that could be used in the field, but which needed further clarification.

I began my research using Southern's classification and refined it with my own observations. I divided the Bald Eagles into adult and subadult categories. Subadults were considered birds from one year through five years of age. The definition of five-year old birds as subadults rather than adults was based on Bent (1937) who notes only two instances in which an eagle other than a "white-headed adult" was observed as a member of a breeding pair. Here I have assumed that five-year old birds, which do not have a pure white head, would not have been classified as adults by Bent. Thus, I have assumed that five-year old birds rarely, if ever, breed and are, therefore, functional subadults.

I have also refined Southern's classification by observing captive Bald Eagles of unknown age at the Seattle Woodland Park Zoo and closely examining the plumage characteristics of these eagles according to Southern's age classes. Through the technique of numbering the flight feathers on these captive eagles I have followed and verified by observation the transition from second to third year plumage, third to fourth year plumage, fourth to fifth year plumage, and fifth to sixth year plumage according to Southern's classification. This plumage research on captive eagles is continuing and will be reported in total at a later date.

Below is the classification of subadults into age classes according to Southern's observations, combined with my own refinements and additions. I have attempted to be as complete as possible and have included some variations I have observed. However, some eagles are difficult or impossible to place in any one category. These birds are probably either between years and

molting (Southern's "transition stage") or are extreme individual variants. I rarely encountered such birds, but when I did they were classified as unknown. Eagles were most reliabely aged by combining as many characteristics as possible on each bird before coming to a decision on its age.

First Year (Southern's Plumage A)

Head- dark brown to black

Beak- dark brown to black

Cere- dark brown to black

Iris- dark brown

Crown- black

Throat- dark brown to black

Breast- uniform dark brown with few light brown feathers, rarely with a few white spots

Back- dark brown with few light brown feathers

Upper wing coverts- dark brown with some light brown feathers, rarely with a few white feathers

Retrices- dark brown often with some greyish-white in central areas of each feather around the shaft; amount of white varies from sprinkling to 60% of central feathers

Tail coverts- dark brown

Second Year (Southern's Plumage B)

Head- brown to dark tawny brown often tan or tawny brown tips on some feathers especially on sides of head and nape

Beak- dark brown to black

Cere- dark brown to black

Iris- light brown to brown

Second Year (continued)

Crown- dark brown usually darker than nape, often a few tawny tips on some feathers, never as black as first year

Throat- dark brown with few tawny feather tips on sides

Breast- upper breast dark brown, lower breast light tawny brown; definite edge between dark upper breast and light lower breast-- this is very definitive character, sometimes few scattered white spots usually occurring as bird begins to molt to third year plumage

Back- dark brown with some light brown feathers

Upper wing coverts- light tawny brown with some darker brown and often few white feathers; some feathers may appear worn-- this light tawny brown is a distinctive characteristic

Retrices- mostly brown or black with varying amounts of dull greyish-white

Tail coverts- brown

Third Year (Southern's Plumage C)

Head- usually dark brown often tawny-tipped feathers scattered over head

Beak- grey-black at base

Cere- grey to dark brown

Iris- light brown

Crown- dark brown with few tawny-tipped feathers

Throat- dark brown to brown with tan often on sides

Breast- upper breast dark brown darker than throat with few white spots lower breast predominately white-grey with scattered dark feathers this produces mostly white effect; definite edge between upper and lower breast

Back- often greyish-white with few dark spots; birds with whitish backs are usually third year

Upper wing coverts- much dull whitish-grey often mixed with some faded tawny brown; predominately very light

Retrices- usually dark brown to black with varying amounts of white to grey-white

Third Year (continued)

Tail coverts- brown

Fourth Year (Southern's Plumage D)

Head- light brown to grey with some greyish cast; tips of feathers tawny to tan; turns greyish as molts to next plumage

Beak- dark yellow to grey on proximal one-half or rarely more, grey overall appearance

Cere- greyish-yellow

Iris- light brown to golden brown, noticeably lighter than third year

Crown- light brown tips with mostly light brown, greyish in early spring of fifth year as molts into fifth year plumage

Throat- brown, whitish on sides

Breast- upper dark brown, lower light brown with white spots scattered throughout; more white in lower breast than second year

Back- primarily brown with some white spots especially in center of back

Upper wing coverts- light brown new darker feathers mixed in; not as faded as second year

Retrices- black to brown with areas of pure white in varying amounts; white areas usually running parallel to feather shafts

Tail coverts- brown with much white speckling

Fifth Year (Southern's Plumage E)

Head- dirty white with area below and around eye usually darker than rest of head; flecks of grey or brown; noticeably duller white than adult; birds in transition between fourth and fifth year often have a darker area running from beak through eye and down the side of the head

Beak- all dull yellow with darker areas of blackish-yellow

Cere- dull yellow

Iris- yellowish to dull white, very slightly darker than adult

Fifth Year (continued)

Crown- dirty white often much browner than rest of head

Throat- dirty white

Breast- dark chocolate brown, very similar to that of adult

Back- chocolate brown, similar to adult

Upper wing coverts- brown with occasional tan or whitish feather

Retrices- mostly dull grey-white with some brown spots, noticeably duller than adult; occasionally birds will have dark tips on tail feathers resembling immature Golden Eagles but dark area is smaller than in a Golden Eagle

Tail coverts- dull white with distinct patches of brown

Sixth Year (Southern's Plumage F) Classified as adult

Head- all white as in adult, rarely brown flecks; white not completely descended on nape but this is difficult to see and is not always present

Beak- completely yellow to pale yellow

Cere- yellow; same color as beak

Iris- cream white

Crown- pure white, occasionally a small dark brown spot directly in the center of the crown

Throat- pure white

Breast- deep chocolate brown; rarely a few white feathers

Back- deep chocolate brown; rarely a few white feathers

Coverts- deep chocolate brown

Retrices- white with no spots; rarely some brown in the two outermost retrices

Tail coverts- white, occasionally a brown spot but primarily white

Age Structure of the Population

I placed each eagle observed on the censuses in both winters into one of six age classes previously described. Any eagle that could not be placed into one of these age classes was classified as unknown. Eagles that were not adults but which I was unable to age to year were classified as subadults (one year old through five years old). All others were classified as adults. Eagles classified as unknown age are not included in figures showing numbers of adults and/or subadults. Unknown age eagles, however, are included in figures showing total numbers of eagles.

In 1973-74 the arrival of large numbers of adults in early December preceeded the arrival of most of the subadult population by approximately one week (Figure 16). Shea (1973) noted the opposite in the Flathead River population with subadults arriving before adults. Southern (1964) also noted that subadults tended to move south before adults.

The 1974-75 data (Figure 17) showed a smaller difference between the arrival time of the subadults and the adults. In both years arrival of the majority of the adult population in early December was closely related with an increase in the numbers of dead chum salmon on the gravel bars (Figure 15). The arrival of the adults at this time may indicate a more rapid adult response to the increase in the food supply. Whether this response is learned through experience and/or due to more coordinated and better-timed movements by the adults is unknown. Probably a combination of both factors is responsible.

Adults did not leave the area significantly sooner than subadults (Figures 16 and 17). Shea (1973) also noted no difference in departure time between age groups, while Southern (1963) found that adults began to move

north before subadults in the Mississippi valley.

The departure of the Skagit eagles seemed to be closely related to the depletion of the food supply (Figure 15) and there seemed to be no difference between adults and subadults in this response. This may indicate no influence of "nesting urge" on adults at this time of year. Assuming that a differential departure schedule for adults and subadults would be due to a "nesting urge" in adults, the data seem to indicate that there is no "nesting urge" in the Skagit adults at this time of year. I do not believe this assumption is justified however, because all eagles are forced to leave at the same time due to a depletion of food. This probably masks any early adult departure of the type seen by Southern (1963).

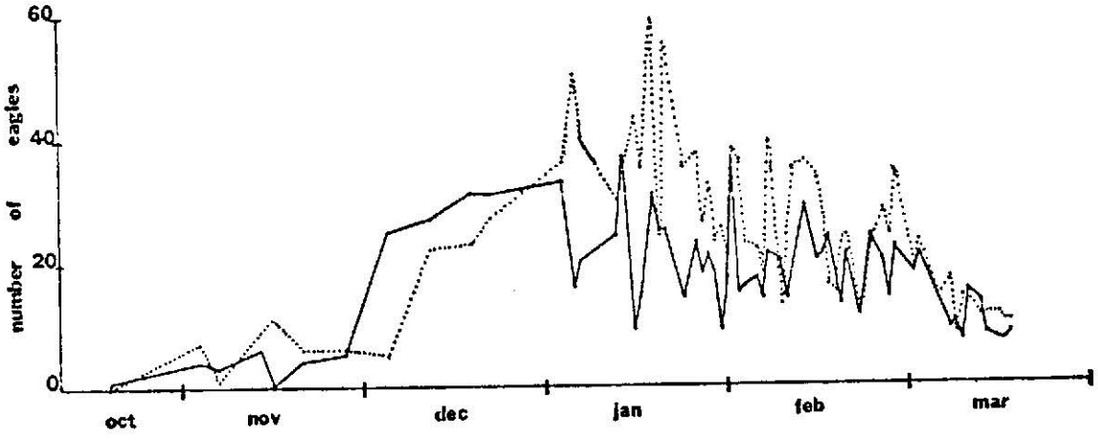
The departure of the Skagit population seems to be related to the depletion of the food supply. The depletion of the Skagit food supply occurs at the same time that other wintering populations begin to disperse and move northward (Table 5). I believe the depletion of the food supply and the photoperiodic response for spring migration occur almost simultaneously in the Skagit population, and a combination of these two factors is responsible for motivating the eagles to begin the northward spring migration. Adults probably begin to move to nesting sites after leaving the Skagit area, while subadults disperse and begin a gradual northward movement mediated primarily by the availability of food sources. More data are needed before this theory can be accepted.

The numbers of adults and subadults in both seasons are presented in Figures 18 through 21. The influx of eagles in mid-February 1975 consisted mostly of subadult eagles. There were a greater number of adult eagles present throughout 1974-75 than 1973-74 (Figures 20 and 21). I speculate

Figure 16. Adult and subadult Bald Eagle numbers, Rockport to Newhalem, 18 October through 15 March 1973-1974.

Figure 17. Adult and subadult Bald Eagle numbers, Rockport to Newhalem, 15 October through 15 March 1974-1975.

1973-74
ROCKPORT TO NEWHALEM
ADULTS — SUBADULTS ----



1974-75
ROCKPORT TO NEWHALEM
ADULTS — SUBADULTS ----

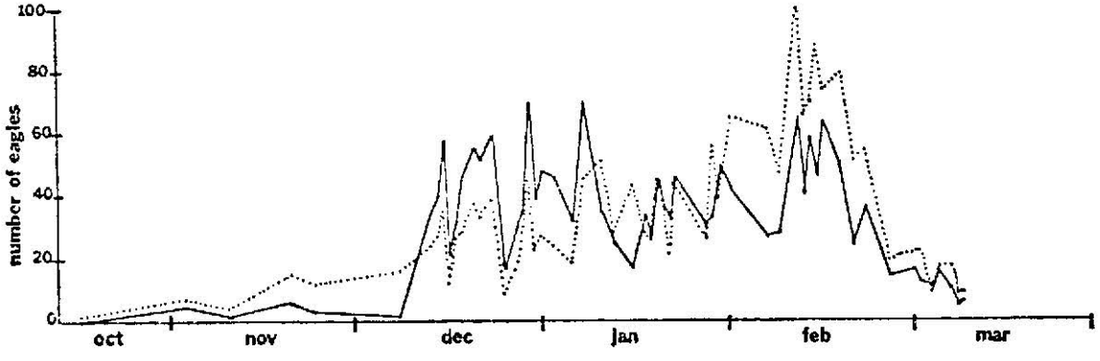
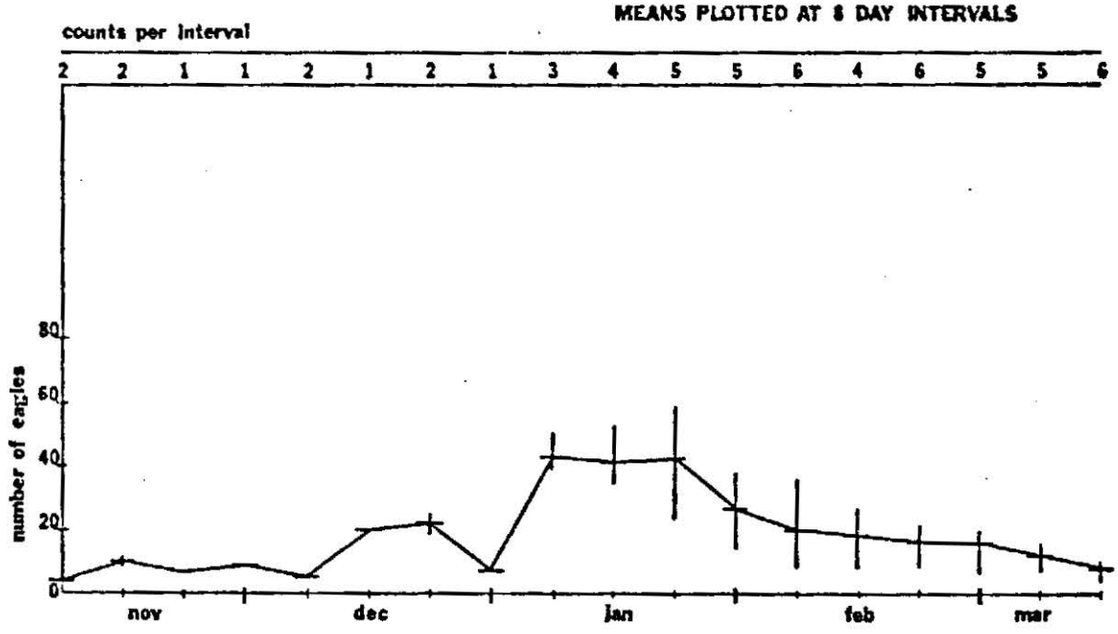


Figure 18. Subadult eagles, Rockport to Newhalem, 7 November through 15 March 1973-1974. Means plotted at 8 day intervals. Vertical lines at each interval indicate the range of counts during that interval.

Figure 19. Subadult eagles, Rockport to Newhalem, 7 November through 15 March 1974-1975. Means plotted at 8 day intervals. Vertical lines at each interval indicate the range of counts during that interval.

1973-74
ROCKPORT TO NEWHALEM
SUBADULT EAGLES
MEANS PLOTTED AT 8 DAY INTERVALS



1974-75
ROCKPORT TO NEWHALEM
SUBADULT EAGLES
MEANS PLOTTED AT 8 DAY INTERVALS

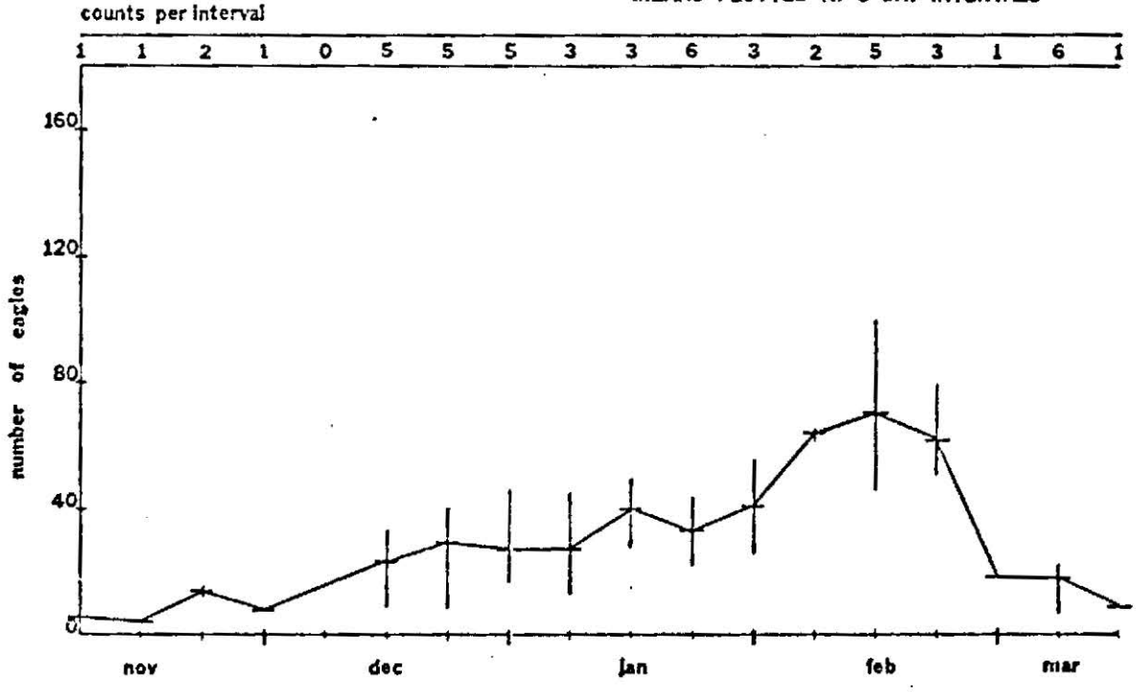
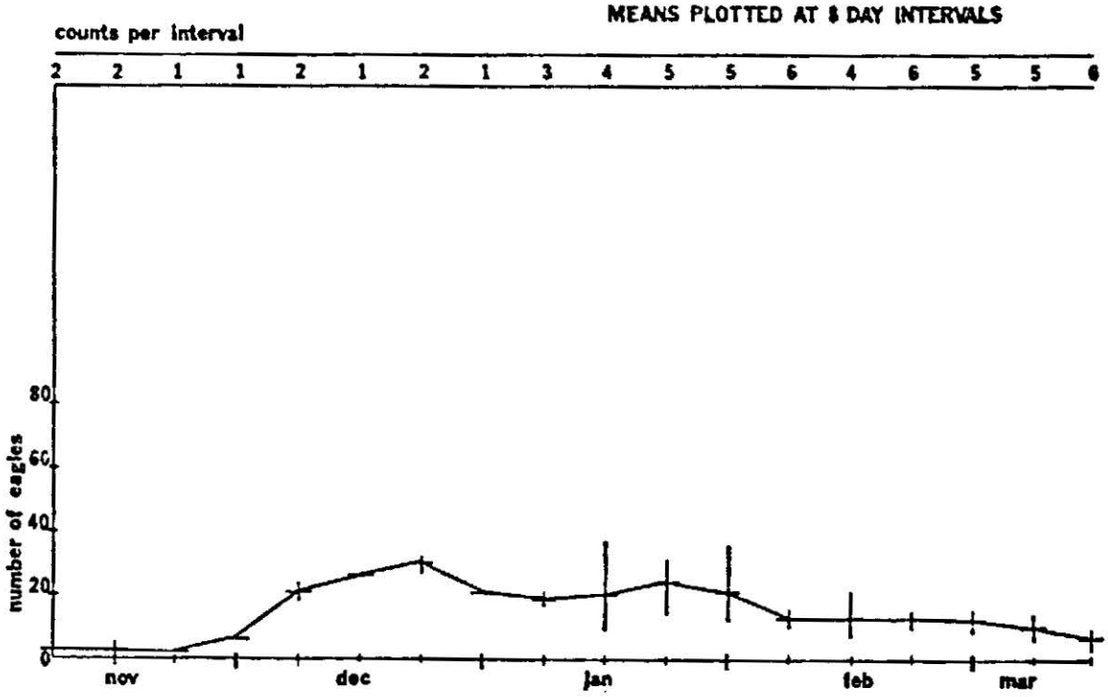


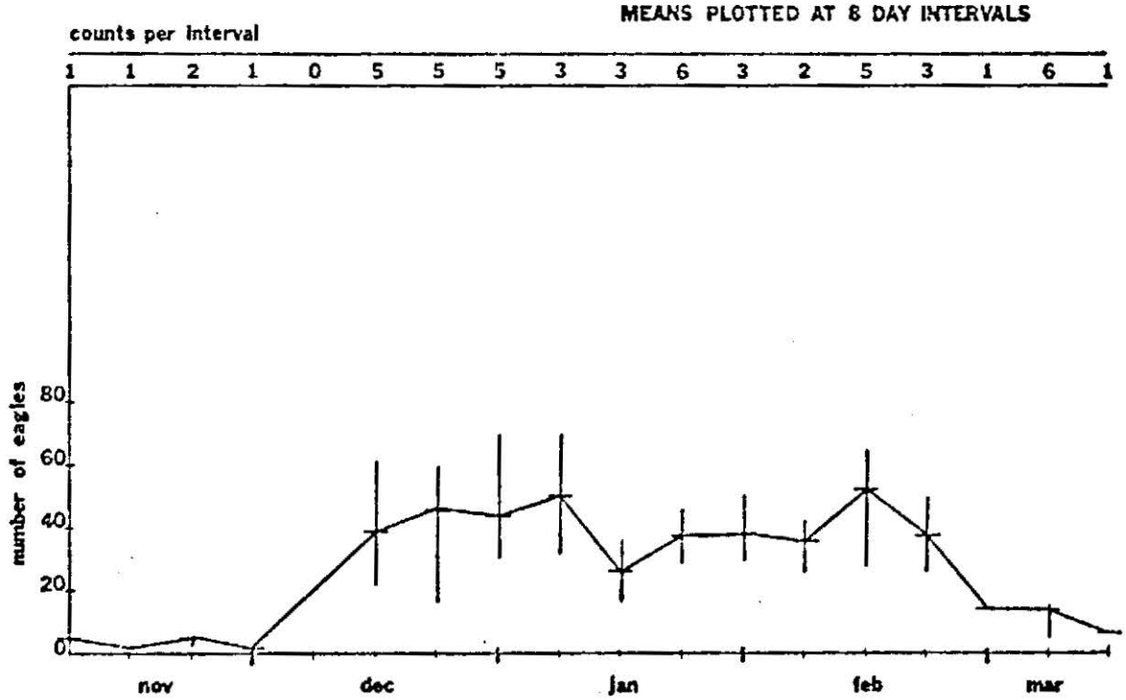
Figure 20. Adult eagles, Rockport to Newhalem, 7 November through 15 March 1973-1974. Means plotted at 8 day intervals. Vertical lines at each interval indicate the range of counts during that interval.

Figure 21. Adult eagles, Rockport to Newhalem, 7 November through 15 March 1974-1975. Means plotted at 8 day intervals. Vertical lines at each interval indicate the range of counts during that interval.

1973-74
ROCKPORT TO NEWHALEM
ADULT EAGLES
MEANS PLOTTED AT 8 DAY INTERVALS



1974-75
ROCKPORT TO NEWHALEM
ADULT EAGLES
MEANS PLOTTED AT 8 DAY INTERVALS



that this increase in numbers was partially due to the effects of the mid-January flood in 1974. This unusual flood (USGS, Water Res. Div., unpub. rec.) removed most of the available food for the rest of the season. The population began to decline after this flood (Figure 13) in response to the lack of food. In 1974-75 there was no flood,and food and eagles were abundant until the end of February (Figures 14 and 15). Thus, it seems that 1973-74 was an abnormal year in terms of food supply and may not be representative of the usual seasonal population fluctuations of the Skagit population.

The Percentage of Subadults in the Population

As previously stated, I classified subadults as all those age one through five years. In order to make a valid comparison of the subadult percentage of the Skagit population to previously published data, the classification of subadults must be identical. Only Southern (1964) and Edwards (1969) have mentioned the criteria they used to classify subadults. Only Southern (1964) and I classified five-year old birds as subadults. I assume that all other researchers combined five-year old birds with the adult age class as did Edwards (1969) because five-year old eagles resemble adults unless carefully observed. My data on percentage of subadults in the population will be proportionally higher than that of all other workers except Southern (1963) because I have included five-year olds with subadults.

The percentage of subadults in the Skagit wintering population is presented in Figures 22 and 23 and Tables 4 and 5. The subadults comprise a relatively high percentage of the population in November, but with the arrival of the adults in December the percentage drops. By the beginning of January more subadults have begun to arrive and the percentage then becomes relatively constant through the rest of the season. The monthly percentage

TABLE 5.
1973-74 PERCENTAGE OF SUBADULT BALD EAGLES IN TOTAL POPULATION
(Subadults as 1 yr through 5 yr plus unknown subadults)

WEEK	COUNTS PER WEEK	HIGH PERCENT-AGE	LOW PERCENT-AGE	WEEKLY PERCENT-AGE MEAN	MONTHLY PERCENT-AGE MEAN
Nov					
1	2	63.6	25.0	44.3	
2	2	100.0	60.0	80.0	59.7
3	1	-	-	60.0	
4	1	-	-	54.5	
Dec					
1	1	-	-	16.7	
2	1	-	-	44.9	35.4
3	2	46.5	42.6	44.5	
4	0	-	-	-	
Jan					
1	3	74.6	51.9	59.5	
2	4	82.7	36.6	56.5	58.6
3	4	67.1	47.1	60.3	
4	7	73.5	50.0	58.0	
Feb					
1	5	67.9	44.9	57.5	
2	6	64.8	35.1	53.7	55.3
3	6	63.9	40.0	49.6	
4	3	63.2	57.1	60.3	
Mar					
1	5	63.0	44.4	50.9	
2	6	61.1	45.8	55.0	53.8
3	1	-	-	55.6	
4	0	-	-	-	

Yearly Average 52.6%

TABLE 6.
1974-75 PERCENTAGE OF SUBADULT BALD EAGLES IN TOTAL POPULATION
(Subadults as 1 yr through 5 yr plus unknown subadults)

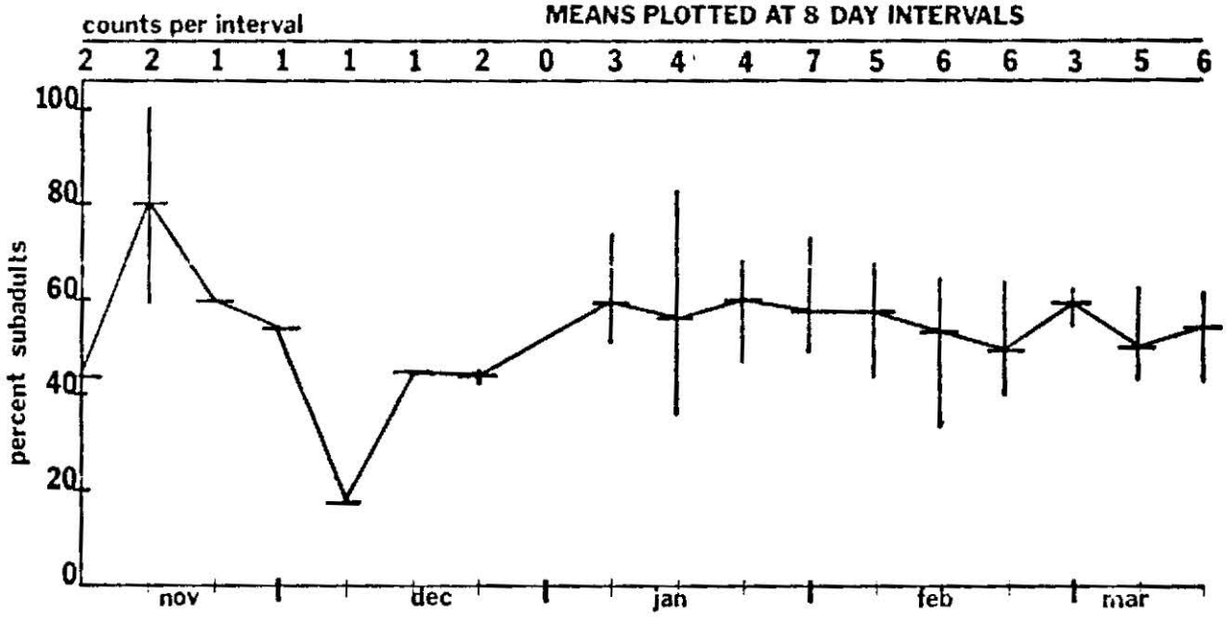
WEEK	COUNTS PER WEEK	HIGH PERCENT-AGE	LOW PERCENT-AGE	WEEKLY PERCENT-AGE MEAN	MONTHLY PERCENT-AGE MEAN
Nov					
1	1	-	-	41.7	
2	1	-	-	66.7	60.6
3	2	80.0	66.7	73.4	
4	0	-	-	-	
Dec					
1	1	-	-	38.9	
2	5	43.9	28.1	36.7	37.7
3	5	39.8	33.3	37.9	
4	5	43.8	32.6	37.2	
Jan					
1	3	39.1	26.0	33.1	
2	3	67.2	52.8	59.4	47.5
3	6	50.0	39.6	46.1	
4	3	62.9	44.4	51.2	
Feb					
1	2	69.7	60.2	65.0	
2	6	64.2	53.6	49.4	58.3
3	3	63.0	59.1	61.1	
4	1	-	-	57.6	
Mar					
1	6	64.7	45.0	57.3	
2	1	-	-	60.0	58.7
3	0	-	-	-	
4	0	-	-	-	

Yearly Average 52.6%

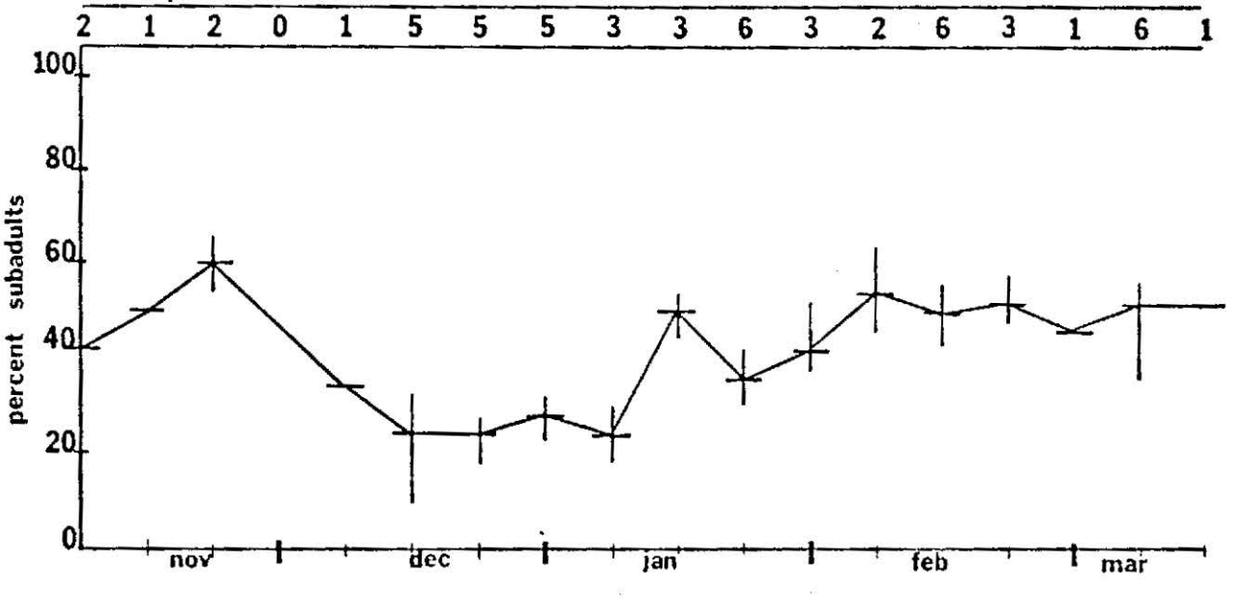
Figure 22. 1973-74 Percentage of subadult Bald Eagles in total population plotted as means at 8 day intervals. Vertical lines at each interval represent the range during that interval. Subadults are eagles one year old through five years old.

Figure 23. 1974-75 Percentage of subadult Bald Eagles in total population plotted as means at 8 day intervals. Vertical lines at each interval represent the range during that interval. Subadults are eagles one year old through five years old.

1973-74 ROCKPORT TO NEWHALEM
PERCENTAGE OF SUBADULTS IN TOTAL POPULATION
MEANS PLOTTED AT 8 DAY INTERVALS



1974-75 ROCKPORT TO NEWHALEM
PERCENTAGE OF SUBADULTS IN TOTAL POPULATION
MEANS PLOTTED AT 8 DAY INTERVALS



means are fairly similar for the two seasons (Tables 5 and 6). The overall yearly mean is identical for both years at 52.6%.

The valid comparison of subadult percentages between different populations must be based on several important assumptions. These include: (1) similar migratory patterns between adults and subadults in different environments; (2) similar habitat selection by adults and subadults; and (3) similar response of adults to environmental factors and human disturbance in the area. Obviously, these assumptions cannot be accepted with the current amount of knowledge available on Bald Eagle ecology and behavior. The comparison of subadult percentages between wintering populations, then, is of limited value and can only be used in the broadest sense to compare the productivity of different populations.

The list of published subadult percentages is extremely varied (Table 6). Most results show a surprisingly low percentage of subadults, especially for a bird that maintains subadult status for at least four years. The data from the Mississippi River are particularly low. Southern's work on the Mississippi (1963) was the most meticulous and yet yielded the lowest subadult percentage of all. Obviously much more needs to be learned about the movements of adults and subadults in the winter before any valid conclusions can be drawn from these types of data.

TABLE 7. Percentage of subadults in different wintering populations.

Source	Area	Subadult Percentage
Fawks (1961)	Michigan	15.9
	Illinois (Mississippi River valley)	23.0
	Mississippi River (19 Feb. 1961)	10.6
Hancock (1964)	Gulf Islands, British Columbia	
	(16 Jan. 1963)	36.0
	(12 Feb. 1963)	53.0
Southern (1963)	Illinois (Mississippi River)	5.6
Sprunt (1962)	46 states	24.0
	Washington state	20.0
Fawks (1974)	Mississippi River (St. Louis to St. Paul)	
	1966	19.6
	1967	13.7
Sprunt (1963)	48 states (Jan. 1963)	21.6
	Washington state	27.0
Edwards (1969)	Utah 1966-67	33.5
	1967-68	34.5
	1968-69	38.0
Shea (1973)	Glacier Park, Montana	
	1971	54.5
	1972	29.2
This study	Skagit River, Washington	
	1973-74	52.6
	1974-75	52.6

Hancock's (1964) study is the only other study on the Pacific Northwest coast with which I have to compare my subadult percentage data. Hancock's data, however, are difficult to interpret. I believe the comparison of the Skagit data to his is of limited value due to his assumptions and the fact

that he does not define how he classified adults and subadults. Using his "peak counts" in February for the islands in his study area I calculate 62.6% subadults. My peak counts in February were also in the 50-70% range. Perhaps this indicates that in 10 years the subadult population has remained constant in the coastal area and that the winter distribution of subadults is similar in the coastal islands and the inland rivers. However, only a study using similar assumptions and methods on coastal wintering birds and inland wintering birds will yield the age distribution data necessary to make this type of comparison.

Subadult Age Classes

The percentage of each subadult age class in the total population is presented in Tables 8 and 9; and in Figure 24. No readily discernable pattern can be seen in the monthly variations for the age classes over the two year period. There is a decrease in the percentage of five-year old birds in the latter part of the season in 1973-74 in comparison with 1974-75. This could be due to a greater responsiveness of these older birds to the depletion of the food source that occurred in 1973-74 during this time. I suspect, however, that the difference is not due to such responsiveness because no similar drop is seen in any of the other age classes.

The larger number of one-year old birds in 1973-74 seems to be reflected in the larger number of two-year old birds that arrived the next year. This may indicate that the productivity of the population that winters in the Skagit area was better in 1973-74 than in 1974-75. Such an extrapolation technique could yield valuable information on year-to-year population productivity, but long-term studies are needed to determine if the technique is valid. If the origin of the Skagit eagles can be determined, a comparison

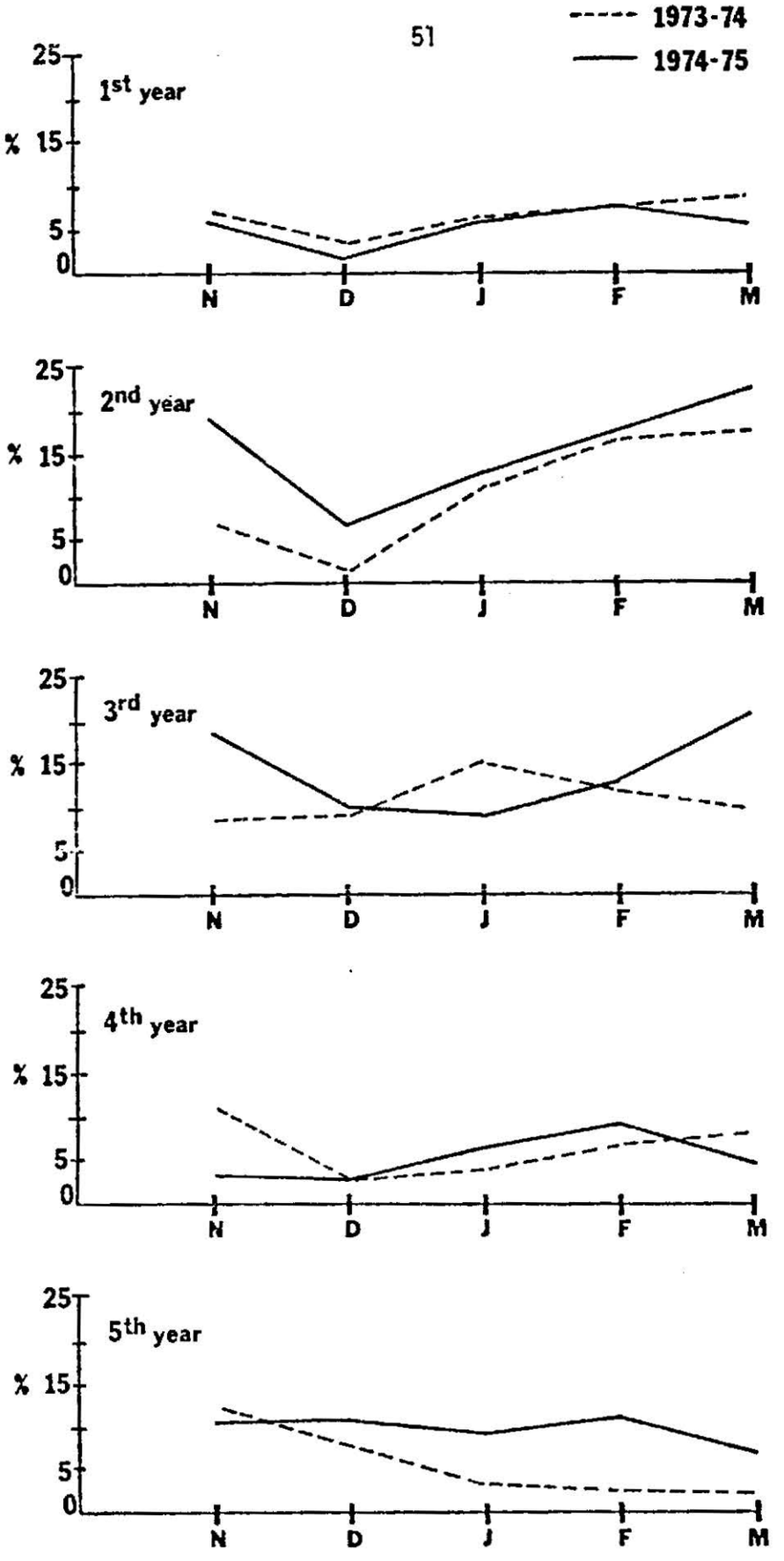
TABLE 8.
1973-74 PERCENTAGE OF EACH AGE CLASS IN TOTAL POPULATION
Seasonal mean for each age class figured with monthly means.

	5 yr		4 yr		3 yr		2 yr		1 yr	
Week	Wk	Mo	Wk	Mo	Wk	Mo	Wk	Mo	Wk	Mo
Nov										
1	0		0		17.0		0		0	
2	14.5	13.0	7.9	13.8	11.3	9.6	6.7	6.7	6.7	6.7
3	10.0		20.0		10.0		20.0		0	
4	27.3		27.3		0		0		0	
Dec										
1	10.0		3.3		0		3.3		0	
2	8.2	7.9	4.1	3.0	16.3	9.9	2.0	1.8	6.1	3.9
3	5.6		1.7		13.4		0		5.6	
4	-		-		-		-		-	
Jan										
1	1.9		4.8		18.6		8.6		7.7	
2	6.5	3.6	3.2	4.1	12.8	15.5	8.0	11.4	4.6	6.4
3	3.7		4.1		14.3		11.7		5.9	
4	2.4		4.3		16.3		17.2		7.4	
Feb										
1	2.7		5.7		18.1		13.5		6.2	
2	2.5	2.2	4.2	6.9	11.7	12.9	15.1	16.1	7.8	7.3
3	2.0		4.8		12.7		14.0		7.3	
4	1.4		13.0		9.9		21.7		7.8	
Mar										
1	1.2		6.7		10.5		18.0		10.2	
2	2.5	3.1	6.6	8.1	8.6	10.1	20.2	16.4	12.0	7.4
3	5.6		11.1		11.1		11.1		0	
4	-		-		-		-		-	
Seasonal Mean		6.0		7.2		11.6		10.5		6.3

TABLE 9.
1974-75 PERCENTAGE OF EACH AGE CLASS IN TOTAL POPULATION
Seasonal mean for each class figured with monthly means.

	5 yr		4 yr		3 yr		2 yr		1 yr	
Week	Wk	Mo	Wk	Mo	Wk	Mo	Wk	Mo	Wk	Mo
Nov										
1	0		8.3		25.0		8.3		0	
2	16.7	10.2	0	4.4	0	18.6	33.3	19.6	16.7	7.4
3	13.8		4.8		30.9		17.2		5.6	
4	-		-		-		-		-	
Dec										
1	5.6		0		16.7		5.6		0	
2	13.2	10.5	5.0	3.7	7.6	10.0	6.4	7.4	1.6	2.2
3	14.1		4.7		7.3		7.4		3.9	
4	8.9		4.9		8.5		10.2		3.3	
Jan										
1	9.6		6.3		4.2		8.3		3.5	
2	9.0	9.3	9.3	7.8	10.5	8.7	17.8	13.9	8.0	6.0
3	10.5		9.0		11.1		11.7		4.0	
4	8.0		6.7		8.8		17.8		8.3	
Feb										
1	10.3		10.0		10.9		17.0		12.0	
2	9.5	12.5	9.6	9.4	14.3	12.5	16.4	17.3	7.6	7.8
3	8.9		9.0		12.6		17.6		8.7	
4	21.1		9.1		12.1		18.2		3.0	
Mar										
1	5.3		3.0		20.6		17.6		5.8	
2	6.7	6.0	6.7	4.9	20.0	20.3	26.7	22.2	0	5.8
3	-		-		-		-		-	
4	-		-		-		-		-	
Seasonal Mean		9.7		6.0		14.0		16.1		5.8

Figure 24. Each age class as an average percentage of the population for each month during the winter. Data derived from Tables 8 and 9.


1973-74
1974-75
1st year
2nd year
3rd year
4th year
5th year
%
25
15
5
0
N
D
J
F
M

between the number of young fledged in the spring and the number of one-year old birds arriving at the wintering area would aid in determining the usefulness of such a technique.

The monthly variation of the one and two-year old populations are similar in both seasons, while the difference in monthly variation between the two seasons is more dramatic for the three, four and five-year old birds. This may indicate that these older eagles have a greater tendency to move during the winter in response to changing food supplies and environmental factors. Such responsiveness may be a result of learning and familiarity with the area. This is speculation of course, but it seems likely that a more experienced bird would know when to leave the wintering area when food supplies become low.

The relatively low percentage of one-year old birds in comparison with two-year olds may indicate that the one-year olds do not tend to move south very far in their first winter. If this is true,then the origin of those that do reach the Skagit area may be from nests near-by such as the San Juan Islands approximately 90 miles west of Marblemount. The data seem to indicate that most one-year olds do not winter with the Skagit population. The question of a differential age migration and where one-year old birds winter are two of the most interesting questions in eagle biology, and more research needs to be done to solve them.

Daily Activity

Daily activity consisted of feeding, perching, flying along the river, soaring in the valley and night roosting. Variable amounts of time were invested in each of these activities depending on the river level, weather, amount of food available and the human presence in feeding and perching areas.

Feeding usually occurred twice each day. When leaving night roosts, eagles would usually move to feeding areas. Feeding sites were used consistently from day to day until the food at that site was depleted or until river conditions changed the availability of the food. Feeding was intensive until approximately 1000 hours. When food was plentiful (see Figure 15), feeding began again in the late afternoon approximately two hours before sunset and continued until the eagles moved to the night roost. When food was scarce in the early and later parts of the season feeding was not limited to two periods, and eagles could be observed feeding and searching for food at any time during the daylight period.

Perching usually followed feeding and was usually done near the feeding area used. After eating, eagles would perch for several hours, often on the same branch. It was not uncommon to observe an eagle perched in the same spot for 6 to 8 hours until the evening feeding period began. This long-term perching usually occurred in poor weather such as heavy rain or wet snow with little or no wind. Eagles would often perch on driftwood on the gravel bars before or after feeding. If the area was free from disturbance some individuals might remain on such perches for hours, but usually trees were the most favored long-term perches.

Flying along the river was usually for travel from the night roost to the feeding area, from one feeding area to another, or from the feeding area to a perching site some distance away. Such flights were usually done at an altitude of 100 meters or less. These flights were characterized by deep wingbeats while enroute and gliding and slow circling around the feeding or perching destination before landing. On two occasions I was able to drive beside a flying eagle along a road paralleling the river. By matching the car speed to

that of the eagle, speeds of 30 and 38 mph were recorded on the car speedometer. These speeds were recorded on calm days and respresent the level flight speed range for the Bald Eagles under calm conditions at low altitudes.

Soaring usually occurred only on days with a strong wind or when there were few clouds and sunlight was able to produce warm thermal columns of air. On such days feeding and perching would be abbreviated and most of the day would be devoted to soaring (Table 10). Soaring usually took place along the ridges on the north side of the valley. The most popular area was between miles 13.0 and 16.0. Soaring was usually done in a group and was often accompanied by chases and dives among the eagles.

If the sun appeared through the clouds in the middle of the day, perched eagles would often begin to fly in circles together as they attempted to find a column of rising warm air to gain altitude. Perched eagles would often respond to the sight of soaring eagles by flying to the area and ascending into the soaring group.

Soaring was observed several times below banks of clouds that formed at the top of ridges. Eagles were rarely observed to enter these clouds but stayed below them along the ridge. When such clouds began to descend the eagles would also descend and would often glide down to perch along the river as the clouds got lower and formed low stratus formations. I did observe eagles entering opaque clouds once (Servheen, in press) and they may do so more often than is generally thought, perhaps in an effort to begin long-distance movements.

I have observed soaring eagles disappear from sight at high altitudes. I believe it possible that they may initiate movements in this way either

between drainages or long-distance migratory movements. More work needs to be done on this subject to determine the amount of movement between drainages and the methods used by such traveling eagles in crossing mountain ranges.

Soaring eagles would often glide down to the river to begin feeding in the late afternoon. The dissolution of the soaring group in this manner was often very rapid with 10 to 20 eagles appearing on the feeding bar in a matter of minutes. The social significance of such group soaring is yet to be established but perhaps it is advantageous in locating food sources.

I located night roosts at mile 13.6, mile 15.3 through 15.6 and on the south-facing ridge opposite mile 14.5 through 15.5. The eagles roosted throughout this timbered south-facing ridge. Roosting activity on this ridge was most intense in 1973-74 when 20 to 30 eagles roosted throughout the season in a group of 12 to 15 dead conifers approximately 1500 feet above the valley floor on the side of the ridge. Roosting in this night roost was observed only twice in 1974-75 when food was much more abundant than in 1973-74. I believe that there may be adaptive value in group roosting when the food supply is clumped and non-randomly distributed along the river. This would agree with the theory that such roosting aggregations are adapted as information centers for those birds that have difficulty in finding food sources (Ward and Zahavi 1973). I suspect that night roosting is part of the social structure of the winter eagle population and that this social structure has evolved partially in response to the distribution of the food source. I also feel that the social structure of the eagles is similar to that of the crows in the area that share the eagles' salmon food source.

Eagle activity is related to environmental conditions. Fewer eagles were perching and more were flying as wind speed increased (Table 10). The percent-

age of eagles feeding also decreased as wind speed increased and more eagles began to soar.

TABLE 10. Percentage of eagles observed on census counts involved in perching, activities on the feeding bar, and flying & soaring at different wind velocities.

	WIND SPEED (mph)				
	0-5	6-10	11-15	16-20	21-30
ACTIVITY					
Perched in tree N=2647	69.5%	67.0%	64.5%	56.8%	48.2%
On feeding bar N=1027	27.2%	27.1%	33.9%	13.5%	19.7%
Flying & soaring N=150	3.1%	7.9%	1.6%	29.7%	35.8%
N= 3824					

Heavy cloud cover increased the number of eagles perching and decreased the number of eagles flying (Table 11). Clear days or days with broken cloud formations allowed sunlight to form thermal columns and this stimulated soaring activity. Little change is seen in the percentage of eagles feeding on gravel bars in response to cloud conditions in contrast to the reduction of eagles on the gravel bars with increased wind speed. This may indicate that high wind is more of a stimulus to soaring-flying activity than is the formation of thermal columns.

TABLE 11. Percentage of eagles observed on census counts involved in perching, activities on the feeding bar, and flying & soaring at different cloud conditions.

	CLOUD CONDITIONS			
	No clouds	Broken clouds	High overcast	Low overcast
ACTIVITY				
Perched in tree N= 2202	57.3%	68.1%	73.0%	70.5%
On feeding bar N=838	26.1%	27.7%	20.5%	26.9%
Flying & soaring N=144	15.1%	4.3%	6.6%	2.5%
N= 3185				

Habitat Utilization

Open gravel bars were preferred over river banks as feeding sites. Salmon carcasses on open bars were initially consumed by the eagles and carcasses in brush or along the narrow river banks were consumed only when nothing else was available. Gravel bars most heavily utilized by feeding eagles were located at mile 12.8 through mile 14.0, mile 14.8, and mile 16.2 through 16.4.

When not feeding eagles often perched in trees along the river. These perching areas were usually adjacent to important feeding sites. The eagles preferred to perch in large trees, probably because of the lack of interfering small branches on such trees and the availability of branches large enough to support their weight. Areas having a uniform stand of second growth along the river and lacking large trees rarely were utilized by perching eagles even when these areas were relatively undisturbed by human activity. The gravel bar

areas previously mentioned as being heavily utilized by eagles all had large trees available for perching in the immediate area and this may have been one of their attractions for the eagles.

The availability of large trees for perching is important to eagles and influences their distribution on the river. Eagles seemed to prefer perching in deciduous trees along the river, although, in the area between Rockport and Marblemount deciduous trees predominate and this may influence the validity of an observed preference. Of 2462 observations of eagles perched in trees along the river 89.0% were in deciduous trees, 9.3% were in coniferous trees and 1.7% were in dead trees.

Most eagles perched in the top one third of trees along the river. Of a total of 2468 observations of eagles perched in trees along the river, 3.8% were in the bottom one third of the tree, 29.1% were in the middle one third, 64.4% were in the top one third, and 2.6% were on the very top of the tree. The eagles perching on the top of the tree were either in coniferous trees or in dead trees since the morphology of deciduous trees makes it impossible for eagles to perch on the top of them. Perch height selection is probably due in part to visibility afforded by the perch and partially due to the availability of suitable branches at the chosen height.

It seemed likely that crop condition would also effect the choice of perch height in that an eagle with a full crop would be less likely to fly to the top of a tree. To test this hypothesis, I determined crop condition of perched eagles with a spotting scope. An eagle that has eaten heavily within one to two hours will display a bulging crop. The results are presented in Table 12. Of 590 observations of perched eagles on which I could observe the crop area, there was a significant difference in the perch height

between those with an empty crop and those with evidence of crop fullness (χ^2 test, $p < .01$, 3 d.f.).

Thus, eagles will choose lower perches after eating. I speculate that this is related to the energetics of flying with up to 10% (Servheen, unpub. data) of their body weight in their crop. There also may be a social factor involved in that eagles who have just eaten have no need to observe from a high perch the movements of other eagles to possible food sources. More data is needed to prove that such visual interaction is important in locating feeding sites.

TABLE 12. Percentage of eagles observed on census counts with empty and full crops at different perch heights.

	PERCH HEIGHT			
	Bottom one-third	Middle one-third	Top one-third	Top
CROP CONDITION				
Empty N=283	42.4%	34.0%	56.2%	64.3%
Full N=307	57.6%	66.0%	43.8%	35.7%
N= 590				

Eagles usually perched or fed in areas of least human activity. Since the main road in the study area runs along the north side of the river,most eagles were observed on the south side. This was especially true in the areas where the main road was close to the river. Of a total of 3494 eagle observations during census counts 68.5% were on the south shore, 19.7% on islands

in the river and only 11.8% on the north shore. Most of the north shore use was at the large feeding bar at mile 13.5.

Distribution

Between Rockport and Newhalem, certain areas are preferred by the eagles. These preferences are largely based on availability of open gravel bars along the river and the salmon carcasses that wash up on these bars. Other factors which have a minor influence on habitat preference are the amount of human development along the river shore and the amount of human activity, either walking on shore or in boats on the river.

The importance of gravel bars in habitat preference can be seen in Figure 25. Each 0.5 mile interval with a high number of observations also has a large amount of open gravel bar. Along with salmon carcass availability, visibility while on the ground is also a factor attracting the eagles to gravel bars. Eagles are reluctant to land on the ground in areas where they do not have good visibility in all directions. This is probably an adaptation to avoid predation, and is shared by birds who need a long flight trajectory to take off and who depend on eyesight to warn them of danger. This affinity for open areas precludes the use of much of the thickly vegetated, narrow shoreline along the river, even when salmon are scarce on the open gravel bars.

The distribution of the eagles on the river changes over the wintering period (Figures 26 and 27 and 32 through 45). The areas initially used are those with the least amount of human disturbance. The most heavily used area that meets this requirement is the area from mile 16.0 through 16.5. This gravel bar is an island and was upriver from the area of most boat traffic. This gravel bar is extensively used until all the salmon carcasses on the bar are eaten. As salmon become scarce at this site, the large concentrations

Figure 25. Bald Eagle distribution along the Skagit River in 0.5 mile intervals for the 1974-75 season. Percent represents percent of total observations at each interval. For river mileages refer to Figures 3 through 9. Total number of census observations is 3560 13 December through 13 March.

OBSERVATIONS BY 0.5 MILE INTERVALS N = 3560

EAGLE DISTRIBUTION FOR 1974-75 SEASON, DEC 13 THRU MAR 13

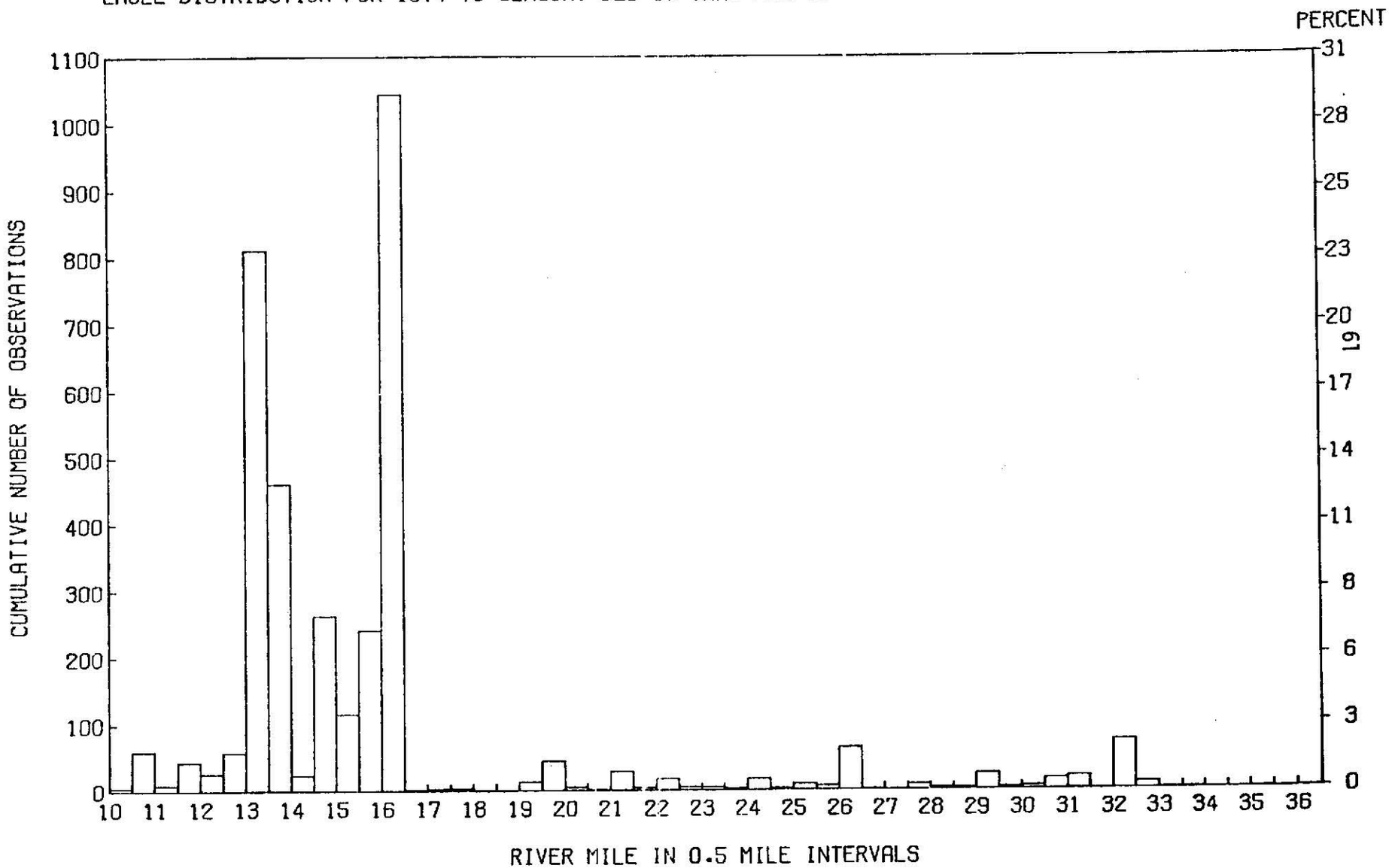


Figure 26. Eagle distribution for week 1, 13 December through 19 December 1974-75.

Figure 27. Eagle distribution for week 12, 28 February through 6 March 1974-75.

Fig. 26

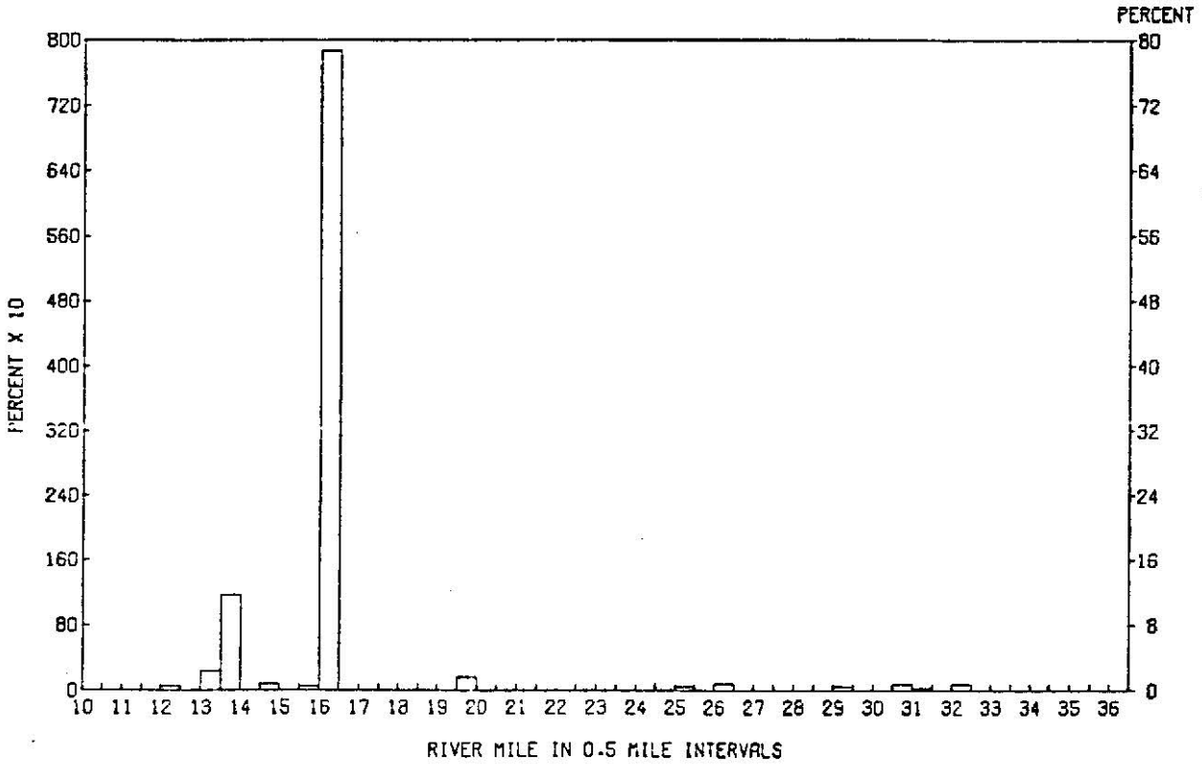
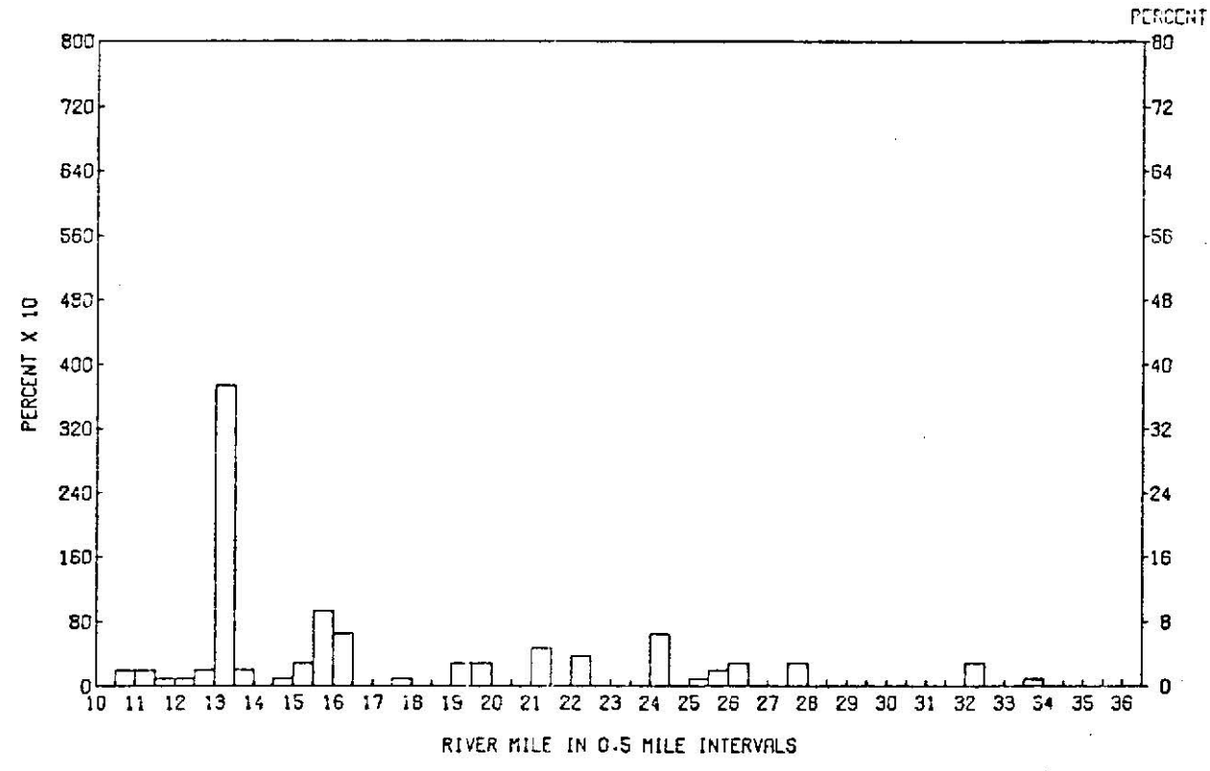

PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS 62 N = 375
EAGLE DISTRIBUTION FOR WEEK 1, DEC 13 THRU 19
PERCENT
PERCENT X 10
800
720
640
560
480
400
320
240
160
80
0
80
72
64
56
48
40
32
24
16
8
0
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
RIVER MILE IN 0.5 MILE INTERVALS

Fig 27


PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 107
EAGLE DISTRIBUTION FOR WEEK 12, FEB 28 THRU MAR 6
PERCENT
PERCENT X 10
800
720
640
560
480
400
320
240
160
80
0
80
72
64
56
48
40
32
24
16
8
0
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
RIVER MILE IN 0.5 MILE INTERVALS

of eagles (up to 90 at one time) that feed on this bar daily begin to move to other bars where the salmon are not yet utilized. Most eagles move to the gravel bars at mile 13.0 through 14.0 and by 24 January 1975 most eagles were using this area (Figure 38).

The heavy use of the mile 16.0 site before mile 13.0 indicates that the eagles prefer areas of minimum human activity. Salmon availability on the two gravel bars is similar in timing and amount. The mile 13.0 gravel bar is on the north shore, is close to the road, and receives human use by fishermen and people walking on the bar. The eagles only began to use this disturbed area when food becomes scarce at the isolated gravel bar at mile 16.0.

When salmon are plentiful in the early part of the winter the eagles concentrate at areas where habitat conditions are favorable. As the season progresses and the concentrated salmon carcasses at favorable sites are consumed, the eagle distribution changes and eagles begin to disperse on the river. This change in eagle distribution reflects the change in food distribution. The eagles are concentrated whenever and wherever there is food and disperse as the concentrated food is utilized. Thus, the eagle distribution changes as food distribution changes, allowing maximum foraging efficiency on a variable food resource.

Food Habits

Salmon are the chief food resource of Bald Eagles wintering between Rockport and Newhalem. The salmon are eaten only after they have spawned and died. Only natural spawning salmon contribute to the eagles food supply. Of these, no data are available on the percentages of natural spawners that are washed up on gravel bars, but is probably small. The increased number of salmon that are artificially spawned each year in the Washington State Depart-

ment of Fisheries Salmon Hatchery at Marblemount (Table 13) are of no consequence to the wintering eagles as the carcasses are sold and not returned to the river. No eagle was observed to capture or attempt to capture a live salmon, although dying salmon in shallow riffles were numerous and in clear view at certain times of the season.

Dead salmon were eaten when they were washed onto gravel bars or were in shallow water near shore. Eagles usually dragged carcasses onto shore to eat, although some were eaten in shallow water when part of the carcass was exposed. Submerged salmon were grasped in the talons and dragged to shore before being consumed. Eagles did not eat salmon carcasses underwater in contrast to Glaucous-winged Gulls (*Larus glaucescens*) and Common Goldeneyes (*Bucephala clangula*) (pers. obs.).

Only twice did I observe eagles capturing live fish. On 16 December 1974 an adult was eating a live fish at mile 30.7. At that time there were no salmon carcasses available in this area and this may have accounted for the taking of live fish. The fish captured was 10 to 15 inches long and was probably a trout as few, if any, salmon spawn at this size. I intensively searched without success for other eagles catching live fish on the river, and I believe it to be an uncommon occurrence.

The other occasion when live fish were captured and consumed occurred in Lucas Slough. Steelhead move into Lucas Slough from the Skagit in order to reach Barnaby Slough where they were raised. These steelhead congregate in large numbers in this shallow slough because they are prevented from entering Barnaby Slough by wire screens. On 19 February 1974 I found the bones and skin of a large steelhead on the shore of Lucas Slough. The remains were fresh and several live steelhead were seen in the area. I noticed eagles perched in

TABLE 13. Salmon returns to the Washington State Department of Fisheries Salmon Hatchery at Marblemount from 1949 through 1973.[1]

YEAR	NUMBER CHINOOK	NUMBER COHO
1949	-	190
1950	-	1,908
1951	-	4,599 [2]
1952	-	1,611
1953	-	841
1954	-	913
1955	-	642
1956	-	275
1957	-	468
1958	-	1,135
1959	-	1,680
1960	-	3,758
1961	-	1,479 [2]
1962	-	1,164 [3]
1963	-	1,352
1964	-	1,139
1965	159	923
1966	556	2,173
1967	133	3,530
1968	259	7,997
1969	346	16,005
1970	1,995	22,204
1971	666	35,528
1972	758	15,853
1973	924	11,486

[1]/ Russ Orrell, personal communication, 20 February 1974.

[2]/ Includes 3,122 coho trapped in Cascade River in 1951. All other totals from Clark Creek only, except 1961 which includes some coho from Cascade River.

[3]/ Figure represents only those fish which were spawned.

branches 10 to 15 feet above the slough, but this was the first indication that they were catching live fish. At this time in 1974 most salmon carcasses had been eaten or washed away by high water, and the eagles were forced to attempt to catch these large steelhead weighing between 5 and 15 pounds. I found the remains of three more steelhead in early 1974. No indication of eagles preying on steelhead was found in 1974-75 when salmon carcasses were more abundant throughout the season. This indicates that the wintering eagles on the Skagit will usually attempt the difficult capture of live steelhead only when salmon carcasses are unavailable.

On two occasions eagles were known to feed on deer carcasses. On 15 February 1975 a deer was hit by a car at Bacon Creek (mile 26.2). Two adults and one two-year old eagle were perched at the site with full crops, and there were eagle footprints in the snow around the site. Two Ravens (*Corvus corax*) were also at the site. On 20 February 1975, 14 eagles and 10 Ravens were congregated in the clearcut area south of Barnaby Slough. A dead two-year old male Black-tail Deer (*Odocoileus hemionus columbianus*) was in a depression in the clearcut. It appeared to have been dead for several months, and I suspect that it was shot and not recovered during the hunting season the previous autumn. Eagles had been feeding at the carcass as evidenced by footprints in the snow, but the Ravens were eating most of the meat. The eagles appeared reluctant to land in the depression where the deer lay.

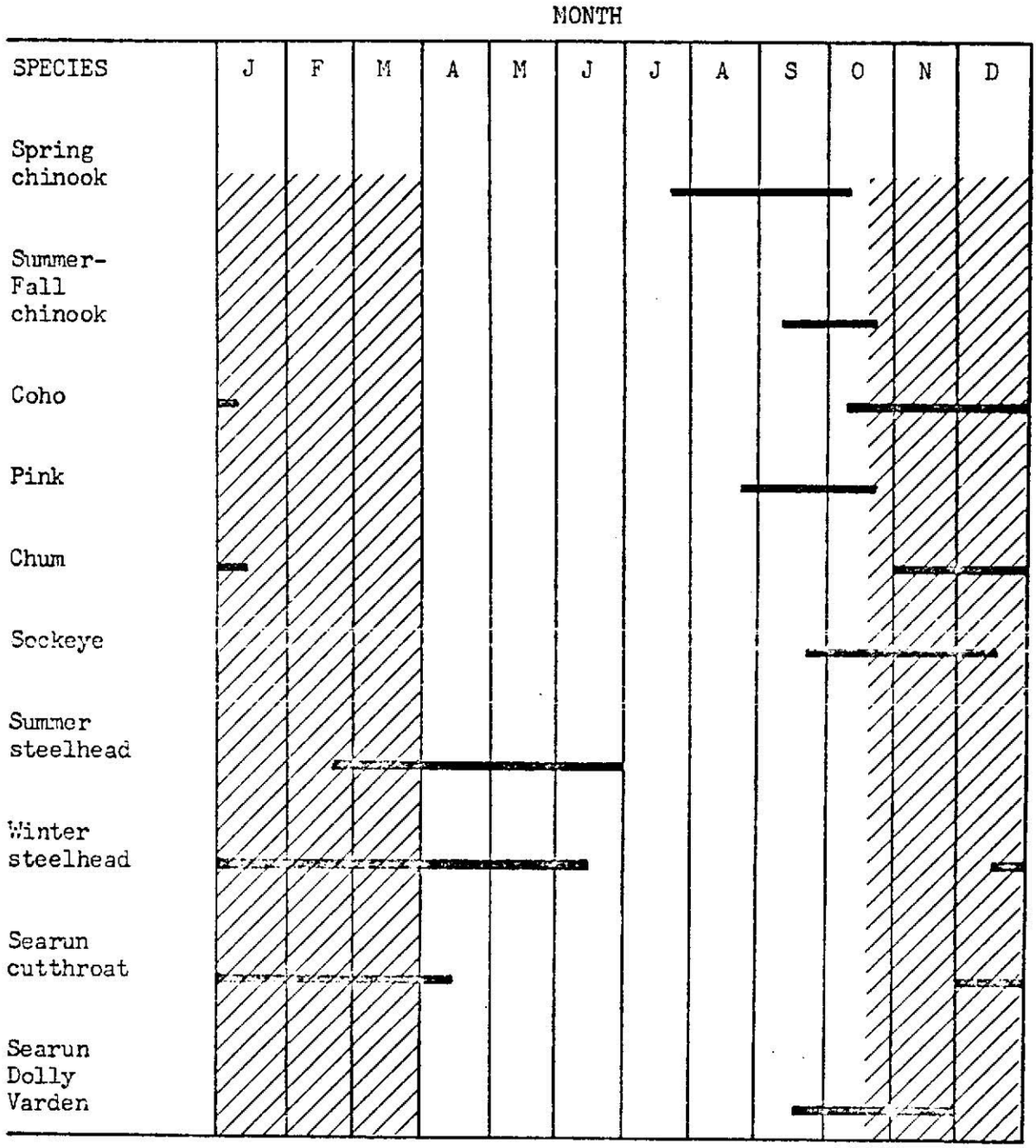
The interesting point about this situation is what had attracted all the birds after the deer had been untouched for so long. Individual eagles were previously seen in the area but none were ever perched above the carcass. The river level on 20 February was two feet higher than the day before and more than two feet higher than the mean level for the entire winter (U.S. Geological

Survey, Water Resources Division, provisional data for water year 1973, 1974, 1975, unpublished data). A rapid rise of the river occurred on the night of 19 February and nearly exceeded the highest level reached in the January flood of 1974 (U.S.G.S., Ibid.) which washed most of the salmon carcasses off the gravel bars. These flood conditions on 20 February prevented the eagles from feeding at the river, and they began to feed on the deer carcass that had remained untouched up to this time. Thus, the eagles prefer to feed along the river, and only when unable to do so will they utilize carrion in areas away from the river.

Eagles were never observed to eat waterfowl and only twice did I see eagles even swoop low over waterfowl. Dick Lichtenburg (pers. com.) saw an adult eagle strike a Common Merganser (*Mergus merganser*) in flight near Rockport in 1973, but the merganser was not seriously injured and was able to escape. Hancock (1964) observed wintering eagles unsuccessfully attacking crippled waterfowl in the Gulf Islands of British Columbia but never observed an eagle attack a healthy duck. Southern (1964) observed several unsuccessful attempts on Common Mergansers on the Mississippi River, and eagles in that area showed no interest in live birds as long as dead waterfowl were available. These data agree with mine and indicate that wintering Bald Eagles prefer dead prey and rarely attack waterfowl when dead prey is available.

Of the eight species of salmon and sea-run trout entering the Skagit to spawn, only salmon are utilized by the eagles. Of the five species of salmon only three are of real importance. These are chinook, chum and pink. Chinooks and chums spawn each year, but pinks, because of their strict two year life cycle, are available to the eagles only on odd-numbered years in the Skagit drainage. Figure 28 shows the timing of spawning of the eight anadro-

FIGURE 28. Timing of salmon and anadromous trout fresh-water spawning in Skagit River. Shaded area represents presence of the wintering Bald Eagle population.[1] Horizontal line represents spawning period.



[1] Adapted from Comprehensive study of water and related land resources, Puget Sound and adjacent waters. Appendix XI. Fish and Wildlife. Puget Sound Task Force of the Pacific Northwest River Basins Committee, 1970.

mous species. At the end of the spawning period the salmon die and their carcasses wash up on gravel bars on the river.

In October, when the eagles begin to arrive in the area, chinook and pinks are available, and in late December chums begin to wash ashore, Thus, the availability of salmon will vary in type and quantity through the season. Figure 29 shows the number of salmon carcasses on a respresentative gravel bar through the 1974-75 season. Since this was an even-numbered year (1974) no pinks were available. The salmon carcasses through the end of November are all chinook. On 9 November, 36 chinook carcasses were on the bar but only one had any flesh available. By 19 November only one carcass was on the bar, the rest having been either washed away in high water or carried away by the eagles. By 11 December the spawning chum salmon in the river had begun to die and there were now 167 chum carcasses on the bar of which 155 had available flesh. The number of chum carcasses continued to increase until 829 were on the 0.5 mile stretch of gravel bar. The low counts during the next week in January were due to snow which covered the carcasses, preventing the eagles from finding them. The numbers in the figure reflect the number of salmon carcasses available to the eagles, and not merely the number on the bar or in the water.

The eagle numbers in the study area are closely related to the amount of available salmon. Figure 30 compares the increase in eagle numbers between Rockport and Newhalem with the increase in salmon carcasses on a representative gravel bar. The eagle numbers increase as the number of chum salmon carcasses increase. As a greater percentage of the population began to feed on this gravel bar in mid-January (Figure 36), the number of salmon carcasses 100% consumed began to increase. When almost all the carcasses were 100% consumed

Figure 29. Number of salmon carcasses available for eagle utilization, mile 13.3 to 13.8 north shore, 7 November through 13 March 1974-1975.

1974-75

NUMBER OF SALMON CARCASSES AVAILABLE FOR EAGLE UTILIZATION

MILE 13.3 TO 13.8 NORTH SHORE

— TOTAL NUMBER OF SALMON CARCASSES --- NUMBER OF SALMON 100% UTILIZED

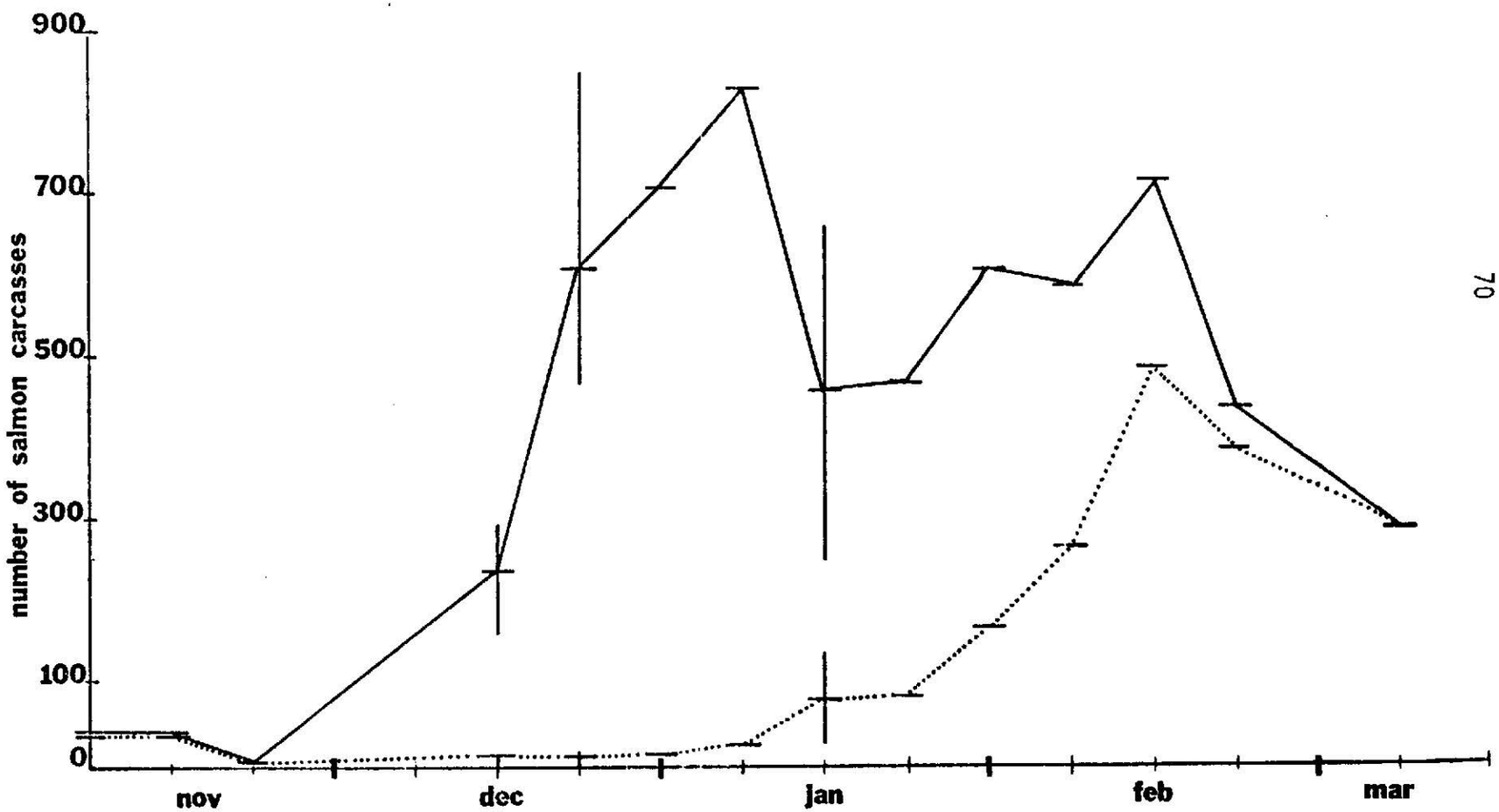
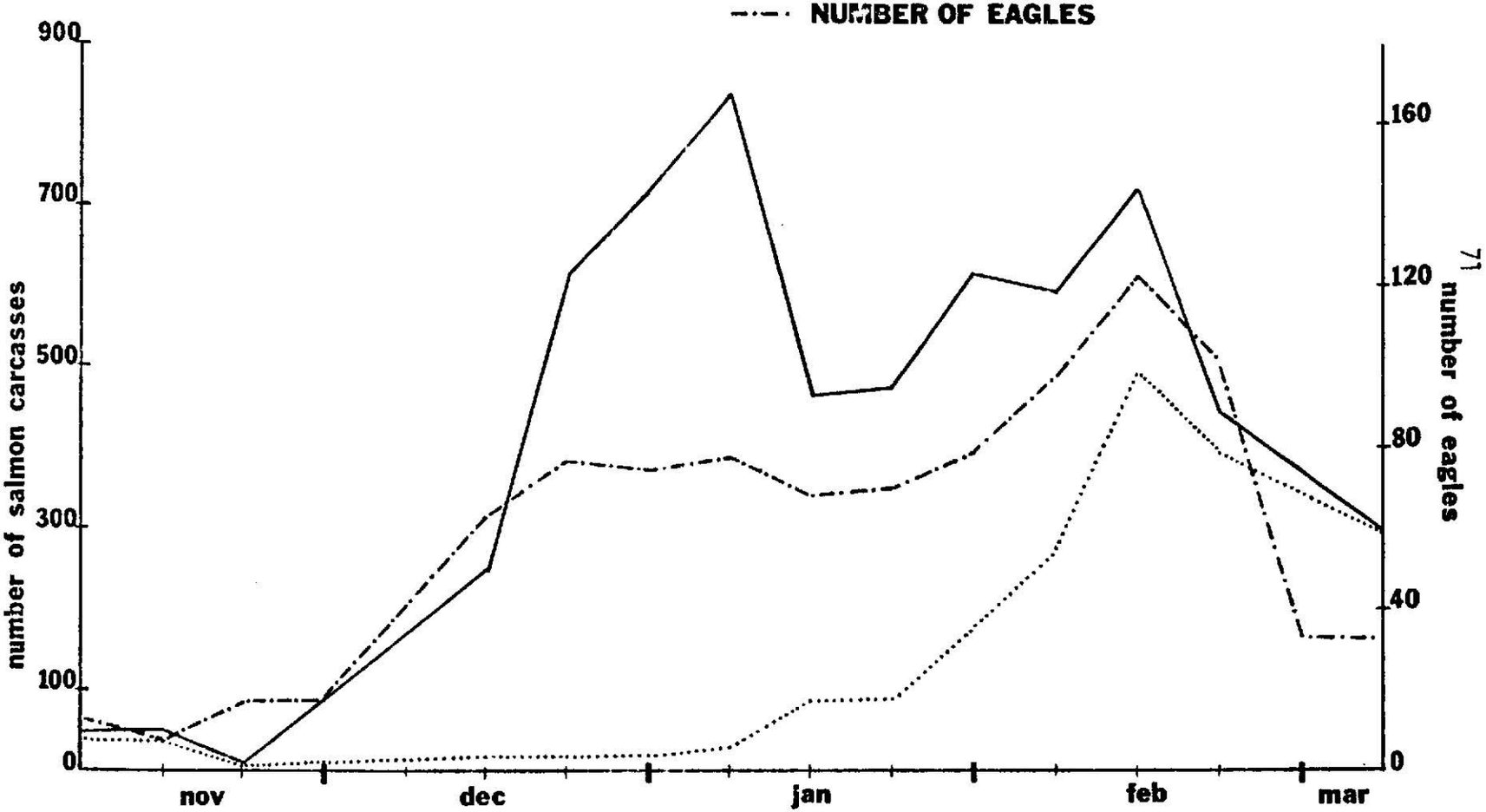


Figure 30. Salmon availability mile 13.3 to 13.8, north shore, in relation to total eagle numbers 7 November through 8 March 1974-1975. Means at weekly intervals.

MILE 13.3 TO 13.8 NORTH SHORE
SALMON AVAILABILITY AND CONSUMPTION
IN RELATION TO EAGLE NUMBERS 1974-75
MEANS AT WEEKLY INTERVALS

—— TOTAL SALMON CARCASSES
····· SALMON CARCASSES 100% CONSUMED
-·-·- NUMBER OF EAGLES



by the end of February, the eagles began to leave the Skagit area. There is a strong relationship between eagle numbers and the amount of salmon 100% consumed at the end of the season (Figure 30), as this gravel bar was the last area of concentrated food supply utilized by the eagles. When all the salmon in this area were consumed, no concentrated food sources remained and the eagles began to disperse and leave the Skagit area.

SUMMARY

The ecology of a wintering Bald Eagle population was studied during the winters of 1973-74 and 1974-75 on the Skagit River between Rockport and Newhalem. The population arrives in mid-October and leaves in late March. The peak in 1973-74 was 93 eagles on 13 January, and the peak in 1974-75 was 165 eagles on 12 February.

The arrival and departure dates of the Skagit population are similar to populations on the Mississippi River (Southern 1964); Gulf Islands, British Columbia (Hancock 1964); Utah (Edwards 1969) and Glacier Park, Montana (Shea 1973). The peak population period was similar to the above studies in 1974-75 but was a month earlier in 1973-74. The abnormal flood from 15 through 17 January 1974 prematurely removed most of the food supply that year, and the eagle population did not reach the high numbers later in the season that it normally does.

The tendency for Bald Eagles to aggregate at concentrated food sources maximizes the utilization of such resources. A social system may have evolved in wintering eagle populations so they can efficiently utilize concentrated food sources. Group night roosting may be an adaptation of this social system. Further work needs to be done to verify this hypothesis and relate the eagle winter behavior to the theory that aggregations are information centers for food finding (Ward and Zahavi 1973).

The seasonal average subadult percentage in the population was 52.6% in both years. This may be slightly higher than comparable published figures because I classified five-year old eagles as subadults in contrast to most previous researchers who grouped five-year olds with adults. This figure is

higher than all other overall published winter subadult percentages except Shea's 1971 figure of 54.5%, and may indicate a healthy, productive population. However, more information is needed on adult and subadult movements and possible differential habitat preferences before valid conclusions can be drawn.

Data on the percentage of each age class comprising the population seem to indicate that one-year old eagles do not winter in the Skagit area in large numbers. Where year-old eagles winter is open to speculation. The possibility exists that one-year olds do not move as far during their first winter as do other age classes. The theory of differential age migration also needs more study.

Field aging of Bald Eagles by plumage characteristics as pioneered by Southern (1964) is a valid and promising technique. Individual variation does occur, but with experience and the use of a spotting scope most eagles can be classified. Experience is necessary and valid data can only be obtained through many hours of observation and comparison. Its application is only useful in certain situations where perched or low-flying eagles can be observed with high power optics, and unfortunately this technique is unsuitable for aerial censusing.

Eagle activity was affected by weather and river level. High wind and sunny weather promoted soaring and flying activity. High river levels forced the eagles to utilize food sources other than salmon. Eagles initially utilized areas on the river isolated from human activity, and only when food was consumed in these areas were areas with more human activity utilized. During the 1974-75 season, of 3,322 eagle observations on census counts 68.5% were

on the south shore, 19.7% on the islands in the river and 11.8% on the north shore where the main road is located and most human activity occurs.

During the 1974-75 season most eagle activity occurred between mile 13.0 and 16.5, mainly because of the many gravel bars in this area. Eagles were concentrated in the early part of the season and became dispersed as the food became more random in the latter parts of the season.

The main food for the eagles is dead naturally spawning salmon. The most important salmon species to the eagles are chinooks and pinks in October and November and chum for the rest of the season. Eagles were never observed to kill live salmon and were known only to have killed one trout and four steelhead. Eagle numbers on the river closely followed the amount of salmon carcasses available. When most salmon carcasses were consumed, eagles dispersed and began to leave the area.

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APPENDIX

MANAGEMENT RECOMMENDATIONS

Due to the popularity of steelhead fishing on the Skagit (Figure 31) it is important to integrate the sport with the needs of the wintering eagles. I have written the following management recommendations with this in mind.

Increasing use of the area between Rockport and Newhalem by people interested in eagles and in recreation poses a threat to the eagle population. It is important to regulate the use of this area so that the balance of factors that attract the eagles to the Skagit will not be upset. With proper regulation of land use, fishermen, recreation seekers and birdwatchers can coexist with the eagles in the future. The following are immediate management needs.

(1) The natural spawning populations of chinook, pink and chum salmon should be maintained in the river. Increased management efforts toward a large number of artificially spawned salmon are of no benefit to the eagles. As much concern should be given to maintaining the natural spawning populations as is given to maintaining artificially spawned populations.

(2) Boat landing on gravel bar islands between mile 13.0 and 17.0 should be prohibited. No benefit can be gained by fishermen doing so, and their presence on these islands makes the eagles wary of using them. This is especially important at mile 16.2 and mile 13.8.

(3) The gravel bar between mile 13.3 and 13.8 on the north shore should be closed to public access, and boat landing on this bar should be prohibited. This could easily be accomplished by erecting a locked

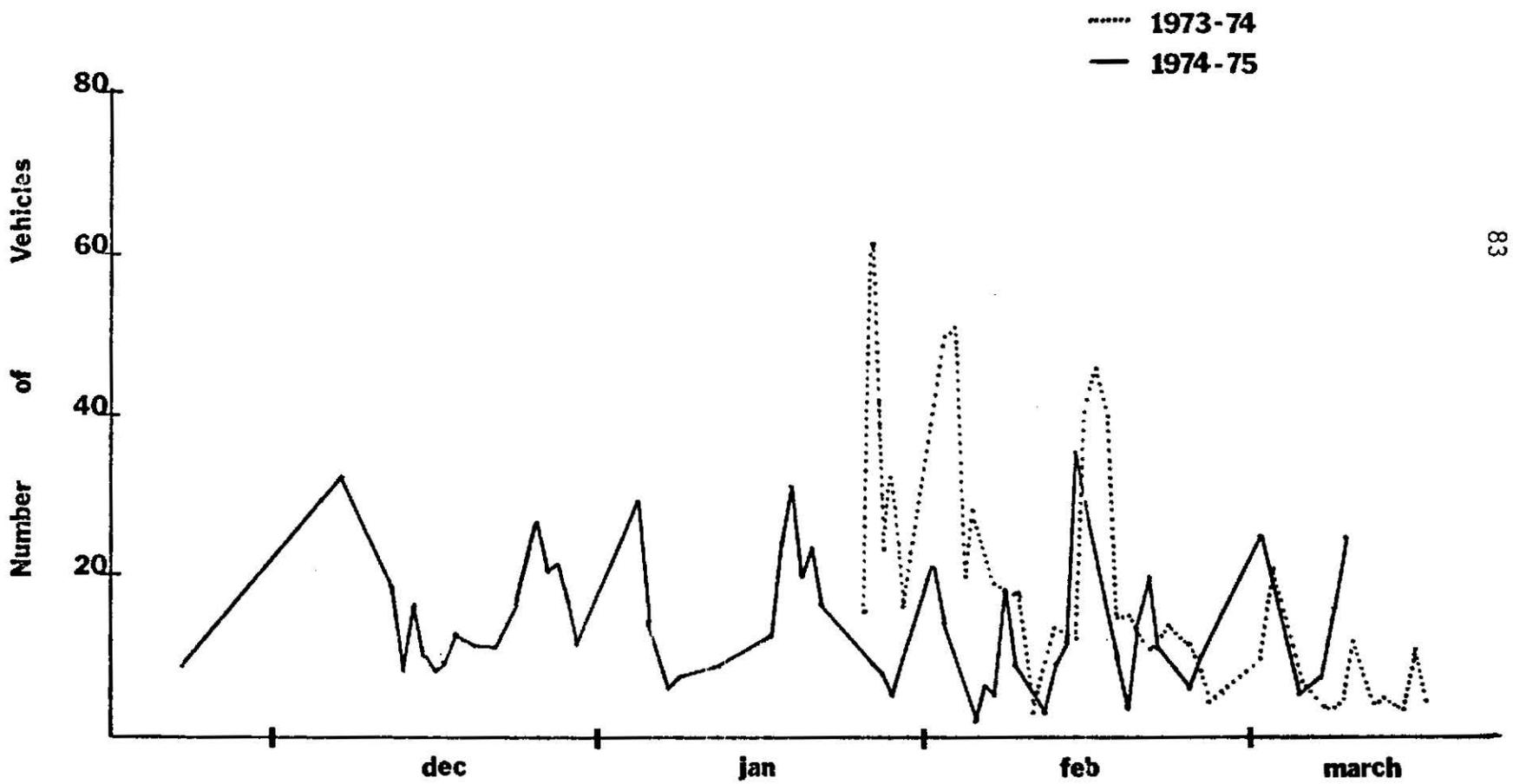
gate and a sign at the access road at mile 13.9. This area is already owned by the Washington State Department of Game so no lengthy negotiations with landowners need occur. The closing of this bar will promote eagle use in the area and public viewing of them from the road on the north shore. No serious fishermen use this bar and excellent steelhead fishing from shore is available one mile downstream at the Lucas Slough fishing access site.

(4) Development along the river should not be permitted between mile 12.0 and 17.0. This is largely being accomplished through the efforts of the Nature Conservancy and the Washington State Department of Game. The inclusion of the Skagit in the Wild and Scenic Rivers Act will also preclude further development along the river and preserve the solitude that the eagles require.

Further management guidelines will be proposed in A Management Plan for the Wintering Bald Eagles on the Skagit River which I am in the process of writing in cooperation with the Nature Conservancy.

Figure 31. Total number of steelhead fishermen vehicles at Rockport north and south access sites and at Lucas Slough access site 1973-74 and 1974-75.

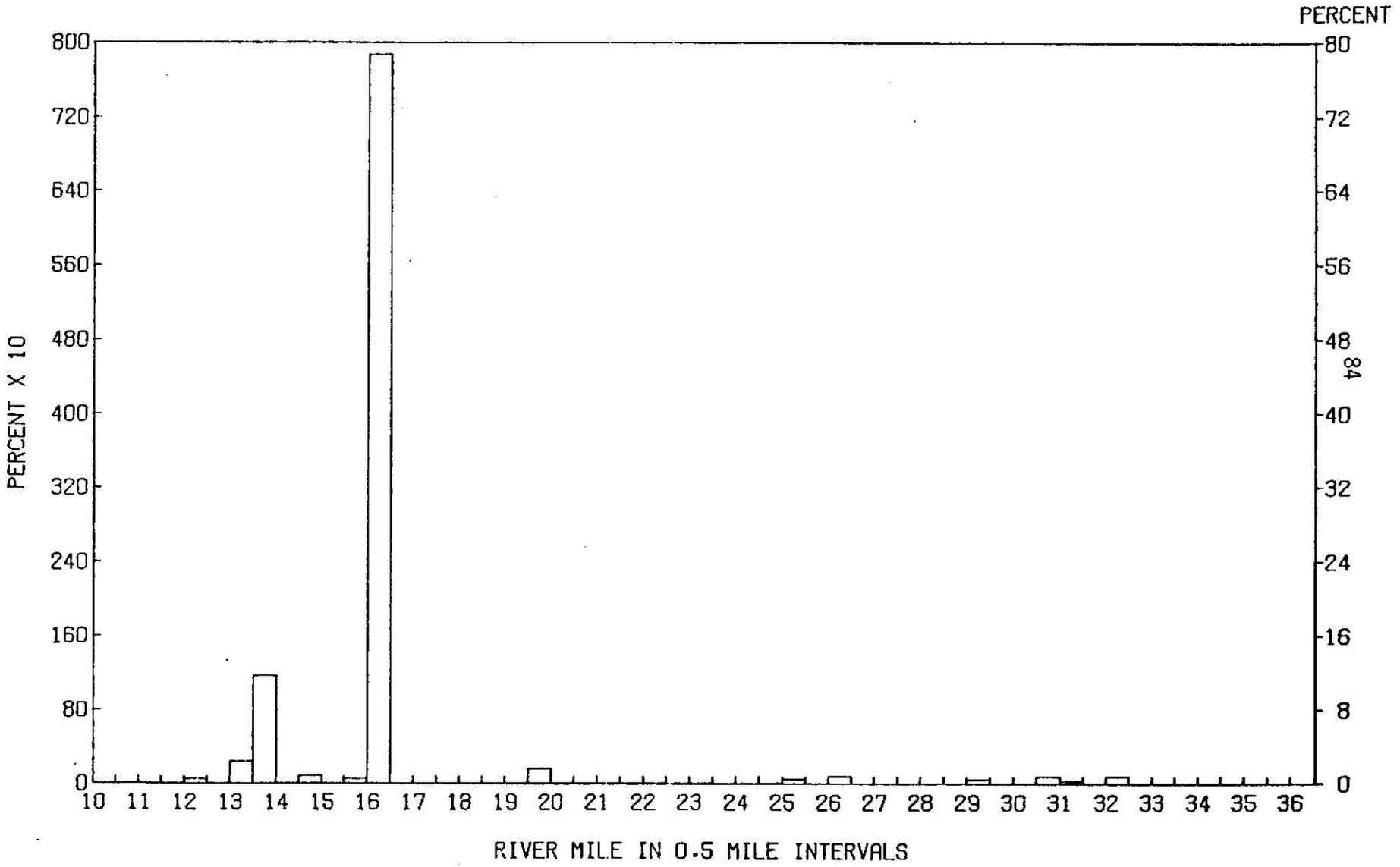
TOTAL NUMBER OF STEELHEAD FISHERMAN VEHICLES AT ROCKPORT NORTH AND SOUTH ACCESS SITES AND LUCAS SLOUGH ACCESS SITE



Figures 32 through 44. Weekly Bald Eagle distribution along the Skagit River between Rockport and Newhalem in 0.5 mile intervals. Percent represents percent of that week's observations at each interval. For river mileages refer to Figures 3 through 9. N is total number of eagles observed on census counts during that week.

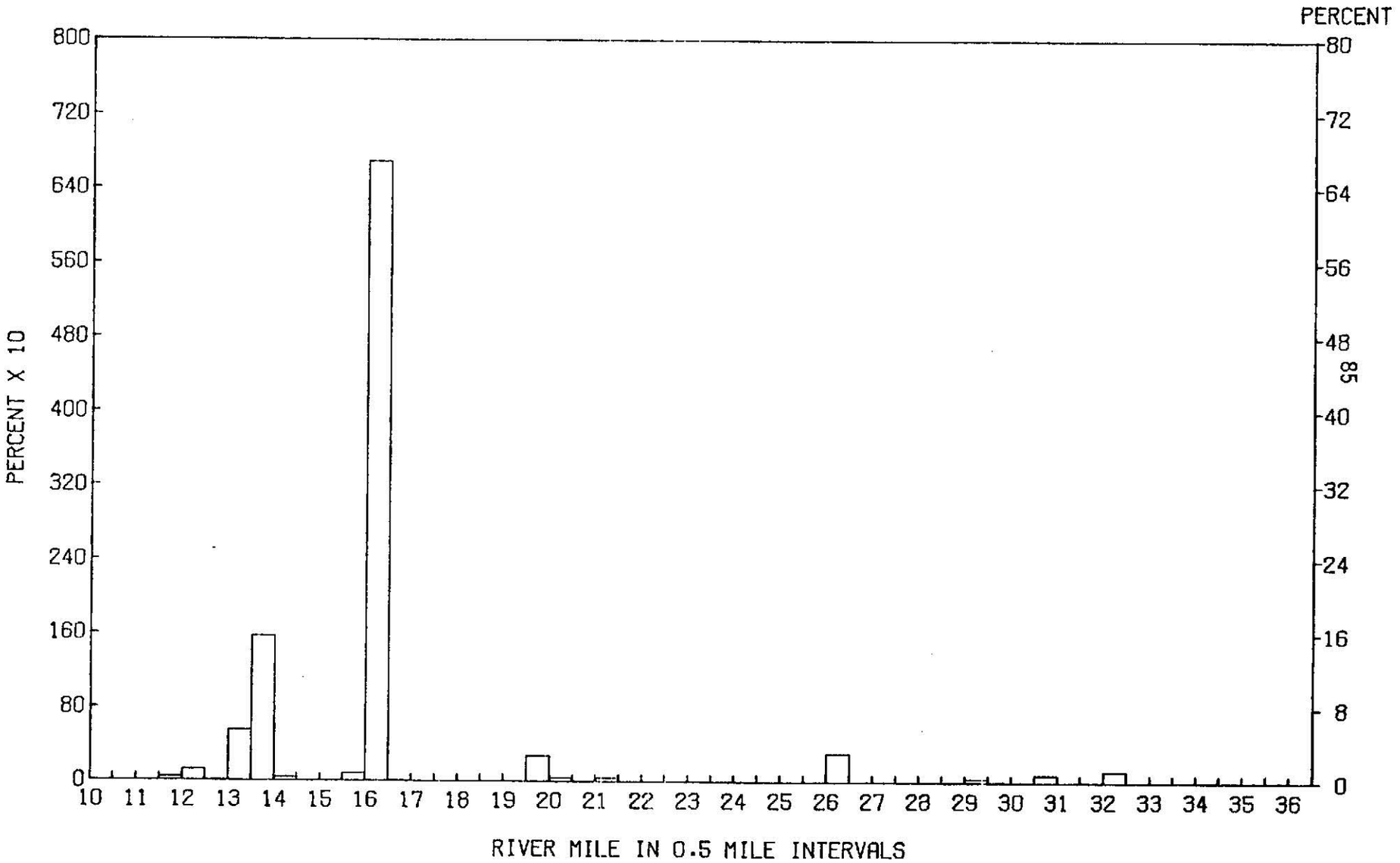
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 375 FIGURE 32

EAGLE DISTRIBUTION FOR WEEK 1, DEC 13 THRU 19



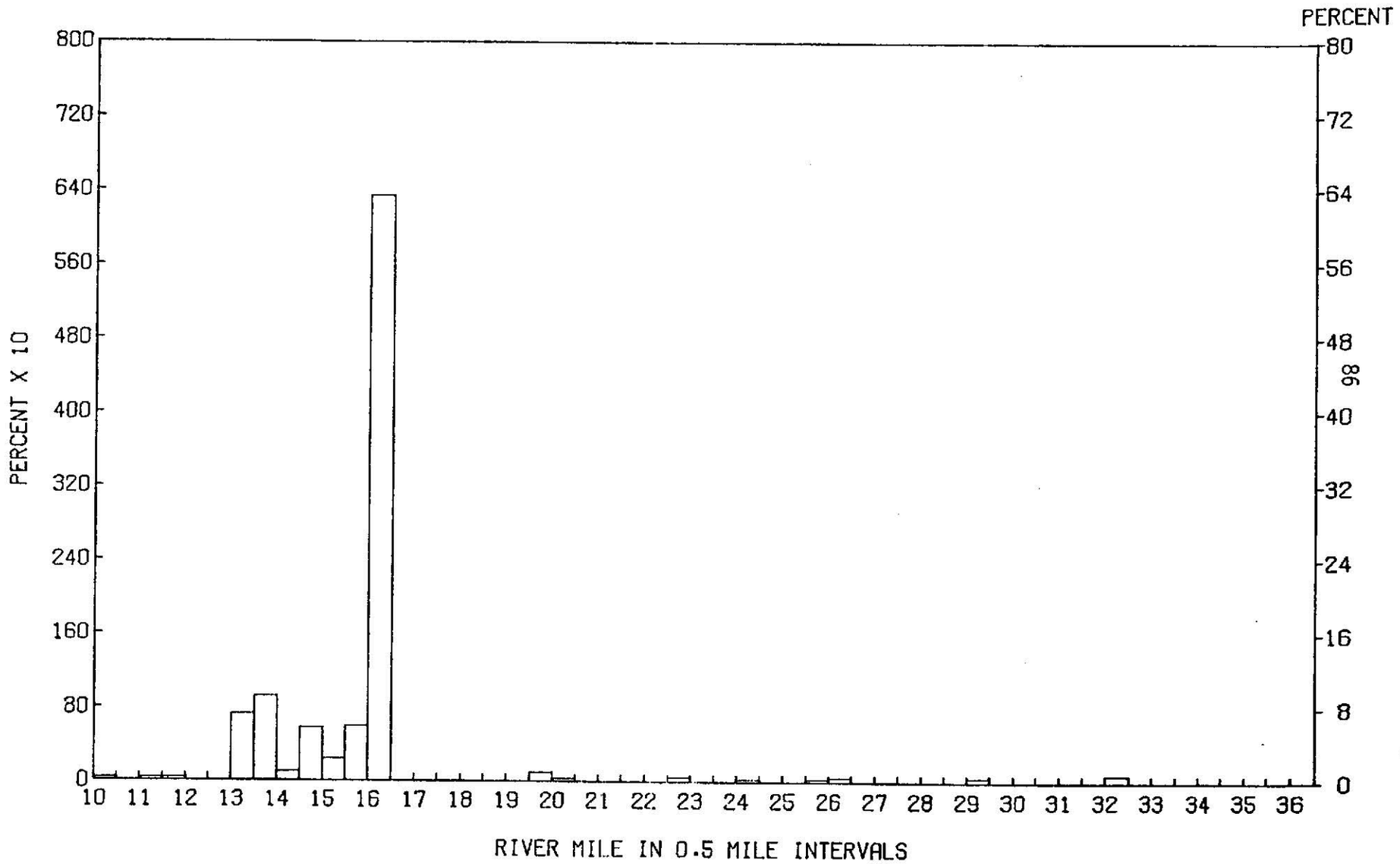
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 254 FIGURE 33

EAGLE DISTRIBUTION FOR WEEK 2, DEC 20 THRU 26



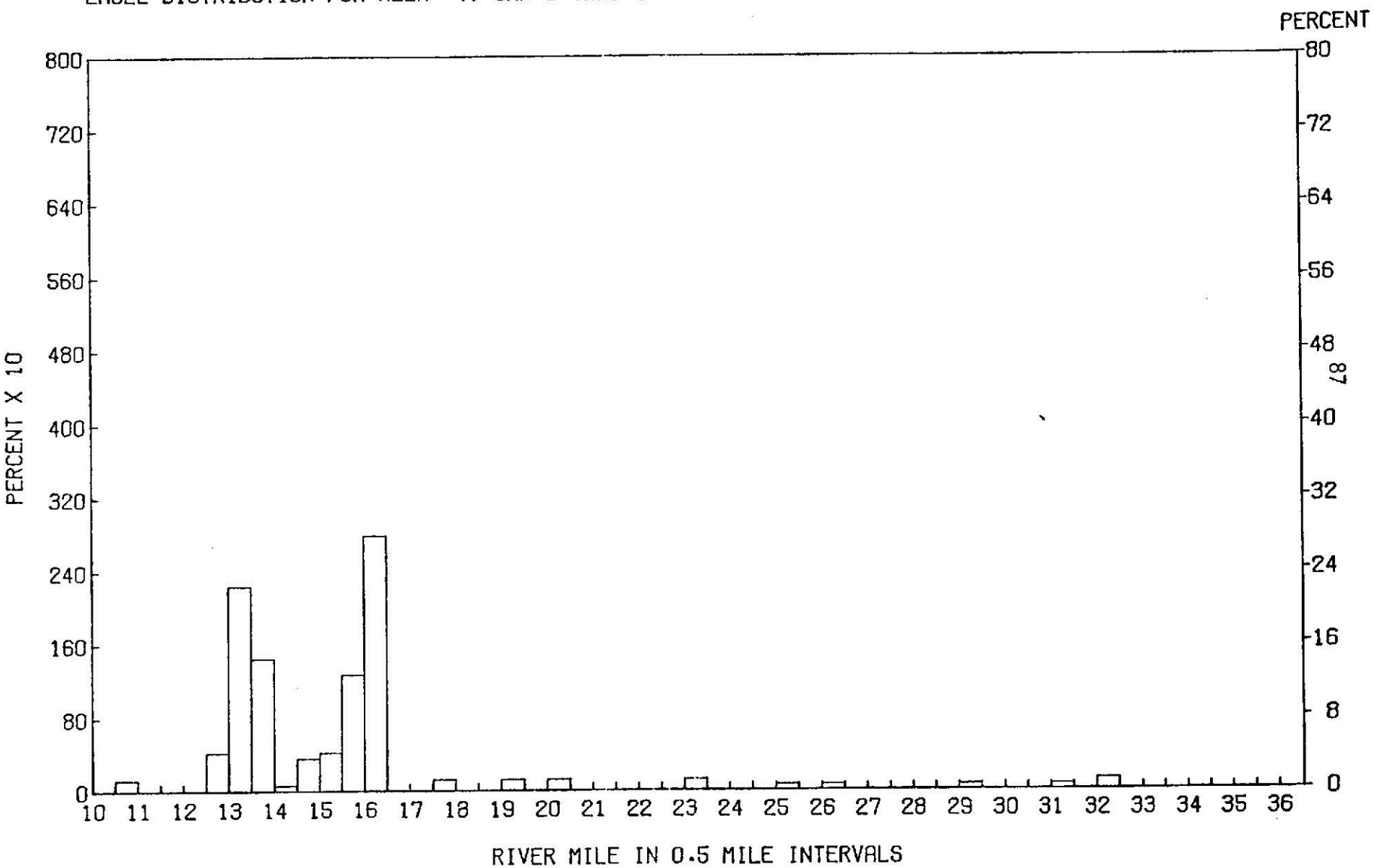
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 382 FIGURE 34

EAGLE DISTRIBUTION FOR WEEK 3, DEC 27 THRU JAN 2



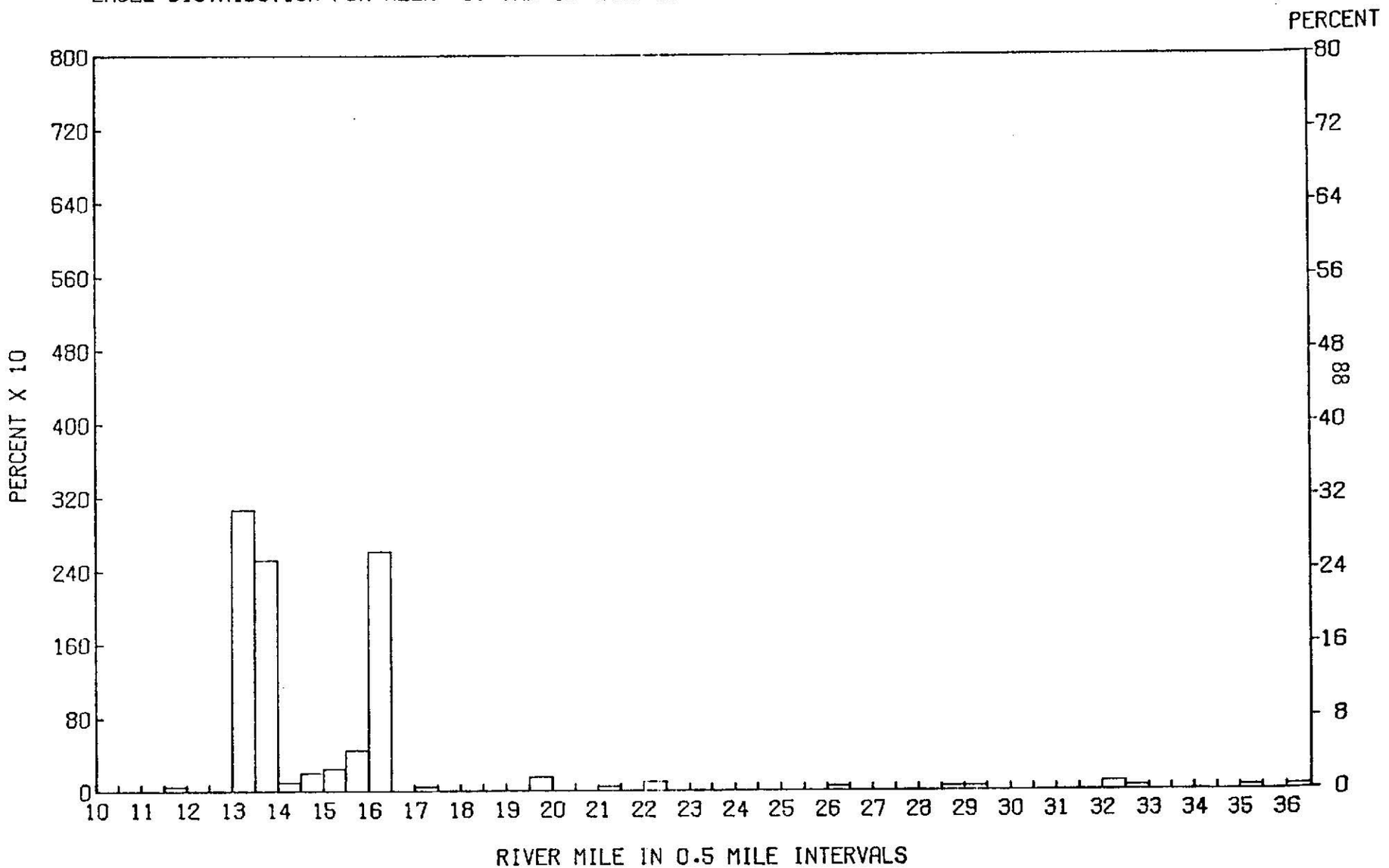
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 165 FIGURE 35

EAGLE DISTRIBUTION FOR WEEK 4, JAN 3 THRU 9



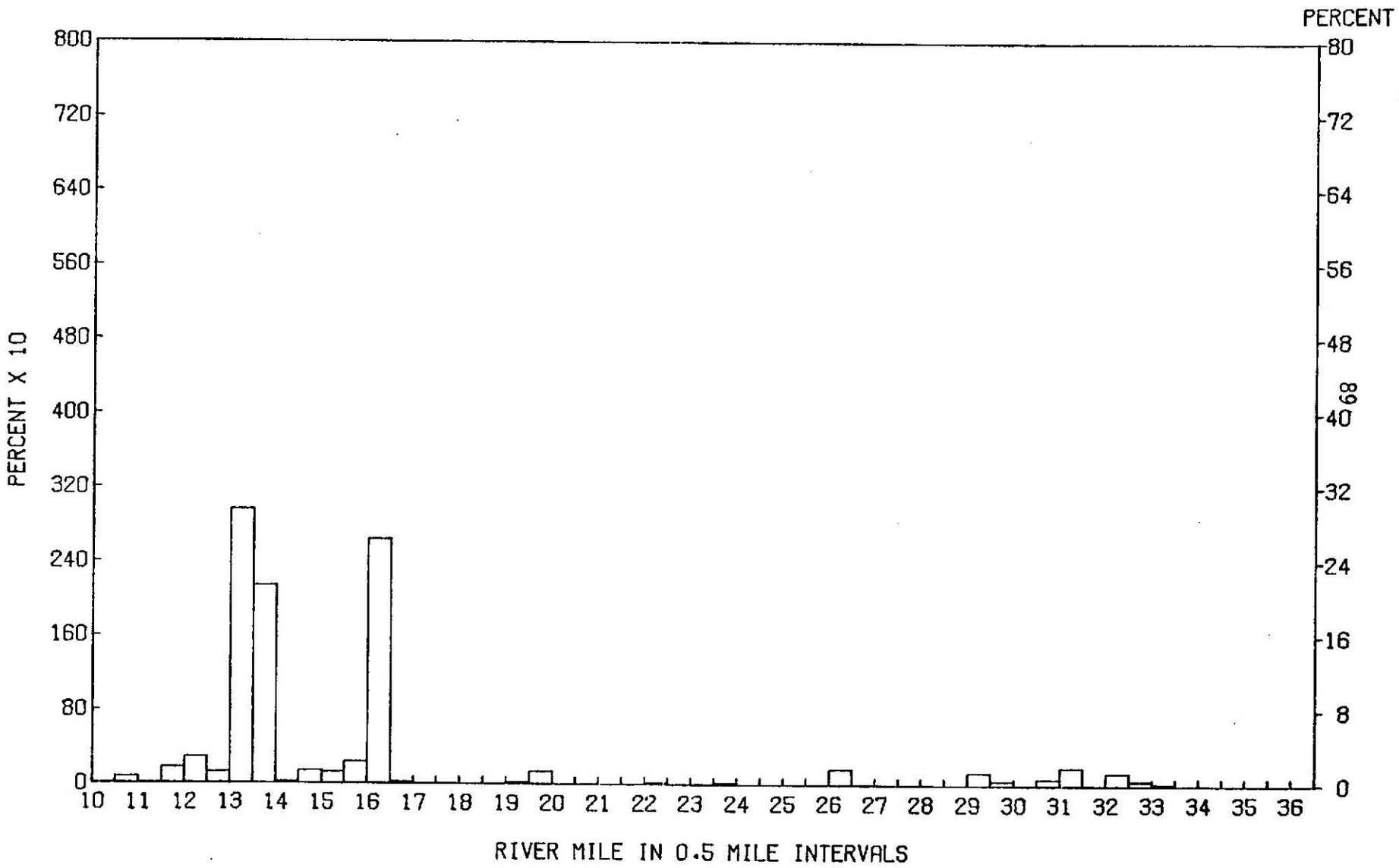
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 202 FIGURE 36

EAGLE DISTRIBUTION FOR WEEK 5, JAN 10 THRU 16



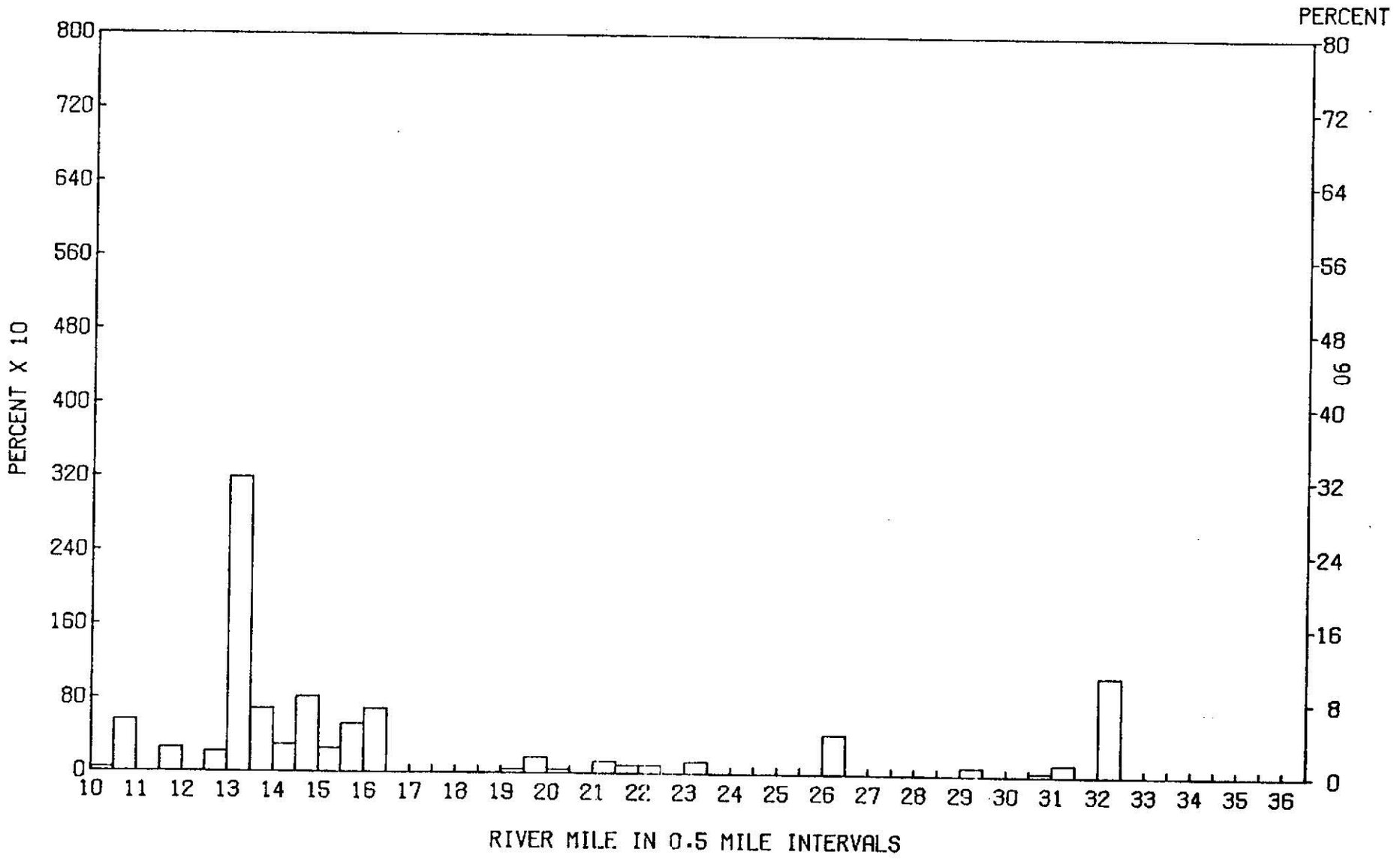
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 416 FIGURE 37

EAGLE DISTRIBUTION FOR WEEK 6, JAN 17 THRU 23



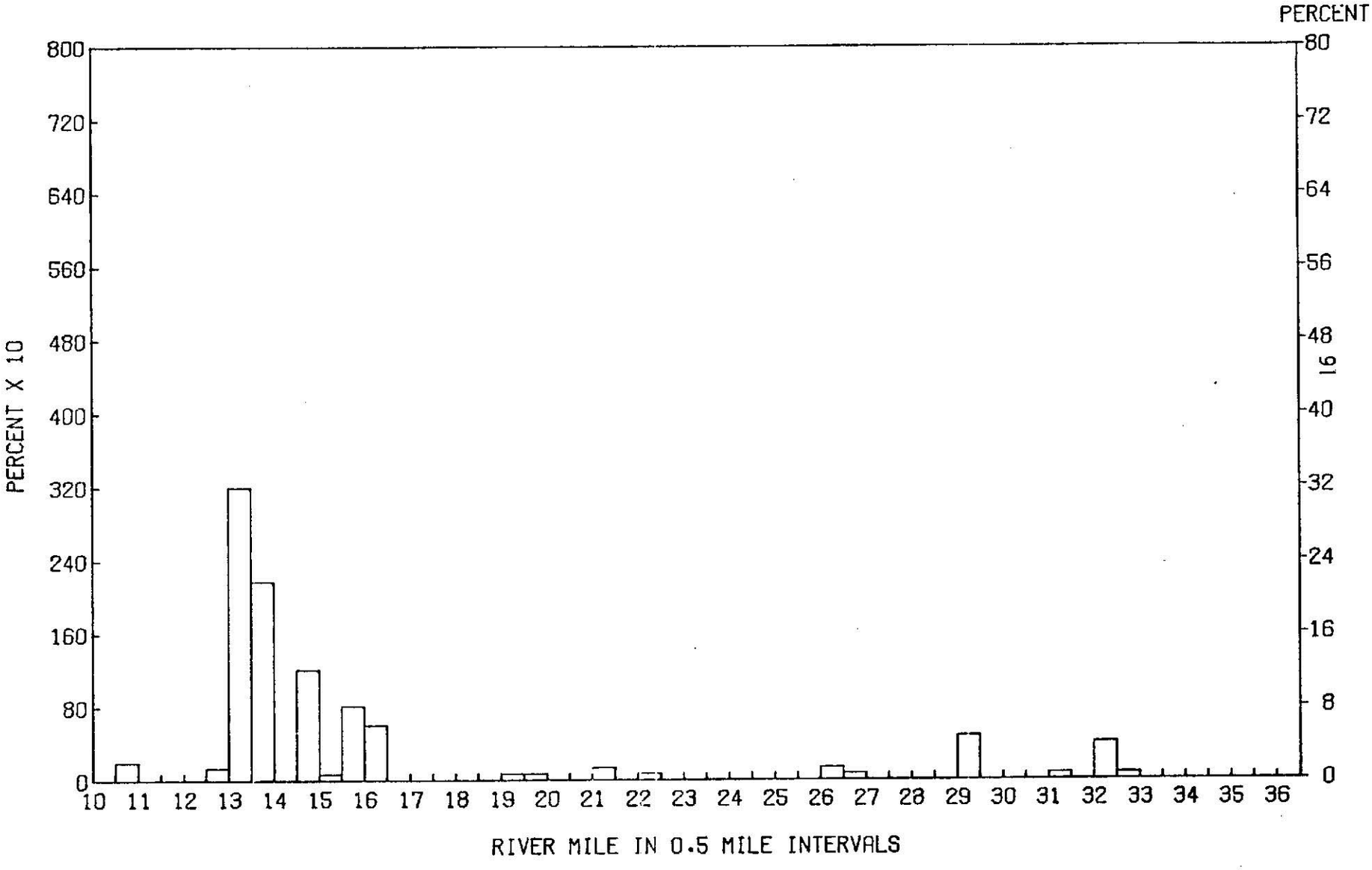
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 232 FIGURE 38

EAGLE DISTRIBUTION FOR WEEK 7, JAN 24 THRU 30



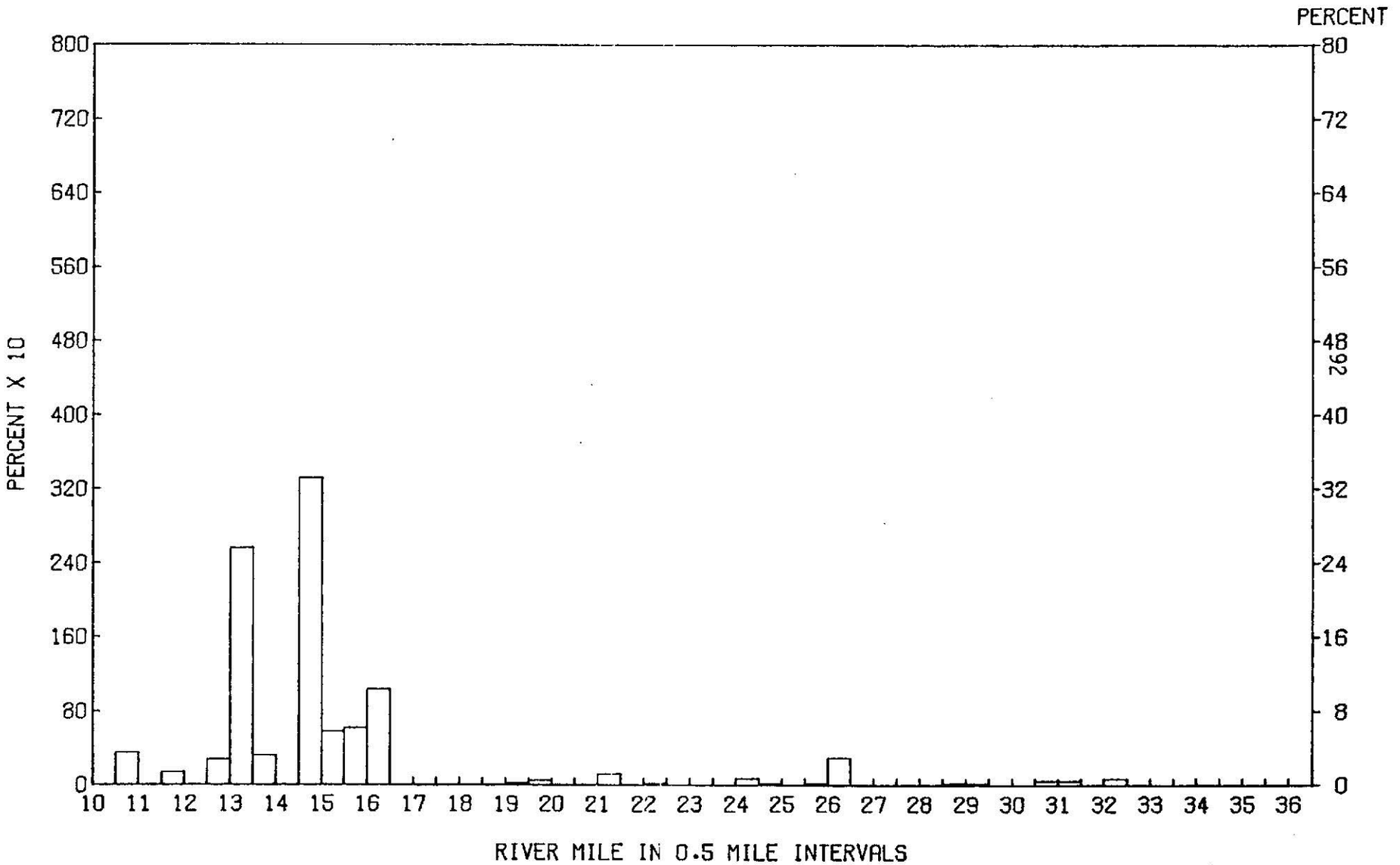
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 147 FIGURE 39

EAGLE DISTRIBUTION FOR WEEK 8. JAN 31 THRU FEB 6



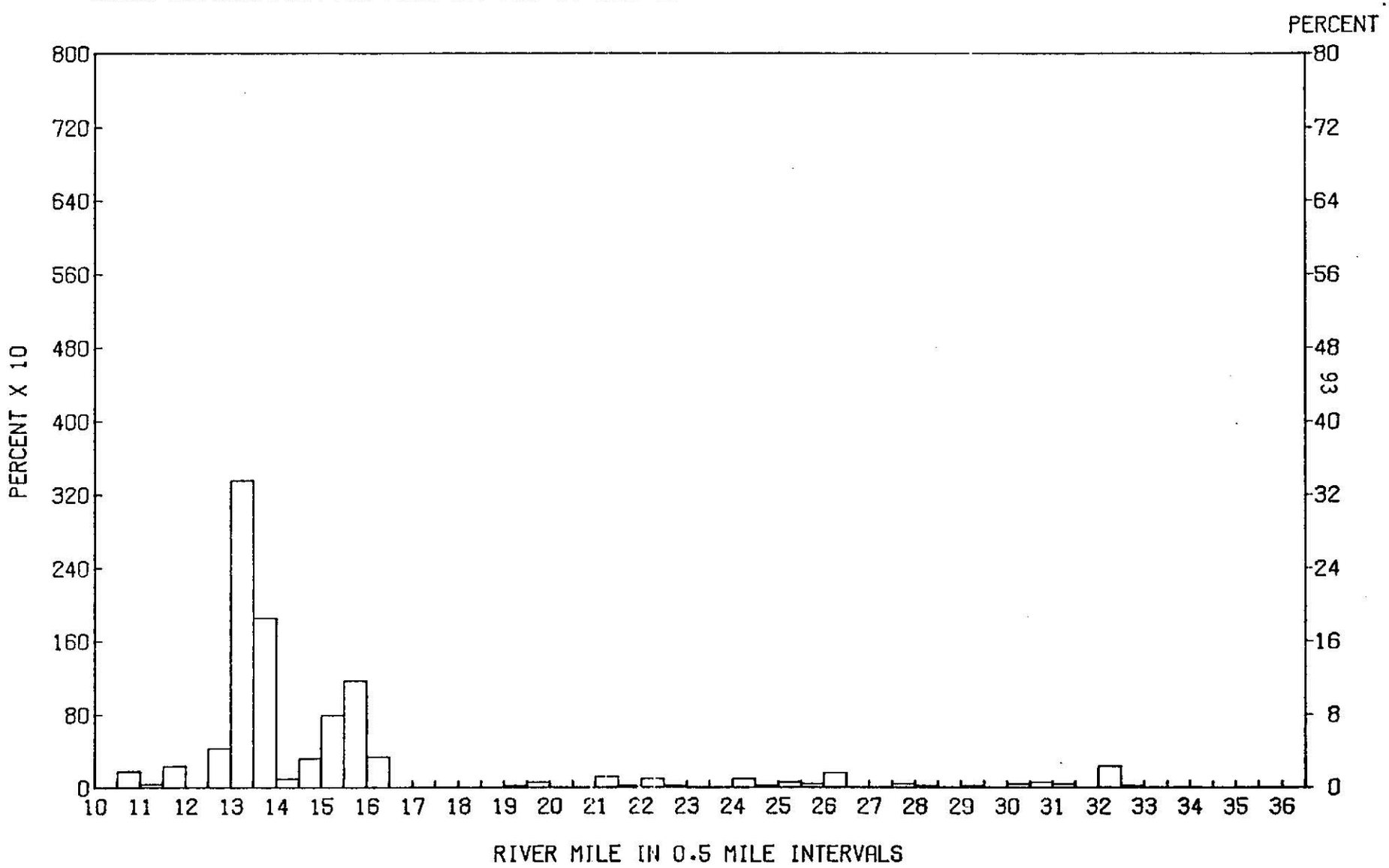
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 434 FIGURE 40

EAGLE DISTRIBUTION FOR WEEK 9, FEB 7 THRU 13



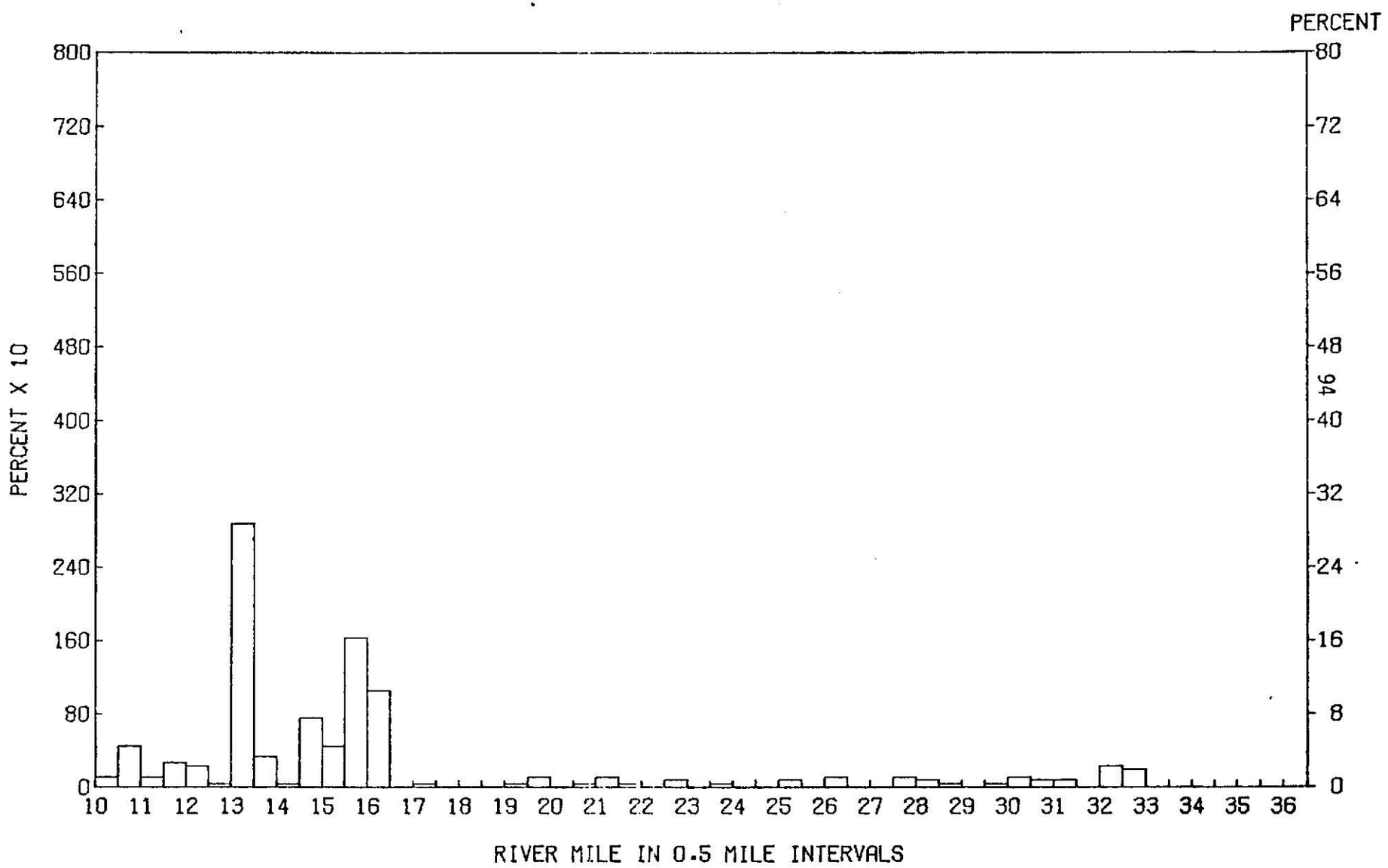
PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 506 FIGURE 41

EAGLE DISTRIBUTION FOR WEEK 10, FEB 14 THRU 20



PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 264 FIGURE 42

EAGLE DISTRIBUTION FOR WEEK 11, FEB 21 THRU 27



PERCENT OF OBSERVATIONS BY 0.5 MILE INTERVALS N = 76 FIGURE 44

EAGLE DISTRIBUTION FOR WEEK 13, MAR 7 THRU 13