

0016-1111
FRI-UW-8816
September 1988

HIGH SEAS DISTRIBUTION OF NORTH AMERICAN STEELHEAD AS EVIDENCED BY RECOVERIES OF MARKED OR TAGGED FISH

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Submitted to
International North Pacific Fisheries Commission
by the
United States National Section

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:

Light, J. T., S. Fowler, and M. L. Dahlberg. 1988. High seas distribution of North American steelhead as evidenced by recoveries of marked or tagged fish. (Document submitted to the International North Pacific Fisheries Commission.) 21 pp. FRI-UW-8816. Fisheries Research Institute, University of Washington, Seattle.

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ABSTRACT

Nearly 76 million steelhead were marked or tagged and released during inshore experiments between 1978 and 1986, and of these, 416 were recovered offshore by research and commercial fishing vessels. Another 1,532 steelhead were tagged and released offshore between 1956 and 1986 during International North Pacific Fisheries Commission (INPFC) tagging experiments, and 73 of these high-seas tagged fish were recovered in North American spawning streams. Information from these 489 recoveries show that North American steelhead migrate westward to at least 162°28'E longitude, and southward to 40°58'N latitude. Steelhead stocks from Alaska to California are widely dispersed and extensively intermingled in the area east of 167°E longitude and north of 41°N latitude. The offshore distribution of summer-run and winter-run races and of inland and coastal groups do not appear to be greatly different in the times and areas sampled.

INTRODUCTION

Offshore tagging of Pacific salmon (*Oncorhynchus* spp.) and steelhead trout (*Oncorhynchus mykiss*, formerly *Salmo gairdneri* and *S. mykiss*) began in 1956 as part of the cooperative research efforts of the newly-formed International North Pacific Fisheries Commission (INPFC) (Sutherland 1973). These efforts were aimed at discovering the distribution and migration patterns of the six species of Pacific salmon that occupy the North Pacific Ocean and Bering Sea during their ocean residence. Asian and North American stocks were thought to intermingle in the areas fished by the Japanese high seas salmon fisheries, but to an unknown extent, and tagging programs were developed to identify the continent of origin of fish within the fishing areas. Initially, steelhead were not a species of interest, although they were captured, tagged, and recorded along with Pacific salmon (Sutherland 1973). In 1978, when the Protocol of the International Convention for High Seas Fisheries of the North Pacific Ocean was revised to accommodate changes brought about by the establishment of national 200-mile fishery zones, the wording concerning "species of interest" was changed from "salmon" to "anadromous species." As an anadromous species, steelhead thus fell within the consideration of the INPFC and its research objectives. In 1980, several North American steelhead carrying coded-wire tags were caught during high seas fishing operations of a Japanese research vessel (Pearcy and Masuda 1982), and this led to concern that an unknown but possibly significant number of North American steelhead were being caught incidentally to salmon by the high seas salmon fisheries (Dahlberg 1981). Since 1980, many more steelhead bearing marks or tags that indicate their North American origins have been recovered offshore, and fish tagged offshore since 1956 during high-seas tagging studies have been recovered in North American spawning streams. In this report, information obtained from these recoveries is summarized and used to describe the high seas distribution of North American steelhead.

Description of Tagging Programs

The two groups of marked or tagged steelhead discussed in this report are differentiated on the basis of where they were marked or tagged, i.e., inshore or offshore.

Inshore Marking and Tagging

Release. Fish in this group are marked or tagged inshore prior to their seaward migration as smolts. Most of these fish are reared in hatcheries, and so offshore recoveries of these fish reflect the ocean distribution of hatchery fish, which may be somewhat different than naturally produced (wild) fish. Fish are typically marked by removal of fins (singly or in combination) or maxillary bones (Johnson 1987). Occasionally, external dyes, freeze brands, or spaghetti tags are used for marking (Johnson and Longwill 1988), but no marks of this type have been reported for steelhead recovered offshore. Coded-wire tags (CWT), small metal wires inserted into the snouts of juvenile fish prior to their seaward migration, are the internal tags most frequently used by fisheries agencies (Johnson and Longwill 1988). These tags are typically used in combination with some form of external mark, usually a clipped adipose fin, to identify the presence of the tag within the fish. Fin-clipped steelhead, especially those with adipose fin clips, carry a strong implication of North American origins because natural fin loss rates are suspected to be low (Foerster 1935, Ricker 1972) and there is no deliberate fin-clipping program in Asia.

Substantial numbers of marked or tagged steelhead have been released from North American hatcheries since inshore tagging programs began. The duration of ocean residence for most steelhead is 1 to 3 years (Sutherland 1973), and for this reason fish released by inshore tagging programs between 1978 and 1986 were the most likely to have been at sea since offshore recovery efforts began in 1981. In the 9-year period between 1978 and 1986, nearly 76 million marked or tagged steelhead smolts were released from North American hatcheries (Table 1; Johnson and Longwill 1988, Pacific Marine Fisheries Commission [PMFC] unpublished data). The majority of these releases (84.1%) were missing their adipose fin, and 16,625,000 carried CWTs. While none of these inshore tagging experiments were designed to investigate the offshore distribution of steelhead, the recovery of fish from these studies has greatly supplemented the information obtained from high seas tagging studies, especially the information obtained from steelhead carrying CWTs.

Recovery. Fish marked or tagged inshore by fin clipping and coded-wire tagging are recovered offshore during fishing operations of research and commercial vessels. Since 1981, scientists aboard salmon research vessels from the United States, Japan, and Canada, as well as U.S. observers aboard foreign fishing vessels have routinely searched for adipose fin-clipped fish among salmonid catches as part of an intensive CWT recovery effort sponsored by the National Marine Fisheries Service (NMFS). The program is coordinated by NMFS in Auke Bay, Alaska, in conjunction with PMFC, an agency that coordinates salmonid tagging and marking programs along the North American Pacific coast. Recovery efforts have focused on adipose-clipped fish because this particular fin clip is commonly used to identify fish carrying CWTs and because it is the most frequently used fin clip for identifying hatchery fish (Johnson and Longwill 1988).

When an adipose-clipped steelhead is found in the catch of a research or commercial vessel, basic biological data and the capture location are recorded, and the snout is removed and stored (salted or frozen or both) for later inspection to detect the presence of a CWT. The snouts of fish potentially carrying a CWT are usually sent to the NMFS laboratory in Auke Bay for processing, although in recent years Canada has processed its own marked-fish recoveries (LeBrasseur et al. 1987, Margolis 1985a).

Offshore Marking and Tagging

Release. In contrast to inshore marking and tagging programs, where a large number of fish are released from a broad area along the coast, offshore tagging experiments capture and release relatively few fish from a limited number of widely-scattered research vessels operating in a vast area. The effectiveness of these tagging experiments for determining continent of origin can be reduced if tagged fish are intercepted by a high seas fishery before reaching their spawning streams, or if these fish return to remote spawning areas where recovery is unlikely (Davis et al. in press). Despite these drawbacks, data collected from the relatively few inshore recoveries of steelhead tagged on the high seas has provided invaluable information on the offshore distribution of North American steelhead.

In offshore tagging experiments, fish are captured alive during research vessel operations with purse seines or surface longlines, tagged (primarily with Peterson disk tags), and released (Davis et al., in press). United States research vessels from the University of Washington's Fisheries Research Institute (FRI) fished with purse seines between 1956 and 1982 (excluding 1979 and 1981 when no tagging experiments were conducted). Between 1983 and 1986, FRI scientists participated in cooperative U.S.-U.S.S.R. tagging studies sponsored by the Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO; Harris 1983). These cooperative studies were conducted on board Soviet research vessels using purse seines. The combined U.S. and U.S.-U.S.S.R. purse seine effort during tagging experiments between 1956 and 1986 totaled 4,138 sets (Figure 1).

Surface longlines were used by Canada (Department of Fisheries and Oceans [DFO], formerly Fisheries Research Board of Canada) in tagging experiments from 1961 until 1967 (Sutherland 1973), and again in 1987 when their tagging program was resumed (LeBrasseur et al. 1987). Japan (Fisheries Agency of Japan [FAJ]) has used longlines exclusively to capture salmonids for tagging since 1962, but reliable records of the numbers of steelhead captured, tagged, and released are not available for years prior to 1976. FRI also made limited use of longlines in 1963 through 1970, and in 1980 and 1982 (Harris 1982; Harris et al. 1980; INPFC 1970, 1971, 1972; Sutherland 1973). In 1953, 1964, and 1965, NMFS fished with longlines but a small number of sets were made and only a few steelhead were caught (Sutherland 1973). For the years between 1961 and 1986, where complete data on the number of steelhead tagged and released are available, the combined longline tagging effort of all three nations totaled 2,823 sets (Figure 2)¹.

A thorough description of fishing gear and methods is found in Hartt (1962, 1963) and Kondo et al. (1965), and is well summarized in Sutherland (1973). Tagging procedures are described in Davis et al. (in press). Most tagging experiments were conducted in spring and summer. Between 1956 and 1986, the combined purse seine and longline tagging efforts of all three nations resulted in a minimum of 1,532 steelhead being tagged and released at sea (Figure 3).

Recovery. Fish tagged offshore are recovered inshore by commercial and sport fisheries when the fish return to spawn. In North America, the inshore recovery program is coordinated by FRI in conjunction with federal, state, and provincial fisheries agencies. The steelhead recovery program relies heavily upon the cooperation of sportfishermen because, with the exception of a limited number of tribal or commercial fisheries, steelhead is not a commercial species. In Asia, the high seas tag recovery program is administered by FAJ.

¹ Japanese longline effort data for the years 1962-1975 were available but were not included because the numbers of steelhead caught during longline operations in these years were not consistently recorded.

METHODS

In this report, the tag recovery information for both inshore and offshore tagging programs was principally derived from published and unpublished data records of the tag-coordinating agencies mentioned previously. The NMFS database was the principal source of information on offshore recoveries of adipose-clipped steelhead. Most adipose-clipped fish that also carried a CWT were previously reported in INPFC documents (Dahlberg 1981, 1982; Dahlberg and Fowler 1985; Dahlberg et al. 1986, 1987; Margolis 1985a; Wertheimer and Dahlberg 1983, 1984). Some fin-clipped steelhead, including a number with CWTs, were recovered during Canadian experimental squid fishing operations in 1985 off the North American coast (Jamieson and Heritage 1987), and also during a Canadian research tagging cruise in 1987 (LeBrasseur et al. 1987). Other fish captured in experimental squid fishing operations during 1985-1987 (mainly between 46°-51°N, 127°-140°W) have not yet been examined and are not included in this analysis. Sixty-six adipose-clipped steelhead (including two with CWTs) caught during 1987 fishing operations of Japan's landbased salmon fishery and recovered during the Japanese port sampling program were not included because precise recovery locations were not available (INPFC unpublished data). Two steelhead carrying CWTs recovered by commercial fisheries off southeast Alaska were also not included owing to a lack of specific recovery data (Karen Crandall, Alaska Department of Fish and Game, personal communication). Information on recoveries of steelhead with clipped fins, other than adipose, or maxillary bones were obtained from Margolis (1985a) and from the unpublished 1985 Canadian (DFO) squid fishery data. Information on the numbers of fish tagged and released offshore and the subsequent recoveries of these fish were obtained from FRI and FAJ data. Only releases through 1986 and recoveries through 1987 are reported. Offshore recoveries of steelhead identified as North American by the presence of certain naturally occurring indicator parasites (Margolis 1984, 1985b) are not included in this report. This parasite information will be summarized in future reports.

Information on the general distribution of steelhead (both Asian and North American forms) in the North Pacific was obtained from catch data (catch-per-unit-effort [CPUE]). Sutherland (1973) used catch data to describe the seasonal distribution and migration patterns of steelhead in the eastern and central North Pacific, and Okazaki (1983) reported the results of a similar analysis for steelhead caught in the western North Pacific. This information was combined with catch data from the 1987 Canadian research vessel cruise in the area south of 41°N near 160°W (LeBrasseur et al. 1987), and with recent FRI and FAJ unpublished catch data to produce an overall distribution map for steelhead on the high seas.

RESULTS AND DISCUSSION

Offshore Recoveries of Marked or Tagged Fish

Since 1980, high seas fishing operations have recovered 416 steelhead whose marks or tags indicate or confirm release from North American hatchery facilities (Figure 4)². Of these recoveries, 384 (92%) were adipose-clipped fish. Among the adipose-clipped fish, 104 (27%) were also found to carry a CWT. Thirty-two fish (8% of the total recoveries) were missing one or more fins other

² Figure 4 does not include marked or tagged fish caught during Canadian experimental squid fishing operations in 1986 and 1987. These fish have not yet been examined for marks or tags.

than the adipose fin or were missing a maxillary bone. Of these 32 steelhead, three (9.4%) carried CWTs (DFO unpublished data, LeBrasseur et al. 1987, Margolis 1985a).

Recoveries of marked or tagged fish were mostly from the eastern (Gulf of Alaska) and west-central North Pacific, with few recoveries between 175°W and 155°W where sampling effort was low (Figure 4). No marked or tagged fish were recovered from north of the Aleutian Islands, but this is not surprising because catch data suggest steelhead are rarely encountered in these waters (Sutherland 1973). The dense cluster of adipose-clipped fish in and around the area between 48°-51°N latitude and 170°E-175°E longitude represents fish captured mostly during fishing operations of the Japanese mothership salmon fishery. The numerous adipose-clipped fish taken along 155°W longitude were captured during cruises of the Japanese research vessel *Oshoro maru*.

The confirmed western-most limit of North American steelhead distribution on the high seas is defined by a coded-wire tagged fish from the Campbell River, Vancouver Island, B.C. This fish was captured by a Japanese research vessel in 1984 at 45°53'N, 167°21'E, which is approximately 4,500 km from the mouth of its natal stream (Dahlberg and Fowler 1985). An adipose-clipped fish of unconfirmed North American origin was captured in 1986 by a Japanese research vessel even further west at 43°49'N, 162°28'E (NMFS unpublished data). The southern-most limit for North American steelhead is identified by three adipose-clipped, coded-wire tagged fish from tributaries of the Snake River (Columbia River Basin) that were captured by a Canadian research vessel in 1987 at 40°58'N latitude, 159°39'W longitude (LeBrasseur et al. 1987).

Releases of adipose-clipped fish, both in absolute numbers and as a proportion of total marked fish, have risen consistently since 1981 (Table 1). A dramatic numerical increase in releases of adipose fin-clipped fish occurred from 1984 through 1986. The proportion of these fish with a CWT dropped substantially, from a high of 83.5% in 1978 to a low of 10% in 1986. The absolute number of CWT fish released each year has shown no upward or downward trends, but has remained between 1.6 and 2.2 million per year from 1978 through 1986 (Table 1). The change in the prevalence of the adipose fin clip results from an increase in the use of this fin clip to mark hatchery fish; this was facilitated by a change in PMFC rules governing the use of the adipose fin clip. Prior to 1983, adipose fin-clipped steelhead released by hatcheries in the Columbia River Basin and in Alaska were required to carry a CWT (Johnson 1982). These restrictions were lifted in 1983 to allow inshore fisheries managers to identify hatchery fish with greater certainty than with less definitive methods (e.g., dorsal fin height measurements; Light 1985). Since 1983, use of the adipose fin clip as a mark for hatchery fish has grown in popularity among fisheries agencies in many areas along the coast; marked fish comprised nearly 60% of the total annual releases of hatchery fish in 1986, and among these almost all (95.9%) were adipose-clipped (Table 1).

The prevalence of coded-wire tagged fish among adipose fin-clipped fish in offshore catches has declined since the first offshore recoveries were made in 1980 (Table 2). Initially, few adipose fin-clipped fish were found in offshore catches, but a large percentage of these adipose-clipped fish carried a CWT. As the recovery program expanded and the number of fish examined for fin clips increased, the number of fish with an adipose fin clip also increased. Between 1984 and 1987, the recoveries of adipose fin-clipped fish as a percentage of the fish examined rose steadily from 3.6% to 18.7%. This generally reflects the trend in inshore releases of adipose fin-clipped fish over that period (Table 1). However, the percentage of adipose fin-clipped fish that carried a CWT decreased from 100% in 1980 to only 9.4% in 1987. This trend also closely echoed the decreasing percentage of adipose fin-clipped fish with a CWT among inshore releases, assuming there was a 2-year lag between year of release and peak of offshore recovery. For example, 15.9% of the 1984 inshore releases were adipose fin-clipped (Table 1), and in 1986 the percentage of adipose fin-clipped fish in offshore catches was 16.1% (Table 2).

Inshore Recoveries of High-Seas Tagged Steelhead

From 1956 to 1987, 72 disk tags and one spaghetti tag have been recovered from steelhead in North American spawning streams. Most of these tags were recovered from fish released in the eastern North Pacific Ocean east of 160°W (Figure 4). Only 4 recoveries have been made from fish tagged west of 180°. No tagged steelhead have as yet been recovered in Asian streams, but the distribution of steelhead spawning stocks in Asia is limited (Okazaki 1983, Savvaitova et al. 1973), and both the suspected overall abundance of Asian steelhead (Harris 1988) and the recovery effort in Asia are low. Accordingly, the chance of recovering a disk-tagged steelhead in Asia is likely to be small.

High Seas Distribution by Area of Origin

Information from recoveries of fish that carried a disk tag or CWT shows that steelhead stocks throughout their North American range undergo substantial marine migrations and intermingle extensively during their ocean residence (Figures 5 and 6). The majority of tag recoveries were from fish in coastal streams of British Columbia and Washington, and from the Columbia River Basin.

Fish from each region were recovered great distances from their home streams, and among these known-origin fish, those found furthest afield were two CWT fish from the upper Columbia River drainage. One of these fish was reared in a hatchery on the Clearwater River, Idaho, and was released below Bonneville dam. This fish was caught in 1983 at 42°51'N latitude, 167°32'E longitude (Figure 6), more than 8,300 km from its natal stream during its second summer at sea (Wertheimer and Dahlberg 1984). The other fish was tagged and released in April 1982, some 845 km upstream from the mouth of the Columbia in the Methow River, Washington, and was recovered 16 months later, in August 1983, at 48°30'N, 171°21'E (Figure 6), approximately 7,900 km from its home stream (Wertheimer and Dahlberg 1984).

Steelhead from British Columbia, Washington, and the Columbia River Basin (Figures 5 and 6) were well dispersed throughout the areas sampled from approximately 41°N latitude northward to the Aleutian Islands in the central North Pacific, and from 167°E longitude eastward to the North American coastline. Three tagged fish from Alaska were recovered in the west-central North Pacific in the same general areas as fish from other regions. All disk-tagged fish recovered in streams of coastal Oregon or California were released in the eastern North Pacific east of 160°W and north of 45°N. No CWT fish from California have been recovered at sea, although approximately 209,000 tagged fish were released each year between 1980 and 1985 (Johnson and Longwill 1988). Oregon fisheries agencies have not released any CWT fish from coastal streams. Overall, steelhead originating in streams across more than 20 degrees of latitude along the North American coastline were found in the same areas in the eastern and west-central North Pacific Ocean. Thus, these fish exhibit extensive marine migrations and substantial overlap in their marine distributions.

Distribution of Races or Regional Groups

Information obtained from disk tags and CWT recoveries suggests the oceanic distribution of seasonal races (i.e., summer- or winter-run) and regional groups (i.e., inland and coastal forms) do not differ greatly (Figure 7). The summer and winter runs are defined by the timing of adult returns to spawning streams and by the state of sexual maturity of fish upon entry into freshwater (Light

1986, Withler 1966). Coded-wire tagged fish provide the best evidence of the offshore distribution of seasonal races because release data often contain a record of the racial origins of the tagged fish, whereas the race of disk-tagged steelhead recovered in spawning streams is often impossible to identify (Sutherland 1973). Exceptions to this are disk-tagged steelhead recovered in streams known to contain exclusively summer-run populations, such as fish from the Skeena River system of the northern British Columbia coast, and the Deschutes River, Oregon (tributary to the Columbia). The marine distributions of 48 summer-run and 54 winter-run steelhead from the tag recovery database show considerable overlap (Figure 7).

These results support the conclusion reached by Light (1986). He initially hypothesized that summer and winter steelhead would have different seasonal patterns of marine distribution to accommodate the wide difference in time of return to freshwater exhibited by the two races. However, in using otolith microstructure to identify the racial origins of several hundred fish sampled from the west-central and eastern North Pacific in 1983 and 1984, he found, contrary to the hypothesis, that in the areas sampled summer-run and winter-run fish overlapped in their high seas distributions.

Inland and coastal groups of steelhead are defined on the basis of LDH-4 and SOD allelic frequencies (Parkinson 1984, Utter and Allendorf 1977). Inland steelhead occur primarily in tributaries of the Columbia and Fraser Rivers east of the Cascade mountain range. To date, tagged fish from the Columbia River Basin are the only inland stocks recovered in tagging programs. A comparison of the offshore distribution of these fish with that of coastal stocks indicates they occupy the same areas in the North Pacific during their marine migrations.

On the basis of genetic analysis, Okazaki (1985) suggested that inland and coastal groups of steelhead migrate to different areas of the North Pacific, with inland steelhead being more abundant in the central and western North Pacific and also in more southerly regions than coastal steelhead. Results of tagging studies do not support this notion. Although tags from inland fish were frequently found at the western edge of known North American steelhead distribution, and inland steelhead were also found the furthest south of the two groups, fish from coastal stocks were found in close proximity to the inland fish throughout the areas sampled. The offshore distributions of both seasonal races and regional groups of steelhead appear to be similar. However, the small number of recoveries of known-origin fish that can be stratified by seasonal race and regional group makes it difficult to draw more detailed conclusions.

Distribution of North American Steelhead

Marking and tagging experiments have added considerable detail to our understanding of the distribution of North American steelhead on the high seas. These experiments show that North American steelhead are distributed throughout a large part of the marine areas known to be traveled by migrating steelhead (Figure 8). The general extent of steelhead marine distribution covers a broad area from the North American continent to the southeastern waters of the Sea of Okhotsk (LeBrasseur et al. 1987, Okazaki 1983, Sutherland 1973). The northern boundary of steelhead distribution closely follows the arc formed by the Aleutian Island chain and the Commander Islands. A few scattered fish (not shown in Figure 8) have been caught in the Bering Sea (Sutherland 1973) and in the northwestern Sea of Okhotsk (Okazaki 1983). The southern boundary of steelhead distribution extends as far south as 39°N latitude, but generally lies between 40°N and 44°N latitude. North American steelhead have been found throughout most of this area except in waters west of 162°E longitude and along the southern fringe of the distribution, where the abundance of steelhead is relatively low (Okazaki 1983, Sutherland 1973). The occurrence of North American steelhead

west of 175°E longitude places these fish well within the areas fished by the Japanese high seas salmon fisheries (Harris 1988). Further work is needed to determine the degree to which North American and Asian steelhead intermingle, both in the fishery areas and in the overall North Pacific range of the species.

CONCLUSIONS

High seas recoveries of marked or tagged steelhead show that North American steelhead occur throughout most of the areas in the North Pacific Ocean that are known to be traveled by migrating steelhead, including the areas fished by the Japanese high seas salmon fisheries. The specific information obtained from tagged fish shows that stocks from different regions along the coast, including fish from summer and winter races or inland and coastal groups, intermingle extensively offshore.

ACKNOWLEDGMENTS

Dr. Leo Margolis, Pacific Biological Station, first suggested the need for this analysis. We thank J. Kenneth Johnson, PMFC, for providing inshore tagging data, and Dr. Robert L. Burgner, Nancy D. Davis, Katherine W. Myers, and Robert V. Walker of FRI for their input and encouragement. We are also grateful to the hatchery personnel and individuals from the following agencies who provided information on releases of smolts from rearing facilities along the Pacific coast: Alaska Dept. of Fish and Game, British Columbia Ministry of Environment and Parks, Washington Dept. of Wildlife, Idaho Dept. of Fish and Game, Oregon Dept. of Fish and Wildlife, California Dept. of Fish and Game, the National Marine Fisheries Service, and the United States Fish and Wildlife Service. This research was funded by NOAA contract No. 50-ABNF-7-00002.

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Table 1. Annual releases (x1,000) of hatchery-reared steelhead along the Pacific coast of North America, 1978-1986, and the proportions of these fish that had clipped fins¹ and that carried a coded-wire tag².

Year of Release	Number of Smolts Released ³	Total Number Marked or Tagged ⁴ (% of smolts released)	Number of Adipose-Clipped Smolts Released (% of marked fish)	No. of Adipose-Clipped Smolts with a Coded-Wire Tag (% of adipose-clipped fish)
1978	16,429	2,990 (18.2)	2,041 (68.3)	1,704 (83.5)
1979	16,636	4,619 (27.8)	2,783 (60.2)	1,866 (67.0)
1980	19,727	3,613 (18.3)	2,521 (69.8)	1,729 (68.6)
1981	20,483	3,834 (18.7)	2,303 (60.1)	1,647 (71.5)
1982	18,071	4,397 (24.3)	3,379 (76.9)	2,031 (60.1)
1983	16,519	5,616 (34.0)	4,345 (77.4)	1,937 (44.6)
1984	22,455	12,995 (57.9)	10,615 (81.7)	1,683 (15.9)
1985	24,344	18,738 (77.0)	17,501 (93.4)	2,161 (12.4)
1986	31,753	19,007 (59.9)	18,234 (95.9)	1,866 (10.2)
Total	186,417	75,809 (40.7)	63,722 (84.1)	16,625 (26.1)

¹ Some of the fin-clipped fish also had clipped maxillary bones.

² All data on marked and tagged fish were provided by J. Kenneth Johnson, Pacific Marine Fisheries Commission, Portland, Oregon.

³ Data obtained from individual agency records (Alaska Dept. of Fish and Game; British Columbia Ministry of Environment and Parks, Fish and Wildlife Branch; Washington Dept. of Wildlife; Oregon Dept. of Fish and Wildlife; Idaho Dept. of Fish and Game; California Dept. of Fish and Game; and national fish hatcheries in Washington, Oregon, Idaho, and California.)

⁴ The actual number of fish marked and released in a given year may be somewhat less than shown because agencies conducting marking experiments often release fewer fish than projected and do not report final totals. This qualification does not apply to releases of coded-wire tagged fish.

Table 2. Incidence of adipose fin-clipped and coded-wire tagged steelhead in catches of commercial and research vessels operating in the North Pacific Ocean, 1980-1987. (Modified from Table 10 in Dahlberg et al. 1987.)

Year	Examined	Number of Steelhead	
		Adipose Fin-Clipped (%) ¹	Adipose Fin-Clipped and Coded-Wire Tagged (%) ²
1980	42	3 (7.1)	3 (100)
1981	151	16 (10.6)	11 (68.8)
1982	762	5 (0.7)	4 (80.0)
1983	531	20 (3.8)	5 (25.0)
1984	1,735	62 (3.6)	32 (51.6)
1985	1,733	116 (6.7)	30 (25.9)
1986	613	56 (9.1)	9 (16.1)
1987	566	106 (18.7)	10 (9.4)
Total	6,133	384 (6.3)	104 (27.1)

¹ The percentage of adipose fin-clipped fish is calculated from the total fish examined.

² The percentage of adipose fin-clipped fish that carried a coded-wire tag is calculated from the total number of adipose fin-clipped fish.

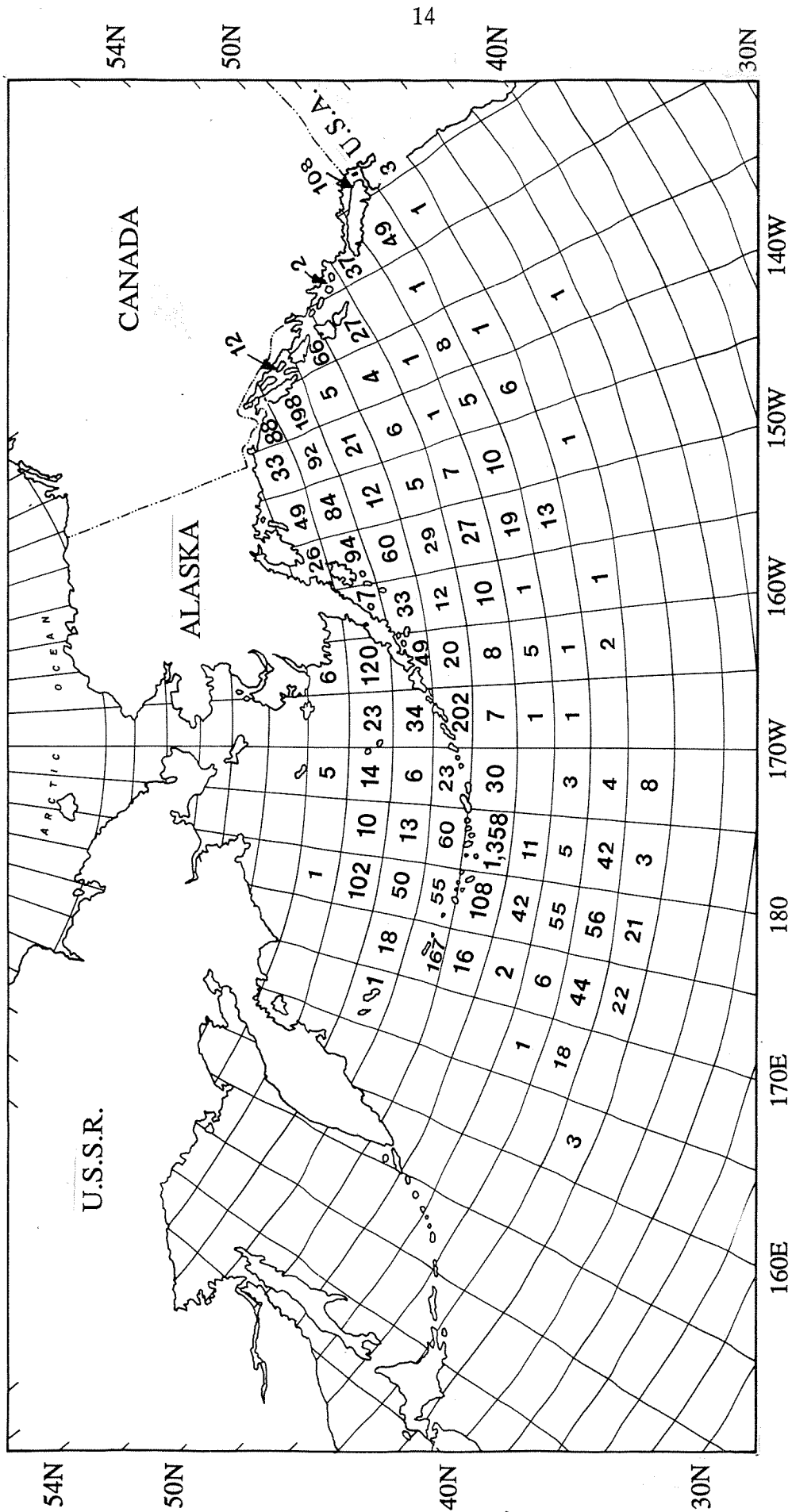


Figure 1. Distribution of U.S. and U.S.S.R. purse seine operations, 1956-1986. N = 4,138. No sets were made in 1979 or 1981.

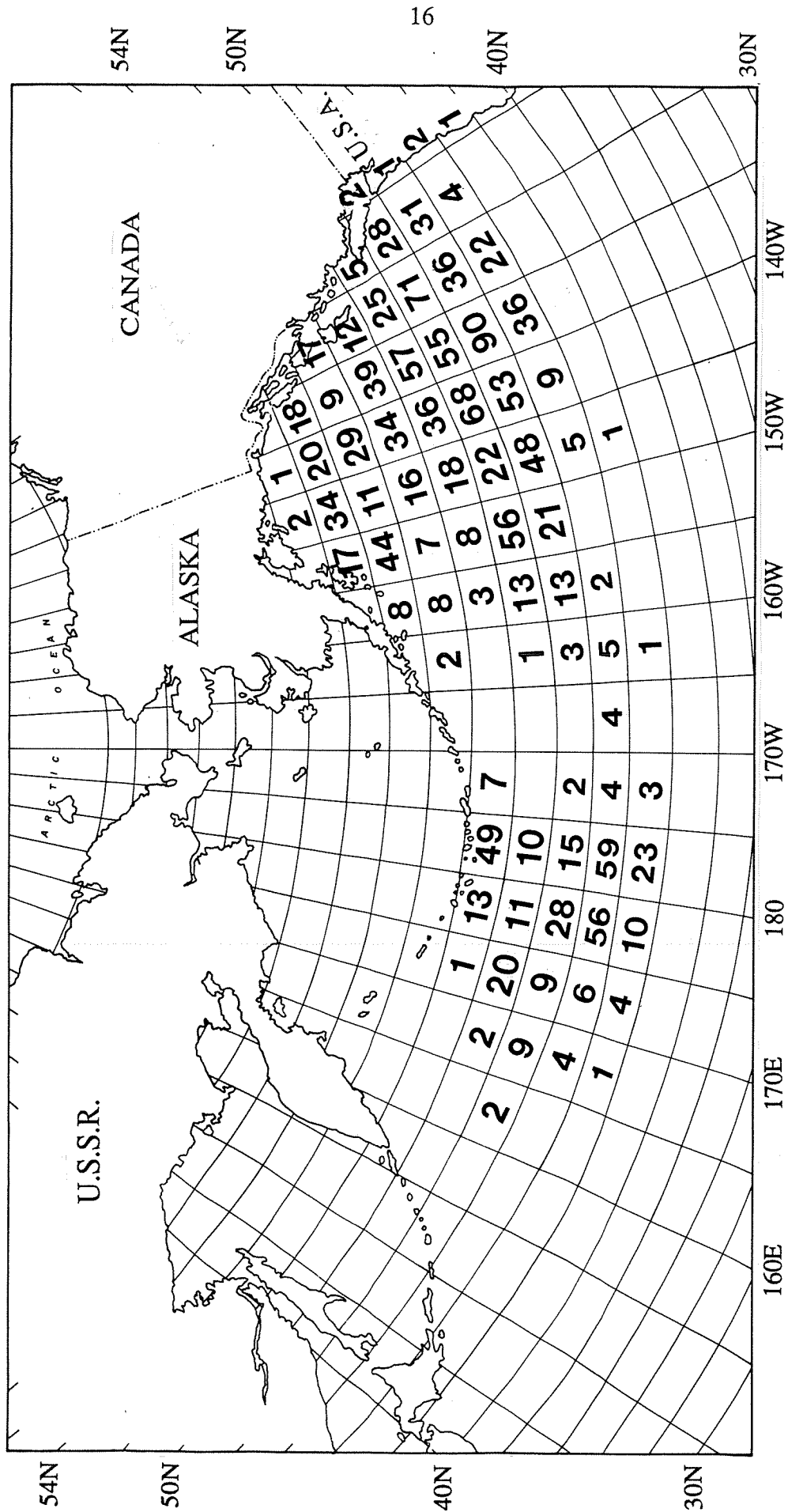


Figure 3. Number and distribution of steelhead tagged and released during INPFC high seas tagging experiments, 1956-1986. N = 1,532. Japanese data for 1962-1975 were not included because steelhead catches in these years were not consistently recorded.

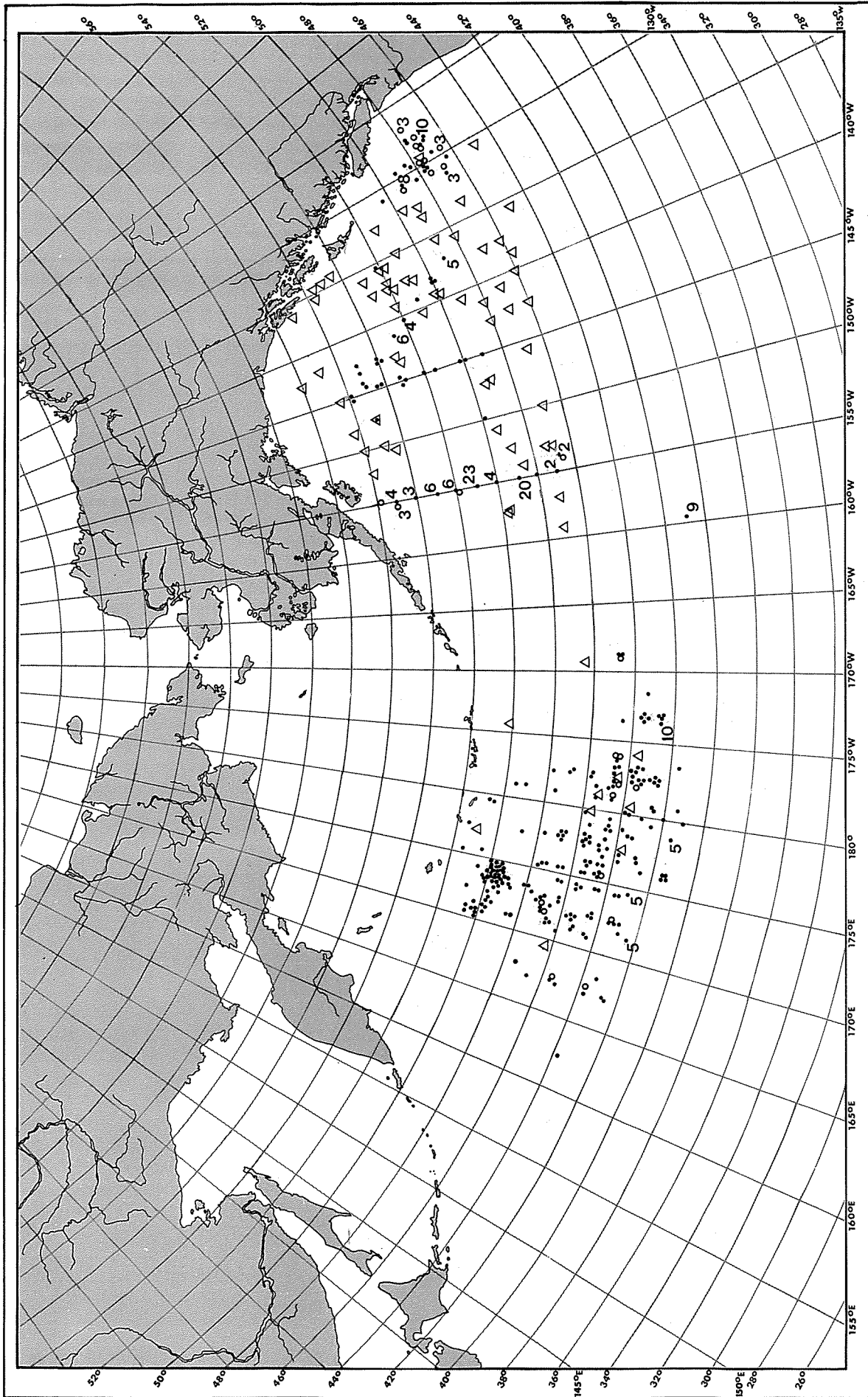


Figure 4. High seas distribution of North American steelhead trout as evidenced by recoveries of fish that carried a disk tag or spaghetti tag (Δ , $n = 73$), or that were missing their adipose fin (\bullet , $n = 384$), or one or more other (non-adipose) fins (\circ , $n = 32$). Numbers indicate the total catch of fin-clipped fish at a single location. Four fin-clipped fish were also missing maxillary bones.

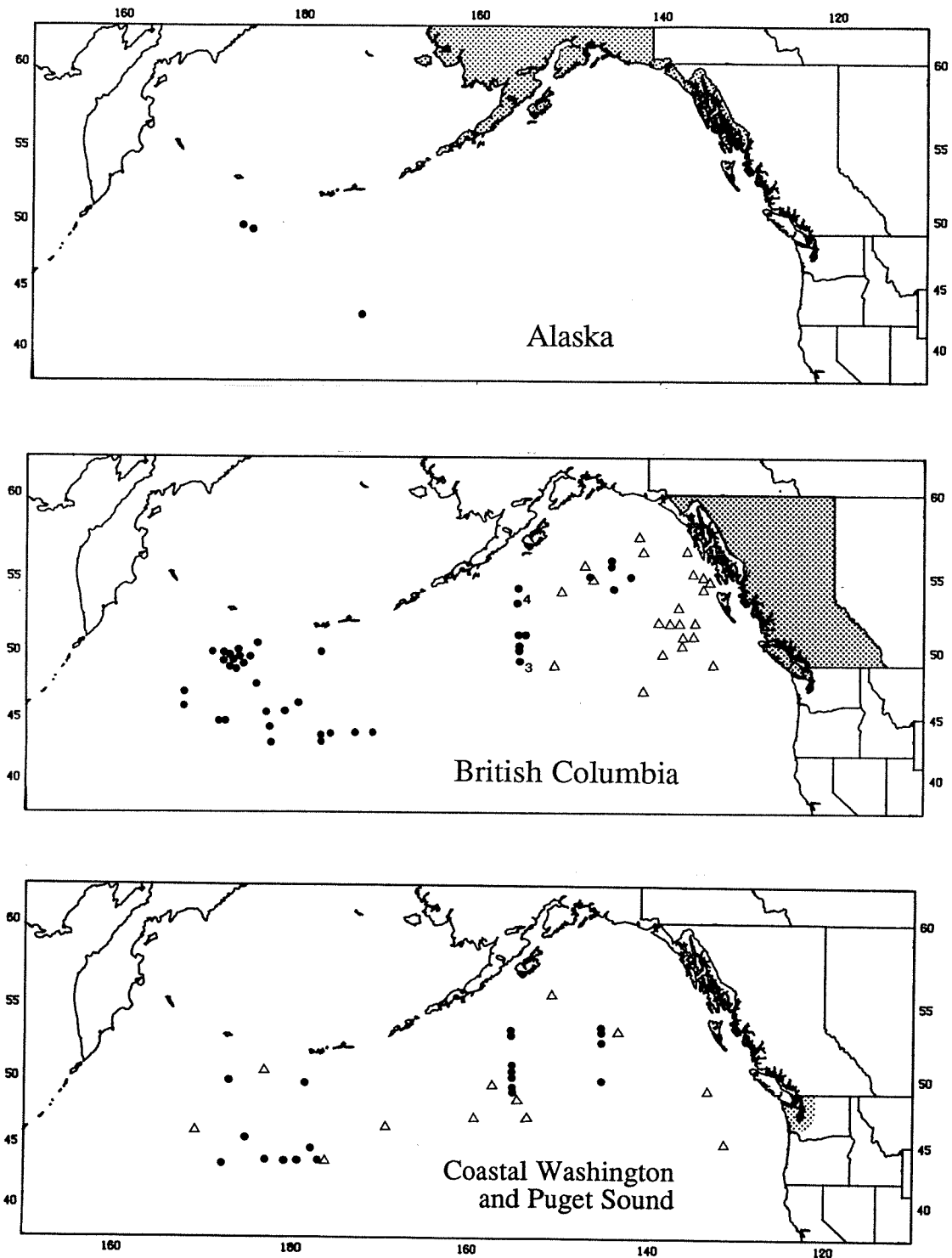


Figure 5. High seas distribution of steelhead trout from Alaska, British Columbia, and coastal Washington and Puget Sound, as evidenced by recoveries of disk tags (Δ) and coded-wire tags (\bullet) during INPFC-related research, 1956-1987. Numbers indicate the total catch of coded-wire tagged fish at a single location.

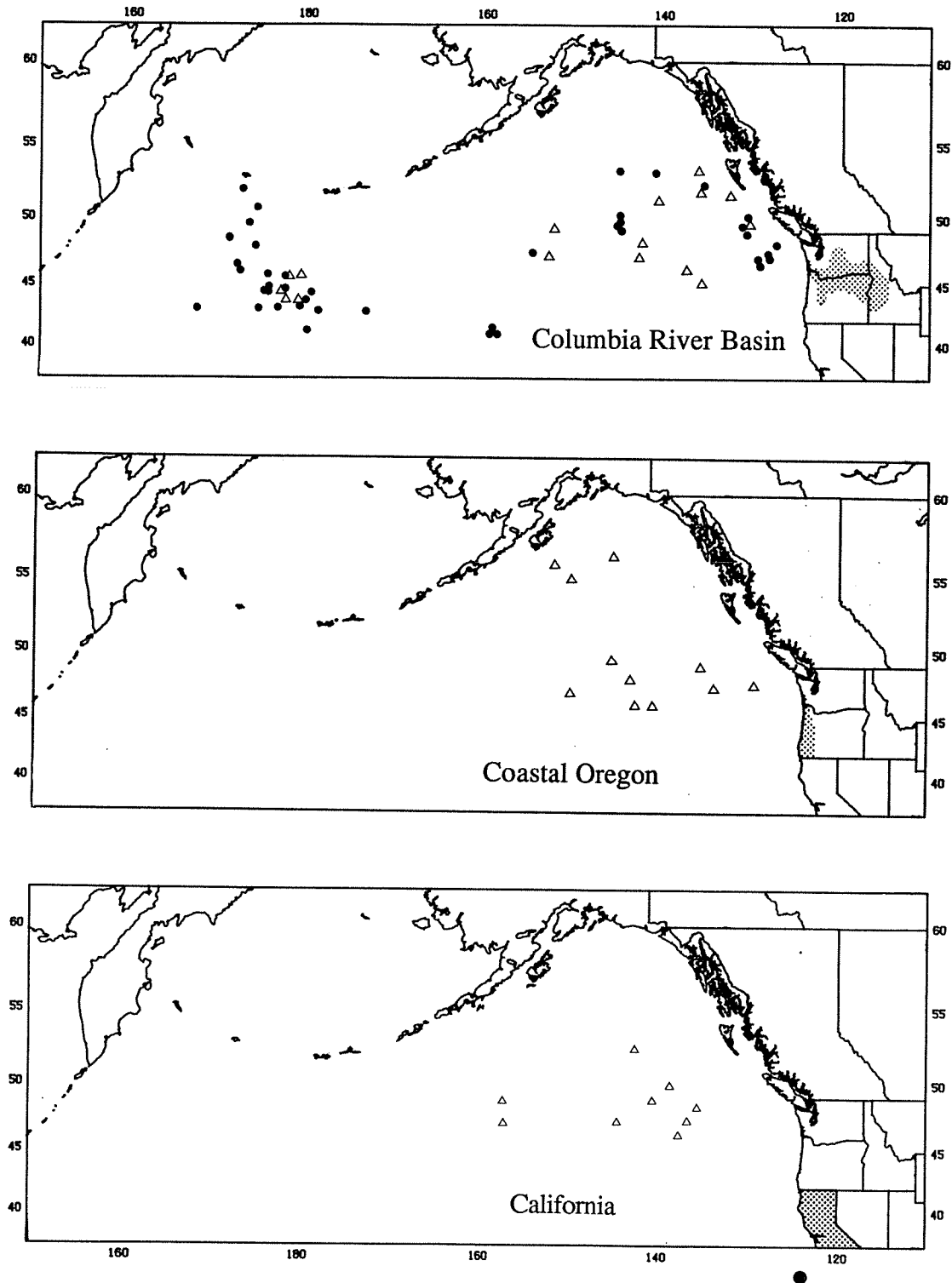


Figure 6. High seas distribution of steelhead trout from the Columbia River Basin, coastal Oregon, and California, as evidenced by recoveries of disk tags (Δ) and coded-wire tags (\bullet) during INPFC-related research, 1956-1987.

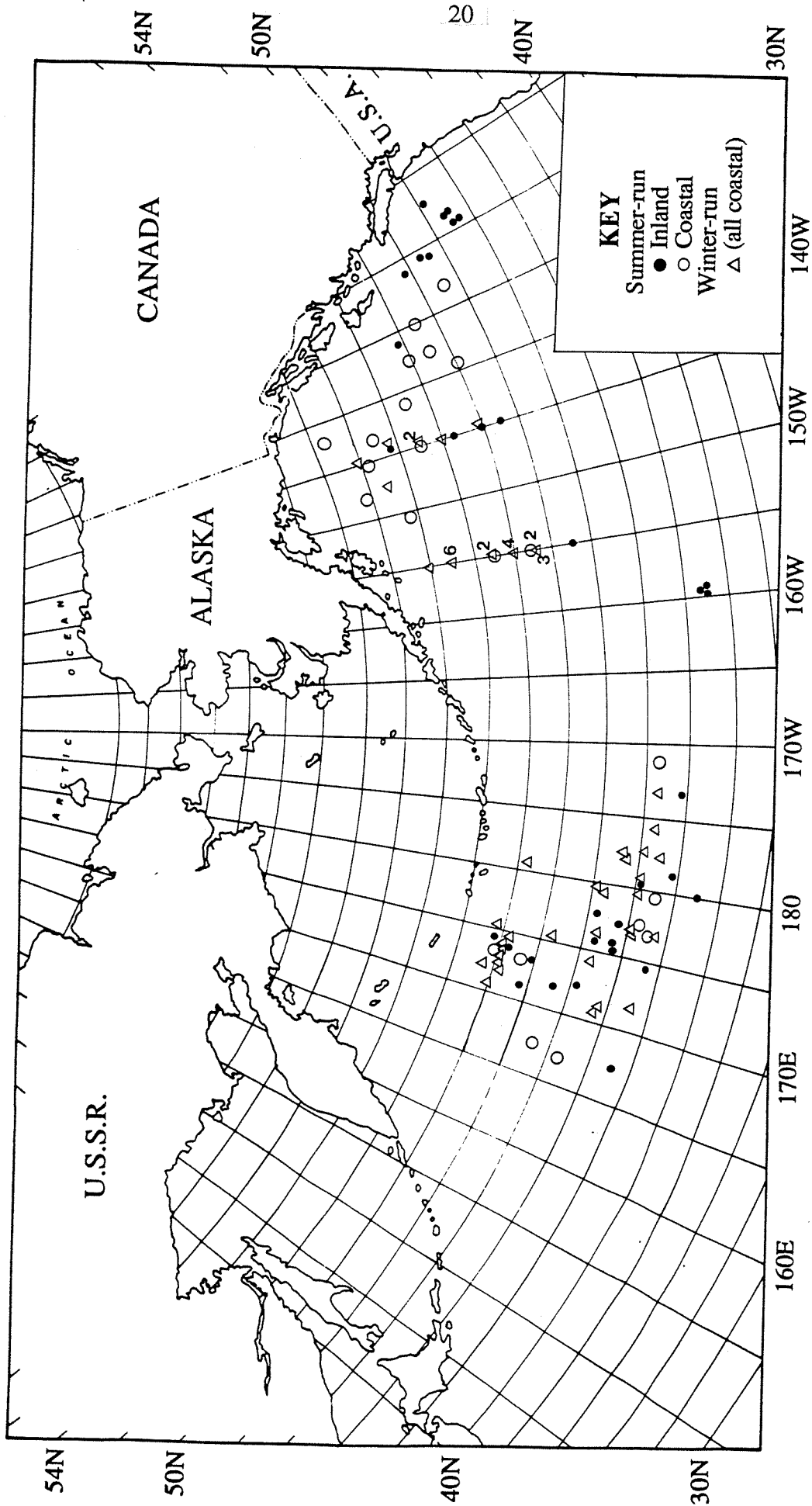


Figure 7. High seas distribution of seasonal races and regional groups of North American steelhead trout, as evidenced by recoveries of tagged fish.

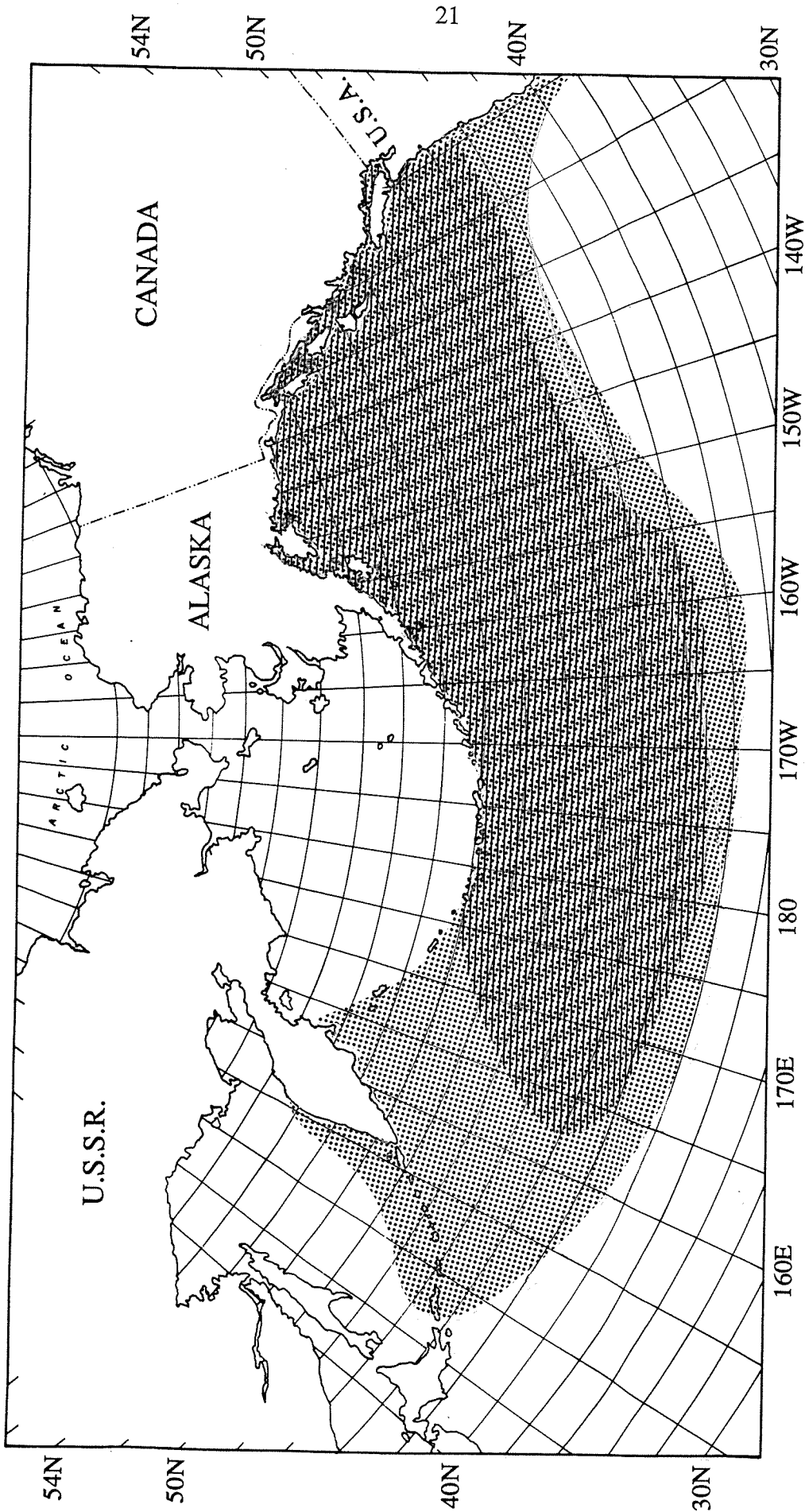


Figure 8. Known distribution of North American steelhead as evidenced by recoveries of marked or tagged fish within the larger distribution of steelhead determined from catch data.