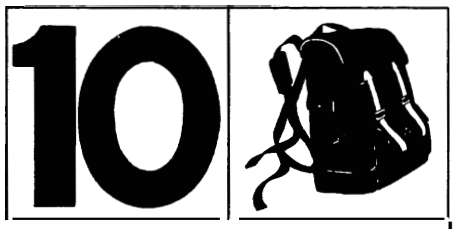

General Technical Report PNW–178
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EDITOR'S
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Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America

Influences of Recreation

Roger N. Clark, Dave R. Gibbons, and Gilbert B. Pauley

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U.S. Department of Agriculture Forest Service
Pacific Northwest Forest and Range Experiment Station

ABSTRACT

Public and private lands in the United States are used by millions of people for recreational activities. Many of these activities occur in or near streams and coastal areas that produce various species of anadromous fish. A major concern of fishery managers is the possible adverse effect of recreational uses on fish habitat. Conversely, the management of fish habitats may have either positive or negative effects on recreation. This report describes interrelations between recreation and fisheries. Recreational issues affecting either the supply of habitat for anadromous fish production and use, or the demand for the fisheries are also discussed. Opportunities for research are outlined.

KEYWORDS: Recreation, fishing, management objectives, resource impacts, anadromous fish habitat.

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INFLUENCE OF FOREST AND RANGELAND MANAGEMENT ON ANADROMOUS FISH HABITAT IN WESTERN NORTH AMERICA

William R. Meehan, Technical Editor

10. Influences of Recreation

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PREFACE

This is one of a series of publications on the influence of forest and rangeland management on anadromous fish habitat in western North America. This paper describes the interrelation between recreation and the anadromous fishery. Our intent is to provide managers and users of forests and rangelands with the most complete information available for estimating the consequences of various management alternatives.

In this series of papers, we summarize published and unpublished reports and data as well as the observations of scientists and resource managers developed over years of experience in the West. These compilations will be valuable to resource managers in planning uses of forest and rangeland resources, and to scientists in planning future research.

Previous publications in this series include:

1. **Habitatrequirements of anadromous salmonids,**by D. W. Reiser and T. C. Bjornn.
2. **Impactsof natural events," b.y Douglas N. Swanston.
3. "Timber harvest,**by T. W. Chamberlain.
4. "Planning forest roads to protect salmonid habitat,**by Carlton S. Yee and Terry D. Roelofs.
6. "Silvicultural treatments;'* by Fred H. Everest and R. Dennis Harr.
7. "Effects of livestock grazing," by William S. Platts.
8. **Effectsof mining," by Susan B. Martin and William S. Platts.
9. "Forest chemicals,*' by L. A. Norris, H. W. Lorz, and S. V. Gregory.
11. **Processingmills and camps," by Donald C. Schmiege.
12. "Rehabilitating and enhancing stream habitat: 1. Review and evaluation,** by James D. Hall and Calvin 0. Baker.
13. **Rehabilitatingand enhancing stream habitat: 2. Field applications,*' by Gordon H. Reeves and Terry D. Roelofs.

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COMMON AND SCIENTIFIC NAMES OF FISHES MENTIONED IN TEXT AND TABLES[1/]

Common name	Scientific name
Shad	FAMILY Clupeidae
	FAMILY Salmonidae
Pink salmon	Oncorhynchus gorbuscha (Walbaum)
Chum salmon	Oncorhynchus keta (Walbaum)
Coho salmon	Oncorhynchus kisutch (Walbaum)
Sockeye salmon (kokanee)	Oncorhynchus nerka (Walbaum)
Chinook salmon	Oncorhynchus tshawytscha (Walbaum)
Golden trout	Salmo aguabonita Jordan
Cutthroat trout	Salmo clarki Richardson
Rainbow (steelhead) trout	Salmo gairdneri Richardson
Brown trout	Salmo trutta Linnaeus
Arctic char	Salvelinus alpinus (Linnaeus)
Dolly Varden	Salvelinus malma (Walbaum)
Inconnu (sheefish)	Stenodus leucicthys (Guldenstadt)
Smelt	FAMILY Osmeridae
	FAMILY Percichthyidae
Striped bass	Morone saxatilis (Walbaum)

[1/] From "A List of Common and Scientific Names of Fishes from the United States and Canada," American Fisheries Society Special Publication 12, Fourth Edition, 1980, 174 p.

INTRODUCTION

Topics covered in this report have potential for intense conflict. Habitats used during critical periods in the life cycle of anadromous fish are generally in the same aquatic and riparian ecosystems in which productive timber stands and wildlife habitat are found. Important recreational opportunities are also in these same areas.

In this paper, we discuss current knowledge on the relation of recreational use to the anadromous fishery--that is, fish and their habitats. The main emphasis is on how recreational use and management directly affect fish habitats, but the implications of fishery management for recreational opportunities and use are also briefly discussed. The information provided in this paper should be valuable in evaluating the consequences of recreational uses and management on the anadromous fishery.

Recreation has direct effects on the fishery, as well as indirect effects through habitat changes. For example, roads and silvicultural treatments may affect both the nature and extent of recreational use, which can lead to additional effects on the fishery. Consequently, we will draw from other papers in this series to develop an understanding of the interrelations between recreational use and the anadromous fishery.

We used three bases for our conclusions: empirical evidence about recreational use and its relation to fish habitats (we will use research that focused on non-anadromous fish as well); existing concepts, theories, and frameworks; and our judgments, based on current knowledge and experience. This report is based on our current perceptions. Continuing professional debate, management experience, and formal research will determine how well the assumptions we make and the conclusions we draw fit real conditions.

OBJECTIVES

The objectives of this paper are to:

- Review new knowledge about the relations of recreation to the anadromous fishery.
- Describe an approach for integrating the recreational and fishery systems.
- Identify links among recreation, anadromous fisheries, and other forest resource systems (for example, timber, wildlife, and forage).
- Establish a basis for evaluating effects of alternative recreation-management options on the anadromous fishery and alternative fishery-management strategies on recreation.
- Outline research needed to improve understanding of recreation-fishery interactions.

DISTRIBUTION OF THE ANADROMOUS FISHERY

Salmonids (salmon and trout) have probably received more attention, both culturally and economically, over a longer time and greater geographic area than any other group of fishes. Ten species of anadromous salmonids are found on the west coast, including five Pacific salmon--chinook, coho, chum, sockeye, and pink; three trout--steelhead, brown, and cutthroat; and two char--arctic and Dolly Varden. Salmon support a large commercial fishing industry; salmon, trout, and char support a valuable sport fishery. These fish are indigenous to the coastal area bordering the North Pacific Ocean that extends from Northern Japan and the USSR in Asia, to the Arctic Ocean and down the coast of North America from Alaska to California (fig. 1). Anadromous salmonids still occur throughout much of their original range, but their numbers in some locations have been greatly reduced by overfishing, habitat degradation, and natural climatic changes. Many millions of adult anadromous salmonids are still produced in the waters of the western United States, including USDA Forest Service Regions 1, 4, 5, 6, and 10 (encompassing about 35 National Forests). This production is fished commercially, for subsistence, and for sport. The centers of abundance vary according to species and even within species. For example, sockeye salmon are most abundant in Alaska (table 1)--specifically in Bristol Bay, waters near Kodiak Island, and Cook Inlet.

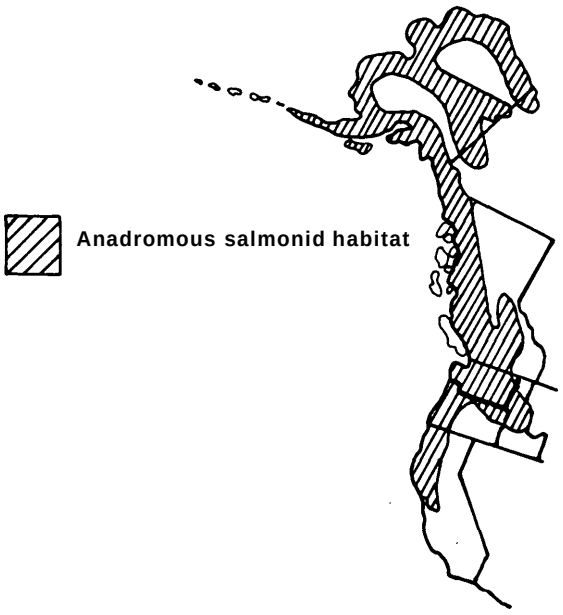


Figure 1.--Distribution of anadromous salmonid habitat in western North America.

Anadromous salmonids use both freshwater and marine environments, and they all have exacting habitat requirements. All species reproduce in fresh water, and most rear there before migrating to sea (as smolts) where they mature (fig. 2). Freshwater habitat requirements differ slightly, but all species share some common requirements. For optimum production, all of them require cool, flowing waters; migratory access to and from the sea; clean gravel substrate for reproduction; high levels of dissolved oxygen in streams, lakes, and intragravel environments; sufficient instream cover; and food organisms. Species preferences for these requirements vary slightly (Reiser and Bjornn 1979).

Table 1—Present occurrence of anadromous salmonids in western North America[1/] [2/]

	Region					
	Continental United States				Canada	Alaska
Species	California	Oregon	Washington	Idaho	British Columbia	Alaska
Pink salmon	Rare to absent[3/]	Rare to absent	Present	Absent	Abundant	Predominant
Chun salmon	Rare	Few	Present	Absent	Abundant	Predominant
Sockeye salmon	Rare	Rare to absent	Few	Rare	Abundant	Predominant
Chinook salmon	Abundant	Abundant	Predominant	Present	Abundant	Present
Coho salmon	Present	Abundant	Abundant	Few	Predominant	Abundant
Cutthroat trout	Present	Predominant[4/]	Abundant	Absent	Present	Present
Rainbow trout (steelhead)[5/]	Abundant	Abundant	Predominant	Present	Abundant	Present
Brown trout	Few[6/]	Absent	Absent	Absent	Absent	Absent
Dolly Varden[7/]	Absent	Few	Present	Absent	Present	Predominant
Arctic char	Absent	Absent	Absent	Absent	Few[8/]	Predominant
Percent usable spawning habitat vs. historic[1/] [9/]	50	75	15	50	100	100

Sources
1/ Atkinson and others (1967).
2/ Scott and Crossman (1973).
3/ McPhail and Lindsey (1970).
4/ Giger (1972).
5/ Sheppard (1972).
6/ Burton (1982).
7/ Clemens and Wilby (1961).
8/ B.C. Ministry of Environment (1981).
9/ Fry (1973).

Definitions
Absent - no fish present.
Rare to absent - occur rarely.
Few - occur occasionally.
Present - supports fishery.
Abundant - readily harvestable numbers.
Predominant - numbers used surpass all others (by region).

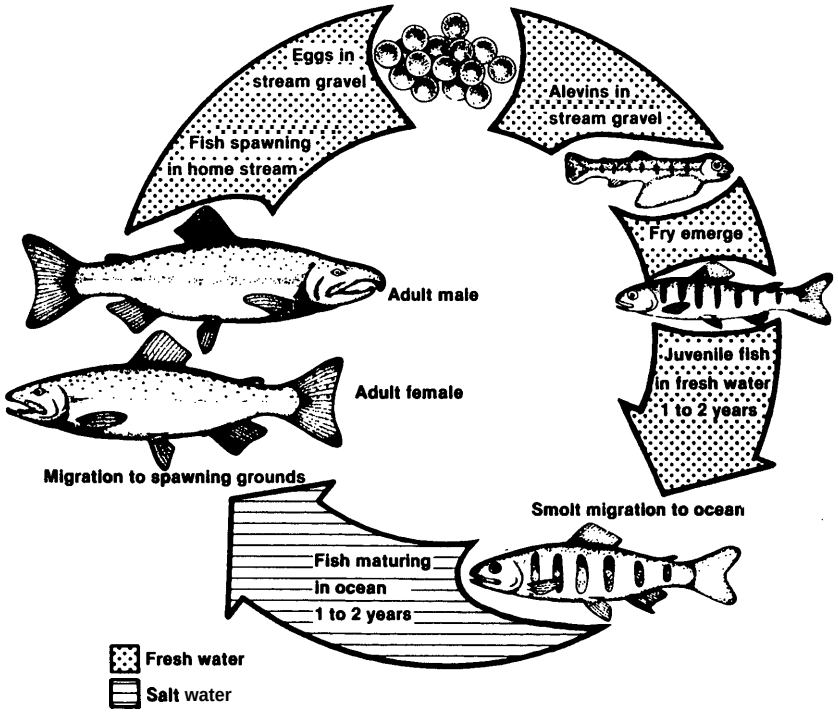


Figure 2.--Typical life cycle of anadromous salmonids.

Table 2—Availability and use of anadromous fisheries on National Forests

Item	West coast (U.S.A.)	Alaska
Miles (kilometers) of stream:		
All fisheries	71,000+ (113 600+)	31,000+ (49 600+)
Anadromous fisheries	43,000+ (68 800+)	30,000+ (48 000+)
Number of fishing trips, anadromous fish	1,921,400	1,427,600

Source: Sport Fishing Institute (1982).

Because of the extensive and variable movements of these fish in the sea, a better picture of the United States distribution is presented by looking at their natal stream habitat. On National Forest lands in southeastern Alaska, anadromous fish are found in over 4,850 streams, which have a length totaling more than 30,000 miles (48 270 km), and 120,000 acres (48 560 ha) of lakes (Everest and Summers 1982). National Forest lands in the West have over 43,000 miles (69 200 km) of streams producing anadromous salmonids annually (USDA Forest Service 1982), and provide about 1,921,400 recreation visitor days (Sport Fishing Institute 1982) (table 2).

Alaska, by having more than 36 times as much freshwater habitat per resident than any other western State, has the greatest potential for fish and angling. Washington, Oregon, and Idaho will have trouble maintaining their present fish production because the construction of hydroelectric dams on the Columbia River has eliminated half of the potential spawning habitat of anadromous fish (Rettig 1980). The 1980 Northwest Power Act is an attempt to stabilize fish production by providing for the protection and maintenance of anadromous fish that use streams with hydroelectric developments. California is the only western State that has an excessive demand for sport fishing, and it has the least of its original fishing habitat accessible. California is the most populous State; it has many new water-development projects planned. The percentage of Californians who sport fish will probably decline because of the reduction of the aquatic habitat needed to produce anadromous fish, which will increase fishing pressure and lead to angler dissatisfaction.

Using artificial propagation is one of the primary issues related to the supply of anadromous salmonids. Historically, salmon and trout from hatcheries have been used to replace lost natural production and to supplement natural producton where the demand for certain species is high. In Oregon and Washington, about 65 salmon and 31 steelhead hatcheries are thought to be supplying about 50 percent of the total production of these fish. Some of these hatcheries are very successful, and others are not. Although hatcheries can produce substantial quantities of salmon and trout, they can be subject to or cause problems, including: high capital and operating costs; disease problems both in the hatchery and by contamination of natural stocks; high probability of major genetic changes both in the hatchery stock and in natural wild stocks through interbreeding; breeding of a "nonbiting" fish that more efficiently escapes both the commercial and the recreational fisheries; and difficulty of harvesting the excess supply of hatchery fish without overharvesting natural stocks with which they mingle (continual planting of hatchery fish stimulates an increase in fishing effort that will persist as long as the catch remains within a satisfactory range).

Artificial production can play an important role in moderating changes in the environment, but it is a less desirable alternative than the natural production of anadromous salmon and trout.

THE MULTIRESOURCE SYSTEMS PERSPECTIVE

The relation between recreation and the anadromous fishery is inherently complex, representing an interaction among people, various resources, and the uses of those resources. For example, not only may recreational use directly affect fish and their habitat, but other resource uses (such as timber harvesting and road building) may affect recreational use, which may lead to additional effects on the fishery. Consequently, to understand how recreation and anadromous fisheries are related requires a multiresource perspective. Recreation specialists can use this perspective to avoid or solve conflicts and to identify and use positive opportunities. Some of the basic parts of this complex system are illustrated in figures 3, 4, and 5.

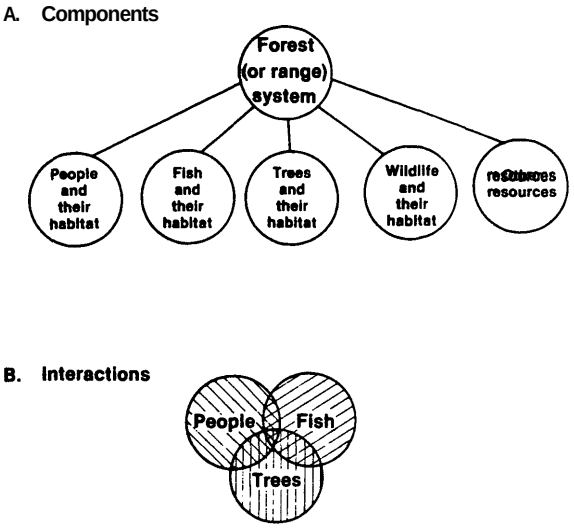


Figure 3.--Resource components and interactions in a forest-resource system.

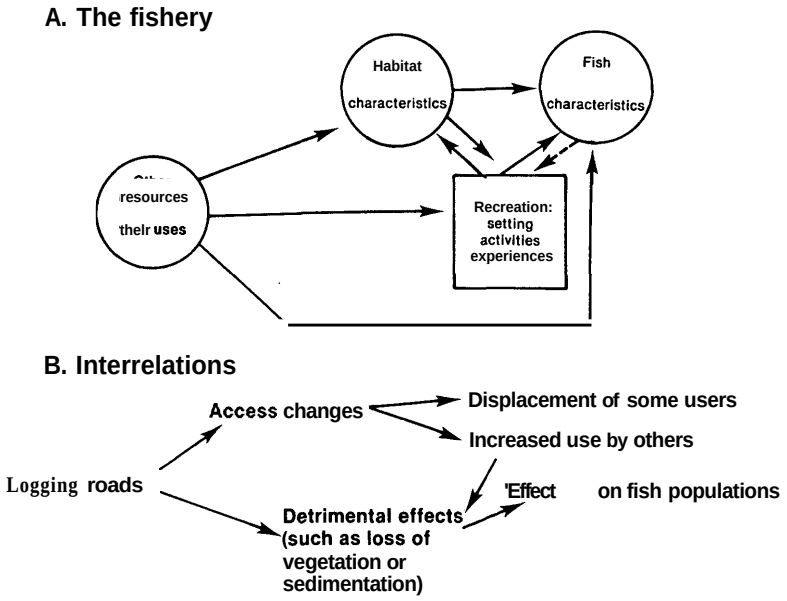


Figure 4.--Interactions of the anadromous fishery and recreation.

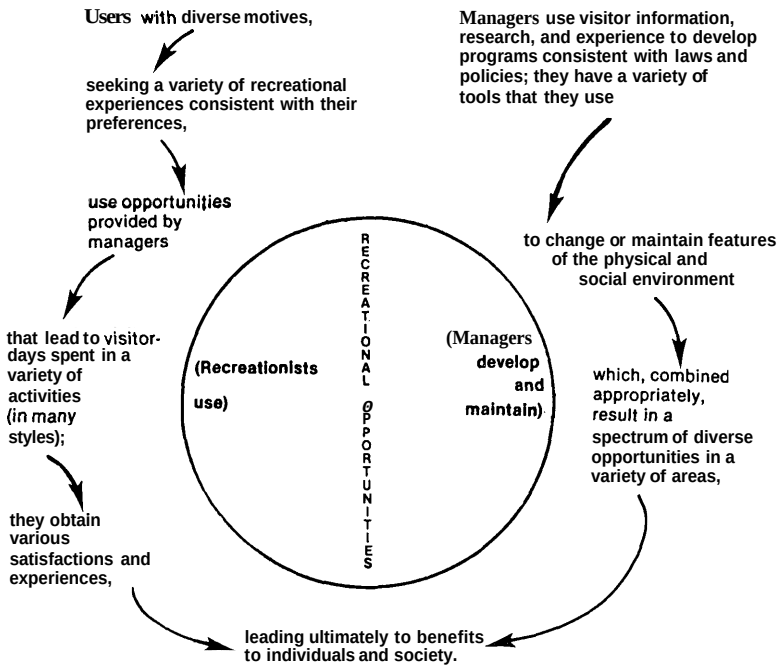


Figure 5.--Link between desires of recreationists and opportunities provided by managers.

The basic social and biological communities present in most areas (fig. 3a) cannot exist without influencing or being influenced by the others (fig. 3b). Most management and research have focused on people or fish or trees, but most of the controversy and problems in resource management are found in the areas of overlap. We know the least about where the various physical and biological systems overlap--and interact.

We will discuss the area where all these interests come together. This simple idea is expanded (fig. 4) to separate the two basic anadromous fishery components (habitat and fish) and recreation, which includes settings ("people habitat"), recreational activities, and recreational experiences. Recreation may affect both fish habitat and fish populations (fig. 4a). Some fish-habitat management programs may affect recreational use as well, either positively or negatively. Other resource uses, such as logging, may have a negative or positive influence on certain types of recreational opportunities and may subsequently affect the fishery system.

Roads built for logging (fig. 4b) may directly cause increased sedimentation, which adversely affects fish survival. Roads also provide access for recreationists that may lead to changing patterns of use in an area (desirable to some people, undesirable to others). Changed or increased use may have either detrimental effects on the fish populations (reduction in stock below optimum) or on fish habitat (loss of vegetation, increased sedimentation), or positive effects on fish populations (harvest limited to reproductive surplus).

The system we are examining is not simple. We will use the general relations briefly presented here to organize current knowledge about recreational effects on anadromous fish.

THE RECREATIONAL SYSTEM

In this section, we describe recreational characteristics that provide a background for evaluating recreational effects on the fishery. We assume that an understanding of people's motives will help in the evaluation and prediction of potential effects on fish habitat.

COMPONENTS

When considering opportunities for outdoor recreation, people choose the setting, the activities, and the kinds of experiences to seek (fig. 5). We will focus on the recreational setting because it is the point of contact between recreation and fishery habitat. Recreationists who have information describing the factors that influence or define the range of possible recreation settings will be in the best position to make recreational choices (Clark and others, in press).

WHAT WE KNOW ABOUT OUTDOOR RECREATION

Since the 1950's, research has addressed recreation in general, as well as specific activities, such as fishing, We will identify some basic conclusions and principles from those studies on interactions between recreation and anadromous fisheries. All recreational activities occurring in areas that support the anadromous fishery will be considered.

In both the formal and popular literature related to outdoor recreation, terms such as motives, satisfactions, and experiences are commonly used, sometimes ambiguously. The definitions used in this paper are as follows:

Motives--the underlying reasons for engaging in a recreational pursuit (for example, health, relaxation, and strengthening of family ties).

Preferences--the favored alternatives for activities, experiences, or setting attributes.

Expectations--conditions presumed to be encountered during recreation (expectations are based on previous knowledge and experience).

Opportunities--chances for recreation, consisting of:

- Settings--the combination of social, managerial, and natural features that give recreational value to a place.
- Activities (uses)--various ways that people behave in their leisure time.
- Experiences--the products resulting from participation in a recreational activity or set of activities in a particular setting.

Satisfaction — the enjoyment that people derive from participation in various recreational pursuits.

The following generalizations suggest how people relate to recreational opportunities and areas that may sustain an anadromous fishery.

1. Recreationists' preferences and motives span a range of settings.

People use particular locations for different reasons. Water, whether in lakes, streams, or oceans, is an important component in recreational choices (Clark and others, in press; Lime 1971; Lucas 1964). Forests, fish, and wildlife also play a key role for many people.

Managers should not presuppose what a particular recreation user finds desirable about specific recreational sites or recreational settings in general. For example, a variety of preferences may be related to users' choices to use areas considered to be habitat for anadromous fish. Anglers will, of course, prefer the presence of fish; however, other attributes--such as a place to camp, parking for vehicles or boats, or a place for family and friends to get together--may be important enough to take precedence over fishing. The extent to which people prefer to engage in activities away from the site will also influence their decision.

2. Recreational activities are diverse.

Recreationists can take part in a wide variety of activities; for example, hiking, camping, boating, hunting, and off-road-vehicle use can all take place in fishing areas. In common among such activities are the base resources used, the number of people using them, and the type of management provided, The fact, that a stream with an abundant anadromous fishery is present does not mean fishing will necessarily be the primary use of the area. The river (or lake) may be important to all users, but the fish may be critical for only some of them. Furthermore, most recreational outings are composed of several activities and an individual's decisions regarding where to go may vary from trip to trip depending on the "primary" purpose of the trip.

When recreational effects on the anadromous fishery are studied, all activities in the areas influencing fish habitats (riparian and related uplands, as well as the aquatic areas) must be considered. Whether a person is standing on a bank fishing or standing on a bank taking photos makes little difference. Important considerations related to all recreational activities are: where they take place in relation to fish habitat (upland, on bank, in water), when they occur (seasons, stage of fish's life cycle), the duration of the activity, the number of people in an area (intensity of use), and how widespread the use is over an area (extent of use).

3. Activities cannot be equated with motives for recreation or resulting experiences.

Recreation managers have concluded that people can have different motives for engaging in the same activity (such as fishing). Motives may include nature appreciation, interaction with other people, challenge, relaxation, and even catching fish, But catching fish (or shooting game) is not necessarily related to satisfaction and enjoyment (Brown 1982, Hendee and others 1977, Potter and others 1973). This knowledge is significant when attempts are made to change patterns of recreational use. Changing these patterns by managing the fishery (increasing or decreasing stocking, changing species composition) will affect only people whose primary motive is catching fish.

Recreationists are satisfied with a particular trip or activity when pretrip expectations are consistent with what they encounter (Clark and Stankey 1979b, Roggenbuck and Schreyer 1977). A high degree of satisfaction can also occur when recreationists are able and willing to modify their plans whenever expectations are not met.

Anadromous fishery habitats can be more effectively managed when the motives of those using them are known. If recreational values are the major reason for fishing, then the fish take a secondary role. When fishing is a trophy or subsistence activity, then the taking of fish is the primary concern. Understanding of various motives for fishing will allow managers to develop strategies consistent with users' values.

4. Access is an important influence on recreational choices, and the location and amount of recreational use.

Of all management factors identified by Clark and Stankey (1979a) in the Recreation Opportunity Spectrum (ROS), access probably plays the most critical role in either facilitating or hindering recreational use. Roads facilitate recreational preferences at the "modern–urban" end of the ROS. Road access will .hinder recreational opportunities that are not compatible (necessary or desired) with roads. Decisions made about roads--needs, location, and type--are not usually made with recreational objectives in mind. Yet, road construction and use may have major detrimental effects on anadromous fish habitats (Gibbons and Salo 1973, Yee and Roelofs 1980). Best management practices have been developed to minimize these effects (Yee and Roelofs 1980). Later in this paper we will discuss considerations for identifying and evaluating both positive and negative implications of access management alternatives.

5. Most people take recreational trips in areas near their communities.

Studies in Alaska demonstrate that most recreational trips by residents are taken in areas around communities (Clark and others 1982). A "home range" exists that is based on type of access and time of travel. In southeastern Alaska, the home ranges for the various communities are generally independent of one another. By understanding the relation between recreational users and available recreational opportunities, resource managers can better predict the consequences of their policies and actions. Some changes by management may have significant effects on patterns of recreational use in areas considered as anadromous fish habitat.

6. Managers and recreationists disagree about the importance of recreational effects.

Studies show that resource managers have a greater concern for the effects of recreation than do recreationists (Clark and others 1971, Clark and Stankey 1979b, Downing and Clark 1979, Lucas 1979). Managers' values differ from those of many users. Because of their training and experience in natural resources, most managers prefer to see recreational areas remain relatively undisturbed. Recreation managers are more likely to favor the more "primitive" end of the Recreation Opportunity Spectrum than are many users. Managers are also likely to have a longer and more intense experience with the effects of recreation than are most users and may be more sensitive to resource changes.

Managers should recognize that such disparities exist and attempt to accommodate user perspectives and educate users concerning the problems that may be created by recreational activities. Each group must understand how the other relates to resource changes before any effective controls can be developed and carried out.

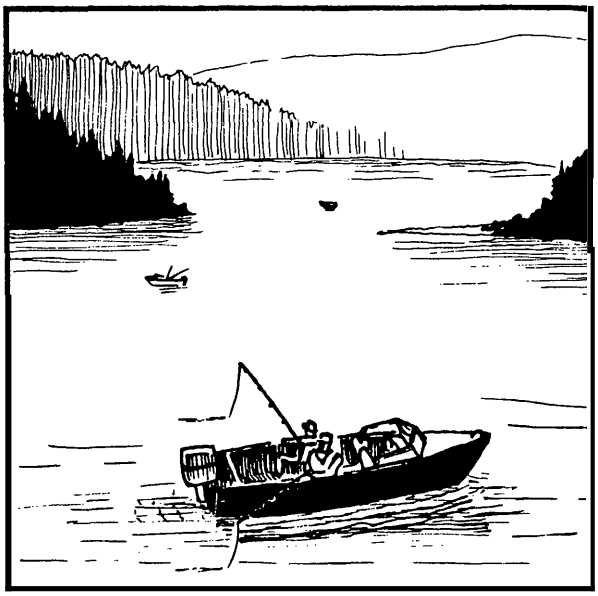
7. The same activity may take on different styles.

People can participate in the same recreational activity in a variety of ways and in places that range from city parks to wilderness. An activity such as hiking is basically the same in all areas, but the motives for engaging in the activity, the style of participation, and the resulting experiences can differ dramatically from one area to another.

Fishing is a good example. Bryan (1976) describes four types of anglers:

> Occasional--novice ability and interest in the sport; any fish will do as long as the challenge is not too difficult.
>
> Generalist--focus on catching numbers of fish by any means or tackle.
>
> Tackle-species specialists--specialize in method (for example, fly-fishing) and species (for example, steelhead); importance placed on the skill and the esthetic quality of the experience, as opposed to catching and keeping fish.
>
> Method-species-setting specialists--specialize in method, species, and setting (spring or meadow streams); preoccupation with skill and overall quality of experience; tend to center much of life around leisure activity.

As the anglers move from the "occasional" to the **method-species-setting specialist," they become more particular as to species, technique, tackle preferences, and setting requirements. Two different philosophies of fisheries management can be used to meet these varied demands: managing the indigenous salmonid populations as part of the natural ecosystem, in which harvest is limited to the reproductive surplus, or the intensive stocking of hatchery fish to build up the fishery. The first option depends on maintenance of the stream habitat to produce fish, and fishery regulations to provide adequate fish escapement. Anadromous fish have remarkable powers to replenish their numbers. As long as stream conditions remain favorable to their individual requirements, many native fish can be harvested without endangering brood stocks. The second option, to use many hatchery fish to increase fish populations, responds to the first two angler types. These anglers generally are concerned more with the number of fish taken than with the quality of the fishing experience.



INTERRELATIONS BETWEEN RECREATION AND THE ANADROMOUS FISHERY

Recreation may affect fish and their habitat, and fishery management influences recreation. We have made an attempt to identify all the potential influences, but because information about the nature and extent of such influences is limited, evaluation of their importance will have to be made case by case.

EFFECTS ON THE FISHERY FROM RECREATION

ZONES OF INFLUENCE

Recreation can affect the fishery in four basic zones--coastal marine, estuarine, riparian-stream, and lake. Various recreational activities have both direct and indirect effects on the fish and their habitats in these locations. Recreational activities occur at the edges of fish habitat zones (lakeside, streamside, and seaside) and in the water in all zones. The importance of effects on the fishery from recreation are shown in table 3.

Table 3—Importance of recreational activities to anadromous fish and fish habitats

Zone of influence	Effects on fish populations	Effects on habitat
Marine:		
Coastal (open ocean)	(X)	0
Estuarine	(X)	0
Freshwater:		
Streams	X	X
Lakes	X	(X)

0 = none likely.
(X) = possible minor effect.
X = possible major effect.

DIRECT EFFECTS ON FISH

In all of these zones, recreational effects on fish occur primarily through fishing. Adult fish of various species (all the anadromous salmonids, smelt, striped bass, shad, and sheefish) are the primary targets of anglers. Fishing, depending on the available fish population and the intensity of fishing, may have either minor or major adverse influences on the fish. Hooking, even if the fish are released, can result in injuries and diseases that may lead to death. Handling hooked fish before releasing them also contributes to mortality. The combination of effects on the fish from harvesting or hooking and releasing can influence the size and species composition of populations. Recreational activities other than fishing apparently do not directly affect fish.

EFFECTS ON FISH HABITAT

The ways in which recreation may influence elements making up the habitat of anadromous fish are summarized in table 4. Recreation is considered in two ways--the factors defining the recreational setting (habitat) and the recreational activities taking place. We have attempted to isolate recreational components that appear related to elements of fish habitat. The habitat requirements of anadromous fish are complex, but are condensed here into four principal components--cover, food, space, and spawning area. These four habitat components are associated (table 5) with migration, spawning, incubation, and rearing, and the habitat zones of influence.

Table 4—Effects from recreational activities by zones of influence

	Upland			Riparian			
	Vegetation			Vegetation			
Activities	Overstory	Understory	Soils	Overstory	Understory	Soils	Aquatic
Hiking	(2)	(1)	(1)	(2)	(1)	(1)	(2)
Horses	(2)	(1)	(1)	(1)	(1)	(1)	(2)
Vehicles:							
On roads	—	—	(2)	(2)	(2)	(2)	(2)
Off roads	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Camping	(1)	(1)	(2)	(1)	(1)	(1)	(1)
Fishing	—	—	—	(2)	(1)	(2)	(1)
Boating	—	—	—	(2)	(1)	(1)	(1)
Waterplay:							
Swimming	—	—	—	(2)	(2)	(2)	(1)
Temporary dams	—	—	—	(2)	(2)	(2)	(1)
Removing debris	—	—	—	(2)	(2)	(2)	(1)
Bathing, dishwashing	—	—	—	(2)	(2)	(2)	(1)

(1) = primary effects.
(2) = secondary effects.

Table 5--Relations of zone of influence to the freshwater habitat requirements and life cycle of anadromous salmonids

Zone of influence	Habitat requirements/freshwater life-cycle phases[1/]			
	Cover/ migration	Food/ spawning	Space/ Incubation	Spawning substrate/ rearing
Upland:				
Vegetation	0/0	0/0	0/0	2/0
Soils	0/0	0/1	0/1	2/0
Riparian:				
Vegetation--				
Understory	1/0	1/0	0/0	0/1
Overstory	1/0	1/0	2/0	0/1
Soils	2/0	0/1	2/1	1/2
Aquatic:				
Vegetation	1/2	1/0	0/0	0/1
Streamflow	2/1	2/1	1/1	1/1
Channel morphology-				
Riffles	2/0	1/1	2/1	1/2
Pools	1/2	1/0	1/0	0/1
Water quality—				
Suspended sediment	2/2	1/0	0/0	0/1
Bedload sediment	1/0	1/1	1/1	1/1
Temperature	0/1	1/1	0/1	0/1
Dissolved oxygen	0/1/2	2/1	2/1	0/1
Bacteria	0/0	2/1/0	0/2	0/1/2
Chemicals	0/2	1/1	0/1	0/1
Barriers	2/1	2/2	2/0	0/1/2
Debris	1/1	2/2	0/0	0/1

[1/] First number is related to habitat requirements; second number is related to life-cycle phase. 0 = none anticipated; 1 = primary effect; 2 = secondary effect.

The literature, our professional experience and judgment, and common sense suggest that certain combinations of recreational factors defining settings, coupled with specific activities, may affect anadromous fish habitat. Whether the possible effects we identify are important cannot be readily determined. Resource managers will have to evaluate the consequences of encouraging or discouraging individual recreational uses.

In the riparian zone, such activities (as well as management actions that support them) may alter habitat elements important to anadromous fish populations. Recreational use of the riparian zone does not always disrupt anadromous fish habitat significantly, however. Both the size and importance of effects must be taken into account in evaluating whether intolerable effects have occurred.

EVALUATING THE EFFECTS FROM RECREATION

Recreational effects differ by region, river type, vegetation and soil conditions, season, and the nature and extent of recreational use. Evaluation of these effects is largely judgmental; seldom are definitive answers available to allow accurate prediction.

Some of the patterns of recreational use that should be considered when evaluating its effects are: temporal variation (daily, weekly, seasonally, duration); intensity of use (concentrated use, dispersed use); spatial distribution (upland--on or off road; riparian; and in water--ocean, estuary, stream, or lake).

Questions that need to be addressed when evaluating the significance of recreational effects include:

- Do use and resulting effects coincide with areas of key fish production?
- Is the effect serious enough to create a change in habitat components? Will the change be quick or slow to occur? Will it be a long- or short-term change? Are cumulative effects likely?
- Are the recreational uses and any resulting effects concentrated in only a small portion of the stream or are they widely dispersed?

Answering these and other related questions will help determine whether any action will be required to prevent or ameliorate further changes in fish-habitat conditions.

Some general observations about recreational use and its relation to anadromous fish habitat are:

- Recreational use is not uniform in its distribution over either time or space--water generally draws and concentrates use.
- The amount of use is not necessarily directly related to the effects on the area. Sometimes the practices of the individual or party in an area are more important than the number of people (Aitcheson and others 1977).
- Most of the change in vegetation results from initial light use (Cole 1979).
- Anglers can significantly affect upland and riparian habitat in addition to directly affecting fish populations because they spend a lot of time in other activities, such as sightseeing, walking, and camping.

When existing or potential effects along a stream are evaluated, knowing how they differ may be useful. Some of the ways effects can differ are: probability of occurrence (likely, unlikely), distribution (intensity, extensity), magnitude (minor, major), duration (short term, long term), recovery (quick, slow), and location (instream, riparian, upland).

A guide for judging the severity of effects from recreational use is shown in figure 6. We believe that by considering both the intensity and extensity of effects, actual or potential effects can be ranked. We believe that "severe" impacts have seldom occurred because of recreation.

After the severity of the possible recreation effects is determined, the manager has several options. When the effects exceed what is acceptable to management objectives, the manager can:

- Do nothing, thereby accepting the consequences of the use or uses in question.
- Mitigate the effects by limiting or eliminating use in critical areas through regulation or by changing site design.
- Redefine fishery objectives for all or part of the area (recreation might be more important than fishery values).
- Use a combination of the second and third alternatives.

Managerial decisions will require judgments about the consequences and feasibility (biological, social, and political) of each alternative. Information about the size of the effect on anadromous fish habitat and the importance of the change for various resource uses, including recreation, will be helpful in making judgments.

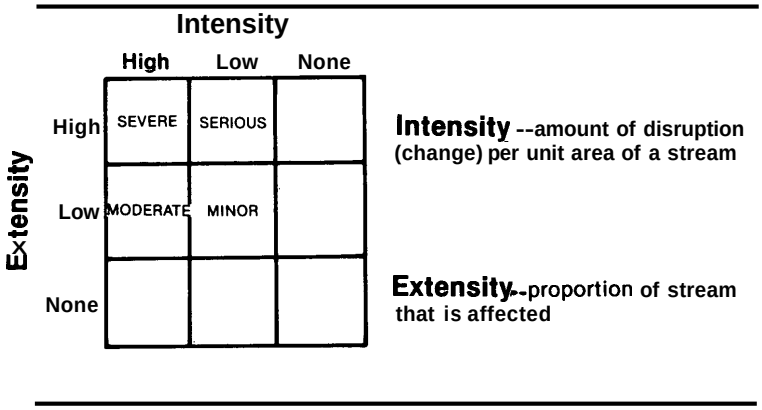
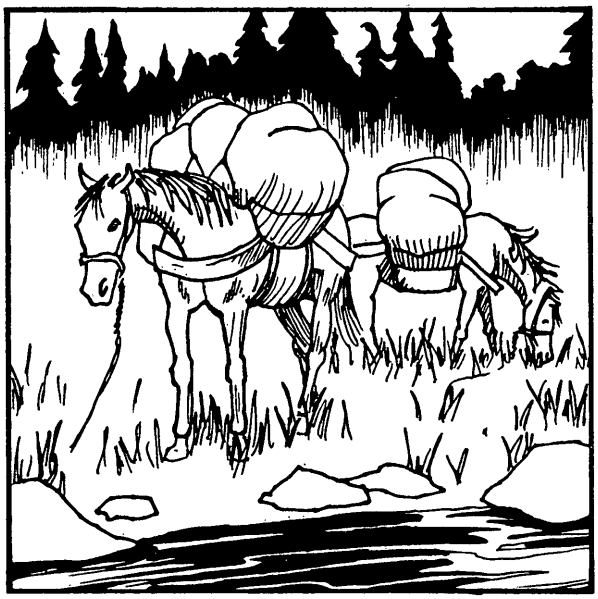


Figure 6.--Effects of existing or potential recreational use along portions of a stream.



GENERAL EFFECTS OF RECREATION ON ANADROMOUS FISH HABITAT

Little documentation exists regarding specific effects of recreation on anadromous fish habitat. Some research--briefly summarized here--has been conducted on the effects of recreation on soils and vegetation in general and along streams in particular. We also speculate about how recreation can affect other environmental factors listed in table 5, and the implications such changes have for anadromous fish in various stages of their life cycle.

We believe recreational use can affect anadromous fish habitat in the following ways:

- Upland changes in soils and vegetation that may affect runoff and erosion.
- Riparian changes that influence erosion, cover, food sources, and water quality.
- Instream changes that affect stream morphology, water quality, stream flow, substrate, and debris.

The nature and extent of such potential changes differ by the intensity and extensity of recreational use.

UPLAND SOILS AND VEGETATION

Changes in vegetation from recreational activities in upland and riparian areas appear to be generally similar to effects of livestock grazing (see Platts 1981 for a discussion of the effects of livestock grazing). Cole (1979) discussed problems in studying recreational effects on vegetation and concluded that most change results from initial light use. Continued or increased recreational use at sites may have little additional effect.

Settergren's (1977) review identified six possible effects on soils of recreation along rivers: compaction, root exposure, destruction of the soil profile through loss of vegetation, reduction in organic matter, increased bulk density, and decreased soil moisture. He concluded (in agreement with Cole) that the greatest compaction occurs immediately after an area is opened for use, after which the soil tends to stabilize. As soil compaction and vegetation loss occur, erosion may accelerate. This can decrease the depth of soil profiles and expose roots.

Landform patterns in upland and riparian areas may also be affected by recreational use. Hiking and use of off-road vehicles or horses may create ruts and trails that gather runoff, leading to increased erosion. Whether such changes will occur, or to what extent, depends on local soils, vegetation, topographic conditions, and the proximity of the damage to riparian areas.

Settergren's (1977) review also described five types of vegetation changes: mortality of overstory, loss of tree vigor, mechanical injury, root kill, and loss of ground cover. Recreational activities can cause direct physical or mechanical injury and indirect physiological and morphological changes by affecting the soil. Settergren concluded that mechanical injury is common, increasing the likelihood of disease and possible subsequent mortality. Decline in tree vigor is sometimes associated with soil degradation, and reduced ground cover (both total amount and number of species) is one of the first signs of recreational use. Settergren believes a shift towards fewer, more tolerant species may occur when vegetation is adversely affected by recreational uses.

The consequences of these changes on the quality of fish habitat are uncertain. Vegetation loss may lead to soil loss, compaction, or both; increased sedimentation; and reduced fish spawning habitat. No research has been specifically conducted establishing whether, or under what conditions, such results might occur.

RIPARIAN

The USDA Forest Service defines a riparian ecosystem as "a transition between the aquatic ecosystem and the adjacent terrestrial ecosystem and is identified by soil characteristics and distinctive vegetation communities that require free or unbound water." For management purposes, riparian boundaries are defined as "the land and vegetation extending at least 100 feet measured horizontally from the edges of all perennial streams, lakes, and other bodies of water" (USDA Forest Service 1980).

When potential effects from recreational activities are evaluated, local conditions affecting the size of the riparian area must be considered. Substantial differences in the recreational use and its effects can occur in areas where the actual riparian area is 300 feet rather than 5 feet wide. In general, greatest disruptions are likely to occur within 15 feet of the stream. Thus, our definition of the riparian zone is the area of land and vegetation that provides a transition between the aquatic and terrestrial environments, and directly influences the stream.

Streamside vegetation directly influences the quality of anadromous salmonid habitat. Riparian vegetation provides shade and an insulating canopy, preventing adverse water temperatures during both summer and winter. It also acts as a filter to prevent addition of sediment, and its roots provide streambank stability and cover for rearing salmonids. Riparian vegetation directly influences the food chain of a stream ecosystem by providing organic detritus and terrestrial insects, and by controlling aquatic productivity that depends on solar radiation.

Understory.--Understory vegetation can be reduced or removed when recreational activities occur along the edge of rivers and lakes, depending on the intensity and type of activity. Loss of understory vegetation directly affects the rearing habitat of salmonids by reducing hiding cover, food production, and streambank stability. Food sources for anadromous fish may be affected in different ways. Loss of streamside vegetation resulting from recreational use will affect insect habitat. Chemicals used for insect control in developed campgrounds will reduce available insect populations.

Undercut banks.--Banks can be destroyed whenever recreational activities take place near the shore of rivers and lakes. How quickly bank-loss occurs and how much of the shoreline will be affected depends on the type of recreational activity taking place and its frequency. Use of off-road vehicles and horses will generally be more disruptive than foot travel. The addition of sediment directly affects spawning gravels, and the loss of undercut banks has a negative effect on rearing areas.

Overstory.--In addition to directly affecting cover, food, and streambank stability as the understory does, the overstory provides shade, resulting in increased rearing space and the cool waters that favor growth of salmonids.

AQUATIC

Vegetation.--When some measure of stabilization of the stream bottom is reached, the substrate becomes habitable for plants and animals. The presence of macro-aquatic vegetation (such as mosses and lily-pads) signifies a stable environment. Habitat is affected when the sedimentation rate or volume of streamflow is changed by either indirect recreational activities or removal of the aquatic vegetation. These effects may be temporary or permanent, depending on the type and duration of the activity. Loss of vegetation can affect fish production by removing cover and reducing available food.

Streamflow.--Significant changes in streamflow can occur as a result of recreational activities, including placement of rocks and debris in the stream, and diversion or impoundment of water. Rocks and debris can be beneficial for fish rearing if they are added in moderate quantities. Large additional quantities, however, can result in channel instability and streambank erosion. Reduction in streamflow, as a result of diversion or by dams, is a common problem that can be directly detrimental to both spawning and rearing habitats. Reduced streamflow can impede or block both downstream smolt movement and upstream adult migration, increase water temperatures, and reduce available rearing and spawning habitat.

Channel morphology, riffles.--The depth and flow of water over and through riffles defines the quality of spawning habitat for the various species of salmonids. Activities such as swimming, boating, and instream use of off-road vehicles can affect riffle quality. Swimming-hole construction or enlargement and streamflow concentration for boat passage can disturb habitat and fish. If the quality of riffle areas decreases, production of usable food will also decrease.

Channel morphology, pools.--A pool is generally deeper and sometimes wider than the average width and depth of the stream, and its velocity is slower than the immediate upstream and downstream segments. Pools are used by salmonids for rearing and for resting during migration. Pools can also be used by recreationists for swimming, boating, suction dredge mining, bathing, and other activities. A change in pool character (depth, width, debris) generally results in a decline in salmonid populations. Pool character is affected most often by a change in the quantity of cover (logs, limbs, rocks, and undercut banks).

Water aualitv, suspended sediment.—The concentration of suspended sediment above which fish resources are damaged and below which they are unaffected is not sharply defined (Gibbons 1982). Unfortunately, little information is available on suspended sediment, and much of it is poorly documented. Many of the life-cycle phases and requirements of salmonids can be affected by suspended sediment; however, intermittent additions of sediment are natural and are thought to have few detrimental effects on fish. Continuous additions may directly influence feeding and indirectly affect critical parts of the life cycle (table 5). Sediment can be produced from almost any recreational activity in uplands and transported to instream locations. Sediment can also affect angling time and success. Phillips (1971) stated that fishing success declines when suspended sediment exceeds 25 mg/liter and may cease when concentrations are greater than 100 mg/liter. Recent studies concerning the effects of sedimentation on rearing fish have indicated seasonal differences ranging from 1500 mg/liter to over 30 000 mg/liter before damage occurs (Noggle 1978). Thus, the intermittent additions of suspended sediment generally affect recreational angling and not necessarily the fish.

Water quality, bedload sediment.—Excessive amounts of fine sediment deposited in streams can reduce aquatic insect populations and diversity, available living space for fish, and survival of incubating embryos. The findings by Gibbons and Salo (1973) and Reiser and Bjornn (1979) show that: sediment can fill gravel interstices, thereby reducing intergravel and intragravel water flow; deposited sediment can physically prevent emergence of fry; and bedload sediment can reduce food resources by creating unfavorable substrates for the production of periphyton and aquatic invertebrates. Research shows the lethal effects of bedload sediment are most pronounced while the embryos are incubating in the gravel. Recreational activities can add sediment to streams by direct trampling of streambanks and, secondarily, by affecting upland soils (table 5). Through the use of riparian management strips, streambank stability can be improved, and upland sediments can be prevented from entering the stream channel.

Water quality, temperature.—Water temperature is a major determinant for salmonid production (table 5). Riparian vegetation directly influences water temperature by providing shade in summer and an insulating effect in winter. Recreational activities can remove this riparian vegetation.

Water quality, dissolved oxygen.—Adequate dissolved oxygen is important to salmonids during all phases of their life cycle. Amount of dissolved oxygen is normally near saturation; recreational activities can, however, decrease these amounts by adding organic waste to slow-moving water. In general, the effects of recreation on dissolved oxygen levels is minor. Other effects would become critical before recreational activities would cause significantly low amounts of dissolved oxygen.

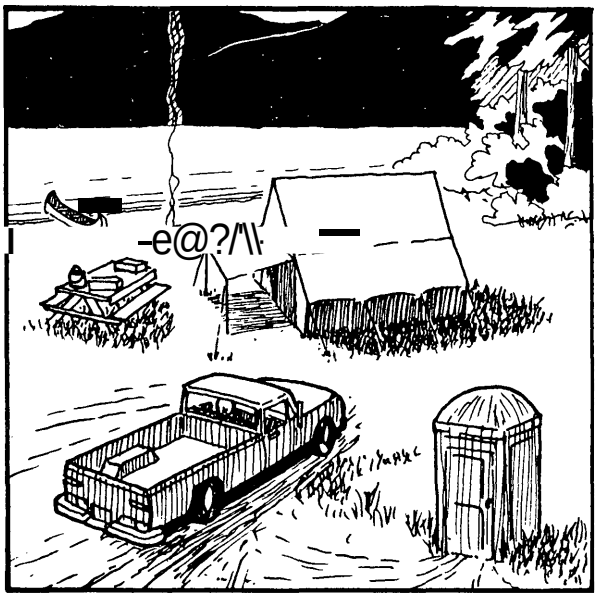
Water aualitv. fecal coliform bacteria.—Water pollution is generally measured in terms of bacterial count and index of coliform bacteria, which reflects the degree of animal (including human) waste. The occurrence of coliform bacteria in water may sometimes be associated with recreational activities. The introduction of coliform bacteria affects dissolved oxygen by increasing biological oxygen demand. Through proper siting and treating of human waste (and pack/riding stock waste), possible additions are then limited to bathing or swimming. The addition of fecal coliform bacteria from these uncontrollable sources should be minor.

Water quality, chemicals.—Bathing and washing soaps, herbicides, and insecticides are the principal recreational contaminators of water. Of these, herbicides and insecticides are of most concern. Spraying chemicals

at campsites to control vegetation and insects can inadvertently result in their entering the water systems. Even low concentrations can drastically affect spawning and rearing success. Chemical additions to streams should not occur as a regular result of recreational activities. Norris and others (1983) thoroughly discussed these effects.

Barriers.--Stream barriers can provide both valuable rearing habitat and migration blocks to anadromous fish. The probability of recreational pursuits creating barriers preventing fish migration is slight, but if they occur, barriers can be critical.

Debris.—Large organic debris is an important habitat component of anadromous fish streams. It serves to: control waterflow, shape the stream channel, provide cover, form pools and riffles, trap and hold bedload sediment, increase habitat diversity, and provide substrate for biological activities of stream organisms (Meehan and others 1977). Swimmers, boaters, anglers, and others sometimes remove debris. Removal of large quantities can result in as much as an 80-percent reduction in anadromous fish populations (Elliott and Hubartt 1978), but such removal would rarely be a result of recreation. Debris removal by recreationists is primarily localized and should have minor effects on the total fish population of any stream.



EFFECTS OF MANAGEMENT OM RECREATION

Three classes of management actions or decisions are: recreation management, fishery management, and timber management. When possible effects of existing and potential recreational uses on anadromous fish habitat are evaluated, the influences of these actions must also be considered. In particular, planners and managers must be alert for possible effects outside of the recreation system itself (such as road construction) that may cause a chain reaction, ultimately changing the nature of recreational opportunities and future activities.

RECREATION MANAGEMENT

Certain decisions and actions of recreation managers may have implications for one or more aspects of fish habitat. Two basic types of actions are Recreation Opportunity Spectrum (ROS) class designation and management of ROS factors.

ROS is a model that helps to clarify relations among recreational settings, activities, and experiences (Brown and others 1978, Buist and Hoots 1982, Clark and Stankey 1979a, Clark 1982). The assumption underlying the ROS is that quality is best assured by providing diverse opportunities. The ROS recognizes that opportunities sought by recreationists range from easily accessible, highly developed areas with modern conveniences to undeveloped areas in remote locations (certain wilderness designations). Within each of the general types of settings, a variety of activities, such as fishing, camping, and hiking, is possible.

A recreation opportunity setting is defined as the combination of social, physical, biological, and managerial conditions that give perceived value to a place. It is distinguished by varying conditions ranging from modern to primitive, or as Nash (1973) phrased it, "from the paved to the primeval." The ROS includes six factors that influence recreational behavior and have significance to management. A more detailed description of these six factors may be found in Clark and Stankey (1979a), but briefly they are:

- Access into and within the area, with degree of difficulty associated with access and the permitted means of conveyance.
- The extent to which other nonrecreation resource uses (such as timber harvest, anadromous fishery management, and mining) are compatible (from the user's perspective) with various outdoor recreational activities.
- Onsite management--the extent, visibility, and complexity of modification, including the use of exotic vegetation, landscaping, traffic barriers, and facilities (tables, toilets, water supplies).
- Social interaction — the relative intensity of use per unit area, including the amount of intergroup contact and the space requirements associated with different opportunities.
- Level of regimentation--the nature, extent, and degree of control over recreational use exercised by management.
- Amount and degree of visitor effects acceptable in different opportunities (as perceived by users).

An example of how these factors can be combined to create a range of settings is shown in figure 7. Each of these factors is characterized by a range of conditions. For example, access ranges from areas where mechanical access on wide, paved highways is appropriate to areas without trails where only foot travel is permitted. Similarly, social interaction varies from high-density use (where it is appropriate and expected, such as in some modern campgrounds) to places of maximum solitude. The appropriateness of these conditions varies along the spectrum. Well-developed roads and large numbers of people with frequent contact between parties are not appropriate in wilderness, although they can be in places like beaches, near an urban area, or in highly developed campgrounds.

A recreation opportunity setting is created by specific combinations of these factors in a particular place. Alternative combinations lead to different opportunity settings, providing many options to recreationists.

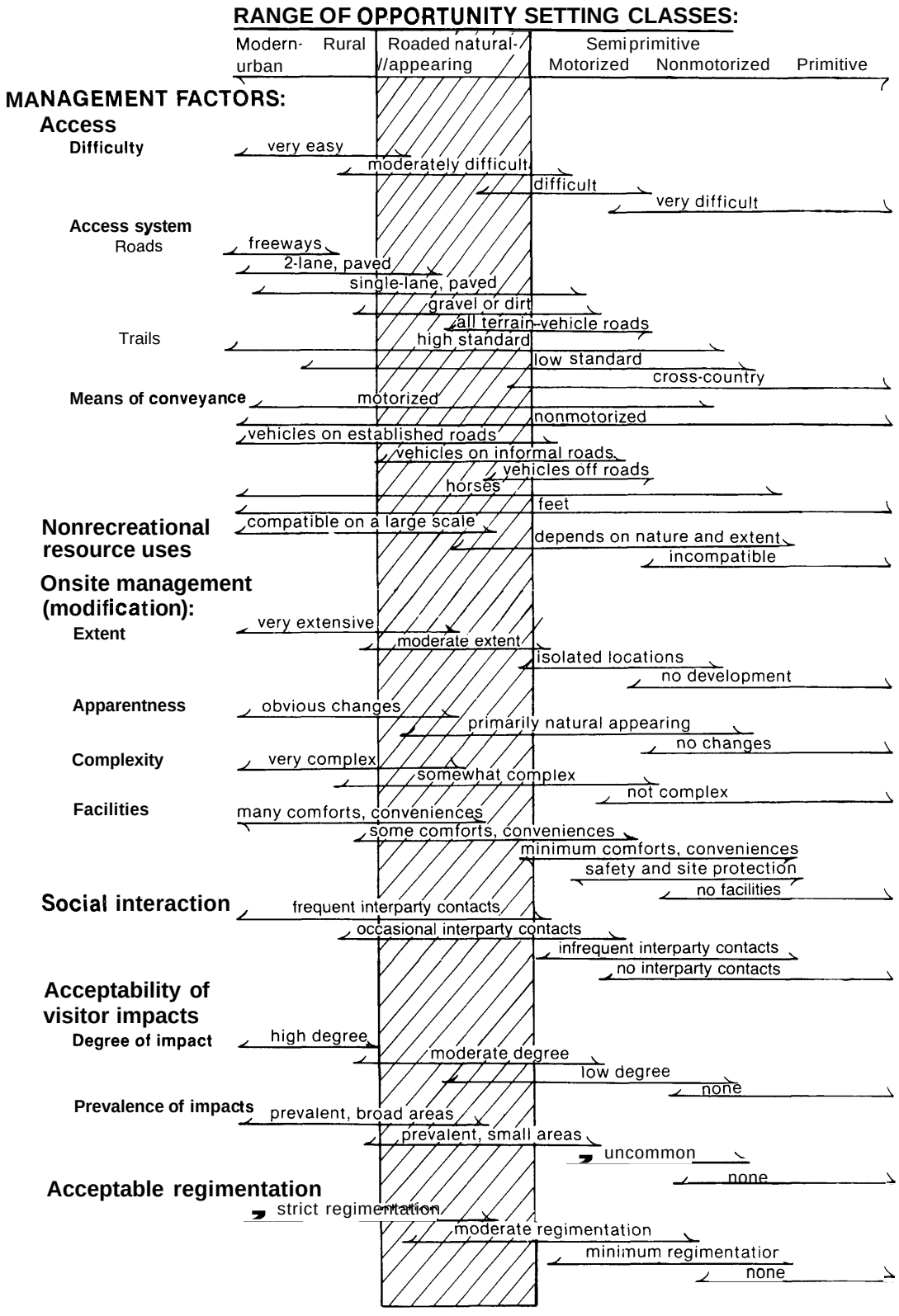


Figure 7.--Link between recreationists and opportunities (from Lucas and others 1984).

A recreation opportunity setting is also composed of other natural features in addition to the six factors. Land-form types, vegetation, scenery, water (lakes and streams), wildlife, and fish are all important elements of recreation environments; they influence where people go and the kinds of activities that are possible. No intrinsic quality of these other natural features suggests 'the appropriate type of recreation opportunity setting, however. Any of the opportunity types are as possible and appropriate in mountainous areas as they are in desert settings. Greatest diversity would be assured if the full spectrum of opportunity types (modern to primitive) could be found across the range of environmental settings.

The nature of participation in recreational activities depends on the place in which it occurs (Cheek and others 1976). Thus, natural features (terrain, rivers, lakes) will influence the activities that are possible. The combination of these environmental settings and opportunity types determines the range of recreational activities in a specific area.

The ROS assists resource planning and management by helping to integrate and coordinate recreation with other resource uses and management activities. The ROS can be applied to all kinds of land-use planning and resource management and is not only for recreation managers. Many of the factors defining recreational opportunity settings (access and use of other resources, for example) are traditionally the responsibility of other disciplines and functions (such as timber management and engineering). Coordination between different areas is necessary to insure that appropriate management objectives are stated (and achieved) and to help point out potential conflicts and compatibilities among resources (Brown and others 1978, Clark and Stankey 1979a).

ROS class designation.--Defining an ROS class in an area will not affect fish habitat until the area is used recreationally. Defining and managing by ROS class, however, may set in motion a chain of events that may affect the fishery. After classes are designated, management standards will be determined that are consistent with recreation goals. Presuming this all occurs according to plan, some general conclusions can be made about the relation between ROS class and anadromous fish habitat.

The modern-urban class is characterized by concentrated use, many facilities, paved roads, and diverse nonprimitive activities. Locating a modern-urban setting (such as in a developed campground) on or near fish habitat can have major implications for the fishery. Locally, substantial loss of vegetation, soil compaction, loss of streambank stability, and even some changes in the stream channel (depending on size) can occur. Water quality may be affected when sanitation facilities are near streams or when insecticides or herbicides are used to control insects or brush. Use of horses or vehicles along or in streams may accelerate deterioration of banks and substrate.

At the other end of the spectrum, the primitive class is characterized by light (dispersed) use, lack of most comfort and safety facilities, and primitive means of transportation (foot or horse.). Effects on fish habitat can range from none to minor, where use is infrequent (although as Cole (1979) points out, initial light use may result in most of the effect on soils and vegetation), to substantial, where use is more concentrated--such as along trails or at popular campsites.

ROS management factors.--Whether the factors helping to define the ROS are managed in an attempt to influence recreational use, or are managed for some other purpose, recreational use can be affected in nature and extent in specific areas (see fig. 7).

Access decisions will have major implications for the nature and extent of recreational use and subsequent effects on fish habitat. The location and design of logging roads and recreation trails will in a large part determine use patterns and amounts. If trail routes are at some distance from the water, effects on fish habitat will be minimized. Where stream crossings occur, disruption is likely and will be related to the nature and extent of the activities. Mode of access--foot, horse, vehicle--may also have different effects. Clark and Stankey (1979a) have indicated that managers can control type of access to anadromous fish streams and the means of conveyance allowed. Both access elements can vary along the spectrum from easy to extremely difficult. Design and management standards are important in defining the range of access. Often, topography and the type of vegetation define the range of possible access. Thus, managers are able to use a combination of natural features, design and maintenance standards, and regulations to maintain the amount of access into any given area. New roads or facilities should be designed and constructed to minimize disturbance. A review of road-construction practices for the protection of salmonid habitat has been presented by Yee and Roelofs (1980). The condition of the access road will have a strong bearing on the recreational pressure (including angling) exerted on the stream. As the distance increases from access points on anadromous fish streams, recreation density (including anglers) will decrease.

Nonrecreational resource uses in an area will influence the type of recreation that occurs.

Onsite modifications provided for recreation--such as boat launches and docks, restrooms, tables, fireplaces, and shelters--can substantially affect the distribution of recreational uses. Some people will find these conveniences disruptive, and they will look for less developed places. People desiring such conveniences will congregate there.

Other management factors.—Other recreation-management actions, such as the spraying of herbicides or insecticides, may also have some significance for fish habitat. Removal of dangerous trees in areas of intense recreation can lead to loss of overhead and instream cover and increased soil and bank instability, which can reduce food sources, cover, and shade for fish.

FISHERY MANAGEMENT

Fishery managers can affect recreation by habitat manipulation, chemical treatment, biological manipulation, and regulatory action. Various specific actions under each of these categories follow:

- Habitat manipulation
  - Installing fish ladders
  - Planting riparian vegetation
  - Removing instream debris
  - Adding instream organic debris and boulders
  - Modifying barriers (removing beaver dams, blasting falls)
  - Creating pools (blasting)
  - Adding spawning gravel
  - Removing fine sediment
  - Creating spawning channels
  - Building weirs and dams
- Chemical treatments
  - Fertilizing lakes
  - Eradicating fish (for example with rotenone)
  - Controlling plants
- Biological manipulation
  - Stocking from hatcheries ("put-and-take" stocking or to build up populations)
  - Installing instream incubation boxes
  - Removing unwanted fish populations (predators or competitors)
  - Introducing exotic species
- Regulatory actions
  - Setting bag limits
  - Setting size limits
  - Setting license limits (rationing)
  - Limiting seasons
  - Regulating gear
  - Limiting access (boat launches)

Habitat-manipulation projects may either decrease or increase recreational use. When roads are necessary for project access and left open for public use, they can increase use. While the project is underway (from 1 week to several months), recreational activities occurring near the project might be disrupted. Structures that result from projects may also have some effect on recreational activities. Regulations in the west coast States usually prohibit fishing, but not other activities, near such structures. The sight of structures may cause people to go elsewhere along the stream, which may expand the area affected by recreational use. Creation of pools, with their potential for swimming, bathing, and fishing, may attract people to an otherwise undesirable site.

Chemical treatments are most often used for lakes, although streams are occasionally treated. For example, in the California Golden Trout Wilderness, brown trout are being eradicated so that the less competitive species--the golden trout--can dominate their native habitats. This type of action may also affect recreational use.

Biological manipulation may result in permanent structures, such as migration barriers, that can affect 'recreation. Stocking influences only where and how much fishing occurs.

Regulatory actions for fishery management are generally limited to effects on fishing, with the exception of such actions as controlling access and building launching ramps.

TIMBER MANAGEMENT

Timber-management activities can have major effects on recreational use. Conversion of a roadless natural area to one with a road changes the recreational setting. Roadless areas receive little use, and it is dispersed over broad areas. Roads and clearings, particularly those near water, provide opportunities for concentrated use. As changes are made, redistribution of use likely will occur (see fig. *4).*

When roads are located near riparian areas, recreational activities have an increased effect on anadromous fish habitat. Where temporary or long-term logging camps are located (such as in Southeast Alaska), recreational use will increase in nearby areas.

MANAGING RECREATION TO PROTECT THE FISHERY

MANAGEMENT OBJECTIVES

Defining clear management objectives in advance of any action is a prerequisite to effective solutions (Brown 1979, Clark and Stankey 1979a, Roggenbuck and Schreyer 1977). Management without such objectives can only be reactive. Objectives based on perception are appropriate if assumptions are made explicit (Clark 1982, Thomas 1979). Coordination among resource uses is critical, and recreational objectives must be integrated with fishery- and timber-management objectives.

ROS FACTORS

Management of ROS factors based on objectives as stated above has important effects on recreation. Because the ROS focuses on specific features of the physical, social, and managerial setting, it simplifies analysis of how proposed management actions will alter the nature of a specific recreational opportunity.

For example, the decision to develop an area for timber harvest has the obvious consequence of changing the amount and obtrusiveness of nonrecreational resource uses, but logging also may improve access to an area. Improved access can lead to higher use and greater demand for facilities. Many of these changes can be anticipated by management. The ROS provides management with a simple, graphic way of portraying these anticipated outcomes and evaluating whether they are appropriate or desirable.

The design and location of roads and trails near rivers will influence the probability and distribution of recreational use, and the resulting resource effects. A road following a river is more likely to have detrimental effects on the fishery than is a road built farther away (fig. 8).

Anticipating and precluding use in certain areas is generally easier than controlling use after a problem has occurred. Careful selection of sites for roads, trails, camps, and other facilities can influence use patterns (Beardsley and Wagar 1971, Settergren 1977). Usually, campgrounds should be located away from riparian areas or in areas of least disruption (Kuska 1977). For the fishery, encouraging recreational use along lake shores rather than along stream banks is preferred because lakes are less likely to be disturbed by recreational activities.

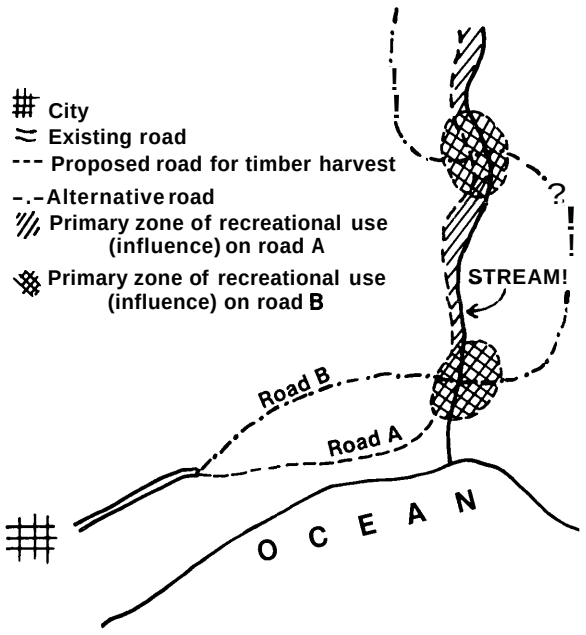


Figure 8.--Potential effects of alternative road locations on recreational use.

ACTIVITY MANAGEMENT

Managing activities directly is often advisable when adverse effects from recreation occur or are expected to occur. Regulating and prohibiting certain activities may help solve problems if users understand and agree with the rationale behind the restrictions (Clark and others 1971). Managers cannot control all use just by regulating fishing because some people using the area may not fish and would not be affected by actions such as creel limits and gear restrictions.

EDUCATION

Educating users might help prevent or control problems. If recreationists are aware of how they may influence the fishery, they might avoid practices endangering fish habitat.

RESTING OF SITES

Allowing sites to rest may reduce the effects of recreational use. Such a policy may spread the effects over a broader area, however (Cole 1979); most of the changes in vegetation result from initial light use and not from continuous and increased recreation. Furthermore, recovery from detrimental effects may take many years or may never occur if users do not comply with the restriction (Cole and Ranz 1983). Other alternatives should be seriously considered before adopting this approach.

Problems can be solved more effectively if a variety of strategies is used. Preventing a problem through planning is easier than controlling one after it occurs (Magill 1977).

CONCLUSIONS

We have described various ways that recreational use and anadromous fish habitat affect each other. Knowledge about these interactions is scarce; hence the conclusions we make in this paper must be regarded as best guesses.

The riparian zone tends to be recreationally more important than other areas. People are drawn to water and, as a consequence, may do things that adversely affect fish production. Riparian areas are managed for a variety of human values, and this management affects the nature and extent of recreational uses.

We believe recreation will usually have an insignificant effect on fish habitat. Any recreational use of upland and riparian areas will have some usually minor effects compared to the influence of roads and logging. The biggest recreational effect is harvesting of fish populations, not destruction of habitat. The effects of recreational fishing throughout the range of anadromous fish in western North America are so variable, however, that they must be evaluated locally. Managers should pay particular attention to vegetative changes along long reaches of important rivers. Healthy vegetation appears to play a critical role in fish-habitat productivity and is one of the first habitat components affected by recreational use.

Establishing management objectives before any onsite action is essential to effective recreation management. Making explicit decisions will help anticipate influences from all uses, including recreation. The ROS helps planners and managers explicitly state their assumptions, management objectives, and presumed consequences to recreational opportunities of management alternatives. A clear understanding of the rationale behind options will help in their application. Identifying problems and issues, and setting management objectives have often been overlooked in resource-management planning (Stankey 1980). The ROS will not make decisions; it does allow planners and managers to test assumptions, and it provides the possible consequences of various options. Stating management objectives (for example, what to provide, how, where, when, and for whom) helps in successfully using the ROS. Defining limits of acceptable change to anadromous fish habitat will simplify monitoring and evaluating changes that occur (Stankey and others, in press). Bjornn and others (1980), Gibbons (1982), and Heller and others (1983) have discussed methods for determining risks to anadromous fish habitat as a result of management activities.

Planners and managers responsible for anadromous fish habitat must have a method for analyzing management actions and their consequences, to be included in making multiresource decisions. Thus, past management actions and results can be used to shape future actions. Recreation is interdependent with other resource uses; if the nature and extent of effects from recreational use are to be understood, these links must be examined.

Roads can be provided specifically for recreation or for other resource uses. Recreational use often increases dramatically when roads are open for public use. Increased road use in sensitive locations may result in unacceptable effects on fish production. Unanticipated effects are less likely to occur when all of the resources are considered during planning.

Fishery managers must be careful that their actions do not detract from recreational opportunities and use. A balance between user and resource must: maintain the natural capacity of the stream to produce wild fish; retain management options for the future; answer demands for recreation, including fish and fishing; consider success of stocked versus wild fish; and preserve esthetic values that are part of the specialist's experience. We should beware of using projections of historical trends as a sole basis for planning, because this can lead to managing for intensive fisheries and to dependence on artificial production. Considering all users equally will provide the means for continuation and use of recreational resources, Managers must understand the demand for fishing, catching fish, and maintaining fish habitat as part of the total recreational experience an area can provide.

We have shown how little documentation exists about the interrelations between recreational uses and the anadromous fishery. Some of the topics that should be studied are summarized below.

Aitcheson and others (1977), Clark and Lucas (1978), and Kuska (1977), pointed out the need for objective baseline information on the supply and use of rivers for a variety of recreational pursuits. In addition, site conditions must be documented to provide a basis for monitoring and evaluating recreational effects on fish habitat. An adequate data base will assist specific studies of both the social and biological systems. Baseline information is needed for regions, watersheds, and specific sites.

For individual river systems, we need to determine the significance of effects from various kinds of recreational uses on components of fish habitat. How these effects differ by river and ecosystem types should also be evaluated. Studies to determine the effects of intensive versus dispersed recreation should be conducted through an experimental design that evaluates alternative recreational use patterns for micro- and macrosites. Strategies to reduce or ameliorate unacceptable effects could be tested.

Studies are also required to separate the effects of recreational use from those associated with roads, logging, grazing, and mining, Determining the conditions under which various uses interact on the habitat of anadromous fish requires multifunctional, multi-systems research.

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