

NPAFC

Doc. No. 157

Rev. No. \_\_\_\_\_

## Recoveries of farmed Atlantic salmon in the Northeastern Pacific

by

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submitted to the

**NORTH PACIFIC ANADROMOUS FISH COMMISSION**

by

CANADA and U.S.A.

October 1995

**This paper may be cited in the following manner:**

McKinnell, S., A. J. Thomson, E. A. Black, B.L. Wing, C.M. Guthrie<sup>III</sup>, J.F. Koerner, J.H. Helle. 1995. Recoveries of farmed Atlantic salmon in the northeastern Pacific. (NPAFC Doc. No. ). 15 p. Dept. of Fisheries and Oceans, Ocean Science and Productivity Division, Pacific Biological Station, Nanaimo, B.C. Canada. V9R 5K6

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## ABSTRACT

In the Northeast Pacific only British Columbia and Washington State rear the non-indigenous Atlantic salmon. Salmon farming is illegal in Alaska. In the early 20th century, attempts were made to introduce approximately 14,000,000 Atlantic salmon (*Salmo salar*) to 52 freshwater bodies in B.C. They were not successful. In the 1970's, salmon farmers in Washington State began raising Atlantic salmon in marine net pens. In B.C. this practice began in 1985. The first recoveries of significant numbers of Atlantic salmon in B.C. waters occurred in 1987. Since then, reported escapes from net pens in B.C. totalled 85,429. The true number of escapes is higher as not all escapes are reported. Since 1987, 8,662 have been caught or reported in the coastal marine waters of B.C., Washington, and Alaska and 131 in freshwater. The most distant recovery was in 1994 from Shumagin Island near the western end of the Alaskan Peninsula. Most of the recoveries have been from the Johnstone Strait area, close to the highest concentration of salmon farms. There have been no reports of successful reproduction of Atlantic salmon in the wild and no feral juveniles have been found. Fish caught in B.C. tend to have a considerable amount of adipose tissue. They are heavier at length than fish recovered in Alaska. The proportion of fish with prey items in their stomachs is low but significantly higher in Alaska (14.3%) than in B.C. (3.8%). Most fish recovered in freshwater are either mature or maturing.

## INTRODUCTION

The first attempt to transplant Atlantic salmon (*Salmo salar*) to British Columbia occurred in 1901. Between 1905 and 1935 a total of 13.2 million Atlantic salmon eggs, alevins, or fry were deposited in 52 separate water bodies (Black, 1995). None of these transplant attempts was successful. In the 1970's, salmon farmers in Washington State began using Atlantic salmon in their commercial salmon farming operations and in 1985 B.C. salmon farmers were authorized to raise Atlantic salmon. Approximately 13,500 metric tons of Atlantic salmon are sold annually in British Columbia. Eighty-five percent of the production is from the protected waters between Vancouver Island and mainland B.C. (Figure 1). Alaska does not allow production of Atlantic salmon, or salmon farming.

Operators of salmon farms in British Columbia are required to report escapes of Atlantic salmon to the Department of Fisheries and Oceans. From 1988 to 1994, 85,429 Atlantic salmon escaped from B.C. salmon rearing facilities in 14 reported incidents. The magnitude of the reported escapes is somewhat correlated with the magnitude of production of Atlantic salmon; 1994 is the exception (Figure 2). The 1994 anomaly was due to 2 very large escapes that resulted from structural failures at net-pen sites. The reported total only reflects those fish that are lost to catastrophic events such as a net-pen failure or large net tears. Leakage from small tears and mishandling is not reported. Therefore it is certain that the reported total underestimates the number of Atlantic salmon that have escaped. Most of the reported escapes in B.C. have occurred in the Johnstone Strait region. Washington State does not keep a formal record of Atlantic salmon escapes.

Atlantic salmon were first reported in B.C. fisheries in 1987. Reports and/or recaptures of Atlantic salmon were infrequent from 1987 through 1991. In 1991 a joint federal/provincial program was initiated by the British Columbia Ministry of Agriculture, Fisheries and Food and the Canadian Department of Fisheries and Oceans to monitor the presence of Atlantic salmon in British Columbia (B.C.) coastal streams. In 1992 the program was expanded to include marine distribution.

The *Atlantic Salmon Watch* program consists of three main efforts: 1) routinely contacting individuals working in fisheries related activities to alert them to the monitoring program, 2) collecting and sampling recaptured Atlantic salmon, and 3) consolidating catch data from several sources to provide information about the number of Atlantic salmon observed in B.C..

## METHODS

Fish sent to the Pacific Biological Station (PBS) were examined to verify species identification. Sex, fork length, body weight, gonad weight, stomach contents, and a qualitative index of fat content were recorded. Atlantic salmon recovered by port samplers of the Alaska Dept. of Fish and Game, in Alaska are sampled first at the Auke Bay Laboratory, U.S. National Marine Fisheries Service (NMFS), then shipped to Seattle and sampled by Atlantic Watch program staff at the Alaska Fisheries Science Centre, NMFS.

Since 1993, the amount of adipose tissue in the body cavity of each fish has been assessed visually on a qualitative scale from 0 to 4. Zero indicated a dressed or greatly decomposed fish where no fat could be found, 1 indicated trace amounts of fat present, 2 indicated larger amounts of fat on major organs, 3 indicated extensive fat throughout the pyloric caeca, and 4 indicated organs completely encased in fat.

Atlantic salmon catch statistics data for B.C. were obtained from two main sources: the Department of Fisheries and Oceans sales slip database and the Mark Recovery Program database. Catch data for Washington State were obtained from the Washington State Department of Fisheries. Alaskan catch data is provided by the Auke Bay Laboratory of the National Marine Fisheries Service and the Alaska Department of Fish and Game.

## RESULTS AND DISCUSSION

### CATCH

From 1987 to 1994, 7394 Atlantic Salmon were reported caught within B.C. marine waters. The catches have been distributed throughout the coastal marine waters of B.C., but concentrated mainly in the Johnstone Strait region at the northern end of Vancouver Island. The largest single catch occurred in the Aug. 7 1993 net fishery in Johnstone Strait, in which 4067 Atlantic salmon were reported caught. This fishery was the first opportunity for capture in the area following two reported escapes, totalling approximately 10,000 fish. Data collected prior to 1992 are not as comprehensive as those collected recently so only data from 1992-1994 are shown (Figure 3). The total Canadian catch of Atlantic salmon was computed by summing catches from 3 sources: the reported catches of Atlantic salmon in the D.F.O. sales slip database, samples of the catch recorded in the Mark/Recovery database, and those samples received in the Atlantic Salmon Watch program (A.S.W.P.). It is certain that the true number of Atlantic salmon caught exceeds this by some unknown factor. A major consideration is the mis-reporting of Atlantic salmon catches as coho or other species with similar value.

In Washington State the commercial catch of Atlantic salmon is monitored through the buyer reporting program administered by the Washington State Department of Fisheries. From 1988-1994 the recorded catch of Atlantic salmon in Washington State commercial and tribal fisheries was 2,216 fish. The majority of the catch from 1992-1994 has occurred in central and lower Puget Sound with only 241 fish reported from northern Puget Sound and Juan de Fuca Strait (Figure 4).

Atlantic salmon were first reported in Alaskan territorial waters in 1990 (Wing et al. 1992). Since that time a total of 63 fish have been reported, the vast majority being captured in the net fisheries of Southeast Alaska. A single Atlantic salmon was caught in a set gillnet on August 6, 1994 on the west side of Nagai Island in the Shumagin Islands (Figure 5).

Between 1991 and 1994, 131 Atlantic salmon were reported caught or sighted in 26 freshwater systems in British Columbia (Figure 6). All were adults exhibiting dorsal and caudal fin wear indicative of previous containment in aquaculture facilities. Atlantic salmon continue to be a relatively rare species in freshwater when compared with the abundance of native species of salmon.

## BIOLOGICAL SAMPLING

There are distinct differences between Atlantic salmon samples (n=312) recovered in B.C. marine fisheries and those (n=49) recovered from Alaskan marine fisheries. The stomach contents of the fish from B.C. had a low incidence of prey items (3.4 %). This is low compared to indigenous Pacific salmon, a sample of chinook and coho ranged from 60.8 - 80.1% prey items, (Waddell et al. 1992) and studies of Atlantic salmon from European farm sites. Hislop et al. (1992) found 35% of escaped Atlantic salmon in Scottish waters contained prey items. Atlantic salmon sampled from Alaskan waters showed a significantly higher incidence of stomachs containing prey items (14.3%). Atlantic salmon reaching Alaskan waters may be more habituated to natural feeding.

Fish taken from Alaskan waters had lesser amounts fat in the body cavity than those recovered in B.C. (Figure 7). This is likely the result of a combination of the time spent away from the enhanced feeding regime of the farm site and the energetic expenditure for the distance travelled. Some Atlantic Salmon are caught very recently after escaping. These fish had commercial fish food in their stomachs. Talbot et al. (1984) showed that even with varying meal sizes and pre- and post-feeding starvation, the maximum time for complete gastric evacuation was 58 hours.

The fish recovered from B.C. marine waters are in general heavier at length than those recovered from Alaskan waters (Figure 8). They are also heavier at length than a natural Atlantic salmon population (Reddin and Lear 1984). This is due to the artificial abundance of food on fish-farms. This suggests that many of the Atlantic salmon that have been recaptured had recently escaped. Food deprivation experiments could be undertaken to test this hypothesis.

Thirteen Atlantic salmon have been recovered from freshwater systems in B.C. and returned to the Pacific Biological Station for analysis between 1991 and 1994. Eleven of the fish showed gonadal development and external colouration associated with sexual maturation.

## ACKNOWLEDGEMENTS

The Atlantic Salmon Watch program is funded through a grant from the B.C. Ministry of Agriculture, Fisheries and Food. We gratefully acknowledge the support and assistance of Ron Ginetz of the Department of Fisheries and Oceans, and Bryan Ludwig of the British Columbia Ministry of Environment, Lands and Parks. Jim Thomas of J.O. Thomas & Associates Ltd. provided the M.R.P. data. Lee Hoines of the Washington Department of Fish and Wildlife provided catch information for Washington State. We would also would like to thank all the fish processors for their co-operation and donation of Atlantic salmon and all the individual fisherman, both sport and commercial, and volunteers who reported Atlantic salmon sightings and captures.

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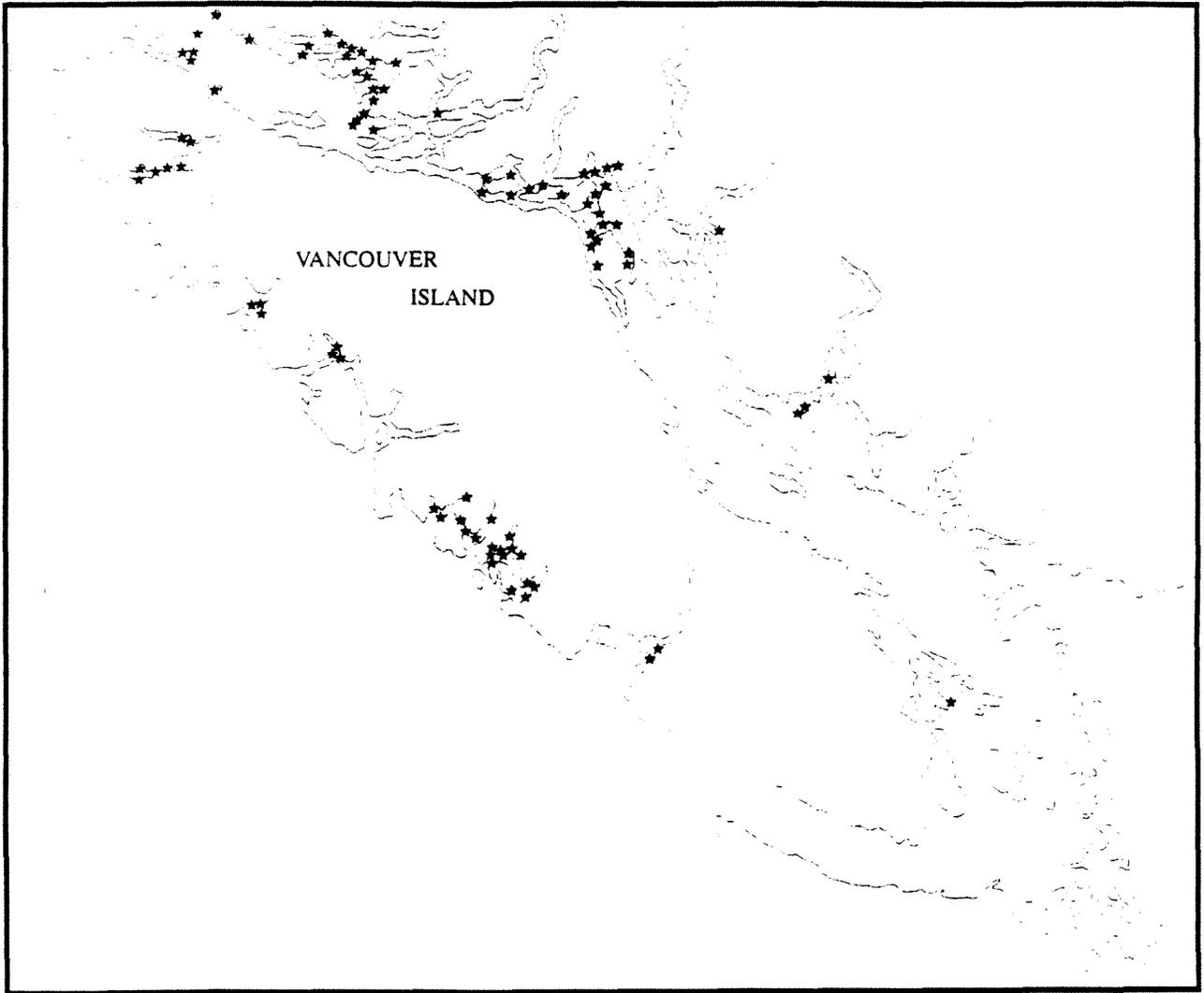


Figure 1. Locations of net-pen sites operating in British Columbia, 1995.

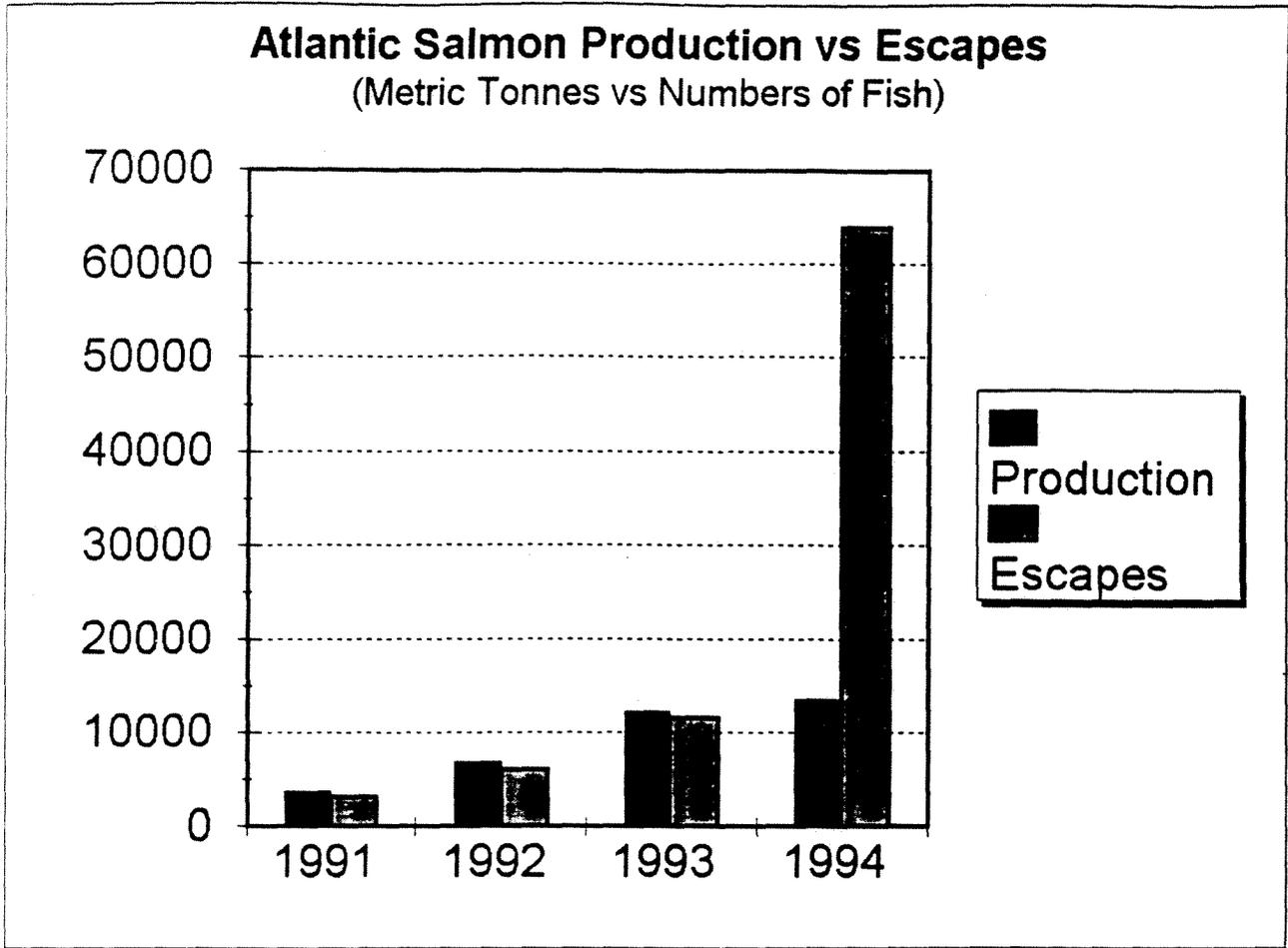


Figure 2. Production (metric tonnes) versus reported escapes (numbers of fish), 1992-94.

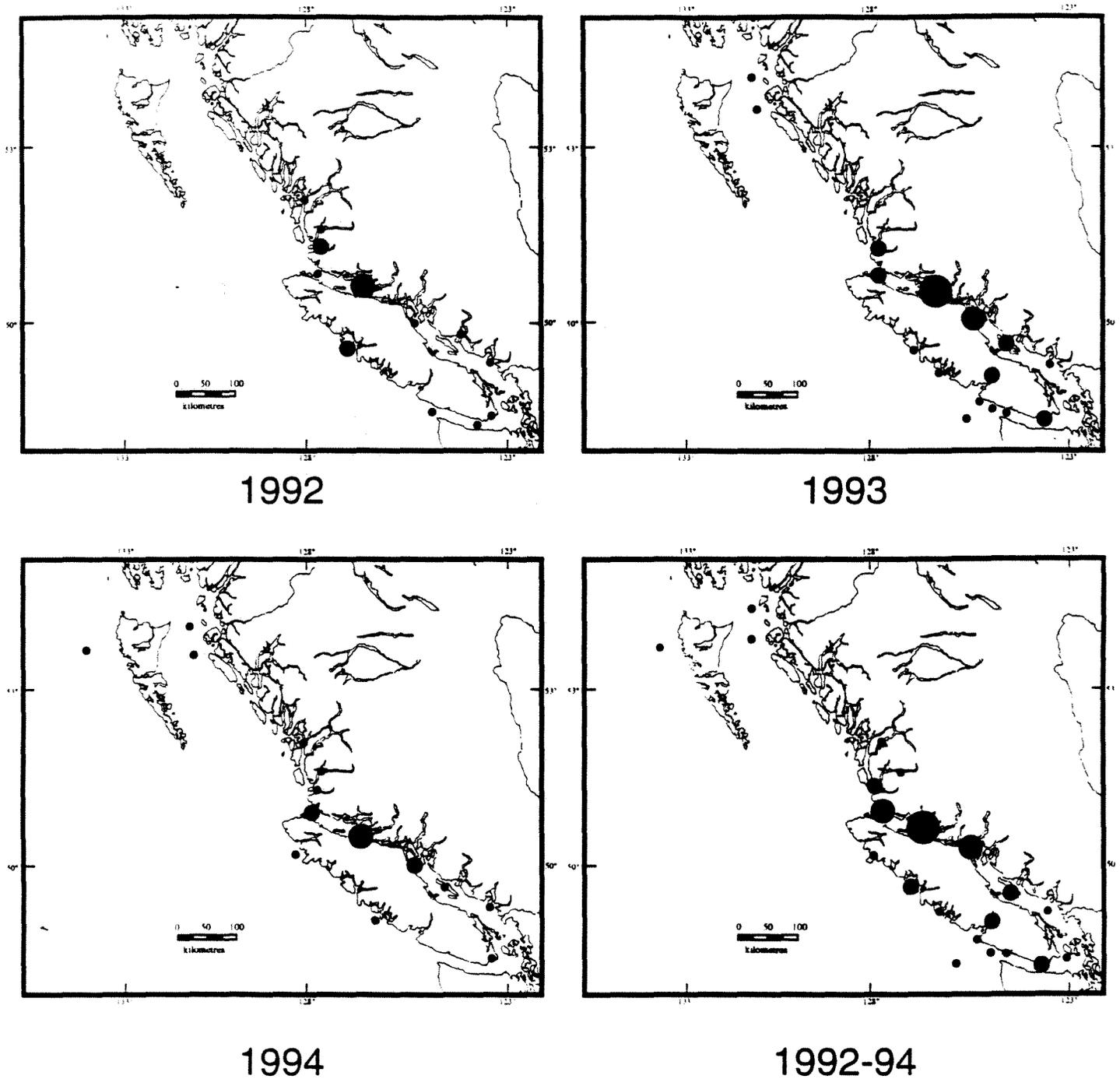
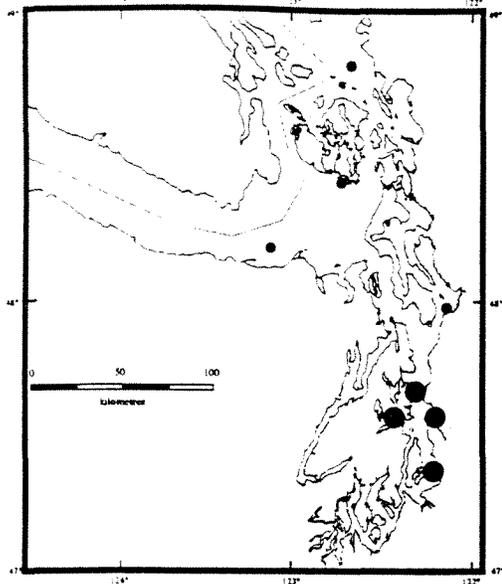
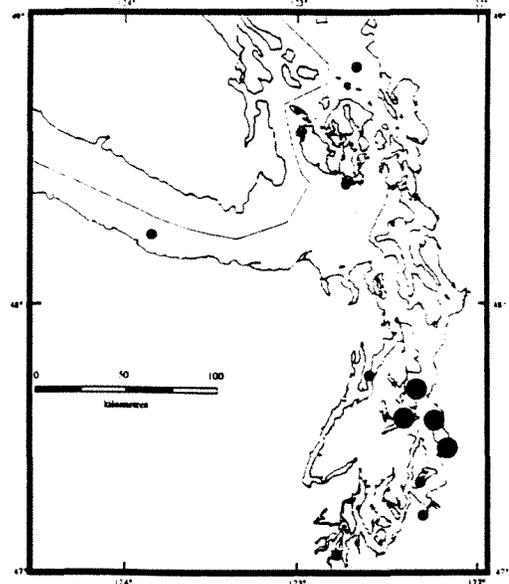


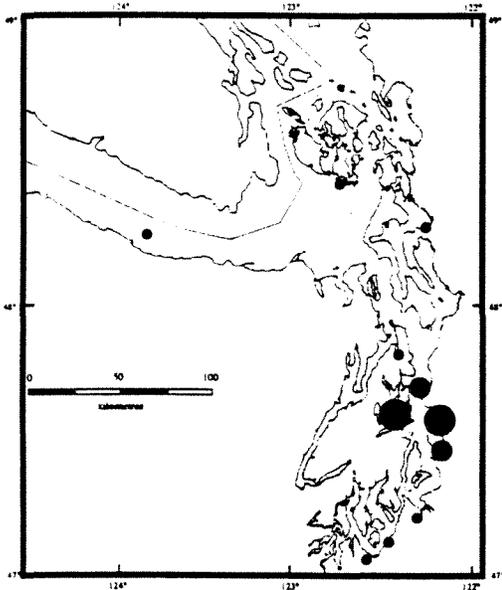
Figure 3. Atlantic salmon reported from marine waters in British Columbia from 1992 to 1994 by D.F.O. statistical area. Data compiled from Sales slip database, Mark Recovery Program and Atlantic Salmon Watch program.



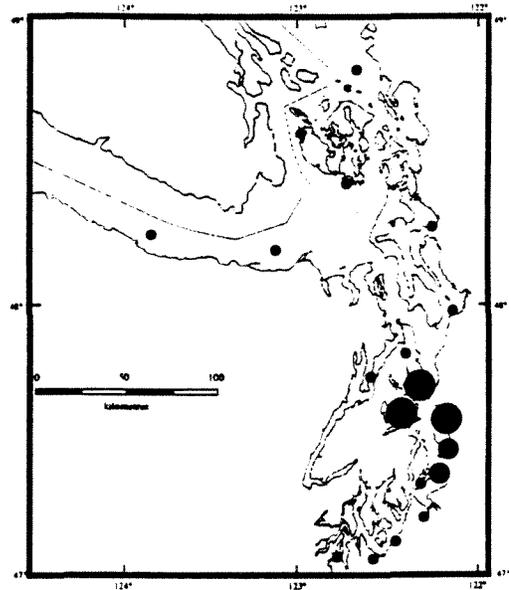
1992



1993



1994



1992-1994

Figure 4: Catch of Atlantic salmon in Washington State in 1988-94, by catch region.

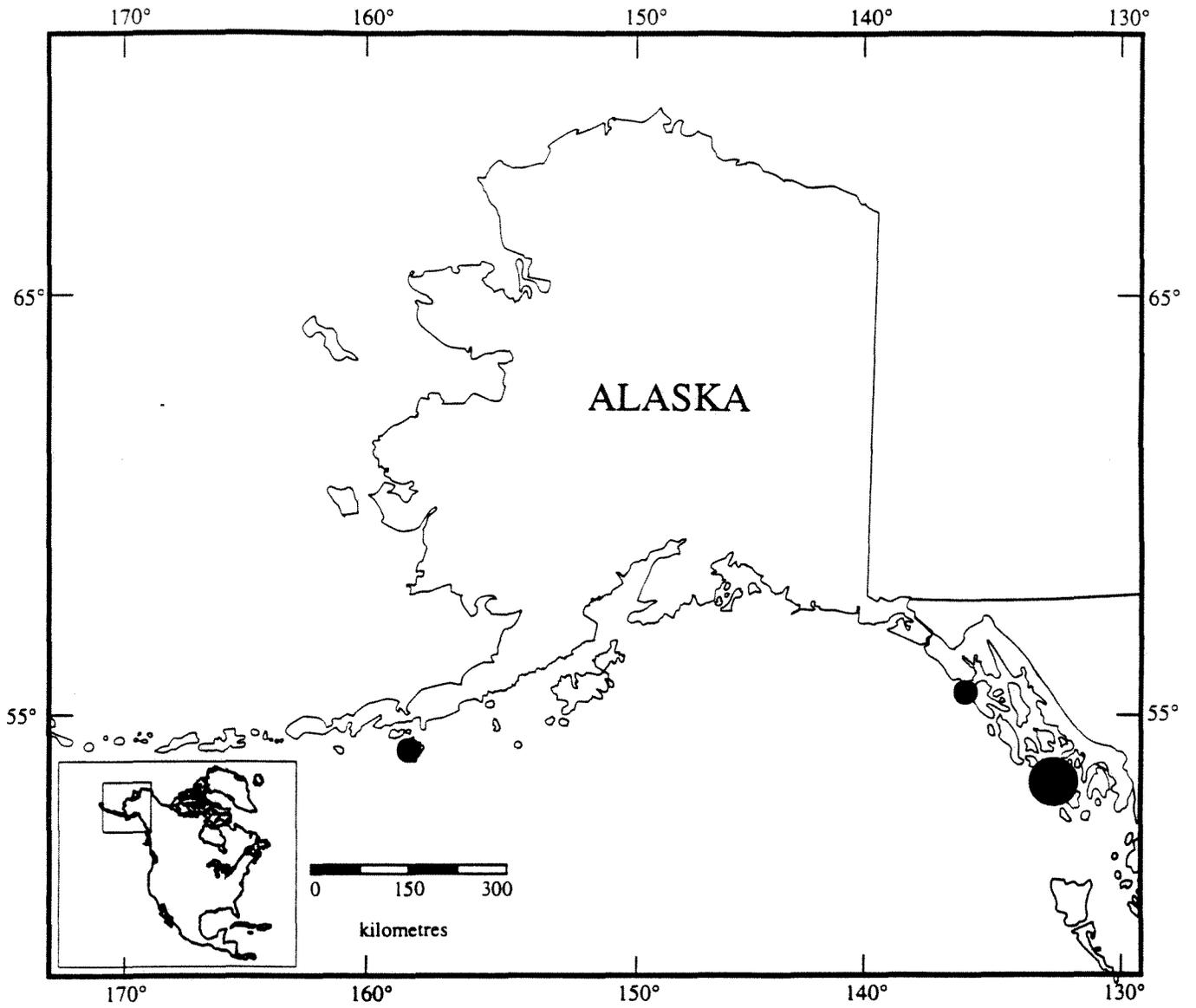


Figure 5. Atlantic salmon catch in Alaskan waters. 1990-94

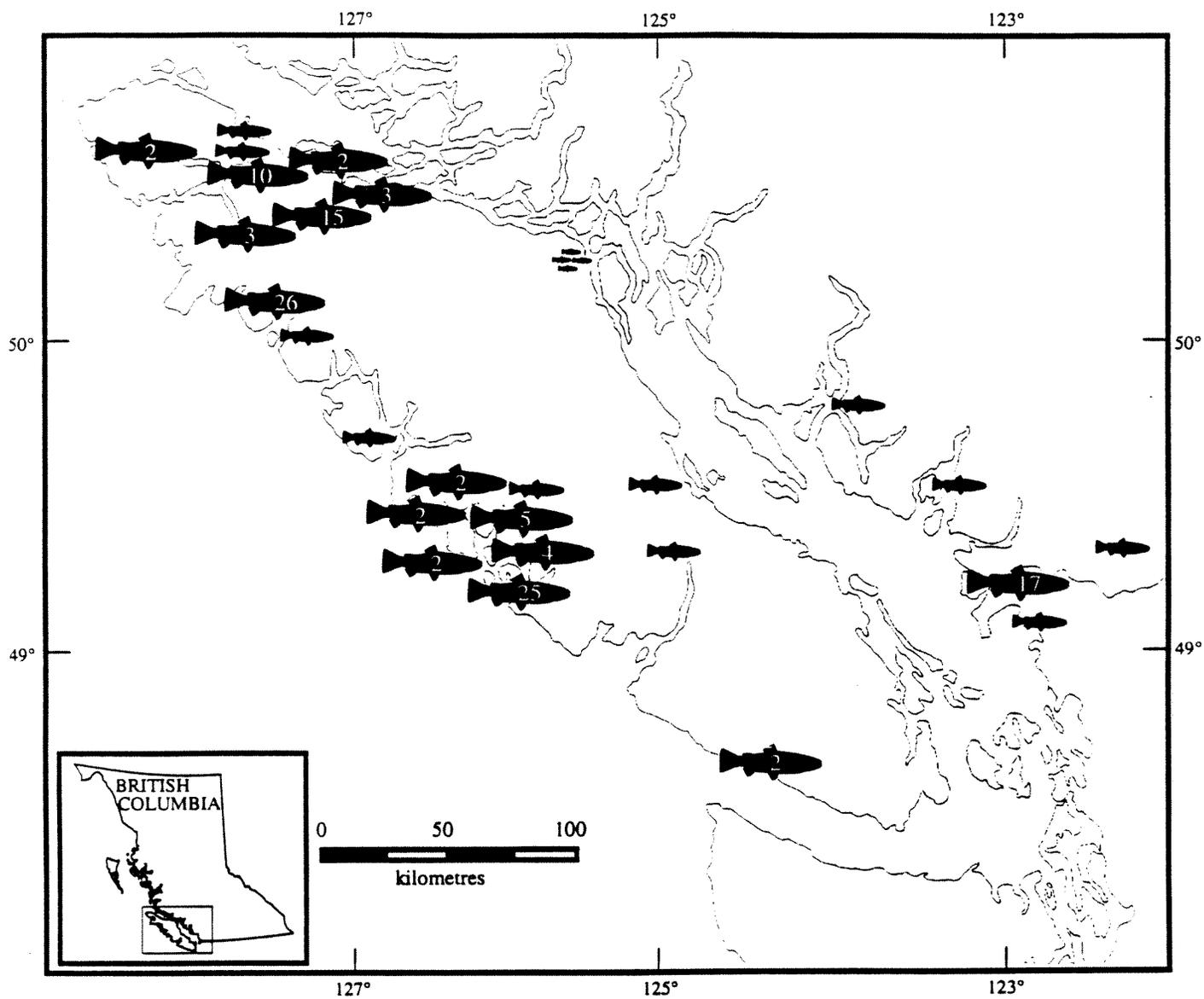


Figure 6. Atlantic salmon reported from freshwater sites in British Columbia, 1991-1994.

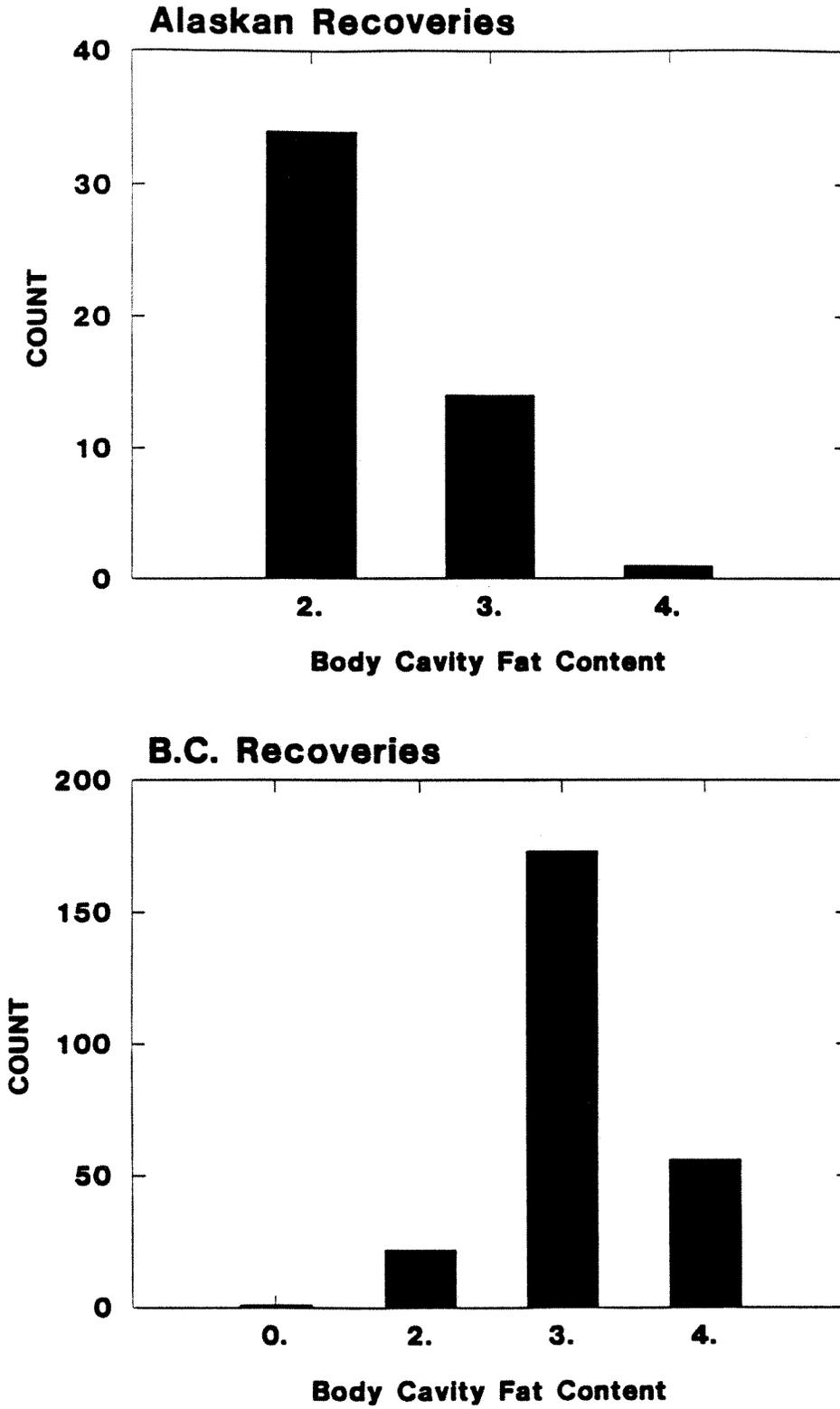


Figure 7. Body cavity fat levels of Alaskan caught Atlantic salmon versus Atlantic salmon caught in B.C. marine waters.

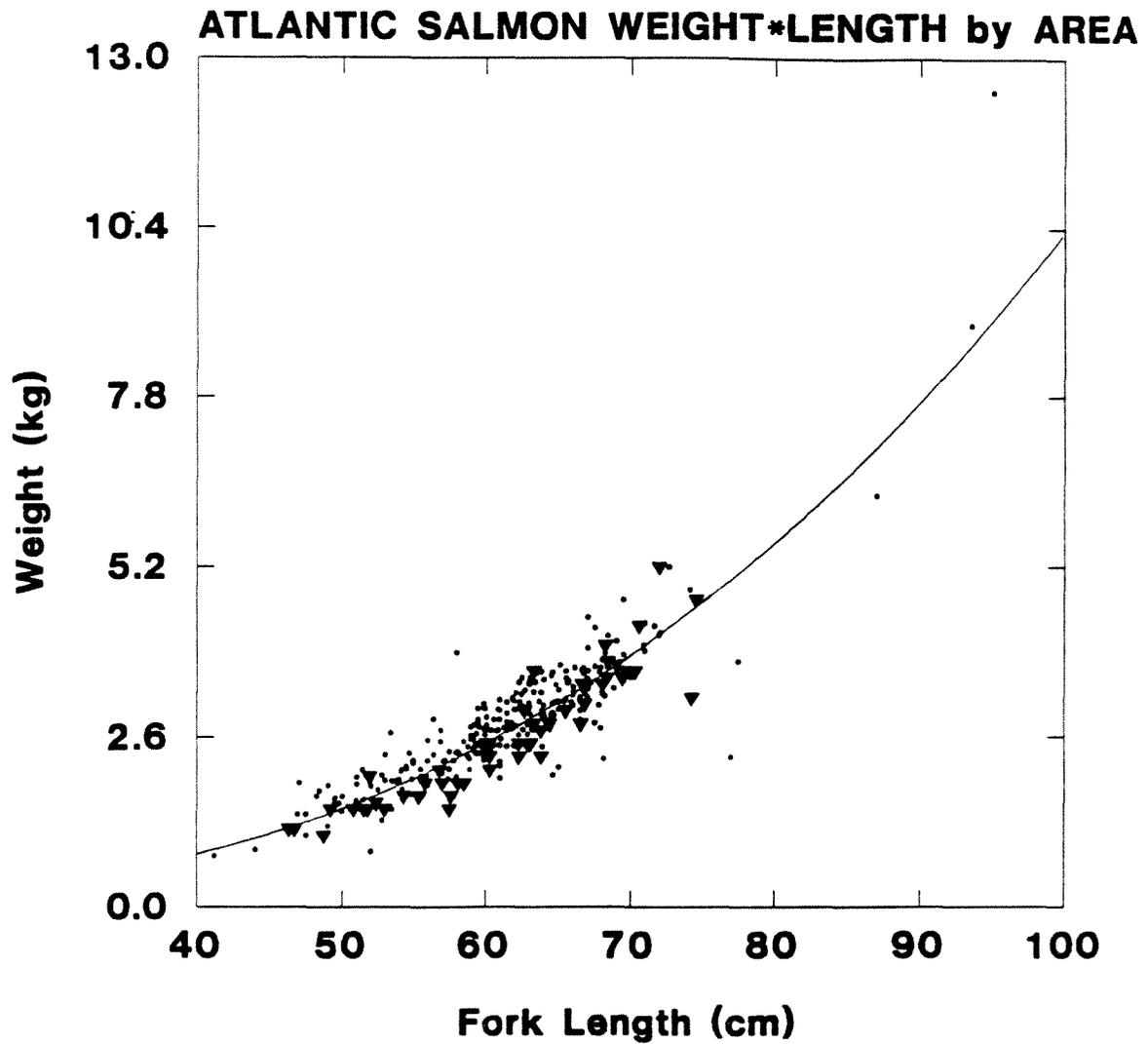


Figure 8. Weight versus length for Alaskan (triangles) and B.C. (circles) caught Atlantic salmon. Line indicates the natural condition factor for a population of Atlantic salmon in Newfoundland (Reddin and Lear, 1984).