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EARLY OCEANIC MIGRATIONS AND GROWTH OF JUVENILE PACIFIC SALMON AND STEELHEAD TROUT

by Allan C. Hartt and Michael B. Dell

VANCOUVER, CANADA, 1986

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BULLETIN No. 46 (E & *J*)—1986: Early oceanic migrations and growth of juvenile Pacific salmon and steelhead trout (A. C. Hartt and M. B. Dell).

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December 1985

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EARLY OCEANIC MIGRATIONS AND GROWTH OF JUVENILE PACIFIC SALMON AND STEELHEAD TROUT

by
Allan C. Hartt[1] and Michael B. Dell[2]

ABSTRACT

Juvenile Pacific salmon were sampled and tagged at sea primarily in the summers of 1964–1968 as part of a comprehensive study of the ocean life history of salmon for the purposes of the International North Pacific Fisheries Commission (Canada, Japan, U.S.). Sampling was by means of large, fine-meshed purse seines. Tags were mainly Floy FT67 internal anchor plastic tube tags. Sampling was conducted primarily from June through September and included both inshore and offshore waters of the Gulf of Alaska from Cape Flattery to the eastern Aleutian Islands, and in the eastern Bering Sea mainly east of 165°W. The results provide a working model of the summer distribution, seasonal abundance, migrations, and growth of juvenile salmonids in the study area.

Distribution and Migrations

Distribution and migration were determined by: (1) catch per unit of effort (CPUE) of juvenile salmon in the purse seine sets over time and space; (2) CPUE according to direction of set of seine; (3) relative size of juvenile salmon according to date and location of sampling; and (4) tag returns.

The main features of summer distribution and migrations of juvenile (age .0) salmon were:

(1) All five species of salmon and steelhead trout had begun to enter the open sea by late June, but coho and chinook salmon and steelhead trout apparently entered earlier than the sockeye, chum, and pink salmon. The migration apparently began earlier in the southern part of the sampling area than in the northern part.

(2) In the Gulf of Alaska, sockeye, chum, and pink salmon occurred primarily along the coastal belt from Cape Flattery to the eastern Aleutian Islands at least through September. Coho and chinook salmon also occurred mainly on the coastal belt but some coho and chinook salmon were well offshore by July. Steelhead trout were rare in the coastal belt. They apparently behave differently than salmon and proceed directly offshore at whatever point they may enter the ocean proper.

(3) In the eastern Bering Sea, juvenile sockeye salmon occurred in substantial numbers during July, August, and September. Chum, pink, and coho salmon were present but scarce and occurred mainly in August and September. Chinook salmon were present in small numbers over wide areas of the eastern Bering Sea from June through September. Juvenile steelhead trout were not caught in the eastern Bering Sea.

(4) Juvenile sockeye, chum, and pink salmon upon entering the ocean, apparently did not scatter randomly, but followed a definite migratory route. Those entering the ocean from Washington State, British Columbia, and southeastern Alaska migrated northward relatively near the shore. The great majority remained within a coastal belt less than 20 miles wide. In the northern Gulf of Alaska where the continental shelf is wider, they extended farther offshore. South of the Alaska Peninsula between Kodiak and Unimak Islands, the migration was southwestward parallel to shore. Here the offshore distribution was relatively broad, but the full extent was not measured. In late September when sampling was terminated, juvenile salmon were still present.

(5) In the eastern Bering Sea, sockeye, chum, and pink salmon were abundant between 160° and 165°W and extended 30 to 50 miles north of the Alaska Peninsula at least through September. Here they migrated to and fro, perhaps under the strong tidal influence, rather than migrating positively in a single direction close to shore as in the Gulf of Alaska.

(6) The distribution of age .1 and older immature sockeye and chum salmon overlapped but little with the distribution of the age .0 group. Age .1 sockeye salmon were virtually absent from

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Source: Contribution No. 659, School of Fisheries, University of Washington, Seattle, Washington.

the eastern Bering Sea, in areas where the age .0 fish were densely distributed. Likewise very few age .1 sockeye and chum salmon were caught along the coastal belt of the Gulf of Alaska where age .0 fish were numerous. Similarly, age .0 sockeye and chum salmon were rare south of the central Aleutian Islands where age .1 fish were abundant.

(7) The migrations of juvenile salmon between late September and the following spring are poorly understood. However, the distribution patterns of the juvenile group in September and the age .1 group in April, clearly indicate that the fish had moved far to sea and had distributed over a considerable range from east to west and north to south. The locations and times that the fish departed from inshore waters are unknown.

(8) Tag returns were sufficient to identify major stocks in the areas where juvenile salmon were abundant. In the coastal belt off southeastern Alaska and Yakutat, the age .0 sockeye, chum, and pink salmon were a mixture from points extending southward to Puget Sound. The age .0 coho and chinook salmon also came from the south and originated in locations as far away as Oregon and California. On the basis of a few tag returns, it is indicated that migrations of some of these stocks extend westward at least to Kodiak Island by late summer.

Tag Return Rates

Overall tag returns were:

Species	Number Tagged	Number Recovered	Percent Recovered	Annual Range
Sockeye	10,411	41	0.4	0–0.4
Chum	4,412	6	0.1	0–0.2
Pink	13,060	56	0.4	0–0.7
Coho	7,015	244	3.5	1.3–5.8
Chinook	276	12	4.3	0–9.4
Steelhead	85	1	1.2	—

Density and Abundance

Catch per seine set during peak periods of catch averaged 300–400 salmonids and ranged up to 4,500 of mixed species. Zero catches were rare in nearshore waters to twenty miles offshore. Thus at this life stage, they may be visualized as rather evenly dispersed rather than schooled densely, with vacant areas between schools as in the case of herring, for example. Similar density levels occurred in both the eastern Bering Sea and off southeastern Alaska. In an area where the average catch per set was 350 fish, the density, based upon the estimated surface area sampled by the seine, was calculated to be 0.0015 salmon per m^2.

Rate of Travel

Rate of travel of juvenile sockeye, chum, and pink salmon along the coasts of British Columbia and southeastern Alaska was estimated to range from 3 to 15 nm/day based upon tagged and recovered fish and an estimated date of entry into salt water.

Length and Growth

Sockeye, chum, and pink salmon entered the open sea at a minimum length of about 10 cm; coho and chinook salmon and steelhead trout entered at a minimum length of about 15 cm. Sockeye, chum, and pink salmon were generally similar in size and showed similar seasonal increases in length.

The mean lengths of age .0 sockeye, chum, and pink salmon in July generally ranged from 12 to 15 cm, whereas age .0 coho and chinook salmon and steelhead trout ranged from about 20 to 25 cm. By September, mean length of sockeye, chum, and pink salmon ranged from 18 to 23 cm, and coho and chinook averaged about 30 cm long.

Estimated daily growth rates for Fraser River and Skeena River sockeye salmon during their first 54 to 123 days at sea ranged from .10 to .18 cm. Chum and pink salmon from these areas exhibited similar growth rates.

At time of tagging as juveniles, sockeye salmon that were recovered 2 years after release were significantly larger than those recovered after 3 years.

For all species, salmon that were later recovered at distant locations were generally larger at tagging than those recovered nearer the point of tagging. Thus, fish that had migrated extensively during their first summer were larger than those that had only recently entered the ocean.

FOOD

Food eaten by juvenile salmon in their first summer at sea varied considerably by season and by location, but overall, the two dominant items were larval fish and euphausids. Amphipods, copepods, and pteropods were prominent in some areas also.

INTRODUCTION

The life histories of Pacific salmon (*Oncorhynchus* spp.) and steelhead trout (*Salmo gairdneri*) in the open sea have been studied intensively during the past 27 years in cooperative research by Canada, Japan, and United States[3]. An underlying objective of the research has been to gain a fuller understanding of all aspects of the oceanic life history of the major stocks of Pacific salmonids, both Asian and North American, from the time of their embarkation as smolts to the time of their return as adults.

Over the years, the research was directed at a succession of subobjectives. Geographic areas of study were altered as data were accumulated and as new priorities became evident. Much of the early research on salmon was directed toward defining the distribution, migrations, and intermingling of the major Asian and North American stocks with respect to the provisional treaty line at 175°W longitude (Fukuhara et al. 1962). Most emphasis in the early years was placed on mature salmon and on immatures of age .1[4] and older, particularly on fish large enough to be caught in commercial gillnet gear. By the early 1960s the oceanic distribution, migrations, and intermingling of the major Asian and North American stocks during spring, summer, and fall were reasonably well known for maturing fish and for immature fish of age .1 and older. Partial information on the winter period was also available (French and Mason 1964; French et al. 1969; French and McAlister 1970; Fisheries Research Board of Canada 1969). Knowledge of the distribution and migrations of post-smolt salmon (age .0) during their first summer and fall at sea was lacking except for fragmentary information derived from incidental catches made while fishing for the older groups (Hartt 1966). For purposes of this report age .0 salmon will be called "juveniles." The lack of information on juvenile fish was due primarily to a scarcity of sampling in the times and places in which juvenile salmon were prevalent, and secondarily to the fact that most of the gear used in the early years was not designed for capturing juveniles.

The present report describes research carried out by the Fisheries Research Institute (FRI) during the years 1964–1968 which was designed specifically to provide information on juvenile salmonids (*Oncorhynchus* spp. and *Salmo gairdneri*)[5]. Our main objectives were to determine the distribution and migrations of juvenile salmonids during their first summer in the open sea, and to tag enough fish to identify the major stocks in areas of concentration. Secondary objectives were to study their feeding and growth, and their relationship with other species of fish. Extensive sampling and tagging were conducted in both the eastern North Pacific Ocean and the eastern Bering Sea. Information from research in years prior to 1964 will be included where pertinent, and reference will be made to information obtained in 1976 on the abundance of juvenile chum salmon in inside waters of Puget Sound. The research has yielded much new information on the ocean life history of salmonids during their critical first few months in the open sea and has revised our concept of the extent of the first summer's migration and its relation to the total oceanic migration.

Some of the information from this research was summarized in the latest series of joint comprehensive

[3] The purpose of the research has been to gain information necessary for implementing the INTERNATIONAL CONVENTION FOR THE HIGH SEAS FISHERIES OF THE NORTH PACIFIC OCEAN which was ratified by the three countries in 1953. The text of the original convention, which was in force from 1953 through 1977, is available in the 1959 Annual Report of the International North Pacific Fisheries Commission.

[4] The age designation of Koo (1962) will be used, in which the number of annuli on the scales is indicated with winters spent in fresh water on the left of the decimal point, and winters spent in the ocean on the right. In most instances references will be to ocean age only, e.g., .0, .1.

[5] The Fisheries Research Institute, School of Fisheries, University of Washington, has been participating in the high seas salmon research (primarily tagging) since 1955 under annual contract from the U.S. National Marine Fisheries Service, NOAA, as part of the research being done for the purposes of the United States Section of the International North Pacific Fisheries Commission.

reports on salmon at sea published by the International North Pacific Fisheries Commission: coho (Godfrey et al. 1975), sockeye (French et al. 1976), chum (Neave et al 1976), chinook (Major et al 1978), and pink (Takagi et al. 1981). The present report includes additional data and compares results for these five species of salmon as well as steelhead trout. The comparisons help to provide perspective and enhance the significance of results for individual species.

Developments in recent years have increased the need for information on the early oceanic life history of salmon. Extensive new foreign and domestic fisheries for non-salmonid fishes have developed in areas of the eastern Bering Sea and the eastern North Pacific Ocean where juvenile salmon are concentrated. These fisheries take massive quantities of pelagic and demersal species of finfish and shellfish which must directly or indirectly influence the trophic dynamics within this key portion of the salmonid habitat. Whether the effect is beneficial or harmful to salmon is unknown. The recent promulgation by the United States and Canada of a 200-mile jurisdictional limit provides better control of these foreign fisheries, but substantial incidental catches of salmon by either foreign or domestic trawl vessels in these waters will undoubtedly continue. Salmon might also be affected by the oil exploration and development operations recently begun along the outer continental shelf of the eastern Bering Sea and the northern Gulf of Alaska. In both of these areas, juvenile salmon are the dominant epipelagic species of fish. Also, recent improvements in artificial propagation of salmon by government agencies and by private enterprise have substantially increased the numbers of smolts entering the ocean along the coast from California to Alaska, and future massive increases are planned. There has been concern that the increased releases may overtax the oceanic food supply. Clearly, a knowledge of migratory habits of juvenile salmon will be needed to test the hypothesis that ocean food resources may be a limiting factor.

METHODS

Methods will be described only briefly. Details of fishing, fish handling and tagging are available in previous reports (Dell 1968, 1974; Hartt 1962a, 1975).

Fishing Gear

Purse seine gear was chosen for sampling juvenile salmon because seines have a high catch per unit of effort (CPUE), are relatively nonselective, and most of the fish caught are in good condition for tagging. In addition, a purse seine can be fished in a manner which provides information on directional movement of fish at the point of capture by controlling the direction of the opening of the seine while it is being held in fishing position (Hartt 1962b).

The purse seines were about 704 m long by 46 m deep. The mesh sizes in the seines used in 1964 and later were 63 mm (stretched measure knot to knot) in the lower half of the net and 51 mm in the upper half. The bunt section (final fish-retaining section) of the seines was 37 m long and was composed of 25 mm mesh. Web material was of knotless construction to minimize injury by web. Such seines were capable of retaining all sizes of juvenile salmon encountered at sea except in unusual cases when tide or mechanical factors caused the net to collapse in sections of the net where the mesh size was 51 mm. The bunt section could retain fish as small as 5 or 6 cm in fork length even if the net collapsed during retrieval of this terminal portion of the net.

Although larger mesh sizes were used in years prior to 1964, the seines were still capable of catching juvenile salmon as long as the net did not collapse due to wind or tide conditions. Juvenile salmon frequently occurred in the catches in the early years in the times and places that juvenile salmon were later found to be prevalent in sampling with fine-meshed seines. Thus, in the early years the seines were capable of detecting the presence of juvenile salmon, but some loss, particularly of small fish, undoubtedly occurred in some of the sets.

The seine was set in a semicircle from a purse seine vessel about 24 m long, held in opened fishing position for 30 minutes, while the vessel towed one end and a powered seine skiff towed the other, and then closed and pursed, and the web retrieved by means of a hydraulic power block.

Data Collected

For each set of the seine a Fishing Effort Form was filled out to record the physical and oceanographic data together with the catch of all species of fish or other organisms. Salmonids were recorded according to species and estimated ocean age. If salmon were tagged, a Tag Data Form was used to record tag type, tag number, species, fork length, scale sample number, and condition of fish at release. Appropriate columns were available on the same form for later entering of recovery data. From most catches, a small sample of fish was saved for examination. Biological data recorded were: species, fork length, stomach contents, sex, maturity, and scale sample number. Some fish were examined fresh aboard the vessel and others preserved in formalin and examined in the laboratory.

Tagging and Recovery Procedures

Since procedures used in tagging age .1 and older salmon caught in purse seines at sea have been described (Hartt 1962b, 1963), the present description will be confined to a summary of procedures pertinent to tagging juvenile salmon.

Types of Tags

The choice of tags to be used on juvenile salmon was limited by certain constraints not applicable to the tagging of older age groups, for which we had found 3/4-inch (19 mm) Petersen disks to be very satisfactory. The tag had to be small enough to be carried by salmon 12–20 cm long and yet still be visible externally 1 to 4 years later when the salmon would have matured and grown to a length of 40–80 cm. The expected geographic range of recoveries was too great to use an internal tag which would require detection devices for recovery. Several types of tags were tested, both in the laboratory and in the field (Dell 1968; Dell, unpublished manuscript)[6]. The two tags found most satisfactory for fish under 20 cm long were the Carlin tag (Carlin 1955) and the Dennison tag (Thorson 1967; Dell 1968). Of the two types of tags, the Dennison tag was considered superior for our needs because, even though their rate of return was slightly less than that of the Carlin tag, they could be applied three to four times faster, so that they yielded more data as measured in number of tag returns per man-hour of tagging. The tag of this type used mainly was the Floy FT 67 internal anchor plastic tube tag. Although rapidity of tagging is not critical under laboratory conditions, it was important in high seas operations because of the time constraints imposed by two of our main objectives, i.e., to study distribution and abundance by means of seining, and to study migrations and origins by means of tagging. Since seining and tagging could not be done simultaneously, we attempted to minimize time spent in tagging in order to maximize the number of purse seine sets that could be made in a day. In addition, rapid tagging enhanced rate of return because the condition of the fish in the holding tank deteriorates with time, particularly when seas are rough (Hartt 1963).

[6] Dell, Michael B. Unpublished manuscript. A comparison of five types of tags used for tagging juvenile Pacific salmon at sea. Fish. Res. Inst., Univ. Washington. 49 pp.

Fish Handling

Fish were dipped from the bunt of the seine into a live tank on deck which held 3,788 liters of sea water supplied at a rate about 568 liters per minute. Tagging was completed as rapidly as possible using one to three teams depending upon the size of the catch. A maximum of about 1,000 juvenile salmon could be held in the tank. Salmon at the juvenile stage are fragile and easily injured so that care in handling was essential. Anesthetic (MS-222 or Quinaldine) was used to minimize injury. Each fish tagged was identified to species and measured to the nearest mm. A scale sample was taken from the first 100 tagged. Condition, based on extent of scale loss, was recorded. Rate of tagging varied from about 100 to 300 per hour per man, depending upon type of tag, weather conditions and experience of personnel. The vessel cruised slowly during tagging so that the released fish were dispersed, presumably making them less vulnerable to predators, especially birds.

Tag Recovery

Considerable effort was expended each year in advertising for tag returns. Letters, informational brochures, posters, and postage-free tag return envelopes were sent annually to coastal Alaskan post offices, and to salmon canneries, fishermen's unions, and government fishery agencies from Oregon to Alaska. Letters, leaflets, and envelopes were mailed to commercial fishermen who had returned tags in past years. Visits were made to canneries and fishermen's unions from Washington State to Alaska. From 1965 to 1972 our brochures and posters stressed the juvenile salmon tagging program and the special types of tags being used.

Throughout our high seas tagging operations, we have had excellent reciprocal cooperation in tag recovery effort from Canada and Japan through the International North Pacific Fisheries Commission (INPFC) and from the USSR through correspondence with central and regional fishery agencies. Despite similar recovery efforts for all types of tags, the small tags used on juvenile salmon were certainly less likely to be returned than the 19 mm disks used on larger fish because of the difference in tag visibility.

Fishing Effort

Figure 1 is a base map for discussion of fishing effort and the subsequent catch and tagging data. Geographical locations and the INPFC statistical area codes are shown, together with a scale of nautical miles.

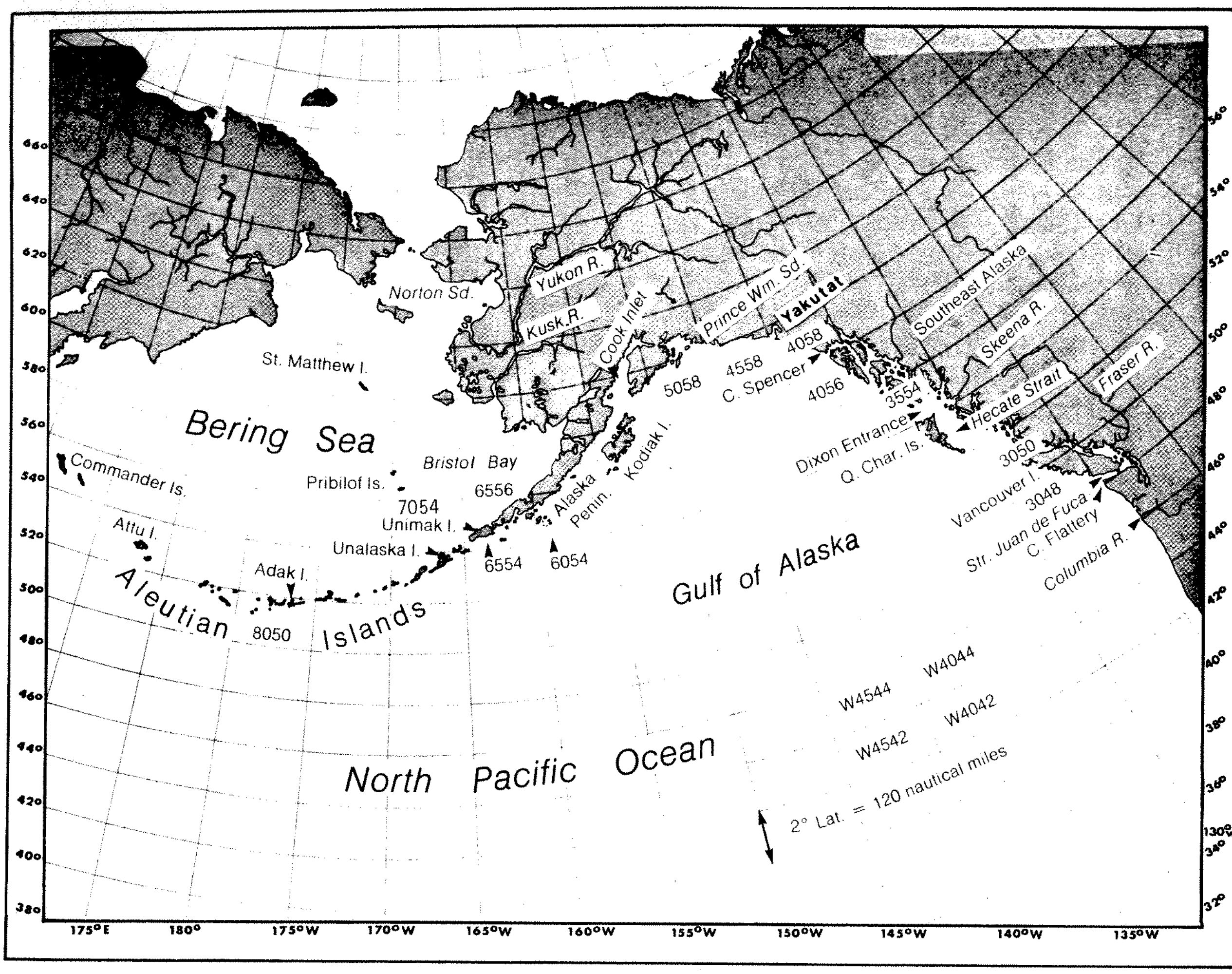


FIG. 1. Base map. The INPFC code for 2° latitude × 5° longitude statistical rectangles is used, with the " W " (indicating west longitude) frequently omitted because of space limitations. Areas 7054, 6554, 6556, and 6054 were modified as shown to avoid including Bering Sea and Pacific waters in one area.

The time and space distribution of purse seine fishing effort is illustrated in Fig. 2, by month and by 2° latitude × 5° longitude geographical rectangle. The rectangles in which specific efforts were made to catch juvenile fish in years 1964–1968 are shaded. In the 15-year period, 1956–1970, 3,073 purse seine sets were made—12 in April, 310 in May, 772 in June, 1,052 in July, 676 in August, 232 in September, and 19 in October.

The distribution of seining varied annually according to the research priorities among the several goals of the high seas research as described in Annual Reports of the INPFC. During 1964–1968 the vessel time for sampling juveniles had to be integrated with early-season offshore longline sampling in a joint operation with Canada, and with mid-season purse seine sampling in the vicinity of Adak where a data base was being developed for forecasting Bristol Bay sockeye runs. Allowing for these constraints, cruises were planned to maximize sampling and tagging of juvenile salmon in two areas: (1) the coastal belt from Cape Flattery to Yakutat and (2) the eastern Bering Sea. Coverage in the northern Gulf of Alaska was accomplished primarily while en route to or from the Aleutian area.

The broadest geographical coverage was in April-June (Fig. 2a) when our primary effort was to capture the older age groups. However, juvenile salmon, if relatively abundant, should have been caught, as discussed earlier. Sampling designed specifically to capture juvenile salmonids began in late June and continued into early October. The amount of offshore fishing was less during this period because even within the inshore rectangles most juvenile salmonids

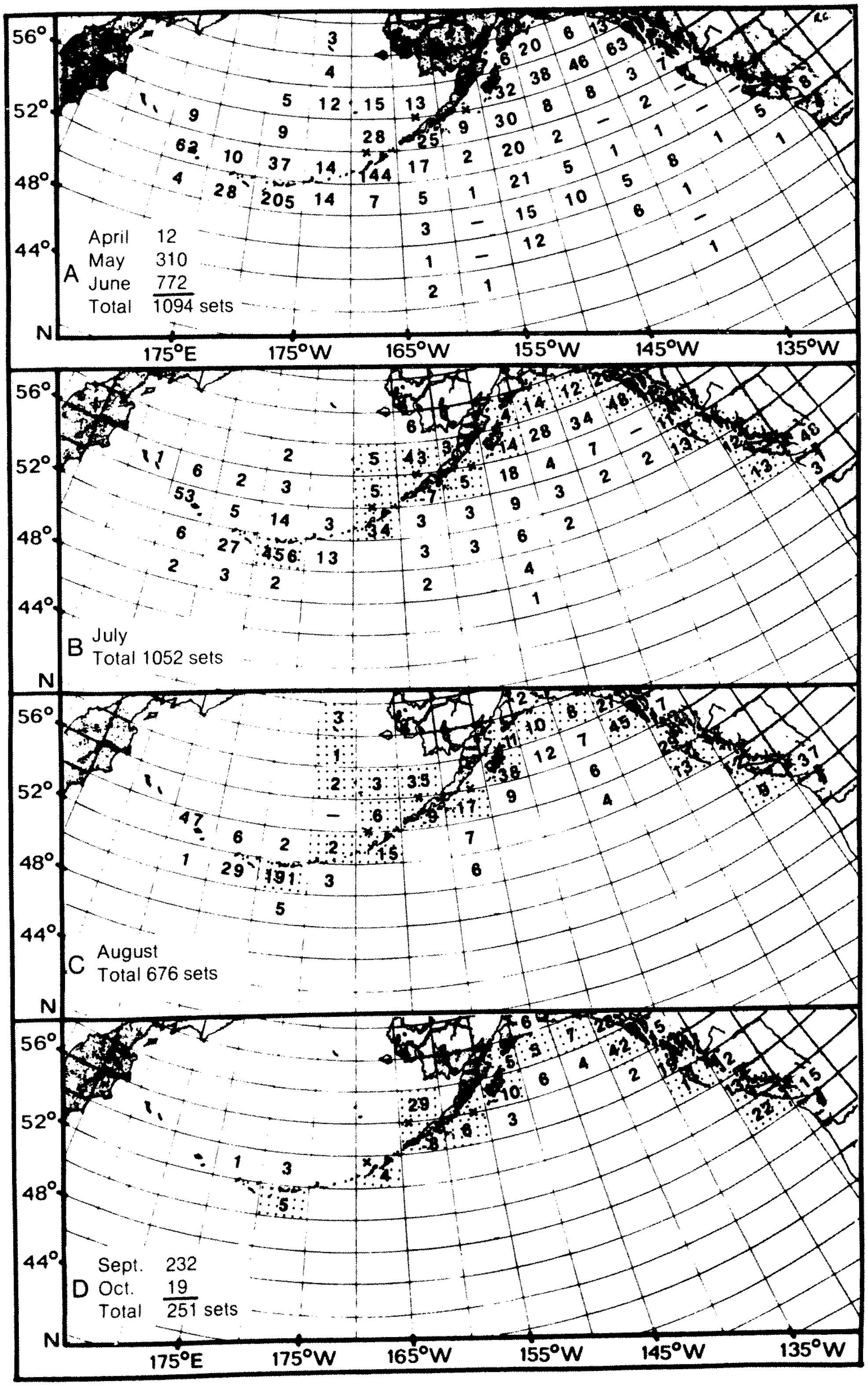


FIG. 2. Numbers of purse seine sets by area, 1956–1970. Shaded areas are those in which juvenile salmon were target species. Total 3,073 sets. The x's indicate modified statistical areas—see Fig. 1.

were found to be concentrated close to shore, at least through August, as will be discussed. Offshore sampling in September and October was probably inadequate (Fig. 2d) to measure offshore migration in those months if it occurred.

GENERAL DISTRIBUTION OF JUVENILE SALMONIDS

The catch-per-set data from the purse seine fishing efforts summarized in Fig. 2 will be used to illustrate the general time-space oceanic distribution of juvenile (age .0) salmonids during the summer and early fall. The data will be analyzed according to species, time, and area. Comparison between species will also be made since there were significant similarities and differences in the distribution of the several species. Following this, the distribution of the more abundant sockeye, chum and pink salmon will be analyzed in more detail by means of larger-scaled charts and more precise fishing locations.

Because of certain variables in the construction and operation of our purse seines, the catches of juvenile salmonids are not strictly comparable between all years, areas and time periods. Nevertheless, the catch data are deemed suitable to show general distribution. One of the chief variables was the direction in which the seine was held open during fishing. All seine sets were used in the analysis despite the fact that in some areas the catch is greatly dependent upon the direction of opening of the seine. However, even in areas where directional movement was pronounced, substantial catches occasionally occurred when the direction of the opening of the seine was opposite to that which was normally the productive direction. Such anomalies were presumably caused by temporary reversals of migration due to strong tides. This subject will be discussed in more detail in the section on migrations.

Another important variable was the possible loss of fish through the larger mesh sizes in the purse seines used prior to 1964, as discussed in the section on fishing gear. Inefficiency of this type probably occurred mainly in the inshore areas since it was associated with collapsing of the net when wind and tide were adverse. In offshore areas, our primary gear was longlines, and for safety reasons, the purse seine was fished only when wind and seas were favorable and the shape of the net could be controlled. Whatever the inefficiency of the nets in the early years, it is not thought serious enough to warrant excluding the data from the analysis. Substantial catches of juvenile salmonids occasionally occurred in the early years and tag returns from some of these experiments added important information on migration. Furthermore, the offshore fishing yielded information on the summer distribution of the age .1 and older fish which contrasted greatly with the distribution of the juvenile fish (age .0), and provided a means of inferring the probable migrations of the juvenile fish during the fall, winter and spring following our summer sampling.

Tables of catches in individual seine sets are not included because of space considerations, but catch and effort data are summarized in Appendix Table A1 by area and 10-day period for the years 1964–1968, respectively. In later sections, catches in some individual seine sets will be shown to illustrate directional migrations and detailed distribution with respect to distance offshore.

General Distribution of Juvenile Sockeye Salmon

The time-space distribution of juvenile sockeye salmon (age .0) based upon the combined fishing effort in the years 1956–1970 is illustrated in Fig. 3. The catch-per-set is shown symbolically by statistical area and by time period.

During April, May, and June (Fig. 3a), despite widespread fishing, juvenile sockeye salmon were caught only in small numbers and only in three areas: 1) the Strait of Juan de Fuca (area W2548) where the average catch was 2.5/set; 2) off southwest Vancouver Island (area W3048) where the average catch was 7.4/set; and 3) off the coast of southeast Alaska (area W4056) where the average catch was 0.3/set. The catches off Vancouver Island occurred on June 15 and 24 and off southeastern Alaska on June 29. Throughout the remainder of the Gulf of Alaska and along the Aleutian Islands and in the eastern Bering Sea no juvenile sockeye salmon were caught despite substantial fishing. The data in Fig. 3a suggest that juvenile sockeye salmon were just beginning to enter the open ocean in late June.

During July (Fig. 3b), juvenile sockeye salmon occurred in most areas fished along the east and northeast coasts of the Gulf of Alaska and in the eastern Bering Sea. They were scarce or absent in sampled areas of the northwestern Gulf of Alaska and south of the Alaska Peninsula and eastern Aleutian Islands. The highest CPUE was in area W6556 in the eastern Bering Sea where abundant stocks from Bristol Bay are found. The symbol in area E7052 near Attu Island indicates a single sockeye salmon caught on July 3, 1959. This fish probably originated in a nearby stream on Attu Island where a small run of sockeye salmon exists. The symbol in offshore area

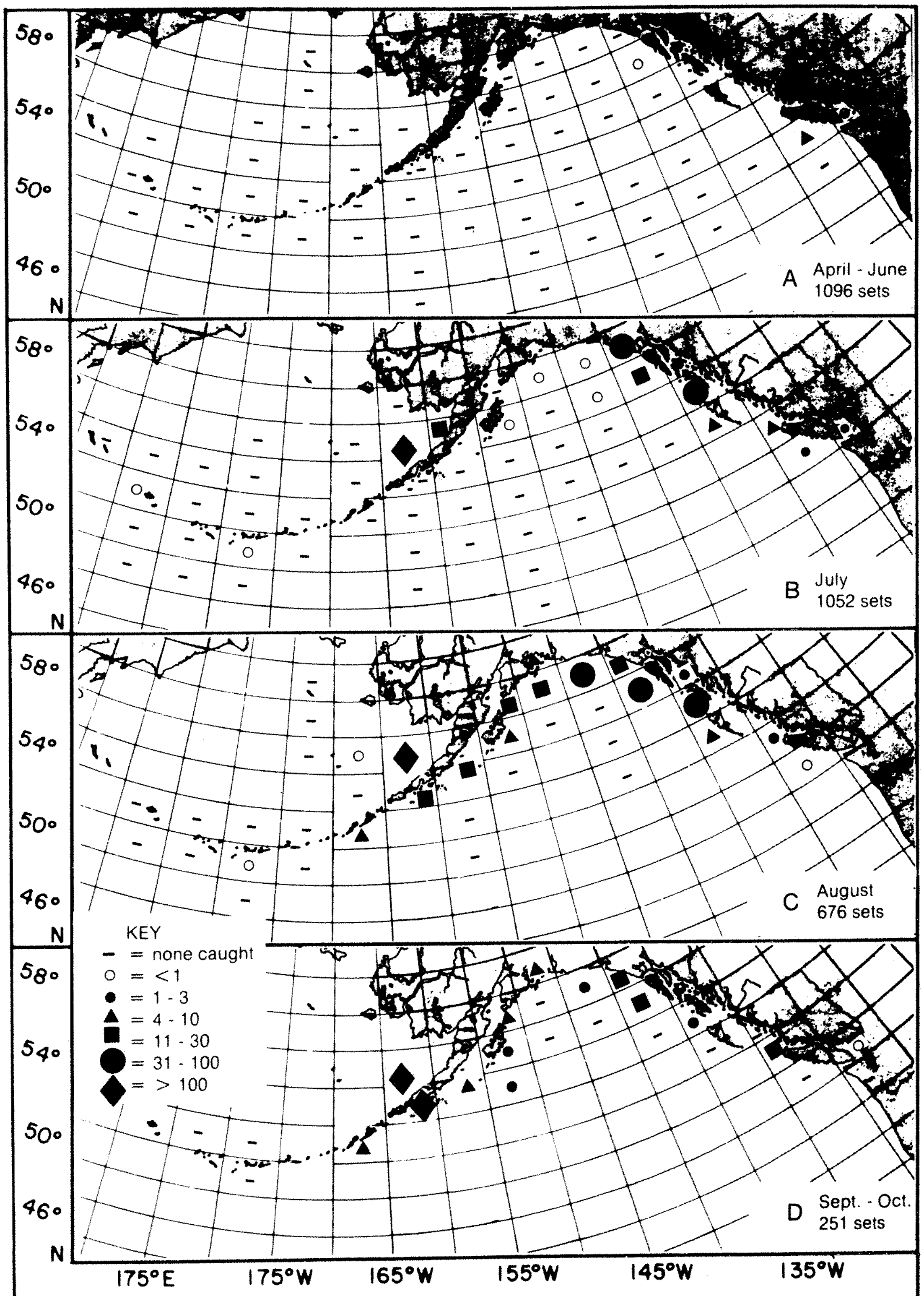


FIG. 3. Mean catch per seine set of juvenile sockeye salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets shown in Fig. 2.

W4556 in the northeastern Gulf of Alaska indicates two juvenile sockeye salmon caught in 34 sets (0.1/set) in this rectangle in July. The catch occurred on July 16 in the extreme northeast corner of the area, but was still the farthest from shore that any juvenile sockeye were taken in any of the time periods. Otherwise, juvenile sockeye salmon were not caught in the offshore areas fished. Thus, by the month of July, juvenile sockeye salmon were present in substantial numbers in coastal waters adjacent to most major production areas, showing that their oceanic embarkation was well underway.

During August (Fig. 3c), the pattern of distribution was similar to that of July except that the CPUE had increased in the northern Gulf of Alaska and south of the Alaska Peninsula and eastern Aleutian Islands, and had decreased in the Strait of Juan de Fuca and off Vancouver Island. Small catches were made in area 8050 south of the central Aleutian Islands. These were probably fish originating from nearby Aleutian Island streams. Thus, by August, juvenile sockeye salmon were distributed in a more or less continuous belt along the coast adjacent to all production areas from Cape Flattery to the eastern Aleutian Islands and in the eastern Bering Sea. Although fishing in offshore areas was not as widespread as in earlier time periods, there was sufficient effort to indicate that juvenile sockeye salmon were not distributed offshore in abundance. The one specimen caught in area W7056 near the Pribilof Islands was about 10 cm longer than the average of those caught in area W6556 where abundance was high.

During September and October (Fig. 3d), juvenile sockeye distribution was similar to that observed in August, but the CPUE along the eastern and northern coasts of the Gulf of Alaska had declined and the catch in area W6554 south of the Alaska Peninsula and eastern Aleutian Islands had increased to over 100/set. Catches also continued high in area W6556 in the eastern Bering Sea. Fishing in October was confined to the eastern Gulf of Alaska between Cape Flattery and Yakutat, but is included with the September data because catches were similar in both months. Thus, in late summer and early fall, juvenile sockeye salmon were still present in substantial numbers along the coastal belt from Cape Flattery to the eastern Aleutian Islands and in the eastern Bering Sea, although abundance had greatly declined in the eastern and southern Gulf of Alaska. Fishing in the more offshore rectangles during this period consisted of only 15 sets, three in area W5554, six in area W5056, four in area W4556, and two in area W4054 (Fig. 2d). Only three sockeye salmon were caught in these operations, all in the northern portion of the area W5554 which is south of Kodiak Island (Fig. 3d). Firm conclusions with respect to offshore distribution cannot be drawn because of the limited sampling coverage and because of the possible inefficiency of the nets used in the early years, but the lack of substantial catches in any of the offshore fishing suggests that juvenile sockeye had not yet moved offshore in large volume.

Viewed as a whole, the data in Fig. 3 indicate that juvenile sockeye salmon first entered the open ocean in late June in the more southerly part of their range, and that between July and September they were distributed along the coastal belt from Cape Flattery to the eastern Aleutian Islands. Areas of abundance tended to shift with time, northward, westward, and southwestward. In the eastern Bering Sea, sockeye were present in substantial numbers from July through September between 160° and 165°W relatively close to the north side of the Alaska Peninsula. Sampling farther offshore, though limited, especially later in the season, yielded few juvenile sockeye salmon.

More detailed information on distribution and estimates of the abundance and of the migrations of the fish within the coastal belt will be discussed in later sections together with information on the probable times and places of offshore migration.

General Distribution of Juvenile Chum Salmon

The time-space distribution of juvenile chum salmon (Fig. 4) was similar to that of the sockeye, although chum salmon were generally less abundant than sockeye, as would be expected on the basis of the relative production of the two species throughout most of the study area.

During the April-June period, juvenile chum salmon were caught only in area W3048 off Vancouver Island (Fig. 4a). The catch occurred on June 24, 1968, and consisted of 68 fish in two sets. Thus, as with the sockeye salmon, juvenile chum salmon began to enter the open sea in late June in the southern part of their range.

During July (Fig. 4b), juvenile chum salmon were caught in all areas fished along the coastal belt between Cape Flattery and Yakutat. In addition, small numbers occurred in the eastern Bering Sea and in the central and western Aleutian Island areas. The latter likely were fish that had originated in local Aleutian Island streams.

During August (Fig. 4c), distribution was similar to that of July except that small numbers were also caught along the north coast of the Gulf of Alaska and south of the Alaska Peninsula. Catches in the

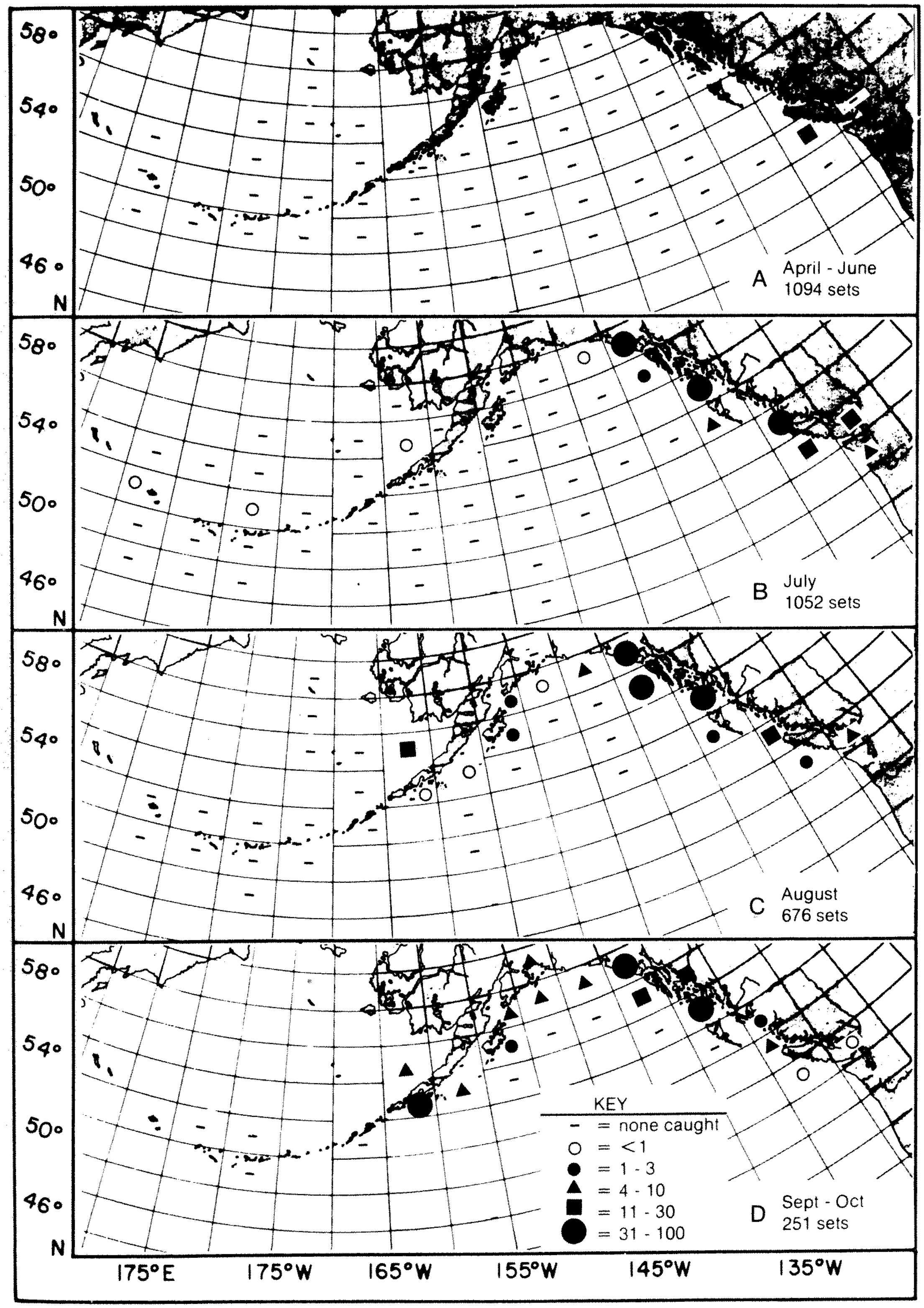


FIG. 4. Mean catch per seine set of juvenile chum salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets shown in Fig. 2.

eastern Bering Sea were larger in August than in July.

During September and October (Fig. 4d), distribution remained similar to that of August, but abundance in the southern areas (Strait of Juan de Fuca and off Vancouver Island) had declined, probably because the peak seaward migration had passed in this area. Catches in the northern Gulf of Alaska and south of the Alaska Peninsula were much larger than in August, which suggests that ocean entry was later in these areas.

Viewed as a whole, the data in Fig. 4 indicate that juvenile chum salmon, like sockeye salmon, enter the open sea from estuaries in late June in the more southern part of their range and between July and September are distributed along the coastal belt from Cape Flattery to the eastern Aleutian Islands. Both occurrence and abundance tended to shift seasonally toward the northwest in the eastern Gulf of Alaska and southwest along the Alaska Peninsula. In the eastern Bering Sea they were present in moderate numbers from July through September. No chum salmon were caught in the offshore sampling.

General Distribution of Juvenile Pink Salmon

The time-space distribution of juvenile pink salmon catches was basically similar to that of the sockeye and chum salmon (Fig. 5). However, for pink salmon, additional and important data were obtained from Canadian longline operations during the late fall of 1966 (Fig. 5d). The purse seine CPUE data were not corrected for the fact that pink salmon in some areas are extremely cyclic as between odd- and even-numbered years. The most pronounced cycles occur in the Fraser River-Puget Sound area (even-year abundance of juveniles) and the eastern Bering Sea (odd-year abundance of juveniles). Since most juvenile pink salmon were caught during the years 1964–1968 inclusive, the data in Fig. 5 are based mainly upon two odd-numbered years (1965, 1967) and three even-numbered years (1964, 1966, 1968).

Juvenile pink salmon appeared first in purse seine catches in late June (June 24; four pink salmon) in the southern part of their range. Between July and October they were caught in the coastal belt of the Gulf of Alaska where their abundance tended to increase seasonally in a northward, westward, and southwestward direction. They were very scarce in the eastern Bering Sea as would be expected from their limited production in this area.

Juvenile pink salmon were particularly abundant (greater than 100/set) during July, August, and September off the northern British Columbia and southeast Alaska coasts where production of this species is substantial. Although abundant inshore, they were not caught in any of the offshore areas fished by purse seine in the Gulf of Alaska. Thus, based upon the purse seine effort, pink salmon, like sockeye and chum salmon, appeared to remain along the coastal belt during their first summer and early fall.

The offshore catches made with Canadian longline gear in November and December (Fish Res. Bd. Can. 1969) provide data on the offshore distribution in late fall which supplement the purse seine data in time and space. As illustrated in Fig. 5d, Canadian research vessels fished with longline gear at 11 stations throughout a wide area of the southern Gulf of Alaska between November 21 and December 7, 1966. A total of 16 juvenile pink salmon were caught at six of the stations. Catch per station ranged from one to six. Catches on a uniform 1,000 hook basis ranged from one to four per set. Although these catches are not directly comparable with the purse seine catches for estimating density of fish, they do indicate that substantial numbers of juvenile pink salmon were distributed far offshore by late November.

The absence of juvenile sockeye and chum salmon at any of the stations in the offshore longline operations by Canadian personnel in 1966 suggests that pink salmon migrate offshore earlier than sockeye or chum salmon. All three species are known to be very vulnerable to longline gear at age .1 and older in spring, when they frequently occur mixed and in large numbers in catches of offshore longline operations. There remains the possibility, however, that all three species could have been present offshore in late fall, but that pink salmon, with their faster growth rate, were more vulnerable to longline gear than sockeye or chum salmon. Given the similarity of the lengths of the three species in September, however (see section on lengths), it would seem that size differential should not have been great enough to eliminate entirely sockeye and chum salmon from the catches. Thus, it appears that during summer most juvenile pink salmon are distributed in a manner similar to sockeye and chum salmon in coastal waters, but that by late fall, at least a portion of the pinks are distributed much farther offshore than the sockeye and chum salmon.

General Distribution of Juvenile Coho Salmon

The time-space distribution of juvenile coho salmon (Fig. 6) was marked by both similarities and contrasts to the distributions of sockeye, chum, and pink salmon (Figs. 3, 4, 5). The similarities were: 1) distribution

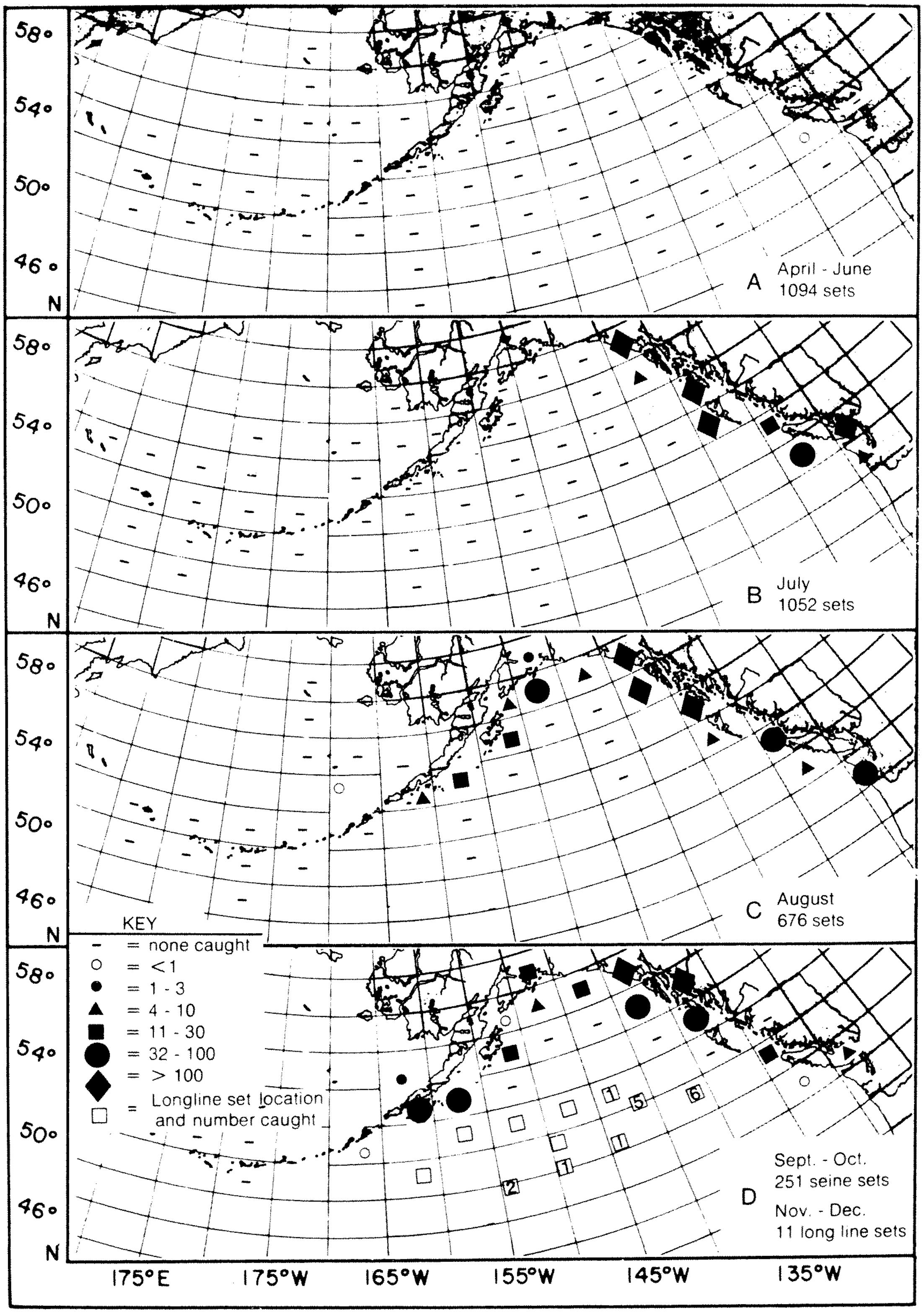


FIG. 5. Mean catch per seine set of juvenile pink salmon by area and by time period; 3,073 sets, 1956–1970. Also catches during Canadian longline operations at 11 stations, Nov. 21–Dec. 7, 1966 (Source: Fish. Res. Board Can. 1969).

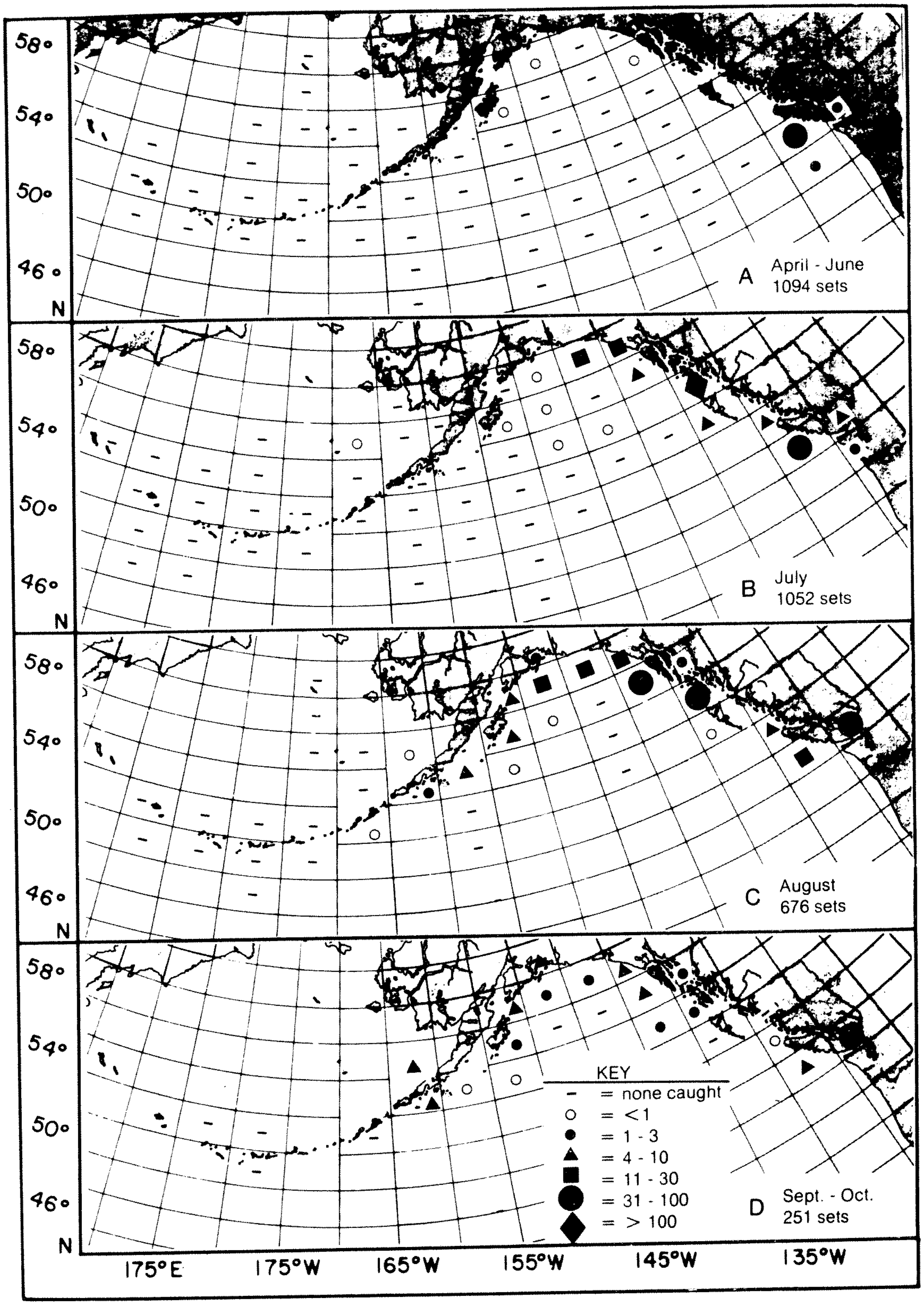


FIG. 6. Mean catch per seine set of juvenile coho salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets shown in Fig. 2.

was chiefly along the coastal belt of the Gulf of Alaska; and 2) there was a seasonal progression in abundance along the coast toward the northwest in the eastern Gulf and southwest along the Alaska Peninsula. The contrasts were: 1) cohos occurred in coastal areas of the northern Gulf of Alaska as early as June 11; 2) they occurred in several offshore areas in July, August, and September; and 3) they continued to be abundant in southern coastal waters off Vancouver Island and the Strait of Juan de Fuca throughout the summer.

The early occurrence of juvenile cohos in offshore areas and in the northernmost coastal areas of the Gulf of Alaska is probably a result of their earlier entry into salt water and their larger size at entry as compared to sockeye, chum, and pink salmon. As will be discussed later, juvenile cohos are typically 10 cm longer than the other three species. Thus, cohos may be farther advanced in seaward migration at a given date than are sockeye, chum, and pink salmon. It is possible also that cohos have intrinsically different migratory habits than these other three species.

The presence of substantial numbers of juvenile cohos in the southern coastal and " inside " waters as late as September and October (Fig. 6d) is to be expected since many cohos, in contrast to sockeye, chum, and pink salmon, frequently spend their entire life in " inside " waters, or make only limited seaward migrations (Haw et al. 1967; Milne 1950, 1957). Sockeye, chum, and pink salmon rarely reside in " inside " waters, although some small populations of " resident " pink salmon have been documented (Jensen 1956). In general, also, coho spawning distribution tends to extend farther south.

Small numbers of cohos were caught in the eastern Bering Sea in July, August, and September, which is in keeping with the relatively small populations originating in streams of Bristol Bay and vicinity.

General Distribution of Juvenile Chinook Salmon

The time-space distribution of juvenile chinook salmon (Fig. 7) was in general similar to that of the other species but was most like that of the coho. In the Gulf of Alaska, chinook salmon appeared earliest in the southern production areas near Vancouver Island and two specimens were caught off southeastern Alaska on June 30. In July, August, and September, they occurred progressively along the coast to the northwest and southwest (Figs. 7b, c, d). Like the coho salmon, chinook salmon also occurred in small numbers in some offshore areas of the Gulf of Alaska in July and August. In September and October, they were still present in southern areas off Vancouver Island and in the Strait of Juan de Fuca. In the latter areas and farther south production of chinook salmon is high and many are known to remain in " inside " waters during all or much of their marine life. Also, like coho, the abundance of chinook salmon tended to decline in September and October in the northern areas as compared to August (Figs. 7c, d). As will be discussed in a later section, chinook salmon, like coho salmon, were typically about 10 cm larger than sockeye, chum or pink salmon in most areas of sampling. This factor may have contributed to the similarities in distribution of coho and chinook salmon. Furthermore, if offshore movement is related to size, then size may account for the presence offshore of coho and chinook salmon, but not sockeye, chum, and pink salmon.

In the eastern Bering Sea, juvenile chinook salmon occurred in every time period, but in small numbers (Fig. 7). The earliest occurrence was on June 29. The westernmost catches were in area 8050 south of the central Aleutian Islands during July (two fish only).

General Distribution of Juvenile Steelhead Trout

The time-space distribution of juvenile steelhead trout (Fig. 8) was substantially different from that of any of the species of salmon. In the Gulf of Alaska, steelhead occurred in offshore areas as early as June (Fig. 8a). In July the largest catches were made in area W4552 in the south-central Gulf of Alaska (Fig. 8b), and small numbers were caught across the full width of the gulf. In August, small catches occurred both inshore and offshore (Fig. 8c). In September, a few steelhead were caught in southern areas off Vancouver Island and in the Strait of Juan de Fuca, presumably fish that had entered salt water late in the summer. Although there are substantial steelhead production areas in the northern Gulf of Alaska, no steelhead were caught in the four northernmost statistical areas of the gulf. However, the main production areas are in British Columbia and to the south. No steelhead were caught in the Bering Sea, which is not surprising, since steelhead are unknown in Bering Sea streams.

From the above, it appears that juvenile steelhead trout, in contrast to salmon, do not remain along the coastal belt of the Gulf of Alaska, but proceed directly seaward during their first summer. Average catches in coastal areas were always less than one per seine set. The largest catches were made in offshore areas where relatively few sets were made. Since steelhead

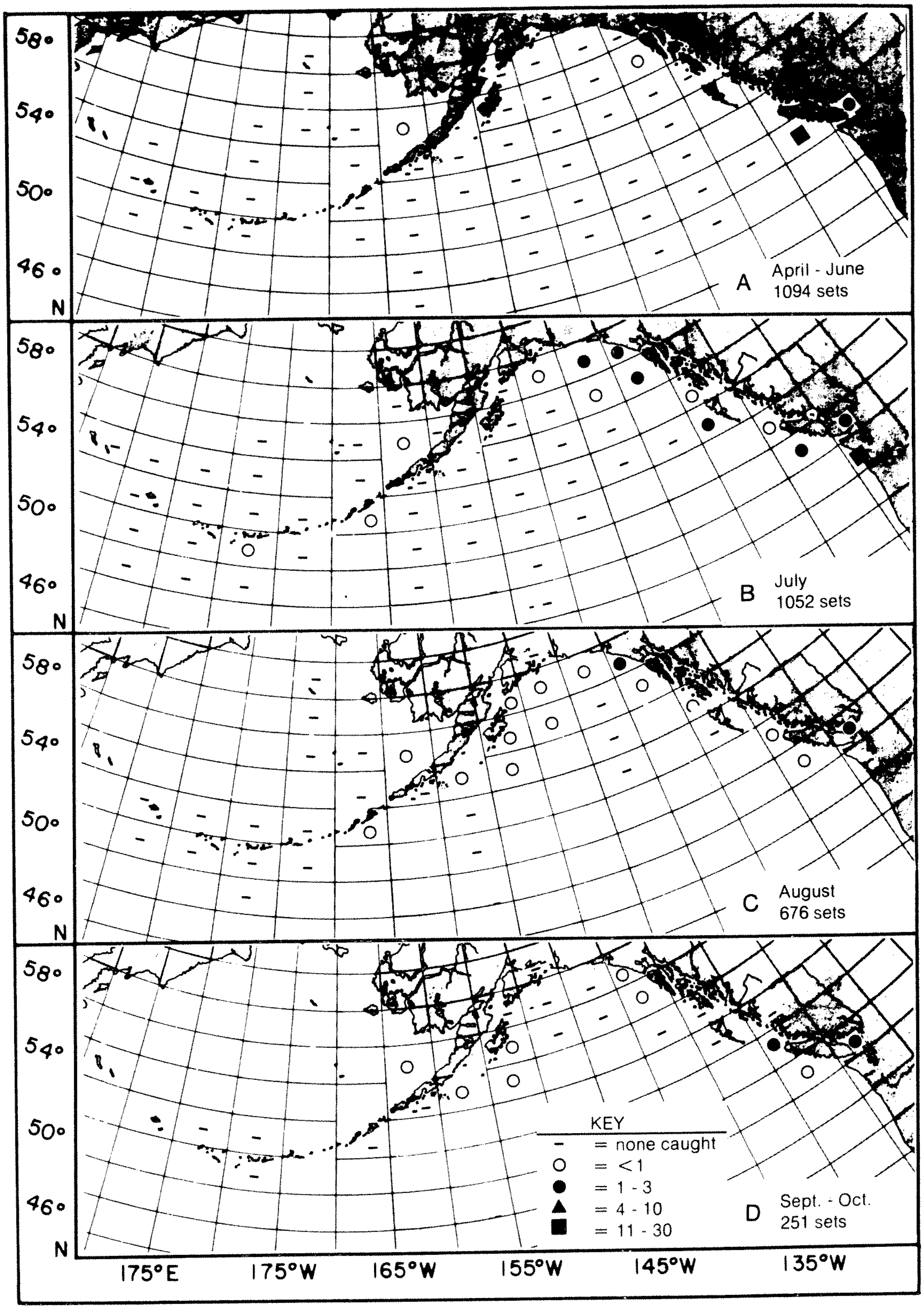


Fig. 7. Mean catch per seine set of juvenile chinook salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets shown in Fig. 2.

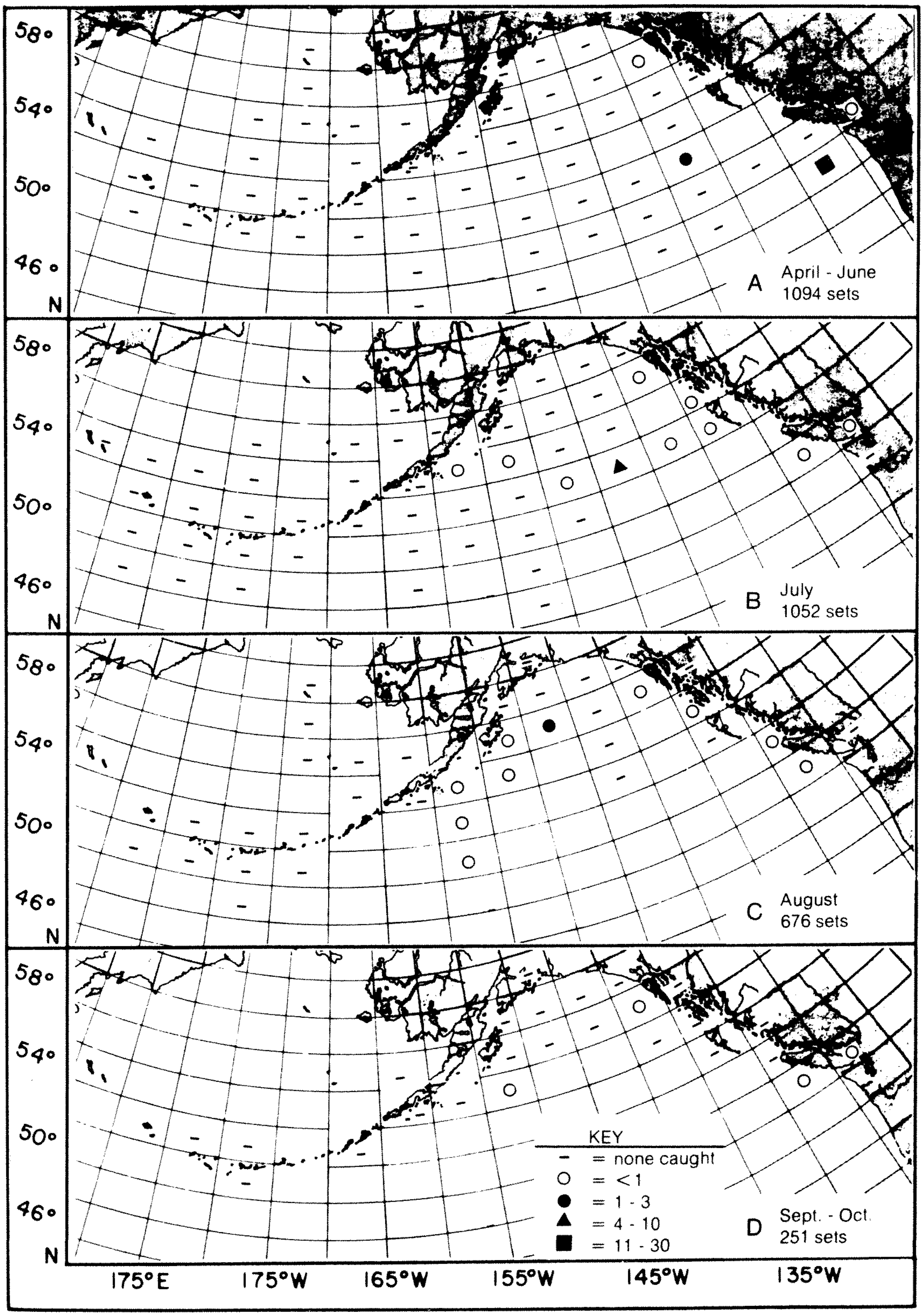


FIG. 8. Mean catch per seine set of juvenile steelhead trout by area and by time period; 3,073 sets, 1956–1970. Number of sets shown in Fig. 2.

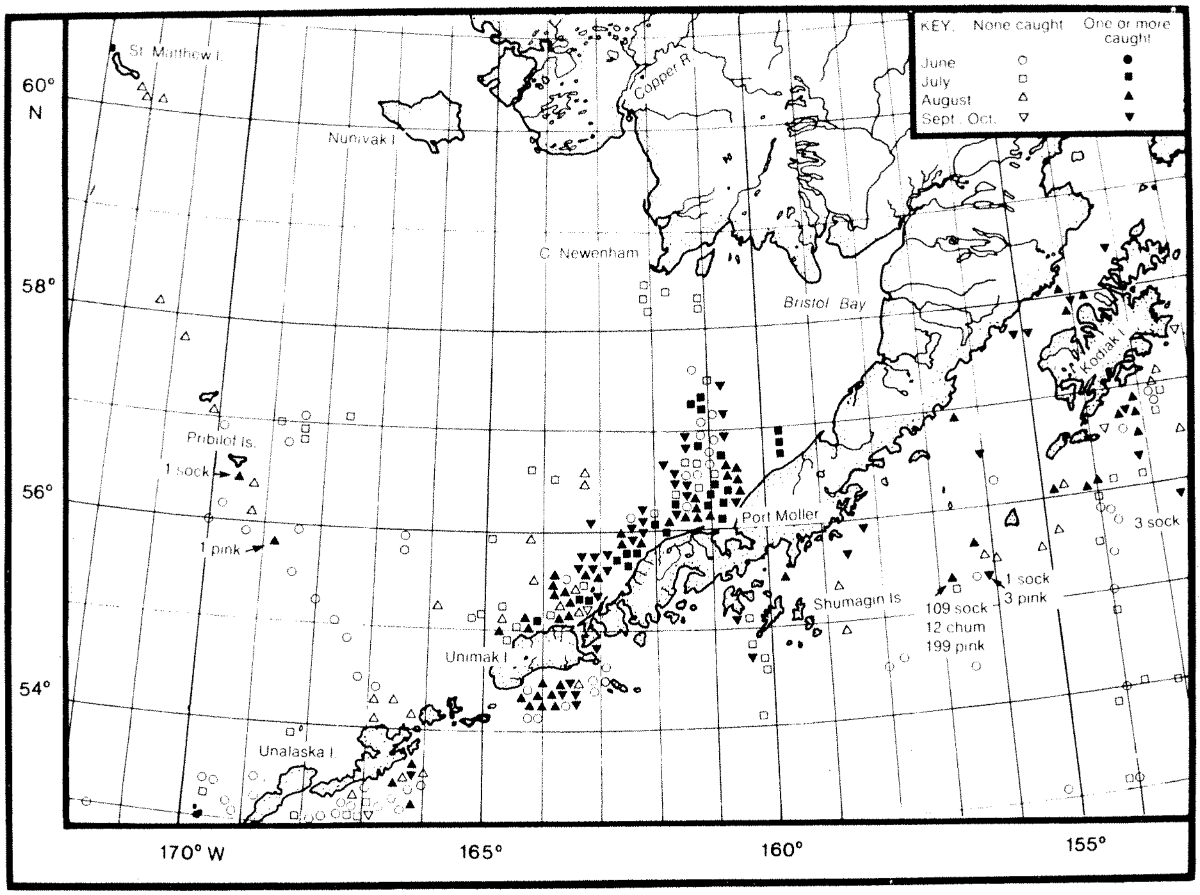


FIG. 9. Locations of purse seine sets in the eastern Bering Sea and south of the Alaska Peninsula, by month, 1956–1968, plus indication of presence or absence of juvenile sockeye, chum, or pink salmon. Multiple sets not shown if symbols identical.

are much less abundant than any of the species of salmon, their frequent occurrence in the catches far from shore becomes more significant and suggests that a large proportion of them must be dispersed widely throughout the Gulf of Alaska. By the same token, the relatively small catches of age .0 coho and chinook salmon in offshore areas, despite their greater abundance as compared to steelhead, indicate that only a portion of the stocks of these species ventures far offshore during their first summer. This is in accord with the evidence that substantial numbers of coho and chinook salmon of all ages are present in coastal areas throughout the whole year. The unique behavior of age .0 steelhead cannot be attributed to size since, as will be discussed later, they are similar in size to coho and chinook salmon.

DETAILED DISTRIBUTION OF SOCKEYE, CHUM, AND PINK SALMON

More detailed features of the distribution of age .0 sockeye, chum, and pink salmon become apparent when the purse seine catches are plotted on larger-scale charts as in Figs. 9–11. Catches of coho and chinook salmon and steelhead trout will not be shown in detail because it would add little new information. The symbols in Figs. 9–11 indicate fishing locations by month and also whether or not juvenile sockeye, chum or pink salmon were caught at the respective locations. The species are grouped because of the similarity in their distributions. The relative abundance of the individual species, of course, varied by area as was shown in Figs. 3–5. In cases where more than one of a given symbol belonged in the same location, the symbol was shown only once, and if two or more different symbols belonged in the same location, they were placed as close as possible to the actual location without overlapping. Where catches occurred far offshore, the numbers of fish were shown next to the symbol.

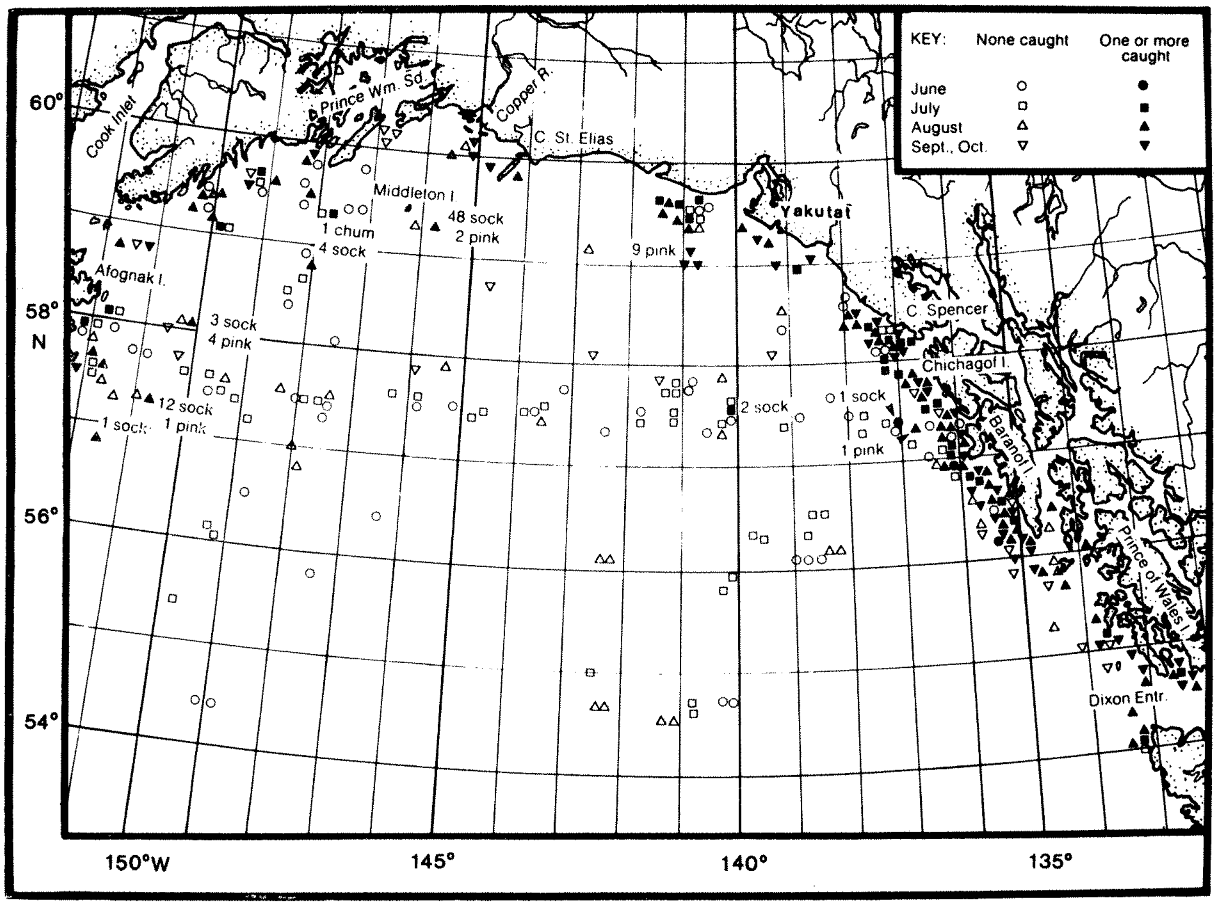


FIG. 10. Locations of purse seine sets in the northern Gulf of Alaska, by month, 1956–1968, plus indication of presence or absence of juvenile sockeye, chum, or pink salmon. Multiple sets not shown if symbols identical.

EASTERN BERING SEA

Considering first the Bering Sea (Fig. 9), it is apparent that catches occurred primarily in the belt along the northern coast of the Alaska Peninsula and Unimak Island between 159°W and 165°W. Although it cannot be shown precisely in Fig. 9, most catches in this area occurred between 10 and 30 nautical miles (nm) offshore, but some catches were made as far as about 60 nm offshore near 161°W. Exploratory fishing farther to the north and northwest of the area of abundance yielded few fish. The depth of the purse seine necessitated that we fish in water deeper than 46 m which in most portions of the north side of the Alaska Peninsula, is between 5 and 10 nm offshore. In 1962, 1963, and 1967 sampling was primarily exploratory, and in 1968 efforts were confined to areas of abundance in order to obtain the maximum number of fish for tagging. Catch per seine set varied from 0 to 2,042 juvenile salmon. For sockeye alone, the average catch was over 100 sockeye per set from July through September (Fig. 3). Almost none were caught in areas and time periods outside of the area of abundance, and none were caught in June despite rather widespread fishing. Also, none were caught in seven sets in July and five sets in August just to the west or northwest of the main center of abundance. Six exploratory sets in July near Cape Newenham and four sets just east of the Pribilof Islands yielded no juvenile salmon of these species. A total of 14 sets spaced irregularly on a diagonal line from St. Matthew Island to Unalaska Island in late August of 1967 yielded only one juvenile sockeye[7] and one juvenile pink near 56°N as shown. Thus, the area where catches were consistently productive along

[7] This lone sockeye was 27.5 cm long, which is much larger than those in the area of concentration close to Port Moller. The matter of length and migration will be discussed in a later section.

TABLE 1. Catch per set of age .0 salmonids, distance offshore, and surface temperatures in Area W4056 off Baranof and Chichagof islands, southeastern Alaska, during August and September, 1964 and 1965. (Includes all 29 sets open south or southeast and excludes four sets open northwest.)

Set No.	Date	Location N. Lat.	Location W. Long.	Distance offshore (naut. miles)	Catch of age .0 salmonids	Surface Temp. °C.
X-103	8/28/65	57°16′	135°59′	4	975	13.3
C-96	8/20/64	56°30′	135°13′	5	49	12.2
C-102	8/30/64	56°47′	135°37′	5	978	12.7
X-68	8/5/65	56°57′	136°00′	5	369	13.8
X-106	9/3/65	56°31′	135°12′	5	262	13.5
C-87	8/10/64	56°17′	135°03′	6	74	11.3
X-100	8/26/65	57°49′	136°38′	6	1,244	13.0
X-118	9/14/65	57°50′	136°41′	6	204	13.0
X-102	8/27/65	57°29′	136°14′	7	452	12.6
X-104	9/1/65	56°49′	135°47′	7	107	13.1
X-111	9/10/65	57°28′	136°12′	7	34	11.5
C-103	8/31/64	56°39′	135°30′	8	1,237	12.5
C-107	9/4/64	56°39′	135°30′	8	102	11.9
C-108	9/5/64	57°24′	136°09′	8	666	12.5
X-101	8/27/65	57°43′	136°37′	8	96	13.4
X-66	8/2/65	56°16′	135°08′	9	91	10.6
X-107	9/3/65	56°29′	135°22′	11	54	12.4
C-104	9/2/64	56°36′	135°37′	12	591	12.4
C-105	9/2/64	56°35′	135°36′	12	453	12.7
C-94	8/17/64	57°20′	136°15′	13	280	11.9
C-97	8/21/64	56°30′	135°27′	13	424	12.7
X-67	8/2/65	56°16′	135°22′	15	154	10.6
C-106	9/3/64	56°34′	135°42′	16	299	12.6
X-69	8/5/65	56°57′	136°19′	16	80	16.3
X-108	9/4/65	56°26′	135°30′	16	66	11.4
X-70	8/5/65	56°57′	136°37′	23	3	16.7
C-93	8/17/64	57°23′	136°46′	25	2	12.6
C-100	8/22/64	56°22′	135°46′	25	0	13.2
X-109	9/4/65	56°19′	135°43′	27	0	12.7

Summary— 4–9 miles 16 sets mean catch = 433.8
11–16 miles 9 sets mean catch = 266.8
23–27 miles 4 sets mean catch = 1.3

the north side of the Alaska Peninsula is probably the main area of concentration of juvenile sockeye, chum, and pink salmon during July and August. Although juvenile salmon were still abundant in the main sampling area in September, no exploratory fishing was done to test whether the fish had started to disperse farther seaward.

Bristol Bay is the highly predominant production area for sockeye and pink salmon in Western Alaska and presumably was the major source of the catches made. It is also the largest production area for chum salmon. Additional information on the distribution and migrations of juvenile salmon through the estuaries and coastal waters of Bristol Bay has been reported by Straty (1974; 1981). Straty's work and the present study are complementary in showing the seasonal migration pattern from the estuaries to the distribution in September as shown in Fig. 9. Straty used gear that could be fished in shallower water and found juvenile salmon present in a continuous band from the estuaries to our sampling areas and extending well inshore of the 46 m line at which our sampling was limited. He also found sockeye that had originated in Bristol Bay rivers present in coastal bays such as Port Moller.

SOUTH OF ALASKA PENINSULA AND EASTERN ALEUTIAN ISLANDS

In the areas south of the Alaska Peninsula and the eastern Aleutian Islands, sampling both nearshore and offshore was conducted from June through September over a 600-nm stretch from 152°W to 168°W (Fig. 9). Sampling was intermittent and scattered, because it was done only as the vessels had opportunity while en route to and from other sampling areas. Juvenile sockeye, chum, and pink salmon were caught only in August and September. Catches ranged from 0 to 801 per set. As will be discussed in the section on tagging, the juveniles in this general area originate in streams of the Alaska Peninsula, Kodiak Island, Cook Inlet, and possibly other areas to the east and south where all three species spawn in substantial numbers. Thus, juvenile sockeye, chum, and pink salmon were scarce or absent in June and July in both coastal and more offshore areas sampled south of the Alaska Peninsula and the eastern Aleutian Islands (152°W to 168°W). In August and September, they were generally present along the coastal belt in all areas fished and relatively few zero catches occurred. Offshore sampling in August and September was inadequate to show the extent of offshore distribution.

Northern Gulf of Alaska

Juvenile sockeye, chum, and pink salmon were concentrated relatively close to shore in all areas fished in the northern Gulf of Alaska from June through September (Fig. 10). Along the coast, juvenile salmon were caught in nearly every set, and catches frequently numbered in the hundreds and occasionally in the thousands. A few juvenile salmon were caught well offshore (over 50 nm), but considering the number of zero catches made offshore, particularly in the area between 56°N and 58°N, the scarcity of juvenile salmon is evident. Where catches occurred offshore, the numbers caught, by species, are entered next to the symbols (Fig. 10). The only catch of substantial size was the 48 sockeye and two pink salmon caught in the set near Middleton Island in August. It is noteworthy that most catches in offshore waters occurred in the northern and northwestern parts of the Gulf of Alaska where the continental shelf is 50 or 60 nm wide, whereas off southeastern Alaska where the continental shelf is narrow, the band of fish was also narrow, probably less than 20 or 25 nm miles wide.

Too few sets were made along the outer margins of the band of fish to define its width precisely; however, catches at a series of stations fished in 1964 and 1965 indicated that the band of fish off Baranof and Chichagof islands was approximately 20 miles wide, and that abundance declined sharply at the outer edge (Table 1). In this area the coastline is relatively straight and the continental shelf narrow and uniformly less than 20 miles wide. The catches indicated that density was high and continuous between 4 and 16 miles offshore. Throughout this band, catches in individual sets ranged from 34 to 1,244 juvenile salmon and no zero catches were made. No sets were made between 16 and 23 miles, but four sets between 23 and 27 miles yielded a total of only five salmon, and in two of the sets, the catch was zero. It is unknown whether or not the width of the band of fish is associated with oceanographic conditions. Surface temperatures which were taken at each station (Table 1) seemed to show no obvious correlation with catches.

Cape Flattery to Dixon Entrance

In the southern coastal area between 48°N and 55°N (Fig. 11), most fishing was close to shore off the Queen Charlotte Islands, Vancouver Island, and in adjacent inside waters. Little can be said about offshore distribution except that in the few sets outside the area of abundance, no juvenile sockeye, chum or pink salmon were caught. Juveniles were caught in the Strait of Juan de Fuca, off the west coast of Vancouver Island, at the northern end of Queen Charlotte Strait, in Hecate Strait, Dixon Entrance, and off the northwest and southwest portions of the Queen Charlotte Islands. None were caught in 10 sets at seven locations along the central west coast of the Queen Charlotte Islands in July, August, and September. Perhaps the fish congregate and feed at the ends of the islands, but migrate north or south mainly through Hecate Strait rather than along the Pacific Ocean side of the islands. An offshore migration cannot be ruled out, but as will be shown later, a general offshore migration in this area during summer is highly unlikely. The migration route of the salmon may be affected by the fact that the continental shelf on the Pacific side is extremely narrow—much of it less than 5 miles wide. In contrast, Hecate Strait is relatively shallow, and perhaps a richer feeding area.

Very large catches of juvenile salmon occurred in the northern part of Dixon Entrance (area W 3554, Appendix Table A1). The mean catch in some of the 10-day periods during July, August, September, and even October was frequently several hundred juvenile salmon of mixed species. This is apparently an area where juvenile salmon concentrate during their early oceanic migrations.

MIGRATIONS OF JUVENILE SALMONIDS

The migrations of juvenile salmonids in the open sea will be discussed based upon the following three major lines of evidence: 1) catch distribution by date and location of both age .0 and .1 life stages; 2)

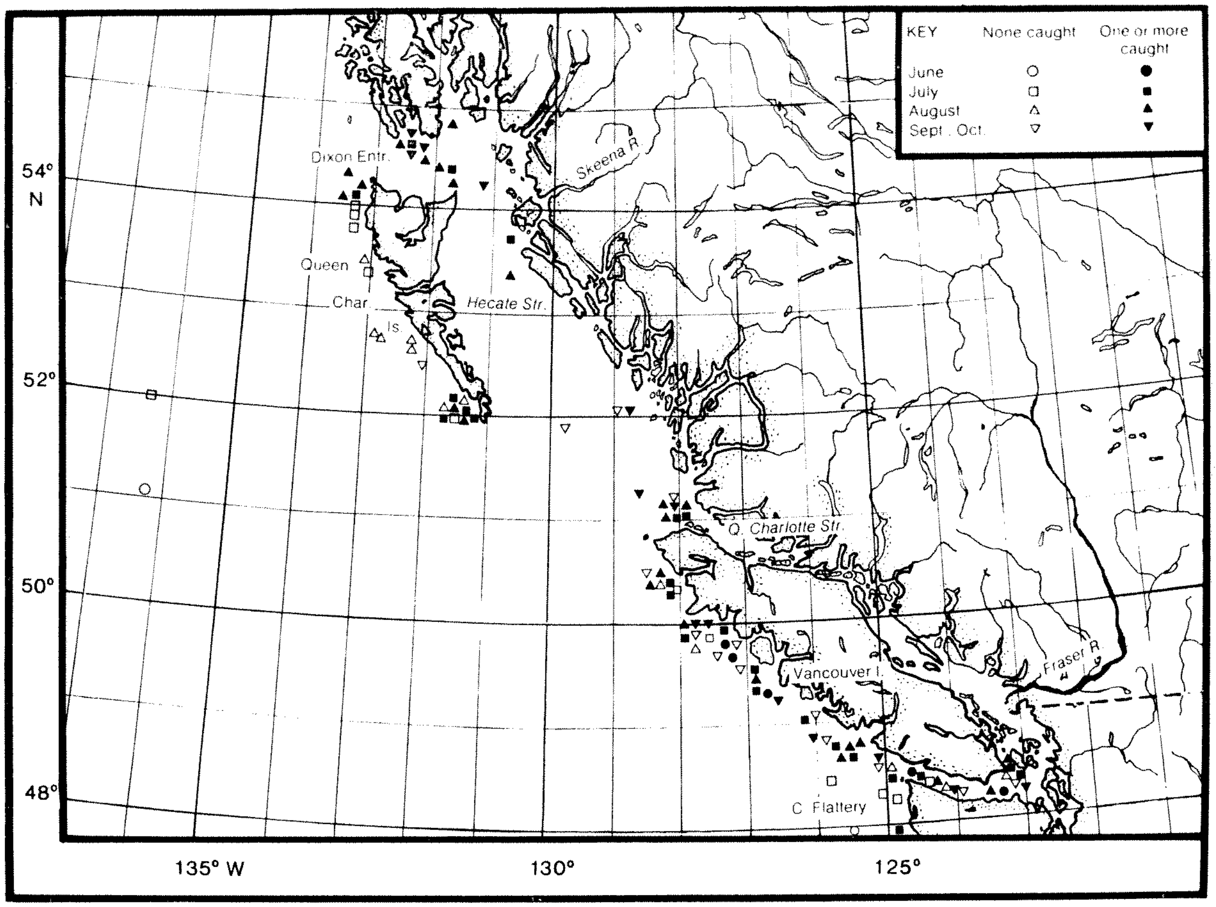


FIG. 11. Locations of purse seine sets in the eastern North Pacific from Cape Flattery to Dixon Entrance, by month, 1956–1968, plus indication of presence or absence of juvenile sockeye, chum, or pink salmon. Multiple sets not shown if symbols identical.

catches with respect to direction of the opening of the seine; and 3) recovery of tagged fish. Other more indirect lines of evidence bearing on migration were: 1) lengths of fish according to location and date of sampling, and 2) density and abundance of fish as derived from the catch/set of the purse seine extrapolated in time and space. The latter evidence provided a measure of the volume, and thus the importance of the body of fish present in, or migrating through, a given sampling area. The first summer's migration proved to be much more extensive and rapid than anticipated, and some of the observed migratory patterns were found to be similar in principle to those observed in salmon in later life stages.

MIGRATIONS INFERRED FROM CATCH DISTRIBUTION OF AGE .0 GROUP

For this analysis summer catch distributions in purse seines were considered, and fall and winter migration was inferred based upon the spring-summer catch distribution of age .1 salmonids in their second year at sea. In the case of pink salmon, late fall catches in Canadian longline fishing was also considered.

Assumptions necessary for inferring migrations from the catch data are as follows:

(1) The efficiency of the purse seines was relatively constant between times and areas of fishing. This was discussed under " General Distribution of Juvenile Salmonids " (p. 8), and although the assumption was not fully satisfied, it seems reasonable to assume that efficiency was sufficiently constant to show the major patterns of abundance from which migrations may be inferred.

(2) The distribution of the fishing was adequate to detect the main concentrations of juvenile salmon during the sampling period. This seems reasonable in view of the large and consistent catches in certain areas and times each year and the consistently smaller

catches in other areas and times.

(3) The juvenile sockeye, chum, and pink salmon remained principally in the coastal belt during summer, and offshore migration was minimal with the possible exception of pink salmon. Supporting evidence is strengthened by comparing the catch distribution of all five species of salmon and steehead.

(4) An increase in catches in a given area of sampling must be due to the entrance into the sea of juvenile fish from adjacent production areas or to the influx of migrants from more distant production areas. Although this is self-evident, it is a necessary principle to bear in mind when considering migrations based upon other lines of evidence.

(5) A corollary of the fourth assumption is that a decrease in abundance in a given sampling area indicates migration out of the sampling area, or that mortality has been greater than recruitment.

Oceanic Areas

Given the above assumptions, the juvenile sockeye catch data presented earlier in Fig. 3 indicate the following. In the Gulf of Alaska a seasonal migration extends northward, westward, and southwestward along the coastal belt from Cape Flattery to the eastern Aleutian Islands. The data are adequate only to show the general trend and approximate timing between late June and early October. In the eastern Bering Sea, substantial numbers of juvenile sockeye had migrated (intuitively) from Bristol Bay rivers to an area between 160° and 165°W by July where they remained abundant at least through mid-September.

Juvenile chum salmon (Fig. 4) apparently migrated in a manner similar to sockeye. In the Gulf of Alaska a high abundance of chum salmon in the Vancouver Island area relative to sockeye salmon is evident in July and August. It is probable that the coastal northward sockeye migration began earlier than that of the chum salmon, and that sockeye in that area had already begun to decline in abundance by July when the sampling became intensive (Fig. 2).

Juvenile pink salmon in the Gulf of Alaska generally followed a distribution pattern similar to that of the sockeye and chum salmon (Fig. 5). However, catches of juvenile pink salmon in Canadian longline operations in late November and early December indicated that some pink salmon leave the coastal belt and migrate far offshore apparently prior to the offshore migration of sockeye and chum salmon (Fig. 5d). The coastal origin of these Canadian-caught fish is unknown. It is also unknown whether they at first migrated along the coast, and then offshore, or whether they moved directly offshore from locations where they entered the sea. The lack of pink salmon at the five stations between approximately 51° and 53°N and 145° and 162°W suggests that pinks did not migrate southward from the waters near the Alaska Peninsula. The continuous occurrence of catches between 136° and 154°W suggests that fish taken there may have moved westward from the British Columbia coast. However, this would place British Columbia stocks much farther west at these latitudes than the western limit of distribution (140°W) previously determined from tagging age .1 pinks (Takagi et al. 1981; Fig. 60). In fact all of the longline catches of juveniles were within the oceanic area ascribed by Takagi et al. (1981) to age .1 pinks originating in coastal areas between the Alaska Peninsula and southeastern Alaska. Thus the origins and migrations of these juvenile fish taken in the Canadian longline operations must remain uncertain.

Few juvenile pink salmon were taken in the Bering Sea.

The data (Figs. 6 and 7) for coho and chinook salmon indicate that at least some individuals migrate in a fashion similar to the sockeye, chum, and pink salmon. However, their presence in offshore waters early in the season, and their continued presence in southern inshore waters late in the season, suggests a more complicated migratory pattern than that of the other three species.

Since the distribution of juvenile steelhead trout (Fig. 8) was vastly different from that of any of the salmon, it follows that their migrations must also have been different. Because migratory data for juvenile steelhead from other lines of evidence are scarce or lacking, deductions about their migrations must be based primarily on their time-space distribution at sea as compared to the locations of their main production areas. Based upon catch distribution, steelhead trout apparently migrate offshore relatively early in the season, and apparently do not migrate northward along the coastal belt. More recent near-shore purse-seine sampling off the coasts of Washington and Oregon also indicates a more rapid offshore movement of steelhead than of chinook and coho salmon (Miller et al. 1983; Pearcy and Masuda 1982; Wakefield et al. 1981).

Strait of Juan de Fuca and Puget Sound

Although this paper deals mainly with the oceanic phase of the migrations of juvenile salmon, our sampling in the Strait of Juan de Fuca in 1968, and sampling by the Suquamish Indian tribe in Puget Sound in 1976 has provided significant new information on the timing and the routes of seaward migration of juvenile salmon in their departure from inside waters.

In 1968 we sampled at three stations on a transect

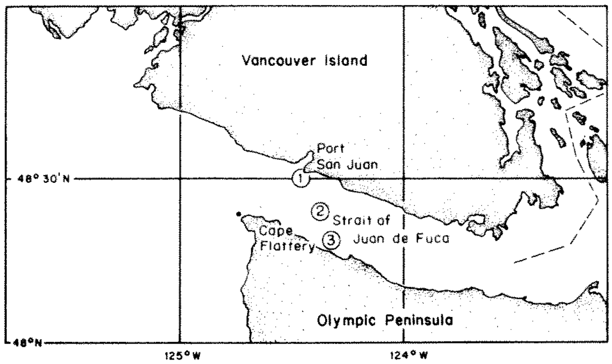


FIG. 12. Locations of the three fishing stations in the Strait of Juan de Fuca referred to in Table 2.

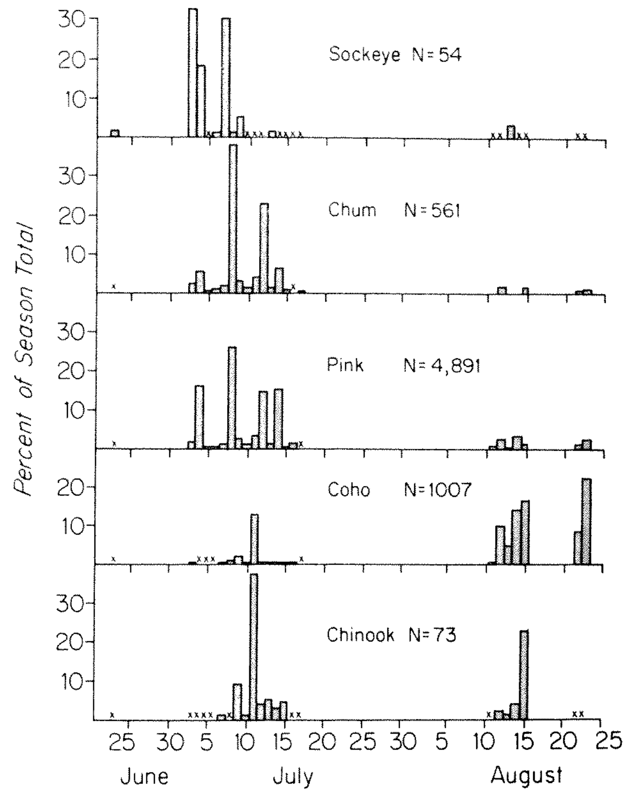


FIG. 13. Average daily catches* of juvenile salmon in the western Strait of Juan de Fuca during two time periods in 1968: June 23–July 17, 39 sets; August 11–23, 14 sets.

*(Daily catch/set expressed as a percent of the season's total catch.)

across the Strait of Juan de Fuca as shown in Fig. 12. Our objectives were to gain information on the timing of migration and to test for any north-south stratification of juvenile salmon as they migrated seaward through the Strait of Juan de Fuca. As shown in Table 2, we made 37 sets between July 3 and July 17, and 13 sets between August 11 and August 23. Although the distribution of the fishing effort at the three stations and during the two time periods was inadequate to draw firm conclusions, the catches were consistent in indicating that juvenile chum, pink, and coho salmon were most abundant at Station 3 near the south shore of the Strait during both time periods. Catches of sockeye were too small to be very indicative, but the limited catches suggested that juvenile sockeye, in contrast to the other three species, were most abundant at Station 1, near the north shore. Thus, the data suggest that juvenile chum, pink, and coho salmon tend to favor the south shore of the Strait of Juan de Fuca, whereas the sockeye apparently favor the north shore. More extensive sampling starting earlier in the season and at other transects would be needed to test the validity and the general applicability of these conclusions.

The catch per set of juvenile sockeye, chum, and pink salmon decreased between the July and August sampling periods, whereas the catch per set of cohos increased. For the first three species, the decrease indicated that the peak of migration occurred prior to August. Furthermore, a comparison of the CPUE among species suggests that the migration of juvenile sockeye salmon occurred sometime prior to the July 3–17 sampling period. Thus, sockeye salmon apparently precede the chum and pink salmon in their sea-

TABLE 2. Catch per purse seine set of age .0 salmon at three fishing stations on a transect across the outer Strait of Juan de Fuca during July and August, 1968 (see Fig. 12).

Period	Station	Number of sets	Catch/set by species				
			Sockeye	Chum	Pink	Coho	Total
July	1	6	3.2	2.5	8.8	2.8	17.3
3–17	2	3	0.6	7.0	32.7	3.0	43.3
	3	28	1.0	16.1	162.6	6.2	186.0
August	1	4	0.5	2.0	33.3	13.8	49.5
11–23	2	0	—	—	—	—	—
	3	9	0	3.0	54.4	80.1	137.5

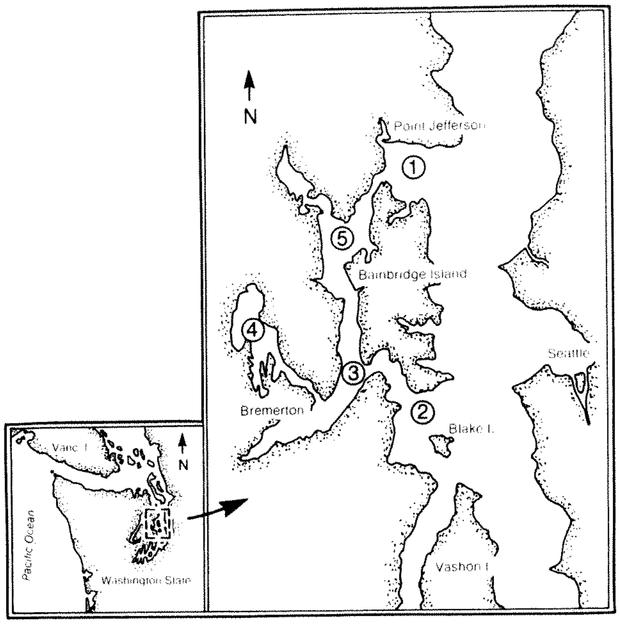


FIG. 14. Base map showing five areas in central Puget Sound where juvenile salmon were sampled in October-November 1976 (see Table 3).

ward migrations at this location. The substantial increase in the coho catch in August indicated a later migration of this species in the outer Strait of Juan de Fuca. Tag returns (to be discussed) indicate that coho salmon do not necessarily migrate positively and continuously seaward as do the sockeye, chum, and pink salmon.

The data from the 1968 sampling in the Strait of Juan de Fuca are shown on a daily basis in Fig. 13. The CPUE of sockeye, chum, and pink salmon was variable but relatively large during the July period, and consistently small during the August period, which indicates that the peak of migration of these three species occurred prior to the August sampling period. It appears also that sockeye salmon migrate somewhat earlier than pink and chum salmon.

Coho and chinook salmon catches were relatively consistent in both time periods. Many juveniles of these species tend to remain in inside waters rather than proceed directly seaward.

Sampling conducted in central Puget Sound in the fall of 1976 by the Suquamish Indian Tribe provided information on juvenile salmon in inside waters that is difficult to reconcile with the distribution and migrations as discussed to this point, particularly with regard to chum salmon. The methods and gear were the same as those used in our 1964–1968 sampling of juveniles, so that the information on abundance and sizes of juveniles in 1976 in Puget Sound should be comparable with the 1964–1968 sampling at sea.

The catches of juvenile salmonids in Puget Sound are summarized in Table 3 by five areas and by species. Figure 14 illustrates the five sampling areas in

TABLE 3. Catches of juvenile salmonids in purse seine operations in five areas of central Puget Sound, October 14—November 26, 1976.

			Total catch/mean catch-per-set by species[1]				
Area	Number of sets	Sockeye	Chum	Pink	Coho	Chinook	Total
1	25	10	789	266	69	89	1,223
		0.4	31.6	10.6	2.8	3.6	48.9
2	26	31	2,497	843	219	281	3,871
		1.2	96.0	32.4	8.4	10.8	148.9
3	8	3	269	91	24	30	417
		0.4	33.6	11.4	3.0	3.8	52.1
4	6	1	48	16	4	5	74
		0.2	8.0	2.7	0.7	0.8	12.3
5	6	1	106	36	9	12	164
		0.2	17.7	6.0	1.5	2.0	27.3
Total	71	46	3,709	1,252	325	417	5,749
		0.6	52.2	17.6	4.6	5.9	81.0

[1] The overall species composition is a rough estimate based upon the composition of a random sample of only 124 specimens retained and examined from a catch of 812 juveniles. The 812 fish were caught in two sets on November 23 in area 2, where abundance was greatest. The overall estimate of composition is deemed to be reasonably representative, since in all sets juvenile salmon were counted and briefly examined while being released alive by dipnet. Although counts by species were not recorded, the great dominance of chum salmon, followed by pink salmon, was observed among released fish in nearly all sets as recorded in field logs.

Source: Unpublished data—Suquamish Indian Tribe.

central Puget Sound together with the adjacent channels leading to the sea 140 nm distant via the Strait of Juan de Fuca.

A total of 5,749 juvenile salmon of all species was caught in 71 purse seine sets, for an average of 81 per set (Table 3). Catches in individual sets ranged from 2 to 662 juvenile salmon.

The species composition, although only an estimate (*see* Methodology in footnote to Table 3), showed chum salmon to be greatly dominant followed by pink salmon. Coho and chinook salmon catches were lower and sockeye were least abundant.

The small catches of juvenile sockeye probably reflect the presence of a few residual or late-migrating fish. The moderate catches of cohos and chinooks would be expected since feeding juveniles of these species are typically present in inside waters the year round. The substantial catch of pink salmon is probably attributable to the presence in Puget Sound of a stock of residual pink salmon that feeds and matures without going to sea, and are frequently caught in the sport fishery throughout the spring, summer, and fall of odd-numbered years (Jensen 1956). There is little likelihood that these fish were ultimately going to migrate to sea as late migrants which had entered salt water at a late date. The juvenile pink caught in Puget Sound in the fall were about 23 cm long which is larger than most pinks that had migrated hundreds of miles in the open sea by September. These residual pinks had probably reached migrating size as early as the seagoing group.

The more substantial catches of chum salmon, however, are difficult to explain, since residual stocks of this species have not been documented. They, too, were 23 cm in average length, equal in size to other chums that had migrated far seaward. If this is an annual phenomenon, they may well be a stock that migrates to sea at some later time at a much larger size than the earlier migrants. If they remain in Puget Sound for their entire life, one would expect records of substantial catches of age .1 and older immature chum salmon in sport and commercial fisheries. A few age .1 chum salmon are caught by sportsmen each year, and a few have occasionally been caught in test sets of our purse seine in Puget Sound in March and April of past years. Their numbers, however, are not as large as would be expected if a body of juvenile chum salmon as abundant as those sampled in autumn 1976 were to remain in Puget Sound for their whole life. Thus, there may be a late fall, winter, or spring seaward migration of chum salmon from Puget Sound which is not reflected in the data discussed in preceding sections. The true volume of this stock of chum salmon would be difficult to estimate based upon the limited sampling of 1976. The CPUE, however, was substantially below the CPUE of chum salmon in several areas of the northern Gulf of Alaska in August and September as shown in Fig. 3 and Appendix Table A1 when CPUE in some areas reached 290/set. Nevertheless, these residual fish could form an important portion of the Puget Sound stock of chum salmon.

Additional information on the presence of juvenile salmon in inside waters during late fall was reported by LeBrasseur and Barner (1964). They reported a catch of 430 juvenile salmon in 16 tows of a midwater trawl in northern Hecate Strait between November 3 and 14, 1963 (six sockeye, 143 chum, 257 pink, four coho, and 20 chinook salmon). Mean lengths of the chums and pinks were approximately 20 and 19 cm, respectively. Catches occurred primarily in surface tows. Catches in individual tows ranged from 0 to 232 juvenile salmon. Although the sampling by LeBrasseur and Barner was nearer the open sea than the purse seine sampling in Puget Sound, it did show that seaward migration, particularly of chum and pink salmon, was still underway in mid-November in Hecate Strait, and that substantial numbers of these species remain in inside waters well into the fall. As in the case of Puget Sound, continued sampling later in the season would be desirable to establish the timing of final seaward migration of juvenile salmon in this area.

Migrations Inferred from Catch Distribution of Age .1 Group

It is pertinent to examine those aspects of the distribution of age .1 fish which shed further light on the migrations of the age .0 group. The relative distributions of the age .0 and age .1 fish during the same sampling times and areas may be assumed to represent the change in distribution of the age .0 fish in a year's time. From the differences in these two distributions, we may infer the migrations of age .0 fish between the respective sampling dates.

In considering the distribution of age .1 salmonids, we can expect differences among species because of their different maturity schedules. Since essentially all pink and coho salmon mature at age .1, we can expect them to be moving toward spawning grounds during their second summer or fall at sea. A few sockeye and chinook salmon and steelhead trout will also mature and return at age .1, but most individuals of these species will be immature and will continue feeding and migrating at sea during their second summer. Since very few chum salmon mature at age .1, we can expect essentially all individuals of this species

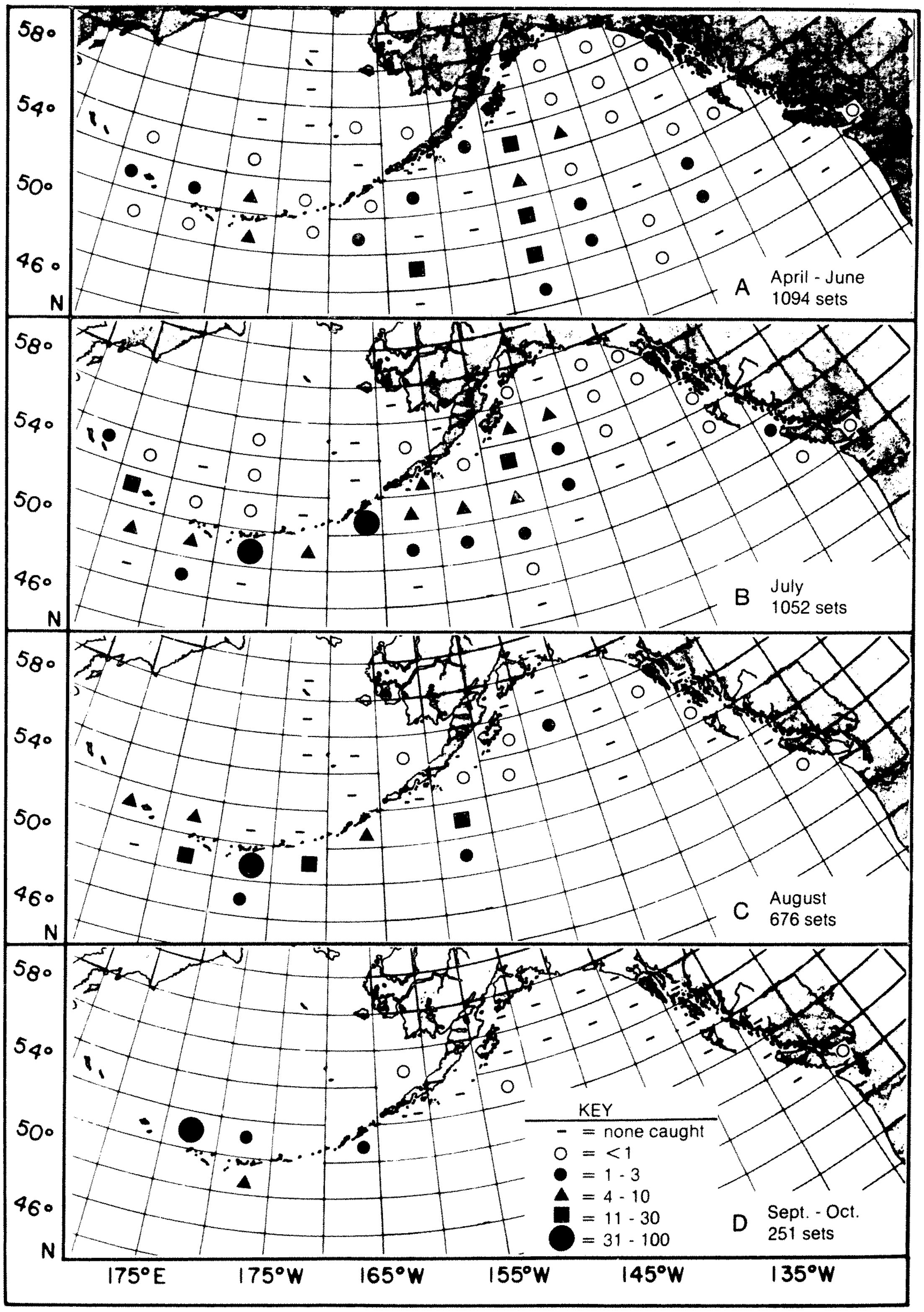


FIG. 15. Mean catch per seine set of age .1 sockeye salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets per area shown in Fig. 2.

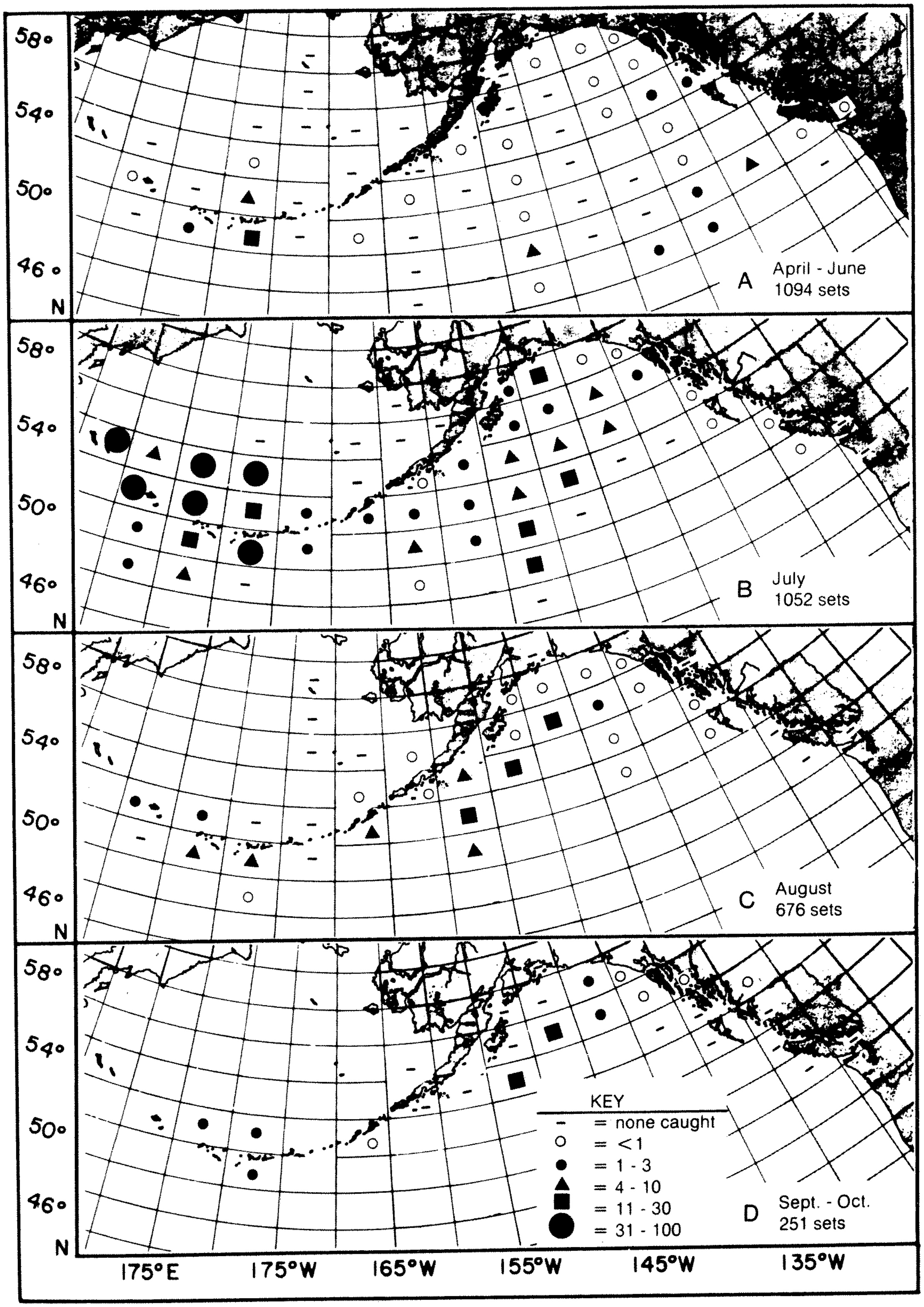


FIG. 16. Mean catch per seine set of age .1 chum salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets per area shown in Fig. 2.

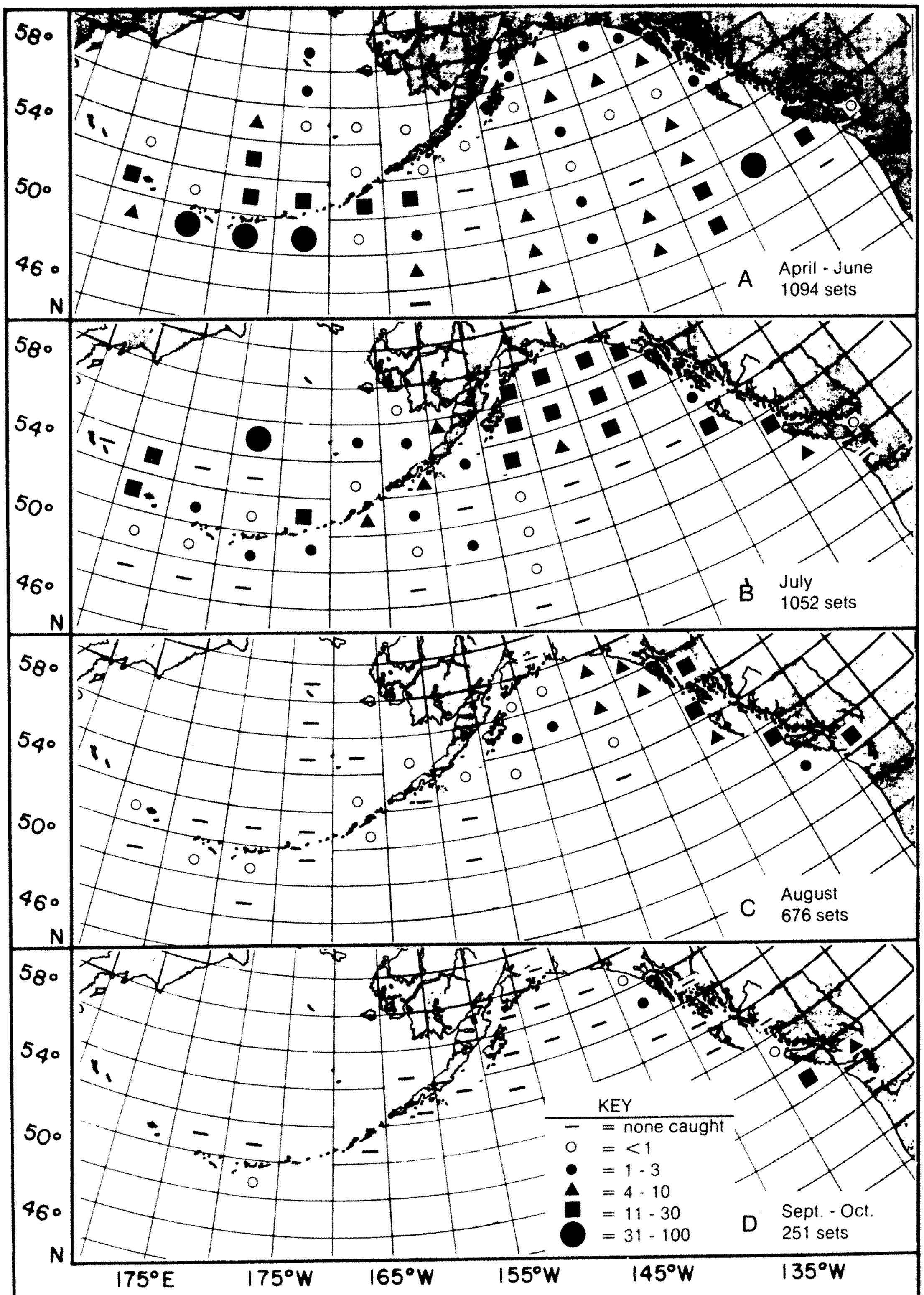


FIG. 17. Mean catch per seine set of age .1 pink salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets per area shown in Fig. 2.

to be immature during the second summer, and thus to continue on their oceanic feeding migration.

Although our seine fishing, particularly in the offshore areas, was too intermittent and sparse to delineate distribution of age .1 salmon precisely, it does appear to be adequate to illustrate the general patterns of distribution, particularly in spring and early summer, when offshore effort was more extensive (Figs. 2a, b). The distribution of age .1 salmon and the seasonal migrations based upon purse seine sampling are in general agreement with those based upon gillnet and longline sampling as discussed below for individual species.

Sockeye Salmon—Age .1

The CPUE of age .1 sockeye salmon is shown in Fig. 15. During late spring sockeye were dispersed widely in the Gulf of Alaska north of 46°N and also along the south side of the Aleutian Islands as far west as sampling was done (Fig. 15a). Abundance was greatest in offshore areas between 150° and 165°W. Very few were caught along the coastal belt of the Gulf of Alaska and in the eastern Bering Sea where catches of age .0 sockeye had been high in September (Fig. 3d). Thus, between fall and spring juvenile sockeye salmon had essentially left coastal waters and had dispersed widely at sea. In July (Fig. 15b) age .1 sockeye had apparently shifted northward in the Gulf of Alaska and were very abundant south of the eastern and central Aleutian Islands. During August (Fig. 15c), sampling was more restricted than in July, but age .1 sockeye were obviously abundant along the south side of the Aleutian Islands and relatively few were caught in the Gulf of Alaska, particularly in the eastern half. The limited sampling in September and October (Fig. 15d) showed that age .1 sockeye were still present in substantial numbers north and south of the central Aleutian Islands, but that they were very scarce in the northern Gulf of Alaska and in those parts of the Gulf coastal belt and in eastern Bering Sea where age .0 fish were prevalent. Thus, the summer migration of age .1 sockeye salmon overlaps but little with that of the subsequent year class of seaward-migrating age .0 fish. The age .1 fish were distributed well offshore in spring, and migrated north and west during summer. They typically do not re-enter coastal waters in areas where age .0 fish are prevalent but are very abundant in coastal waters south of the Aleutian Islands well to the west of areas occupied by the age .0 group. This pattern of migration of age .1 sockeye is in agreement with that based upon extensive gillnet and longline sampling (French et al. 1976).

The few age .1 sockeye that occurred mixed with age .0 fish in purse seine catches in coastal waters were a mixture of maturing precocious fish (mainly males) and immature fish. The maturing specimens may never have left coastal waters, or may have migrated well offshore and were again passing through coastal waters en route to spawn. The latter migration was evident from in-year tag returns of age .1 sockeye tagged offshore as will be discussed.

Chum Salmon—Age .1

The age .1 chum salmon were also distributed widely offshore in spring and early summer (Figs. 16a, b) and were generally scarce in the coastal belt where age .0 chum salmon had been prevalent in September (Fig. 4d). Thus, juvenile chum salmon must have left their coastal habitat and dispersed widely offshore sometime between September and April. Unlike sockeye salmon, chum salmon of age .1 in inshore areas were essentially all immature which is in keeping with the typical life history of chums.

The abundant age .1 chum salmon in the Aleutian Islands area and the western Bering Sea are nearly all of Asian origin (Neave et al. 1976) and do not relate to the samples of age .0 chum salmon illustrated in Fig. 4.

The distribution and seasonal migration of age .1 chum salmon as indicated by purse seine sampling was in general agreement with findings based upon gillnet and longline sampling as reported by Neave et al. (1976).

Pink Salmon—Age .1

Age .1 pink salmon were also widely distributed in offshore areas of the Gulf of Alaska and along the Aleutian Islands during spring and early summer (Fig. 17a). Other studies indicate that catches along the Aleutians were primarily of Asian origin. Between September and June, many of the juvenile pinks in the Gulf of Alaska had left the coastal belt (Fig. 5) and dispersed far to sea (Fig. 17). Unlike sockeye and chum salmon, age .1 pink salmon were also relatively abundant in coastal waters where age .0 fish had been prevalent the previous September. Since essentially all pink salmon mature at age .1, we should expect a pronounced inshore migration at appropriate times during the second summer. Throughout July, August and September (Figs. 17b, c, d) catches in offshore areas diminished and catches inshore increased and then decreased as maturing fish passed through coastal waters en route to their respective bays and estuaries[8]. Thus, seaward migrat-

[8] For a thorough analysis of migrations of mature age .1 pink salmon in the Gulf of Alaska based upon extensive synoptic

ing age .0 pink salmon occupy the same waters along the coastal belt through which maturing age .1 fish migrate en route to their spawning streams. This mixing of two age-classes undoubtedly occurs also in inner channels and bays.

The large catches of age .1 pink salmon along the south side of the central Aleutian Islands are a special case. As shown in Figs. 17a, b, c, d, pinks were abundant in June, but scarce in July. This is because age .1 pink salmon in this area are en route primarily to distant spawning grounds of East Kamchatka and northwestern Alaska where the inshore runs peak in late July (Hartt 1962a). Thus, these fish were actually far offshore with respect to their final destination when passing through the central Aleutians in June. Runs to local Aleutian Island streams are relatively small.

Coho Salmon—Age .1

Age .1 coho salmon, essentially all maturing, were widely distributed in offshore waters of the Gulf of Alaska and were also present in some coastal areas and inside waters in late spring and early summer (Fig. 18a). There was also an apparent northward and inshore movement of age .1 coho during the summer (Figs. 18a, b). The mixed inshore and offshore distribution of age .1 cohos presumably results because some stocks of cohos migrate extensively and may move well offshore during their first summer, while other stocks tend to remain in coastal oceanic areas or even in inside waters during their whole marine sojourn as was discussed with respect to Fig. 6. Because of this variable migratory behavior, it is difficult to infer the fall and winter migrations from relative distributions of age .0 and age .1 cohos as seen in Figs. 6 and 18, respectively. It seems likely that the age .1 cohos that were far offshore throughout the Gulf of Alaska in the spring (Fig. 18a) were the same stocks which had migrated extensively to the north along the coastal belt the previous year as age .0 fish. This assumes that many cohos migrate in a fashion similar to that of the sockeye, chum, and pink salmon as discussed earlier.

Chinook Salmon—Age .1

The distribution of catches of age .1 chinook salmon (nearly all immature) is illustrated in Fig. 19. Like the coho salmon, they occurred in both inshore and offshore areas throughout the sampling period, but the catch/set of chinooks, particularly in offshore areas, was generally very low. For this reason, the migrations of chinook salmon between the juvenile and the age .1 stages cannot be inferred from the relative distributions shown in Figs. 7 and 19. The small catches of age .1 chinook salmon far offshore south of Kodiak Island between 46°N and 48°N in the spring (Fig. 19a) indicate that at least some individuals of this species migrate far offshore. The validity of offshore distribution as shown by purse seine catches is confirmed by longline and gillnet catches of young chinook salmon at a number of offshore stations in the Gulf of Alaska (Major et al. 1978). The source of the fish and migration routes are unknown.

The only substantial catches of age .1 chinook salmon in offshore areas occurred in the central Bering Sea (Fig. 19) where stocks are primarily of Yukon River, Kuskokwim River, and Bristol Bay origin (Major et al. 1978). Data on distribution of age .0 chinook salmon in the Bering Sea, however (Fig. 7), were inadequate for inferring migrations between juvenile and age .1 stages. The relatively large catches of the age .1 group in offshore areas of the Bering Sea do suggest, however, that these far-north chinook salmon stocks tend to migrate offshore more than do those of the Gulf of Alaska. Finally, chinook salmon may be considered unique in that immature age .0 and age .1 life history groups occur mixed in both inshore and offshore areas (Figs. 7 and 19). Since both groups of chinook salmon consist essentially of immature fish, their mixing is different from that of pink and coho salmon in which cases the age .1 groups are maturing and must necessarily return to coastal waters where the age .0 group is present.

Steelhead Trout—Age .1

The distribution of catches of age .1 steelhead trout is illustrated in Fig. 20. Considering all time periods, small catches of age .1 steelhead occurred over wide areas at sea, indicating a widespread distribution of this species throughout the Gulf of Alaska and Aleutian Islands area. As with the age .0 group (Fig. 8), none were caught in the Bering Sea. This is in agreement with reports by other authors that steelhead apparently do not enter the Bering Sea during their oceanic migrations (Sutherland 1973).

Although appreciable numbers of steelhead mature at age .1, the data show little evidence of a seasonal shoreward movement, as was seen for pink and coho salmon, probably because steelhead are relatively few in number, and because most steelhead enter streams much later in the season (November-March) than salmon.

The only indication of an area of concentration of

longline catches and upon tag returns, *see* Fisheries Research Board of Canada (1964a, 1964b, 1966); Neave et al. (1967); and Takagi et al. (1981).

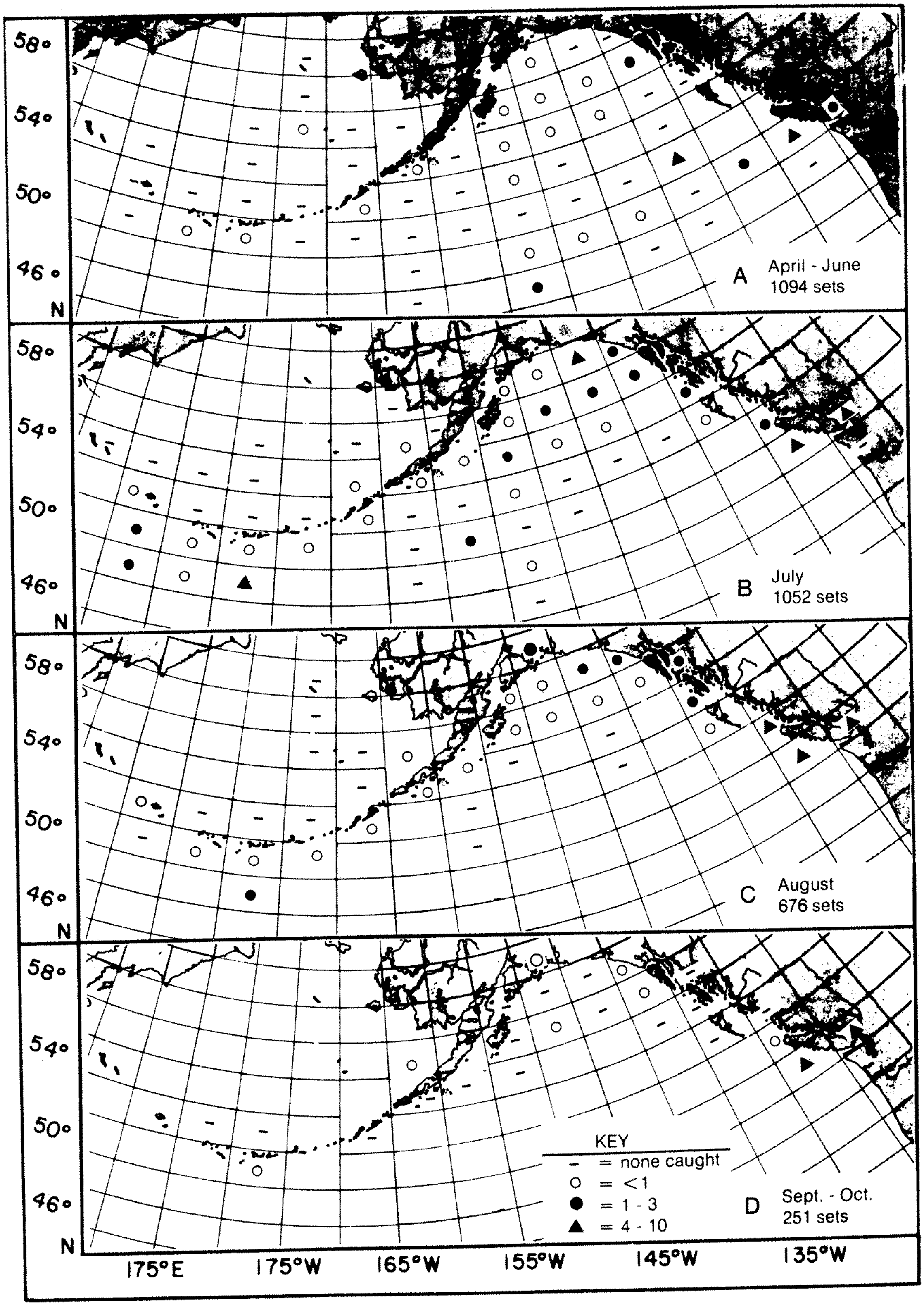


FIG. 18. Mean catch per seine set of age .1 coho salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets per area shown in Fig. 2.

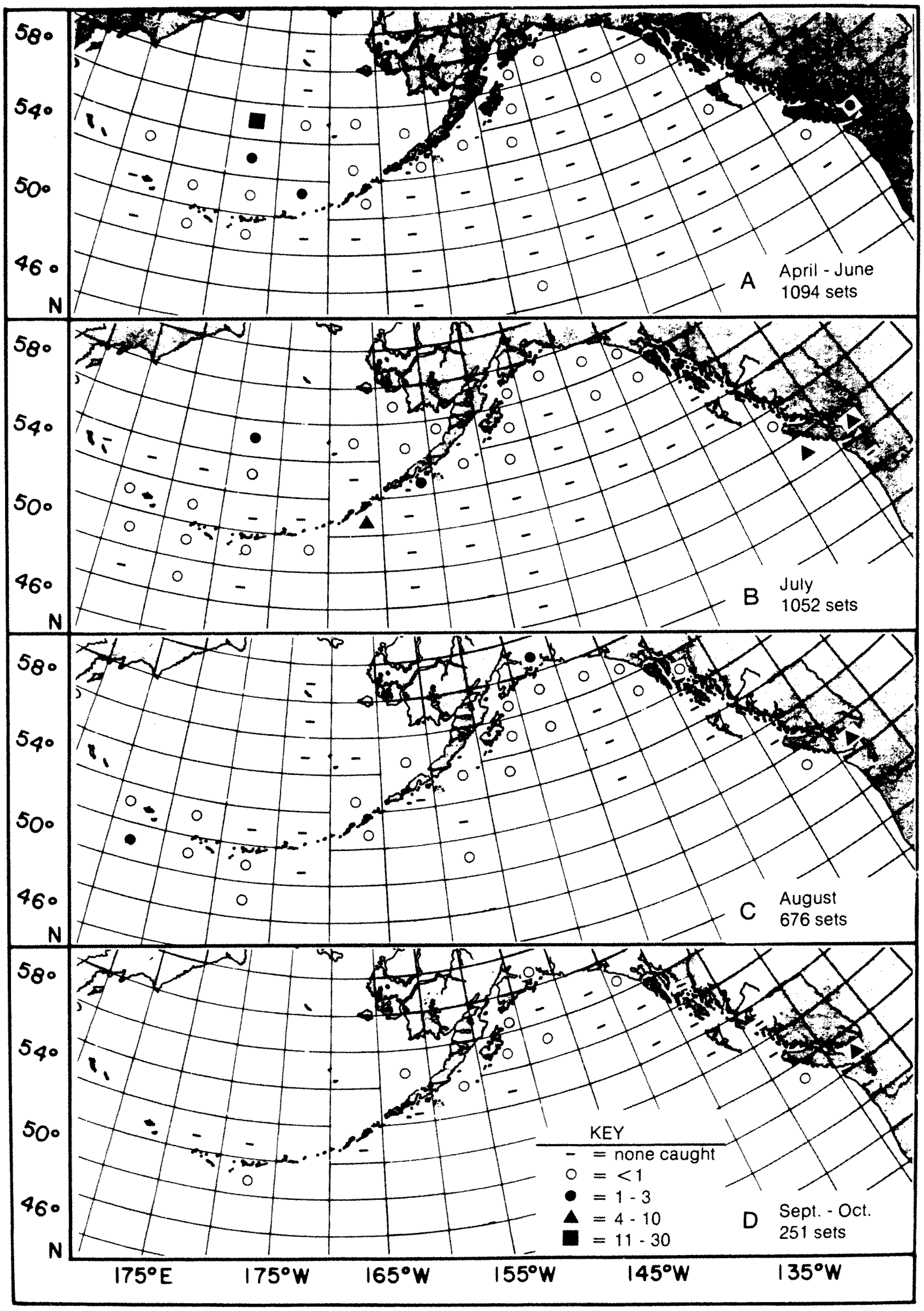


FIG. 19. Mean catch per seine set of age .1 chinook salmon by area and by time period; 3,073 sets, 1956–1970. Number of sets per area shown in Fig. 2.

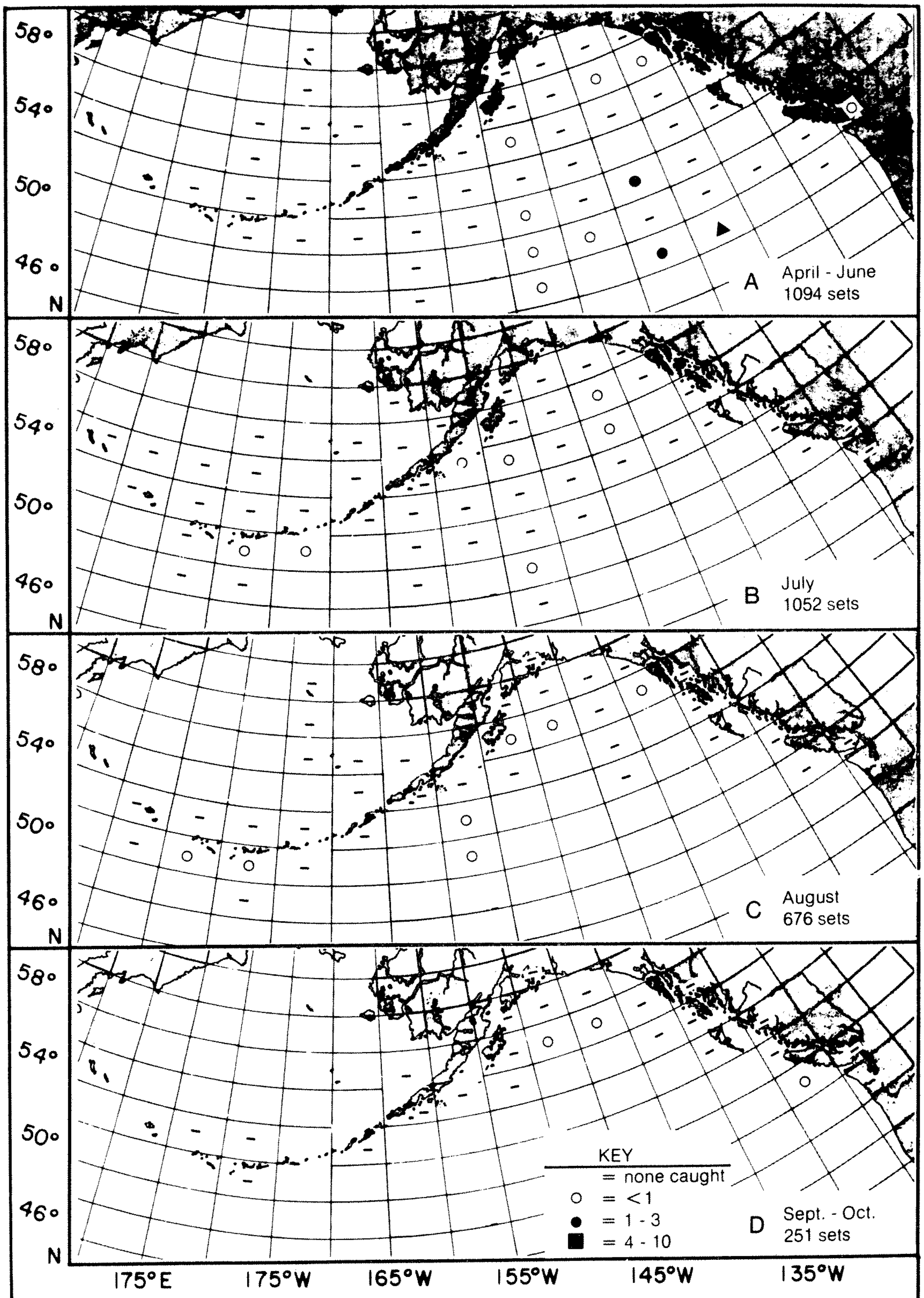


FIG. 20. Mean catch per seine set of age .1 steelhead trout by area and by time period; 3,073 sets, 1956–1970. Number of sets per area shown in Fig. 2.

TABLE 4. Numbers of juvenile and of maturing salmonids caught in nineteen pairs of purse seine sets in which the net was held open in opposite directions. (Consecutive sets made on the same dates and at the same locations along the outer coastal belt from Cape Flattery to Yakutat, 1964–1967.)

Area	Date	Set numbers	Juvenile salmonids: Net open SE	Juvenile salmonids: Net open NW or N*	Maturing salmonids: Net open SE	Maturing salmonids: Net open NW or N*
W3048	7/14/66	H–46, 47	57	25	43	33
W3048	7/26/66	H–57, 58	1,213	0	0	5
W3050	7/26/65	X–54*, 55	75	0*	9	20*
W3050	7/27/66	H–59, 60	241	0	7	74
W3050	7/6/67	X–8, 9	387	4	22	9
W4056	8/20/64	C–95, 96	49	3	4	0
W4056	8/21/64	C–97, 98	424	0	19	129
W4056	9/3/65	X–105, 106	262	5	4	2
W4056	8/5/66	H–69, 70	110	0	3	17
W4056	8/11/66	H–72, 73	426	1	33	34
W4056	8/18/66	H–77, 78	116	1	6	56
W4056	8/21/66	H–81, 82	258	14	22	27
W4056	8/29/66	H–92, 93	119	167	1	8
W4056	9/9/66	H–94, 95	31	0	0	0
W4056	7/26/67	X–27, 28	231	92	0	57
W4056	9/1/67	X–61, 62	23	95	0	14
W4058	8/15/64	C–89, 90	14	4	7	67
W4058	8/16/64	C–91, 92	1,216	9	14	5
W4058	9/10/66	H–97, 98	36	688	0	24
Total catch 19 seta			5,288	1,108	194	581
Average catch/set			278	58	10	31

* Set X–54 (area W3050) open N, all others open NW.

the age .1 group occurred during the April-June period well offshore between 46°N and 52°N and between 135°W and 145°W (Fig. 20a) where catch per set in three areas was greater than one. By contrast, several instances of greater than one per set of the age .0 group occurred in three time periods and in scattered offshore areas throughout the Gulf of Alaska (Figs. 8a, b, c). Steelhead of both age groups, however, were typically found spread thinly over broad areas. Because of the small catches, and because of the early offshore migration of the age .0 group, the distribution of catches of age .1 steelhead offers little information on the probable migrations of juvenile fish between late summer and the following spring. The scarcity of steelhead of any age in catches along the coastal belt including the Aleutian Islands indicates that steelhead, unlike salmon, tend to remain in offshore waters not only during their first summer but also during their entire oceanic life.

Migrations Inferred from Direction of Set of Seine

As discussed in the section on fishing gear, the purse seines were set in a semicircle, held open for 30 min and then closed and pursed in a standard manner. Thus, it was possible to infer the general direction of migration of salmon at the point of sampling by setting the seines in appropriate directions, and comparing the numbers caught according to the direction of set. Such information proved to be a valuable supplement to migration data derived from other lines of evidence. In previous research on mature and immature salmon, it was found that direction of migration in some areas was strongly unidirectional, whereas in other areas, migrations were opposed or random (Hartt 1962b, 1966, 1975; Royce et al. 1968). Similar migration phenomena were observed with juvenile salmon.

The most consistent evidence of directional movement was seen in our sampling along the coastal belt from Vancouver Island to Yakutat where opposed sets were frequently made. Table 4 summarizes the catches in 19 pairs of seine sets which were made to determine directional movement. Each pair of sets was made consecutively on the same date and at essentially the same location. The catch data are shown separately for juvenile and maturing salmonids according to the direction of opening of the net. Species are combined since the general trend prevailed for all.

The catches of juvenile salmon will be discussed first. In 19 sets with the net open southeast, the catch was 5,288 juvenile salmon (mean catch per set, 278), and in 19 corresponding sets with the net open north or northwest, the catch was 1,108 juvenile salmon (mean catch, 58). The dominant nature of the northwestward trend of migration is apparent.

If in fact there was a strong and continuous migration to the southeast, it should have been noted in areas farther south or in tag returns, but this was not the case. The positive nature of the northwest migration is also evident in the fact that no zero catches were made in sets open southeast, whereas six zero catches were made in sets open northwest—frequently in instances when sets open southeast yielded large catches (Table 4). The northwest migration applied to all species of juvenile salmon that were abundant enough to provide significant catches. Migration was also apparently continuous from area W3048 to area W4058 between Vancouver Island and Yakutat (Table 4).

The few substantial catches in sets open northwest may have resulted from a temporary reversal of direction of migration under tidal or other influence. Factors that can cause catches to occur under such circumstances are discussed by Hartt (1966, 1975). It is of note, however, that the three instances in which catches of juvenile salmon were dominant and substantial when the net was open northwest all occurred relatively late in the season (Table 4—August 29 and September 10, 1966; September 1, 1967). It is possible that some shift in migration direction had begun, particularly in the northern areas, but the data are inadequate to draw firm conclusions.

In the case of maturing salmon, catch/set was 31 fish when the net was held open northwest, as compared to 10/set when the net was held open southeast. The results indicated some opposed migration in all areas of fishing, but with a general dominance of migration toward the southeast. The main direction of migration of maturing salmon was thus opposite to that of the juveniles. Such contrasting results help alleviate any concern that the efficiency of the seine was affected by direction of opening.

A dominant southeastward migration of maturing salmon in this area would be expected based upon observations in a number of coastal tagging experiments and in experiments relating seasonal distribution of maturing salmon at sea and locality of associated tag returns (Neave 1964). Neave found that maturing salmon of all species tended to migrate northward throughout the central Gulf of Alaska from spring to summer, and that many of them continued north of their river of origin, so that they were obliged to make a final homing migration to the southeastward. Some catch of maturing salmon irrespective of direction of opening of the seine would also be expected since fishing was done close inshore where salmon typically exhibit a to-and-fro movement as they search for their home estuaries (Verhoeven 1952).

For juvenile salmon, a northwestward migration coincides with direction of flow of the Alaskan Gyre which flows northwesterly and westerly along the eastern and northern coasts of the Gulf of Alaska (Dodimead et al. 1963; Favorite et al. 1976). Despite this coincidence of direction of current and of juvenile salmon migration, the catch data from the opposed seine sets indicate that the fish fairly consistently swim actively with the current rather than randomly while being carried passively downstream. If the latter were true, then catches should be made irrespective of direction of opening of the seine (Hartt 1966). Whether or not the fish detect and respond to the current is open to conjecture, but in any case, the presence of the current must accelerate rate of migration. A similar rapid and extensive downstream migration of both mature and immature salmon has been observed in the Aleutian Stream (Royce et al. 1968) which is an extension of the Alaskan Gyre and flows westward along the south side of the Alaska Peninsula and the Aleutian Islands (Dodimead et al. 1963; Favorite et al. 1976). The subject of the effects of currents on the measured rates of travel of juvenile salmon over long distances is discussed in the section on Growth Rates and Migration Rates.

Although relatively few purse seine sets were made in the northcentral part of the Gulf of Alaska (areas W5058 and W4558), the substantial catches made with the seine held open to the east suggest that the northwestward migration described earlier continued westward across the north-central part of the Gulf of Alaska. Two sets open east were made in area W4558 in early August in 1965 in which the catches of juvenile salmon were 279 and 284, respectively. Also in early August of 1965, three sets open east were made in area W5058 and the catches of juvenile salmon were 0, 57, and 571, respectively. Although no opposed seine sets were made, catches of this magnitude would be consistent with a westerly migration.

Average catches in area W6554 at the western tip of the Alaska Peninsula and south of Unimak Island were sufficiently large when the seine was held open northeast to suggest a southwesterly trend of migration. The most complete data were obtained in 1968 when 11 sets were made in area W6554, all of them open east or northeast. Catches ranged from 3 to

TABLE 5. Numbers of juvenile salmonids caught in eight pairs of purse seine sets in which the net was held open in opposite directions (consecutive sets made on the same dates and at the same locations in area W6556 in the eastern Bering Sea in 1966 and 1968).

Date	Set numbers	Net open NE	Net open SW
7/7/66	C–53, 54	835	62
7/28/66	C–91, 92	154	550
8/9/66	C–104, 105	91	286
8/11/66	C–108, 109	6	27
8/18/68	C–69, 70	496	17
8/25/68	C–77, 78	7	20
9/8/68	C–104, 105	9	42
9/12/68	C–107, 108	31	10
Total catch 8 sets		1,629	1,014
Average catch/set		204	127

785 juvenile salmon and averaged 128 per set. Although no opposed sets were made, the magnitude of catches suggest a southwesterly migration consistent with migrations of older age groups of salmon in this area. Commercial fishermen have, through long experience, found that both mature and immature salmon move consistently southwestward in this area from May through July. Also, in our sampling of mature and immature salmon in this area, and in area W7052 adjacent to the west, in the years 1956–1960, we found a positive southwestward movement to prevail (Hartt 1962b, 1966). The fish apparently migrate downstream in the Alaskan Stream. The migration might be considered an extension of the northwesterly and westerly migration observed in the Gulf of Alaska.

In the eastern Bering Sea, catches of juvenile salmon with respect to direction of the opening of the seine indicated variable direction of migration, sharply in contrast to that in the eastern Gulf of Alaska (Table 5). In eight pairs of sets, substantial catches were made with the net open either to the northeast or to the southwest and no zero catches occurred. The average catch in sets open to the northeast was 204, and in sets open to the southwest, 128. The net movement of fish originating in Bristol Bay estuaries is undoubtedly to the southwest (Straty 1974), but it is apparently not a directed, positive migration as in the Gulf of Alaska. The different behavior in the eastern Bering Sea is probably related to geographic and oceanographic conditions. In contrast to the steep and narrow continental shelf in eastern Gulf of Alaska and south of the Alaska Peninsula, the continental shelf in eastern Bering Sea is broad and flat with depths less than 30 fathoms extending 50 to 100 miles offshore. As a result, tidal currents are strong and variable (Hebard 1959). In this part of the Bering Sea a counterclockwise gyre flows northeastward along the north side of the Alaska Peninsula, and then northward and northwestward along the northern coast of Bristol Bay. Thus, juvenile salmon must migrate against the residual currents in proceeding seaward rather than with the current as in the Gulf of Alaska and south of the Alaska Peninsula. Food availability may also have a part in affecting the pattern and speed of seaward migration. Dense schools of euphausiids and larval fish were observed in the seine during brailing much more frequently in the eastern Bering Sea than in other areas (Hartt et al. 1970). Such rich feeding conditions may explain the lingering behavior of juvenile salmon.

MIGRATIONS INFERRED FROM TAG RETURNS

Tag returns provided the most definitive information on migrations of juvenile salmon, and also corroborated migrations inferred from seasonal catch data and from catches with respect to direction of opening of the seine. Although the numbers of tag returns were limited, they were sufficient to identify some major stocks present in areas where juvenile salmon were abundant and to show that migration can be rapid and extensive during the first ocean summer.

Tag returns occurred in the year of tagging and up to 4 years later, depending upon species and age at maturity. Some were recovered in the year of tagging while still juveniles. These types of recoveries added further information on migrations. The chief assumption necessary in determining migrations of tagged juvenile salmon is that the fish originated at or near the location where it was recovered as a maturing fish. Thus, a juvenile salmon is assumed to have migrated seaward from the recovery point to the point at which it was captured and tagged. In most instances the assumption was satisfied, since recoveries typically occurred in coastal or estuarine fisheries, and some tagged fish were recovered in rivers. In a few instances, however, recoveries occurred at points that were obviously far from the final destination of the fish.

Sockeye Salmon Tag Returns

The numbers of juvenile sockeye salmon tagged during the years 1956–1968 are summarized in Fig. 21 by convenient geographic areas together with a breakdown of totals by years. Also summarized are numbers of returns by year of release and year of recovery, and percent of returns. The numbers tagged were in rough proportion to their abundance in our catches. Nearly all of the tagging in the Gulf of Alaska was in the years 1964–1968, and in the Bering Sea and south of the Alaska Peninsula in 1966, 1967, and 1968. Only 528 of the total were tagged in the years prior to 1964. Forty-one tag returns were received from the total of 10,411 released in all years. Overall rate of return was 0.4 percent, and by years of release this rate varied from 0 to 0.6 percent. Rates of return are not directly comparable by area or by year because of a number of factors such as the type of tag used, methods of handling fish, the percentage of the run of mature fish that was taken in the commercial fishery versus the numbers allowed to escape, and the size and condition of the fish tagged.

The release and recovery locations for the 41 returns are diagrammed in Fig. 22. Detailed release and recovery information for individual fish is given in Appendix Table A2. In Fig. 22 release locations are shown as circles and arrows are drawn to recovery locations. The actual migrations during the 2 or 3 years between release and recovery are, of course, not indicated, although much is known about the annual migrations of the major stocks of sockeye salmon during their total oceanic sojourn (French et al. 1976; Hartt 1966; Neave 1964; Royce et al. 1968). The key information conveyed by the diagram is that the juvenile fish must have migrated from their home estuary to point of tagging during their early ocean life. Thus, for those fish recovered in " terminal " fishing areas, the migration arrows should be viewed in reverse, i.e., that the fish, while still a juvenile, had migrated from the arrowhead to the circle during the interval between leaving their home estuaries and their capture at sea for tagging. In a later section the subject of probable migrations between tagging and recovery will be discussed, based upon seasonal distribution and upon tag returns from sockeye tagged at age .1 or older.

In the western release areas, we received no returns from 51 juvenile sockeye salmon tagged in areas west of 165°W (Fig. 21), while the 5,550 fish released in area W6556 in the Bering Sea yielded 11 returns. These were all from fish released in 1968 when 4,452 of the total were tagged. The distribution of tag recoveries was as follows (Fig. 22 and Appendix Table A2): one in the Japanese high seas mothership fishery in 1971 south of Attu Island at 49°0′N, 173°26′E; one from the United States coastal fishery south of Unimak Island in 1971; eight in the Bristol Bay commercial fishery (five in 1970, three in 1971); and one in either Bristol Bay or south of the Alaska Peninsula near False Pass, probably in 1970.[9]

The distribution of returns confirmed that the juvenile salmon which occur in heavy concentration along the north side of the Alaska Peninsula (Fig. 3) are primarily of Bristol Bay origin. The two returns from outside of Bristol Bay were within the known time-space distribution of Bristol Bay sockeye based upon tagging of mature fish and immatures of age .1 and older. The fish recovered in the Japanese high seas fishery at age .3 was near the southwest limit of the known distribution of Bristol Bay sockeye based upon tagging of mature fish. It was recovered on May 25, 1971, and would have had ample time to traverse the 1,200 nm return journey by early July when the peak of migration occurs in Bristol Bay estuaries. Tagged maturing sockeye frequently travel 30 nm per day during their last 30–40 days at sea (Hartt 1962b, 1966). Another fish recovered June 15, 1971 in the United States fishery south of Unimak Island was in all likelihood en route to Bristol Bay. A substantial number of Bristol Bay sockeye pass westward through this area in June each year as they return from feeding areas in the north-central Gulf of Alaska (French et al. 1976).

The eight known returns from Bristol Bay were distributed to river systems as follows: Nushagak River—4; Naknek-Kvichak Rivers—2; Egegik River —1; Bear River (north side of the Alaska Peninsula) —1. Despite the small numbers returned, the results suggest that the juvenile sockeye in the eastern Bering Sea in August and September are a mixture from all Bristol Bay rivers as well as from streams of the north side of the Alaska Peninsula. Although we received

[9] The uncertainty of location and year came about because the tag was discovered in a can of salmon in 1972. From the label on the can it was possible only to determine that the fish most likely had been canned in 1970, but possibly in 1971, at False pass, Alaska. Most of the sockeye canned by this cannery in 1970 and 1971 were caught in Bristol Bay and a relatively small proportion was caught south of the Alaska Peninsula. It is not surprising that a tag of this type should be found in a can of salmon. Very little of the tag protrudes from the body after 2 or 3 year's growth so that the tags are frequently not seen during the catching and processing of the mature fish.

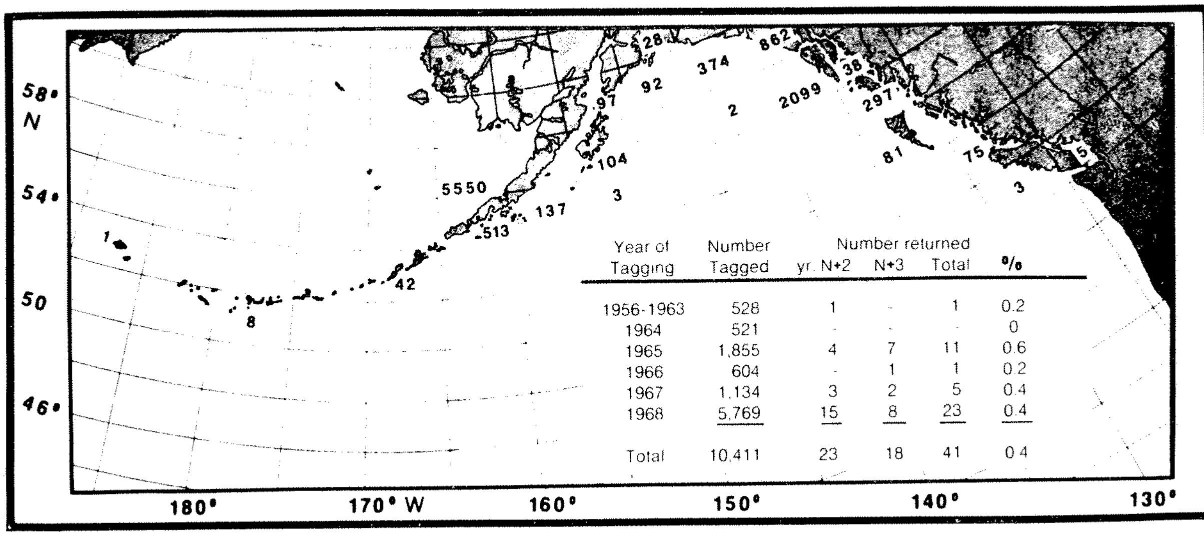


FIG. 21. Numbers of juvenile sockeye salmon tagged, 1956–1968, by geographic area, and numbers returned by years of release and recovery and percent returned.

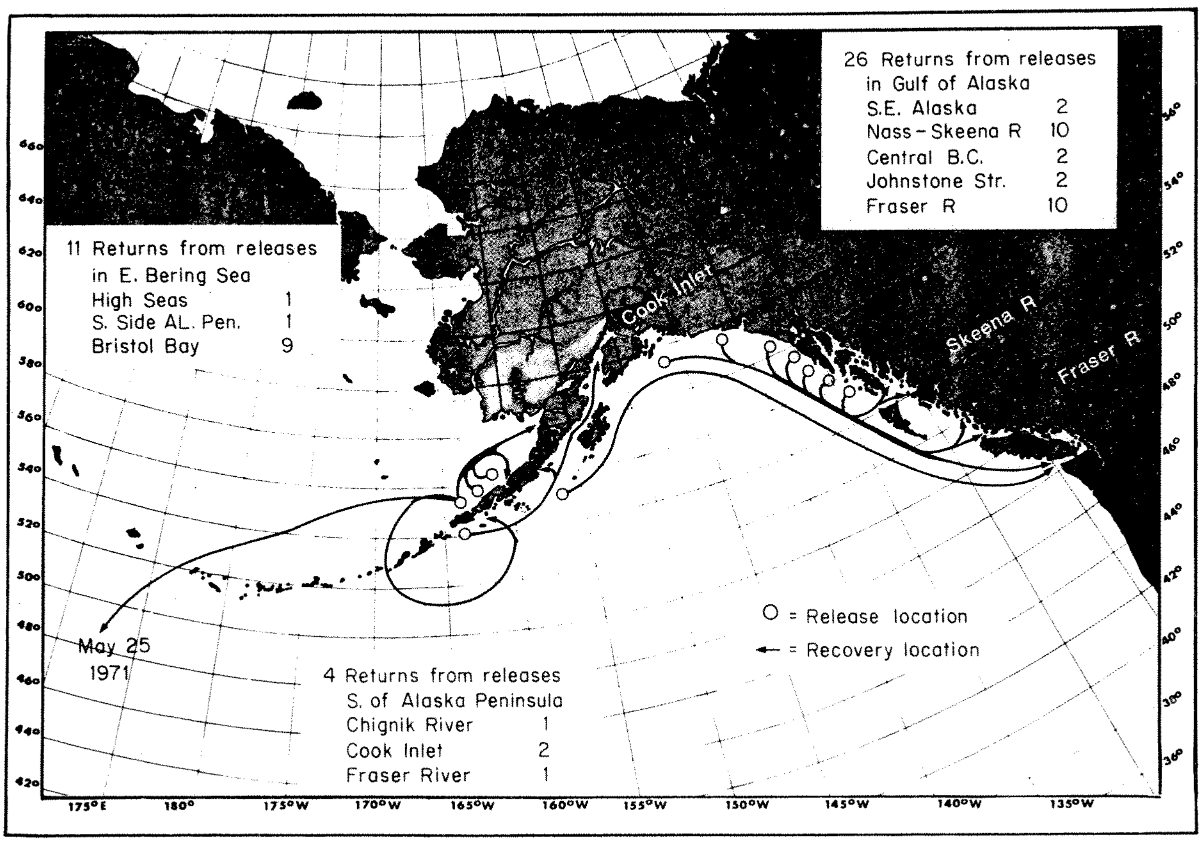


FIG. 22. Release and recovery locations for 41 sockeye salmon tagged as juvenile fish and recovered 2 or 3 years later. Release years: 1958 and 1965–1968; recovery years, 1960 and 1967–1971. Source: Appendix Table A2.

no tag returns from the Ugashik River, the presence of Ugashik River fish among our samples was shown by our capture of a juvenile sockeye on September 7, 1967, north of Unimak Island at 55°36′N×162°57′W that had been dye-marked by biologists of the National Marine Fisheries Service (NMFS) in the Ugashik River between May 29 and June 3, 1967. The specimen had been marked in connection with a comprehensive study of the early estuarine and marine life of juvenile salmon in Bristol Bay (Straty and Jaenicke 1971).

The rate of return of the juvenile sockeye salmon released in the eastern Bering Sea in 1968 was 11/4,452 or about 0.2 percent. This is much lower than the annual return rates of age .1 immature sockeye salmon (0.5–3.0 percent) tagged south of the central Aleutian Islands and recovered in Bristol Bay or in the Japanese high seas fishery 1 or 2 years later (Hartt 1966). The low rate of return of juvenile salmon may be attributed to several factors: 1) tagging mortality, which, though unmeasured, must be high considering the size and fragile nature of juvenile sockeye salmon; 2) poor visibility (as compared to the 3/4-inch disk tags used on age .1 sockeye) of the short portion of tag protruding from the body of the fish at recovery; and 3) natural mortality during the 2 or 3 years between tagging and recovery.

The 650 juvenile sockeye salmon tagged south of the Alaska Peninsula in areas W6554 and W6054 yielded four returns. One was recovered in the Chignik River on the south side of the Alaska Peninsula, two in Cook Inlet and one in the Strait of Juan de Fuca (Fig. 22). The latter was most probably destined for the Fraser River. Thus, juvenile sockeye salmon in this area are a mixture from very widespread sources. The three Alaskan recoveries must have migrated as juvenile fish southwestward along the coast to the point where they were tagged south of Unimak Island. The specimen recovered in the Strait of Juan de Fuca presumably reached the tagging location by following the coast northwestward, westward, and finally southwestward to the point of tagging. Via this coastal route, it would have traveled over 1,500 nm by August 30 when it was tagged.

All three of the recoveries of fish released in area W6554 south of Unimak Island were from 1968 releases. One was recovered in 1970 (Cook Inlet) and two in 1971 (one in Chignik River and one in Cook Inlet). The specimen tagged south of the Alaska Peninsula in area W6054 and recovered in the Strait of Juan de Fuca was released in 1958 and recovered in 1960.

The rate of return from releases in area W6554 in 1968 was 3/513 or 0.6 percent. The rate of return from releases in area W6054 in 1958 was 1/58 or 1.7 percent. These rates of return were substantially higher than the 0.2 percent rate of return of fish tagged in area W6556 in the eastern Bering Sea. The higher rate may have resulted from the larger size of fish tagged south of the Alaska Peninsula as compared to those in the Bering Sea. The mean fork lengths were about 16 cm in the Bering Sea and about 22 cm south of the Alaska Peninsula.

We received no tag returns from 204 juvenile sockeye salmon released in the three rectangles adjacent to Kodiak Island between 150° and 155°W (Figs. 21 and 22).

We received 26 returns from among 3,792 juvenile sockeye salmon tagged along the northeast coast of the Gulf of Alaska from area W5058 south of Prince William Sound to area W3554 which includes Dixon Entrance, between southeastern Alaska and British Columbia (Fig. 1). Release and recovery locations for these returns are shown in Fig. 22. Two were recovered in southeastern Alaska, 10 in the Nass-Skeena River areas of British Columbia, two in central British Columbia, two in Johnstone Strait, and 10 in the Fraser River or its approaches. In all cases recovery location was southeast of release location, indicating that as juvenile fish, these sockeye had migrated northwestward from their points of origin toward the respective tagging locations. Fifteen were recovered 2 years after tagging and 11, 3 years after tagging. Fourteen were recovered in more northerly areas between Rivers Inlet, British Columbia, and the northern part of southeastern Alaska, and 12 were recovered farther south and were primarily destined for the Fraser River. The two recovered from Johnstone Strait were arbitrarily placed in this group.

The overall rate of tag return of sockeye released in the northeastern Gulf was 26/3,792 or 0.7 percent for all years combined. This relatively high rate was probably because the juvenile fish released in this area were relatively large (mean fork length ranging from 17–20 cm). A second contributing factor might be that sockeye stocks in the recovery areas are generally subjected to a high rate of exploitation, and the probability of tag returns is considerably higher among fish caught in a commercial fishery than among those contributing to the escapement.

Further information on migrations of juvenile sockeye salmon is available in the tag recovery of sockeye tagged at sea at age .1 and recovered the same year as "jacks" in estuaries or streams. Eighteen such returns were received from tagging by Canada and the United States in the Gulf of Alaska and eastern Bering Sea (Fig. 23). These age .1 fish were tagged between May 19 and August 14 and

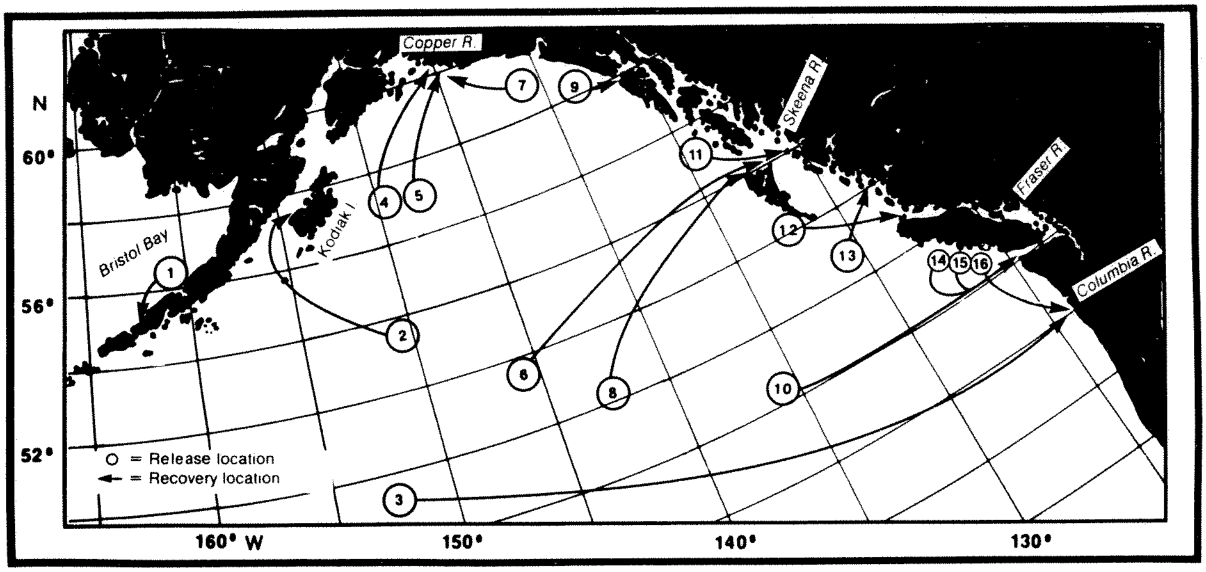


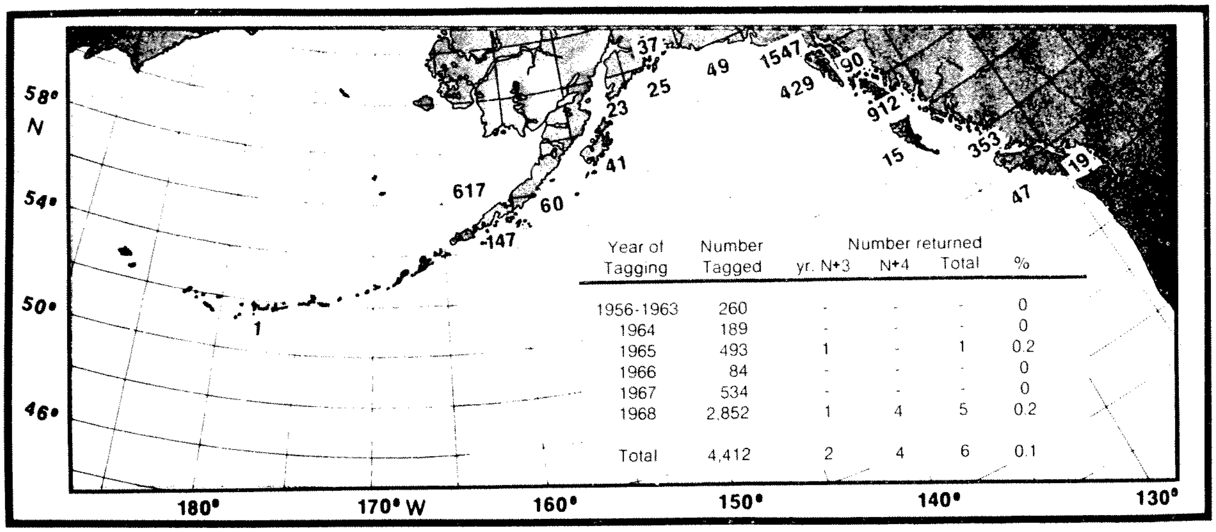
FIG. 23. Release and recovery locations of 18 sockeye salmon that were tagged as age .1 fish and were recovered in the same year in estuaries or streams. (Nos. 17 and 18 released in Strait of Juan de Fuca and recovered in Fraser River.) Source: unpublished tables of Canadian and United States tagging, 1960–1968.

ranged in length from 33 to 47 cm. The results indicate that sockeye salmon were by their second summer dispersed widely throughout the Gulf of Alaska. The tag returns are from roughly the same production areas as were the tag returns of age .0 fish shown in Fig. 22. Thus, a comparison of Figs. 22 and 23 indicates that juvenile salmon must migrate extensively offshore and southward sometime between their first and second summers at sea. This offshore migration was similar to that inferred from the relative catch distributions of ages .0 and .1 sockeye discussed previously (Figs. 3 and 15).

The distribution of tagging and recovery locations in Fig. 23 indicates that at least some of the jack sockeye salmon migrate extensively during their 1+ years at sea. Presumably, some of them were caught and tagged near the extreme limits of their migration, whereas others had migrated considerably shoreward before being tagged. The single jack recovered in the Bering Sea was tagged relatively close to point of recovery, so that it is not known how far the jacks from Bristol Bay may migrate. It appears, however, that Bristol Bay jacks may not leave the Bering Sea and enter the Pacific Ocean, since no coastal returns in the year of tagging have been received from the many thousands of age .1 sockeye tagged south of the Aleutian Islands (French et al. 1976). In contrast, age .2 sockeye tagged near the central Aleutians as late as July 14, have yielded coastal returns from Bristol Bay in the year of tagging. The lack of returns of jacks, however, may be partly because jacks are relatively scarce among Bristol Bay stocks as compared to Gulf of Alaska stocks.

Tag returns have further shown that immature age .1 sockeye have a wider distribution than do maturing jacks (French et al. 1976, Figs. 65–67). This would be expected since the nonmaturing group are free to continue their seaward migration during their second summer without the time constraint of the homing migration. The tagging reported by French et al. (1976) showed that age .1 immature sockeye salmon originating in Gulf of Alaska coastal areas are distributed as far west as the western Aleutian Islands (176°E) and age .1 sockeye originating in Bristol Bay are distributed in the Pacific Ocean along the full length of the Aleutian Islands as well as widely in the central and northwestern Bering Sea.

Thus, the results of the tagging of the age .1 group indicate that the extensive first summer's migration of juvenile sockeye seen in Fig. 22 is only a portion of their total seaward migration. Obviously, the mixture of stocks which had reached the northwestern Gulf of Alaska during their first summer must have continued to migrate far to the west in the Alaskan Stream so that in their second summer some had reached the western Aleutian Islands. The proportion that make this long westerly migration is not known. Others of the same group in their second summer were distributed widely in offshore waters of the Gulf of Alaska southward at least to 48°N. The



Year of Tagging	Number Tagged	Number returned yr. N+3	N+4	Total	%
1956-1963	260	-	-	-	0
1964	189	-	-	-	0
1965	493	1	-	1	0.2
1966	84	-	-	-	0
1967	534	-	-	-	0
1968	2,852	1	4	5	0.2
Total	4,412	2	4	6	0.1

FIG. 24. Numbers of juvenile chum salmon tagged, 1956–1968, by geographic area, and numbers returned by years of release and recovery and percent returned.

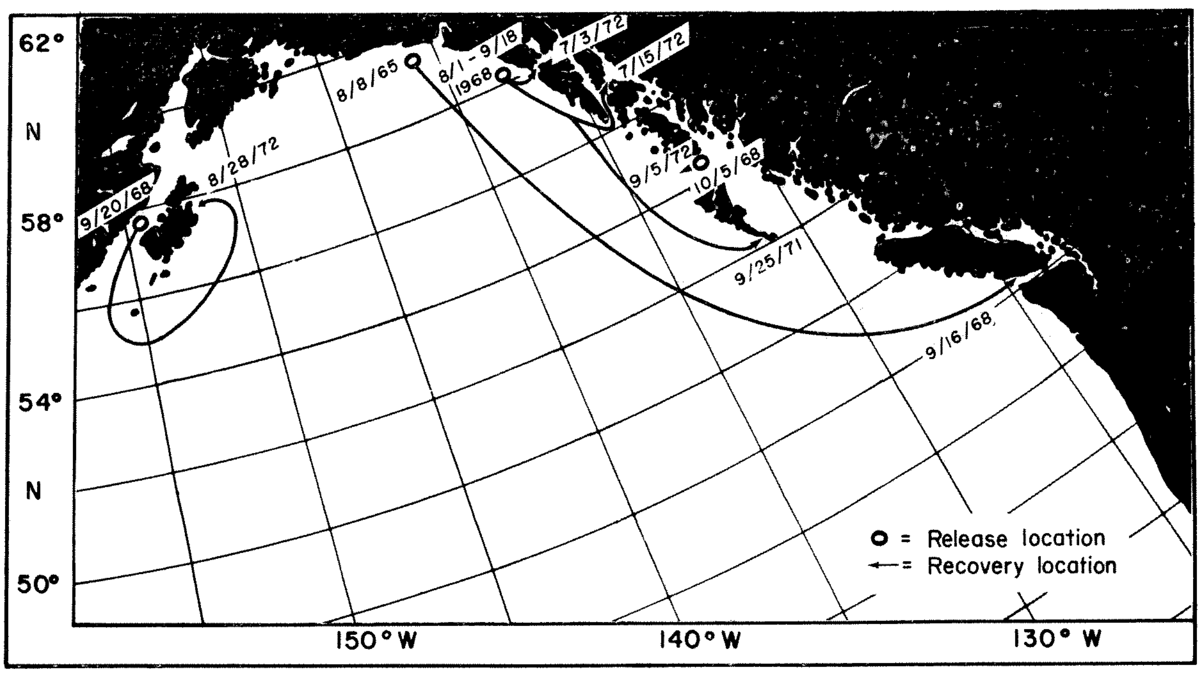


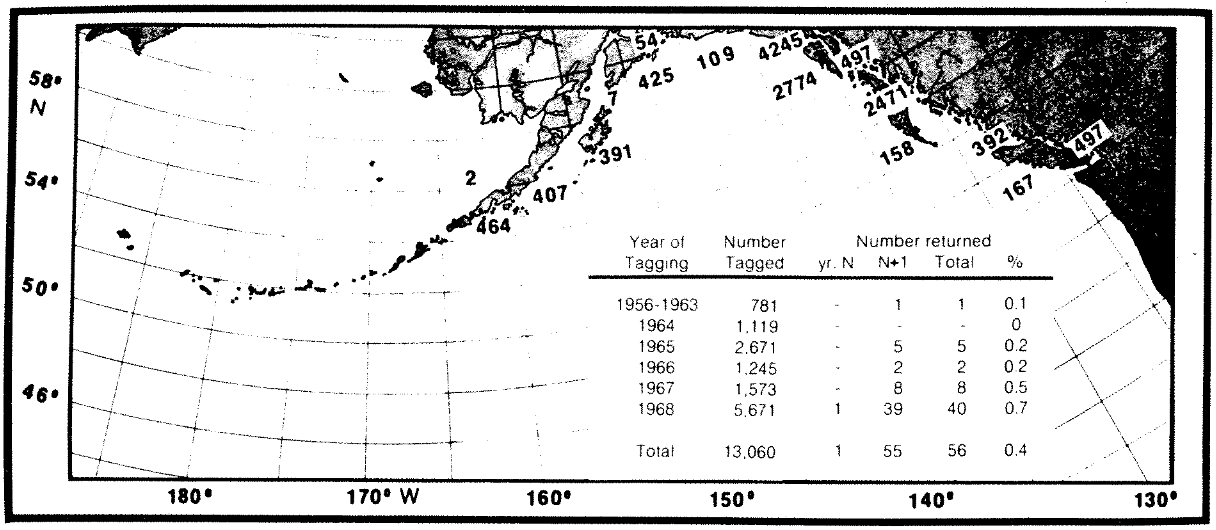
FIG. 25. Release and recovery locations for six chum salmon tagged as juvenile fish and recovered 3 or 4 years later. Source: Appendix Table A3.

locations and time periods in which the offshore migrations of juvenile salmon began are not known.

Chum Salmon Tag Returns

The numbers of juvenile chum salmon tagged during the years 1956–1968 are shown in Fig. 24. As in the case of sockeye salmon, the chum salmon were tagged roughly in proportion to their abundance in the catches. Nearly all of the tagging in the Gulf of Alaska was in the years 1964–1968 and in the Bering Sea and south of the Alaska Peninsula in 1966, 1967, and 1968. Only 260 of the releases were in years prior to 1964.

Only six chum salmon tag returns were received,



Year of Tagging	Number Tagged	Number returned yr. N	N+1	Total	%
1956-1963	781	-	1	1	0.1
1964	1,119	-	-	-	0
1965	2,671	-	5	5	0.2
1966	1,245	-	2	2	0.2
1967	1,573	-	8	8	0.5
1968	5,671	1	39	40	0.7
Total	13,060	1	55	56	0.4

FIG. 26. Numbers of juvenile pink salmon tagged, 1956–1968, by geographic area, and numbers returned by years of release and recovery and percent returned.

five from the 1968 releases and one from the 1965 releases (Fig. 24). The overall rate of return was only 6/4,412 or 0.1 percent. The release and recovery locations for the six returns are diagrammed in Fig. 25. The migration pattern of chum salmon was similar to that of sockeye, in that recovery locations were generally south of release locations. Thus, the chums as juveniles had migrated northward along the coast prior to being captured and tagged. The one specimen tagged in Shelikof Strait had apparently moved west or southwest of its point of origin which is in agreement with the southwestward migration inferred earlier from seine catch data in this area. Detailed information on release and recovery including lengths, is provided in Appendix Table A3.

Pink Salmon Tag Returns

The numbers of juvenile pink salmon tagged during the years 1956–1968 are summarized in Fig. 26. As with sockeye and chum salmon, the numbers of pink salmon released were roughly in proportion to the abundance in our catches. Tagging in the northeastern Gulf of Alaska was mainly in the years 1964–1968, whereas south of the Alaska Peninsula, tagging was mainly in the years 1966, 1967, and 1968. Only 781 juvenile pink salmon were tagged in the years prior to 1964—the first year in which juvenile salmon were a major sampling objective. A total of 56 tag returns was received from the 13,060 released—1 in the year of release and 55, one year later. The overall rate of return of 0.4 percent compares with the 0.4 percent for sockeye (Fig. 21), and 0.1 percent for chum (Fig. 24), but the rates are not directly comparable among species because of the differences in time between tagging and recovery.

The complete lack of returns of pink salmon as well as sockeye and chum salmon from the tagging experiments of 1964 (Figs. 21, 24, 26) was very likely due to the type of tag used that year. We used a single barbed dart tag that was inserted into the dorsal musculature just under the skin by means of a hollow needle 3.2 mm in diameter. As found by Dell (*see* footnote 6) this type of tag was frequently shed, particularly when applied to salmonids less than 20 cm long. Thus, the zero return from releases of sockeye, chum, and pink salmon in 1964 should not be viewed as comparable with other years.

The release and recovery locations for 55 pink salmon recovered 1 year after tagging are shown in Fig. 27 according to odd-numbered and even-numbered years. Detailed release and recovery data are available in Appendix Table A4.

All of the 14 returns from fish released in odd-numbered years (Fig. 27a) were from southeastern Alaska. Two of the returns were from unknown locations in southeastern Alaska. The remaining 12 were mainly from inside channels and estuaries and may have been nearing their respective points of origin when recovered. In general, the returns were from points southeast of the release locations, so that the fish, during their first summer, had migrated northwestward toward the tagging locations. Because of the extensive network of sounds and channels in southeastern Alaska, the actual seaward routes followed by juvenile salmonids cannot be inferred. Verhoeven (1952) showed that returning adult pink salmon wander to

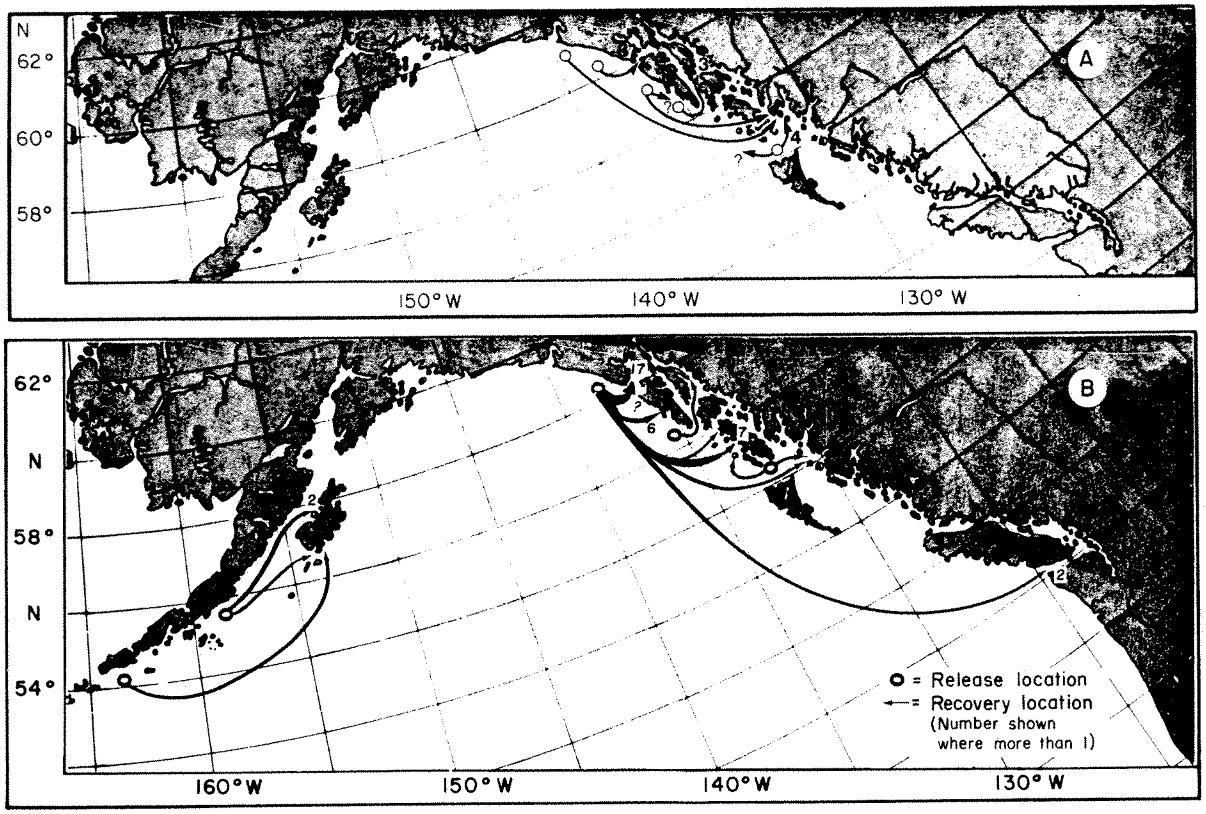


FIG. 27. Release and recovery locations for 55 pink salmon tagged as juvenile fish and recovered 1 year later. A=14 fish released in odd-numbered years; B=41 fish released in even-numbered years. Source: Appendix Table A4.

and fro extensively in their final homeward migrations. The seaward migrations of juvenile pink salmon may be of a similar nature.

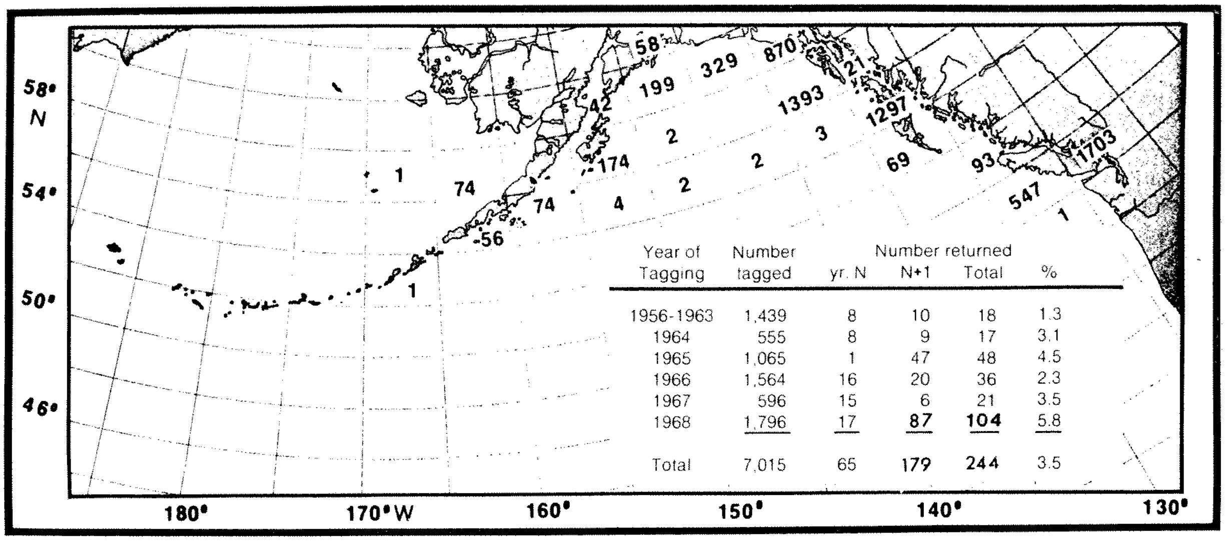
The 41 tag returns from pink salmon released in even-numbered years are shown in Fig. 27b. From 871 juvenile pink salmon released in areas W6554 and W6054 south of Unimak Island and the Alaska Peninsula (Fig. 26) we received four returns, all from Kodiak Island. These fish had apparently migrated southwestward along the south side of the Alaska Peninsula during their first summer at sea in a pattern similar to that observed for sockeye and chum salmon (Figs. 22 and 25). All four of these recoveries were from releases in 1968 (Appendix Table A4). Dates of release were September 15 and 18. Thus, the juvenile pink salmon from Kodiak Island were distributed over a range of at least 400 nm by mid-September. The rate of return from releases in these western areas considering all years was 4/871 or 0.5 percent.

Tagging in the vicinity of Kodiak Island and the north-central Gulf of Alaska yielded no returns (391 releases in area W5556, 425 in area W5058, and 109 in area W4558; Fig. 26).

Tagging in the northeastern Gulf of Alaska in even-numbered years yielded 37 returns. The general pattern of migration was similar to that of the fish released in odd-numbered years. Thirty-three returns were from points in southeastern Alaska and two were from the Nass-Skeena River areas of British Columbia. Another two returns were from far to the south; one from the Fraser River and one from the San Juan Islands, a fish which might also have been destined for the Fraser River. Release dates for these two fish were August 12, 1966, and July 29, 1968. Thus, they must have migrated over 800 miles toward the northwest by late July and early August of their first summer at sea.

In summary, the migrations of juvenile pink salmon in both odd- and even-numbered years were similar to those of the sockeye and chum salmon (Figs. 22 and 25).

In addition to the 55 pink salmon recovered as maturing fish a year after tagging, one tagged specimen was recovered by our own research vessel 22 days after release. The fish was tagged August 8,



Year of Tagging	Number tagged	Number returned yr. N	N+1	Total	%
1956-1963	1,439	8	10	18	1.3
1964	555	8	9	17	3.1
1965	1,065	1	47	48	4.5
1966	1,564	16	20	36	2.3
1967	596	15	6	21	3.5
1968	1,796	17	87	104	5.8
Total	7,015	65	179	244	3.5

FIG. 28. Numbers of juvenile coho salmon tagged, 1956–1968, by geographic area, and numbers returned by years of release and recovery and percent returned.

1968, in area W3554 in the entrance to Cordova Bay which lies between Dall Island and Prince of Wales Island just north of Dixon Entrance (*see* Fig. 1). It was recovered within a mile or two of the release location on August 30 (Appendix Table A4). The fork length at tagging was 15.6 cm. It was noted that the tag wound appeared to be healing well. It is unknown, of course, whether the fish had remained in the vicinity of tagging for the full 22 days or whether it had migrated elsewhere and returned.

No tag returns were received from juvenile pink salmon released in areas south of 54°N despite the fact that 1,214 were tagged in these areas (158 tagged in area W3552, 392 in area W3050, 167 in area W3048, and 497 in area W2548, Fig. 26). A major cause of the lack of returns was presumably tagging mortality resulting from the smaller size of fish released in these areas, which will be discussed in more detail in a later section. The same phenomenon occurred with sockeye and chum salmon and probably for the same reason.

Coho Salmon Tag Returns

More information was derived from the coho salmon tagging than from the other species because there were more returns and a higher rate of return. The numbers of juvenile coho salmon tagged during the years 1956–1968 are summarized in Fig. 28 by geographic area together with a summary of releases and returns by year. The distribution of tagging was roughly in proportion to their abundance in our catches. A total of 244 tag returns were received from the 7,015 released in all years. Overall rate of return was 3.5 percent, and the annual rate ranged from 1.3 to 5.8 percent. Sixty-five were recovered in the year of release (0.9 percent) and 179 in the year after release (2.6 percent). Some reasons for the relatively high rate of return of tagged coho salmon are: 1) since juvenile coho salmon were larger than sockeye, chum, or pink salmon at tagging they presumably retained their tags better and suffered lower tagging and natural mortalities; 2) cohos are more available to recovery in the year of tagging as well as a year later, and are commonly recovered in both sport and commercial fisheries and in both marine and fresh waters; and 3) a substantial number of cohos were tagged in the Strait of Juan de Fuca where sport and commercial fisheries are intense, and where tag return efficiency is probably high.

Returns 1 Year After Tagging. Tag returns 1 year after release will be discussed first. Details of release and recovery are available in Appendix Table A5. The results of tagging in areas west of 140°W are summarized in Fig. 29. No returns were received from 75 juvenile cohos tagged in the Bering Sea. Twelve returns were received from 943 releases in the North Pacific between 140°W and 167°W (1.3 percent). Three fish tagged south of the Alaska Peninsula and recovered in Cook Inlet, indicated a southwestward migration of some Cook Inlet cohos during their first summer. A fish tagged south of Kodiak Island and recovered off the Oregon coast had undergone the longest first summer's migration observed in our study. If the recovery location was near the stream of origin, the fish when tagged was about 1,200 nm away. If the age .0 juvenile had followed the coastline, which

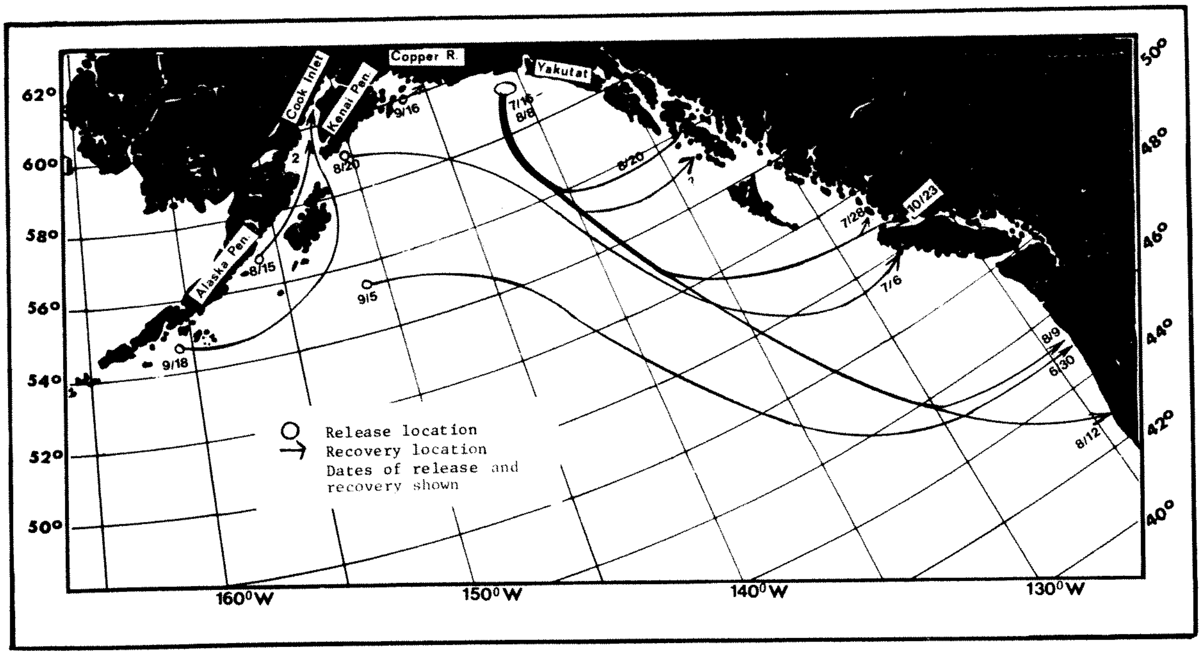


FIG. 29. Release and recovery locations for 12 coho salmon tagged as juvenile fish in areas west of 140°W and recovered 1 year later. Source: Appendix Table A5.

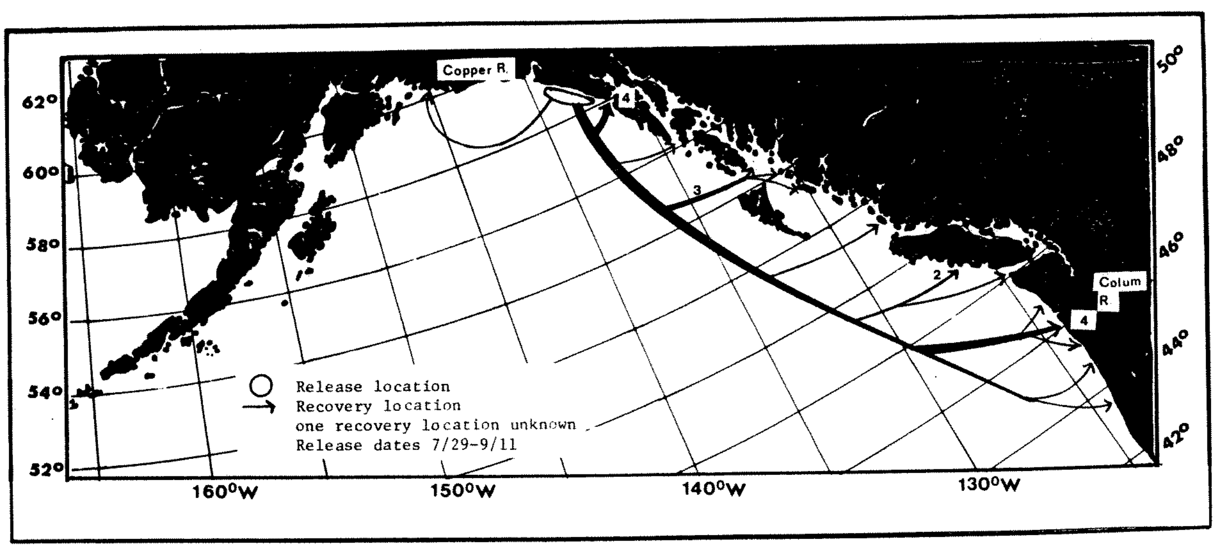


FIG. 30. Release and recovery locations for 22 coho salmon tagged as juvenile fish in area W4058 and recovered 1 year later. Source: Appendix Table A5.

is more likely, the distance traveled was about 1,600 nm. The coho was tagged on September 5, 1958, and recovered off Depoe Bay, Oregon, on June 30, 1959 (Fig. 29, Appendix Table A5). Although the origin of a mature coho caught off the coast of Oregon in late June cannot be stated with certainty, the great majority originate in streams along the Washington-Oregon-California coasts (Washington State Department of Fisheries (WDF) 1959).

Tagging off the Kenai Peninsula in area W5558 and off Yakutat in area W4558 yielded seven returns in the following year from points to the south extending from southeast Alaska to central Oregon (Fig. 29). These fish had migrated extensively northward and westward during their first summer. One specimen tagged in area W5060 just south of Prince William

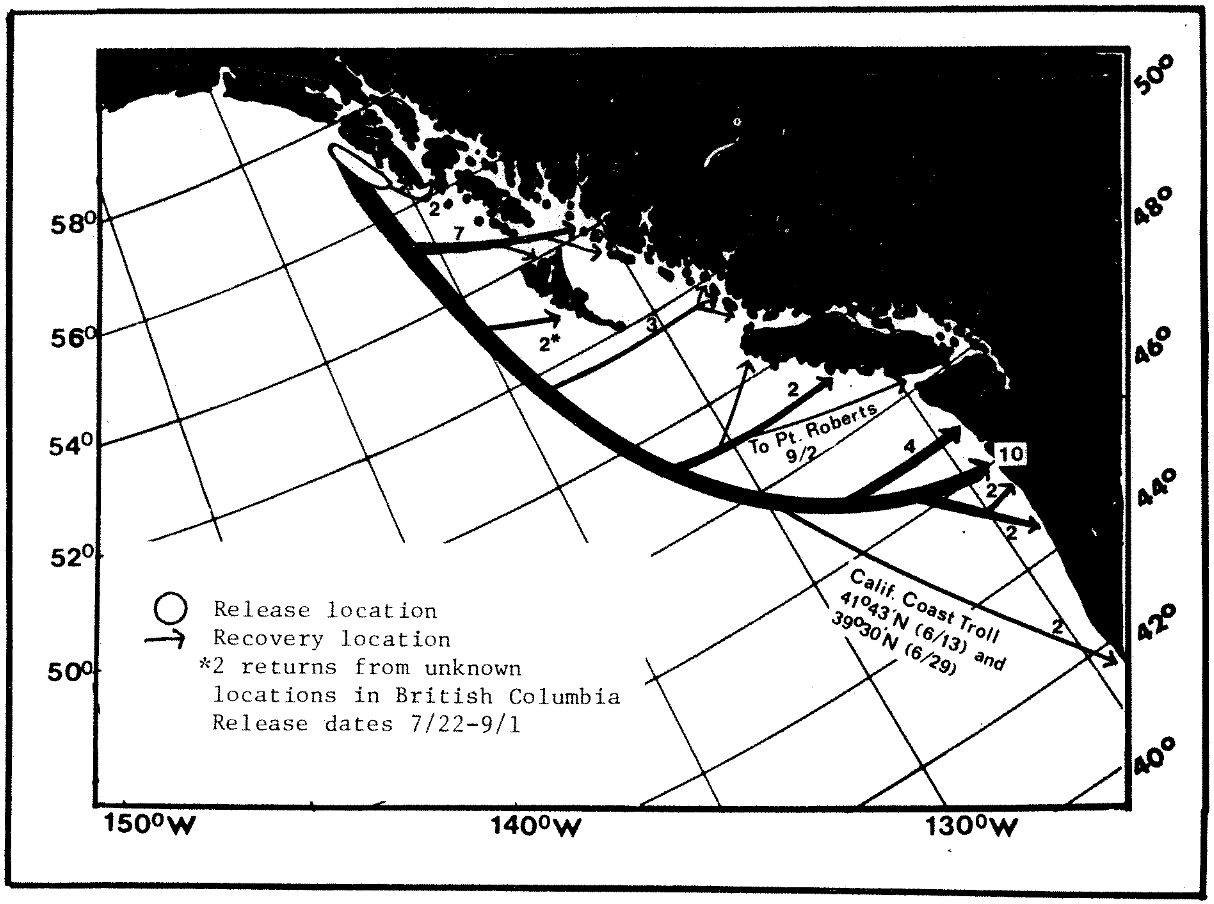


FIG. 31. Release and recovery locations for 39 coho salmon tagged as juvenile fish in area W4056 and recovered 1 year later. Source: Appendix Table A5.

Sound was recovered in the Copper River, and thus had migrated only slightly west by September 16 when it was tagged. In total, the data in Fig. 29 indicate an extensive northward and westward coastwise migration of juvenile coho during their first summer similar to that observed for sockeye, chum, and pink salmon. However, unlike sockeye, chum, and pink salmon, many cohos do not make such long migrations, as will be shown. It is noteworthy that there were no recoveries in Puget Sound or Fraser River of cohos tagged west of 140°W despite the relatively large populations of cohos returning to these two production areas. It has long been recognized that even for individual coho salmon stocks there are "ocean" types and "inside" types (Godfrey et al. 1965). It may be that among the "ocean" types there are also those that migrate much longer distances than others.

Figure 30 illustrates release and recovery information for 22 juvenile coho salmon tagged in area W4058 in the northeastern Gulf of Alaska and recovered a year later. Rate of return was 22/870 or 2.5 percent. Twenty-one returns were from coastal locations extending from the northern part of southeastern Alaska to central Oregon. One was recovered in the Copper River and had thus migrated eastward to the tagging location. The results indicate that juvenile coho in the northeastern Gulf of Alaska are a mixture of stocks originating in many production areas as far south as Oregon. Those recovered off the Oregon coast were caught by troll or sport fishing gear between June 18 and July 4, and thus may have been destined for production areas either north or south of the recovery location (WDF 1959). Again, it is noteworthy that none of the returns were from Puget Sound or the Fraser River despite the abundance of stocks returning to these areas.

Figure 31 illustrates release and recovery information for 39 juvenile coho salmon that were tagged in area W4056 off the northern part of southeastern Alaska. Rate of return was 39/1,393 or 2.8 percent. The results were similar to those for area W4058 in

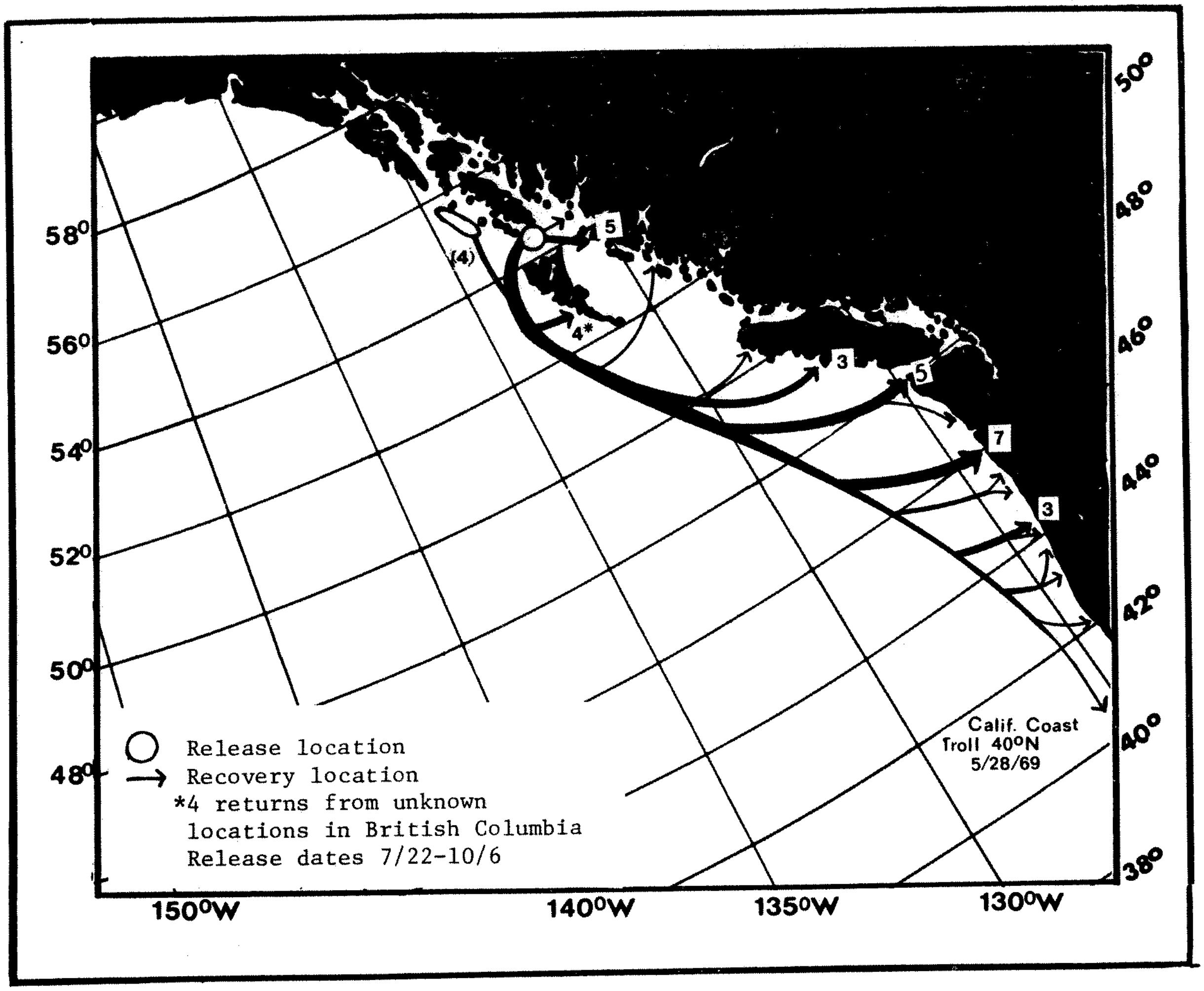


FIG. 32. Release and recovery locations for 38 coho salmon tagged as juvenile fish in area W3554 and recovered 1 year later. Source: Appendix Table A5.

showing that the tagged fish were a mixture from many production areas to the south of the release area. The dates of recovery of the two fish returned from the troll fishery off the California coast were June 13 and 29, respectively, and they may or may not have been of California origin. Maturing cohos caught off California, particularly in June, include stocks from Oregon and Washington. The single return from Point Roberts, Washington, was an indication that relatively few Puget Sound or Fraser River coho stocks migrate to the northern Gulf of Alaska during their first summer.

Figure 32 illustrates release and recovery information for 38 juvenile coho salmon that were tagged in area W3554 and recovered the following year. Rate of return was 38/1,297 or 2.9 percent. Four were tagged west of Prince of Wales Island and 35 in the northern part of Dixon Entrance, mainly in Cordova Bay between Dall Island and Prince of Wales Island. Recoveries occurred at many coastal locations southward to California. As noted on Fig. 32, the southernmost recovery occurred on May 28 at 40°N in the California troll fishery. The final destination of this fish was likely a stream of either Oregon or California, based upon studies of mature cohos in this area (WDF 1959). The distribution of the five returns indicated by the arrow pointing to the Strait of Juan de Fuca included four from the outer strait west of 124°W and one from the inner strait off Port Townsend at the north entrance to Admiralty Inlet. The final destinations of these five fish cannot be stated with any certainty. The complete lack of returns from southeastern Alaska suggests that juvenile cohos from this source were not present among samples tagged. This would indicate that cohos from southeastern Alaska migrate northward during their first summer, which

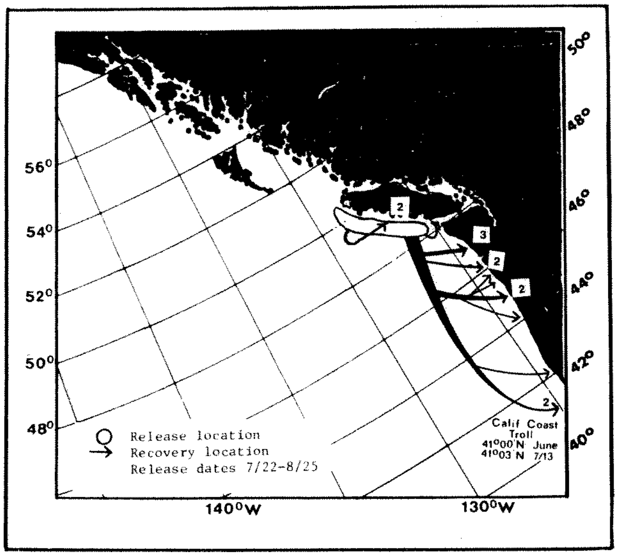


FIG. 33. Release and recovery locations for 16 coho salmon tagged as juvenile fish in areas W3048 and W3050 and recovered 1 year later. Source: Appendix Table A5.

is in keeping with the trend observed elsewhere.

The tag returns from the releases in Dixon Entrance are significant also in showing that the mixed stocks of juvenile coho that migrate northward each summer do not necessarily remain offshore, but are also present in entrances and channels such as Cordova Bay between Dall Island and Prince of Wales Island. It is unknown whether these fish migrated northward through Hecate Strait or on the seaward side of the Queen Charlotte Islands. In view of the very small catches made on the west side of the Queen Charlotte Islands, however, as discussed earlier with respect to Fig. 6, it is probable that Hecate Strait was the main route of migration.

The 69 juvenile cohos tagged west of the Queen Charlotte Islands in area W3552 (Fig. 28) yielded no returns.

The 16 returns from juvenile coho released in area W3050 (two returns) and W3048 (14 returns) are illustrated together in Fig. 33. Rate of return was 16/640 or 2.5 percent. All of those recovered had been tagged along the west side of Vancouver Island within the area depicted in Fig. 33. All returns were from locations south of the release points. The distribution of recovery locations extended from the release area to northern California. The two fish recovered in California were caught in the commercial troll fishery; one in the month of June, and one on July 13. Because of their recovery dates, these two fish could have been destined for rivers of origin north of California. There were no returns from Puget Sound or the Fraser River. The destination is unknown for two fish recovered off the west side of Vancouver Island and one recovered in the outer Strait of Juan de Fuca.

The results of tagging of juvenile coho salmon in the Strait of Juan de Fuca contribute some new information on the matter of migrations in inside and outside waters. Figure 34 illustrates release and recovery information for 53 juvenile coho salmon tagged in the outer Strait of Juan de Fuca (area W2548) and recovered 1 year later. Rate of return after 1 year was 53/1,703 or 3.1 percent.

Twenty of the 53 returns a year after tagging were from points to the north or northwest, three were from points south, two were from within the release area and 26 were from points to the east including Hood Canal and Puget Sound marine and river locations. No returns were from the Fraser River, a major producer of coho salmon. On the basis of these 53 recoveries from among 1,703 juvenile cohos released in the outer Strait of Juan de Fuca between July 11 and September 24 of 1964, 1966, and 1968, it appears that the mixture of fish was composed principally of Puget Sound stocks. It is conceivable that the three fish recaptured off the Washington coast may have been Puget Sound fish intercepted while in ocean feeding areas to the south. A southward migration of many Puget Sound cohos was shown by finclipping experiments (Wright and Bernhardt 1969). The final destination of those fish that were recovered offshore to the north and northwest along Vancouver Island is uncertain.

These results of tagging immature cohos in the outer Strait of Juan de Fuca are in sharp contrast to results of earlier tagging of mature cohos. As reported by Milne et al. (1958), the distribution of returns from mature coho salmon tagged in the western Strait of Juan de Fuca included 105 from the British Columbia-Fraser River area (Point Roberts to Johnstone Strait) and 186 from Puget Sound waters (San Juan Islands and southward). Thus, in Milne's experiments more than one-third of the returns which occurred in waters east of the Strait of Juan de Fuca were from the Fraser River. In view of these results, the lack of inside British Columbia-Fraser River returns from among juvenile salmon which we tagged in the outer Strait of Juan de Fuca suggests that either the migratory route or the timing of outmigration of Fraser River cohos is drastically different from that of Puget Sound cohos.

Returns in the Year of Tagging. Figure 35 illustrates release and recovery information for 58 juvenile coho salmon that were tagged in the outer Strait of Juan de Fuca and recovered in the year of release. Rate

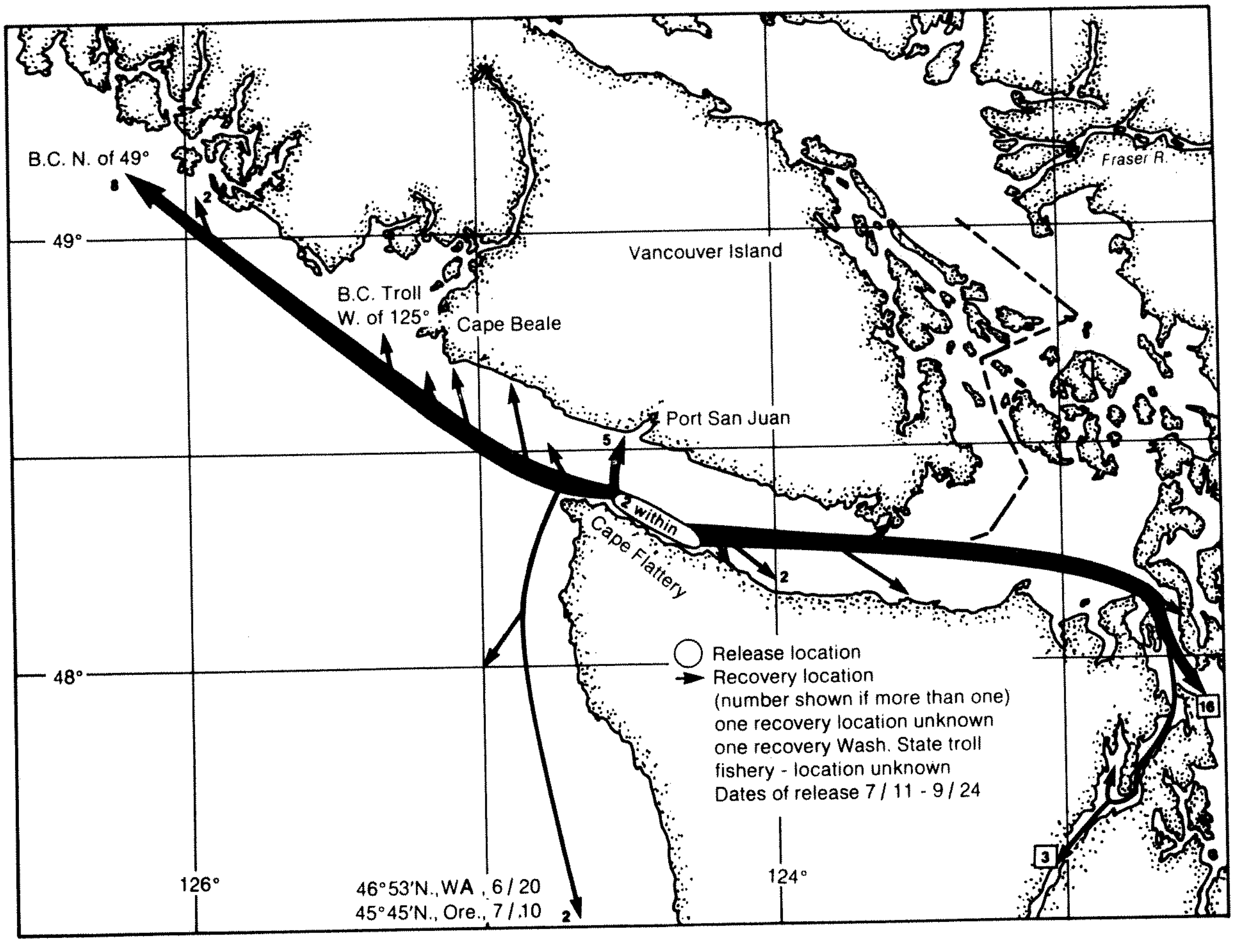


FIG. 34. Release and recovery locations for 53 coho salmon tagged as juvenile fish in the Strait of Juan de Fuca and recovered 1 year later. Source: Appendix Table A5.

of return was 3.4 percent (58/1,703). The recoveries occurred in commercial and sport fisheries in the Strait of Juan de Fuca and in marine waters and rivers of Puget Sound. Those recovered in rivers were, of course, jacks that had matured after their first summer in salt water. Most of those recovered in marine waters were presumably still immature and would have continued feeding at sea for another year had they not been recaptured. The high rate of return was probably at least partly because salmon tagged with disk tags are vulnerable to gillnets and purse seines because of the tendency of the tag to become entangled in the web even though the fish may be small enough to escape through the meshes of the web.

The distribution of returns in the year of release showed both similarities and contrasts with the distributions of coho recovered a year after tagging (Fig. 35 versus Fig. 34). Returns in both years were similar in showing recoveries in Puget Sound and none in the Fraser River. They contrasted in that 45 of 58 of the in-year returns (75.9 percent) were from the Strait of Juan de Fuca as compared to only 12 of 53 (22.6 percent) of the second summer returns. Also, only the second summer returns included outside locations to the northwest along Vancouver Island and to the south along the Washington-Oregon coast. The full year at liberty probably accounted for the greater dispersion of the second summer returns. Also, after a full year's sea growth, these fish were much more vulnerable to the ocean troll and sports fisheries than were juveniles in their first year. The actual migrations of all of the fish recovered in their second summer are, of course, unknown and probably were quite extensive as compared to the migrations of the in-year returns.

Dates and locations of in-year returns indicate that many juvenile cohos remain and apparently "mill" in the Strait of Juan de Fuca for a considerable time. Time at liberty varied from 1 to 71 days with 14 fish

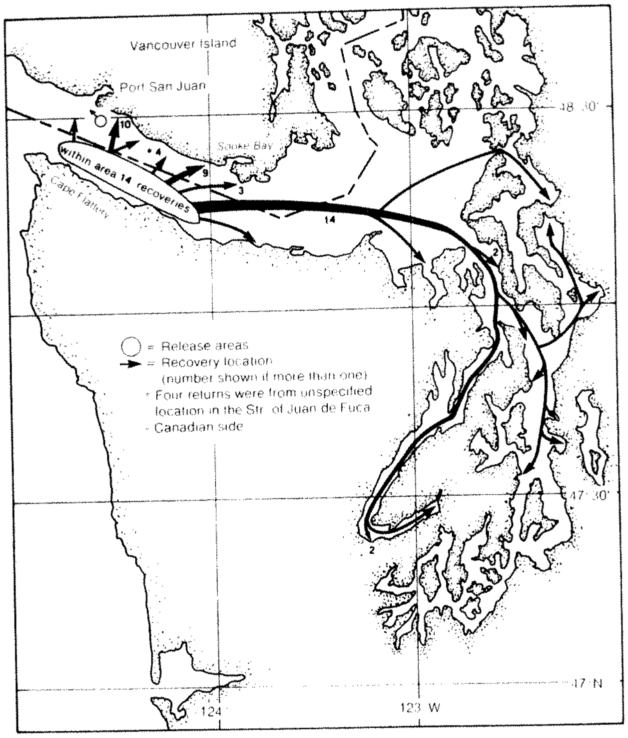


FIG. 35. Release and recovery locations for 58 coho salmon tagged as juvenile fish in the Strait of Juan de Fuca and recovered in the same year. Source: Appendix Table A5.

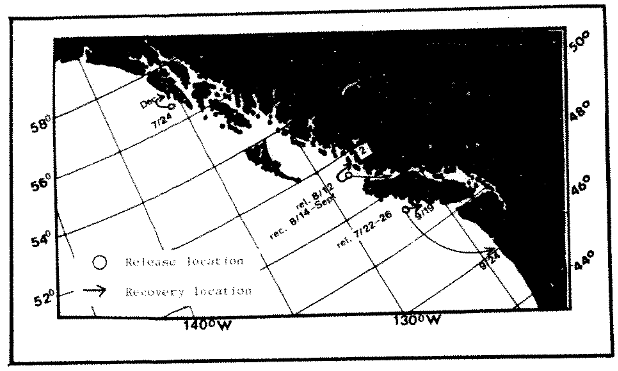


FIG. 36. Release and recovery locations for six coho salmon tagged as juvenile fish in areas W4558, 4056, 3050, and 3048 and recovered in the same year. Source: Appendix Table A5.

being recaptured after 21 or more days (Appendix Table A5). Many of the returns were from points east of the release locations, showing that their migration was not directly seaward through the Strait of Juan de Fuca as apparently was the case for juvenile sockeye, chum, and pink salmon. Such limited migratory behavior of juvenile cohos from Puget Sound is consistent with the observation (Figs. 29–33) that relatively few juvenile cohos from Puget Sound migrate to the northern Gulf of Alaska.

An additional six juvenile coho salmon tagged at several locations north of the Strait of Juan de Fuca were recovered in the year of release (Fig. 36). These returns provide important additional information on first summer migrations, particularly those that were at liberty for a month or more. One specimen tagged on July 24 off Baranof Island was recovered in December inside Sitka Sound Thus, after 5 months at liberty this fish was recovered only 13 nm north of the release point. It was 22.6 cm in length at release (Appendix Table A5). Its length and state of maturity at recovery are unknown, but it was most likely immature since it was caught in salt water in December. The actual migration during this period is unknown.

Three juvenile coho salmon tagged in area W3050 north of Vancouver Island on August 12 were recovered within the vicinity of release (Fig. 36). Two of them were recovered 2 and 3 days, respectively, after release. They traveled only about 15 or 20 nm between tagging and recovery. The third specimen was recovered in Queen Charlotte Strait about a month after release. This fish had migrated 30 or 40 nm to the southeast, and from outside waters to inside waters. Its maturity at recovery was unknown. The eastward migration of this specimen was similar to that discussed for many of the juvenile coho tagged in the outer Strait of Juan de Fuca.

Finally, two juvenile coho salmon tagged in area W3048 west of central Vancouver Island were recovered in the year of release, one off central Vancouver Island in mid-September and one in the Columbia River in late September (Fig. 36). The fish recovered off Vancouver Island was recovered only 40 or 50 nm southeast of the point of release. The state of maturity was unknown. Between July 22 and September 19 it grew from 21.0 to 30.5 cm. The specimen recovered in the Columbia River was a mature male at recovery and thus provided some indication of the distance that a jack coho may migrate during its single summer at sea, which in this case was about 240 nm each way. It was recovered in Young's Lagoon in the lower Columbia River estuary on September 24. The only other known jack cohos recovered were those tagged in the Strait of Juan de Fuca and recovered in streams of Puget Sound and Hood Canal (Fig. 35).

SUMMARY OF COHO TAG RETURNS FROM RELEASES IN THE NORTHEASTERN GULF OF ALASKA

When examined together, the 129 tag returns from juvenile coho salmon tagged along the outer coast

Table 6. Returns of juvenile coho salmon tagged in northeastern Gulf of Alaska according to major release and recovery areas. (Source: Appendix Table A5*).

	Number of returns by area of recovery					
	Alaska	British Columbia	Wash. State and Juan de Fuca Strait	Columbia River	Oregon-Calif.	Total
Kodiak Island to 56°N.						
W4558**	3	3	0	0	3	9
W4058	8	4	2	4	3	21
W4056	4	15	5	8	8	40
Subtotal	15	22	7	12	14	70
Percent	21.4	31.4	10.0	17.1	20.0	99.9
56°N. to Cape Flattery						
W3554	0	15	6	6	11	38
W3050	0	4	1	0	0	5
W3048	0	2	3	3	8	16
Subtotal	0	21	10	9	19	59
Percent	0	35.6	16.9	15.3	32.2	100.0
Totals	15	43	17	21	33	129
Percent	11.6	33.3	13.2	16.3	25.6	100.0

* Excluding one fish for which recovery location was unknown.

** Also including one release each from areas W5060, 5554, and 5558.

from Cape Flattery, Washington to Kodiak, Alaska (Figs. 29–33), provide a means for estimating the proportions of the major stocks tagged throughout this coastal belt. The array of returns by recovery areas and by release areas are summarized in Table 6 with subtotals for releases in areas between Kodiak Island and 56°N and for areas between 56°N and Cape Flattery.

For the present gross comparison, the possible biases between areas in rates of tag return are ignored (bias caused by time/space distribution of tagging, by non-uniform return efficiency among recovery areas, and by higher tag return rates for larger fish). The latter factor would favor returns from southern production areas because these salmon were larger at tagging.

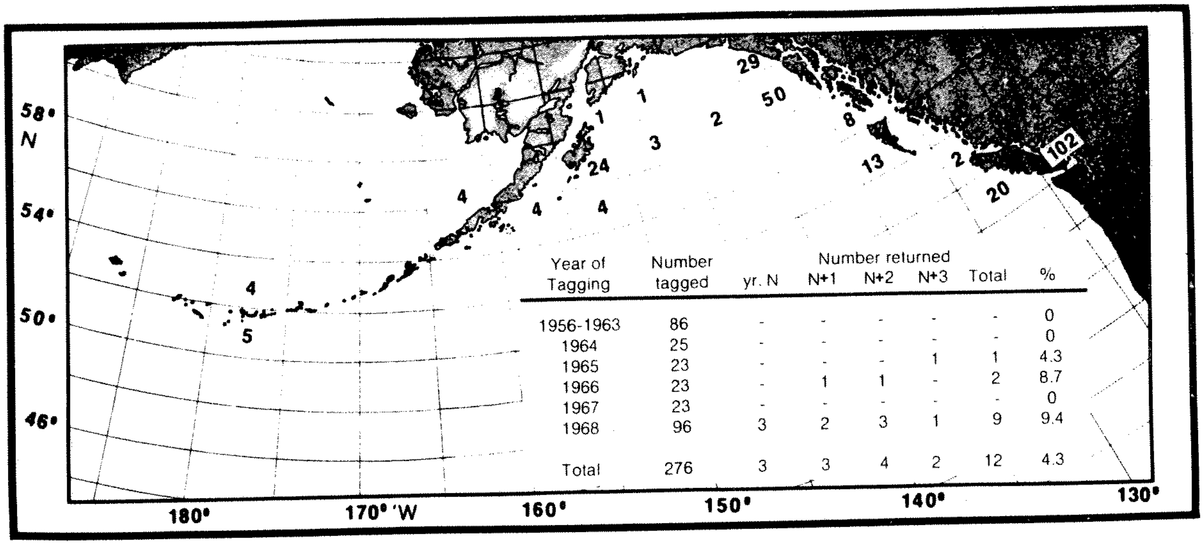
Considering first the fish released in the northernmost Gulf of Alaska (Kodiak Island to 56°N [Table 6]), there were returns 1 year later from all five production areas—Alaska, British Columbia, Washington State, Columbia River, and Oregon. Percentages ranged from 31.4 percent (British Columbia) to 10.0 percent (Washington State). The most distant release areas (W4558 and westward) yielded no returns from Washington State or from the Columbia River. This may be significant at least for Washington State, since overall returns from Washington were low. Oregon and California returns occurred in relatively high proportion (20 percent) from these distant release areas. The proportion of tagged cohos recovered from the Columbia River and south was 37 percent. However, some of the tagged coho recaptured may have been finally destined for production areas other than those in which they were recovered.

Juvenile cohos tagged in the coastal areas between 56°N and Cape Flattery yielded a similar array of returns, except for a lack of returns to inside Alaskan waters. A scarcity of Alaskan coho in tag returns would be expected based upon the locations of tagging and the fact that early seaward migration is mainly northward. As in the more northerly releases, the largest return of tags was from British Columbia (35.6 percent). This was followed by 32.2 percent from Oregon and California streams or fisheries. Including the Columbia River, the returns were 47.5 percent of the total. The overall return from all areas displays a similar trend (41.9 percent from Columbia River and southward).

The data in Table 6 thus indicate that juvenile coho from the Columbia River, Oregon, and California may form a large portion of the stocks of this species that migrate northward along the coastal belt each summer.

Chinook Salmon Tag Returns

The numbers of juvenile chinook salmon tagged during the years 1956–1968 are summarized in Fig. 37. The numbers tagged were in rough proportion to their abundance in our catches. Twelve returns



Year of Tagging	Number tagged	yr. N	Number returned N+1	N+2	N+3	Total	%
1956-1963	86	-	-	-	-	-	0
1964	25	-	-	-	-	-	0
1965	23	-	-	-	1	1	4.3
1966	23	-	1	1	-	2	8.7
1967	23	-	-	-	-	-	0
1968	96	3	2	3	1	9	9.4
Total	276	3	3	4	2	12	4.3

FIG. 37. Numbers of juvenile chinook salmon tagged, 1956–1968, by geographic area, and numbers returned by years of release and recovery and percent returned.

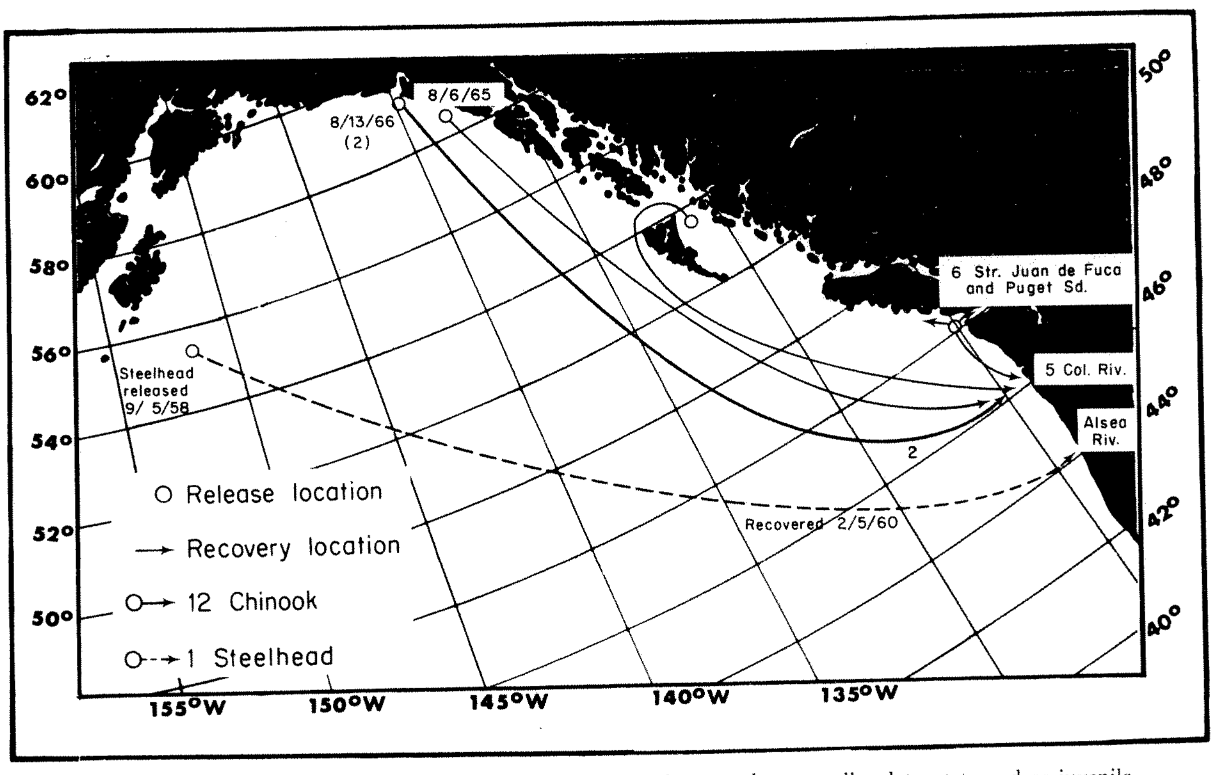


FIG. 38. Release and recovery locations for 12 chinook salmon and one steelhead trout tagged as juvenile fish and recovered up to 3 years later. Source: Appendix Table A6.

(4.3 percent) were received from 276 juveniles tagged in all years.

Release and recovery locations of the 12 returns are diagrammed in Fig. 38. Detailed information for individual recoveries is given in Appendix Table A6. No returns were received from 52 juvenile chinook salmon tagged in areas west of 140°W.

Of 29 releases in area W4058 in the northeastern Gulf of Alaska, three were recovered, all in the Columbia River. Recoveries occurred 1, 2, and 3 years after release (Appendix Table A6). Release dates were August 6, 1965, and August 13, 1966. Thus, juvenile chinook salmon from the Columbia River are capable of migrating 1,000 nm by August of their first summer at sea. All three of the chinooks recaptured must have been of spring-run stocks since dates of recovery in the Columbia River ranged from March 17 to May 25.

A juvenile chinook tagged in the northern part of Hecate Strait on July 20, 1968, was recovered in the Columbia River on April 16, 1970, also a spring-run fish. The four tag returns cited suggest that the spring-run stocks from the Columbia River tend to migrate more extensively than the fall-run stocks, which is consistent with the findings of Major et al. (1978).

An additional eight chinook salmon tagged in the outer Strait of Juan de Fuca in 1968 were recovered (Fig. 38). Three were recovered in the year of release, two in 1969, two in 1970, and one in 1971. One of the three recovered in the year of release was recovered near the point of release after about a month, and the other two were recovered after migrating extensively eastward to the San Juan Islands and Hood Canal (Skokomish River), respectively. The latter must have been a maturing jack.

The two recovered in 1969 were captured in the Strait of Juan de Fuca and off west-central Vancouver Island, respectively. The two recovered in 1970 were captured in Puget Sound and in the Columbia River, respectively. The latter was recovered on September 23, and was thus a fall-run fish. The specimen recovered 3 years after release was captured in the Strait of Juan de Fuca near the point of release. Although the actual migrations of these eight juvenile chinook salmon tagged in the outer Strait of Juan de Fuca are unknown, the results suggest that some migrations were not extensive. Obviously, some of them had migrated eastward toward inside waters during their first summer and fall rather than proceeding seaward.

From these few tag returns, it appears that chinook salmon from the Puget Sound area, like the coho salmon, do not migrate extensively northward. Some stocks of chinook salmon from the Columbia River, however, like some of the cohos from the Columbia River and from the coasts of Washington, Oregon, and California, apparently migrate far to the north during their first summer at sea.

Steelhead Trout Tag Returns

Eighty-five juvenile steelhead trout were tagged during the years 1956–1968 (Fig. 39). As discussed in the section on distribution, steelhead trout, unlike the salmon, appear to migrate directly offshore upon entry into the ocean rather than to follow the coastline. This is evident in Fig. 39 even from the limited numbers tagged.

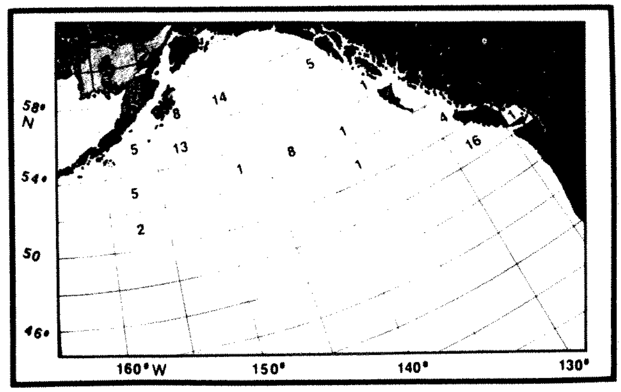


Fig. 39. Numbers of juvenile steelhead trout tagged, 1956–1968, by geographic area. Total tagged = 85. One recovered in year N+2 = 1.2%.

Only one tag return was received. A juvenile steelhead tagged in the northwestern Gulf of Alaska near Kodiak Island on September 5, 1958, was recovered in the Alsea River, Oregon, on February 5, 1960 (Fig. 38). During its 1 1/2 years at liberty, it grew from 36.5 cm to 57.8 cm. Additional information is available on this fish, since it also bore a fin clip which identified it as having been released from the Alsea River hatchery in April of 1958. Thus, in its first 4 or 5 months at sea, it had traveled at least 1,200 nm at an average rate of travel of at least 8 or 10 nm per day. Little more can be concluded from a single tag return, except that steelhead trout may migrate as extensively during their first summer at sea as do salmon.

Migration Models

Taken together, the data from all three lines of evidence—seasonal catch distribution, direction of set of the seine and tag returns—yielded a fairly coherent picture of the migrations of juvenile salmon during their first summer, together with additional inferential information on migrations through the first fall and winter. The migrations were more obvious for some species than for others, because their distribution patterns or maturity schedules were more sharply defined or they were more abundant. A comparison between species aided in interpreting migrations of a single species.

Sockeye, Chum, and Pink Salmon

Since the basic patterns of migration of juvenile

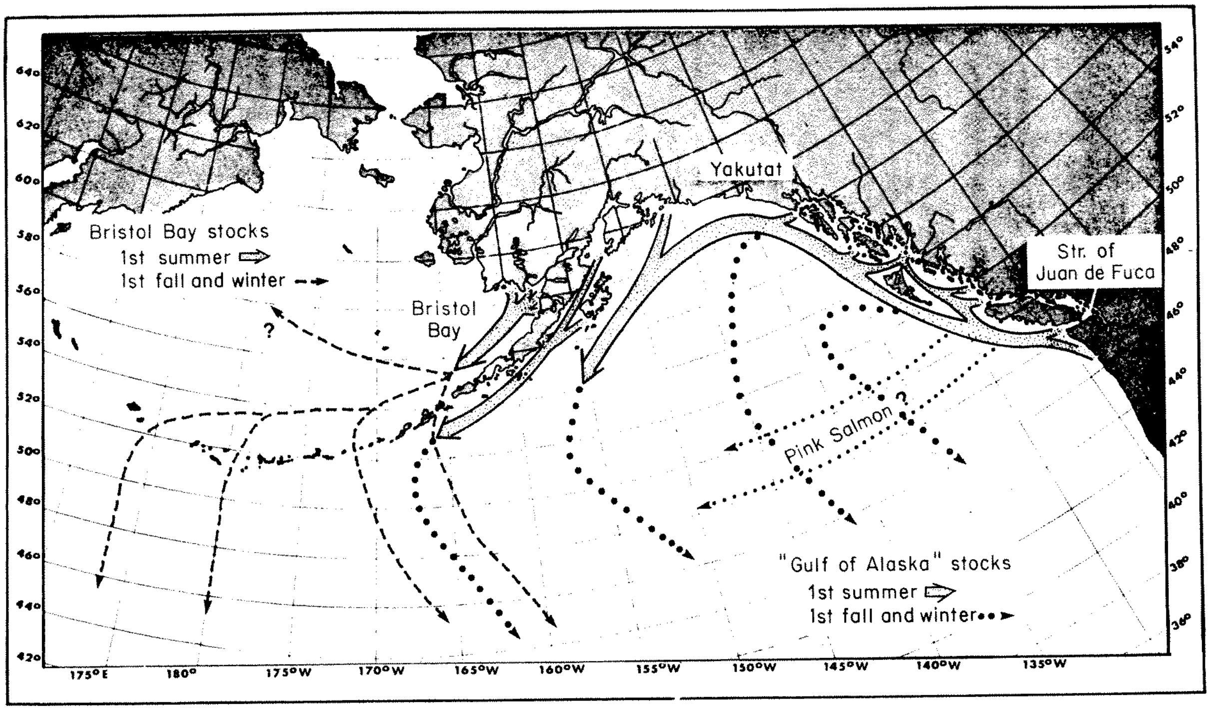


FIG. 40. Diagram of oceanic migration patterns of some major stocks of North American sockeye, chum, and pink salmon during their first summer at sea, plus probable migrations during their first fall and winter.

sockeye, chum, and pink salmon during their first summer were similar, their migrations are diagrammed together in Fig. 40. These three species are by far the most abundant of the Pacific salmonids, generally occur mixed in our seine catches, and are usually similar in size. Migrations of chum and pink salmon originating north of Bristol Bay are not shown for lack of sampling in the appropriate areas of the Bering Sea.

The Bristol Bay stocks migrate relatively slowly in their first summer, and by September, substantial numbers of juvenile salmon are still present only 250–300 nm from their estuaries of origin (Fig. 40). They tend to favor the north side of the Alaska Peninsula, remaining mainly within 50–60 nm of shore. Direction of migration is variable and apparently influenced by tidal currents, but the net movement is southwestward. The full extent of migration in September is unknown because of lack of sampling farther west or northwest after August. Extended sampling in September and October is needed to determine the western limit of migration in late summer or early fall.

The presumed migrations during fall and winter are shown in Fig. 40 by dashed lines. The ends of the dashed arrows depict the general distribution of age .1 sockeye of Bristol Bay origin during their second spring, based upon seasonal distribution and migration as determined by sampling with gillnet, longline, and purse seine gear, and by tag returns (French et al. 1976). The actual routes and the timing of migration from the Bering Sea to the north Pacific Ocean are not known, nor is it known if some fish remain in the Bering Sea throughout winter. Sampling by means of gillnet gear has shown the presence of age .1 sockeye in the south-central Bering Sea in January, February, and March (French and Mason 1964).

Gulf of Alaska stocks apparently migrate much more rapidly and extensively than those of Bristol Bay. By August, substantial numbers of all three species from as far south as the Strait of Juan de Fuca have migrated at least as far as Yakutat (900 nm) and some sockeye have reached waters near Kodiak Island (1,500 nm). They also tend to remain much closer to shore than do the Bristol Bay stocks, particularly off southeast Alaska where the continental shelf is narrow and the band of migrating juvenile salmon is less than 20 nm wide. In the northern Gulf of Alaska, the band tends to widen. Evidence of a summer migration extending southwest off Kodiak is based upon recovery of only one tagged juvenile sockeye salmon, and may not apply to chum and pink salmon. However, seining revealed a band of southwestward migrating sockeye, chum, and pink salmon extending along the south side of the Alaska Peninsula and the eastern Aleutian Islands. Tag returns have shown that the band includes stocks from Cook Inlet, the Alaska Peninsula, and Kodiak Island, and it is possible that stocks from farther east and southeast in the Gulf of Alaska may also be present. The width of the band along the south side of the Alaska Peninsula and eastern Aleutian Islands has not been measured during late summer when abundance is high, and offshore distribution may be expected. The westward extent of the migration along the Aleutian Islands also is not known, but the purse seine catch data indicated that Unalaska Island (167°W) was about the western extent of the migration through September. Extensive purse seine fishing effort showed that juvenile salmon were extremely rare in the central Aleutian Island area through September (Figs. 3–5).

It seems probable that the juvenile sockeye, chum, and pink salmon at some point or points depart from the coastal belt of the Gulf of Alaska and begin to disperse offshore. The locations and times of offshore migration are unknown, but the dotted lines extending from the main arrows in Fig. 40 are drawn as possible routes that would lead to the distributions of the age .1 groups of these species which were discussed earlier with respect to Figs. 15, 16, 17, and 23. The three species may differ somewhat in locations and timing of their offshore dispersion because of differences in maturity schedules and temperature preferences. As discussed earlier, fishing by Canadian research vessels indicated that juvenile pink salmon, but not sockeye or chum salmon, were distributed far offshore in the Gulf of Alaska by late November. Accordingly, a migration route unique to pink salmon, at least in timing, is shown in Fig. 40. Moreover, different stocks within species may migrate differently. Fish in the vanguard and in the rear of the migration may proceed offshore at vastly different locations. In fact, fish of the vanguard may have made a lengthy coastwise migration and started offshore before the late migrants of the same species have left inside waters. The presence of substantial numbers of juvenile pink and chum salmon and of a few sockeye in Hecate Strait in November as reported by LeBrasseur and Barner (1964) and as observed in Puget Sound in November in the present study (Table 3), shows that a contingent of these species may enter the sea too late to be part of the distribution and migrations summarized in Fig. 40. The late migrants may not make the extensive northward and westward migrations depicted, but may either proceed directly offshore from their point of entry, or may migrate along the coasts for a short distance before proceeding seaward. Fall and winter sampling and tagging at several key points along the coast and in the major channels leading to the sea are needed to resolve these important aspects of early ocean migrations.

Figure 40 also indicates the probable area in which stocks of juvenile salmon from Bristol Bay and stocks from the Gulf of Alaska begin to overlap. This is near the eastern Aleutian Islands (165°W) and probably occurs in the late fall or early winter. Later in their life, stocks from these two areas overlap much more widely in their distribution. Bristol Bay salmon, particularly sockeye, become distributed eastward in the Gulf of Alaska to about 140°W and westward in the north Pacific Ocean and the Bering Sea to about 165°E. Gulf of Alaska stocks, particularly sockeye, are distributed westward to about 175°E (French et al. 1976). The overlap of chum and pink salmon is not as extensive but ranges approximately from the central Aleutian Islands to the central Gulf of Alaska for chum salmon and to Kodiak Island for pink salmon (Neave et al. 1976; Takagi et al. 1981). Thus, the overlap depicted in Fig. 40 is only the beginning of a much wider mixing which results in a widespread sharing of common feeding grounds by these two major groups of stocks. The mixing is, however, apparently minimal until the winter or spring following their entry into the ocean.

Coho and Chinook Salmon

Oceanic migration patterns of juvenile coho and chinook salmon in the Gulf of Alaska are diagrammed in Fig. 41. Data were not available for depicting juvenile Bering Sea stocks. In the Gulf of Alaska the basic pattern of migration was similar to that of sockeye, chum, and pink salmon, in which the juvenile salmon migrate in a narrow band northward, westward, and southwestward along the coast of the Gulf of Alaska. For coho and chinook salmon, the band originates farther south than for sockeye, chum, and pink salmon, and includes stocks from Oregon and probably from California coastal streams. Unlike sockeye, chum and pink salmon, some coho and chinook salmon are found offshore in the north-central Gulf of Alaska (Figs. 6 and 7), and these are depicted by arrows in Fig. 41. Since the offshore migratory routes followed by these fish are unknown, the arrows are accompanied by question marks. The extended dotted arrows depict probable southward and eastward migrations toward the areas in the southern Gulf of Alaska in which numerous age .1 coho and a few chinook salmon were found in spring and early summer (Figs. 18 and 19). It is important to reiterate that the oceanic migrations shown in Fig. 41 apply to only a portion of the coho and chinook salmon stocks and that many of these species remain in inside waters or in nearshore oceanic waters for their whole

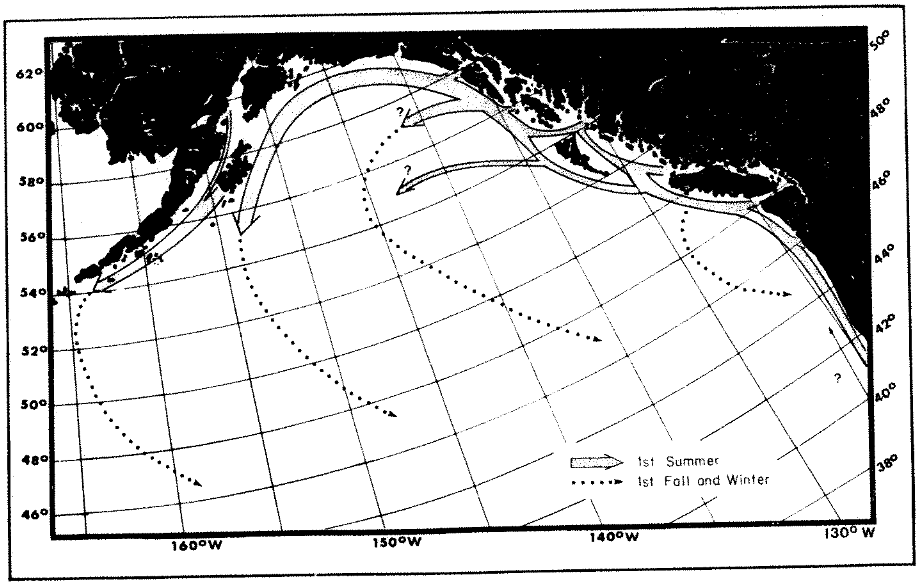


FIG. 41. Diagram of oceanic migration patterns of some major stocks of coho and chinook salmon during their first summer at sea, plus probable migrations during their first fall and winter.

marine feeding life.

The migrations shown in Fig. 41 probably include the maximum extent of migration of the great majority of Gulf of Alaska cohos, since tag returns from age .1 cohos show a maximum westward and southward migration of about 155°W and 42°N (Godfrey et al. 1975), except for one coho which was tagged south of the central Aleutian Islands near 176°W and recovered in Kodiak Island waters.

Although most juvenile chinook salmon of Gulf of Alaska origin appear to remain within the area illustrated by Fig. 41 for their whole life, some do migrate west of 165°W. Two chinook salmon (age .2) tagged south in the central Aleutian Islands near 177°W have been recovered in areas tributary to the Gulf of Alaska. One was recovered in southeastern Alaska and one was recovered in a tributary of the Columbia River in Idaho (Hartt 1962b). It is unknown what portion of the long westward migration occurred during their first summer and what portion occurred during subsequent summers as age .1 or age .2 fish. The Columbia River specimen that was tagged south of the central Aleutian Islands was also a spring-run fish (recovered July 7 in the Salmon River, Idaho) and adds to the evidence discussed with respect to Fig. 38 that juvenile spring-run Columbia River chinook salmon tend to migrate more extensively at sea than fall-run fish.

The ocean distribution of coho salmon from the Gulf of Alaska overlaps considerably with Bering Sea stocks from Bristol Bay and northwest Alaska. The latter stocks extend eastward to about 140°W in the Gulf of Alaska and thus overlap with Gulf of Alaska stocks between 140°W and 155°W (Godfrey et al. 1975). It is unknown whether the overlap occurs among juvenile cohos during their first summer or fall at sea or whether the overlap begins sometime later in the winter or spring when the fish are maturing at age .1.

Overlap between Bering Sea and Gulf of Alaska chinook salmon stocks at the juvenile stage or at any stage is apparently minimal. Two chinook salmon tagged in the North Pacific and recovered in northwestern Alaska were tagged close to the eastern and central Aleutian Islands, respectively. Recent evidence shows some chinook of Gulf of Alaska origin enter the Bering Sea in the vicinity of the eastern Aleutians (Myers 1983). As mentioned previously, tag returns indicate that a few chinook salmon of Gulf of Alaska origin migrate as far as the central Aleutian Islands where such overlap could occur. There is no evidence that they overlap at the juvenile stage.

STEELHEAD TROUT

Models of the early oceanic migrations of steelhead trout must be based primarily on catch distribution of the age .0 and age .1 groups, respectively, since few data are available from tag returns or from direction of set of the seine. The catch distribution data, however, as discussed with respect to Figs. 8 and 20 showed clearly that steelhead migrate differently from any of the salmon. Steelhead apparently migrate directly offshore from whatever point they may enter the sea, rather than migrating northward and west-

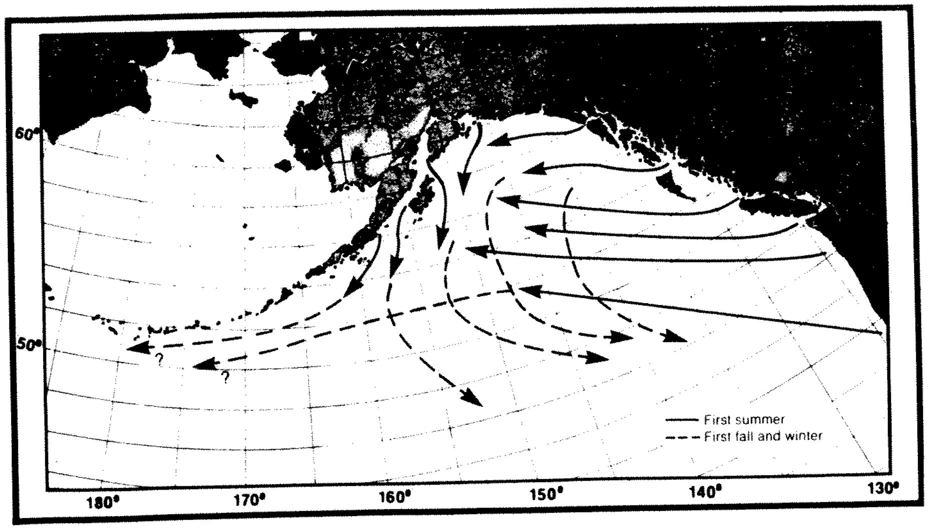


FIG. 42. Diagram of oceanic migrations of some stocks of steelhead trout during their first summer at sea, plus probable migrations during their first fall and winter.

ward along the coastal belt. Accordingly, steelhead migrations are depicted in Fig. 42 as being offshore during their first summer and then southward and eastward during fall and winter. Such migrations would be consistent with the distributions of the age .0 and age .1 group as shown by purse seine catches in Figs. 8 and 20, respectively, and by the single tag return illustrated in Fig. 38. In addition, however, Fig. 42 also depicts a westward migration along the south side of the Aleutian Islands since age .1 steelhead occur in waters south of the Aleutian Islands (Fig. 20). Whether they perform this migration during their first fall and winter is unknown.

A more direct offshore migration of juvenile steelhead as compared to salmon was also found in recent migration studies conducted off the Oregon and southern Washington coasts (Miller et al. 1983). Purse seine sampling was conducted at a series of transects extending to 40 km offshore between Tillamook Head, Oregon, and Copalis Head, Washington. Juvenile steelhead, migrating out of adjacent streams (mainly the Columbia River) generally occurred farther offshore than juvenile coho and chinook salmon, and also moved out of the sampling area earlier than the salmon. This offshore movement was confirmed by additional purse seine sampling by Oregon State University researchers (Wakefield et al. 1981; Pearcy and Masuda 1982).

LENGTH AND GROWTH

The length measurements of salmon and steelhead in our purse seine catches provided substantial data on sizes and growth of juvenile salmonids during their first summer at sea. The length data are analysed according to species, area, date and, where appropriate, freshwater age. Length at release of tagged fish that were subsequently recovered provided additional information on relative sizes and growth of a given stock according to year of maturity and distance migrated. For Bristol Bay stocks, the length data further provided a point estimate of mean length of juvenile sockeye in late summer as a means for estimating ocean growth between age .0 and age .2.

LENGTH BY SPECIES

The general size relationship of the several species of salmonids during their first summer at sea is illustrated in Fig. 43 by length frequency distributions of salmon caught in areas W4056 and W4058 in the northeastern Gulf of Alaska in 1966 and 1967. These two consecutive years were selected in order to provide annual comparisons, particularly for pink salmon with their distinct generations in odd- and even-numbered years. Steelhead samples, because of their scarcity, are pooled for all areas and all years, 1964 through 1968. Areas W4056 and W4058 were chosen for the comparisons because they are areas where all species of juvenile salmon occur mixed and in abundance each year over a long period of time. Undoubtedly, the stock compositions with respect to areas of origin varied between species and between years depending upon the strength and timing of migration of the stocks from the numerous contributing areas. As seen in the tagging results discussed earlier, juvenile salmon captured in the northeastern Gulf of Alaska are from many production areas—some far to

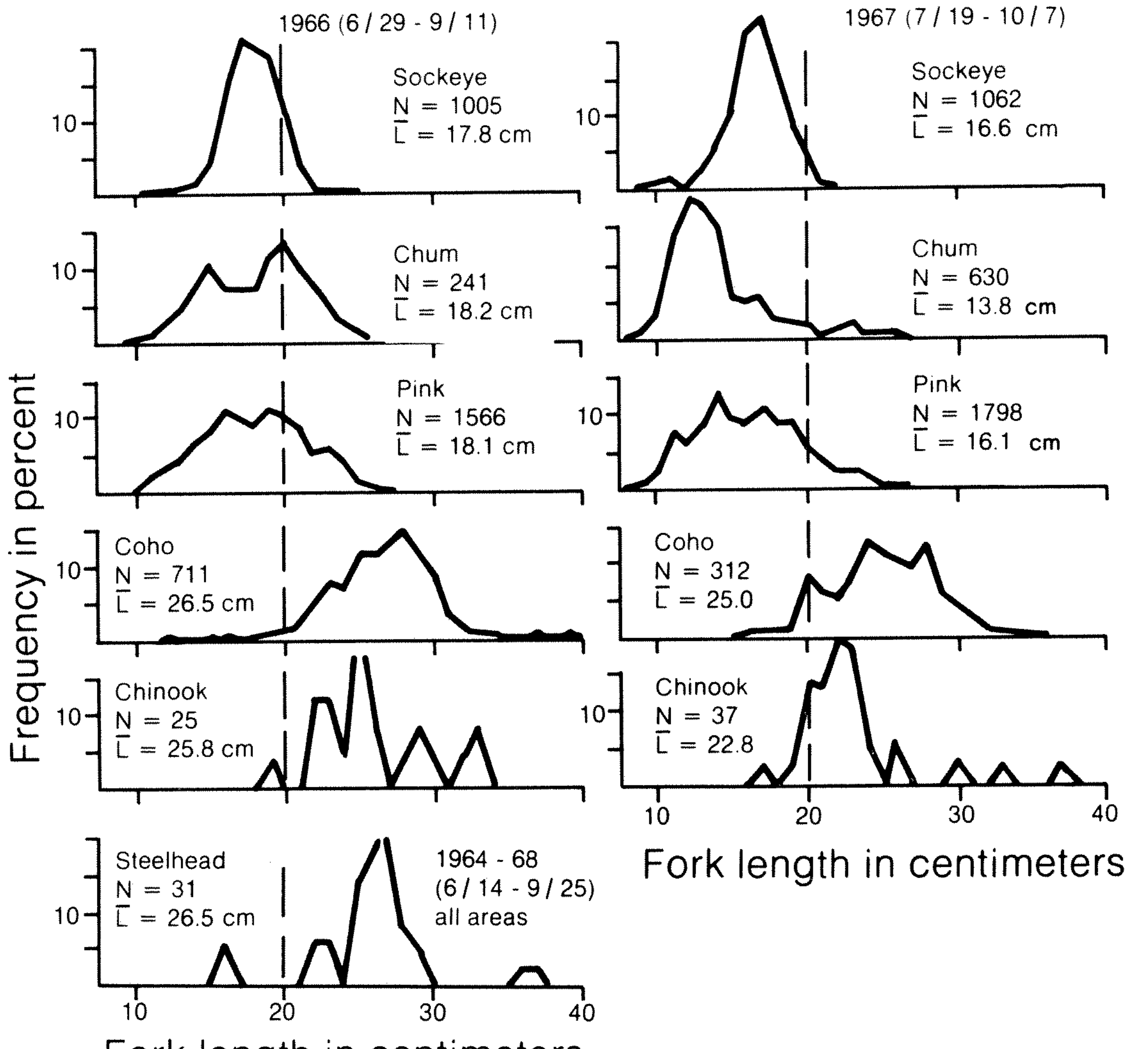


FIG. 43. Fork lengths of juvenile (age .0) salmon by species in the northeastern Gulf of Alaska (areas W4058 and 4056 combined) in 1966 and 1967, respectively, and fork lengths of juvenile steelhead trout from all areas sampled, 1964–1968.

the south.

The data show that sockeye, chum, and pink salmon are similar in size. Overall, their fork lengths ranged between approximately 10 and 25 cm and their mean fork lengths ranged from 14 to 18 cm. The similarity in size of these three species generally prevailed in all areas of sampling, which indicates that chum and pink salmon by midsummer have overcome the typical size differential that prevails at salt-water entry (chum and pink salmon, 3–6 cm; sockeye salmon, 7–12 cm). The size range of sockeye salmon was noticeably narrower than that of the chum and pink salmon, and the chum and pink salmon lengths tended to be bimodal in some cases. The size differentials, both within and among species, are presumably a function of length of time spent at sea and growth rate characteristics of individual stocks. The smaller fish had probably only recently entered the sea from nearby production areas, whereas the larger fish had probably been at sea longer and presumably migrated farther. Thus, the routes and timing of the migration of the species and the stocks within species through areas W4056 and W4058 are important factors in the size distributions seen in Fig. 43.

The coho and chinook salmon in areas W4056 and W4058 were substantially larger than the other three species. Fork lengths ranged from about 16 cm to 36 cm; means from 23 to 27 cm. This general size relationship also prevailed in other sampling areas. Chinook salmon were slightly smaller than coho salmon which might be expected on the basis of the typically larger size of coho salmon at entry into salt water and on the basis of the very rapid growth of coho salmon. The wide range of lengths seen in Fig 43 is probably a reflection that juvenile coho and chinook salmon in the northeastern Gulf of Alaska are a mixture of stocks—some from as far south as California.

The times and locations where samples of steelhead trout were obtained (Fig. 39) were different from those for salmon (Fig. 43). In order to obtain a meaningful sample of lengths of steelhead it was necessary to pool all samples from the Gulf of Alaska for years 1964–1968. Steelhead lengths in the pooled sample of 31 fish ranged from 16 to 36 cm, and the mean was 26.5 cm. Thus, during their first summer at sea, juvenile steelhead tend to be larger than sockeye, chum, and pink salmon, and similar in size to coho and chinook salmon.

Length by Area

An examination of the lengths of the juvenile salmon by sampling location and date yields information on the migration, growth and intermingling of major stocks, particularly when considered in light of the foregoing sections on distribution and migration. The most significant information was obtained in 1964 when a single vessel fished 1 or 2 days at each of a series of stations extending from Cape Flattery (48 1/2°N) to Yakutat (59°N) during a 14-day period, August 4–17. Thus, samples were obtained at a series of points along the coast at approximately the same time. This eliminated the possibility of resampling the same group of fish at successive locations. The resultant data are illustrated in Fig. 44 for sockeye, chum, and pink salmon by statistical sampling area. Sampling is shown at two locations in area W3554 because this area was sampled near both its southern and northern limits, which are south and north of Dixon Entrance, respectively (Fig. 1). Although sample sizes were generally small in the southern sampling locations, the lengths are probably representative in view of the fact that all three species show the same size relationship to samples taken farther north. There was a general increase in mean length from south to north extending from area W3048 to area W3554 (sockeye, 14.0–18.2 cm; chum, 13.5–18.9 cm; pink salmon, 12.8–18.2 cm). This trend indicates that fish sampled in the southernmost area had probably entered the sea more recently than those sampled in the more northerly areas and that many of the fish sampled in the northern areas had probably migrated from more southerly production areas. In area W3554 and northward, the growth trend was less obvious. The main trend was toward a much broader size range than in areas farther south. Some of the pink salmon in area W4056, for example, were as small as those sampled at the southernmost area and yet included fish as large as 22 cm. This wide range of lengths is consistent with the evidence from tagging that juvenile salmon taken in the northern sampling area are a mixture of stocks from southern areas and from nearby rivers.

The length distributions of the entire 1968 season's sampling in areas from the Strait of Juan de Fuca to Bering Sea are shown in Fig. 45 in sequence for sockeye, chum, and pink salmon, respectively. The year 1968 was chosen for this within year comparison because of the relatively thorough time and space coverage that year.

Referring first to the Bering Sea (area W6556), the sockeye and chum salmon were similar in size and had rather normal length distributions and mean lengths of 15.3 and 15.1 cm, respectively. No juvenile pink salmon were caught in 1968 because of the typical cyclic scarcity of mature pink salmon in Bristol Bay in odd-numbered years and the resultant scarcity of juvenile pinks in even-numbered years.

The juvenile salmon sampled south of the Alaska Peninsula were vastly different from those in Bering Sea both in species composition and in size. Sockeye and chum salmon south of the Alaska Peninsula were substantially larger than those on the north side in the Bering Sea. Mean length for the two species were 21.8 cm and 21.3 cm, respectively, or 6–7 cm larger than the Bristol Bay fish. Also, the size range of the fish sampled south of the peninsula was much broader, probably because there is a broad mixture of stocks south of the peninsula. Here, there was also an abundance of pink salmon that were relatively large, although about 1 cm smaller than the sockeye and chum salmon.

Juvenile sockeye, chum and pink salmon south of the Alaska Peninsula (areas W6554 and W6054) were larger than those in areas along the coast of the Gulf of Alaska from area W5048 and southward. Possible reasons are: 1) the fish present in W6554 and W6054 included stocks that had entered the sea early and had spent considerable time in migrating and feeding prior to being captured; 2) feeding conditions are better in the more northerly area; or 3) the fish include genetically rapidly growing stocks. That a juvenile sockeye salmon was tagged in this area and recovered in the Fraser River (Fig. 22) gives some support to reason 1 above. This fish was 23.0 cm long at release, which would place it among the larger of the sockeye illustrated in Fig. 45.

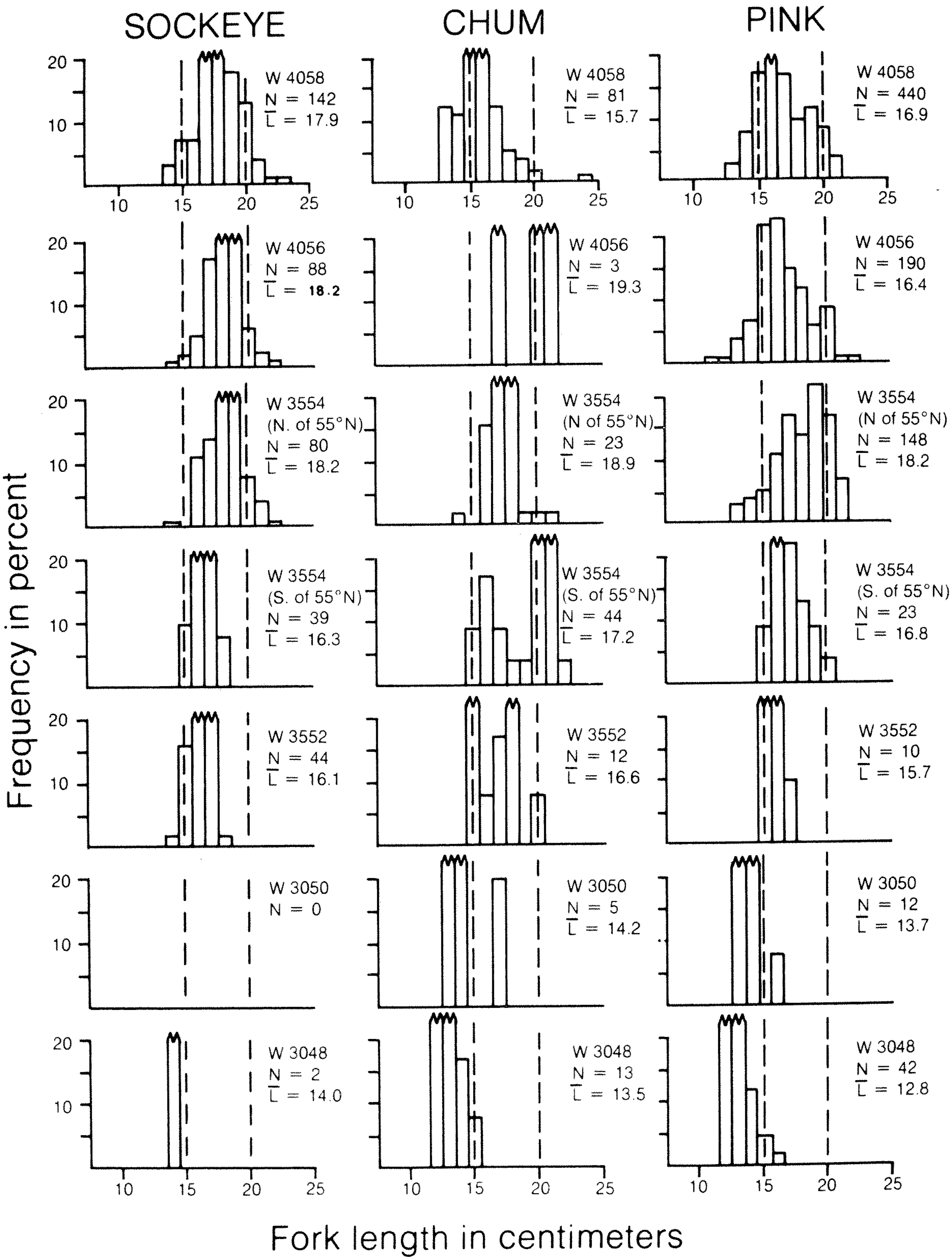


FIG. 44. Fork lengths of juvenile sockeye, chum, and pink salmon by sampling area along the coast of the eastern Gulf of Alaska between Yakutat and Cape Flattery during the 14-day period August 4–17, 1964.

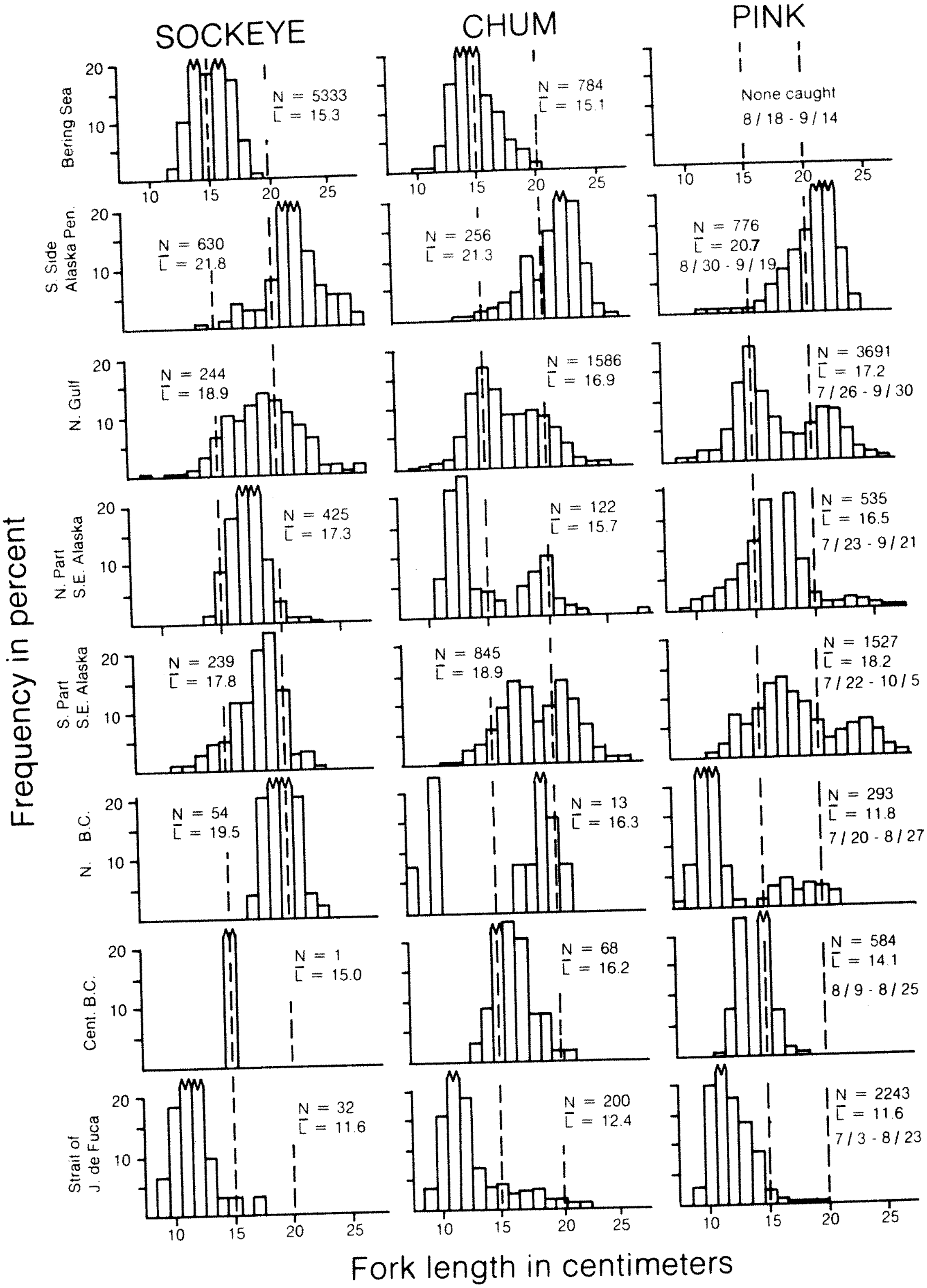


FIG. 45. Fork lengths of juvenile sockeye, chum, and pink salmon by sampling area along the coast from Bristol Bay (Bering Sea) to the Strait of Juan de Fuca in 1968.

The remainder of the 1968 length samples were from areas extending from W4058 in the northeast Gulf of Alaska to W2548 in the Strait of Juan de Fuca (Fig. 44). In general, there was a decrease in mean size from north to south but with some exceptions. The lengths of all three species of juvenile salmon in area W2548 (Strait of Juan de Fuca) were less than in any of the areas to the north. The size range of juvenile sockeye, chum, and pink salmon in this area is probably more representative of the typical size at which they enter the ocean. Most sockeye and pink salmon fell within the 9- to 15-cm range. Most chums also fell within this range, but the size distribution tended to be skewed to the right, with some ranging up to 22 cm. This possibly reflects the size differences between early and late emerging populations of chum salmon.

The samples in areas progressively to the north, of course, had opportunity to include a mixture of stocks, some originating in local rivers and others in rivers from areas to the south. These mixtures are evident in the varying size compositions of individual species in the several areas. Some samples, particularly of chum and pink salmon, were clearly bimodal. Bimodality could be caused either by a mixture of both early and late migrants from the same local production areas or by a mixture of local fish and fish from more distant production areas.

Length by Date Within Area

Further information on the migrations and growth of juvenile sockeye, chum, and pink salmon is available from an analysis of the lengths of the fish by area and time. Area W4056 off the northern part of southeast Alaska (Fig. 1) was chosen to analyze changes in length within season because 1) it is an area where there is a mixture of stocks, 2) the fish captured there appear to migrate in a narrow band, and 3) it is an area where we obtained a long sequence of samples in some years. Further, 1964 and 1967 were chosen for the analysis because in 1964 (Fig. 46) we obtained several samples from August 10 through September 7, and in 1967 (Fig. 47), we obtained intermittent samples over a wider range of dates from July 19 through October 7.

The 1964 length samples (Fig. 46) are arranged chronologically from August 10 to September 5. Daily samples were combined in cases where lengths were similar during 2 to 3 consecutive days of sampling. Although there was a slight increase in size as the season progressed in 1964, the overall change over the 20 or 30 day sampling period was not great. Sockeye and chum salmon showed only a 1- or 2-cm increase in length, but pink salmon which were sampled over a longer period, showed increases up to about 6 cm, some seasonal reversals in length, and some bimodal distributions. Thus, the length data in Fig. 46 show mainly the day-to-day variations in the mixture of stocks passing northward through area W4056. Such sampling does not show true growth of a given group of fish, of course, because each day's sample is presumably from a different group inasmuch as a continuous band of fish progresses northward through the sampling area. Viewed in this light, juvenile sockeye that migrated through area W4056 in 1964 were relatively uniform in size and their mean lengths ranged only from 18.3 to 19.6 cm between August 17 and September 5. Since tag returns showed juvenile sockeye in this area to be mainly from the Fraser and Skeena Rivers (Fig. 22), the lengths in Fig. 46 might be reflective of the lengths of Fraser and Skeena River sockeye at this location and time in their seaward migration.

Chum salmon tended to have a wider range of lengths, slightly bimodal at times. The greater variation in the size of chum salmon presumably results from the extensive mixture of chum salmon stocks that could occur in area W4056, including numerous local stocks as well as stocks from sources far to the south.

Pink salmon showed a pattern similar to that of the chum salmon. Since 1964 was an even-numbered year, the juvenile pinks were of odd-year stocks (1963 specifically) and could have included stocks of local origin, as well as fish from southern production areas where only odd-year runs occur.

The length data obtained in 1967 are shown chronologically in Fig. 47 for the 2.5 month period July 19–October 7 in order to compare lengths between years. Seasonal mean size increases are pronounced, particularly for chum and pink salmon because of the prolonged sampling periods. The sockeye and chum salmon sampled in 1967 were clearly smaller than those sampled on comparable dates in 1964. On August 28, 1967, for example, the mean lengths of sockeye and chum salmon were 16.8 and 16.9 cm, respectively, whereas on August 30 and 31, 1964, they were 19.3 and 18.5 cm, respectively. Although the sample contained only 27 chums in 1967, the sample of 57 sockeye would seem adequate in view of the seasonal consistency in the lengths of this species (Figs. 46 and 47).

Pink salmon were caught at more frequent intervals, but showed a size and distributional pattern similar to that of chum salmon. There was less evidence of bimodality in samples of pink salmon in 1967 than in 1964, perhaps because of the cyclic absence in 1967 of juvenile pinks from the southern

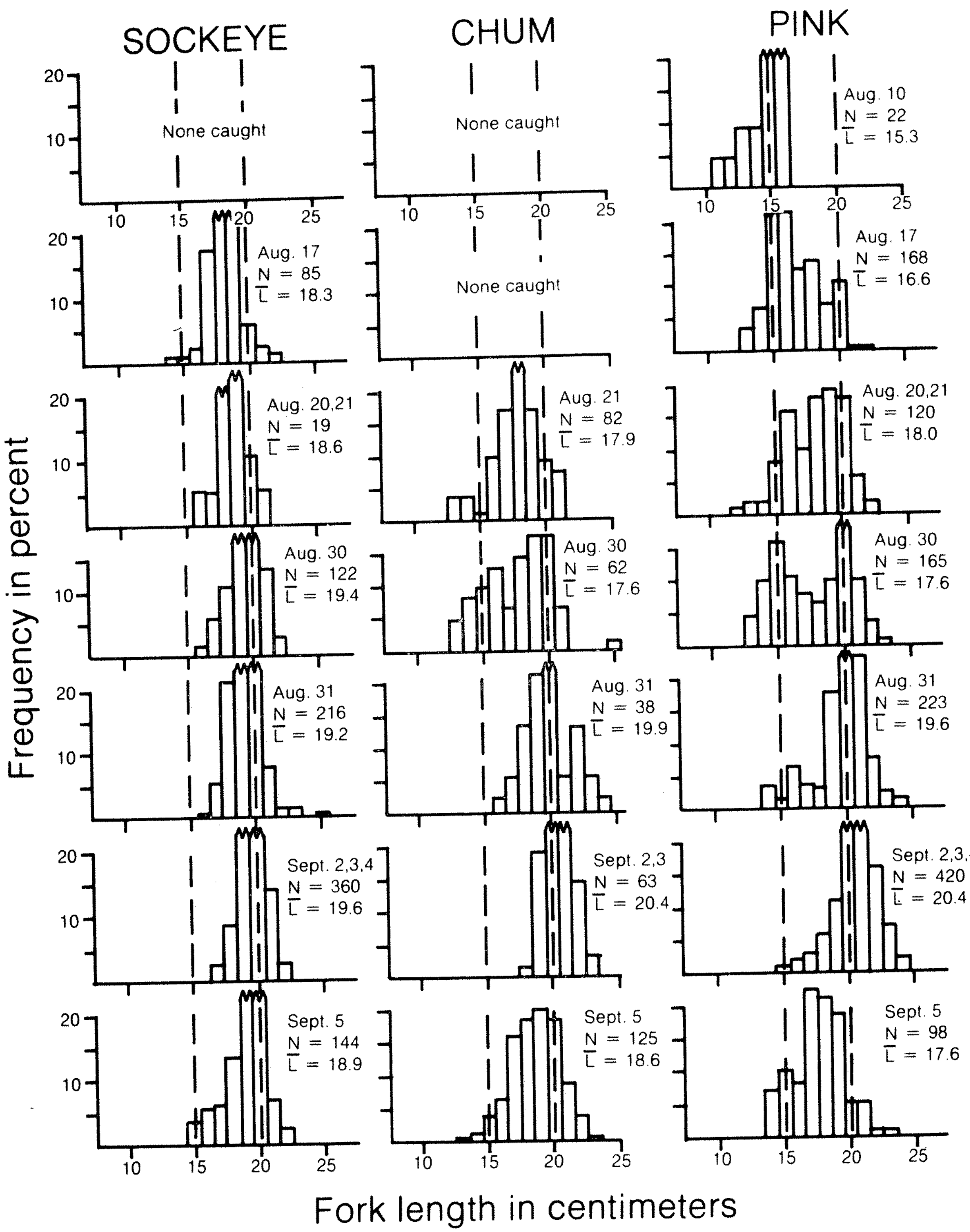


FIG. 46. Fork lengths of juvenile sockeye, chum, and pink salmon sampled in area W4056 by date, August 10–September 5, 1964.

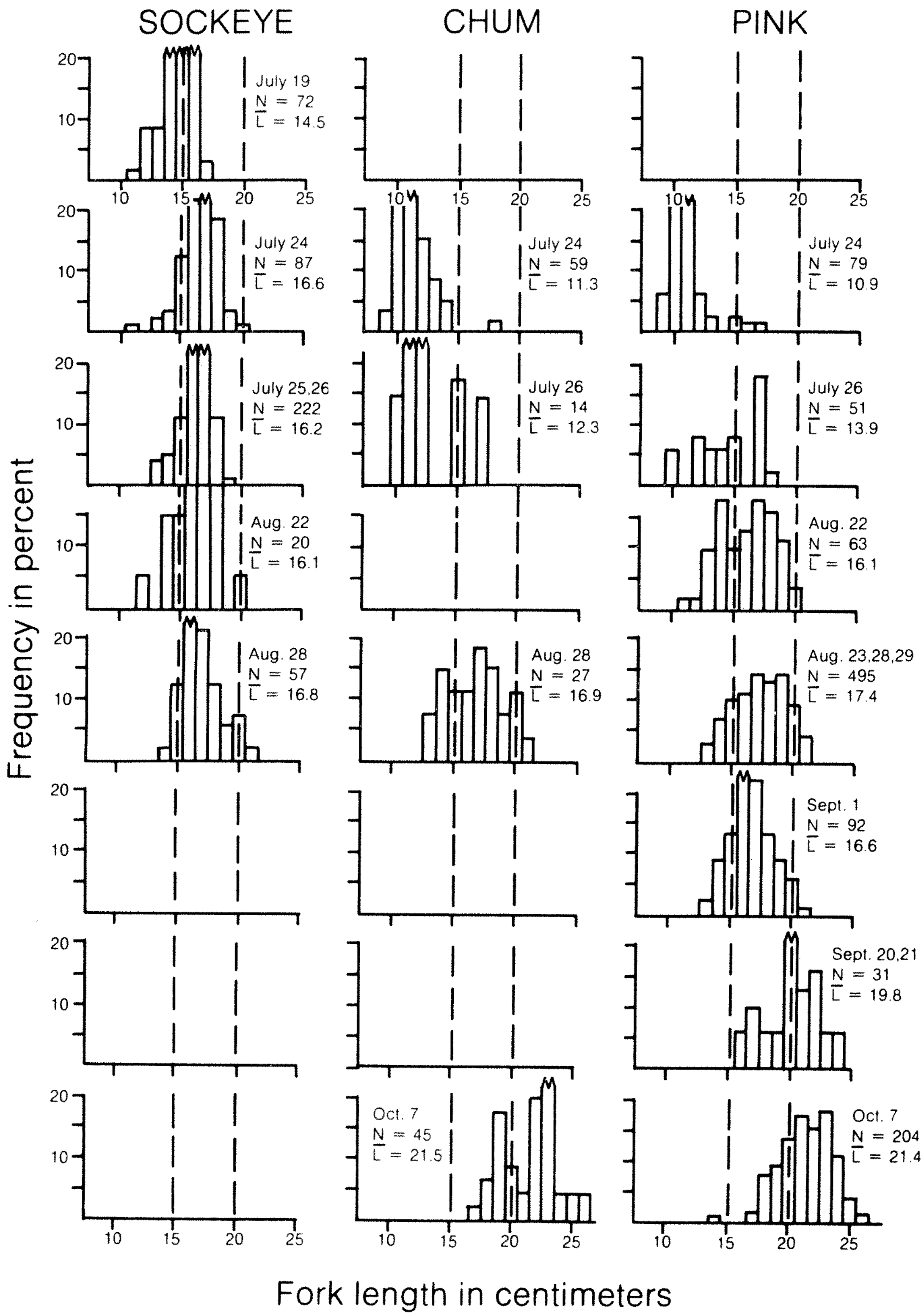


FIG. 47. Fork lengths of juvenile sockeye, chum, and pink salmon sampled in area W4056 by date, July 19–October 7, 1967.

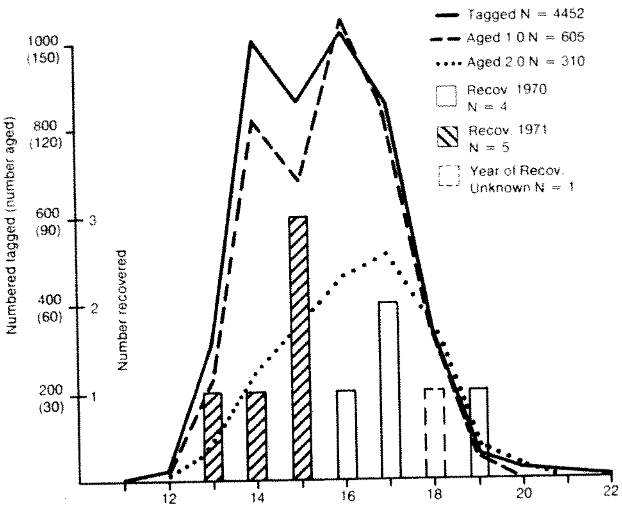


FIG. 48. Fork lengths of 4,452 juvenile sockeye salmon tagged in the eastern Bering Sea in 1968 and lengths at release of 10 fish recovered in 1970 and 1971. Also shown are lengths of a subsample by freshwater age. Length at release was not available for one fish recovered in 1970.

production areas where outmigration is earlier, and the fish larger.

The samples obtained in October 1967 in area W4056 were our latest seasonal observations on lengths of chum and pink salmon in an open sea sampling area. They indicate that in early October, juvenile chum and pink salmon are of similar size, and at this location, range from about 17 to 26 cm and average about 21.5 cm long. These lengths are similar to those observed during the first 2 weeks of September in samples taken south of the Alaska Peninsula as discussed in conjunction with Fig. 45. By early October, however, the lengths of fish occurring south of the Alaska Peninsula were probably even larger. Nevertheless, the October samples in area W4056 and the September samples in areas W6554 and W6054 provide estimates of the size range and mean size of sockeye, chum, and pink salmon juveniles during early fall. Such samples should prove useful in estimating fall, winter, and spring growth by comparing with sizes of fish sampled at sea at age .1.

LENGTH BY YEAR OF RECOVERY

The tag return data for sockeye salmon indicated a relationship between lengths of juvenile salmon sampled in a given area at sea and their year of return. Complications between year of recovery and location of recovery made it difficult, however, to draw firm conclusions from the tagging data.

An examination of the lengths of the juvenile sockeye salmon tagged in the eastern Bering Sea in 1968 according to year of recovery showed that the fish recovered in 1970 were significantly larger at release than those that were recovered in 1971 (Fig. 48). Four fish which were returned in 1970 after 2 years at sea, ranged from 16.1 to 18.6 cm at release, whereas the five which returned in 1971 after 3 years at sea, ranged from 13.2 to 15.1 cm at release. Those recovered in 1970 were released between August 26 and September 14 and those recovered in 1971 were released between August 18 and September 4 (Appendix Table A2). The 10-day average difference in time of release should not have caused the substantial difference in size according to year of return. Thus, it appears on the basis of the small amount of data in Fig. 48, that length at release affected year of return.

The same relationship—between lengths at release and year of recovery—was observed among the four fish tagged south of the Alaska Peninsula. Two fish recovered 2 years after tagging were 23.0 and 24.5 cm long at release, and two fish recovered after 3 years were 21.0 and 22.8 cm long at release. In the case of these four fish, however, such a relationship may have been fortuitous inasmuch as fish tagged south of the Alaska Peninsula were a mixture from widespread production areas (Chignik River, Cook Inlet, Fraser River), with different dates of entering the sea and resultant saltwater growth histories. By

TABLE 7. Length distributions of 26 juvenile sockeye salmon tagged in the Gulf of Alaska according to year of return (source-Appendix Table A2).

Length in cm	Number returned after 2 years	Number returned after 3 years
17	2	5
18	3	4
19	4	2
20	4	0
21	1	0
22	1	0
	15	11

comparison, the fish tagged in the eastern Bering Sea were from a relatively homogeneous source, i.e., the Bristol Bay rivers.

The juvenile sockeye salmon sampled in the northeastern Gulf of Alaska showed the same relationship between size and ultimate age of maturity that had been observed among the Bristol Bay fish. The data are summarized in Table 7 in which 15 fish recovered after 2 years ranged from 17 to 22 cm in length at time of tagging, and 11 fish recovered after 3 years at liberty ranged from 17 to 19 cm in length. Again, the age of return was highly dependent upon the source of the fish as will be mentioned in the next section. However, the data do illustrate the general principle that at any point in sampling, the fish destined to return after 2 years are typically larger than those destined to return after 3 years. Isolating the freshwater age effect was not a problem in this instance since essentially all were age 1.0 (freshwater ages were available for 17 out of the 26 fish listed in Table 6, and 16 of the 17 were age 1.0).

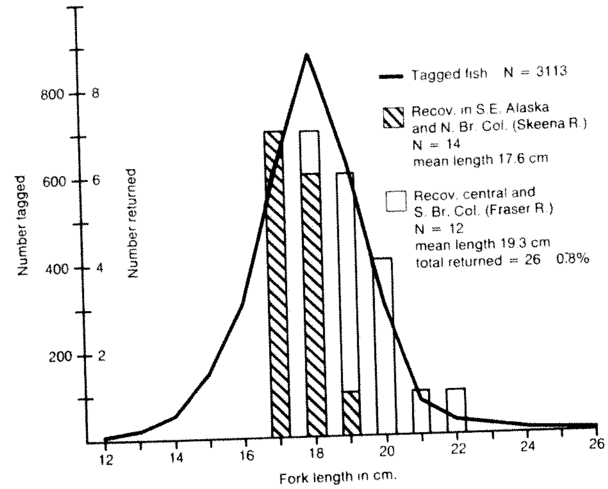


FIG. 49. Fork lengths of juvenile sockeye salmon tagged in areas W4058, 4558, 4056, and 3554 in years 1965–1968, and lengths at release of returns according to two general areas. Test of H_0: $P=1/2$ (or recovery location is independent of length), Chi-square = 16.50, 4 d.f. significant at 1% level.

LENGTH BY AREA OF RECOVERY

In view of the migration and timing patterns discussed in previous sections, we might expect a relationship between the size of juvenile salmon at any given sampling point and the geographic source of the fish. In this section, pertinent data will be used to examine this potential relationship.

SOCKEYE SALMON

Sockeye salmon tagged in five statistical areas in the northeastern Gulf of Alaska in 1968 yielded 26 returns which showed a significant relationship between length at release and area of recovery (Fig. 49). The length of the 3,113 tagged fish formed a normal unimodal distribution typical of juvenile sockeye, yet based upon tag returns the mixture included two major components of significantly different size, which for convenience we will designate northern (mainly Skeena River) and southern (mainly Fraser River). The mixture was generally prevalent throughout all areas and times of sampling. The northern component of 14 fish ranged from 14 to 19 cm in length (mean 17.6 cm) and the southern component of 12 fish ranged from 18 to 22 cm (mean 19.3 cm). A Chi-square test showed the size difference to be significant at the 1 percent level. The larger size of the southern group is presumably a reflection of their earlier entry into salt water and resultant longer period of marine growth.

The length distribution of the recovered fish indicates a bias in favor of large fish which probably results from a greater tagging mortality of small fish. If the smaller fish also tend to include a greater proportion of fish that will remain at sea for 3 years instead of 2 years, then this factor would also reduce tag returns because of additional natural mortality during the extra year at sea.

PINK SALMON

For pink salmon, the relationship between length and distance to origin is more difficult to demonstrate than for sockeye because of shortcomings in the data, but the basic trend seems to agree with the result for sockeye. The pink salmon released in area W4058 in the northeastern Gulf of Alaska in 1968 were selected for analysis in terms of length and origin because of their wide range of lengths and because returns came from several distant locations. The length distributions of released and recovered fish are illustrated in Fig. 50 according to two time periods, July 27 through August 1, and September 15 through September 30. The time division was a natural one because of the gap between sampling dates and because of the vastly different length compositions of the juvenile pink salmon taken in the two periods.

The 1,640 juvenile pink salmon released from July 27 through August 1 yielded 21 returns of which recovery locations are given in Fig. 50a. Fifteen of the returns were from northern southeastern Alaska (north of 56°N). Their lengths at release ranged from 14 to 17 cm. Five were recovered in the southern southeastern Alaska (south of 56°N). Three of the 5 were

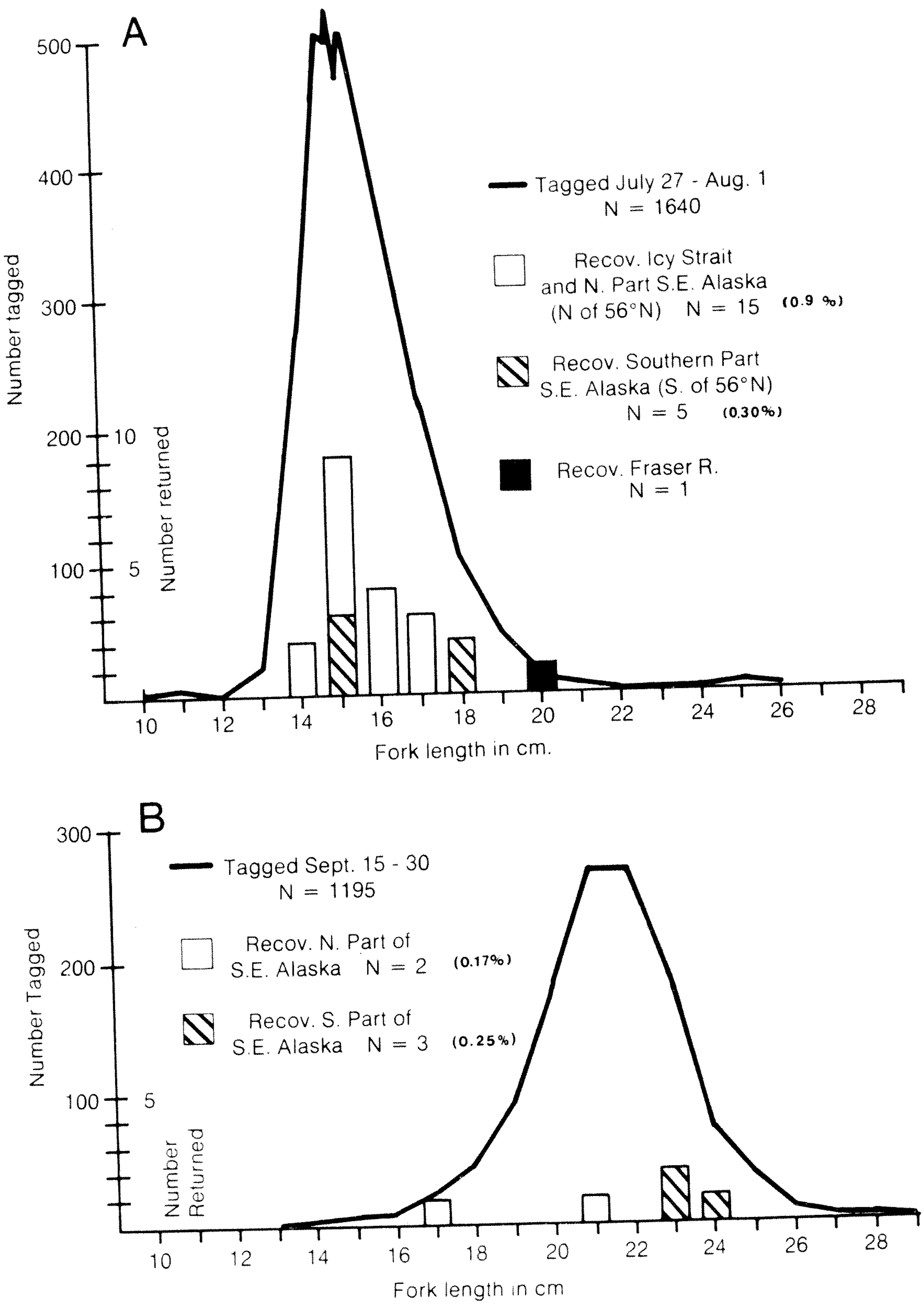


FIG. 50. Fork lengths of juvenile pink salmon tagged in area W4058 during two time periods in 1968, and lengths at release of 26 returns in 1969 by general area of recovery.

15 cm and two were 18 cm at release. The area of release and the distribution of returns with respect to 56°N are illustrated in Fig. 27. In addition, there was one return from the Fraser River that was 21 cm long at release. This was among the largest fish tagged, which would be expected based upon its probable earlier entry into the sea. Thus, the data for southeastern Alaska show some relationship between length at tagging and distance to geographic source, and the large size of the single fish from the Fraser River does support such a general relationship. Because of the proximity of the two recovery areas in southeast Alaska and because of the wide range of timing of the downstream migration of pink salmon, it would probably require a large sample of returns to test critically the size relationship for these adjacent stocks.

Although there were only five returns from the September releases, there was a clear separation of length at release according to location of recovery (Fig. 50b). The length of released fish ranged from 16 to 26 cm. Two returns from northern southeastern Alaska were 17 and 21 cm at time of release, and three returns from southern southeastern Alaska included two at 23 cm and one at 24 cm. Although results based upon such a small sample cannot be considered conclusive, they agree with the results shown more clearly by sockeye salmon and by pink salmon from more distant production areas.

The total returns in 1969 from the early release period including those from uncertain recovery locations, were 26 of 1,640 released or 1.6 percent, and from the late release period six returns of 1,195 released or only 0.5 percent. Normally, a higher rate of return would be expected from the later sample because they were larger, but in this case it is possible that the relative rates of return were biased by unequal fishing effort on the two release groups when they returned in 1969. In 1969, the northern part of southeastern Alaska had a substantial run of pink salmon which permitted an intensive fishery to harvest a large percentage of the run. Conversely, in the southern part of southeastern Alaska, the run in 1969 was weak, and relatively little fishing was permitted. Since tagged fish in the commercial catch are much more likely to be recovered than those in the escapement, the fish tagged during the early period in 1968 should have had a higher probability of return in 1969 since they were destined for the northern part of southeastern Alaska by a margin of 15 to 5 based on tag returns (Fig. 50a). Conversely, the low rate of recovery in the northern fishery from the late-season releases (2/1195=0.17 percent as compared to 15/1640=0.91 percent from early releases), suggests that there was a low percentage of northern stocks among the late-season group. The number of returns to the southern fishery was perhaps too low for a comparison between release periods, but the rates were similar for the two periods (0.30 percent early; 0.25 percent late).

Coho Salmon

The relationship between length and location of recovery of coho salmon followed the pattern observed with sockeye and pink salmon. Because of the high recovery rates of coho salmon, data for several years can be compared. Releases in areas W4058 and W4056 in the northeastern Gulf of Alaska were chosen for analysis because juvenile coho are abundant in these areas and are, as discussed in context to Figs. 30 and 31, a mixture from various sources. Accordingly, Fig. 51 shows length data for coho released in areas W4058 and W4056, 1964–1968, plus length at release of those recovered a year later. Symbols indicate whether recovery locations were north or south of 49°N (or other appropriate latitudes if the data warranted a broader separation). Latitude 49°N falls at about the middle of Vancouver Island and was chosen as a separation point between British Columbia-Alaska returns and Washington-Oregon-California returns (*see* Figs. 30 and 31).

Although there is some overlap, the results indicate that the smaller fish at tagging were generally recovered in the northern division, and the larger fish in the southern division. The trend occurred each year for which data were available. The results illustrate that among the mixed stocks of cohos tagged in the northern Gulf of Alaska, the larger fish were from more distant production areas to the south and the smaller fish were mainly from nearby areas.

There is little likelihood of serious bias in Fig. 51 from fish being recovered in the north division that were actually destined for a stream in the south division or vice-versa. As shown in Appendix Table A5, a majority of the northern recoveries were caught in inside waters or in rivers, frequently late in the season. Similarly, many of the larger tagged specimens were recovered well to the south, often in rivers, and late in the year. Since the summer migrations of maturing coho are chiefly northward (Godfrey et al. 1965, 1975), it is possible that some fish recovered in ocean fisheries in the southern region in early summer might have been destined for northern production areas, but such bias was probably minimal.

A scarcity of returns from among the smaller fish released (20–25 cm) was obvious each year. Reasons are not clear, since we would expect cohos over 20 cm to be large enough to carry the tag easily and to

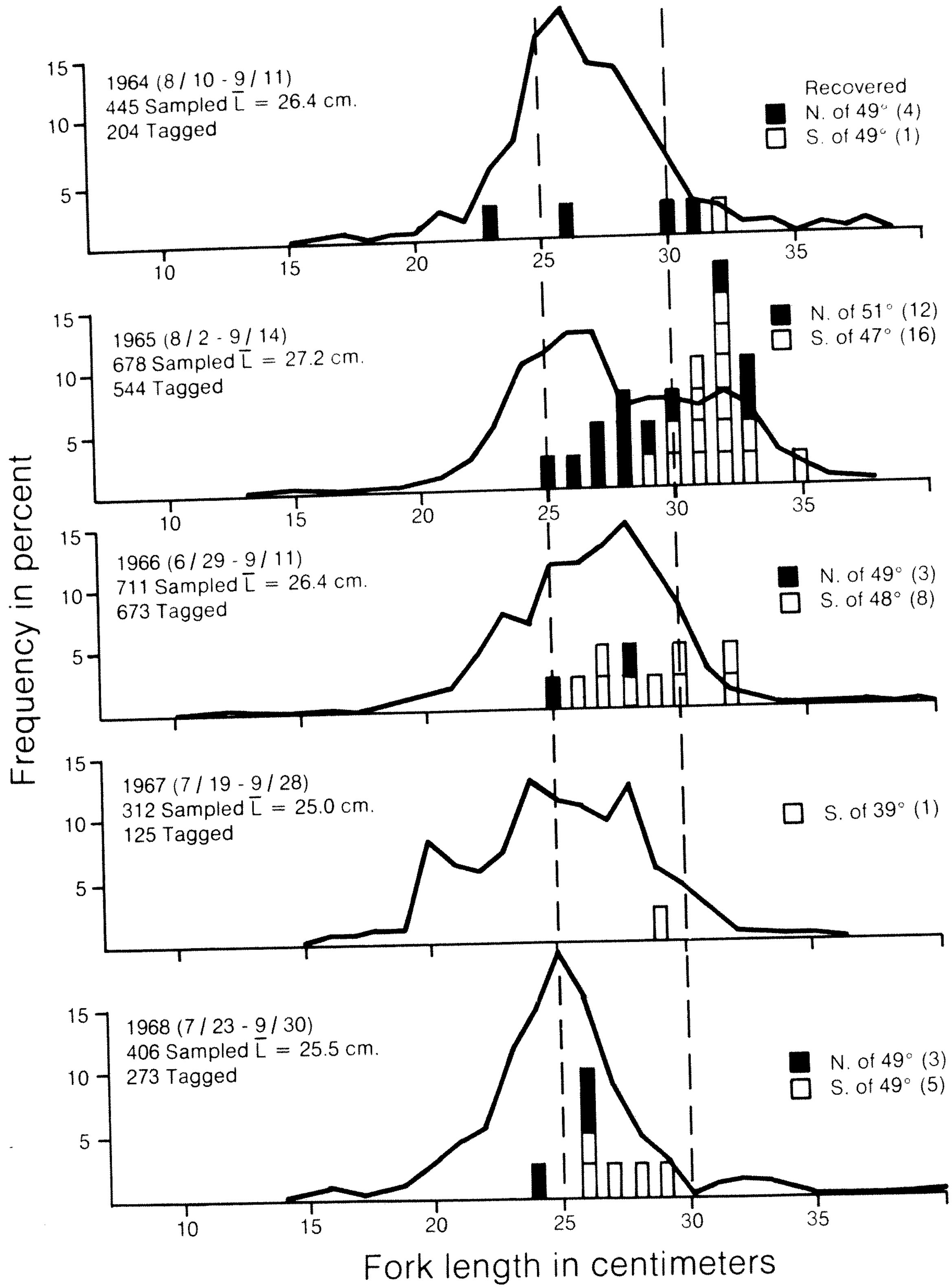


FIG. 51. Fork lengths of juvenile coho salmon sampled in areas W4058 and 4056 by years, 1964–1968, and lengths at release of returns in years 1965–1969 by general latitude of recovery.

TABLE 8. Coho salmon tag returns one year after release by recovery area and method of recovery. (Release areas Dixon Entrance to Unimak Island—release years 1958–1968.) Source: Table A5 and unpublished data tables.

Recovery area	Method of recovery (numbers and percent)						Total	
	Troll, sport or hatchery		Gillnet		Purse Seine			
Alaska and Canada	32	63%	17	33%	2	4%	51	100%
Washington to California	48	89%	5	9%	1	2%	54	100%

yield a reasonably high rate of return. Although data are not available for comparison, it is likely that the catch/escapement ratio is higher in the southern areas than in the northern, which should enhance tag return rates in the south because recovery efficiency is much higher in the catch than in the natural spawning escapement. The recovery methods may also have favored returns from southern areas as suggested by the data in Table 8. Among 54 returns to the southern area, 48 (89 percent) were taken by methods that require handling fish individually (troll or recreational gear, or at hatcheries), whereas only 63 percent of 51 returns from northern areas were by such means. These differences could at least partially account for the lesser return rates of the smaller cohos released.

GROWTH RATES AND MIGRATION RATES

Selected tag release and recovery data were used to estimate the rates of growth and rates of travel of juvenile sockeye and pink salmon during their early oceanic migrations. Ideally, to derive such rates we would need the following information:

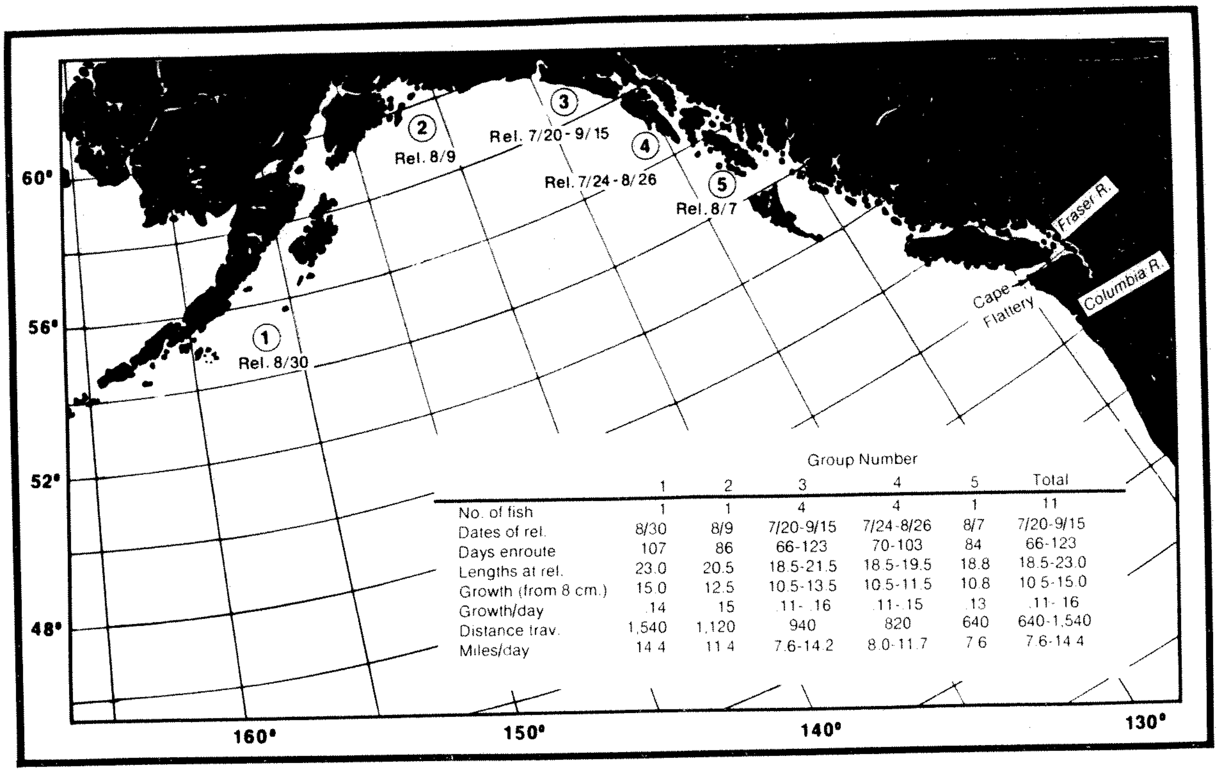
1) date of saltwater entry;
2) date of start of directed, oceanic migration;
3) location of saltwater entry;
4) length at saltwater entry;
5) date of tagging;
6) location of tagging;
7) length at tagging.

Items 5–7 are known precisely from tag release data, and tag recovery information usually provides a good fix on item 3. Thus, items 1, 2, and 4 must be estimated in order to derive rates of growth and travel.

SOCKEYE SALMON

Growth and migration rates for juvenile sockeye salmon from the Fraser and Skeena Rivers will be examined and compared because the juveniles from these rivers occur mixed together during their first summer at sea. Figure 52 shows the release location and the estimated growth and migration rates for 11 Fraser River sockeye salmon based upon an estimated saltwater entry date of May 15 at a length of 8 cm and migration via the Strait of Juan de Fuca. May 15 was used as the estimated date of entry into salt water as a rough mean between some of the more abundant early and late migrating races. The time of saltwater entry of Fraser River sockeye smolts ranges from about April 5 to June 5 and mean fork lengths range from 7 to 9 cm, depending on the race (Mr. John Roos, International Pacific Salmon Fisheries Commission, personal communication). It is recognized that some of the fish may have migrated via Johnstone Strait rather than the Strait of Juan de Fuca, but since the majority of the maturing fish return via the Strait of Juan de Fuca, it is assumed that the majority of smolts leave via this route. Also, the calculations are based on the assumption that the tagged fish had proceeded rather directly seaward after entering salt water. Since most of the tagged fish had migrated rather far, it is probable that they were among the early entrants into salt water and had not lingered extensively in the Gulf of Georgia.

The firm information in Fig. 52 is that 11 juvenile sockeye salmon which were caught and tagged along the coast at distances ranging from 640 to 1,540 nm from the Fraser River from July 20 to September 15 and at lengths ranging from 18.8 to 23.0 cm were later recovered in or near the Fraser River as maturing fish. Estimated information is that the days en route ranged from 66 to 123; total growth after entry into salt water ranged from 10.5 to 15.0 cm; growth per day ranged from 0.11 to 0.16 cm; and nautical miles per day ranged from 7.6 to 14.4. Although these are first order estimates, they do provide a range that is probably indicative of rates of growth and migration of Fraser River sockeye during early oceanic migrations. Since most of the tagged fish probably entered salt water earlier than average and at larger than average size, the lower figures of growth per day (0.11 cm) and nautical miles per day (7.6) may be more representative of the true mean values. If,



	Group Number					
	1	2	3	4	5	Total
No. of fish	1	1	4	4	1	11
Dates of rel.	8/30	8/9	7/20-9/15	7/24-8/26	8/7	7/20-9/15
Days enroute	107	86	66-123	70-103	84	66-123
Lengths at rel.	23.0	20.5	18.5-21.5	18.5-19.5	18.8	18.5-23.0
Growth (from 8 cm.)	15.0	12.5	10.5-13.5	10.5-11.5	10.8	10.5-15.0
Growth/day	.14	.15	.11-.16	.11-.15	.13	.11-.16
Distance trav.	1,540	1,120	940	820	640	640-1,540
Miles/day	14.4	11.4	7.6-14.2	8.0-11.7	7.6	7.6-14.4

FIG. 52. Estimated rates of migration and growth of Fraser River sockeye salmon during their early oceanic migrations based upon 11 tag returns from the Fraser River area of fish that had been tagged as juveniles at five distant locations. Calculations based upon estimated saltwater entry on May 15 at a length of 8 cm and oceanic embarkation via Strait of Juan de Fuca. Lengths in cm; distances in nautical miles. Source: Appendix Table A2.

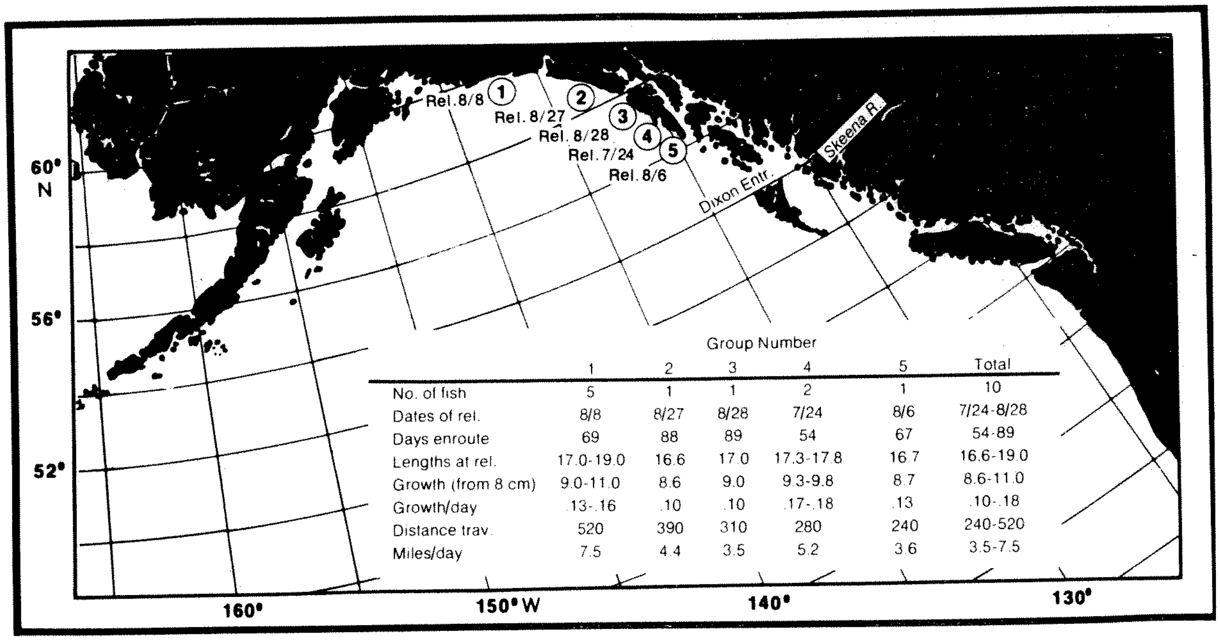
however, the fish tended to linger in the vicinity of salt water entry prior to starting their northward migration, then the actual rate of travel may be better represented by the upper figure of 14.4 nm per day.

Accordingly, the average rate of travel of juvenile salmon in the eastern Gulf of Alaska will be considered as a nominal 10 nm/day. This speed will be used in later sections where fish density is discussed. This rate is, of course, a " ground speed " measured over a substantial distance. Undoubtedly, pervasive ocean currents and local tidal currents accelerated or retarded this ground speed at times and places along the route. The actual speed and direction of swimming through the water in the short term are unknown.

An obvious physical feature that must influence the rate of travel is the northerly flow of the Gulf of Alaska Gyre. However, the details of this major oceanographic feature and the short-term behavior of the fish are not sufficiently known to estimate its impact on speed of migration. In their review of the oceanography of the subarctic Pacific Region, Favorite et al. (1976, p. 24) describe the Gulf Gyre as follows:

> " Flow along the North American continent north of 45°N was chiefly northward. Surface speeds fluctuated at various points in the region between 1 and 45 cm/sec. The highest values 30–45 cm/sec, were found near the coast; below 300 m, speeds decreased gradually to 1–5 cm/sec. Comparison of observations of currents made at anchored buoy stations during the 29th voyage of *Vityaz* in 1958–59 with computed values indicated that speeds of observed currents were almost twice the geostrophic currents and the directions were entirely different."

If cm/sec values are translated to nm/day, the computed currents (chiefly northward) ranged from 0.5 to 21 nm/day, and the high values near the coast ranged from 14 to 21 nm/day. From these current speeds it might be concluded that all or most of the northerly migration of juvenile salmon is accounted for by the Alaska Gyre. However, the variables in the actual currents, particularly nearshore, and the many possible variations in fish behavior probably obscure any relationship between migration speed and the calculated Gulf Gyre transport. Examples are:



	Group Number					
	1	2	3	4	5	Total
No. of fish	5	1	1	2	1	10
Dates of rel.	8/8	8/27	8/28	7/24	8/6	7/24-8/28
Days enroute	69	88	89	54	67	54-89
Lengths at rel.	17.0-19.0	16.6	17.0	17.3-17.8	16.7	16.6-19.0
Growth (from 8 cm)	9.0-11.0	8.6	9.0	9.3-9.8	8.7	8.6-11.0
Growth/day	.13-.16	.10	.10	.17-.18	.13	.10-.18
Distance trav.	520	390	310	280	240	240-520
Miles/day	7.5	4.4	3.5	5.2	3.6	3.5-7.5

FIG. 53. Estimated rates of migration and growth of Skeena River sockeye salmon during their early oceanic migrations based upon 10 tag returns from the Skeena River area of fish that had been tagged as juveniles at five distant locations. Calculations based upon estimated saltwater entry on June 1 at a length of 8 cm and oceanic embarkation via Dixon Entrance. Lengths in cm; distances in nautical miles. Source: Appendix Table A2.

1) the variable and turbulent currents as measured by the anchored buoy stations referenced above; 2) the observation aboard our purse seine vessels that during the 1 1/2–2 hr duration of our seine sets, the drift of the vessel varied from 0–3 nm northward to 0–2 nm southward; 3) the evidence from seine catches that at certain times and places, migration of juvenile salmon may be temporarily southward—as discussed with respect to Table 4 (p. 83)—and 4) the evidence from tag returns that juvenile salmon from the southern extreme of the study area entered " inside " waters such as Dixon Entrance and Hecate Strait, where for unknown periods, they were not subject to major ocean currents.

Estimates of migration and growth rates of juvenile Skeena River sockeye salmon are illustrated in Fig. 53 based upon an estimated saltwater entry date of June 1, a length of 8 cm, and an assumed migration to sea via Dixon Entrance. The June 1 date is based upon an average midpoint migration date past the Babine smolt counting fence 250 miles upstream from the sea, of May 20–25 (Mr. Howard D. Smith, Canada Department of Fisheries and Oceans, personal communication).

The firm data are that 10 juvenile sockeye salmon which ranged in fork length from 16.6 to 19.9 cm were tagged along the coast at distances ranging from 240 to 520 nm from the Skeena River on dates ranging from July 24 to August 28 and were later recovered as maturing fish in or near the Skeena River. Estimated information is that the days en route ranged from 54 to 89; total growth ranged from 8.6 to 11.0 cm; growth/day ranged from 0.10 to 0.18 cm; and nm/day ranged from 3.5 to 7.5. Thus, the estimated growth rate of the Skeena River fish (0.10–0.18 cm/day) was similar to that of the Fraser River fish (0.11–0.16 cm/day), but the rates of travel were considerably less (Skeena River 3.5–7.5 nm/day; Fraser River 7.7–14.4 nm/day). The slower apparent rate of travel of Skeena fish was probably in part due to their fewer days at sea. The Skeena fish had spent an average of 69.7 days at sea and the Fraser River fish 85.8 days. Thus, any time spent lingering near their estuary would have formed a larger proportion of their time at sea which, in turn, would have caused a corresponding reduction in apparent rate of travel. It is also probable that young samon tend to travel more rapidly as they grow so that the earlier migrating, and thus larger, Fraser River fish were more capable swimmers and migrated more rapidly than the Skeena fish even after they became intermingled, presumably in the vicinity of Dixon Entrance (Figs. 52 and 53).

There were six returns of Bristol Bay sockeye that could be used for estimating rates of growth and

TABLE 9. Estimated rates of growth and rates of travel during early ocean residence for 6 juvenile sockeye salmon of Bristol Bay origin that were tagged in 1968 (Source: Appendix Table A2).

River of origin	Estim. date of entry into estuary	Date caught at sea	Estim. length at entry (cm)*	Length at capture at sea (cm)	Estim. days en route	Estim. growth (cm)	Estim. growth cm/day	Nautical miles traveled	Rate of travel nm/day
Nushagak	6/10	8/29	9.1	16.8	80	7.7	0.10	290	3.6
"	"	9/8	9.1	16.9	90	7.8	0.09	200	2.2
"	"	9/4	10.5	14.5	86	4.0	0.05	230	2.7
Nak.-Kvi.	5/31	9/4	9.1	16.1	96	7.0	0.07	210	2.2
"	5/31	8/29	9.1	15.1	90	6.0	0.07	310	3.4
Egegik	5/31	8/18	9.1	14.3	80	5.2	0.07	170	2.1

* Estimated mean dates and lengths at entry into estuary in 1968 from personal communication from Dr. D. E. Rogers, Fish. Res. Inst., Univ. Wash. (age 1.0 smolts=8.5 cm, age 2.0 smolts=10.5 cm, approx. mean for all rivers). The 9.1 cm length in col. 4 is a weighted mean based upon freshwater age composition of the sample tagged at sea and was used for the 5 fish for which freshwater age at tagging was not known.

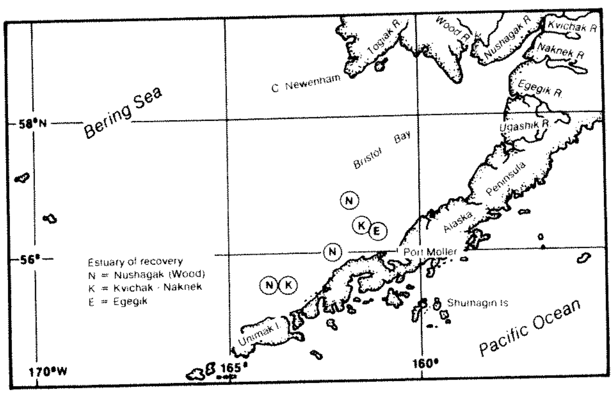


FIG. 54. Release locations of six juvenile sockeye salmon tagged in 1968 and recovered in 1970 and 1971 in Bristol Bay estuaries. For details see Table 9.

travel for comparison with Skeena and Fraser River stocks (Table 9). All of the returns had been caught and tagged in the Bering Sea between Port Moller (161°W) and Unimak Island (164°W) within 50 nm of the north side of the Alaska Peninsula as illustrated in Fig. 54.

Estimated growth rates of the Bristol Bay sockeye (0.05–0.10 cm/day) were considerably less than those of the Fraser and Skeena Rivers (0.10–0.18 cm/day). Part of the explanation may be that feeding conditions in the extreme eastern portion of Bristol Bay are relatively poor (Straty 1974), and that growth, therefore, is slow until the migrants reach richer feeding grounds farther west. Once the juvenile fish reach the area west of 160°W, however, they presumably grow rapidly since food organisms were extremely abundant in the waters where our sampling and tagging were done (Hartt et al. 1969, 1970).

The estimated rates of travel of the Bristol Bay sockeye (2.1–3.6 nm/day) were somewhat slow compared to the Skeena River fish (3.5–7.5 nm/day) and much slower than the Fraser River fish (7.6–14.4 nm/day). The slower rates are in agreement with the previously discussed random movements observed in the eastern Bering Sea as compared to the positively-directed northward movement along the coast of Canada and southeastern Alaska.

PINK SALMON

From the 55 pink salmon tag returns (Fig. 27), three were selected as suitable for estimating rates of travel and growth. Recovery locations for the three were the San Juan Islands, the Fraser River, and the Nass River, British Columbia, respectively, and thus provide data for comparing with sockeye from the Fraser River and Skeena River. Particulars of release and recovery from Appendix Table A4 are listed below:

Tagging area and location	Recovery location	Tagging date	Recovery date
W4058 58°31′N×137°54′W	Nass River‘ B.C.	9/10/66	7/23/67
W4058 58°32′N×137°55′W	San Juan Islands	8/12/66	9/17/67
W4058 58°17′N×137°02′W	Fraser River, B.C.	7/29/68	10/28/69

Data for estimating rates of travel and growth for the three fish are:

	Nass River Return	San Juan Islands Return	Fraser River Return
Estimated date of salt-water entry	5/15	4/30	4/30

Continued . . .

	Nass River Return	San Juan Islands Return	Fraser River Return
Estimated location of saltwater entry	Nass River	Fraser River	Fraser River
Estimated number of days to tagging	97	104	90
Estimated distance traveled (nm)	390	960	960
Estimated rate of travel (nm/day)	4.0	9.2	10.7
Estimated length at saltwater entry (cm)	4.0	4.0	4.0
Actual length at tagging (cm)	22.0	23.5	20.0
Estimated growth to day of tagging (cm)	18.0	19.5	16.0
Estimated growth/day	0.19	0.19	0.18

The specimen recovered in the San Juan Islands was assumed to have originated in the Fraser River. The dates of saltwater entry of the two Fraser River fish and the Nass River fish were assumed to be 15 days earlier than the entry dates used for sockeye in the Fraser and Skeena Rivers, respectively. The resultant rates of travel for Fraser River pink salmon were 9.2 and 10.7 nm/day which falls within the range of 7.6–14.4 nm/day for Fraser River sockeye (Fig. 52). The growth rates of 0.18 and 0.19 cm/day for pink salmon were well above the range of 0.11–0.16 cm/day for Fraser River sockeye, but a greater growth rate for pink salmon should be expected since they are substantially larger than sockeye when they both reach age .1. Thus, the results suggest that the rapid growth rate of pink salmon begins early in their life.

The pink salmon recovered in the Nass River, which is in northern British Columbia near the Skeena River, showed an estimated growth rate similar to the two Fraser River fish of 0.19 cm/day. It had been tagged after 97 days at a distance of 390 nm from the Nass River. Its rate of travel was 4 nm/day which is considerably less than that of the Fraser River pink salmon, but the rate falls within the range estimated for Skeena River sockeye salmon (3.5–7.5 nm/day). Thus, even though the Nass River pink salmon had not migrated as far from its origin as the two Fraser River fish had, all three fish apparently grew at about the same rate.

Although the above calculated rates of growth and travel may be reasonable estimates for the small sample of recovered fish, they are probably higher than the average for the stocks they represent. This is because the recovered fish tend to be larger than the mean size of the sample tagged as discussed in a previous section. Such size bias would affect growth estimates directly, and would affect rate of travel if larger fish swim more rapidly.

DENSITY, ABUNDANCE, AND FOOD

The foregoing evidence on distribution and migrations indicates that, although juvenile salmon may migrate extensively during their first summer, they tend to be concentrated in a relatively limited nearshore area as compared to a widespread offshore dispersion at later stages of the oceanic feeding period. Thus, density of salmon per unit surface area must be relatively high in the main areas occupied by juveniles. In this section, the purse seine catch data will be examined as a means of estimating the density and abundance of juvenile salmon in areas where sampling and tagging were conducted. Data on abundance provide rough estimates of the numbers of salmon present in the mixed populations that were tagged. Although food and feeding habits are treated only superficially in this paper, data on density may prove useful in future studies of feeding and food competition.

Density

Because of the method of operation of the purse seine and because of its efficiency, rough estimates of the minimal numbers of juvenile salmon per unit surface area may be derived from the purse seine catches. As described in an earlier section, the purse seines used in these experiments were about 704 m long on the cork line and about 46 m deep. The seine was set in an approximate semicircle for 30 minutes, then closed and pursed. The mesh sizes were such as to retain essentially all juvenile salmon of the sizes encountered in the areas and times to be used for density estimates. Thus, the density estimate is based upon the area enclosed by the seine plus any additional area from which salmon migrated during the 30 minutes of set as illustrated in Fig. 55.

An average of 350 juvenile salmon per set was used as a typical catch that occurred during August and September in areas W4056 and W4058 in the northern part of southeast Alaska in several of our sampling years (Appendix Table A1). These areas were chosen for density estimates because direction of migration of juvenile salmon is typically northward as shown by tag returns, and by catches in opposed seine sets (Table 4). For this average catch, the calculated density was 0.0015 salmon per square meter (m^2) or 681 m^2 per salmon. Assumptions in the estimate are:

1. The seine is 100 percent efficient for the juvenile

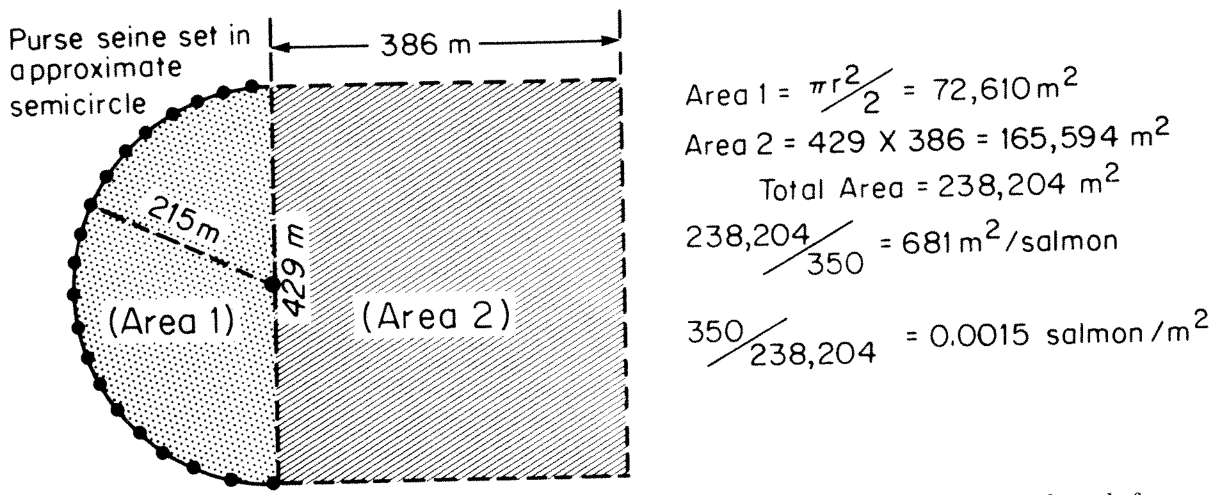


FIG. 55. Diagram of area sampled by purse seine during a 30-minute set, and assuming a rate of travel of 10 nm/day.* Also resultant estimates of fish density where mean catch was 350/set.

* International nautical mile = 1,852 m.

salmon that cross the imaginary diameter line at the entrance of the semicircle of the seine.

2. All salmon are migrating in a direction perpendicular to the diameter line of the seine.
3. The rate of travel is uniformly 10 nm per day.

Because assumptions 1 and 2 are obviously not met, the calculated density figures must be considered minimal. The efficiency of the seine is certainly not 100 percent, since there is always a possibility of salmon escaping either under the seine or around the ends, either during the towing or the pursing phases of the set. When visual conditions are ideal, salmon are sometimes seen escaping around the ends of the net. Escapement under the net by juveniles is unlikely, and fish swimming deeper than the net is also unlikely. The direction of migration is known to vary substantially (Table 4) so that the seine was probably seldom set for optimum catch in a given area, and even when the direction of set was optimum, there probably were some juvenile salmon migrating at least temporarily in directions which would render them nonvulnerable to capture. Error in the estimated rate of travel (assumption 3) could cause either a positive or negative error in the density estimate. If the rate of travel were actually greater than 10 nm/day, then the fish caught in a set would be from a greater area than assumed and density would be overestimated; if rate of travel were less than 10 nm/day, then the opposite would hold. The figure of 10 nm/day was approximately that estimated previously for Fraser River sockeye that were tagged in the northern Gulf of Alaska. Since bias in assumptions 1 and 2 would tend to yield reduced density estimates, we may conclude that the density of all species of juvenile salmon off the coast of the northern part of southeastern Alaska in August and September is at least 0.0015 per m² or one fish per 681 m².

The pattern of dispersion of the fish is probably characterized by small, uniformly distributed patches or schools rather than by large compact schools with extensive vacant or sparsely populated areas between. As mentioned with respect to Tables 1 and 4, seine sets with zero catches very seldom occurred except farther offshore, or when the seine was set in a nonoptimum direction.

The density of salmon in the eastern Bering Sea was probably similar to that calculated for the northeastern Gulf of Alaska. Since the direction of migration of juvenile salmon in the Bering Sea is much more variable than in the northeastern Gulf of Alaska as discussed earlier with respect to Tables 4 and 5, assumption 2 becomes even less valid for the Bering Sea area than for the Gulf of Alaska area. In order to derive a more equitable CPUE for the eastern Bering Sea, the catches in sets open northeast and southeast should be summed before applying the density formula. Thus, from Table 5, the mean catch would be 331 per set which would yield a density similar to that in the northeastern Gulf of Alaska. Since the rate of travel of the juvenile salmon in the eastern Bering Sea was only 2 or 3 nm/day, the actual density was probably even greater than in the northeastern Gulf of Alaska.

The maximum density of salmon in the areas which we sampled can also be calculated from catches in individual seine sets. The largest catch (4,551) was in set X-16 in area W3554 (Dixon Entrance) on July 14, 1967. Other individual seine catches from 1,000 to 2,000 occasionally occurred in various areas of both the northeastern Gulf of Alaska and eastern Bering Sea. The catch of 4,551 juvenile salmon in the set mentioned above would yield a density factor of 0.0193 juvenile salmon per m^2 or one fish per 53 m^2. This catch probably resulted from a fortuitous seine set in which a large school or several schools were momentarily concentrated by a tide rip or by feeding conditions. This set was made within 6 miles of Cape Muzon, Dall Island, in northern Dixon Entrance where juvenile salmon from many nearby production areas probably tend to concentrate. In the open sea areas of the northeastern Gulf of Alaska and in the eastern Bering Sea, however, catches also occasionally reached 1,000 to 2,000 per set, indicating that minimum densities of 0.0042 to 0.0084 fish per m^2 or one fish per 238 to 119 m^2 do occur in offshore areas.

The maximum catch of older age groups of salmon as observed in our seine operations was very close to that of the maximum catch of juvenile salmon. The largest catch of older salmon was 4,819, which occurred in set S-18 on July 13, 1969, 7 miles south of Adak Island in the central Aleutian Islands. This compares with a maximum catch of 4,551 juveniles as discussed above. The species composition in the case of the older fish was primarily sockeye and chum salmon and a few were maturing fish, but the great majority was age .1 and age .2 immature fish. Also, the older fish occasionally yielded catches of 1,000 to 2,000 per set south of the central Aleutian Islands, not unlike the situation with juvenile salmon in the northeastern Gulf of Alaska and eastern Bering Sea. In view of the large number of seine sets made over vast areas at sea (3,073 sets, Fig. 2), the results suggest that there is an upper limit to the density of salmon during their oceanic migrations that may apply to all age groups. However, it should be borne in mind that the density indicated by a given CPUE may be substantially less for older salmon than for juvenile salmon because of the faster rate of travel of the older salmon. Average rates of travel of immature salmon of age .1 and age .2 in the central Aleutian Islands area, for example, have been shown by precise tag return data to range from 10 to 30 nm per day (Hartt 1966). Average rates for maturing salmon during their last 30 days at sea ranged between 25 and 30 nm per day. Thus, the density indicated by a given CPUE would be considerably less for larger salmon than for juvenile salmon because of the greater area sampled in the case of a purse seine catch of older salmon.

Abundance

The purse seine CPUE can also be used to estimate the numbers of salmon in a sampling area by extrapolating the appropriate density estimates over time and space. This method would ideally require that sampling be adequate to establish density isopleths over the area in which the population was to be estimated. Although our sampling was inadequate for such a precise method, it is possible to make gross population estimates for limited areas where repeated sampling was done and where the approximate width and length of the fish distribution was known. By this means, a population estimate may be made for a coastal strip in the northern Gulf of Alaska from the center of area W4058 to the southern boundary of area W4056. A conservative estimate of the area based on our seining would yield a strip 150 nm long by 15 nm wide or 2,250 nm^2. A density of 0.0015 salmon per m^2 would yield 5,145 salmon per nm^2 or 11,576,250 juvenile salmon in the 2,250 nm^2 coastal strip. This figure would be greater if corrected for inefficiency of the purse seine and for direction of movement factors discussed earlier. Rate of travel might either increase or decrease the figure. This would of course be an instantaneous population, and because of the dynamic nature of the fish, the population would be constantly fluctuating during the 2 or 3 months of migration through the area. A population of this magnitude would seem a minimum in view of the known presence of stocks from production areas extending southward to Washington and Oregon at least. Furthermore, at a rate of travel of 10 nm/day, the population would be renewing itself every 15 days as the migration proceeded through the coastal strip. For a 60-day period the population would be 4×11.6 million or 46.4 million.

The area of distribution in the eastern Bering Sea which was illustrated in Fig. 9 might conservatively be estimated as 30 nm by 100 nm or 3,000 nm^2, which at 0.0015 salmon per m^2 would yield a population of 50,435,000 juvenile salmon (mainly sockeye). This would seem a credible figure and probably a minimum in view of the substantial runs of mature sockeye to Bristol Bay each year. This estimate would also be an instantaneous population estimate and would not include those fish that had migrated outside the bound of our sampling or those which were inshore of the 37-m line where juvenile salmon were shown by Straty (1974) to be abundant. An estimate of 50 million juvenile sockeye, if applied to the year 1968, would be about 10% of the estimated 500 million smolts (Rogers 1977) that migrated from all of the major Bristol Bay rivers in 1968.

Food

It is not possible at this stage of our knowledge to relate the density and abundance figures cited above to the matter of food availability and feeding competition. Since juvenile salmon are relatively small, the food requirements per fish must be far less than for larger fish at later life history stages. Nevertheless, the grazing rate on food organisms of suitable size in the epipelagic waters where juvenile salmon are concentrated must be substantial. The grazing rate must be particularly high off southeastern Alaska where catch data indicate that masses of juvenile salmon migrate continuously northward within a narrow coastal belt for 2 or 3 months. Similar high food requirements must apply in the eastern Bering Sea where juvenile sockeye are very concentrated for a 2- or 3-month period.

Although a thorough analysis of the food habits of juvenile salmon is beyond the scope of this paper, a summary of the stomach data as analyzed to date will be presented. As described under *Methods*, data on feeding were collected in two ways: 1) shipboard examination of stomachs of fresh fish, and 2) laboratory examination of stomachs of whole fish preserved in formalin.

Stomach contents of shipboard samples were recorded according to major taxonomic groups and general degree of fullness. The data have not been formally analyzed but the major food items have been reported qualitatively for some years in INPFC Annual Reports based upon tabulations of samples from key areas (Hartt et al. 1969, 1970). Euphausids and larval fish were greatly dominant in most samples of juvenile sockeye, chum and pink salmon. Empty stomachs occurred in only a small proportion of the fish examined. There were no areas or time periods when empty stomachs were numerous, or where fish appeared emaciated. On the contrary, in many areas of concentration of juvenile salmon an abundance of food organisms could be observed from the vessel during the purse seine operations (Hartt et al. 1969). In the Bering Sea in particular, dense schools of food organisms including euphausids and larval fish were frequently observed both inside the net and outside the net from the surface and from underwater. Throughout large areas of the eastern Bering Sea, the juvenile salmon could be described as swimming through a " soup " of food organisms.

The laboratory samples of juvenile sockeye collected in 1967 and 1968 were analyzed and reported by the late Rollin D. Andrews III in an unpublished manuscript entitled, " Food, feeding habits, and some related topics about sockeye salmon in their first summer of ocean residence," (Fish. Res. Inst. 1970, 124 pp.). Major findings reported by Andrews were:

1. Based on pooled stomachs of 996 specimens collected in 1967 and 1968 from both the Bering Sea and the Gulf of Alaska, the top five food items were:
   a. Euphausids—42.0% of weight of stomach contents
   b. Larval fish —30.8% of weight of stomach contents
   c. Pteropods — 6.2% of weight of stomach contents
   d. Copepods — 5.1% of weight of stomach contents
   e. Amphipods— 1.6% of weight of stomach contents

   A wide variety of other items occurred, usually in small quantities. Variations by year, season, and area were substantial, but the great dominance of euphausids and larval fish was generally applicable.
2. The incidence of empty stomachs varied according to location and time of day, but the overall incidence was 7.9%.
3. The weight of stomach contents ranged from 0 to 2.4% of body weight for individual fish and averaged 0.42% for all samples.

SUMMARY AND DISCUSSION

Despite gaps in the data, the sampling and tagging of juvenile salmon reported herein have provided a working model of the distribution and migrations of some major stocks of North American salmonids during their first summer at sea. This model, when combined with information on the distribution and migrations of the older age groups, makes possible a preliminary model of the oceanic distribution and migrations of these stocks throughout their full oceanic feeding cycle. A combined generalized model based on earlier sampling was proposed by Royce et al. (1968), and models for sockeye, chum, and pink salmon, respectively, were proposed in the recent series of INPFC joint comprehensive reports (French et al. 1976; Neave et al. 1976; and Takagi et al. 1981).

As was pointed out in several sections of the present report, there is a clear need for additional sampling and tagging in key locations and time periods to fill important gaps in the data for juvenile salmon. These gaps are further identified in the summary and discussions below.

Distribution and Migration

The main feature of the summer distribution of juvenile salmon in the Gulf of Alaska was that the great majority of fish occurred in a narrow belt along the coast from Cape Flattery to the eastern Aleutian Islands. Within this belt, migration of all species was markedly northward, westward and southwestward parallel to the coastal curve. The band of fish was apparently very narrow (less than 20 nautical miles wide) off the coast of southeast Alaska where the continental shelf is narrow and the band widened in the northern Gulf of Alaska where the shelf is wider. Tag returns showed that juvenile salmon from many production areas as far south as California occurred along the coastal strip at least to the northern Gulf of Alaska. Salmon tagged along the south side of the Alaska Peninsula and eastern Aleutian Islands were mainly from adjacent production areas but some fish from as far south as Oregon were present. Thus, juvenile salmon, upon entering the sea, typically do not disperse randomly, but turn northward on a directed migration within a relatively narrow band close to shore. As a result, the mixture of juvenile salmon at any given point consists of fish from nearby production areas that have just entered the open sea plus fish from southern production areas that have been migrating northward for some time. There were significant differences among species, however. Sockeye, chum, and pink salmon typically remained within the coastal belt during summer, but coho and chinook salmon occurred both in the coastal belt and in areas well offshore. Steelhead trout were relatively rare in the coastal belt but occurred in a number of areas far offshore. Thus, some coho and chinook salmon migrate offshore early in their first summer at sea and steelhead trout apparently migrate directly offshore at whatever point they enter the ocean proper.

Although early season sampling was limited in time and space, the catches indicated that juvenile salmon begin to enter the sea in volume in June in the southern part of the Gulf of Alaska and that the migration was progressively later toward the north. By August and September, the numbers of juvenile salmon in the southern part of the Gulf of Alaska near Cape Flattery and off British Columbia had diminished, but abundance continued to be high in the northeast Gulf and northwest Gulf when sampling was terminated in late September and early October. Since only occasional small catches of the abundant sockeye, chum, and pink salmon occurred in offshore areas during summer, it is probable that the major offshore migration of these species does not begin until September or October. Canadian sampling by means of longline gear showed that appreciable numbers of pink salmon were distributed far offshore in the Gulf of Alaska between 50° and 54°N in late November-early December.

Implicit in the above summer distribution and migration features are some important biological principles pertaining to the life history, growth, and survival of salmon in their critical first summer at sea. Some of the more obvious of these principles are:

1. The concentration of juvenile salmon in a limited coastal belt would seem to render them more vulnerable to predation and disease, than if they dispersed widely offshore. In future sampling of juvenile salmon at sea, a study of predation and disease would be well worthwhile.

2. The nearshore distribution of juvenile salmon during their first summer in the Gulf of Alaska results in minimal overlap with age .1 and older immature salmon. This behavior may have value in minimizing feeding competition and possibly cannibalism and interspecific predation, although by the time juvenile salmon reach the open sea, they are large enough that cannibalism and predation is less likely. The nearshore distribution also minimizes overlap with large predator species such as albacore, pomfret and jack mackerel, which migrate northward in the offshore waters of the central Gulf of Alaska in August and September each year.

3. An obvious feature of the nearshore distribution of juvenile salmon is that they occupy waters which are directly in the path of maturing salmon en route to their spawning streams. Furthermore, since maturing salmon in the Gulf of Alaska typically move southeastward along the coast on their homing migration (Neave 1964), they traverse many miles of the belt of concentration of juvenile salmon. In our operations, we frequently examined the stomachs of mature salmon in areas where juvenile salmon were abundant, and found that predation on juvenile salmon was extremely rare even among the larger coho and chinook salmon. It might be speculated that behavioral patterns such as depth of swimming or feeding habits tend to minimize predation at this critical crossroads in the salmon's oceanic life history.

4. The phenomenon of a continuous northerly migration of large masses of juvenile salmon through a relatively restricted coastal belt poses some interesting questions as to interactions among stocks and species and the impact on their food supply. This is particularly important when it is remembered that the band of fish is over 1,000 nm long and that the migration continues for at least 3 months. It might be asked whether the fish in the vanguard enjoy better

feeding conditions than those bringing up the rear, or whether the fish from southern production areas have a significant feeding advantage since they are larger than the fish newly entering the sea in the northern areas. Since the coastal belt occupied by the juvenile salmon is a turbulent ecosystem with upwelling, eddies from coastal entrances, passages and channels, and a generally northerly flow in a counterclockwise gyre (Dodimead et al. 1963; Favorite et al. 1976), food organisms are likely abundant but patchy. Thus, the availability of food organisms to epipelagic fish throughout the coastal belt is probably continually changing in species composition, size, life stage, and depth, as well as in horizontal distribution, in which case the position of the salmon in the progression of migration may not be critical as to food supply. It might be conjectured that in areas and at times in which the juvenile salmon are most concentrated, their grazing would limit the food supply. In our qualitative examination of stomach contents, the types and quantities of food varied greatly, but in no sampling area was there evidence of a widespread paucity of food in stomachs, nor fish in obviously emaciated or starved condition. If size is an advantage in food competition, then the coho and chinook salmon should fare better than sockeye, chum, and pink salmon, but it must be remembered that coho and chinook salmon are much less numerous than sockeye, chum, and pink salmon and in addition, many coho and chinook salmon remain in inside waters such as Puget Sound, the Strait of Georgia, and Johnstone Strait during much of their first summer and even longer. Thus, potential competition between small and large juvenile salmon in the coastal belt tends to be limited.

5. The extent to which juvenile salmon in their coastal procession use the inside passages, such as Johnstone Strait, Hecate Strait, Chatham Strait, Prince William Sound, and Shelikof Strait, is unknown. It is possible that they may even reenter some of these passages after having migrated extensively on the outside. The scarcity of juvenile salmon in our sampling west of the Queen Charlotte Islands suggested that they may use Hecate Strait rather than the outer coast in that area. If juvenile salmon from southern production areas do reenter such passages, it would bring them into competition with much smaller salmon from local production areas—that is, fish which were less than the 10-cm minimum size found in coastal ocean waters. This reentry question could be answered by sampling throughout the season in some of the major passages and by tagging both the large and the small fish.

6. The fact that many coho and chinook salmon remain in inside waters for a year or longer is well established, but the degree to which sockeye, chum, and pink salmon remain in inside waters has been relatively little studied. In this report, examples of juvenile sockeye, chum, and pink salmon which were still present in northern Hecate Strait and in central Puget Sound in November were given. The species composition was primarily chum and pink salmon in Hecate Strait and primarily chum salmon in central Puget Sound. The Puget Sound samples were clearly local fish that were still residing in inside waters whereas the Hecate Strait samples were in rather open water and could have been within a few days of entering the ocean. They, nevertheless, were probably of local origin based upon size. Present evidence indicates that the great majority of juvenile sockeye, chum, and pink salmon goes to sea during summer, but it is evident that substantial numbers, particularly of chum and pink salmon, remain in some inside waters until at least late fall. As discussed earlier, the pink salmon in Puget Sound were probably part of a residual group that typically remains in Puget Sound to maturity. Sockeye and chum salmon, however, probably would ultimately go to sea.

A study of the relationship between the abundant summer migrants and the less abundant residuals might yield some useful information on the basic biology of the species. It would be useful to know whether or not the residual chum salmon in Puget Sound were a particular stock which typically lingers and feeds in the inside waters. Since they were relatively large fish (23 cm mean fork length) this question might be answered by tagging if other means of identification were not feasible. It is also important that the length of these fish indicates that they had experienced good feeding in salt water for several months and that growth, and therefore the availability of food, must have been comparable to that in the ocean environment. This would imply that the availability of food was not necessarily an impetus for migration to sea, although population pressure and food availability at some earlier stage may have been factors in the earlier seaward migration of the main body of fish. It would also be useful to compare the relative survival of the residual and the migratory groups. Finally, it would be useful to determine the timing of seaward migration of the residual group. As discussed earlier, they apparently migrate at some time prior to age .2.

7. Although the rationale is largely circumstantial and speculative, it is possible that the northerly nearshore migration of juvenile salmon in the eastern Gulf of Alaska functions as an aid in their homing as

adults. While proceeding along the coast after entering the sea, juvenile salmon experience a sequence of sensory cues that may be imprinted for orientation during the return journey.

Future Studies

Major future studies, that are needed to fill gaps in our understanding of the oceanic life history of juvenile salmon, are listed below:

1. The development of improved methods of capture and handling that will reduce injury and increase rate of tag return especially of fish less than 15 cm long.
2. Improved tags and applicators plus intensive and imaginative recovery efforts.
3. Sampling at several key locations early enough in the season to obtain timing profiles of ocean entry of juvenile salmon of all species.
4. Similar sampling throughout and late enough in the season to obtain complete summer profiles of abundance, growth, and direction of migration.
5. Synoptic sampling at a series of stations in the Gulf of Alaska extending offshore at several key locations to determine the width of the band of fish throughout the season and to determine the location and times at which extensive offshore migration begins.
6. Similar sampling in the Bering Sea to determine the timing and the route followed by the juvenile sockeye as they move farther seaward from the area where they are known to be concentrated during the summer.
7. Physiological studies of juvenile salmon at this fragile, early oceanic stage are needed particularly for minimizing mortality in handling and tagging, in addition to studies of disease, parasites, predators, and feeding habits.
8. In sampling of juvenile salmon at sea, all coho and chinook salmon should be examined for coded wire tags. In view of the large numbers of coded wire tags being applied by Alaska, Canada, Washington State, and Oregon, returns of age .0 fish would greatly increase our information on the early oceanic distribution of stocks and their migrations, growth, and rate of travel.

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APPENDIX TABLES A1—A6

APPENDIX TABLE A1. Average purse seine catches of juvenile salmonids in key coastal areas from the Bering Sea to Cape Flattery by year and by 10-day periods 1964–1968.

Area and sub-area (See Fig. 1)	Year	10-day periods	No. of sets	Catch per set						
				Sock.	Chum	Pink	Coho	Chin.	Steel.	Total
Bering Sea										
W6556	1966	June 21–30	9	0	0	0	0	0	0	0
		July 1–10	8	112	0	0	0	0	0	112
		July 11–20	16	157	.1	.1	0	0	0	158
		July 21–31	5	159	0	0	0	0	0	159
		Aug. 1–10	10	39	3	0	0	0	0	42
		Aug. 11–20	3	11	.7	0	0	0	0	11
	1967	Sept. 1–10	9	306	4	8	7	.2	0	325
		Sept. 11–20	2	128	3	2	2	0	0	135
	1968	Aug. 11–20	4	226	53	0	3	0	0	282
		Aug. 21–31	13	313	41	0	.5	.1	0	354
		Sept. 1–10	14	46	10	0	1	0	0	57
		Sept. 11–20	4	116	20	0	6	.3	0	141
South side Alaska Penin.										
W6554	1966	Aug. 11–20	1	0	0	0	0	0	0	0
	1967	Sept. 11–20	4	146	20	57	6	0	0	230
	1968	Aug. 21–31	7	35	.3	6	3	0	0	45
		Sept. 11–20	4	90	57	125	2	0	0	274
W6054	1965	May 21–31	1	0	0	0	0	0	0	0
	1966	Aug. 11–20	2	46	.5	10	44	0	0	100
	1967	Sept. 11–20	1	0	0	23	1	0	0	24
	1968	Sept. 11–20	3	17	20	87	.3	0	0	124
Kodiak Island Shelikof Strait										
W5558	1965	Aug. 11–20	6	46	.5	5	10	.2	0	61
	1966	Aug. 21–31	1	0	0	9	0	0	0	9
W5556	1965	Aug. 11–20	8	10	6	58	3	.2	0	77
	1966	Aug. 11–20	2	1	0	0	6	0	0	7
	1967	Sept. 21–30	2	.5	4	34	0	0	0	38
	1968	Sept. 11–20	2	2	8	10	2	.5	0	22
Northern Gulf of Alaska										
W5058	1965	Aug. 1–10	3	23	1	162	3	0	0	189
	1966	Aug. 11–20	1	0	0	0	0	0	0	0
W4558	1965	Aug. 1–10	2	225	20	22	14	0	0	282
	1966	Aug. 11–20	1	4	0	3	43	0	0	50
Yakutat, Alaska to C. Flattery, Washington										
W4058	1964	Aug. 11–20	5	39	19	300	31	.2	0	386
		Sept. 1–10	2	45	38	342	9	0	0	433
		Sept. 11–20	1	18	13	96	6	0	0	133
	1965	Aug. 1–10	5	.4	1	5	31	2	0	39
		Aug. 21–31	3	10	42	100	17	.3	0	169
		Sept. 11–20	6	10	24	47	2	0	0	83
	1966	Aug. 11–20	3	45	16	127	44	6	0	238
		Aug. 21–31	1	25	2	96	51	2	0	176
		Sept. 1–10	2	24	35	302	.5	0	0	241
		Sept. 11–20	2	176	14	72	50	2	0	313
	1967	July 21–31	4	392	61	77	16	0	0	546
		Aug. 21–31	2	94	118	258	2	0	0	472
		Sept. 21–30	2	2	4	16	4	4	0	30
	1968	July 21–31	5	25	165	404	53	.2	0	647
		Aug. 1–10	3	18	258	342	10	.2	0	628
		Sept. 1–10	1	1	9	6	2	0	0	18
		Sept. 11–20	5	26	188	349	3	0	0	565

Continued . . .

APPENDIX TABLE A1. Continued.

Area and sub-area (See Fig. 1)	Year	10-day periods	No. of sets	Catch per set Sock.	Chum	Pink	Coho	Chin.	Steel.	Total
		Sept. 21–30	4	7	18	33	1	0	0	60
W4056	1964	Aug. 1–10	1	4	0	22	48	0	0	74
		Aug. 11–20	4	22	2	45	13	.5	.2	84
		Aug. 21–31	6	92	38	278	31	.2	0	440
		Sept. 1–10	5	133	44	228	17	.2	0	422
	1965	Aug. 1–10	5	78	12	10	37	2	0	139
		Aug. 11–20	4	252	54	322	63	1	0	692
		Sept. 1–10	7	32	4	24	16	0	0	75
		Sept. 11–20	1	64	25	107	8	0	0	204
	1966	June 21–30	2	6	0	0	5	0	.5	12
		July 1–10	1	0	0	0	0	0	0	0
		Aug. 1–10	4	109	6	78	61	.5	0	256
		Aug. 11–20	4	33	8	76	18	0	.2	136
		Aug. 21–31	4	16	6	82	35	0	.2	140
		Sept. 1–10	3	6	4	3	2	.3	0	15
	1967	July 11–20	2	36	2	.5	16	4	0	60
		July 21–31	4	86	19	33	38	4	0	181
		Aug. 21–31	5	49	215	677	11	.2	0	954
		Sept. 1–10	2	4	0	46	8	0	0	59
		Sept. 21–30	2	1	0	16	0	1	0	18
		Oct. 1–10	1	3	46	205	0	1	0	255
		Oct. 11–20	1	0	0	1	0	0	0	1
Yakutat, Alaska to C. Flattery, Washington										
W4056	1968	July 21–31	4	59	3	4	20	.5	0	86
		Aug. 1–10	2	94	44	232	26	2	0	397
		Sept. 1–10	4	2	9	14	2	.2	0	28
		Sept. 11–20	2	0	.5	1	1	0	0	2
		Sept. 21–30	3	0	0	6	.3	0	0	6
W3554	1964	Aug. 1–10	6	53	26	118	48	0	0	245
		Sept. 11–20	2	3	.5	8	0	0	0	12
	1965	July 21–31	5	19	1	5	5	.4	0	30
		Aug. 1–10	1	2	0	0	48	1	0	51
	1966	July 21–31	1	15	15	19	52	0	0	101
		Aug. 1–10	3	372	19	310	345	2	.3	1,048
		Aug. 21–31	7	25	12	276	20	0	0	334
	1967	July 11–20	4	173	47	928	11	.5	.2	1,160
		Aug. 11–20	4	10	110	1,466	71	.5	0	1,658
		Sept. 11–20	1	0	1	59	1	0	0	61
		Oct. 1–10	8	2	28	162	1	0	0	194
		Oct. 21–31	1	0	9	69	1	0	0	79
	1968	July 21–31	1	140	127	448	1,152	1	0	1,868
		Aug. 1–10	2	105	92	472	59	.5	0	729
		Aug. 21–31	2	25	184	230	18	1	0	458
		Oct. 1–10	2	2	290	174	4	0	0	470
W3552	1964	Aug. 1–10	2	22	6	5	0	0	0	33
	1965	July 21–31	3	.3	.3	0	0	0	0	.7
	1966	July 21–31	2	0	0	0	0	0	0	0
	1967	July 1–10	2	29	9	66	0	.5	0	104
		July 21–31	2	.6	0	1	.5	0	0	3
		Aug. 11–20	4	0	0	.2	0	0	0	.2
		Sept. 11–20	1	0	0	0	0	0	0	0
	1968	July 21–31	2	6	4	645	45	6	0	706
		Aug. 21–31	1	42	4	54	3	0	0	103

Continued . . .

APPENDIX TABLE A1. Continued.

Area and sub-area (See Fig. 1)	Year	10-day periods	No. of sets	Catch per set						
				Sock.	Chum	Pink	Coho	Chin.	Steel.	Total
W3050	1964	Aug. 1–10	1	0	5	12	2	0	0	10
		Sept. 21–30	1	0	17	2	0	0	0	10
	1965	July 21–31	2	2	20	12	2	.5	0	38
	1966	July 11–20	2	0	0	0	.5	0	0	.5
		July 21–31	2	1	24	94	2	0	0	120
		Sept. 21–30	2	94	4	40	0	0	0	138
Yakutat, Alaska to Cape Flattery, Washington										
W3050	1967	July 1–10	4	28	64	14	16	2	0	123
		July 21–31	1	2	551	52	4	0	0	609
		Aug. 11–20	5	4	27	90	16	.6	.2	139
		Sept. 11–20	1	2	3	64	4	0	0	73
		Oct. 1–10	1	2	44	146	0	0	0	192
	1968	Aug. 1–10	2	.5	32	318	2	0	0	352
		Aug. 21–31	2	0	4	2	2	0	0	8
W3048	1964	July 21–31	1	0	0	0	0	5	0	5
		Aug. 1–10	3	.7	4	14	14	0	0	33
		Sept. 21–30	1	0	0	2	13	2	0	17
	1965	July 21–31	4	1	9	8	156	.2	0	174
		Aug. 21–31	1	0	9	0	0	0	0	9
	1966	July 11–20	2	3	20	3	14	.5	.5	41
		July 21–31	2	4	89	520	4	0	0	616
		Sept. 21–30	2	0	0	1	8	0	0	10
	1967	June 11–20	1	20	0	0	131	69	0	220
		July 1–10	3	3	8	.3	5	1	0	18
		Aug. 1–10	3	.3	1	0	20	2	.3	23
		Sept. 1–10	3	0	0	0	5	0	0	5
		Sept. 11–20	2	0	.5	.5	5	0	0	6
	1968	June 21–30	2	8	34	2	24	2	0	70
W2548	1964	Sept. 21–30	2	0	1	0	318	13	0	332
	1965	July 21–31	1	0	0	0	56	9	0	65
		Sept. 21–30	1	0	0	0	13	0	1	14
	1966	July 21–31	6	3	14	204	8	.2	0	230
		Aug. 21–31	11	1	2	75	69	.2	0	147
		Sept. 1–10	1	0	4	50	1	0	0	55
		Sept. 21–30	3	0	4	34	9	0	0	45
	1967	June 11–20	3	.7	.3	0	0	1	.3	2
		July 1–10	4	0	1	0	8	0	0	10
		Aug. 1–10	6	0	5	0	15	1	0	22
		Sept. 1–10	1	0	0	0	0	0	0	0
		Sept. 11–20	2	0	.5	0	91	0	0	92
		Oct. 21–31	1	4	0	0	21	0	0	25
	1968	July 1–10	19	3	16	129	2	.5	.1	151
		July 11–20	18	0	12	103	9	2	.1	125
		Aug. 11–20	10	.2	3	43	48	2	0	96
		Aug. 21–31	4	0	3	42	82	0	0	126

Appendix Table A2. Release and recovery data for 41 sockeye salmon tagged as age .0 juvenile fish in 1958 and 1965–1968 and recovered 2 or 3 years later.

Area of Release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.[1]	Date: Release	Recov.	Fork length (cm) Release Recov.	Age at release	Tag number
W6556	55–51	162–30	58–57	158–29[2]	1968	1970	—	.0	87—[2]
	E. Bering Sea		Nushagak Area		8/26	7/2	—		
W6556	55–27	163–43	58–45	158–40	1968	1970	16.8	.0	F19242
	E. Bering Sea		Nushagak Area		8/29	7/10	—		
W6556	56–26	161–30	59–58	154–51	1968	1970	16.1	.0	F20262
	E. Bering Sea		Naknek-Kvichak		9/5	8/—	—		
W6556	56–47	161–51	59–22	157–30	1968	1970	16.9	.0	C01042
	E. Bering Sea		Nushagak Area		9/8	7/9	61.0		
W6556	55–30	163–18	56–10	160–26	1968	1970	18.6	.0	F20804
	E. Bering Sea		N. Side Alaska Pen.		9/14	7/27	—		
W6556	55–30	161–18	—	—	1968	1970	18.0	.0	C01135[3]
	E. Bering Sea		Bristol Bay[3]		9/14	—	—		
W6556	56–18	161–04	58–13	157–22	1968	1971	14.3	.0	F01268
	E. Bering Sea		Egegik		8/18	7/11	60.7		
W6556	55–51	162–30	49–01	173–26E[1]	1968	1971	14.7	.0	07018[1]
	E. Bering Sea		High Seas		8/26	5/25	56.7		
W6556	55–51	162–30	54–37	163–35	1968	1971	13.2	.0	F02007
	E. Bering Sea		S. Unimak I.		8/26	6/15	—		
W6556	55–27	163–43	58–43	157–00	1968	1971	15.1	.0	F19335
	E. Bering Sea		Naknek-Kvichak		8/29	7/8	—		
W6556	56–00	162–14	58–45	158–40	1968	1971	14.5	2.0	F20042
	E. Bering Sea		Nushagak Area		9/4	7/12	—		
W6554	54–32	164–09	60–43	151–24	1968	1970	24.5	.0	F19664
	S. Unimak I.		Cook Inlet		8/30	7/—	—		
W6554	54–35	163–42	56–20	158–29	1968	1971	22.8	.0	F20929
	S. Unimak I.		S. Alaska Pen.		9/15	7/4	—		
W6554	54–35	163–42	60–30	151–30	1968	1971	21.0	1.0	F20872
	S. Unimak I.		Cook Inlet		9/15	7/21	62.5		
W6054	55–20	156–40	—	—	1958	1960	23.0	.0	21576
	S. Alaska Pen.		Str. Juan de Fuca		8/30	8/1–11	—		
W5058	59–22	145–40	55–00	127–23	1965	1967	20.5	1.0	05554
	N. Gulf Alaska		Fraser R. System		8/9	8/21	48.5		
W4558	59–42	141–22	54–07	130–05	1965	1968	17.5	.0	00334
	N. Gulf Alaska		Skeena R. (BC)		8/8	7/19	—		
W4558	59–42	141–22	55–17	128–06	1965	1968	18.0	1.0	00338
	N. Gulf Alaska		Skeena R. (BC)		8/8	8/5	—		
W4558	59–42	141–22	54–48	130–55	1965	1968	17.0	2.0	00427
	N. Gulf Alaska		Ketchikan Area		8/8	8/12	55.9		
W4558	59–37	141–27	53–54	130–16	1965	1968	17.0	1.0	05543
	N. Gulf Alaska		Skeena R. (BC)		8/8	7/18	—		
W4558	59–37	141–27	54–09	130–05	1965	1968	18.0	1.0	00490
	N. Gulf Alaska		Skeena R. (BC)		8/8	7/29	—		
W4558	59–37	141–27	54–06	130–06	1965	1968	19.0	1.0	00441
	N. Gulf Alaska		Skeena R. (BC)		8/8	7/30	—		
W4058	58–13	135–24	58–10	134–58	1966	1969	17.0	1.0	C03649
	Icy Strait		Icy Strait		9/11	7/9	64.8		
W4058	58–13	137–06	48–39	124–51	1967	1969	19.5	1.0	C00640
	N. E. Gulf Alaska		Str. Juan de Fuca		7/20	7/24	66.0		

Continued . . .

Appendix Table A2. Continued.

Area of Release	Location: Release		Location: Recovery		Date		Fork length (cm)	Age at release	Tag number
	Release	W. Long.	N. Lat.	W. Long.[1]	Release	Recov.	Release Recov.		
W4058	58–13	137–06	48–	122–	1967	1969	19.5	1.0	C00645
	N. E. Gulf Alaska		San Juan Is.		7/20	8/11	—		
W4058	58–13	137–06	48–	122–	1967	1969	18.5	1.0	C00647
	N. E. Gulf Alaska		San Juan Is.		7/20	8/–	—		
W4058	58–13	137–06	51–50	127–50	1967	1970	18.0	1.0	C00646
	N. E. Gulf Alaska		Rivers-Smith (BC)		7/20	7/19	—		
W4058	58–19	137–18	54–09	130–05	1967	1970	16.6	.0	F00519
	N. E. Gulf Alaska		Skeena R. (BC)		8/27	6/22	63.4		
W4058	58–10	137–04	48–32	124–25	1968	1970	21.5	.0	F05909
	N. E. Gulf Alaska		Str. Juan de Fuca		9/15	8/10	55.9		
W4056	57–49	136–38	50–30	126–20	1965	1967	20.0	1.0	01333
	Gulf of Alaska		Johnstone Strait		8/26	8/16	63.0		
W4056	57–49	136–38	48–15	122–40	1965	1967	19.0	.0	C00232
	Gulf of Alaska		Puget Sound		8/26	8/23	61.0		
W4056	57–49	136–38	48–30	124–30	1965	1967	19.5	1.0	05996
	Gulf of Alaska		Str. Juan de Fuca		8/26	8/24	—		
W4056	57–16	135–59	54–30	131–	1965	1968	17.0	.0	06829
	Gulf of Alaska		Nass R. (BC)		8/28	7/20	—		
W4056	56–49	135–42	53–10	128–42	1968	1970	18.1	.0	F04292
	Gulf of Alaska		Central B. C.		7/24	7/9	—		
W4056	56–49	135–42	54–09	130–05	1968	1970	17.3	.0	F04276
	Gulf of Alaska		Skeena R. (BC)		7/24	7/21	—		
W4056	56–49	135–42	54–10	130–05	1968	1970	17.8	1.0	F06333
	Gulf of Alaska		Skeena R. (BC)		7/24	8/13	56.5		
W4056	56–49	135–42	50–25	121–25	1968	1970	18.5	.0	F06373
	Gulf of Alaska		Fraser R.		7/24	9/18	—		
W4056	56–49	135–42	50–20	126–08	1968	1970	17.5	.0	F04324
	Gulf of Alaska		Johnstone Strait		7/24	10/30	—		
W4056	56–49	135–42	50–35	119–50	1968	1970	18.8	1.0	F03717
	Gulf of Alaska		Fraser River		7/24	11/03	55.0		
W4056	56–17	135–01	55–23	126–35	1968	1970	16.7	1.0	07255
	Gulf of Alaska		Skeena R. (BC)		8/6	8/21	—		
W3554	55–17	133–50	49–05	123–09	1968	1971	18.8	1.0	07732
	Gulf of Alaska		Fraser River		8/7	9/24	—		

[1] All *West Longitude* except tag No. 07018 recovered at sea in *East Longitude*.

[2] Tag identified at recovery only by type and color. This provided date and location of release since yellow Dennison tags were applied in only one experiment.

[3] Tag found in can of salmon in 1972. Label on can identified source as Bristol Bay or south side of Unimak I. Year probably 1970; possibly 1971.

APPENDIX TABLE A3. Release and recovery data for 6 chum salmon tagged as age .0 juvenile fish in 1965 and 1968 and recovered 3 or 4 years later.

Area of release	Location				Date		Fork length (cm)	Tag Number
	Release		Recovery					
	N. Lat.	W. Long.	N. Lat.	W. Long.	Release	Recov.	Release Recov.	
W5556	57–50	153–59	57–45	152–50	1968	1972	18.3	08957
	Shelikof Strait		Kodiak Island		9/20	8/28	—	
W4558	59–37	141–27	48–30	124–30	1965	1968	19.5	05527
	N. Gulf Alaska		Str. Juan de Fuca		8/8	9/16	—	
W4058	58–14	137–00	52–20	131–30	1968	1971	23.5	F05862
	N.E. Gulf Alaska		Queen Charlotte Is.		9/15	9/25	—	
W4058	58–13	137–04	58–18	134–45	1968	1972	15.3	F07955
	N.E. Gulf Alaska		SE Alaska Icy Str.		8/1	7/3	—	
W4058	58–13	137–09	56–50	134–25	1968	1972	21.8	4612
	N.E. Gulf Alaska		SE Alaska Chatham		9/18	7/15	—	
W3554	54–42	132–33	54–57	133–00	1968	1972	20.7	F11309
	Dixon Entrance		SE Alaska Pr. Wales		10/5	9/5	63.5	

Appendix Table A4. Release and recovery data for 56 pink salmon tagged as age .0 juvenile fish in years 1961–1968 and recovered in the same year (1 fish) or a year later (55 fish).

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Date: Recovery	Fork length (cm) Release Recovery	Tag number
W6554	54–35	163–42	56–51	154–00	1968	1969	21.8	08575
	S. Unimak Island		Kodiak Island		9/15	8/1	—	
W6054	55–46	158–36	56–51	154–00	1968	1969	19.0	08777
	S. Alaska Pen.		Kodiak Island		9/18	8/8	—	
W6054	55–46	158–36	57–50	153–30	1968	1969	21.2	08780
	S. Alaska Pen.		Kodiak Island		9/18	7/25	53.3	
W6054	55–46	158–36	57–48	154–04	1968	1969	19.6	08842
	S. Alaska Pen.		Kodiak Island		9/18	7/27	41.4	
W4058	59–02	138–34	55–06	132–00	1961	1962	23.0	50819
	N.E. Gulf Alaska		SE Alaska-Ketchikan		9/22	9/5	—	
W4058	58–26	137–42	58–15	136–20	1965	1966	16.0	05882
	N.E. Gulf Alaska		SE Alaska Icy Str.		8/24	8/1	—	
W4058	58–32	137–55	48–58	123–05	1966	1967	23.5	C01840
	N.E. Gulf Alaska		San Juan Islands		8/12	9/17	63.0	
W4058	58–31	137–54	54–43	130–15	1966	1967	22.0	08113
	N.E. Gulf Alaska		Nass R. (BC)		9/10	7/23	—	
W4058	58–22	137–32	57–19	133–30	1967	1968	15.2	F00327
	N.E. Gulf Alaska		SE Alaska Chatham		8/27	8/7	—	
W4058	58–22	137–32	57–19	133–30	1967	1968	17.7	F00343
	N.E. Gulf Alaska		SE Alaska Chatham		8/27	8/7	—	
W4058	58–14	136–59	58–17	135–47	1968	1969	16.3	F04475
	N.E. Gulf Alaska		SE Alaska Icy Str.		7/27	7/10	52.1	
W4058	58–14	136–59	57–58	134–46	1968	1969	16.5	F04367
	N.E. Gulf Alaska		SE Alaska Chatham		7/27	7/22	49.0	
W4058	58–14	136–59	—	—	1968	1969	15.1	F04397
	N.E. Gulf Alaska		SE Alaska unknown		7/27	8/–	—	
W4058	58–14	136–59	57–40	134–20	1968	1969	14.2	F06512
	N.E. Gulf Alaska		SE Alaska Chatham		7/27	8/5	—	
W4058	58–17	137–04	58–04	135–04	1968	1969	15.3	F07359
	N.E. Gulf Alaska		SE Alaska Icy Str.		7/27	7/6	—	
W4058	58–17	137–04	55–30	133–40	1968	1969	14.6	F06613
	N.E. Gulf Alaska		SE Alaska Pr. Wales		7/27	7/15	—	
W4058	58–17	137–04	55–30	133–40	1968	1969	15.4	F06663
	N.E. Gulf Alaska		SE Alaska Pr. Wales		7/27	7/15	—	
W4058	58–17	137–04	55–30	133–40	1968	1969	14.7	F04580
	N.E. Gulf Alaska		SE Alaska Pr. Wales		7/27	7/16	—	
W4058	58–17	137–04	55–30	133–40	1968	1969	17.8	F04584
	N.E. Gulf Alaska		SE Alaska Pr. Wales		7/27	7/16	—	
W4058	58–17	137–04	57–25	134–50	1968	1969	16.1	F04657
	N.E. Gulf Alaska		SE Alaska Chatham		7/27	7/23	—	
W4058	58–17	137–04	57–47	134–57	1968	1969	14.5	F06750
	N.E. Gulf Alaska		SE Alaska Chatham		7/27	7/29	—	
W4058	58–17	137–04	58–02	134–57	1968	1969	15.9	F04620
	N.E. Gulf Alaska		SE Alaska Icy Str.		7/27	—	—	
W4058	58–17	137–04	—	—	1968	1969	15.9	F06616
	N.E. Gulf Alaska		SE Alaska unknown		7/27	—	—	
W4058	58–20	136–59	—	—	1968	1969	14.9	F07409
	N.E. Gulf Alaska		SE Alaska unknown		7/28	—	—	
W4058	58–17	137–02	59–01	133–09	1968	1969	16.5	F07872
	N.E. Gulf Alaska		Taku River (BC)		7/29	7/12	—	
W4058	58–17	137–02	58–18	134–45	1968	1969	17.0	F05142
	N.E. Gulf Alaska		SE Alaska Icy Str.		7/29	7/16	—	
W4058	58–17	137–02	58–05	134–46	1968	1969	16.1	F07623
	N.E. Gulf Alaska		SE Alaska Chatham		7/29	7/16	—	
W4058	58–17	137–02	—	—	1968	1969	14.6	F07636
	N.E. Gulf Alaska		SE Alaska unknown		7/29	7/28	—	

Continued . . .

Appendix Table A4. Continued.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Recovery	Fork length (cm) Release Recovery	Tag number
W4058	58–17	137–02	55–30	133–40	1968	1969	17.6	F07583
	N.E. Gulf Alaska		SE Alaska Pr. Wales		7/29	8/5	—	
W4058	58–17	137–02	49–	121–	1968	1969	20.0	F07830
	N.E. Gulf Alaska		Fraser River		7/29	10/28	—	
W4058	58–13	137–04	58–25	135–26	1968	1969	15.1	F08163
	N.E. Gulf Alaska		SE Alaska Icy Str.		8/1	7/17	—	
W4058	58–13	137–04	48–15	136–20	1968	1969	14.6	F05377
	N.E. Gulf Alaska		SE Alaska Icy Str.		8/1	7/30	—	
W4058	58–13	137–04	58–15	136–20	1968	1969	14.7	F05339
	N.E. Gulf Alaska		SE Alaska Icy Str.		8/1	7/–	—	
W4058	58–13	137–04	58–15	136–20	1968	1969	15.3	F05598
	N.E. Gulf Alaska		SE Alaska Icy Str.		8/1	7/–	—	
W4058	58–13	137–04	—	—	1968	1969	16.6	F08014
	N.E. Gulf Alaska		SE Alaska unknown		8/1	7/–	—	
W4058	58–13	137–04	58–18	134–45	1968	1969	14.0	F05432
	N.E. Gulf Alaska		SE Alaska Icy Str.		8/1	8/7	—	
W4058	58–10	137–04	55–30	133–40	1968	1969	22.8	F06963
	N.E. Gulf Alaska		SE Alaska Pr. Wales		9/15	7/15	—	
W4058	58–10	137–04	57–20	135–44	1968	1969	17.4	F05970
	N.E. Gulf Alaska		SE Alaska Icy Str.		9/15	8/13	—	
W4058	58–12	137–05	58–15	136–20	1968	1969	21.4	04477
	N.E. Gulf Alaska		SE Alaska Icy Str.		9/17	7/–	—	
W4058	58–12	137–05	55–30	133–40	1968	1969	22.5	04342
	N.E. Gulf Alaska		SE Alaska Pr. Wales		9/17	8/5	—	
W4058	58–12	137–05	56–21	133–37	1968	1969	24.3	04089
	N.E. Gulf Alaska		SE Alaska Sumner Str.		9/17	8/23	—	
W4058	58–14	135–25	—	—	1968	1969	22.1	F11165
	N.E. Gulf Alaska		SE Alaska unknown		9/30	8/–	—	
W4056	57–49	136–38	55–35	132–12	1965	1966	20.0	06321
	Gulf of Alaska		SE Alaska Pr. Wales		8/26	8/4	—	
W4056	56–27	135–11	—	—	1967	1968	20.9	07197
	Gulf of Alaska		SE Alaska unknown		10/7	8/24	—	
W4056	56–17	135–01	57–19	133–30	1968	1969	18.3	09812
	Gulf of Alaska		Stephens Passage		8/6	7/15	—	
W3556	56–13	134–55	56–54	134–13	1965	1966	18.5	02495
	Gulf of Alaska		SE Alaska Chatham		9/5	8/1	45.7	
W3556	56–13	134–55	56–29	134–11	1965	1966	18.5	07086
	Gulf of Alaska		SE Alaska Chatham		9/5	8/7	46.0	
W3556	56–13	134–55	56–29	134–11	1965	1966	16.0	02523
	Gulf of Alaska		SE Alaska Chatham		9/5	8/16	47.0	
W3554	54–43	132–32	—	—	1967	1968	19.8	06347
	Dixon Entrance		SE Alaska unknown		10/1	8/15	—	
W3554	54–43	132–32	55–41	132–33	1967	1968	21.5	06488
	Dixon Entrance		SE Alas. Petersburg		10/1	8/20	—	
W3554	54–43	132–32	55–33	132–17	1967	1968	20.4	06648
	Dixon Entrance		SE Alaska Pr. Wales		10/1	8/–	—	
W3554	54–42	132–34	—	—	1967	1968	23.4	03465
	Dixon Entrance		SE Alaska Ketchikan		10/2	7/29	—	
W3554	54–42	132–34	54–47	131–57	1967	1968	22.0	03447
	Dixon Entrance		SE Alaska Ketchikan		10/2	8/15	—	
W3554	54–42	132–33	54–44	132–32	1968	1968[1]	15.6	09025
	Dixon Entrance		SE Alaska Pr. Wales		8/8	8/30	—	
W3554	54–42	132–34	55–30	133–40	1968	1969	23.7	F11699
	Dixon Entrance		SE Alaska Pr. Wales		10/6	8/20	—	
W3554	54–42	132–34	54–10	130–02	1968	1969	26.7	F11583
	Dixon Entrance		Skeena River (BC)		10/6	8/25	—	

[1] Recovered by tagging vessel near release point 22 days after tagging.

APPENDIX TABLE A5. Release and recovery data for 244 coho salmon tagged as age .0 juvenile fish in years 1958–1968 and recovered in the same year (parentheses) or a year later (no parentheses).

Area of release	Location				Date		Fork length (cm)	Age at release	Tag number
	Release		Recovery						
	N. Lat.	W. Long.	N. Lat.	W. Long.	Release	Recov.	Release, Recov.		
W6554	54–40	160–12	60–53	151–46	1967	1968	29.0	.0	77959
	S. Alaska Pen.		Cook Inlet		9/18	8/28	61.0		-
W6054	56–57	156–28	60–30	151–30	1966	1967	21.0	1.0	C00565
	S. Alaska Pen.		Cook Inlet		8/15	9/—	—		
W6054	56–57	156–28	62–05	150–05	1966	1967	22.0	2.0	C00571
	S. Alaska Pen.		Cook Inlet		8/15	9/1	55.9		
W5558	59–13	130–08	50–00	129–25	1965	1966	27.0	1.0	00996
	N. Gulf Alaska		W. Vancouver I.		8/20	7/6	50.0		
W5554	55–42	151–49	44–40	124–04	1958	1959	31.0	.0	46290
	S. of Kodiak I.		Depoe Bay, Oregon		9/5	6/30	—		
W5060	60–13	146–58	60–15	144–55	1961	1962	27.0	.0	50262
	N. Gulf Alaska		Copper R. Alaska		9/16	9/5	55.9		
W4558	59–35	140–41	—	—	1961	1962	26.5	2.0	16207
	N. Gulf Alaska		SE Alaska Troll		7/16	—	—		
W4558	59–35	140–41	44–45	124–05	1961	1962	27.0	.0	16104
	N. Gulf Alaska		Foulweather, Oregon		7/16	8/9	—		
W4558	59–33	140–44	56–03	133–04	1961	1962	25.0	.0	16432
	N. Gulf Alaska		SE Alaska Clar. Str.		7/25	8/20	—		
W4558	59–33	140–44	49–27	124–35	1961	1962	27.5	.0	16397
	N. Gulf Alaska		Str. of Georgia		7/25	10/23	—		
W4558	59–42	141–22	51–00	128–35	1965	1966	29.0	3.0	00422
	N. Gulf Alaska		Rivers-Smith Inlet		8/8	7/28	—		
W4558	59–37	141–27	42–50	124–33	1965	1966	32.0	2.0	00496
	N. Gulf Alaska		C. Blanco, Oregon		8/8	8/12	—		
W4058	58–23	137–20	58–18	135–22	1961	1962	28.0	.0	16731
	NE. Gulf Alaska		SE Alas. Icy Str.		8/16	8/28	—		
W4058	58–32	137–46	49–	126–	1964	1965	31.5	.0	03749
	NE. Gulf Alaska		W. Vancouver I.		9/11	8/—	62.2		
W4058	58–32	137–43	46–10	124–10	1965	1966	29.5	2.0	05413
	NE Gulf Alaska		Columbia River		8/6	9/25	80.0		
W4058	58–32	137–43	46–	124–	1965	1966	28.5	3.0	05440
	NE Gulf Alaska		Columbia River		8/6	9/26	—		
W4058	58–32	137–52	44–40	124–04	1965	1966	32.0	.0	70380
	NE Gulf Alaska		Depoe Bay, Oregon		8/6	6/18	46.0		
W4058	58–27	138–03	45–25	124–	1965	1966	32.0	.0	05462
	NE Gulf Alaska		Oregon Coast		8/7	8/	—		
W4058	58–18	137–03	53–	131–	1965	1966	25.5	.0	01120
	NE Gulf Alaska		Central B. C.		8/25	7/4	—		
W4058	58–18	137–03	43–45	124–14	1965	1966	32.5	2.0	01128
	NE Gulf Alaska		Oregon Coast		8/25	7/4	—		
W4058	58–14	137–10	56–48	133–55	1965	1966	27.0	2.0	01174
	NE Gulf Alaska		SE Alas. Petersburg		8/25	9/8	—		
W4058	58–13	136–53	58–02	134–56	1965	1966	28.0	1.0	02769
	NE Gulf Alaska		SE Alas. Icy Str.		9/11	8/14	62.2		
W4058	58–32	137–55	46–19	124–02	1966	1967	30.0	.0	C01836
	NE Gulf Alaska		Columbia River		8/12	7/30	66.1		

Continued . . .

APPENDIX TABLE A5. Continued.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Date: Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W4058	58–32	137–55	48–10	124–54	1966	1967	32.0	3.0	C01846
	NE Gulf Alaska		C. Flattery, Wash.		8/12	9/7	73.0		
W4058	59–22	140–00	48–58	125–30	1966	1967	28.0	2.0	07756
	NE Gulf Alaska		W. Vancouver I.		8/13	8/28	69.8		
W4058	59–22	140–00	60–07	144–25	1966	1967	25.0	2.0	07779
	NE Gulf Alaska		Copper R., Alaska		8/13	9/5	68.6		
W4058	58–13	135–24	—	—	1966	1967	30.0	2.0	C03694
	Icy Strait		Unknown N. America		9/11	—	—		
W4058	58–13	135–24	58–24	134–57	1966	1967	27.5	1.0	08268
	Icy Strait		SE Alaska Chatham		9/11	8/13	71.1		
W4058	58–17	137–02	49–	126–	1968	1969	26.5	1.0	F04949
	NE Gulf Alaska		W. Vancouver I		7/29	8/9	—		
W4058	58–17	137–02	46–53	124–06	1968	1969	25.8	.0	F07600
	NE Gulf Alaska		Grays Harbor, Wash.		7/29	8/11	65.0		
W4058	58–17	137–02	46–11	123–57	1968	1969	29.1	.0	F05208
	NE Gulf Alaska		Columbia River		7/29	8/25	—		
W4058	58–17	137–02	54–08	132–47	1968	1969	26.4	.0	F07617
	NE Gulf Alaska		Dixon Entrance		7/29	8/–	—		
W4058	58–17	137–02	58–53	135–19	1968	1969	24.2	1.0	F04868
	NE Gulf Alaska		SE Alaska Icy Str.		7/29	9/25	66.0		
W4058	58–13	137–04	53–50	130–40	1968	1969	25.5	.0	F05510
	NE Gulf Alaska		Hecate Strait		8/1	8/–	—		
W4056	56–54	135–57	49–00	125–44	1961	1962	28.5	.0	16223
	E. Gulf Alaska		W. Vancouver I.		7/22	7/3	45.7		
W4056	56–54	135–57	49–06	125–55	1961	1962	25.0	.0	16229
	E. Gulf Alaska		W. Vancouver I.		7/22	8/22	59.7		
W4056	56–40	135–38	50–47	128–26	1961	1962	31.0	.0	50880
	E. Gulf Alaska		W. Vancouver I.		9/26	6/24	—		
W4056	57–50	137–00	48–58	123–05	1962	1963	29.5	2.0	03114
	E. Gulf Alaska		Point Roberts, Wa.		7/23	9/2	71.1		
W4056	56–17	135–03	51–28	127–36	1964	1965	29.5	1.0	03318
	E. Gulf Alaska		Rivers Inlet, B.C.		8/10	9/7	—		
W4056	57–20	136–15	56–36	135–02	1964	1965	25.5	1.0	01062
	E. Gulf Alaska		SE Alaska Icy Str.		8/17	6/23	—		
W4056	56–30	135–27	51–47	127–53	1964	1965	31.0	1.0	05272
	E. Gulf Alaska		Central B.C. Coast		8/21	9/13	—		
W4056	56–39	135–30	56–28	132–22	1964	1965	22.5	1.0	01657
	E. Gulf Alaska		SE Alaska Wrangell		8/31	8/11	—		
W4056	56–16	135–08	45–45	123–58	1965	1966	31.5	1.0	05289
	E. Gulf Alaska		C. Falcon. Oregon		8/2	7/6	60.0		
W4056	56–16	135–08	51–02	127–43	1965	1966	28.5	1.0	05287
	E. Gulf Alaska		Q. Char. Sd. (B.C.)		8/2	8/14	—		
W4056	56–16	135–22	41–43	124–15	1965	1966	33.0	2.0	00219
	E. Gulf Alaska		Central Calif. Coast		8/2	6/13	62.4		
W4056	56–16	135–22	44–40	124–04	1965	1966	30.0	2.0	00207
	E. Gulf Alaska		Newport, Oregon		8/2	7/25	—		
W4056	56–16	135–22	54–	132–	1965	1966	28.0	.0	00198
	E. Gulf Alaska		Queen Charlotte Is.		8/2	8/4	—		
W4056	56–16	135–22	53–40	130–45	1965	1966	27.0	.0	00208
	E. Gulf Alaska		Central B.C.		8/2	9/7	—		

Continued . . .

Appendix Table A5. Continued.

Area of release	Location: Release N. Lat.	Location: Release W. Long.	Location: Recovery N. Lat.	Location: Recovery W. Long.	Date: Release	Date: Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W4056	56–16	135–22	46–10	124–10	1965	1966	31.5	.0	00195
	E. Gulf Alaska		Columbia River		8/2	9/12	79.0		
W4056	56–57	136–00	54–02	133–11	1965	1966	25.0	.0	05379
	E. Gulf Alaska		Queen Charlotte Is.		8/5	8/13	64.8		
W4056	56–57	136–00	45–20	124–01	1965	1966	31.0	3.0	70350
	E. Gulf Alaska		Central Oregon Coast		8/5	8/31	54.0		
W4056	56–57	136–19	45–43	123–58	1965	1966	31.0	2.0	00315
	E. Gulf Alaska		N. Oregon Coast		8/5	7/14	78.7		
W4056	56–57	136–19	46–53	124–07	1965	1966	32.0	2.0	00289
	E. Gulf Alaska		Westport, Wa.		8/5	9/3	68.6		
W4056	56–57	136–19	46–40	124–00	1965	1966	30.5	.0	00304
	E. Gulf Alaska		Willapa Hbr. Wa.		8/5	9/23	66.0		
W4056	57–29	136–14	45–03	124–02	1965	1966	30.5	.0	01903
	E. Gulf Alaska		Central Oregon Coast		8/27	7/14	62.0		
W4056	57–29	136–14	54–	130–	1965	1966	30.0	.0	01957
	E. Gulf Alaska		Skeena R. (BC)		8/27	7/20	—		
W4056	57–29	135–14	54–04	131–47	1965	1966	33.0	2.0	01978
	E. Gulf Alaska		Queen Charlotte Is.		8/27	8/7	67.8		
W4056	57–29	136–14	53–16	129–17	1965	1966	28.0	2.0	01915
	E. Gulf Alaska		Central B.C. Coast		8/27	8/10	—		
W4056	57–29	136–14	46–10	124–15	1965	1966	31.5	.0	06621
	E. Gulf Alaska		N. Oregon Coast		8/27	8/10	—		
W4056	57–29	136–14	56–29	134–11	1965	1966	33.0	.0	01909
	E. Gulf Alaska		SE Alaska Chatham		8/27	9/4	62.0		
W4056	57–16	135–59	54–40	130–	1965	1966	32.0	.0	70505
	E. Gulf Alaska		Dundas I. (B.C.)		8/28	7/22	—		
W4056	56–49	135–47	46–	124–	1965	1966	35.0	.0	70521
	E. Gulf Alaska		Columbia River		9/1	9/20	63.0		
W4056	56–16	135–24	46–11	124–11	1966	1967	31.5	.0	J00560
	E. Gulf Alaska		Columbia River		8/4	7/10	—		
W4056	56–16	135–24	47–54	124–38	1966	1967	26.0	.0	C03209
	E. Gulf Alaska		La Push, Wa.		8/4	8/1	73.2		
W4056	56–16	135–24	46–14	123–53	1966	1967	27.0	.0	07649
	E. Gulf Alaska		Columbia River		8/4	8/4	—		
W4056	56–16	135–24	46–19	124–02	1966	1967	29.5	2.0	C03117
	E. Gulf Alaska		Columbia River		8/4	8/22	61.0		
W4056	56–16	135–24	46–53	124–07	1966	1967	26.5	.0	C03227
	E. Gulf Alaska		Westport, Wa.		8/4	9/9	66.0		
W4056	56–16	135–24	46–16	123–39	1966	1967	29.0	.0	J00576
	E. Gulf Alaska		Columbia River		8/4	9/20	—		
W4056	57–34	136–26	39–30	124–15	1967	1968	29.0	.0	02230
	E. Gulf Alaska		N. Calif. Coast		7/24	6/29	59.5		
W4056	57–02	135–58	54–	130–	1967	1968	32.6	1.0	F00257
	E. Gulf Alaska		N. Br. Col.		8/22	—	58.0		
W4056	56–49	135–42	57–02	135–12	1968	(1968)	22.6	.0	F04301
	E. Gulf Alaska		SE Alas. Sitka Sd.		7/24	12/–	—		
W4056	57–38	136–33	54–19	130–	1968	1969	25.5	.0	F06405
	E. Gulf Alaska		B.C. unknown		7/25	7/–	58.0		
W4056	57–38	136–33	46–18	122–55	1968	1969	28.2	.0	F06435
	E. Gulf Alaska		Toutle R. (Col. R)		7/25	9/22	—		
W4056	57–38	136–33	45–37	122–21	1968	1969	25.7	.0	F06439
	E. Gulf Alaska		Washougal R. (Col. R.)		7/25	10/22	60.0		

Continued . . .

Appendix Table A5. Continued.

Area of release	Location: Release N. Lat.	Location: Release W. Long.	Location: Recovery N. Lat.	Location: Recovery W. Long.	Date: Release	Date: Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W3554	55–44	134–24	46–	123–	1965	1966	32.0	.0	05208
	E. Gulf Alaska		Columbia River		8/1	9/22	—		
W3554	54–41	132–31	49–30	126–50	1966	1967	26.0	1.0	03442
	Dixon Entrance		W. Vancouver I.		8/2	6/20	67.3		
W3554	54–41	132–31	44–36	124–02	1966	1967	21.0	.0	C01773
	Dixon Entrance		Central Oregon Coast		8/3	8/7	61.5		
W3554	54–39	133–02	46–07	124–00	1966	1967	29.0	1.0	03537
	E. Gulf Alaska		N. Oregon Coast		8/3	7/29	—		
W3554	54–39	133–02	50–27	128–02	1966	1967	25.5	2.0	03584
	E. Gulf Alaska		W. Vancouver I.		8/3	8/5	—		
W3554	54–41	132–30	43–40	124–12	1966	1967	29.0	.0	C03402
	Dixon Entrance		Central Oregon Coast		8/23	7/17	55.1		
W3554	54–22	131–48	54–38	130–38	1967	1968	26.9	1.0	02559
	Dixon Entrance		Nass R. (BC)		8/16	7/13	—		
W3554	54–32	132–11	—	—	1967	1968	26.6	.0	02735
	Dixon Entrance		B.C. unknown		8/17	8/14	—		
W3554	54–32	132–11	48–30	124–30	1967	1968	26.5	.0	02738
	Dixon Entrance		Str. Juan de Fuca		8/17	9/29	—		
W3554	54–42	132–33	40–00	124–00	1968	1969	26.5	1.0	F03410
	Dixon Entrance		Central Calif. Coast		7/22	5/28	—		
W3554	54–42	132–33	44–26	124–04	1968	1969	24.6	.0	F03551
	Dixon Entrance		N. Oregon Coast		7/22	6/16	63.0		
W3554	54–42	132–33	53–30	130–40	1968	1969	23.2	.0	F06241
	Dixon Entrance		Hecate Str. (BC)		7/22	6/29	71.1		
W3554	54–42	132–33	48–33	124–25	1968	1969	22.4	.0	F06271
	Dixon Entrance		Str. Juan de Fuca		7/22	8/7	—		
W3554	54–42	132–33	44–40	124–04	1968	1969	27.0	.0	F06123
	Dixon Entrance		N. Oregon Coast		7/22	7/7	67.0		
W3554	54–42	132–33	42–03	124–16	1968	1969	27.3	.0	F03506
	Dixon Entrance		Chetco R. Oregon		7/22	7/11	—		
W3554	54–42	132–33	45–15	124–00	1968	1969	22.8	.0	F03555
	Dixon Entrance		N. Oregon Coast		7/22	7/15	55.9		
W3554	54–42	132–33	44–40	124–04	1968	1969	22.7	.0	F03417
	Dixon Entrance		Depoe Bay, Oregon		7/22	7/16	—		
W3554	54–42	132–33	49–05	125–55	1968	1969	22.2	.0	F06194
	Dixon Entrance		W. Vancouver I.		7/22	8/1	—		
W3554	54–42	132–33	54–09	130–05	1968	1969	19.8	.0	F03591
	Dixon Entrance		Skeena R. (BC)		7/22	8/6	—		
W3554	54–42	132–33	48–06	122–45	1968	1969	26.1	.0	F06112
	Dixon Entrance		N. Puget Sound		7/22	8/12	—		
W3554	54–42	132–33	48–40	125–	1968	1969	22.5	.0	F06272
	Dixon Entrance		W. Vancouver I.		7/22	8/15	—		
W3554	54–42	132–33	48–23	124–37	1968	1969	25.5	.0	F06164
	Dixon Entrance		Str. Juan de Fuca		7/22	8/24	63.5		
W3554	54–42	132–33	—	—	1968	1969	21.0	1.0	F03407
	Dixon Entrance		B.C. unknown		7/22	8/26	—		
W3554	54–42	132–33	48–23	124–37	1968	1969	27.8	.0	F06156
	Dixon Entrance		Str. Juan de Fuca		7/22	8/28	53.0		
W3554	54–42	132–33	53–30	129–13	1968	1969	23.2	.0	F06175
	Dixon Entrance		Central B.C. Coast		7/22	9/4	—		
W3554	54–42	132–33	54–09	130–05	1968	1969	22.8	.0	F03634
	Dixon Entrance		Skeena R. (BC)		7/22	9/9	—		

Continued . . .

Appendix Table A5. Continued.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Date: Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W3554	54–42	132–33	—	—	1968	1969	22.0	.0	F03602
	Dixon Entrance		B.C. unknown		7/22	9/15	—		
W3554	54–42	132–33	43–21	124–11	1968	1969	26.8	.0	F06129
	Dixon Entrance		Coos Bay, Oregon		7/22	9/21	—		
W3554	54–42	132–33	45–43	123–58	1968	1969	26.0	.0	F03614
	Dixon Entrance		Nehalem R. Oregon		7/22	9/22	55.9		
W3554	54–42	132–33	45–10	122–20	1968	1969	28.2	.0	F03649
	Dixon Entrance		Eagle Cr. (Col. R.)		7/22	10/27	71.0		
W3544	54–42	132–33	45–10	122–20	1968	1969	25.0	.0	F06188
	Dixon Entrance		Eagle Cr. (Col. R.)		7/22	10/27	56.0		
W3554	54–42	132–33	46–00	122–15	1968	1969	26.6	.0	F06224
	Dixon Entrance		Klickitat R. (Col. R.)		7/22	11/18	57.0		
W3554	54–42	132–33	46–53	124–06	1968	1969	25.2	.0	F06119
	Dixon Entrance		Grays Hbr., Wa.		7/22	12/6	—		
W3554	54–42	132–33	46–06	123–11	1968	1969	26.7	1.0	F03421
	Dixon Entrance		Columbia River		7/22	12/19	64.0		
W3554	54–42	132–33	45–58	123–59	1968	1969	23.1	1.0	F03403
	Dixon Entrance		Columbia River		7/22	12/28	—		
W3554	54–42	132–33	52–	127–	1968	1969	23.5	.0	F06267
	Dixon Entrance		B.C. unknown		7/22	—	—		
W3554	55–17	133–50	53–25	131–	1968	1969	26.2	.0	10073
	E. Gulf Alaska		Hecate Str. (BC)		8/7	7/17	—		
W3554	55–42	132–34	54–15	131–00	1968	1969	29.5	.0	F11601
	Dixon Entrance		Hecate Str. (BC)		10/6	7/5	53.4		
W3050	50–27	128–10	48–55	126–10	1965	1966	26.0	.0	00193
	N. Vancouver I.		W. Vancouver I.		7/26	7/13	68.6		
W3050	51–05	127–51	51–15	128–00	1967	(1967)	34.0	.0	69240
	N. Vancouver I.		Rivers-Smith Inlet		8/12	8/14	—		
W3050	51–05	127–51	51–15	128–00	1967	(1967)	38.0	.0	69273
	N. Vancouver I.		Rivers-Smith Inlet		8/12	8/15	39.4		
W3050	51–05	127–51	50–45	127–15	1967	(1967)	23.5	1.0	69242
	N. Vancouver I.		Queen Charlotte Str.		8/12	9/–	—		
W3050	50–27	128–15	48–18	124–00	1968	1969	25.6	1.0	F04121
	N. Vancouver I.		Str. Juan de Fuca		8/25	8/15	—		
W3048	49–28	126–51	49–05	125–56	1965	(1965)	21.0	2.0	C02572
	W. Vancouver I.		W. Vancouver I.		7/22	9/19	30.5		
W3048	49–28	126–51	41–00	124–15	1965	1966	31.0	2.0	C02627
	W. Vancouver I.		N. Calif. Coast		7/22	6/–	—		
W3048	49–28	126–51	48–55	125–30	1965	1966	25.5	.0	00119
	W. Vancouver I.		W. Vancouver I.		7/22	6/16	55.1		
W3048	49–28	126–51	42–05	124–10	1965	1966	28.0	.0	00113
	W. Vancouver I.		S. Oregon Coast		7/22	7/2	56.0		
W3048	49–28	126–51	45–43	123–58	1965	1966	28.5	1.0	C02565
	W. Vancouver I.		N. Oregon Coast		7/22	7/14	60.5		
W3048	49–28	126–51	44–00	124–05	1965	1966	28.0	2.0	00078
	W. Vancouver I.		Cent. Ore. Coast		7/22	7/16	—		
W3048	49–28	126–51	47–24	124–22	1965	1966	28.0	.0	00067
	W. Vancouver I.		Cent. Wa. Coast		7/22	8/15	—		
W3048	49–28	126–51	45–56	124–01	1965	1966	28.5	2.0	C02640
	W. Vancouver I.		N. Oregon Coast		7/22	8/23	70.0		

Continued . . .

APPENDIX TABLE A5. Continued.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W3048	49–28	126–51	46–53	124–06	1965	1966	28.0	.0	00141
	W. Vancouver I.		Westport, Wa.		7/22	9/10	—		
W3048	49–28	126–51	44–48	124–05	1965	1966	30.0	2.0	C02617
	W. Vancouver I.		N. Oregon Coast		7/22	9/10	77.4		
W3048	49–28	126–51	46–11	124–11	1965	1966	26.5	2.0	C02601
	W. Vancouver I.		Columbia River		7/22	9/12	—		
W3048	49–28	125–51	—	—	1965	1966	25.5	1.0	C02537
	W. Vancouver I.		Washington Coast		7/22	—	—		
W3048	49–55	127–26	41–03	124–09	1965	1966	29.0	2.0	C00044
	W. Vancouver I.		N. Calif. Coast		7/23	7/13	—		
W3048	49–55	127–26	46–19	124–02	1965	1966	30.5	2.0	C00045
	W. Vancouver I.		Columbia River		7/23	8/6	62.2		
W3048	49–55	127–26	44–40	124–04	1965	1966	31.0	.0	C00046
	W. Vancouver I.		Cent. Oregon Coast		7/23	9/11	70.0		
W3048	49–34	126–57	46–	123–	1966	(1966)	29.5	.0	82639
	W. Vancouver I.		Columbia River		7/26	9/24	—		
W2548	48–30	124–39	48–19	124–00	1961	(1961)	41.5	.0	29478
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/5	41.9		
W2548	48–30	124–39	48–32	124–25	1961	(1961)	29.0	.0	29329
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/20	—		
W2548	48–30	124–39	48–30	124–30	1961	(1961)	30.0	.0	29294
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/27	—		
W2548	48–30	124–39	48–30	124–30	1961	(1961)	27.0	.0	29353
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/27	—		
W2548	48–30	124–39	48–18	124–00	1961	(1961)	28.0	.0	29295
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	10/1	—		
W2548	48–30	124–39	48–32	124–25	1961	(1961)	30.0	.0	29418
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	10/20	—		
W2548	48–30	124–39	48–10	122–23	1961	(1961)	28.5	.0	29494
	Str. Juan de Fuca		Puget Sound		8/30	11/10	—		
W2548	48–18	124–20	48–	123–	1964	(1964)	27.5	.0	51375
	Str. Juan de Fuca		Str. Juan de Fuca		9/24	9/28	—		
W2548	48–18	124–20	48–20	123–46	1964	(1964)	30.0	.0	51391
	Str. Juan de Fuca		Str. Juan de Fuca		9/24	10/–	—		
W2548	48–18	124–20	48–20	123–46	1964	(1964)	28.0	2.0	51367
	Str. Juan de Fuca		Str. Juan de Fuca		9/24	10/3	—		
W2548	48–18	124–20	48–09	122–36	1964	(1964)	25.5	.0	51452
	Str. Juan de Fuca		Admiralty Inlet		9/24	10/4	—		
W2548	48–18	124–20	48–03	122–53	1964	(1964)	29.0	1.0	51320
	Str. Juan de Fuca		Discovery Bay		9/24	10/6	—		
W2548	48–18	124–20	48–20	123–40	1964	(1964)	27.5	.0	51355
	Str. Juan de Fuca		Str. Juan de Fuca		9/24	10/12	—		
W2548	48–18	124–20	48–29	124–29	1964	(1964)	25.0	.0	51356
	Str. Juan de Fuca		Str. Juan de Fuca		9/24	10/19	—		
W2548	48–18	124–20	48–05	122–37	1964	(1964)	27.0	.0	51325
	Str. Juan de Fuca		Admiralty Inlet		9/24	10/21	27.4		
W2548	48–22	124–31	—	—	1964	1965	36.5	2.0	51309
	Str. Juan de Fuca		Unknown*		9/24	—	—		
W2548	48–18	124–20	45–45	123–58	1964	1965	24.5	1.0	51359
	Str. Juan de Fuca		N. Oregon Coast		9/24	7/10	40.0		

Continued . . .

Appendix Table A5. Continued.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W2548	48–18	124–20	48–18	124–00	1964	1965	28.5	.0	51435
	Str. Juan de Fuca		Juan de Fuca		9/24	8/8	50.0		
W2548	48–18	124–20	47–49	122–52	1964	1965	26.0	.0	04641
	Str. Juan de Fuca		Hood Canal		9/24	12/3	49.0		
W2548	48–17	124–03	48–20	124–03	1966	(1966)	24.5	2.0	82567
	Str. Juan de Fuca		Str. Juan de Fuca		7/24	10/3	33.0		
W2548	48–16	124–07	48–23	124–36	1966	(1966)	25.5	2.0	J00527
	Str. Juar de Fuca		Str. Juan de Fuca		7/24	9/6	30.0		
W2548	48–16	124–07	48–20	123–45	1966	(1966)	27.5	1.0	82586
	Str. Juan de Fuca		Str. Juan de Fuca		7/24	9/27	—		
W2548	48–26	124–42	48–25	124–42	1966	(1966)	25.5	1.0	67590
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	8/31	—		
W2548	48–26	124–42	48–23	124–36	1966	(1966)	31.0	2.0	67593
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	8/31	32.0		
W2548	48–26	124–42	48–23	124–36	1966	(1966)	26.5	2.0	67602
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	8/31	27.0		
W2548	48–26	124–42	48–25	124–42	1966	(1966)	28.5	.0	67615
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	8/31	—		
W2548	48–26	124–42	47–48	122–28	1966	(1966)	30.5	.0	67648
	Str. Juan de Fuca		Puget Sound		8/30	9/–	—		
W2548	48–26	124–42	48–23	124–36	1966	(1966)	31.0	.0	67587
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/5	(30.0)		
W2548	48–26	124–42	48–29	124–18	1966	(1966)	30.5	.0	67556
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/7	32.4		
W2548	48–26	124–42	48–	124–	1966	(1966)	28.5	2.0	67548
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/15	—		
W2548	48–26	124–42	48–	124–	1966	(1966)	31.5	.0	67561
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	9/27	—		
W2548	48–26	124–42	48–30	124–40	1966	(1966)	28.0	.0	67603
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	10/17	—		
W2548	48–26	124–42	48–32	124–30	1966	(1966)	30.0	2.0	67566
	Str. Juan de Fuca		Str. Juan de Fuca		8/30	—	—		
W2548	48–21	124–01	48–12	122–17	1966	(1966)	31.0	1.0	08348
	Str. Juan de Fuca		Puget Sound Snohomish R.		9/25	10/16	(31.0)		
W2548	48–26	124–42	50–56	127–59	1966	1967	30.5	1.0	67641
	Str. Juan de Fuca		N. end Vancouver I.		8/30	9/–	—		
W2548	48–14	124–02	48–22	123–55	1967	(1967)	27.0	.0	69594
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/12	—		
W2548	48–14	124–02	48–22	123–55	1967	(1967)	29.0	1.0	69608
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/12	—		
W2548	48–14	124–02	48–15	124–14	1967	(1967)	29.0	1.0	69617
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/12	30.2		
W2548	48–14	124–02	48–22	123–55	1967	(1967)	27.5	.0	69647
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/12	—		
W2548	48–14	124–02	48–22	123–55	1967	(1967)	31.0	.0	69668
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/12	—		
W2548	48–14	124–02	48–12	124–06	1967	(1967)	28.0	.0	69587
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/17	—		
W2548	48–14	124–02	48–12	124–06	1967	(1967)	30.0	1.0	69593
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/17	—		
W2548	48–14	124–02	48–12	124–06	1967	(1967)	27.5	.0	69599
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/18	—		

Continued . . .

Appendix Table A5. Continued.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Date: Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W2548	48–14	124–02	48–30	124–30	1967	(1967)	29.5	1.0	69609
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/19	—		
W2548	48–14	124–02	48–29	124–17	1967	(1967)	28.5	2.0	69604
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/20	30.5		
W2548	48–14	124–02	48–22	123–55	1967	(1967)	28.0	1.0	69586
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	9/26	—		
W2548	48–14	124–02	48–30	124–30	1967	(1967)	30.0	.0	69652
	Str. Juan de Fuca		Str. Juan de Fuca		9/11	—	—		
W2548	48–30	124–26	48–33	124–27	1968	(1968)	34.5	2.0	J00958
	Str. Juan de Fuca		Str. Juan de Fuca		7/9	9/4	38.1		
W2548	48–18	124–21	47–55	122–31	1968	(1968)	26.5	.0	F03236
	Str. Juan de Fuca		N. Puget Sound		7/11	10/24	—		
W2548	48–18	124–21	47–18	123–10	1968	(1968)	26.0	.0	F03237
	Str. Juan de Fuca		Hood Canal Skok. R.		7/11	11/30	33.0		
W2548	48–21	124–28	48–23	123–57	1968	(1968)	40.0	1.0	01785
	Str. Juan de Fuca		Str. Juan de Fuca		8/12	8/14	—		
W2548	48–19	124–24	47–	122–	1968	(1968)	29.2	1.0	09750
	Str. Juan de Fuca		Puget Sound Green R.		8/14	10/4	35.6		
W2548	48–19	124–24	47–34	122–33	1968	(1968)	27.0	1.0	09748
	Str. Juan de Fuca		Central Puget Sound		8/14	10/28	—		
W2548	48–19	124–23	48–25	124–03	1968	(1968)	32.5	1.0	01880
	Str. Juan de Fuca		Str. Juan de Fuca		8/15	8/19	—		
W2548	48–19	124–23	48–10	123–43	1968	(1968)	29.0	.0	01870
	Str. Juan de Fuca		Str. Juan de Fuca		8/15	9/3	—		
W2548	48–19	124–23	48–13	124–05	1968	(1968)	35.5	.0	01863
	Str. Juan de Fuca		Str. Juan de Fuca		8/15	9/5	—		
W2548	48–19	124–23	48–23	124–37	1968	(1968)	35.5	.0	01902
	Str. Juan de Fuca		Str. Juan de Fuca		8/15	9/5	—		
W2548	48–19	124–23	48–33	124–27	1968	(1968)	30.5	2.0	01911
	Str. Juan de Fuca		Str. Juan de Fuca		8/15	9/26	—		
W2548	48–19	124–23	47–18	123–10	1968	(1968)	31.2	.0	10210
	Str. Juan de Fuca		Hood Canal Skok. R.		8/15	10/19	(31.0)		
W2548	48–19	124–23	47–32	122–02	1968	(1968)	29.0	1.0	10238
	Str. Juan de Fuca		Puget Sd. Issaquah Cr.		8/15	11/20	32.0		
W2548	48–19	124–24	48–18	122–20	1968	(1968)	29.7	.0	F08569
	Str. Juan de Fuca		P.S. Skagit R.		8/23	9/–	—		
W2548	48–19	124–24	48–16	124–16	1968	(1968)	26.9	1.0	F08610
	Str. Juan de Fuca		Str. Juan de Fuca		8/23	9/8	—		
W2548	48–19	124–24	47–17	122–50	1968	(1968)	27.0	1.0	F08590
	Str. Juan de Fuca		Hood Canal		8/23	11/6	35.6		
W2548	48–18	124–21	48–00	125–00	1968	1969	25.0	.0	F03187
	Str. Juan de Fuca		Washington Coast		7/11	6/20	—		
W2548	48–18	124–21	48–38	125–05	1968	1969	23.5	.0	F03160
	Str. Juan de Fuca		W. Vancouver I.		7/11	6/23	68.6		
W2548	48–18	124–21	48–20	124–35	1968	1969	28.5	.0	F03242
	Str. Juan de Fuca		Str. Juan de Fuca		7/11	6/25	64.8		
W2548	48–18	124–21	49–	126–	1968	1969	24.0	.0	F03194
	Str. Juan de Fuca		W. Vancouver I.		7/11	8/–	—		
W2548	48–18	124–21	49–	126–	1968	1969	23.5	.0	F03209
	Str. Juan de Fuca		W. Vancouver I.		7/11	8/29	—		
W2548	48–18	124–21	47–19	122–09	1968	1969	24.0	.0	F03230
	Str. Juan de Fuca		P.S. Green R.		7/11	10/–	—		

Continued . . .

Appendix Table A5. Continued.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
W2548	48–18	124–21	47–40	122–30	1968	1969	24.5	.0	F03204
	Str. Juan de Fuca		Cent. Puget Sound		7/11	10/6	67.8		
W2548	48–18	124–21	47–18	123–10	1968	1969	22.0	.0	F03197
	Str. Juan de Fuca		P.S. Green R.		7/11	11/5	67.0		
W2548	48–18	124–21	47–32	122–02	1968	1969	24.5	.0	F03231
	Str. Juan de Fuca		P.S. Issaquah Cr.		7/11	11/13	55.0		
W2548	48–18	124–21	47–22	122–42	1968	1969	23.0	.0	F03188
	Str. Juan de Fuca		P.S. Minter Cr.		7/11	11/25	57.2		
W2548	48–21	124–28	48–35	125–10	1968	1969	27.8	1.0	09594
	Str. Juan de Fuca		W. Vancouver I.		8/12	6/28	—		
W2548	48–29	124–23	47–19	122–09	1968	1969	26.6	.0	09635
	Str. Juan de Fuca		P.S. Green R.		8/13	12/15	61.0		
W2548	48–19	124–24	48–	123–	1968	1969	26.4	.0	09697
	Str. Juan de Fuca		Str. Juan de Fuca		8/14	8/–	—		
W2548	48–19	124–24	49–	125–	1968	1969	28.5	1.0	09789
	Str. Juan de Fuca		W. Vancouver I.		8/14	8/14	71.1		
W2548	48–19	124–24	48–30	124–30	1968	1969	29.8	1.0	09727
	Str. Juan de Fuca		Str. Juan de Fuca		8/14	8/23	—		
W2548	48–19	124–24	48–30	124–30	1968	1969	24.6	.0	09738
	Str. Juan de Fuca		Str. Juan de Fuca		8/14	8/24	—		
W2548	48–19	124–24	49–10	125–55	1968	1969	27.3	.0	09740
	Str. Juan de Fuca		W. Vancouver I.		8/14	9/10	—		
W2548	48–19	124–24	47–18	123–10	1968	1969	28.7	.0	09700
	Str. Juan de Fuca		P.S. Green R.		8/14	11/–	—		
W2548	48–19	124–23	48–39	124–51	1968	1969	25.8	1.0	10252
	Str. Juan de Fuca		W. Vancouver I.		8/15	4/22	—		
W2548	48–19	124–23	47–54	122–31	1968	1969	30.0	1.0	10264
	Str. Juan de Fuca		Puget Sound		8/15	8/25	61.0		
W2548	48–19	124–23	47–52	121–42	1968	1969	28.6	1.0	10213
	Str. Juan de Fuca		P.S. Sky. R.		8/15	10/29	68.6		
W2548	48–19	124–23	47–52	121–42	1968	1969	27.8	.0	10332
	Str. Juan de Fuca		P.S. Sky. R.		8/15	11/7	71.0		
W2548	48–19	124–23	47–32	122–02	1968	1969	27.5	1.0	10245
	Str. Juan de Fuca		P.S. Issaquah Cr.		8/15	11/13	57.0		
W2548	48–20	124–22	49–	126–	1968	1969	29.1	2.0	F08416
	Str. Juan de Fuca		W. Vancouver I.		8/22	7/–	—		
W2548	48–20	124–22	47–22	122–42	1968	1969	29.1	.0	F08407
	Str. Juan de Fuca		P.S. Minter Cr.		8/22	11/18	52.0		
W2548	48–22	124–31	49–	126–	1968	1969	24.0	.0	F08468
	Str. Juan de Fuca		W. Vancouver I.		8/22	8/1	—		
W2548	48–22	124–31	48–29	124–44	1968	1969	29.2	1.0	F08470
	Str. Juan de Fuca		Str. Juan de Fuca		8/22	8/13	—		
W2548	48–22	124–31	48–30	124–30	1968	1969	28.8	1.0	F08452
	Str. Juan de Fuca		Str. Juan de Fuca		8/22	9/–	—		
W2548	48–22	124–31	48–33	124–25	1968	1969	25.0	1.0	F08437
	Str. Juan de Fuca		Str. Juan de Fuca		8/22	9/1	—		
W2548	48–22	124–31	48–	125–	1968	1969	28.7	1.0	F08433
	Str. Juan de Fuca		W. Vancouver I.		8/22	9/15	—		
W2548	48–19	124–24	49–	126–	1968	1969	29.3	.0	F08593
	Str. Juan de Fuca		W. Vancouver I.		8/23	6/17	—		
W2548	48–19	124–24	48–15	124–17	1968	1969	31.4	.0	F04096
	Str. Juan de Fuca		Str. Juan de Fuca		8/23	6/22	—		

Cotinued . . .

Appendix Table A5. Continued.

Area of release	Location				Date		Fork length (cm) Release, Recov.	Age at release	Tag number
	Release		Recovery						
	N. Lat.	W. Long.	N. Lat.	W. Long.	Release	Recov.			
W2548	48–19	124–24	46–53	124–06	1968	1969	28.5	.0	F08537
	Str. Juan de Fuca		S. Washington Coast		8/23	7/20	—		
W2548	48–19	124–24	49–05	125–55	1968	1969	27.6	.0	F08582
	Str. Juan de Fuca		W. Vancouver I.		8/23	7/31	—		
W2548	48–19	124–24	49–	126–	1968	1969	29.7	.0	F08571
	Str. Juan de Fuca		W. Vancouver I.		8/23	8/1	—		
W2548	48–19	124–24	48–30	124–30	1968	1969	30.4	.0	F08543
	Str. Juan de Fuca		Str. Juan de Fuca		8/23	8/4	—		
W2548	48–19	124–24	48–09	123–38	1968	1969	29.9	2.0	F08480
	Str. Juan de Fuca		Str. Juan de Fuca		8/23	8/31	—		
W2548	48–19	124–24	48–09	122–36	1968	1969	27.7	1.0	F08515
	Str. Juan de Fuca		P.S. Lagoon Pt.		8/23	9/6	70.1		
W2548	48–19	124–24	47–24	123–10	1968	1969	28.3	1.0	F08490
	Str. Juan de Fuca		Hood Canal, Hoodsport		8/23	9/8	—		
W2548	48–19	124–24	48–15	124–35	1968	1969	26.5	.0	F08479
	Str. Juan de Fuca		Str. Juan de Fuca		8/23	9/14	—		
W2548	48–19	124–24	48–12	124–06	1968	1969	29.6	.0	F04079
	Str. Juan de Fuca		Str. Juan de Fuca		8/23	9/23	58.4		
W2548	48–19	124–24	47–24	123–10	1968	1969	27.8	1.0	F04066
	Str. Juan de Fuca		Hood Canal, Hoodsport		8/23	9/27	—		
W2548	48–19	124–24	47–32	122–02	1968	1969	30.0	.0	F04060
	Str. Juan de Fuca		P.S. Issaquah Cr.		8/23	10/27	52.0		
W2548	48–19	124–24	47–24	123–10	1968	1969	32.0	1.0	F04112
	Str. Juan de Fuca		Hood Canal, Hoodsport		8/23	10/27	65.0		
W2548	48–19	124–24	47–18	123–10	1968	1969	28.1	.0	F04091
	Str. Juan de Fuca		P.S. Green R.		8/23	11/5	60.0		
W2548	48–19	124–24	47–32	122–02	1968	1969	31.2	2.0	F08587
	Str. Juan de Fuca		P.S. Issaquah Cr.		8/23	11/10	73.0		
W2548	48–19	124–24	47–19	122–09	1968	1969	30.0	.0	F08520
	Str. Juan de Fuca		P.S. Green R.		8/23	12/13	60.0		
W2548	48–19	124–24	—	—	1968	1969	29.1	.0	F04114
	Str. Juan de Fuca		Wash. commercial troll fishery		8/23	—	60.0		

* Tag only found in shrimp trawl in Shumagin Islands area in August, 1972.

APPENDIX TABLE A6. Release and recovery data for 12 chinook salmon tagged as age .0 juvenile fish in 1965, 1966 and 1968 and recovered up to 3 years later, plus one steelhead trout tagged in 1958 and recovered 2 years later.

Area of release	Location: Release N. Lat.	Release W. Long.	Recovery N. Lat.	Recovery W. Long.	Date: Release	Date: Recov.	Fork length (cm) Release, Recov.	Age at release	Tag number
				CHINOOK SALMON					
W4058	58–32	137–43	45–51	122–47	1965	1968	35.0	2.0	05421
	N.E. Gulf Alaska		Columbia River		8/6	3/17	83.7		
W4058	59–22	140–00	45–	116–	1966	1967	29.0	1.0	C03343
	N.E. Gulf Alaska		Columbia River		8/13	5/25	—		
W4058	59–22	140–00	45–56	119–18	1966	1968	29.5	.0	C03368
	N.E. Gulf of Alaska		Columbia River		8/13	5/2	61.0		
W3552	53–42	130–43	45–49	122–48	1968	1970	23.7	1.0	F03308
	Hecate Str. (BC)		Columbia River		7/20	4/16	—		
W2548	48–23	124–31	48–20	122–40	1968	1968	38.5	1.0	00776
	Str. Juan de Fuca		San Juan Is.		7/12	11/4	—		
W2548	48–19	124–23	47–18	123–09	1968	1968	29.0	.0	01906
	Str. Juan de Fuca		(Skokomish R.) Hood Canal		8/15	9/22	—		
W2548	48–19	124–23	48–30	124–30	1968	1968	38.5	1.0	01881
	Str. Juan de Fuca		Str. Juan de Fuca		8/15	9/25	—		
W2548	48–19	124–21	48–27	124–30	1968	1969	38.0	1.0	00885
	Str. Juan de Fuca		Str. Juan de Fuca		7/15	8/8	—		
W2548	48–19	124–23	48–55	125–30	1968	1969	36.0	.0	01856
	Str. Juan de Fuca		W. Vancouver I.		8/15	8/20	—		
W2548	48–19	124–20	47–55	122–32	1968	1970	35.5	1.0	00766
	Str. Juan de Fuca		Central Puget Sound		7/12	8/8	—		
W2548	48–19	124–23	45–	122–	1968	1970	33.5	1.0	01865
	Str. Juan de Fuca		Columbia River		8/15	9/23	—		
W2548	48–18	124–21	48–24	124–35	1968	1971	32.5	1.0	01644
	Str. Juan de Fuca		Str. Juan de Fuca		7/11	6/18	67.3		
				STEELHEAD TROUT					
W5554	55–42	151–49	44–22	124–00	1958	1960	36.5	.0	46288
	S. of Kodiak I.		Alsea R., Oregon		9/5	2/5	57.8		