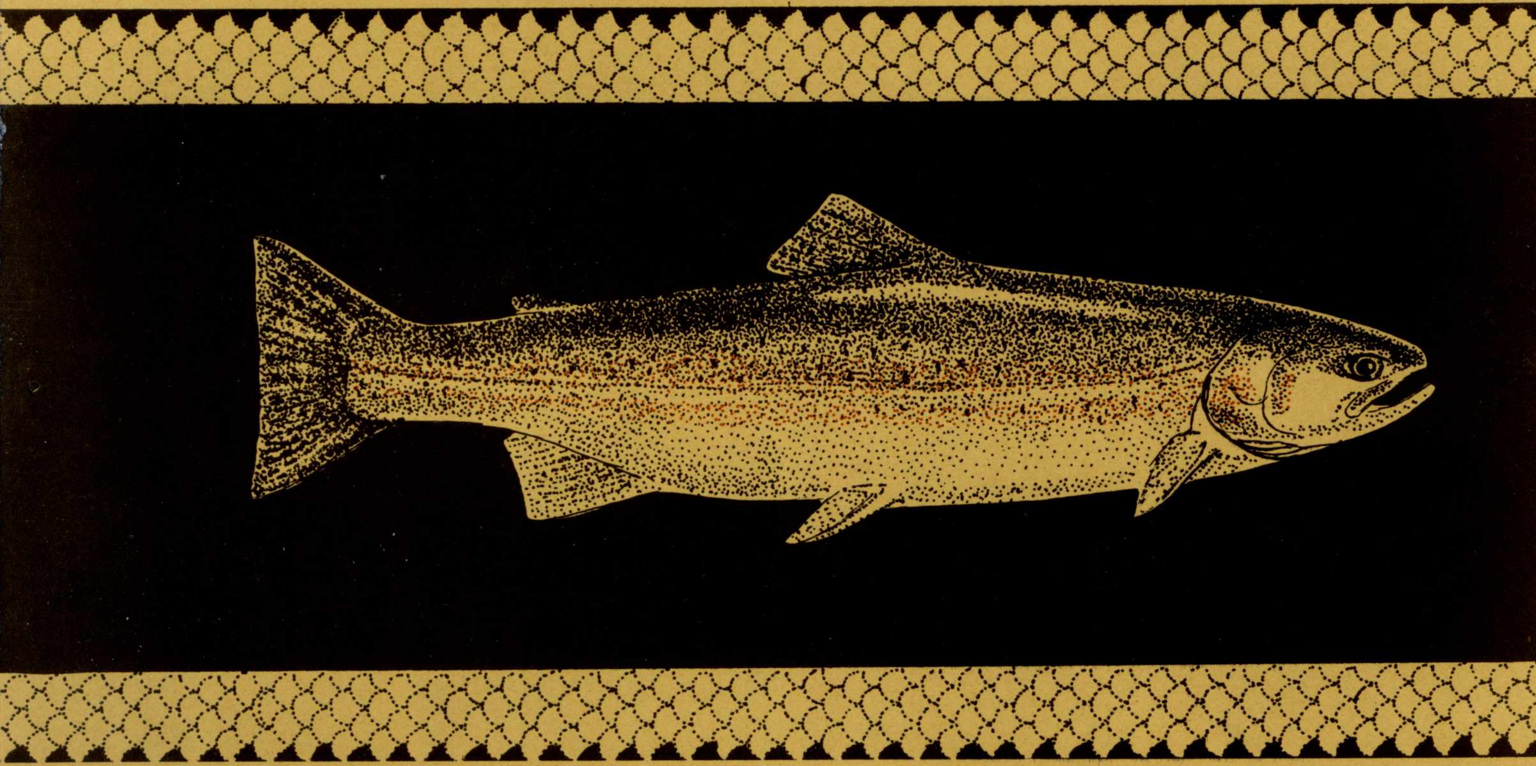
# RESEARCH NEEDS FOR INTENSIVE MANAGEMENT OF BRITISH COLUMBIA STEELHEAD



**by**

**Fred C. Withler**



**Fisheries Research Board Of Canada**
**Pacific Biological Station, Nanaimo, B. C.**

Circular No. 92 October 1972

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Leaping 15 lb. Oyster River, B. C., steelhead -- photo by Barry M. Thornton.

## INTRODUCTION

The purpose of this report is to identify research activities which should be undertaken in advance of, or in conjunction with, intensified management of British Columbia's steelhead resources. An earlier version of the report was presented to the Tenth Meeting of the Federal-Provincial B. C. Fisheries Committee (July 11-12, 1972). The present version contains some up-dating of statistical material and minor editing; the scope and intent remain unchanged. It is prepared in two parts. A background section contains brief reviews of distribution and life history of steelhead, past and present harvesting, current demands, and current management practices. Following the reviews, recommendations for studies which merit first attention for management of British Columbia stocks are presented.

## BACKGROUND

### Distribution and life history

"Steelhead" is the popular name given to the sea-going form of the rainbow trout *Salmo gairdneri*. Rainbow trout in North America were first described and given a scientific name by J. R. Richardson in 1836, on the basis of steelhead specimens taken from the Columbia River at Fort Vancouver (McPhail and Lindsey 1970; Smith 1968).

The rainbow's *native* range extends around the North Pacific rim from northwestern Mexico through Alaska and the Aleutian chain to the Kamchatka Peninsula and Okhotsk Sea drainages (Fig. 1). The rainbow forms on the Asian side of the Pacific are called *Salmo mykiss* and *S. penshinensis* (Behnke 1966).[1] In North America the non-anadromous rainbow has *also penetrated* the headwaters of the Peace and Athabasca Rivers of the MacKenzie system. With its natural beauty, its readiness to take baits and lures, its exceptional fighting ability and its good eating qualities, the rainbow has become a prized game fish. This popularity, coupled with its modest environmental demands (cool and fairly clean fresh water) and its easy culture, has led to its spread by man from its native range onto all of the world's continents except Antarctica (MacCrimmon 1971). *Outside* of its native range, the rainbow has nowhere developed the pronounced sea-running habit the steelhead form displays in the North Pacific Ocean, although some rainbow populations introduced into South African streams may spend short periods in river estuaries (Hewitson 1966).

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[1]The relationship between *Salmo mykiss* and *S. penshinensis* is not clear, although from descriptions of their movement into rivers given by Berg (1948) *mykiss* might be interpreted as a "summer" steelhead and *penshinensis* as a "winter" steelhead. Russian authors are not certain that *mykiss* and *gairdneri* are synonymous (Savvaitova and Lebedev 1966), but they believe that *mykiss* is closer to the steelhead than to the American cutthroat *S. clarkii* (Savvaitova and Maksimov 1969).

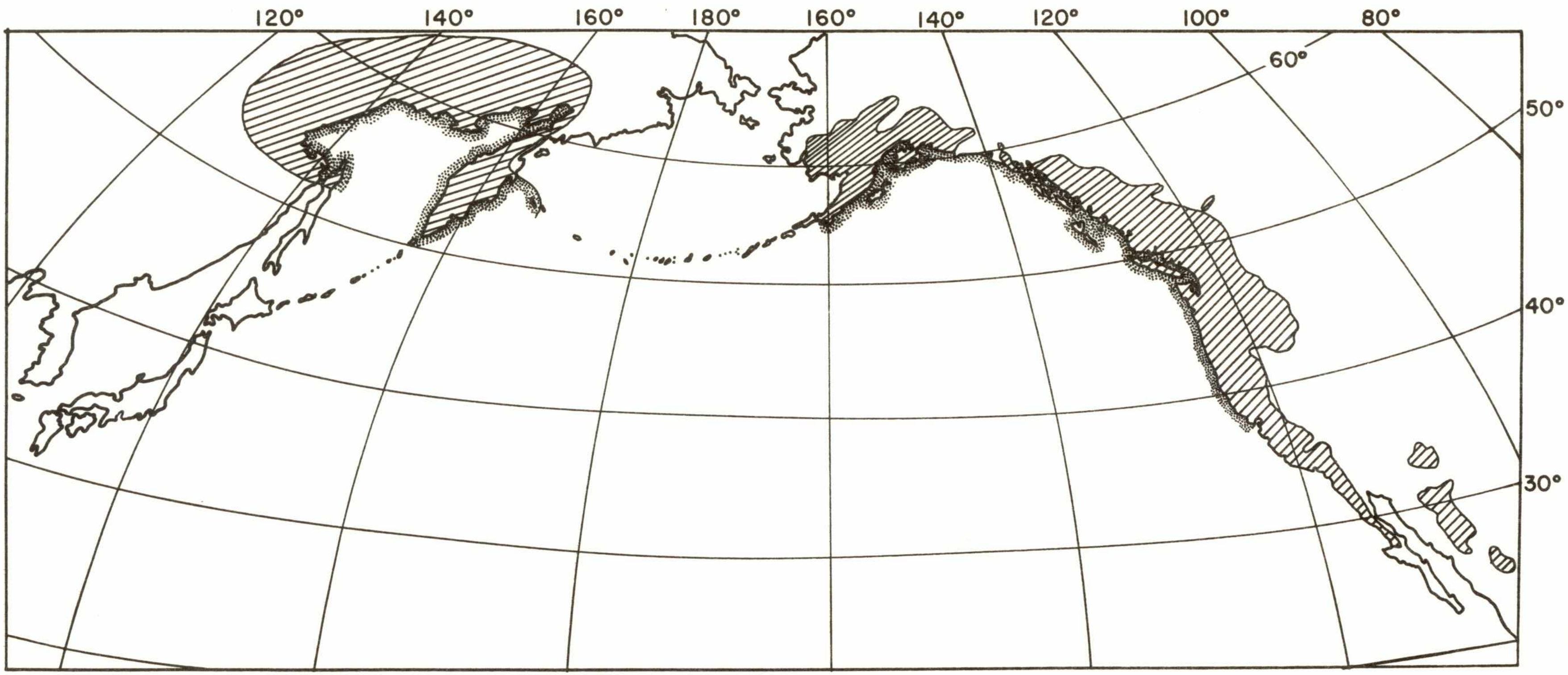


Fig. 1. Distribution of rainbow and steelhead forms of _Salmo gairdneri_ around the North Pacific rim. Hatched areas indicate the native land distribution of rainbow trout; stippled areas indicate coastline areas in which watersheds containing steelhead empty into the sea.

Hence the steelhead (anadromous) forms of the rainbow are confined to the watersheds of the seacoasts of the rainbow's native range (Fig. 1). They are found only in those river systems which drain into the North Pacific Ocean and the Okhotsk Sea. The southern limit of steelhead distribution in North America has now retracted to the vicinity of San Francisco, since most populations in California south of San Francisco have been decimated by water development and diversion projects (Shapovalov 1967). In watersheds where both sea-going and non-sea-going forms exist (which is over most of the rainbow's native range), it is still a moot question whether both occur mostly because of inherited differences, or mostly because of fortuitous environmental differences affecting individual young fish leading them either to migrate or to remain in the stream.

Steelhead spawn in the early months of the year (January to June). The female digs a nest ("redd") in the gravel of a stream or river bottom and deposits eggs which are fertilized by the male as she drops them into the redd. The eggs are covered by gravel dislodged by the female digging upstream of the redd. After hatching, the embryos remain in the gravel until their yolk sacs are used up. They then emerge into the stream as free-swimming fry, from June to September (depending on the time the eggs were laid and upon stream temperatures). The fry live and grow in the streams, rivers or lakes of the watershed for periods of one to five years (Shapovalov and Taft 1954; Withler 1966; Narver 1969; Narver and Withler 1971). Upon reaching appropriate size, juveniles transform during spring months into the silvery "smolt" form physiologically suited to sea life, and migrate to sea.

Steelhead may live in the sea for as little as a few months to as long as four years (Shapovalov and Taft 1954; Withler 1966; Narver 1969; Narver and Withler 1971). While it is likely that those that remain in the sea for only a few months before returning to spawn the first time do not range far, steelhead have been caught over a wide area of the North Pacific Ocean (Turner and Aro 1968), and a few individuals tagged at sea have been recovered in streams thousands of miles from the place of tagging (Giovando 1969). While little is known of their ocean behaviour, feeding habits (Taylor and LeBrasseur 1957) and the areas occupied by stocks from different watersheds, it is nevertheless clear that many steelhead move great distances while feeding at sea and that most return to the streams in which they were born and reared (Shapovalov and Taft 1954). Steelhead have a strong tendency to return to the native stream but, when transplanted from one watershed to another, will in many cases return to the adopted waters.

The timing and routes of the steelhead's migration to the home stream are unknown. However, at least on the North American coast from California to British Columbia, two types of steelhead are recognized by the time of year they enter the home stream: "summer" steelhead enter the rivers in a sexually immature state usually between May and September; "winter" steelhead enter in a sexually mature state usually from November to April. It has been shown that these types are genetically distinct and that they maintain their separateness during spawning in spite of the fact that both types may be present in the same watershed and that both spawn at about the same time (Smith 1968). Summer steelhead tend to spawn in the upper reaches of watersheds and winter steelhead closer to the sea (Withler 1966). The great difference in time of stream entry means that summer steelhead may remain in fresh water for up to 10 months (and at least 5 months) prior to spawning, whereas winter steelhead will remain in the streams not more than 4 or 5 months and in some cases probably less than one. Since steelhead eat little during their stream residence prior to spawning, it is not surprising to note that summer steelhead tend to have greater fat reserves at time of entry than do winter fish, and that in fact this greater fat reserve is apparent as early as the smolt stage (Smith 1968).

For nearly all stages of the steelhead's life in fresh water and the sea, parallels may be found amongst the Pacific salmons Oncorhynchus, which are believed to have arisen from a steelhead-like ancestor (Neave 1958). Aside from minor differences in anatomy, however, steelhead differ from the Pacific salmons in one important way -- Pacific salmon spawn once and die almost immediately whereas most steelhead survive the first spawning and some return to the rivers and spawn again. A few spawn several times.

## Commercial fisheries

Steelhead have been fished specifically for commercial purposes on the North American coastline from the mid-1800's up to the present (Sheppard 1972). Initially, commercial fisheries for steelhead existed in Washington, Oregon and California. They produced as much as 8 1/2 million pounds in total (about 900,000 fish) in a single year, and the catch frequently exceeded 4 million pounds (Table 1). Since the 1920's, catches have declined to the point where the entire commercial catch in these states is now about 600 thousand pounds (or 60,000 + pieces) a year.

The decrease has been brought about at least partly by regulations which specifically disallowed commercial fishing for steelhead and by other limitations on type of gear and times of fishing designed to alter the proportions of salmon to steelhead caught when they are present together (Gunsolus and Wendler 1971). Commercial fishing for steelhead in California was ended by legislation in 1924. In Washington, commercial fishing for steelhead has become restricted to various Indian tribes on their reservations or at alternate sites when their traditional fishing areas were flooded after dam construction. In Oregon, commercial fishing for steelhead became restricted to only the Columbia River in 1963, and further curtailment followed the declaration by the Oregon legislature in 1969 that the steelhead was to be classed as a game fish. Thus the only remaining official commercial fisheries for steelhead are those by Indians of Washington and Oregon under tribal rights. These are now restricted by the states to certain time periods, when the fish are to be sold; fishing for personal use is not restricted. Steelhead caught by non-Indian fishermen in Washington and Oregon are now considered to be incidental to their salmon catches, and most of this incidental catch is in the Columbia River.

Elsewhere steelhead are, and have been, taken commercially only incidentally in fisheries for salmon. In Alaska, the commercial catch of steelhead is small (Table 1), probably because they are not numerous (or may even be absent) in the Bristol Bay region where there are intensive summer fisheries for sockeye, and because in Southeastern Alaska the steelhead populations are mostly of the "winter" type and thus not generally available to the summer and fall net fisheries.

Table 1. Commercial catches of steelhead in Alaska, British Columbia, Washington, Oregon and California, 1892 to 1971 (in 000's of pounds). Sources of information are given in Appendix A.

| Year | Alaska | British Columbia | Washington | Oregon | California | Total |
|---|---|---|---|---|---|---|
| 1892 | No data | No data | 2,419 | 2,587 | 310 | 5,316 |
| 1895 | " | " | 4,971 | 3,220 | 461 | 8,652 |
| 1899 | " | " | 1,507 | 1,104 | 114 | 2,725 |
| 1904 | " | " | 1,859 | 1,104 | 55 | 3,018 |
| 1908 | " | " | 2,339 | 2,469 | 76 | 4,884 |
| 1915 | " | " | 2,114 | 2,366 | 32 | 4,512 |
| 1918 | " | " | No data | No data | 22 | No data |
| 1919 | " | " | " | " | 17 | " |
| 1920 | " | " | " | " | 7 | " |
| 1921 | " | " | " | " | 4 | " |
| 1922 | " | " | 476 | 1,821 | 3 | 2,300 |
| 1923 | " | " | 1,401 | 2,856 | 3 | 4,260 |
| 1924 | " | " | 1,143 | 3,605 | 87 | 4,835 |
| 1925 | " | " | 1,719 | 2,307 | No data [a] | 4,026 |
| 1926 | " | " | 2,562 | 2,657 | " | 5,219 |
| 1927 | " | " | 2,167 | 2,196 | " | 4,363 |
| 1928 | " | " | 1,632 | 1,814 | " | 3,446 |
| 1929 | " | " | 1,658 | 1,548 | " | 3,206 |
| 1930 | " | " | 2,074 | 1,880 | " | 3,954 |
| 1931 | " | " | 1,835 | 1,729 | " | 3,564 |
| 1932 | 3 | " | 1,317 | 1,142 | " | 2,462 |
| 1933 | 11 | " | 1,346 | 1,356 | " | 2,713 |
| 1934 | 52 | " | 1,371 | 1,459 | " | 2,882 |
| 1935 | 12 | " | 574 | 1,594 | " | 2,120 |
| 1936 | 42 | " | 452 | 2,241 | " | 2,735 |
| 1937 | 22 | " | 340 | 1,725 | " | 2,087 |
| 1938 | 8 | " | 404 | 1,860 | " | 2,272 |
| 1939 | 4 | " | 272 | 1,548 | " | 1,824 |
| 1940 | <.5 | " | 418 | 2,738 | " | 3,156 |
| 1941 | <.5 | " | 426 | 2,356 | " | 2,782 |
| 1942 | 10 | " | 425 | 1,780 | " | 2,215 |
| 1943 | 14 | " | 244 | 1,296 | " | 1,554 |
| 1944 | 3 | " | 358 | 1,535 | " | 1,896 |
| 1945 | 18 | " | 387 | 1,687 | " | 2,092 |
| 1946 | 30 | " | 363 | 1,518 | " | 1,910 |
| 1947 | 3 | " | 254 | 1,459 | " | 1,716 |
| 1948 | 1 | " | 117 | 1,424 | " | 1,542 |
| 1949 | 4 | " | 198 | 852 | " | 1,054 |
| 1950 | 15 | " | 129 | 926 | " | 1,070 |
| 1951 | 2 | 408 | 216 | 1,024 | " | 1,650 |
| 1952 | 31 | 509 | 273 | 1,396 | " | 2,209 |
| 1953 | 38 | 463 | 548 | 1,566 | " | 2,615 |
| 1954 | 37 | 562 | 647 | 1,056 | " | 2,302 |
| 1955 | 19 | 242 | 534 | 922 | " | 1,717 |

(cont'd)

Table 1 (cont'd)

| Year | Alaska | British Columbia | Washington | Oregon | California | Total |
|---|---|---|---|---|---|---|
| 1956 | 19 | 229 | 434 | 632 | " | 1,314 |
| 1957 | 7 | 164 | 394 | 537 | " | 1,102 |
| 1958 | 12 | 251 | 454 | 479 | " | 1,196 |
| 1959 | 9 | 125 | 317 | 506 | " | 957 |
| 1960 | 16 | 245 | 411 | 540 | " | 1,212 |
| 1961 | 14 | 204 | 368 | 543 | " | 1,129 |
| 1962 | 10 | 240 | 458 | 558 | " | 1,266 |
| 1963 | 20 | 145 | 535 | 798 | " | 1,498 |
| 1964 | 10 | 235 | 68[1] | 361 | " | 674 |
| 1965 | 13 | 134 | 79[1] | 413 | " | 639 |
| 1966 | 31 | 306 | 200 | 399 | " | 936 |
| 1967 | 26 | 253 | 193 | 424 | " | 896 |
| 1968 | 48 | 221 | 236 | 393 | " | 898 |
| 1969 | 31 | 142 | 116[2] | 383 | " | 672 |
| 1970 | 31 | 125 | No data | No data | " | No data |
| 1971 | No data | 177 | " | " | " | " |

[1]Does not include steelhead caught by Indians and sold in other states, in these years.

[2]Figure given is Washington landings from the Columbia River district only.

[3]No commercial landings recorded after 1924.

In British Columbia steelhead are taken incidentally by commercial fishermen in net and troll fisheries for salmon. Largest catches occur in the gillnet fisheries in the approaches and estuaries of the Skeena, Nass, Bella Coola and Fraser Rivers (Table 2) where substantial numbers of steelhead move upriver during the summer and fall when sockeye and pink salmon fisheries are at their peaks. The Johnstone Strait catch is probably composed mainly of steelhead originating in the Fraser. These summer and fall runs presumably are parts of the well-known Kispiox, Babine and Morice runs on the Skeena, of the Dean and Bella Coola runs of the central B.C. coast, and the Thompson and Chilcotin runs on the Fraser. Steelhead are taken by net and troll fisheries elsewhere in coastal B.C. waters, over wide areas and in rather small numbers. Gillnet fisheries account for over 90% of the steelhead taken commercially, with purse seine and troll fisheries taking up the remainder about equally (Table 2).

## Food fisheries

Steelhead form part of the Indian food fishery from Alaska to Oregon. No figures are available to indicate the size of the catch in Alaska, although it is believed to be small. In Washington, Indians take steelhead under treaty not only for food purposes but also for sale, provided the fish are sold out of the state. No record is available of the numbers taken for personal consumption, although they are believed to be in the tens of thousands. To the writer's knowledge there is no record of numbers taken in the Indian fisheries of Oregon for personal consumption.

Records for the Indian food catch of steelhead in British Columbia are incomplete. Figures given in Table 3 are derived from tabulations from Fishery Officers' reports.[2] In this writer's opinion the total B.C. Indian food catch of steelhead is probably less than 10,000 fish per year.

## Anglers' catches

Table 4 lists available estimates of anglers' catches of steelhead by province and state in North America. By far the most steelhead are angled in Washington and Oregon. For the three seasons for which catch estimates are most complete (1967-68 to 1969-70), the combined catches in these two states amounted to 79-84% of all steelhead caught by anglers in North America each year. Washington State catches alone accounted for 46-56%. Anglers in British Columbia took 8-9% of the total each year, California anglers took 4-7%, and Idaho anglers about 4%. Alaskan anglers took only small numbers. Thus, currently, British Columbia ranks a distant third in numbers of steelhead caught by anglers.

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[2]Figures for the Nass, Skeena and Fraser Rivers are probably the most accurate since most of the steelhead are taken by the Indians in their regular sockeye, pink and coho food fishing operations, which are monitored regularly by the Officers. Catches in coastal streams are the most inaccurate since most are taken in nets set only sporadically during the winter and from which the fish are consumed fresh.

Table 2. Numbers of steelhead landed by British Columbia commercial fishermen 1960-1971 by area of fishing, and proportions of annual catches made by gillnet, purse seine and troll (British Columbia catch statistics by area and type of gear (1960-71). Variously, Canada Department of Fisheries, Canada Department of Fisheries and Forestry, and Department of the Environment, Fisheries Service, Pacific Region, Vancouver, B. C.).

| Area | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | Average 1960-1971 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Skeena | 7,300 | 7,300 | 8,000 | 619 | 551 | 2,759 | 14,408 | 10,174 | 8,200 | 5,343 | 4,752 | 8,425 | 6,486 |
| Nass | 2,200 | 1,600 | 2,100 | 2,855 | 10,200 | 1,220 | 3,012 | 1,973 | 2,404 | 1,209 | 864 | 1,547 | 2,599 |
| Fraser | 5,400 | 2,400 | 2,500 | 2,691 | 3,763 | 1,322 | 2,064 | 1,574 | 2,765 | 1,249 | 1,216 | 1,200 | 2,345 |
| Bella Coola | 3,200 | 3,000 | 3,900 | 2,572 | 2,892 | 2,215 | 2,583 | 2,719 | 1,573 | 794 | 1,235 | 2,297 | 2,415 |
| Johnstone Str. | 1,500 | 1,900 | 1,000 | 1,798 | 1,870 | 1,393 | 2,148 | 3,073 | 1,969 | 2,511 | 1,699 | 962 | 1,819 |
| Other | 5,800 | 5,400 | 6,400 | 4,641 | 5,559 | 5,468 | 6,709 | 5,451 | 5,050 | 3,684 | 3,111 | 3,481 | 5,063 |
| Total | 25,400 | 21,600 | 23,900 | 15,176 | 24,835 | 14,377 | 30,924 | 24,964 | 21,961 | 14,790 | 12,877 | 17,912 | 20,726 |
| Gear | | | | | | | | | | | | | |
| Gillnet | - | - | - | 91% | 94% | 88% | 94% | 91% | 91% | 92% | 92% | 90% | |
| Purse seine | - | - | - | 6 | 4 | 9 | 4 | 6 | 4 | 3 | 3 | 4 | |
| Troll | - | - | - | 3 | 2 | 3 | 2 | 3 | 5 | 5 | 5 | 6 | |

Table 3. Summary of Indian food fishery catches of steelhead as reported by Fishery Officers, by districts, 1965 to 1969.

| Areas | 1965 | 1966 | 1967 | 1968 | 1969 | Average 1965-1969 |
|---|---|---|---|---|---|---|
| Fraser R. and Howe Sd.[1] | 3,875 | 3,621 | 2,295 | 1,898 | 1,510 | 2,640 |
| Str. of Georgia and Juan de Fuca[2] | 20 | 50 | 10 | 117 | - | 39 |
| West and north coast of Vancouver I. and Johnstone Str.[3] | 47 | 21 | 54 | 88 | 15 | 45 |
| Central B. C. coast[4] | 325 | 415 | 365 | 520 | 415 | 408 |
| Nass R., Skeena R., and north B. C. coast[5] | 689 | 1,875 | 864 | 1,147 | 877 | 1,090 |
| Queen Charlotte I.[6] | - | - | - | 25 | - | 5 |
| | 4,956 | 5,982 | 3,588 | 3,795 | 2,817 | 4,228 |

[1]District 1 and 2

[2]District 3

[3]District 4 and 5

[4]District 6 and 7

[5]District 8

[6]District 9

Table 4. Estimated total annual catches of steelhead by anglers in British Columbia, Washington, Idaho, Oregon, California and Alaska. Data sources are listed in Appendix B.

| Year | Alaska | British Columbia | Washington | Idaho[1] | Oregon[1] | California | Total[6] |
|---|---|---|---|---|---|---|---|
| 1947-48 | No data | No data | 22,987[2] | No data | No data | No data | - |
| 1948-49 | " | " | 39,914[2] | " | " | " | - |
| 1949-50 | " | " | 56,375[2] | " | " | " | - |
| 1950-51 | " | " | 60,341[2] | " | " | " | - |
| 1951-52 | " | " | 118,285[2] | " | " | " | - |
| 1952-53 | " | " | 122,721[2] | " | " | " | - |
| 1953-54 | " | " | 168,822[2] | " | 88,000 | 310,000 | - |
| 1954-55 | " | " | 130,773[2] | 12,000 | 74,000 | 340,000 | 556,773 |
| 1955-56 | " | " | 161,324[2] | 13,000 | 50,000 | 360,000 | 584,324 |
| 1956-57 | " | " | 120,541[2] | 8,000 | 71,000 | 600,000 | 799,541 |
| 1957-58 | " | " | 140,756[2] | 20,000 | 51,000 | No data | - |
| 1958-59 | " | " | 126,507[2] | 30,000 | 77,000 | " | - |
| 1959-60 | " | " | 148,279[2] | 31,000 | 100,000 | " | - |
| 1960-61 | " | " | 117,449[2] | 30,000 | 80,175 | " | - |
| 1961-62 | " | " | 193,533[2] | 25,000 | 69,613 | " | - |
| 1962-63 | " | " | 257,443 | 19,000 | 106,067 | 6,410[5] | - |
| 1963-64 | " | " | 281,611 | 26,000 | 97,468 | 10,720[5] | - |
| 1964-65 | " | " | 212,327 | 18,000 | 85,954 | 15,470[5] | - |
| 1965-66 | " | " | 301,463 | 20,000 | 111,439 | 14,800[5] | - |
| 1966-67 | " | 66,373[3] | 303,620 | 20,000 | 168,083 | 120,000 | - |
| 1967-68 | 1,500 | 48,508 | 296,161 | 24,500 | 134,040 | 24,124[5] | 526,833 |
| 1968-69 | 1,500 | 41,672 | 289,553 | 24,500 | 153,909 | 20,936[5] | 530,570 |
| 1969-70 | 1,600 | 37,319 | 181,513 | 17,000 | 130,432 | 27,881[5] | 394,245 |
| 1970-71 | No data | 33,977 | 264,559 | 20,500 | 165,000 | 19,548[5] | - |
| 1971-72 | " | 36,733 | 65,572[4] | No data | No data | No data | - |

[1]Catches given by calendar year. In the table, calendar year catches have been assigned to the season following, e.g., 1965 catches are assigned to 1965-66.

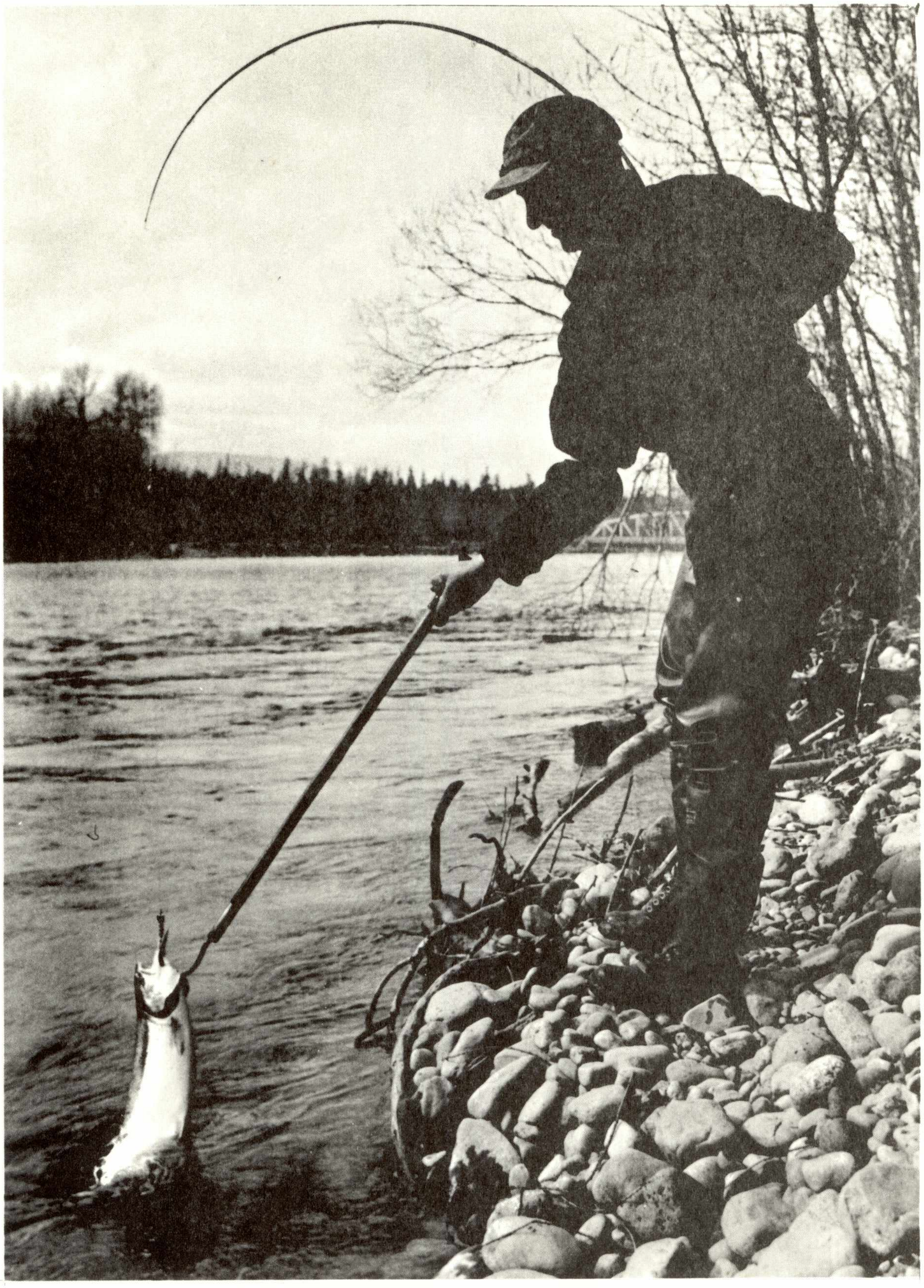
[2]Winter steelhead only.

[3]Estimated from incomplete data.

[4]Summer steelhead only.

[5]Sacramento River only.

[6]All totals are incomplete for lack of data in some area.



Steelhead fishing, Cowichan River, B. C. -- B. C. Government photo.

A glance at the tables listing steelhead harvests in North America will be sufficient to indicate the incompleteness and inadequacy of the data for deducing trends over a long term. Nevertheless, it is possible to arrive at approximations of the total numbers of steelhead caught each year on the west coast in some recent years. For the 1967-68 and 1968-69 seasons, total listed catches amount to about 625,000 annually.[a] Bearing in mind the fisheries for which information is incomplete (the California anglers' catch, the B.C. Indian food catch) or is lacking entirely (the Indian food fisheries of Alaska, Washington and Oregon), the annual total catches in these two recent years must have been 700,000 or more fish.

Further, when it is borne in mind that the Columbia River and its tributaries produce perhaps one-half or more of the anglers' catches in Washington and Oregon and the whole of the anglers' catch in Idaho, and that the commercial catches of Washington and Oregon come largely from the lower river, it is clear that the Columbia has been, and remains, the major single steelhead producer in North America, in terms of catch. Although escapement figures are incomplete, even for the Columbia, and virtually non-existent for other watersheds, it seems likely that the Columbia River historically has been the North American centre of steelhead abundance, especially for "summer" fish.

Although estimates of the proportions of total catches of steelhead in recent years taken by the various users must be considered very skeptically because of the lack of information about Indian food catches almost everywhere along the west coast, it would appear that 70-80% of the catch is taken by anglers, 15-20% by commercial fishermen, and 5-10% by Indians for food.

## Angling demand

The numbers of licenses issued to fishermen, where the information is sufficient to indicate trends, show that there is a rapidly increasing demand for sport fishing, including fishing for steelhead, along the west coast. The mounting pressure for steelhead fishing is most apparent in Oregon and Washington (Table 5). Information about numbers of anglers fishing especially for steelhead in California is lacking, but the long-term trend to increasing demand there for sport fishing generally is evident. Trends in angling demand in Idaho, as reflected by numbers of licensees, are harder to assess because there have been changes in the licensing system during the few years information is available. In British Columbia, over the period 1966 to 1971, the number of licensees has increased moderately -- the period of observation is too short to reflect accurately the rate of change and probably underestimates the increasing pressure.

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[a]Commercial landings of 896,000 and 898,000 lb for 1967 and 1968 (Table 1). would represent about 95,000 steelhead in each of these two years, on the basis of 9.5 lb per fish.

Table 5. Numbers of steelhead angling licensees, annual catches and calculated annual numbers of steelhead retained per licensee (success ratio) for British Columbia, Washington, Idaho, Oregon and California, 1949 to 1971. Sources of data given in Appendix C.

| | British Columbia | | | Washington | | | Idaho[13] | | | Oregon[13] | | | California[13] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | No. Licensees[1] | Annual Catch | Success Ratio | No. Licensees | Annual Catch | Success Ratio | No. Licensees | Annual Catch | Success Ratio | No. Licensees[10] | Annual Catch | Success Ratio | No. Licensees[12] | Annual Catch | Success Ratio |
| 1948-49 | No data | No data | - | 41,000[3] | 39,914[3] | 0.97 | No data | No data | - | No data | No data | - | No data | No data | - |
| 1949-50 | " | " | - | 50,000 | 56,375 | 1.13 | " | " | - | " | " | - | 992,000 | " | - |
| 1950-51 | " | " | - | 50,000 | 60,341 | 1.21 | " | " | - | " | " | - | No data | " | - |
| 1951-52 | " | " | - | 62,500 | 118,285 | 1.89 | " | " | - | " | " | - | 1,015,246 | " | - |
| 1952-53 | " | " | - | 77,300 | 122,721 | 1.59 | " | " | - | " | " | - | No data | " | - |
| 1953-54 | " | " | - | 89,300 | 168,822 | 1.89 | " | " | - | 173,000 | 88,000[11] | 0.51 | 1,187,234 | 310,000 | 0.26 |
| 1954-55 | " | " | - | 71,200 | 130,773 | 1.84 | " | 12,000 | - | 171,000 | 74,000 | 0.43 | 1,240,043 | 340,000 | 0.27 |
| 1955-56 | " | " | - | 88,700 | 161,324 | 1.82 | " | 13,000 | - | 165,000 | 50,000 | 0.30 | No data | 360,000 | - |
| 1956-57 | " | " | - | 85,300 | 120,541 | 1.41 | " | 8,000 | - | 166,000 | 71,000 | 0.43 | 1,380,787 | 600,000 | 0.43 |
| 1957-58 | " | " | - | 85,400 | 140,756 | 1.65 | " | 20,000 | - | 135,000 | 51,000 | 0.38 | 1,433,630 | No data | - |
| 1958-59 | " | " | - | 84,400 | 126,507 | 1.50 | " | 30,000 | - | 215,000 | 77,000 | 0.36 | No data | " | - |
| 1959-60 | " | " | - | 87,900 | 148,279 | 1.69 | " | 31,000 | - | 286,000 | 100,000 | 0.35 | " | " | - |
| 1960-61 | " | " | - | 93,300 | 117,449 | 1.26 | " | 30,000 | - | 172,000 | 80,000 | 0.47 | 1,465,440 | " | - |
| 1961-62 | " | " | - | 144,980[4] | 193,533[4] | 1.33 | " | 25,000 | - | 203,000 | 70,000 | 0.34 | 1,475,440 | " | - |
| 1962-63 | " | " | - | 151,700 | 257,443 | 1.70 | "[6] | 19,000 | - | 221,000 | 106,000 | 0.48 | No data | 6,410[14] | - |
| 1963-64 | " | " | - | 160,375 | 281,611 | 1.76 | "[6] | 26,000 | - | 236,000 | 97,000 | 0.41 | " | 10,720[14] | - |
| 1964-65 | " | " | - | 171,400 | 212,327 | 1.24 | 36,933[7] | 18,000 | - | 257,000 | 86,000 | 0.33 | 1,585,615 | 15,470[14] | - |
| 1965-66 | " | " | - | 187,525 | 301,463 | 1.61 | 37,792[7] | 20,000 | 0.49 | 276,000 | 111,000 | 0.40 | No data | 14,800[14] | - |
| 1966-67 | 37,500[2] | 66,373[2] | 1.77 | 202,666 | 303,620 | 1.50 | 48,865[7] | 20,400 | 0.53 | 288,000 | 168,000 | 0.58 | " | 120,000 | - |
| 1967-68 | 39,388 | 48,508 | 1.23 | 202,750 | 296,161 | 1.46 | 48,209[8] | 24,500 | 0.51 | 326,000 | 134,000 | 0.41 | " | 24,124[14] | - |
| 1968-69 | 39,775 | 41,672 | 1.05 | 200,050 | 289,553 | 1.45 | 51,662[8] | 24,500 | 0.47 | 312,000 | 154,000 | 0.49 | " | 20,936[14] | - |
| 1969-70 | 45,824 | 37,319 | 0.81 | 142,610[5] | 181,513 | 1.27 | 54,995[8] | 17,187 | 0.31 | 327,424 | 130,000 | 0.40 | 1,935,593 | 27,881[14] | - |
| 1970-71 | 43,750 | 33,977 | 0.78 | 145,647 | 264,559 | 1.82 | 22,750[9] | 20,681 | 0.91 | 353,183 | 165,000 | 0.47 | No data | 19,548[14] | - |
| 1971-72 | 26,253[5] | 36,733 | 1.40 | No data | 65,572 | - | 20,174 | No data | - | No data | No data | - | " | No data | - |

[1] Only about one-half of the licensees actually fished for steelhead in the years listed.
[2] Estimated on the basis of incomplete data in 1966.
[3] Winter steelhead only.
[4] Includes winter + summer steelhead from 1962.
[5] Introduction of $2.00 charge for card.
[6] No attempt was made to determine the number of permits issued to anglers.
[7] Estimated numbers of steelhead and salmon permits.
[8] Steelhead + salmon permits - only 45.8% fished for steelhead (Keating 1970).
[9] 1970 was first year of issuing a separate permit for steelhead fishing ($1.00).
[10] Steelhead + salmon permits - only about 25-30% do not fish both species (Sheppard 1972).
[11] Corrected for non-response bias.
[12] Includes all inland anglers plus ocean salmon anglers.
[13] Catches reported by calendar year. In the table, calendar year catches and licenses have been assigned to the season following, e.g., 1965 catches are assigned to 1965-66.
[14] Sacramento River only.

Within the two states for which there is sufficient information to assess trends in annual catch per licensee (Washington and Oregon), the success ratio is apparently being maintained and is neither markedly increasing nor declining (Table 5).[4] Maintenance of the success ratio in spite of increasing demand is brought about by a combination of expansion of the fishing effort into streams more remote from centres of population, by a marked reduction of the commercial catch, and by an expanded and improved system of artificial propagation. Reduction of commercial fishing in the Columbia River has also helped to maintain the sport catch in Idaho, and recent rapid expansion of artificial aids is now also providing significant returns to anglers there (Corley and Welsh 1971). The situation in California is difficult to assess but it is almost certain that the success ratio is declining as watersheds are diverted to domestic and industrial use (Sheppard 1972) coincident with increasing fishing pressure. The overall trend in success ratio in British Columbia is impossible to assess from the short span of years for which there is information, but it is certainly not increasing.

Within British Columbia, the demand (in terms of licenses issued) and the opportunity to fish for steelhead successfully close to home are out of step. As would be expected, demand is greatest in the areas of greatest population -- the Lower Mainland Coast Area and Vancouver Island (Table 6). Residents of the Lower Mainland Coast Area take out 45% of all licenses issued and Vancouver Island Area residents 26%. Next greatest demand is in the Upper Mainland Coast Area which accounts for 9%. Licenses issued to residents of other than these areas account for only 20%.

As a measure of the opportunity to catch steelhead in each area, the numbers of streams in each area which produced among the top 30 in the province for each year from 1966 onwards is shown in Table 7.[5] On this basis, opportunity is greatest for Vancouver Island and Upper Mainland Coast residents whose areas contain over 60% of the top-producing rivers. The high-demand Lower Mainland Coast Area contains only 18% of the 30 top-producing streams, in spite of the fact that this system of assessment tends to inflate the estimated potential of Lower Mainland waters, in comparison with the less heavily-fished streams elsewhere.

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[4] The success ratios calculated for the two states are based on different statistics and should not be compared directly; the Washington licenses are for steelhead fishing only, licenses in Oregon are for both steelhead and salmon fishing.

[5] This is a strongly biased measure of opportunity since heavily-fished streams (such as some of those of the Lower Mainland) may produce as many fish to anglers as might more lightly-fished streams (such as those of the Upper Mainland Coast), even though the total numbers of fish available in the lightly-fished streams were greater.

Table 6. Numbers of steelhead angling licenses issued in British Columbia by area of residence of licensee, 1966 to 1971. From: Steelhead harvest questionnaire analyses, 1966-67 to 1971-72. B. C. Fish and Wildlife Branch, Department of Recreation and Conservation, Victoria, B.C.

| Area | Area No. | 66-67 | 67-68 | 68-69 | 69-70 | 70-71 | 71-72[1] | Avg. | % |
|---|---|---|---|---|---|---|---|---|---|
| Lower Mainland Coast | (1) | 16,600 | 16,941 | 17,597 | 21,799 | 19,694 | 11,269 | 17,316.7 | 44.7 |
| Vancouver Island | (0) | 10,500 | 10,523 | 10,871 | 10,731 | 11,315 | 6,082 | 10,003.7 | 25.8 |
| Upper Mainland Coast | (6) | 3,500 | 3,797 | 3,436 | 4,079 | 4,135 | 2,669 | 3,602.7 | 9.3 |
| Northern Interior | (5) | 1,600 | 2,089 | 1,940 | 2,095 | 2,053 | 1,261 | 1,839.7 | 4.7 |
| Kamloops | (2) | 1,100 | 1,355 | 1,135 | 1,441 | 1,262 | 780 | 1,178.8 | 3.0 |
| Cariboo | (4) | 1,000 | 1,161 | 1,056 | 1,006 | 982 | 687 | 982.0 | 2.5 |
| Okanagan-Kootenays | (3) | 500 | 578 | 669 | 771 | 690 | 420 | 604.7 | 1.6 |
| Queen Charlotte I. | (7) | 100 | 118 | 156 | 268 | 290 | 358 | 215.0 | 0.6 |
| Can. outside B.C. | (8) | 800 | 965 | 988 | 1,235 | 1,149 | 803 | 990.0 | 2.6 |
| Outside Can. | (9) | 1,800 | 1,761 | 1,927 | 2,399 | 2,180 | 1,924 | 1,998.5 | 5.2 |
| | | 37,500 | 39,288 | 39,775 | 45,824 | 43,750 | 26,253 | 38,731.8 | 100.0 |

[1] Introduction of $2.00 steelhead license.

Table 7. Numbers of streams in each area of British Columbia which produced among the top 30 in all the province, 1966 to 1971. From: Steelhead harvest questionnaire analyses, 1966-67 to 1971-72. B. C. Fish and Wildlife Branch, Department of Recreation and Conservation, Victoria, B.C.

| Area | Area No. | 66-67 | 67-68 | 68-69 | 69-70 | 70-71 | 71-72 | Avg. |
|---|---|---|---|---|---|---|---|---|
| Lower Mainland Coast | (1) | 4 | 6 | 4 | 6 | 5 | 7 | 5.3 |
| Vancouver Island | (0) | 16 | 12 | 13 | 10 | 13 | 12 | 12.7 |
| Upper Mainland Coast | (6) | 6 | 7 | 8 | 9 | 8 | 7 | 7.5 |
| Northern Interior | (5) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kamloops | (2) | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| Cariboo | (4) | 3 | 4 | 4 | 3 | 2 | 2 | 3.0 |
| Okanagan-Kootenays | (3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Queen Charlotte I. | (7) | 0 | 0 | 0 | 1 | 1 | 1 | 0.5 |
| | | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

This brief assessment of opportunity is summarized in Table 8 where the numbers of licensees in an area is compared with the number of top-producing streams within it. On this scale (aside from those areas in which there are no steelhead streams -- Northern Interior and Okanagan-Kootenays) the opportunity for Lower Mainland Coast steelhead anglers to fish successfully within their own area is at best only about one-third that of those in any other. It is obvious that it is in the Lower Mainland Coast region that intensive management is most urgent. The rate of increase of fishing pressure arising from the conflict between increasing demand and limited opportunity in this area is probably underestimated by the figures shown in the table: the population of the Lower Mainland Coast is burgeoning, and as the density of people increases, the streams themselves are increasingly diverted to uses inimical to steelhead production (domestic and agricultural water supplies, sewage disposal), and free access to the streams is correspondingly cut back as the land around them is developed.

## Intensive management in the Western States

Everywhere along the United States' west coast there are increasing pressures on steelhead stocks. Angling demand builds up as the population grows not only because there are greater numbers of people wishing to fish but also because they have more time and money to do so. The mushrooming population also places greater demands on the steelheads' freshwater environment for domestic, agricultural and industrial purposes. The urgency of these demands, which applies everywhere, is illustrated by the following excerpt from Gunsolus and Wendler (1971) reporting on the status of Columbia River salmon and steelhead stocks: "Historical records show that salmon and steelhead once extensively utilized the Columbia River and its tributaries. Chinook salmon migrated nearly 1,200 miles up the Columbia River to Lake Windermere, Canada, and 600 miles up the Snake River to Shoshone Falls near Twin Falls, Idaho. The construction of dams has gradually reduced the areas accessible to anadromous fish, especially in the valuable salmon-producing tributaries of the upper watershed.... Early in the 20th century, irrigation and hydroelectric dams were built on the upriver tributaries, but hydroelectric development of the main stem Columbia and Snake Rivers did not get under way until construction of Rock Island Dam in 1933. Since then dams have been built in the Columbia River drainage at an increasing rate.... Access to over 500 miles of the upper Columbia River, excluding tributaries, was blocked by the construction of Grand Coulee Dam in 1941. Another 52 miles of the main stem were lost with the building of Chief Joseph Dam, the present upstream limit of salmon and steelhead in the Columbia River. Over 50% of the originally inhabited main stem of the Snake River is no longer accessible to anadromous fish. Hells Canyon Dam now limits access to the lower 247 miles of this stream. Main stem dams in the migration path of anadromous fish, although provided with passage facilities, have further reduced production of salmon and steelhead by creating impoundments which inundate much of the remaining natural stream and reduce water quality. In the Columbia River only 50 miles of free-flowing stream remain near Pasco, Washington, and that would be impounded by the proposed Ben Franklin Project. The main stem Snake River is also being impounded. Presently, only 140 miles of natural stream remain between the Little Goose and Hells Canyon projects...." Yet it was shown earlier in this report that the Columbia was probably the centre of the world's abundance of steelhead (and still may be).

Table 8. Average numbers of streams which produced among the top 30 in British Columbia, average numbers of licensees, and numbers of streams per thousand licensees. By area, 1966-72. Data from Tables 6 and 7.

| Area | Area No. | Avg. no. of streams in top 30 | Avg. no. licensees in thousands | No. top-producing streams per thousand licensees |
|---|---|---|---|---|
| Lower Mainland Coast | (1) | 5.3 | 17.3 | 0.3 |
| Vancouver Island | (0) | 12.7 | 10.0 | 1.3 |
| Upper Mainland Coast | (6) | 7.5 | 3.6 | 2.1 |
| Northern Interior | (5) | 0 | 1.8 | 0 |
| Kamloops | (2) | 1.0 | 1.2 | 0.8 |
| Cariboo | (4) | 3.0 | 1.0 | 3.0 |
| Okanagan-Kootenays | (3) | 0 | 0.6 | 0 |
| Queen Charlotte I. | (7) | 0.5 | 0.2 | 2.5 |
| Can. outside B.C. | (8) | - | 1.0 | - |
| Outside Canada | (9) | - | 2.0 | - |
| | | 30.0 | 38.7 | 0.8 |

To satisy anglers' demands under these conditions, state fishery managers have intensified their efforts to maintain and increase steelhead stocks and to divide the allowable catch equitably among the participants. A plethora of regulations too numerous to list respecting when, where, and how angling is to be permitted, and how many fish may be taken, reflects their attempts to tailor the fishing to the supply of fish and the anglers' needs. In addition, the view that steelhead are more valuable economically and socially as sport fish than as a commercial product has brought about increasing restriction of commercial fishing for steelhead, either as the prime target or as an incidentially-caught product of salmon fishing.

The main device to meet the demand, however, has been an expanded and improved steelhead hatching and rearing system. Table 9 illustrates the trend. In general, the numbers of young steelhead released each year in the four Western States is increasing. Even so, these figures underestimate the true increase in effort; earlier releases and plants contained high proportions of steelhead eggs and fry and relatively few older and larger fish. The trend recently has been to release rather large, healthy fish at the smolt stage, ready to go to sea and demanding little of the freshwater environment after release. Marking of hatchery-reared smolts and later observation of catches have shown that up to 10% of healthy smolts, released at the right size and time, will return to the river in which they were released (Wagner 1967). The most intensive and best-reported studies of the effects of time, size and location of release of hatchery-raised steelhead on their survival and return have been carried out by Dr. Harry Wagner and his colleagues of the Research Division of the Oregon State Game Commission. The techniques developed by this group warrant close attention by anyone considering hatchery production of steelhead in British Columbia.

Placing a steelhead in an angler's creel by hatchery methods is expensive. From figures available it is possible to generalize current costs under the most favourable conditions: to produce a healthy smolt of the required size is reported to cost about 10¢ (Wagner 1970; Ward 1969, as reported by Sheppard 1972; Millenbach 1965). With a return of 10% from the sea (a figure which has been achieved only rarely in hatchery operations to date) the cost of an adult returning to the river would be about $1.00. From this point production cost to the angler's creel depends upon the proportion of the returning hatchery fish which are caught, e.g. at a catching rate of 25% the cost per fish would be $4.00, at 50% the cost would be $2.00, and at 75% the cost would be about $1.35.

Some estimates of the actual costs of putting a steelhead in the creel have been made. Wagner (1967) has produced the best documentation available. Cost estimates for an adult fish returning to the Alsea River in Oregon ranged from $1.20 to $13.50 and averaged $2.07 for the period 1958-64. The average production cost of a <u>creeled</u> hatchery steelhead in the Alsea was $3.78. On Wilson River the average for a fish in the creel was $3.70; on Sandy River the average cost to the river was $8.64 and $18.24 to the creel. In Washington state the average cost of a creeled hatchery-produced steelhead has been reported as $4.00 (Washington Department of Game 1971). In California the estimated average cost was $8.33 some years ago (California Fish and Game 1960, as reported by Sheppard 1972).

The above estimates of the cost of producing a steelhead smolt suitable for liberation must be considered minimal because most of them either do not include capital costs, or are based on capital cost figures which are unrealistically low at today's prices. A modern, efficient hatchery capable of producing one million smolts annually would probably cost about $2,500,000. At such a price a hatchery would have been blessed with an abundant supply of good water cheaply provided, it probably would not have facilities for public viewing or research, nor would it provide for treatment of effluent water. Assuming an amortization period of 25 years and an interest rate of 7%, capital costs on an annual basis would amount to about $215,000 a year. At this rate capital costs <u>alone</u> ascribable to each smolt would amount to 21.5¢. When annual operating costs of, say, $200,000 are added to the annual capital cost, the cost per smolt rises to over 40¢. The generalized figures given earlier, based on a cost per smolt of 10¢, would have to be adjusted accordingly.

Attempts to circumvent the high capital cost of hatching and rearing facilities have been made. In Washington, for example, semi-natural rearing ponds in which fingerlings are fed supplemental diets have been developed recently by enclosing side channels of streams. Such methods are reported to be effective so far, although it is perhaps too early to assess whether disease can be controlled adequately both within the ponds and in the effluent.

Table 9. Numbers of young steelhead released from hatcheries annually in Washington, Oregon, Idaho and California, numbers of hatcheries either partially or wholly devoted to steelhead production, and numbers of semi-natural rearing ponds employed. Data sources listed in Appendix D.

| | Washington | | | Oregon | | | Idaho | | | California | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | No. released | No. hatcheries | No. rearing ponds | No. released | No. hatcheries | No. rearing ponds | No. released | No. hatcheries | No. rearing ponds | No. released | No. hatcheries | No. rearing ponds |
| 1960 | 2,432,332 | 15 | - | 1,541,530 | 15 | - | No data | No data | - | 3,820,867 | 6 | - |
| 1961 | 1,496,000 | 15 | - | 2,491,256 | 12 | - | " | " | - | 5,106,352 | 6 | - |
| 1962 | 1,803,000 | 16 | 2 | 3,531,699 | 12 | - | " | " | - | 2,870,524 | 6 | - |
| 1963 | 3,375,000 | 16 | 3 | 3,049,378 | 12 | - | " [1] | " | - | 2,498,885 | 6 | - |
| 1964 | 3,529,000 | 16 | 3 | 2,125,377 | 11 | - | " [1] | " | - | 4,279,923 | 7 | - |
| 1965 | 3,701,500 | 19 | 5 | 2,702,368 | 14 | - | 24,291[1] | 3 | - | No data | No data | - |
| 1966 | 4,121,000 | 18 | 6 | 2,340,481 | 12 | 1 | 142,769[1] | 3 | - | 282,245[3] | 3 | - |
| 1967 | 3,487,500 | 16 | 5 | 3,753,178 | 11 | 2 | 2,355,263[1] | 3 | - | 1,911,926 | 4 | - |
| 1968 | 3,852,000 | 16 | 8 | 2,822,207 | 14 | - | 2,508,415[1] | 3 | - | 1,749,263 | 4 | - |
| 1969 | 4,385,000 | 16 | 10 | 3,311,435 | 15 | - | 2,076,743[1] | 3 | - | 1,682,115 | 4 | - |
| 1970 | 5,513,000 | 14 | 9 | 3,701,363 | 13 | 1 | 2,545,098[1] | 4 | - | 4,511,154 | 5 | - |
| 1971 | 5,178,000 | 18 | 10 | No data | No data | - | 5,800,000[2] | 4 | - | 2,178,957[4] | 7 | - |

[1]Eyed eggs also planted 1970 - 2,007,500; 1969 - 700,000; 1968 - 963,340; 1967 - 848,455; 1966 - 480,598; 1965 - 249,682; 1964 - 390,897; 1963 - 484,000; 1962 - 102,500.

[2]Steelhead production goal for 1971.

[3]Fingerling releases only.

[4]Does not include fingerling releases.

Steelhead fishing, Big Qualicum River, B. C. -- photo by Barry M. Thornton.

In summary, in the Western States, the demand for steelhead angling is mounting at the same time as the freshwater environment's capacity to rear young fish is being eroded. The demand is being satisfied by increasingly severe restriction of the commercial fishery and by supplementing natural production with expanded and improved hatchery operations. Where hatchery production is efficient and angling pressure on hatchery-produced fish is heavy, it is reported that a steelhead can be put in the angler's creel for a production cost of about $4.00 per fish, or slightly less. This cost must be considered conservative in terms of building and operating hatcheries at today's prices.

## INFORMATION NEEDS AND RECOMMENDATIONS FOR RESEARCH

### Objectives of the management program

In attempting to list research priorities in anticipation of intensified management of steelhead angling in British Columbia, it is first necessary to define the objectives of the management program. Nearly any study which might be done regarding steelhead or steelhead angling will provide information which sooner or later will prove useful. But certain kinds of information will be needed earlier than some others and, under the reasonable assumption that funds and effort are not limitless[6], it will be necessary to put information needs in some order of urgency.

The fisheries management objective of the Fish and Wildlife Branch of the Department of Recreation and Conservation, which is currently the agency directly concerned with management of steelhead angling in British Columbia, was enunciated some time ago by Mr. E. H. Vernon, Chief of Fisheries Management:

"The primary objective of fisheries management is to maximize present and future opportunities for the pursuit of freshwater angling in the public waters of British Columbia.

"The following assumptions are recognized as being inherent in the definition of the primary objective:

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[6]For perspective in thinking about the amount of research effort which could be expended on steelhead, the research for intensive management of Pacific salmon can be used for comparison. In spite of the many years and vast amounts of money that have been expended on research directed at improving management of Pacific salmon stocks, much remains to be known, and useful new information becomes available each year. When one considers the great new understanding of the salmons' ocean life which has arisen in only the last 10 to 15 years (through the joint efforts of the United States, Japan and Canada through the International North Pacific Fisheries Commission), it would be unreasonable to expect that all that might be known about steelhead could be made available very soon or without considerable expense.

1. That the main purpose of fishery management is to satisfy human needs for recreational fishing as a means of close personal involvement with fish in their natural habitat.

2. That the principal object of angling is the capture of desirable species of fish in satisfactory numbers and sizes.

3. That it is desirable to promote a wide variety of angling opportunities by encouraging the appreciation and use of many species and by recognizing the distinctive qualities of diverse types of fisheries and fishing methods.

4. That the quality of recreational fishing is enhanced by an uncrowded natural setting in which the integrity of the aquatic environment has been maintained with minimal disturbance to surroundings other than that required for ready access to the waters.

5. That it is necessary to promote an equitable distribution of fishing opportunities throughout the province within the limits imposed by the availability and productivity of natural waters and with consideration given to the distribution of public demand.

6. That an equitable division of effort must be made between activities which lead to long-term future benefits and those leading to immediate or short-term benefits to the angling public."

In considering the research needed to manage steelhead angling in a manner consistent with the above objective (particularly as it is further defined by the underlying assumptions), two points are worth noting. Most importantly, it is clear that the intent is to provide the opportunity to <u>enjoy</u> angling, not only in terms of providing satisfactory numbers of fish to be caught, but also in providing a pleasant environment for the angler himself. To achieve this second goal it will be necessary to understand what motivates the angler to go fishing in the first place and what he hopes to find when he later arrives at the riverbank. Since some forms of intensive management may be very expensive, it is apparent that the angler's wishes should be well understood before the available management funds and effort are dispensed. There will probably be alternative ways in which the funds at the managers' disposal may be used to meet the objective. Some studies have already been made in which consideration of anglers' preferences have been considered (Pearse Bowden Economic Consultants Ltd. 1970, 1971).

Attention should also be directed to assumption 5 above. We have already observed that the most critical area in British Columbia steelheading lies in the Lower Mainland Area where the province's largest concentration of anglers is associated with a limited number of steelhead streams. It is in this area that intensive management should be applied soonest. However, with increasing mobility, modern anglers each year open up areas considered remote the year before, and the critical areas can be expected to extend farther and farther out from the lower mainland.

Before considering research proposals now most needed for British Columbia steelhead management, it should be pointed out that several valuable studies of British Columbia steelhead have been made. Some have been referred to earlier in this report. Most have been done by staff of the Fish and Wildlife Branch or have been sponsored by it.

Information needs and research recommendations

I. The most urgent need is for fishery managers to become aware of what steelhead anglers really want when they go fishing, while at the same time anglers must become aware of the constraints which may stand in the way of satisfying their wants.

The problem of communication between the angler and the fishery manager responsible for providing the opportunity for the angler to enjoy his sport was put most effectively by R. L. Haig-Brown (1959) several years ago:

"No one owes more to fish and game biologists than I do, no one has more respect for their skills. And I think I have done my little share toward bringing them to some of the honored positions they hold today. Scientific thinking has done wonders for them in their researches and explorations. They have already learned more than I expected would be known in my lifetime. But when they come to dealing with the intangibles of sport, which are a sizeable section of human psychology, scientific thinking utterly betrays them.

"What has to be understood is that the quality of sport is all-important. And the quality of sport is not something that can be readily measured; it is the sum of generations of tradition, ethics and restraint. The quality of sport is in what anglers themselves have imagined, developed, tested and proved over hundreds of years. It is something that has evolved, not something that has been imposed. It is in what a man dreams of by the fireside at home and goes out next day or next year to try and realize on his favourite lake or stream. Even the unsophisticated fisherman dreams, and his dreams are not of being bullied into taking the crop.

"Biologists have, and always will have, a tremendous job to do in the management of public game fisheries; and they can do it far better than untrained minds, provided they first understand the real meaning and purpose of sport. It is not their business to change the desires of the angler to suit their own purposes; it is their business to recognize and understand these desires and then to provide for them so far as can humanly be done."

Haig-Brown, elsewhere in his comments on the relationship between the fishery biologist and the angler, points out that the management biologist often has assumed that fishermen simply want to catch more fish and that, in giving them the opportunity to harvest all the surplus stock, he has discharged his duties.

On the other hand, it is also true that the angler is often unaware of the problems of fishery managers. He has heard that hatcheries are very effective at producing more fish, while at the same time he remains unaware of the failures (which fishery managers usually are loathe to publicize) and the very real costs of producing fish artificially. That these costs may include a deterioration of the quality of his sport, and possibly, a hazard to natural populations which hopefully will be there to provide the bulk of his catch for many years to come, may not be immediately apparent. It is also true that most anglers are unaware of the constant war that dedicated fishery biologists wage against the forces of "development" which in most cases erode the waters' ability to produce steelhead naturally and which intrude on the angler's own environment. It is the natural environment that provides a good part of the "quality" of his sport.

So, it becomes clear that communication between angler and fishery manager must become such that the manager's efforts are directed at providing what anglers really desire, not just what the manager thinks is good for him and the resource. On the other hand, anglers must be realistically aware of the problems which the fishery manager must overcome in meeting the desires of the angler, so that their efforts support the manager and do not distract him from their mutual purpose. The eventual goal should be to involve the anglers with management of the resource and themselves, so that they accept responsibility for management actions (as the fishery managers <u>alone</u> do now) at the same time as they benefit from participation.

<u>It is recommended that methods of communication be developed to reveal what it is that anglers desire for their sport, so that management can be directed toward satisfying those desires. At the same time information techniques should be developed which reveal to the angler how steelhead populations may be maintained or increased, and how the intrusions of human population and industrialization into the environment of the fish and the fisherman may be prevented or ameliorated. To develop these methods will probably require the help of sociologists and economists working in conjunction with both the management biologist and the angler.</u>

II. <u>There is an urgent need to inventory and describe the province's steelhead stocks. First priority should be given to those which are endangered by immediate industrial or domestic development, to major stocks, and to those in high angling-demand areas.</u>

Currently it is fair to say that, with the exception of the Capilano and Big Qualicum Rivers and perhaps the Babine River, there are no reliable estimates of steelhead escapements in British Columbia. With the exception of the Capilano and Big Qualicum not a single British Columbia stream is monitored on a regular basis to provide estimates of annual spawning runs or to assess changes in abundance. Tentative assessments of the relative abundances of stocks can be made by assuming that anglers' catches from individual streams represent abundance, but the amount of fishing effort and the availability of the fish to the angler probably varies markedly from year to year and from stream to stream, making such estimates tenuous at best.

Information about annual angling harvests in individual streams is much better. A questionnaire survey method has been developed by the Fish and Wildlife Branch which appears to provide reasonably good estimates of the anglers' take from individual streams. Annual commercial catches of steelhead are known from statistics provided by the Fisheries Mission of the Department of the Environment. Since most steelhead caught commercially are associated with net fisheries near the mouths of major rivers, the river of origin of many commercially-caught steelhead can be identified. However, no studies have been made to determine from which stocks within the major systems the steelhead are taken. Indian catches of steelhead for food are poorly known. No published record of catches for food purposes is maintained, and such regular monitoring of Indian food catches as is done is carried out by Officers of the Fisheries Mission in conjunction with their observation of salmon food catches in the summer and fall. Hence, Indian food catches of winter steelhead are largely unknown and certainly are largely unrecorded.

Other important information about steelhead stocks is lacking entirely. There is no published information for any British Columbia river clearly defining the extent of spawning areas used by the stocks within the system. Even less is known about the dispersal of young fish from the spawning areas into the river and lake systems during their period of freshwater residence before first going to sea.

Without much of the information indicated above as lacking, effective management of steelhead stocks will be difficult at best and proportionately inaccurate, as angling and industrial pressures increase. Without knowledge of the numbers of fish in a stock (the numbers originating from a single river, say) and the proportion which are harvested, it is difficult to assess whether the stock is being maintained, is underharvested or is declining. Without knowing its condition, it will be impossible to know whether angling should be encouraged or restricted, or whether aid in some form of artificial propagation would be useful. If it is not known whether the nursery areas are sufficiently well populated, it will be impossible to know whether more fry (which are cheaper to produce) are needed to exploit the nursery capacity or whether more smolts (expensive to produce) will be required in the event that artificial support of the stock is decided upon. Without knowledge of how many fish are present in a watershed and in what way the stream is used by them, it will be difficult to assess the effects of water diversion or impoundment, or pollution, on the stock. Without such assessment it will be difficult to counter unfavourable demands for the water with convincing arguments, or to effectively ameliorate the consequences of other use by the introduction of counter measures.

<u>To inventory all streams in the province in an adequate manner will be a large task. Priorities among streams or stocks will have to be established. Those priorities indicated above might be considered. Once priorities are set, research is needed on chosen streams to establish their stock size (catch and escapement), the current intensity of harvesting, and the nature of dispersal of young into the river system from the stocks' spawning areas. Assessments of whether or not the nursery areas available are being fully used are needed to determine how artificial aids or stream improvement could be best applied.</u>

III. <u>There is a need to develop methods of improving steelhead production in natural streams.</u>

Currently, in the Western States, where industrial development and heavy demand for fishing are bringing increasing pressure on the steelhead resource, fishery managers are turning increasingly to hatcheries to supplement the stocks. Hatcheries, by their nature, tend to be favoured by managers because they offer a convenient solution to the managers' problems. If a power company, say, wishes to flood out a section of river containing spawning or nursery grounds, a hatchery makes a tangible and monetarily understandable package by way of compensation. If anglers complain that there aren't enough fish to go around, a hatchery with nursery ponds teeming with fingerlings again offers tangible evidence of money and effort expended to increase the fish available. We have seen that hatchery production may prove to be a very expensive supplement, and alternative methods should be sought aggressively.

In spite of the proliferation and unquestioned effectiveness of hatcheries to meet certain needs (there may be no other form of compensation for a power dam!), steelhead production even in the Western States probably still comes mainly from natural spawning. As yet, in British Columbia (except in certain restricted areas) neither industrial nor angling pressures have reached the critical stage they have in the Western States, and greater opportunities for increasing production in natural streams by manipulating the environment or supplementing the food supplies remain. Not much is known about the conditions which limit steelhead production in streams -- food supplies, stream flows and temperatures, streambank or instream cover, competition, and predators probably have their effects. Which of these, or others, are most critical and which are amenable to modification for improvement can mostly only be guessed at now.

It is recommended that research be undertaken to identify those conditions which tend to suppress steelhead production in natural streams, and that studies be initiated to examine the possibilities of modifying stream conditions with the objective of improving natural production.

IV. There is a need to discover the most effective and economical methods for producing steelhead by artificial means, adapted to the special conditions of British Columbia.

There is now no question that effective methods have been developed in the Western States for producing young steelhead capable of going to sea and returning to the river in which they were released. However, in terms of today's costs for construction, maintenance and operation of hatcheries and nursery ponds, it is also clear that the costs of producing steelhead by artificial means are going to be high, probably much higher than the costs now reported in the Western States where many hatcheries were built some years ago and the capital costs are now unrealistically low. In addition, the techniques developed in the Western States are appropriate for the stocks indigenous to those areas and for those watersheds. Whether or not the methods which currently succeed there can be applied unchanged to British Columbia stocks and waters is not known. Currently, hatchery operators aim mainly at producing healthy young steelhead as smolts ready to go to sea, at one year of age, even though steelhead normally migrate first to sea at two or more years of age. The reason for promoting early, fast growth is simple: the total input of food and care is less, and nursery ponds are used most efficiently when a brood is put out each year. Methods for producing fish meeting the size and condition criteria on schedule are becoming well established. Early-spawning stocks have been selected in some cases to give the hatchery operator a longer period in which to grow the fish to the desired size, diets have been developed which convert into fish flesh efficiently and at low cost, disease control techniques are being developed which eliminate or control the common diseases to which fish in crowded conditions are prone, criteria for water supplies (desirable temperatures, freedom from disease organisms, turbidity) have been developed, and methods of inducing smoltification are being discovered. These techniques are now available to the British Columbia hatchery operator, if and when the admittedly high cost of hatchery supplementation of stocks is required.

It will be necessary to adapt these techniques to British Columbia stocks and conditions. Our stocks are probably somewhat different genetically from those to the south, as would be expected since they have adapted to different natural conditions. Our waters, in general, are colder than those to the south and it is reasonable to expect that allowance will have to be made for this difference if growth during the nursery stage is to equal that achieved in hatcheries with warmer water supplies.

Ironically, the success of some salmon and steelhead hatcheries in the Western States has brought an unanticipated problem. Sometimes the effectiveness of harvesting the fish surplus to hatchery requirements has not kept pace with the greater numbers of fish returning, so that gluts of fish occur near hatchery weirs which anglers cannot harvest effectively, or if they can, only under conditions which are aesthetically undesirable. Little effort has been directed at conditioning hatchery fish to be especially vulnerable to anglers, although such vulnerability may be desirable to achieve adequate harvest and to reduce the fish-in-the-creel cost of hatchery production. Investigation may also show that it is desirable to remove hatchery-produced fish from the rivers, to maintain the genetic integrity of wild stocks.

It is recommended that the most successful of the steelhead rearing techniques developed in the Western States be tested for their applicability to British Columbia stocks and waters. Concurrently, ways of minimizing the costs of producing fish to the creel artificially should be sought out, either by modifying developed techniques while maintaining their effectiveness, or by developing less expensive alternatives.

V. There is a need to know, before major plantings from hatcheries and/or transfers between streams are made, whether or not natural stocks are likely to be endangered by introduction of disease or by genetic pollution.

Attention to the identification and control of fish diseases has mushroomed as artificial culture of fish has developed. In the wild state disease among fish stocks tends to pass unnoticed even though many kinds of potentially harmful pathogens are always present on the fish and in the fishes' environment. It is usually only when fish become less able to resist disease pathogens because of inherited defects, or because of unusual conditions which impose stress, that fish succumb in sufficient numbers to be noticed.

Disease becomes much more noticeable among cultured stocks, however, and most of the efforts at identifying and controlling fish diseases have been made because culturists needed help to maintain healthy stocks under conditions which are conducive to the proliferation and spread of diseases. The crowding of eggs and juveniles in hatcheries and nursery ponds makes them potential focal points for disease production; artificial diets may reduce the fishes' ability to resist infection; mixing together of different stocks (or at least the common use of water supplies and structures) facilitates the spread from one stock to another; and the sometimes unnatural water flows and temperatures may provide the opportunity for development of disease. In general, culturists have developed a "first-aid kit" of treatments which can be applied as common disease problems arise.[7] Methods of rearing, quarantine and medication are being developed sufficiently well to eradicate or at least control disease until such time as fish are released.

However, there remain areas in which there is virtually no understanding: what is the likelihood of transmitting disease from cultured fish to wild populations, and to what extent is there a danger of depleting wild steelhead populations by releasing diseased fish among them? To what extent are wild fish populations endangered by hatchery-enhanced disease organisms introduced through hatchery and pond effluents among the wild stocks? Effluent treatment is being incorporated in some new hatcheries; the process is expensive and may not in itself be sufficient if the released fish themselves become the vectors for disease among wild populations. Recently, fish pathologists have become alarmed by the spread of diseases through transplanting of fish from one watershed to another, and recommendations for control and inspection of eggs and fish are being prepared by scientists of the Department of the Environment.

In another area the potential for damage to wild stocks is also unknown. Currently, in the Western States spawn is obtained from one or a few stocks which spawn at the right time to serve the culturist's production schedules, or are near at hand, or easily caught. After culture, the progeny are distributed among watersheds to which the donor stocks are foreign. Since not all the introduced hatchery fish are caught by anglers or taken for spawning by the culturist, many remain to mingle with the wild stocks already present in watersheds. There is virtually no understanding of the effects of such genetic pollution on wild stocks. In fact, because relatively successful artificial propagation techniques have been developed only recently, it is likely that any deleterious effects of such mixing of inheritance would not yet be apparent. To illustrate the possibility of danger it is only necessary to contemplate the enforced mixing of genetic characteristics of winter and summer steelheads (quite possibly by accident) by culturists in a watershed which contained both types.

<u>It is recommended that studies of the transmittability of diseases of hatchery fish to wild populations be undertaken to assess the potential for damage to wild stocks through planting hatchery-reared steelhead. It is further recommended that studies be undertaken to identify the genetic distinctness or similarities of steelhead stocks with a view to anticipating the hazards of genetic pollution brought about by the admixture of stocks.</u>

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[7]A common item listed under the operating expenses of a hatchery is now "medication".

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# APPENDIX A

Data sources for annual commercial catches (Table 1).

Alaska:

Statistical leaflets (No. 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21). Alaska Department of Fish and Game, Juneau, Alaska.

British Columbia:

British Columbia catch statistics by area and type of gear (1960-71). Variously, Canada Department of Fisheries, Canada Department of Fisheries and Forestry, and Department of the Environment, Fisheries Service, Pacific Region, Vancouver, B. C.

Washington:

Fisheries statistics of the United States (for the years 1960 to 1967). Statistical Digests 53, 54, 56, 57, 58, 59, 60, 61. United States Department of the Interior, Bureau of Commercial Fisheries, Washington, D. C.

Fisheries statistics of the United States 1968. Statistical Digest 62. U. S. Department of Commerce, National Marine Fisheries Service, Washington, D. C.

1969 Fisheries Statistical Report. Washington Department of Fisheries, Olympia, Washington.

Oregon:

Biennial Report of the Fish Commission of Oregon for 1970. Fish Commission of Oregon, Portland, Oregon.

# APPENDIX B

Data sources for annual anglers' catches (Table 4).

Alaska:

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British Columbia:

Steelhead harvest questionnaire analyses, 1966-67 to 1971-72. B. C. Fish and Wildlife Branch, Department of Recreation and Conservation, Victoria, B. C.

Washington:

Annual summaries of Washington steelhead catches. Washington State Game Department, Olympia, Washington.

Idaho:

Keating, J. F. 1971. Annual survey of the salmon and steelhead sport fishery harvest in Idaho. Annual Completion Report, Statewide Fishing Harvest Survey, Project F-18-R-17, Idaho Fish and Game Department, Boise, Idaho. 1-27.

Oregon:

Annual report of the Oregon State Game Commission for 1969 and 1970. Oregon State Game Commission (Fishery Division), Portland, Oregon.

California:

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Ryan, J. H. 1959. California inland angling estimates for 1954, 1956, and 1957. California Fish and Game 45: 93-109.

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APPENDIX C

Data sources for numbers of angling licensees and annual catches (Table 5).

British Columbia:

Steelhead harvest questionnaire analyses, 1966-67 to 1971-72. B. C. Fish and Wildlife Branch, Department of Recreation and Conservation, Victoria, B. C.

Washington:

Annual summaries of Washington steelhead catches. Washington State Game Department, Olympia, Washington.

Idaho:

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# APPENDIX D

Data sources for numbers of steelhead released from hatcheries (Table 9).

Washington:

Millenbach, C., Chief, Fisheries Management Division, Washington State Department Game. (Personal communication)

Oregon:

Oregon Fish Commission, 1960-1970 Biennial Reports.

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