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**THE CONSTRUCTION OF A DATABASE FOR PACIFIC HERRING TAGGED
AND RECOVERED IN BRITISH COLUMBIA FROM 1936 TO 1992**

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ABSTRACT

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Pacific herring in British Columbia have been tagged and recovered since 1936. The earliest tagging programs (1936-1967) employed metallic 'belly tags' inserted into the body cavity and recovered with magnetic detectors. More recent tagging programs (1979-1991) used plastic 'anchor' tags that were visually detected, usually in fish processing plants. Most, but not all of these tagging studies, have been reported in a variety of publications. To date, however, there has not been a definitive description or record of all methods and results. This paper presents a detailed description and review of all tag releases and recoveries. All previous publications were assembled and reviewed and some new, previously unpublished data from more recent anchor tagging work in the late 1980's and 1990's were included. All pertinent data were entered into a new herring tagging database that combined results from both the belly and anchor tagging work. The original objectives and techniques of each herring tag release program are presented when appropriate. Database structure and fields are described, discrepancies in the data are examined, and data entry decisions are discussed.

RÉSUMÉ

Daniel, K., B. McCarter, and D. Hay. 1999. The construction of a database for Pacific herring tagged and recovered in British Columbia from 1936 to 1992. Can. Tech. Rep. Fish. Aquat. Sci. 2280:

Depuis 1936, le hareng de Colombie-Britannique fait l'objet de programmes de marquage-récupération. Dans les premiers programmes (1936-1967), on employait des marques métalliques qui étaient insérées dans la cavité abdominale et récupérées à l'aide de détecteurs magnétiques. Les programmes plus récents (1979-1991) faisaient appel à des étiquettes de plastique à ancrage qui étaient détectées visuellement, généralement dans l'usine de transformation. La plupart de ces études, mais pas toutes, ont été rapportées dans diverses publications. Jusqu'à maintenant, il n'existait toutefois aucune étude complète décrivant les méthodes suivies et les résultats obtenus ; nous présentons ici une description détaillée et un examen complet de toutes les opérations de marquage et de récupération. Nous avons compilé et examiné toutes les publications antérieures, ainsi que des données nouvelles et inédites concernant des travaux de marquage par ancrage réalisés à la fin des années 80 et dans les années 90. Toutes les données pertinentes ont été versées dans la nouvelle base de données sur le marquage du hareng, qui combine les résultats des travaux réalisés avec les deux méthodes de marquage (marques métalliques et étiquettes de plastique). Les objectifs et techniques de chaque opération de marquage du hareng sont présentés le cas échéant. Nous décrivons la structure de la base de données et ses champs, examinons les divergences dans les données et analysons les décisions prises en ce qui concerne l'entrée des données.

INTRODUCTION

Pacific herring were first tagged in British Columbia in 1936 and in most of the following years until 1991. The herring tagging programs were conducted mainly by the Pacific Biological Station and the Department of Fisheries and Oceans. Results were documented nearly every year that tagging occurred. Most of the early results, from 1936-1957, were published in annual publications of the British Columbia Provincial Department of Fisheries (Hart and Tester, 1937-1940; Hart *et al.*, 1941 and 1942; Stevenson, 1950; Stevenson *et al.*, 1952 and 1953; Stevenson and Lanigan, 1951; Stevenson and Outram, 1953; Taylor, 1955; Taylor *et al.*, 1956 and 1957; Taylor and Outram, 1954; Tester, 1944-1946; Tester and Boughton, 1943; Tester and Stevenson, 1947 and 1949). Juvenile herring tagging studies from 1951 to 1956 were published in a series of Pacific Biological Station Manuscript reports and in a Doctorate Thesis by Hourston (1952, 1954a, 1954b, 1955, 1956a, 1956b and 1957). More recent results were published in other reports, mainly the Department of Fisheries and Oceans Data, Industry, Manuscript and Technical Report Series and Pacific Stock Assessment Review Committee (PSARC) working papers (Armstrong *et al.*, 1990; Farlinger, 1986, 1988, 1989a, 1989b; Farlinger *et al.*, 1991; Haegele, 1981, 1984a, 1984b, 1984c and 1986; Haegele and Hopwo, 1984; Haegele *et al.*, 1982a, 1982b, and 1983).

Although there were many periodic summaries among these reports the herring tagging data has not been developed as a single, comprehensive database, nor has there been any single, definitive source or description of the entire data set. The objectives of this report were to present key information relative to the construction of a herring tagging database and document all essential information relative to the tagging methods, releases and recoveries, from 1936 to 1992. The report also comments on some discrepancies in release and recovery data among earlier publications. Such discrepancies are reconciled and decisions about data entry are explained. Therefore, in addition to providing a single comprehensive description of all previous herring tagging work, this report is also designed to serve as a guide to the British Columbia herring tagging database.

PURPOSE AND DESIGN OF TAGGING PROGRAMS

The primary purpose of the first herring tagging program in British Columbia was to examine the intermingling and migration of herring runs (Hart and Tester, 1937). Additional goals of early herring tagging programs were "(1) to add to the general knowledge of the life history of herring in British Columbia waters; (2) to determine the extent of herring movements; and (3) to determine the strength of tendency of herring to form local populations" (Tester and Boughton, 1943).

Early work attempted to tag and release at least 3,000 herring per location (Tester, 1944). During 1946-1947, a stated objective of the west coast of Vancouver Island (WCVI) tagging studies was to determine the cause of natural fluctuations in abundance and the average minimum spawning stock necessary to provide maximum sustainable yield (Tester and Stevenson, 1947). Stevenson and Lanigan (1951) also believed the WCVI studies would provide critical data needed to calculate the rate of exploitation from one season to the next.

Juvenile herring tagging was also conducted in the 1950's, mainly "to determine the strength of a year class subsequent to its recruitment to fish stock" (Hourston, 1952). Further objectives of the juvenile tagging program were "(1) to follow the dispersal and migration of stocks; (2) to study the rate of growth of young herring and compare this factor from year to year and from population to population for possible controlling factors; (3) to determine whether homing instinct is that of individual fish, of juvenile schools, or the adult school it joins; (4) to study the metamorphosis of the herring and (5) to determine the mortality rate prior to the juvenile stage by comparing with population estimates of earlier stages" (Hourston, 1952).

Juvenile tagging began in 1951 in Barkley Sound and Departure Bay (Hourston, 1952). During the following seasons until 1957, juvenile herring tagging was conducted in Barkley Sound, Nootka Sound, Clayoquot Sound, Esperanza Inlet, Departure Bay and Strait of Georgia (Hourston, 1954a, 1954b, 1955, 1956a, 1956b and 1957).

The 1957-1967 adult herring tag releases and recoveries were compiled by Taylor (1973a and 1973b). Tagging was conducted in the Strait of Georgia to define the boundary between middle and lower east coast of Vancouver Island (ECVI) herring populations and to determine the relationships between stocks during the 1955-1956 season (Taylor, 1973a). Also, in 1957, summer herring were tagged to determine the relationships between stocks fished in summer "offshore" localities with those of the regular, winter fishery (Taylor, 1973a). The 1964 tagging program was completed in the Queen Charlotte Islands (QCI) to identify the QCI herring populations and to determine their relationship with other major northern and central herring populations. The 1965-1967 Swiftsure Bank tagging program was conducted to determine the stock relationship between the large summer and early fall fisheries on the Swiftsure Bank. The 1967 upper ECVI summer tagging concentrated on stock relationships between the ECVI summer fishery in "offshore" areas near Mexicana Point and the regular winter fishery. Also, between 1953 and 1959, herring tagging was completed in Washington State to examine the extent of intermingling of herring stocks from Puget Sound and adjacent waters, and to determine if these stocks contributed to the Canadian fishery. Only Washington State herring tags caught during the Canadian herring fisheries were recorded in Canadian publications and are discussed in this publication.

The development of the roe fishery led to a renewal of the herring tagging program in 1979 (Haegele, 1981). Pilot studies examined recovery rates from fish plants (Hay and Mitchell, 1979 and Hay *et al.*, 1979) and the tag retention and survival of tagged fish in captivity (Hay, 1981). Other herring tagging evaluation studies were conducted (Haegele, 1981) but the coast wide tagging program was later suspended mainly due to lower than expected returns during the 1980-1981 fishing season (Haegele *et al.*, 1982). It was determined that future tagging should be conducted in the following locations: "(1) offshore the west coast of Vancouver Island, in conjunction with hydroacoustic biomass estimate cruises, to determine where these fish are intercepted in fisheries and where they spawn; (2) the lower Strait of Georgia in late fall to determine which spawning stocks are intercepted during the food and bait fishery there; (3) inshore the west coast of Vancouver Island in the late winter to examine fish movements immediately prior to spawning and (4) the north coast to determine what spawning

stocks are fished during the Browning Entrance food and bait fishery and to determine the discreteness of spawning stocks" (Haegele *et al.*, 1982).

Between 1986 and 1992 additional tagging was conducted, primarily in the northern part of British Columbia (Figures 1 and 2) to "examine incoming migrations of herring to the spawning grounds and their contribution to the fishing locations within the stock boundaries" (Farlinger, 1989a). Unlike earlier tagging studies, approximately 1,000 tags were applied per tagging location (Farlinger, 1989a and 1989b). In 1989, however, 500 to 1,000 herring were tagged per location in the Central Coast (Figure 3), Strait of Georgia (Figures 4 and 5) and the west coast of Vancouver Island (Figure 6). During the 1990 roe herring season, herring tagging was extended along the entire coast of British Columbia (Armstrong *et al.*, 1990).

HERRING TAGGING TECHNIQUES

During the 1936-1967 tagging experiments, the tags or magnets used were made of 19 x 4 x 1.6 mm nickel plated iron with rounded ends (Hart and Tester, 1937) (Figure 7). However, war-time shortages in the 1940's led to the replacement of these nickel tags with silver plated iron tags (Tester, 1944). Silver plated tags had several different dimensions, depending on the manufacturer, compared to the nickel plated tags (Tester, 1944). Efficiency tests were performed during the 1946-1947 season using both types of tags. These tests resulted in no significant differences in recovery rates or mortality (Tester, 1946). According to Taylor *et al.* (1956) juvenile herring tags during the 1950's were 13 x 3 x 0.5 mm in size and adult tags were 21 x 4 x 1 mm in size. Hourston (1952) records juvenile tags weighing 0.18 grams (13 x 3 x 0.5 mm), and adult tags weighing 0.92 grams (19 x 4 x 1.6 mm). In 1964, stainless steel Norwegian tags replaced nickel and silver plated tags (Taylor, 1973a).

Herring destined for tagging were caught primarily by commercial seines during the fishing season. Purse seines, beach seines, dip nets and salmon traps were also used (Hart and Tester, 1939). Juvenile herring were sometimes captured using herring rakes when conditions for seining were unfavourable or by attracting and netting the fish using lights and dip nets (Hourston, 1952). After capture, herring were held in floating impoundments or bait boxes prior to tagging.

The insertion of metallic tags into the body cavities of herring involved several steps. Usually, two person teams performed the tagging. One person would dip net the fish while the other inserted the tag. Tag insertion involved cutting a small incision into the side of the herring between the opercle and vent (Hart and Tester, 1937). The tag was then pushed into the body cavity by hand or by using a tagging gun (initially used in 1937). The tagging gun could hold up to 100 tags which improved application rates (Hart and Tester, 1938). A detailed description and diagram of the tagging gun (Figure 8) is provided in Hart and Tester (1938). Juvenile herring had to be equal to or greater than 80 mm in length before they were tagged (Hourston, 1952). Tagged herring were released after being held for a short recovery period.

In 1964, a procedural modification was implemented to minimize the "loss of scales, shock, and infection, possible causes of mortality" (Taylor, 1973a). Herring were placed in one of two, 500 gallon tanks (~1500 fish per tank) and immediately prior to tagging the fish were dipped into an anaesthetic solution (Taylor, 1973a). The anaesthetic immobilized the herring for 5 minutes with partial recovery beginning after 10 minutes and full recovery in an hour (Taylor, 1973a). The tagged herring were then held for 4-24 hours and released all at one time to reduce predation from birds, mammals and other fish (Taylor, 1973a).

Beginning in 1979, herring were tagged with anchor tags. The basic anchor tag structure (Figure 9) was an external plastic tube attached to a monofilament with a T-shaped end that anchors into the musculature of the fish (Haegele, 1981). A hollow needled gun with a plunger was used to push the tag through the skin and into the musculature. The tag was inserted near the "posterior margin of the dorsal fin at a 30 degree angle to the dorso-ventral surface" (Haegele, 1981). Beginning in 1981, herring were tagged at the anterior margin of the dorsal fin to increase tag retention (Haegele *et al.*, 1983). In addition to anchor tags, lock-on tags were applied at one tag release location during the 1981-1982 season (Haegele *et al.*, 1983). Fish handling procedures were adapted from previous

tagging studies. A maximum of 10 fish were dip netted from a seine net into small holding tanks prior to tagging to minimize scale loss and panic behaviour (Haegele *et al.*, 1981). Two thousand fish could be tagged in an hour. Tagged fish were held in holding pens and released when tagging was completed.

HERRING TAG RECOVERY TECHNIQUES

Herring tag recovery was accomplished with induction detectors, magnet detectors and fish plant crews located along the British Columbia coast. Tester (1945a) differentiated between induction and magnet recoveries by stating "the former recovers the tagged fish from a chute in the unloading system of canneries or reduction plants; the latter recovers the tag only, from a meal-line of reduction plants". The main advantages of the induction detector were greater certainty in determining the tag recapture location and the opportunity to examine the tagged fish (Hart and Tester, 1939). The magnet detector did not provide the same degree of recovery precision. The installation of induction detectors, however, was extremely expensive and required constant staffing by herring investigators (Hart and Tester, 1939). The magnet detectors were cheaper to run and, consequently, large quantities of tags could be recovered at little expense (Hart and Tester, 1939).

Efficiency testing of detectors was a necessary step in the recovery process. It provided an opportunity to detect problems and fine tune the equipment. The primary technique used to test plant detector efficiency was to insert a known number of tagged fish into a particular shipment. Efficiency was determined by the quotient of the known tags recovered and the known tags added to the shipment.

The rate and number of tag returns were influenced by many factors. In 1942, small monetary rewards were offered using posters in workplaces to encourage tag returns from canneries and reduction plants. No reward returns, however, were received in the first year (Tester and Boughton, 1943). In the 1948-1949 season, a greater number of magnet recoveries was attributed to an increase in the use of magnet detectors, a higher number of fish tagged on the WCVI, and a greater interest by plant crews to collect tags due to the rewards offered (Stevenson, 1950). A decline in herring catches in the 1949-1950 season resulted in a decrease in the number of herring tags recovered. Juvenile herring tags were only recovered during the 1950's by magnet detectors in reduction plants (Taylor *et al.*, 1957). During the 1954-1955 season, several tag detector problems were documented. There were suspicions that tags were missed because the tag impulse and line voltage frequencies of the detectors were too similar (Taylor, 1955). Hourston (1956) also explained the potential reason for lower returns as "(1) the selective effects of the fishery and (2) differential mortality in the tagged fish; (a) due to differences in the condition of the fish prior to tagging (i.e. overcrowding live pounds, leaving fish confined), (b) due to differences in the effect of tagging operation and (c) due to differences in the effect of environment after tagging".

Physiological stresses on tagged herring were thought to be a major factor influencing tag returns. Water temperature, salinity and feeding conditions were identified as possible reasons for lower returns (Hourston, 1956). On average, only 0 to 2% of juvenile herring tagged were recovered (Hourston, 1956). No belly tags were recovered after the 1968-1969 season when the reduction fishery was closed and only bait and food fisheries were permitted (Taylor, 1973).

In 1979, anchor tagging was initiated which eliminated the need for induction and magnet detectors. The highly visible anchor tags were recovered by plant crews during herring roe extractions. During the 1980-1981 herring fishery a \$2.00 reward was offered for any herring tags recovered during the fishery (Haegele *et al.*, 1982). Despite this award, tag returns for that season were lower than expected. Haegele *et al.* (1982) proposed that vessel crews did not properly tag the herring or handle them properly thus increasing their vulnerability to predation. The incidence of uncertain or "Unknown" recovery locations increased during the 1982 roe fishery due to the fact that most of the catch was frozen and not processed until June (Haegele *et al.*, 1983).

HERRING TAG RECOVERY PRECISION

A major difference in the recovery information between belly and anchor tags is that the date of belly tagging recoveries is known only to the nearest year. This was because most belly tags were recovered using magnetic detectors in recovery plants and then retrieved at the end of the season. Also, the locations of many belly tags recoveries were not exact, and were often reported as being from one of several possible areas, usually within a broader area, such as the Strait of Georgia, or west coast of Vancouver Island (Hart and Tester, 1937-1940; Hart *et al.*, 1941 and 1942; Stevenson, 1950; Stevenson *et al.*, 1952 and 1953; Stevenson and Lanigan, 1951; Stevenson and Outram, 1953; Taylor, 1955, 1973a and 1973b; Taylor *et al.*, 1956 and 1957; Taylor and Outram, 1954; Tester, 1944-1946; Tester and Boughton, 1943; Tester and Stevenson, 1947 and 1949; Hourston, 1952, 1954a, 1954b, 1955, 1956a, 1956b and 1957). In contrast, the anchor tag recoveries were usually reported exactly to the day of recovery, often with a precise geographical location, corresponding to a roe fishery opening (Armstrong *et al.*, 1990a; Farlinger, 1986, 1988, 1989a and 1989b; Farlinger *et al.*, 1991; Haegele, 1981, 1984a, 1984b, 1984c and 1986; Haegele and Hopwo, 1984; Haegele *et al.*, 1982a, 1982b, and 1983).

HERRING TAGGING DATABASE SOURCES

A summary tagging report by Hourston (1981) was used as the definitive source for all 1937-1967 tag releases entered into the database. This report lists herring tag release locations, release dates and numbers released. These data were compared with release tables in each of the BC Department of Fisheries reports (1937-1957).

British Columbia Department of Fisheries reports were used as the definitive source for the 1937-1957 tag recovery data. Summary tables in Hourston (1981) could not be used because individual tag recoveries were not recorded. Also, recovery dates and location were presented with greater precision in the BC Department of Fisheries reports. These reports also have separate tables for induction detector, plant crew and magnet detector recoveries. These types of tag recoveries, however, were not distinguished in the tagging database. In five reports (Hart and Tester, 1938; Tester, 1944; Tester and Stevenson, 1949; Stevenson, 1950 and Stevenson and Lanigan, 1951), different plant detector recoveries were separated. In most other reports, induction detector recoveries were summed together for the entire coast. Italicized numbers in the tables indicated a higher level of certainty. Actual tag recoveries, however, (bracketed in tables or in two separate tables) were entered into the database rather than adjusted recoveries. Adjustment calculations were not performed consistently or defined clearly in the reports. Descriptions of tag recovery locations were provided, but only tag recoveries listed in tables were entered. Occasionally, a statistical area number was listed rather than an actual location name so that the location had to be determined by the descriptions. In cases where the fishing season was the only source for the date, (e.g., 1946-1947 fishing season), the latter year was entered as the recovery year. Tag recoveries at a single location were summed for a particular season and release group, checked against Hourston (1981) and then entered into the database. During the 1952-1953 season no tag recoveries were made due to a strike where over 80% of the catch was processed at a plant without tag recovery equipment (Stevenson and Outram, 1953).

Hourston (1981) listed a total of 49 juvenile tag releases (Table 1). Many of the recoveries from these juvenile releases were not listed in the BC Department of Fisheries reports, but instead in a series of Pacific Biological Station Manuscript reports and a Doctorate Thesis (Hourston, 1952, 1954a, 1954b, 1955, 1956a, 1956b and 1957). Sometimes multiple recovery locations were listed for a single or group of tags from a tagging release location. Also, in a table footnote, Hourston (1955) stated "alternative possible localities of recovery are given in parentheses". These recoveries were consequently entered into the database as multiple recovery positions.

Summer and winter fishery tag recoveries from 1957 to 1967 were entered into the database using Taylor (1973a and 1973b) as the data source. Taylor (1973b) tabled both certain and questionable recoveries. "Questionable recoveries" were due to the observation that "plants received and processed fish in quantity from several areas at once. There was no way of knowing which areas contained tags. All such areas were therefore considered as possible but uncertain or questionable areas of recovery." (Taylor, 1973a). Since many of the recoveries from the BC Department of Fisheries reports were documented in this manner (e.g., statistical areas 13-19) the questionable recoveries from Taylor (1973b) were also entered into the database as multiple recovery positions. The 1960-1961 and 1964-1965 winter fishery recoveries (Taylor, 1973b), were entered as "Unknown" recovery locations because only the total questionable recoveries were listed. Furthermore, all recoveries in Taylor (1973b) were listed as statistical areas and sections except for the Swiftsure Bank recovery location. The 1957 summer fishery recoveries and 1958-1959 winter recoveries for Holmes Harbour and Hood Canal (Taylor, 1973b) could not be entered until referring to a technical report by Taylor (1973a). Recoveries could not be linked with releases because the tagging year was missing in Taylor (1973b), but the year was given in Taylor (1973a). Winter fishery "questionable" tag recoveries were not recorded by statistical area in Hourston (1981), but were listed under a "?" category in these tables.

Haegle (1986) summarized herring tagging and returns from 1979 to 1985. Each annual tagging report was reviewed but only data in Haegle (1986) was entered into the database. Unlike, most earlier records, tag recoveries had exact locations and precise dates (year, month and day). Some tag releases were summed and entered when there were several smaller tag releases listed separately at the same location within a period of a few days. The date entered into the database was usually the first day of release at that location.

Herring tag releases and recoveries from 1986 to 1992 were entered into the database from several unpublished data sources and PSARC (Pacific Stock Assessment Review Committee) working papers. Tag release data was located in PSARC working papers (Armstrong *et al.*, 1990; Farlinger, 1988, 1989a and 1989b; Farlinger *et al.*, 1991), however, tag recoveries were listed only in unpublished tables (Anonymous, 1992; Armstrong *et al.*, 1990; Farlinger, 1988-89 and 1991). The unpublished recovery tables did not always list the actual tagging location but only the statistical area name. Therefore, the tag series numbers (e.g., H472001) recorded both in these unpublished tables and the PSARC papers were essential in order to link releases with recoveries. The tag series numbers and the corresponding herring database location codes are located in Appendix Table 1. Some tag releases or recoveries from the same location, but a few days apart, were summed before entry into the database. Also, the date entered into the database was always the first day of release at that location. All unpublished data from 1986-1992 tagging programs were photocopied to facilitate subsequent retrieval.

HERRING TAGGING DATABASE STRUCTURE

The database was designed so that all herring tag releases and recoveries between 1936 and 1992 could be included. Histograms of the total number of tags released and recovered each year are shown in Figure 10. The column headers or fields of the database were chosen to ensure data entry efficiency without losing any data processing capability. Sixteen fields were used in the electronic version of the database. Appendix Table 2 lists the first 14 fields. Appendix Table 3 lists Location Codes (Field 10) and corresponding latitudes and longitudes (Fields 15-16). The first field, 'TagGroup', uniquely identified each group of tagged fish released. A four digit, numeric code was assigned, with the first 2 digits representing the year and the last 2 digits representing the group release number. In Hourston (1981), Taylor (1973) and in the BC Department of Fisheries reports, tag releases were linked to recoveries using a 'Season' number and 'Group' letter code. This alphanumeric identification system was recorded in the database in fields 2 and 3, for cross-referencing and data checking purposes only. This alphanumeric system was discontinued in 1968. The 'TagGroup' field, functions as the release-recovery linkage throughout the entire database.

Fields 4-6, corresponding to the 'Year', 'Month' and 'Day' were used to record the date of tag release or recovery. Field 7, 'TagRole' differentiated between releases and recoveries, and also distinguished between juvenile and adult releases. In this field, a juvenile release was specified as a "1", an adult release as a "2" and a recovery as a "3". Field 8, 'Position', indicated the precision of a tag release or recovery location. An exact or single recovery location was indicated by a "1" and a multiple area of recovery (e.g., Central Coast - statistical areas 6-10) was indicated by a "9". Many of the tagging records prior to 1968 recorded tag recovery areas using a range of several statistical areas. This was done because boats fished multiple areas per landing and herring from different areas were often mixed at fish plants. The exact tag capture location could not be determined and instead, all probable statistical areas of recovery were listed.

Field 9, 'Number', recorded the total number of tags released or recovered at each location and date. Field 10, 'LocCode', is a 4 digit numeric code documented by Haist and Rosenfeld (1988) which lists all British Columbia herring locations and their location codes. This code was used because it could be linked to an existing geo-referenced data file consisting of latitude and longitude co-ordinates, location names and codes, herring sections, statistical areas and regions. A location code was entered for each tag release and recovery location. A regional location code (31-39) was entered if a tag recovery was at a regional level of precision. A statistical area, location code (0-29) was entered if a tag recovery was at a statistical area level of precision and a section, location code (2001-2293) was entered if a tag recovery was at a section level of precision. Recoveries designated as "?" or "Unknown" were entered into the database using the missing value code (9999). The location code 9999 was also used to describe the position of a tag release or recovery that did not match location code and location name in Haist and Rosenfeld (1988). Field 11, 'AreaName', described or named the release or recovery location.

Fields 12-14 facilitated geographic partitioning of the data into 'Region', 'StatArea' and 'Section'. Numbers in these fields were obtained from a separate geo-referenced file with a location code linkage. Figures 1-6 show maps of the 6 regions, 30 statistical areas and 108 sections currently in use. Table 2 defines other regions used by the BC Department of Fisheries from 1937 to 1957 using a range of statistical areas. New region codes were assigned for Washington State (7), Alaska (8) and USA (9) tag recoveries. A new statistical area code and section area code were assigned for USA (30 and 300 respectively) tag recoveries. Missing value codes (99 and 999) were entered for statistical areas and herring sections respectively.

Fields 15-16 contained 'Latitude' and 'Longitude' co-ordinates which facilitated computerized mapping of all releases and recoveries and their linkages. Co-ordinates were entered manually for locations without location codes using the British Columbia Gazetteer (Canadian Permanent Committee on Geographical Names, 1985), Sailing Directions for the British Columbia Coast (Canada Dept. of Fisheries and Oceans and Canadian Hydrographic Service, 1990 and 1991), or from Canadian Hydrographic Service marine charts.

DATABASE SOURCE DISCREPANCIES

Appendix Table 4 documents source discrepancies and values chosen for the database. Several discrepancies were identified among 1937-1967 tag releases. In the 1943-1944 BC Department of Fisheries report (Tester, 1944), a correction for tag release 5L (TagGroup 4103) changed the number of tags released from 1697 tags to 1797 tags. This correction was not recorded in Hourston (1981), however, the change was entered into the database. There were similar discrepancies in the number of tags released for tag releases 16FF, 17TT and 18MM in Hourston (1952, 1954, 1956b and 1981) and Taylor and Hourston (1957). For these three cases, values in Hourston (1981) were entered into the database.

Several discrepancies were also discovered among 1937-1967 tag recoveries. Hourston (1981) listed some recovery areas as different statistical areas than those in the BC Department of Fisheries

reports. The middle to lower ECVI (statistical areas 13-19) in Stevenson *et al.*, (1952) was represented as statistical area 18 in Hourston (1981). Similarly, the upper to lower ECVI (statistical areas 11-19) in Stevenson *et al.*, (1952) was designated as statistical area 17 in Hourston (1981).

Both text and tables in Taylor *et al.* (1956) had to be considered in order to enter recoveries from herring tagged in Washington State. Taylor *et al.*, (1956) states that tags from Agate Pass, Holmes Harbour and Waldron Island, Washington, were recovered in the lower ECVI. Some American herring tag recoveries were not entered into the database because no tag release year was provided with the location name (no link with TagGroup or Season code). Table 3 lists all tag recoveries that could not be entered into the database because they could not be linked to a tag release group. In all other cases, tag recoveries from the BC Department of Fisheries reports, Taylor (1973a and 1973b), and Hourston (1952, 1954a, 1954b, 1955, 1956a, 1956b and 1957), were entered into the database, rather than those from Hourston (1981).

In Hourston (1981) there were two 20Y juvenile tag releases: Ruxton Passage near DeCourcy Island and Gambier Island in Howe Sound. Two different TagGroups (5521 and 5524 respectively) were assigned in the database to these two geographically separate, 20Y releases. Hourston (1981), also used different Season codes for several 1955 juvenile tag releases than those originally assigned in a BC Department of Fisheries report. Table 4 lists occurrences of inconsistent Season codes. Hourston (1981) Season codes were entered into the database rather than those from the BC Department of Fisheries reports.

Only a couple of tag recovery discrepancies were identified among juvenile tags. Firstly, in Taylor *et al.* (1957) a single juvenile recovery was listed from tag release 17YY in 1953. However, there was no 17YY tag release documented in 1953 so this recovery could not be entered into the database. Secondly, Taylor *et al.* (1957) lists a tag recovery for 19B as a juvenile release, but, it is recorded as an adult release. After referring to Taylor (1958) it was determined the recovery was from juvenile release 20S. Only one discrepancy was identified among anchor tag releases and recoveries. In Farlinger (1989) the tag release location, "Point Blackway", was actually Port Blackney.

A large number of people were involved in the collection and analyses of herring tagging data. Over a 60-year period, the herring fishery changed several times, the development and availability of tagging equipment changed and the formats of tagging publications changed. Any future analyses and interpretations of the tagging data should be cognisant of these changes. They should also expect that, given the duration and variation of these tagging programs, there will be some errors in the recovery information. We hope, however, that these are corrected, and where apparent errors or deficiencies still exist, in the tagging database we encourage readers to consult the original publications, as presented in the reference section of this report.

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Table 1. Juvenile herring TagGroup release codes used in the database and corresponding Season and Group Codes recorded in Hourston (1981).

Fishing Season	TagGroup (database)	Season & Group	Fishing Season	TagGroup (database)	Season & Group
1951-52	5128	16FF	1953-54	5351	18JJ
1951-52	5129	16GG	1953-54	5352	18KK
1951-52	5130	16EE	1953-54	5353	18LL
1951-52	5131	16HH	1955-56	5518	20R
1952-53	5228	17AAA	1955-56	5519	20S
1952-53	5229	17BBB	1955-56	5520	20T
1952-53	5230	17CCC	1955-56	5521	20Y
1952-53	5231	17DDD	1955-56	5522	20W
1952-53	5232	17EEE	1955-56	5523	20X
1952-53	5233	17FFF	1955-56	5524	20Y
1952-53	5234	17GGG	1955-56	5525	20Z
1952-53	5235	17HHH	1956-57	5616	21I
1952-53	5236	17III	1956-57	5617	21J
1952-53	5237	17JJJ	1956-57	5618	21K
1952-53	5238	17KKK	1956-57	5619	21L
1952-53	5239	17LLL	1956-57	5620	21M
1952-53	5240	17MMM	1956-57	5621	21N
1953-54	5343	18CC	1956-57	5622	21P

1953-54	5344	18DD	1956-57	5623	21Q
1953-54	5345	18EE	1956-57	5624	21R
1953-54	5346	18MM	1956-57	5625	21S
1953-54	5347	18FF	1956-57	5626	21T
1953-54	5348	18GG	1956-57	5627	21V
1953-54	5349	18HH	1956-57	5628	21W
1953-54	5350	18II			

Table 2. Region names from BC Department of Fisheries reports and respective statistical areas.

Region of Recovery	Statistical Area Within the Region
West QCI (2W)	0
East QCI (2E)	2
North	3, 4, 5
Central	6, 7, 8, 9, 10
Upper Central	6
Lower Central	7, 8, 9, 10
Upper East Coast of Vancouver Island*	11, 12
Middle-East Coast of Vancouver Island*	13, 14, 15, 16
Lower East Coast of Vancouver Island*	17, 18, 19
Lower West Coast of Vancouver Island	23, 24
Upper West Coast of Vancouver Island	25, 26, 27

* between 1938-1942 the East Coast of Vancouver Island was Statistical Areas 12-18

Recovery Date	Tagging Location/ Year Tagged	Detector Method	# Tags recovered	Location Recovered
Nov. 8, 1936	Unknown	Magnet	1	Trincomali Ch, off Porlier Pass
Nov. 11, 1936	Unknown	Magnet	1	Trincomali Ch, off Porlier Pass
Nov. 12, 1936	Unknown	Magnet	1	Pylades Ch
Nov. 13, 1936	Unknown	Magnet	1	Pylades Ch
Nov. 20, 1936	Unknown	Magnet	1	Swanson Ch
Nov. 23, 1936	Unknown	Magnet	1	Trincomali Ch, off Porlier Pass
Nov. 25, 1936	Unknown	Magnet	1	Trincomali Ch, off Porlier Pass
1938-1939	Unknown	Magnet	1	ECVI
1938-1939	Unknown	Magnet	3	Unknown
1939-1940	Unknown	Magnet	1	Unknown
1943-1944	Unknown	Magnet	5	Unknown
1945-1946	Unknown	Magnet	1	Queen Charlotte Strait
1953-1954	WA State, 1953	Magnet	1	Lower ECVI
1953-1954	WA State, 1953	Magnet	1	WCVI
1953-1954	Unknown	Inductor	3	Northern Stat Area 3-5
1953-1954	Unknown	Inductor	13	Central Stat Area 6-10
1953-1954	Unknown	Inductor	4	Upper ECVI Stat Area 11-12
1953-1954	Unknown	Inductor	8	Middle ECVI Stat Area 13-16
1953-1954	Unknown	Inductor	28	Lower ECVI Stat Area 17-19
1953-1954	Unknown	Inductor	11	WCVI Stat Area 23-17

1954-1955	Stat 4	Inductor	1	Stat Area 6
1954-1955	Stat 6	Inductor	1	Stat Area 6
1954-1955	Stat 7	Inductor	1	Stat Area 8
1954-1955	Stat 15	Inductor	1	Stat Area 13
1954-1955	Area 172	Inductor	1	Area 173
1954-1955	Area 172	Inductor	1	Stat Area 18
1954-1955	Area 173	Inductor	6	Stat Area 18
1954-1955	Stat 18	Inductor	11	Stat Area 18
1954-1955	Stat 23	Inductor	1	Stat Area 18
1954-1955	Stat 24	Inductor	1	Stat Area 18
1954-1955	Stat 25	Inductor	2	Stat Area 27
1954-1955	Stat 27	Inductor	2	Stat Area 27
1955-1956	WA State	Magnet	1	Lower Central Stat Area 7-10
1955-1956	WA State	Magnet	1	Lower WCVI Stat Area 23-24
1956-1957	17BB (1953) Juvenile (No such tag)	Magnet	1	Middle-Lower ECVI Stat Area 13-19
1956-1957	San Juan Is, WA State	Magnet	2	Middle-Lower ECVI Stat Area 13-19
1957	Area 150	Magnet	1	Stat Area 18
1957	WA State (6M6)	Magnet	1	Stat Area 18
1957-1958	WA State (5I5)	Magnet	1	Area 172
March 23, 1991	QCI West Tag Series # 551156 doesn't exist (1990)	Plant Crew	1	Spiller Channel
March 24, 1992	CTL Kwakshua Tag Series # 498306	Plant Crew	1	Central Stat Area 7

Table 3.
could not be
release groups
the herring
database).

	doesn't exist (1992)			
		TOTAL	127	

Herring tags that
linked to tag
(not entered into
tagging

Table 4.
TagGroup
used in the database and corresponding Season Codes from British Columbia Department of Fisheries reports (1937-1957), Taylor (1973a) and Hourston (1981) reports. Codes listed in this table are only those that use three different coding systems and require cross-referencing.

Year	TagGroup	BC reports & Taylor (1973) Season Code	Hourston (1981) Season Code
1955	5518	19N	20R
1955	5519	19O	20S
1955	5520	19P	20T
1955	5521	19Q	20Y
1955	5522,5523	19R	20W, 20X
1955	5524	19S	20Y
1955	5525	19T	20Z
1956	5623	20Q	21Q
1956	5622	20P	21P

Juvenile herring
release codes

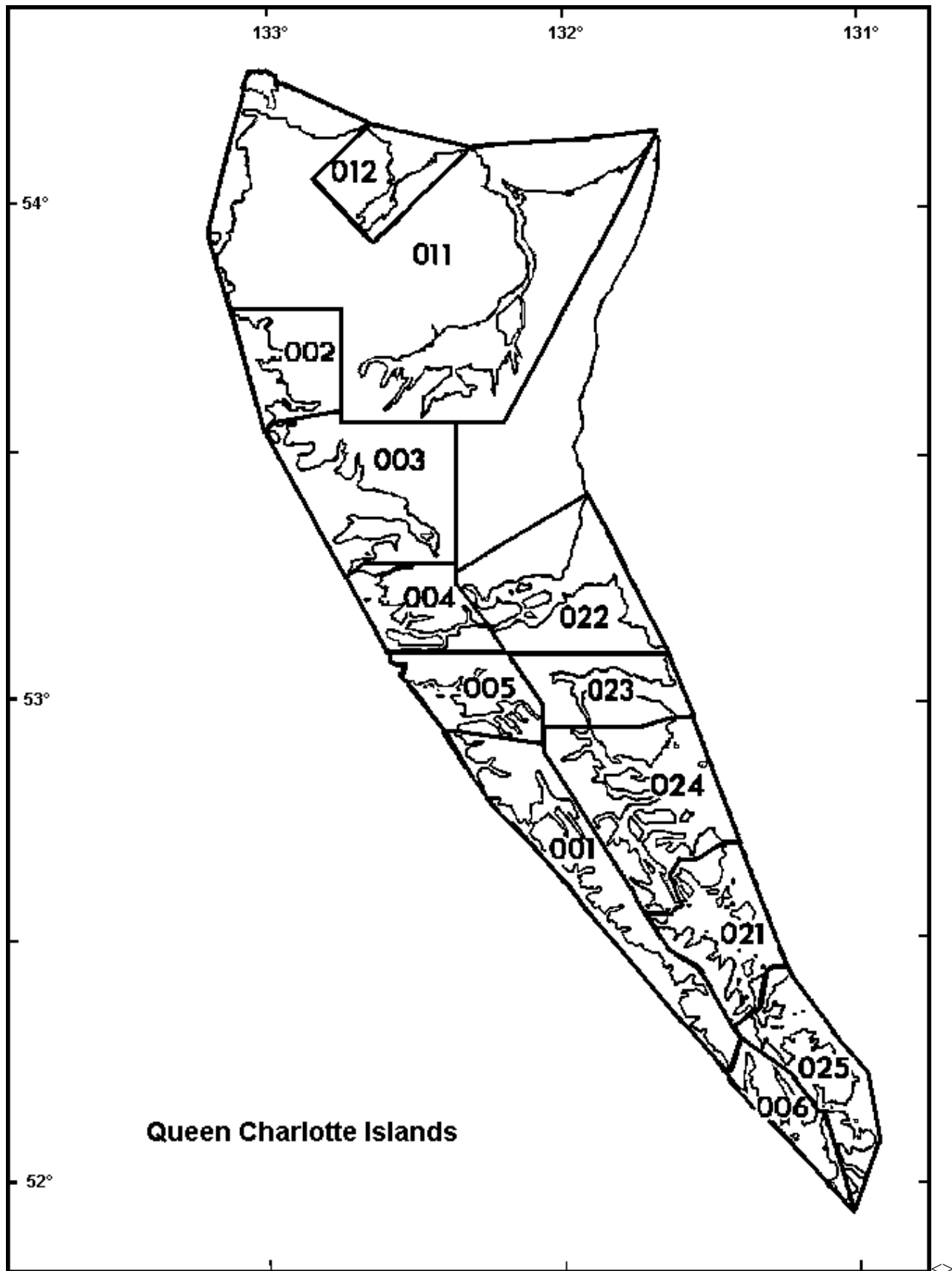


Figure 1. Herring sections in the Queen Charlotte Islands - Region 1 (Haist and Rosenfeld, 1988).

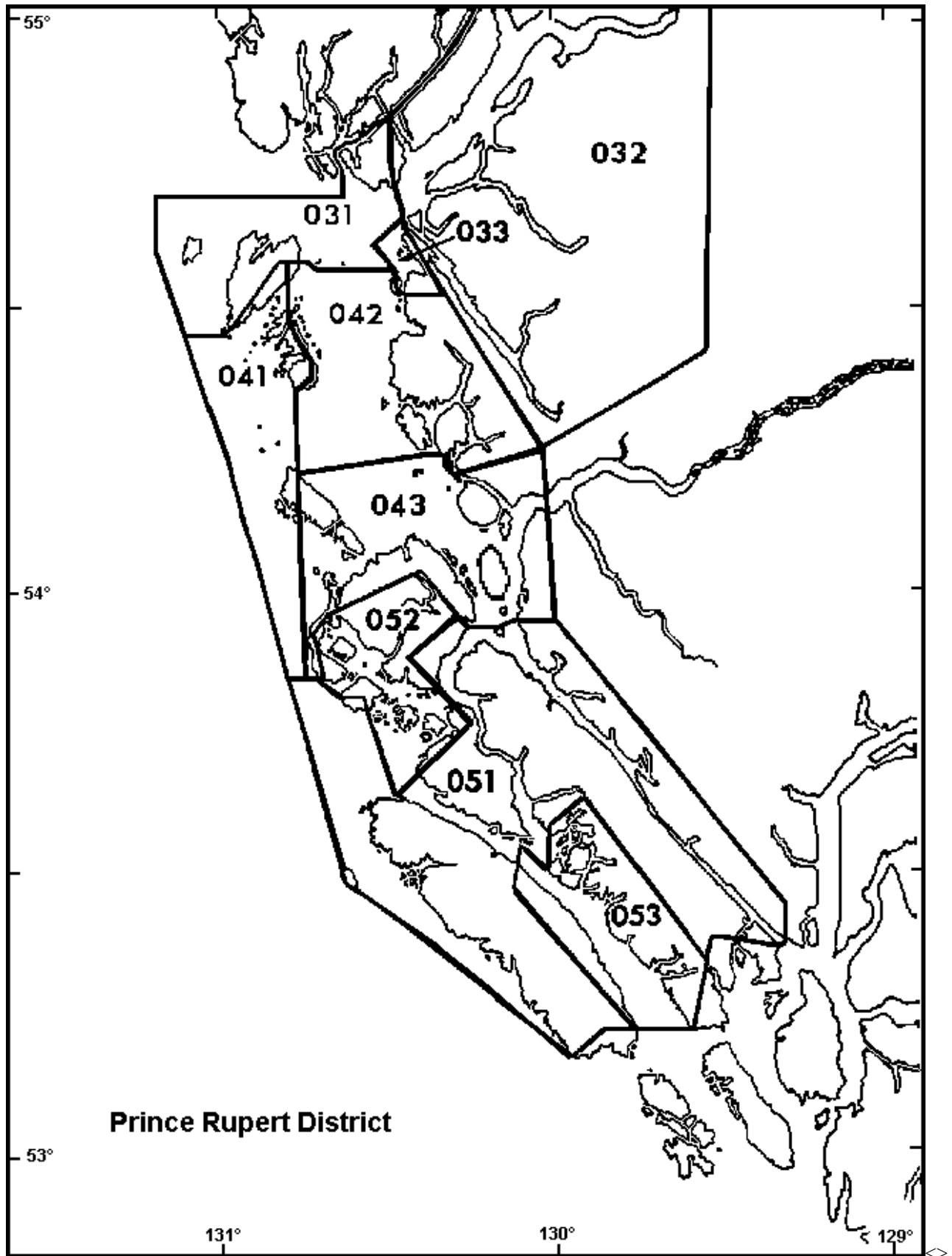


Figure 2. Herring sections in the Prince Rupert District - Region 2 (Haist and Rosenfeld, 1988).

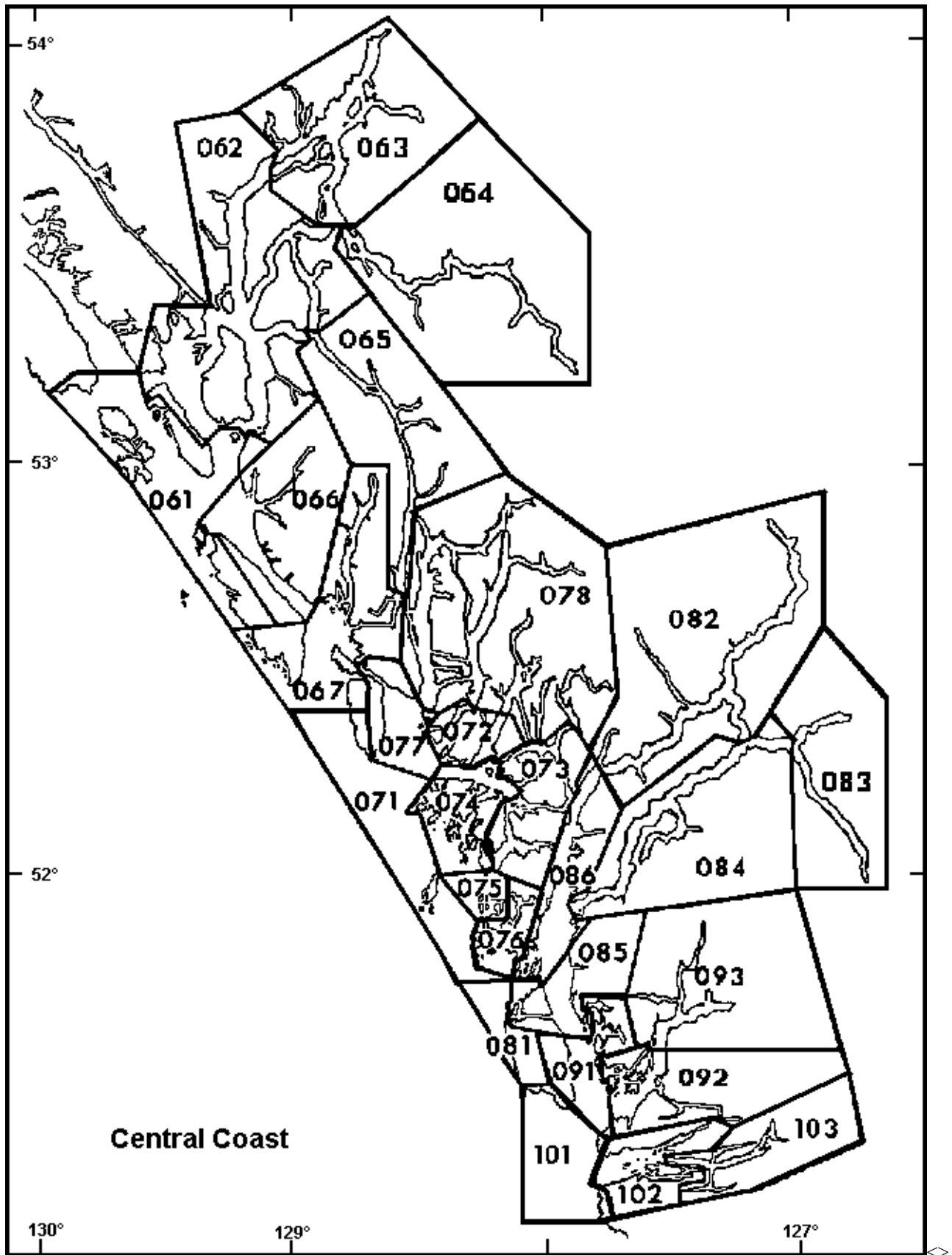


Figure 3. Herring sections in the Central Coast - Region 3 (Haist and Rosenfeld, 1988).

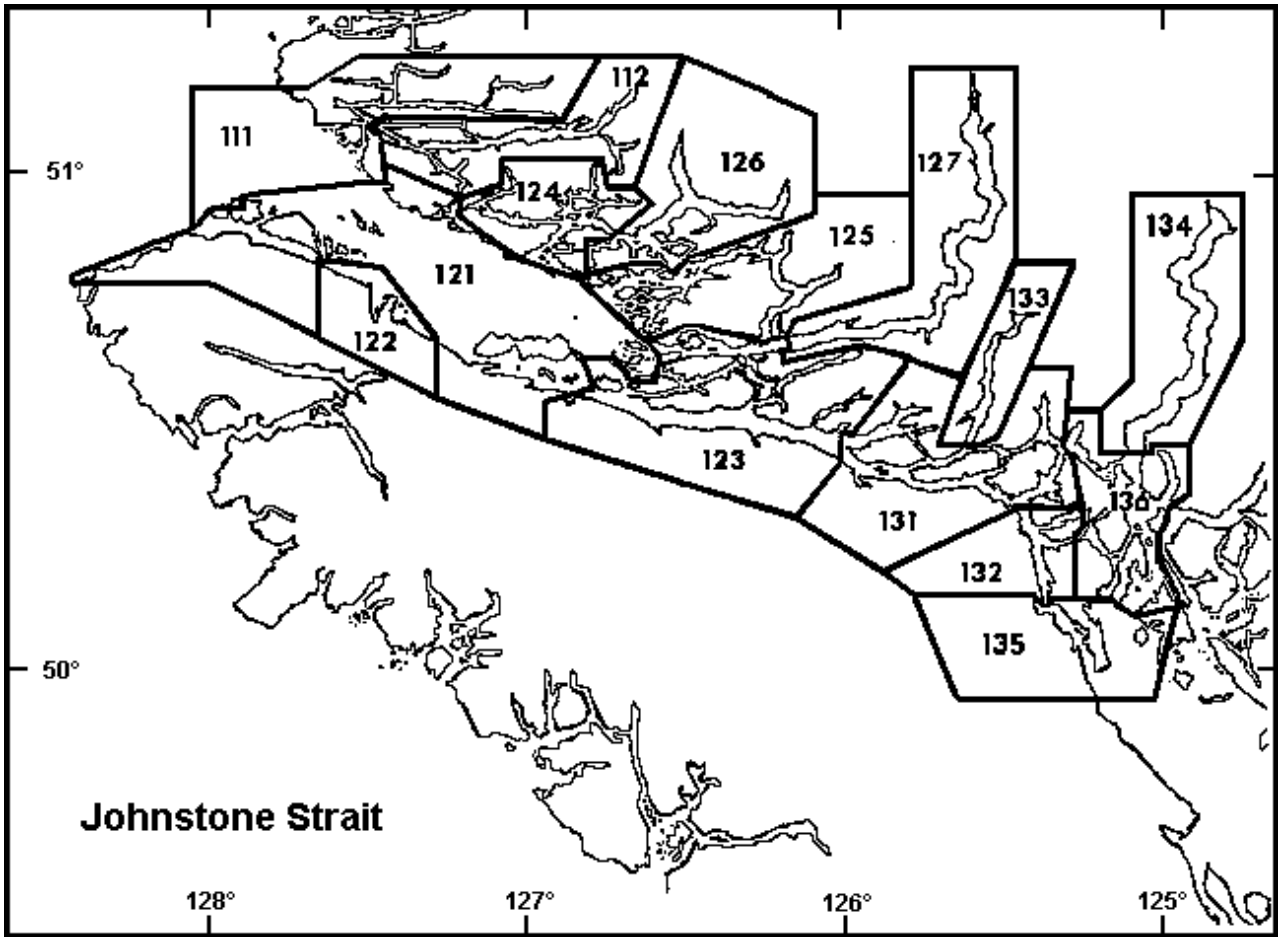


Figure 4. Herring sections in Johnstone Strait - Region 4 (Haist and Rosenfeld, 1988).

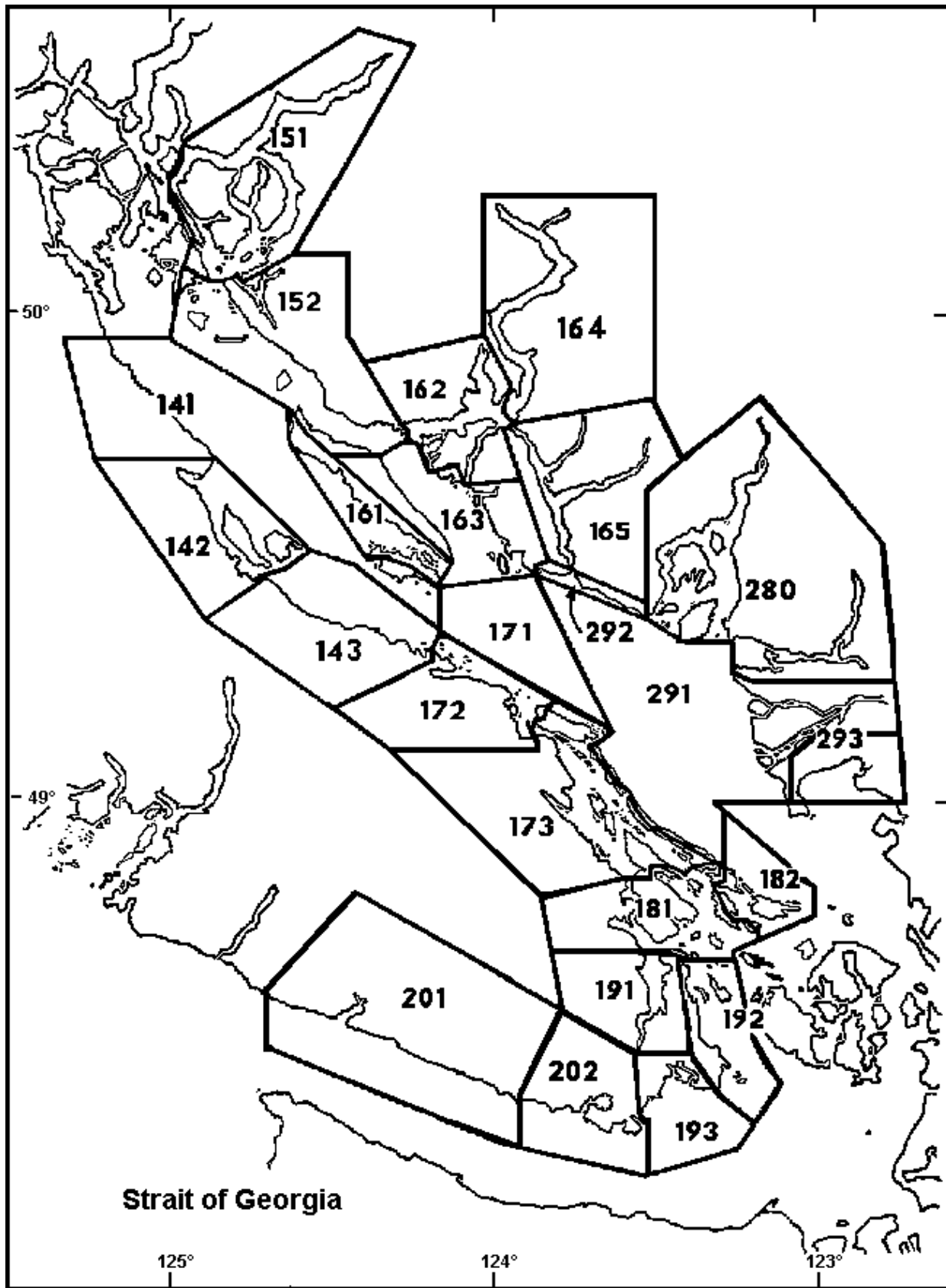


Figure 5. Herring sections in the Strait of Georgia - Region 5 (Haist and Rosenfeld, 1988).

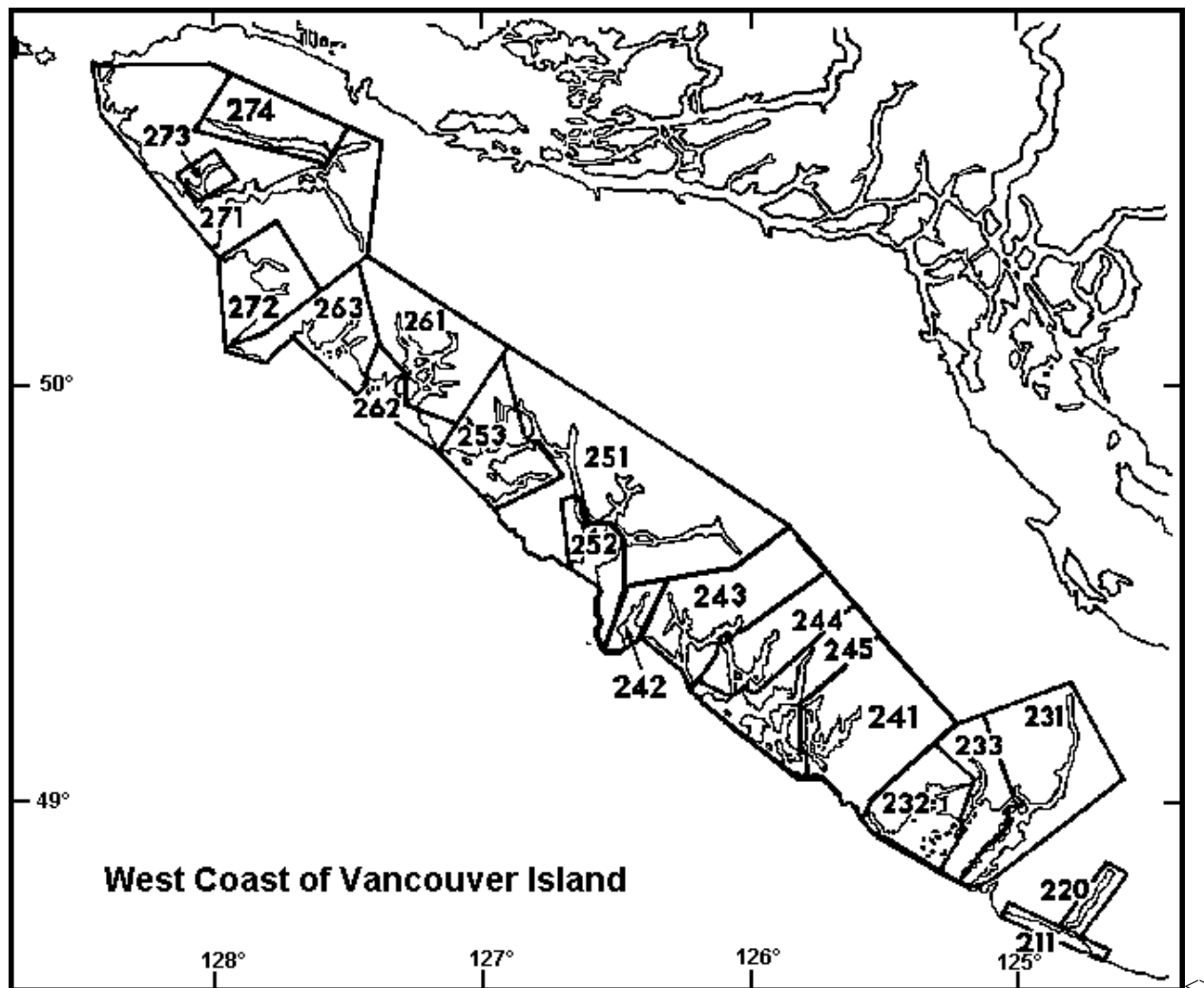


Figure 6. Herring sections on the west coast of Vancouver Island - Region 6 (Haist and Rosenfeld, 1988).

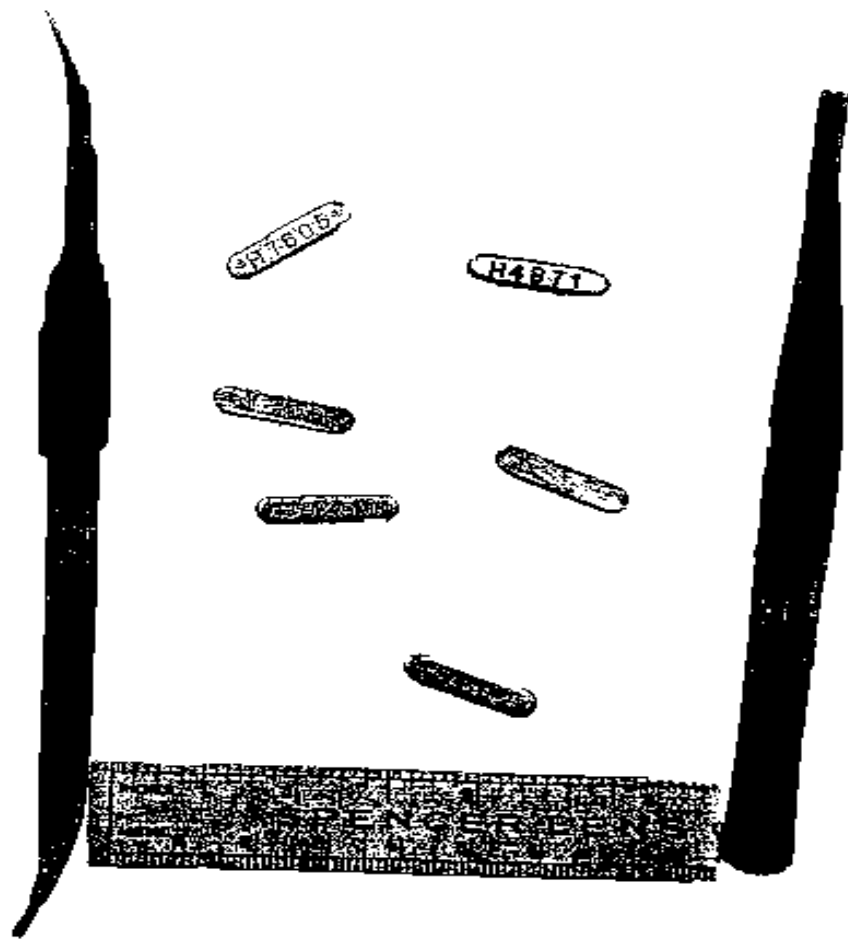
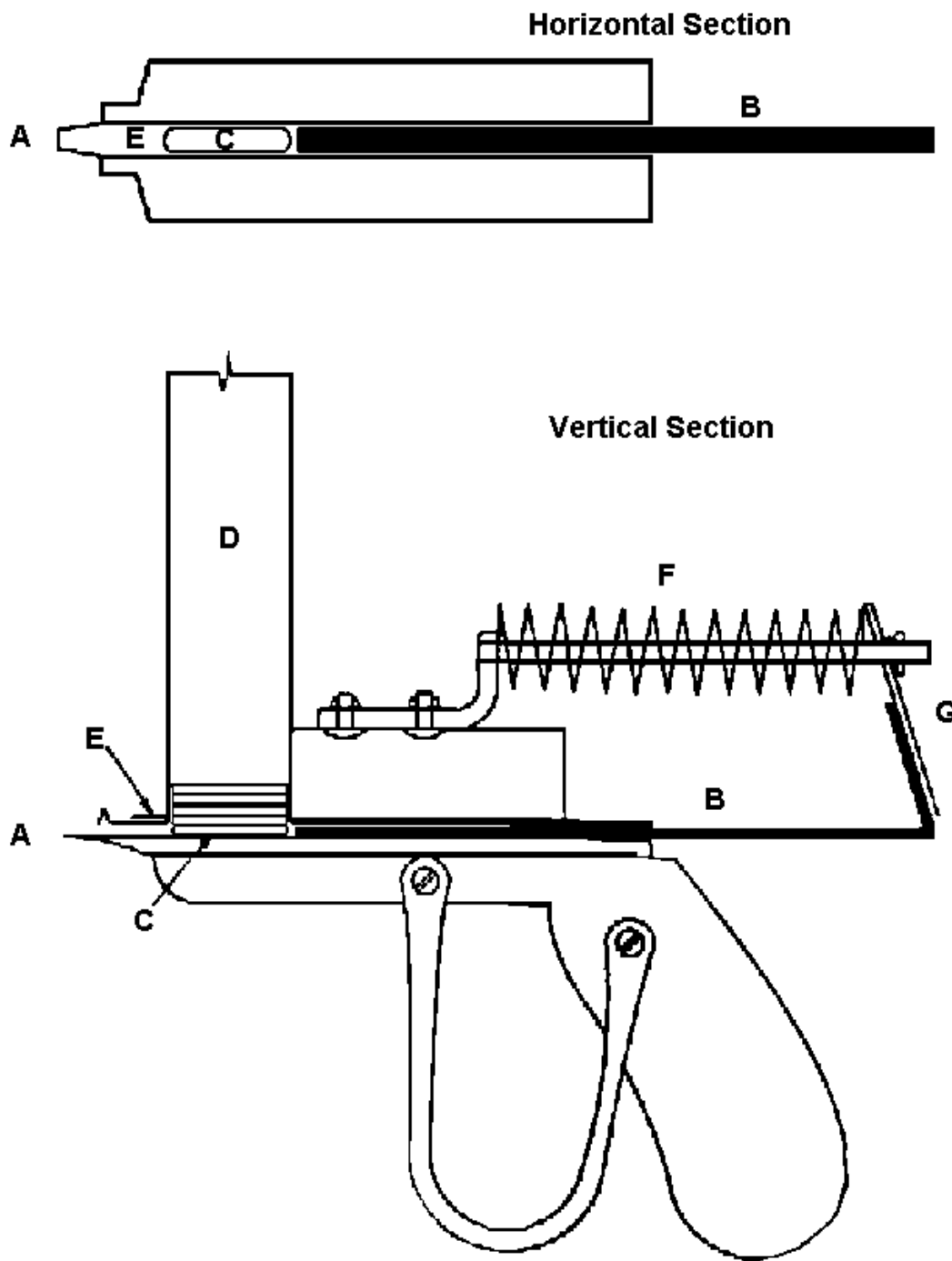


Figure 7. Herring belly tags and tagging "irons or knives" (Hart and Tester, 1937).



After an incision has been made in the side of the fish with the cutting-edge (A), the plunger (B) is depressed. This pushes the lower-most tag (C) from the stack of tags in the barrel (D) along a groove (E) and over the knife edge (A) into the incision in the fish. The plunger is forced back by the compression-spring (F) when the thumb is removed from the plate (G) and another tag drops into place.

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Figure 8. Tagging gun used to insert belly tags (Tester, 1938).

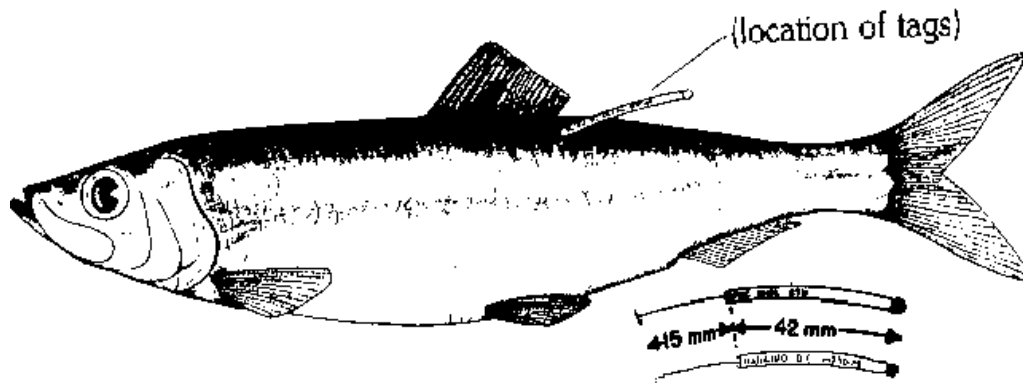


Figure 9. Location of anchor tag implantation on herring and dimensions of tag (Hay, 1981).

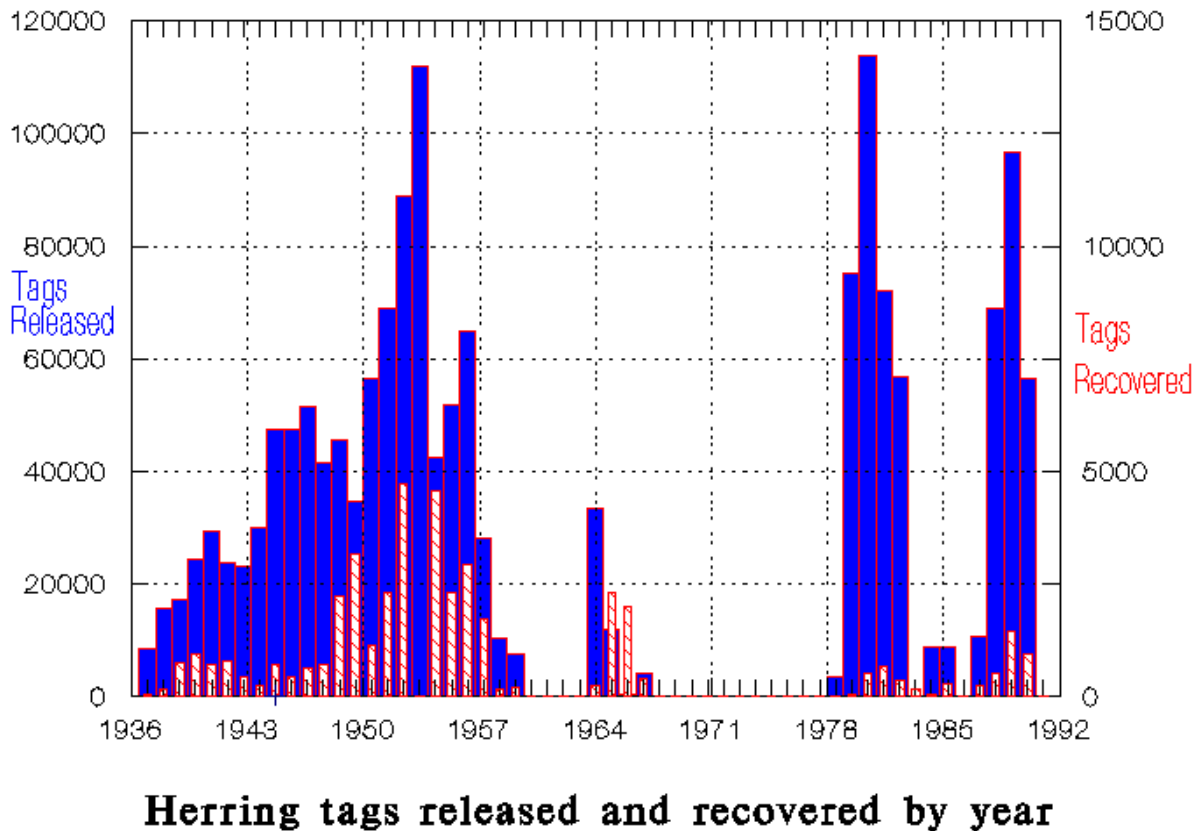


Figure 10. Total number of herring tags released and recovered each year (note different scales on y-axes).

Please refer to hard copy publication for Appendix Tables

Figure 6. Herring sections on the west coast of Vancouver Island - Region 6 (Haist and Rosenfeld, 1988).

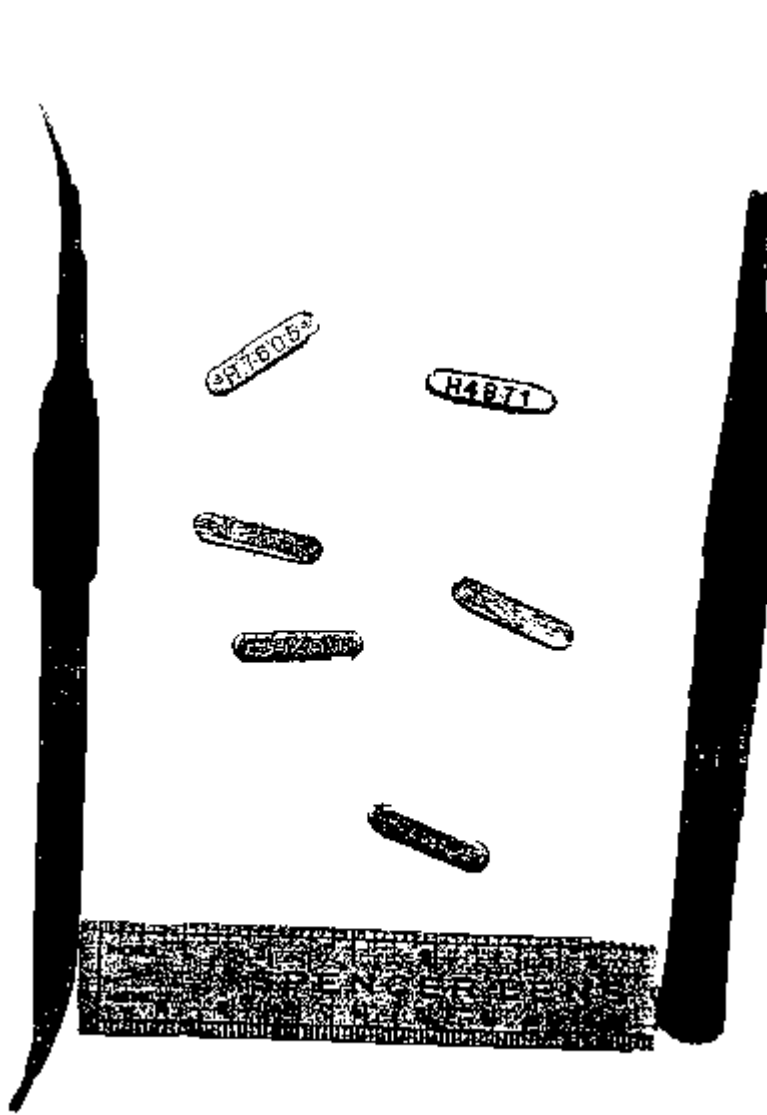
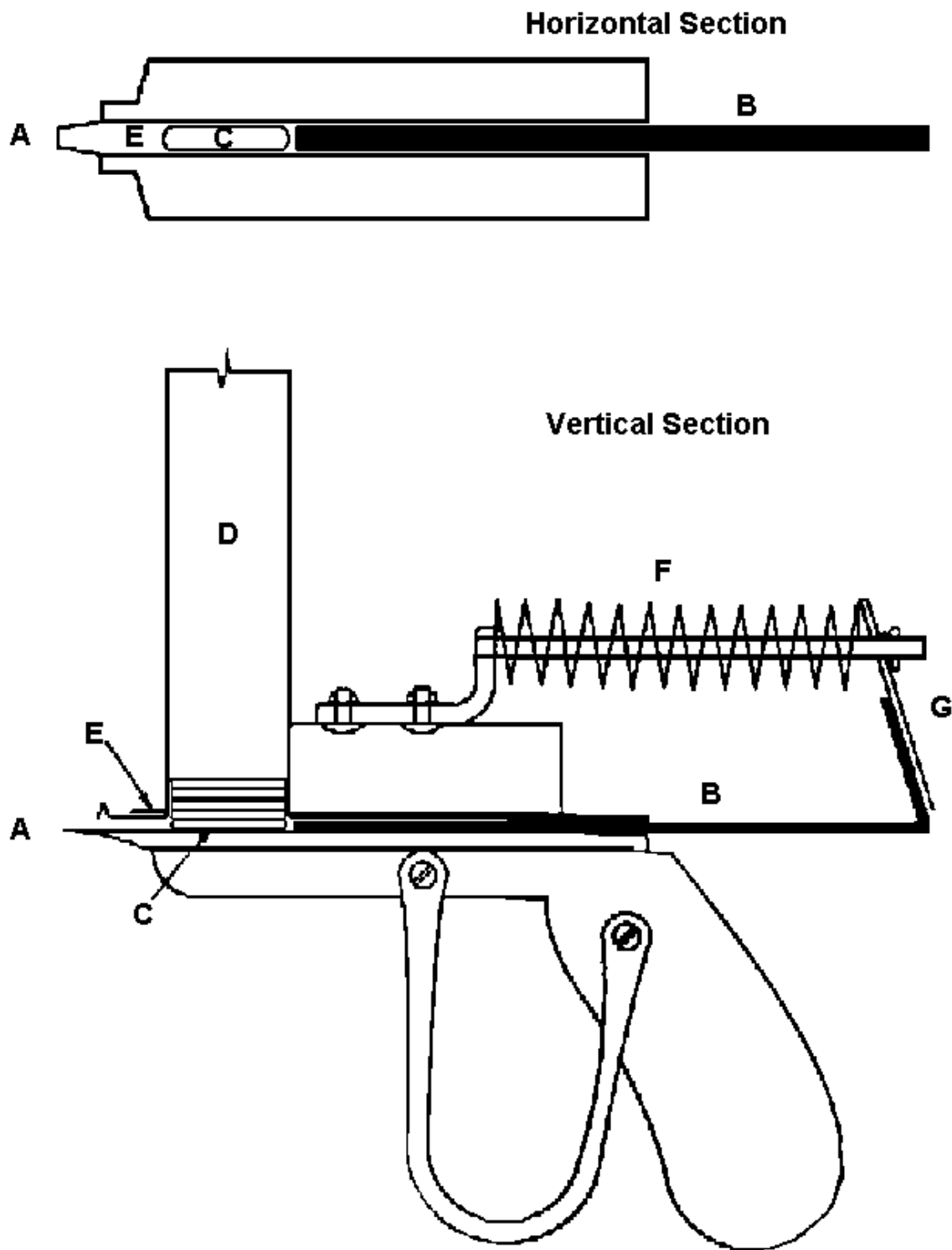


Figure 7. Herring belly tags and tagging "irons or knives" (Hart and Tester, 1937).



After an incision has been made in the side of the fish with the cutting-edge (A), the plunger (B) is depressed. This pushes the lower-most tag (C) from the stack of tags in the barrel (D) along a groove (E) and over the knife edge (A) into the incision in the fish. The plunger is forced back by the compression-spring (F) when the thumb is removed from the plate (G) and another tag drops into place.

< font>

Figure 8. Tagging gun used to insert belly tags (Tester, 1938).

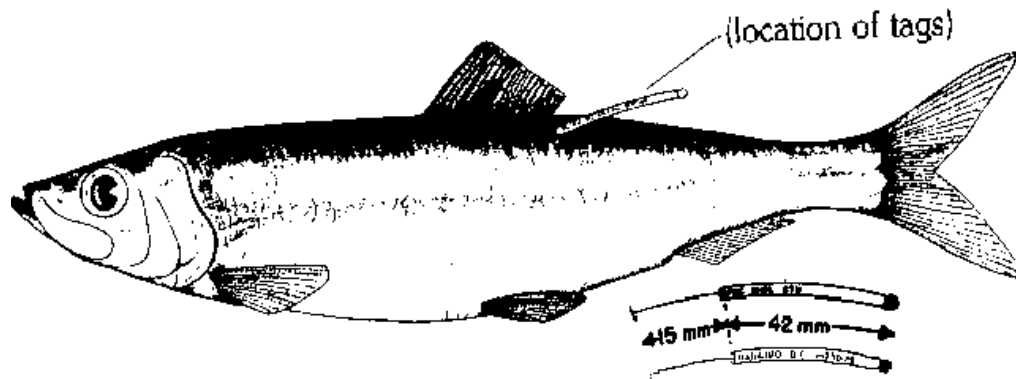


Figure 9. Location of anchor tag implantation on herring and dimensions of tag (Hay, 1981).

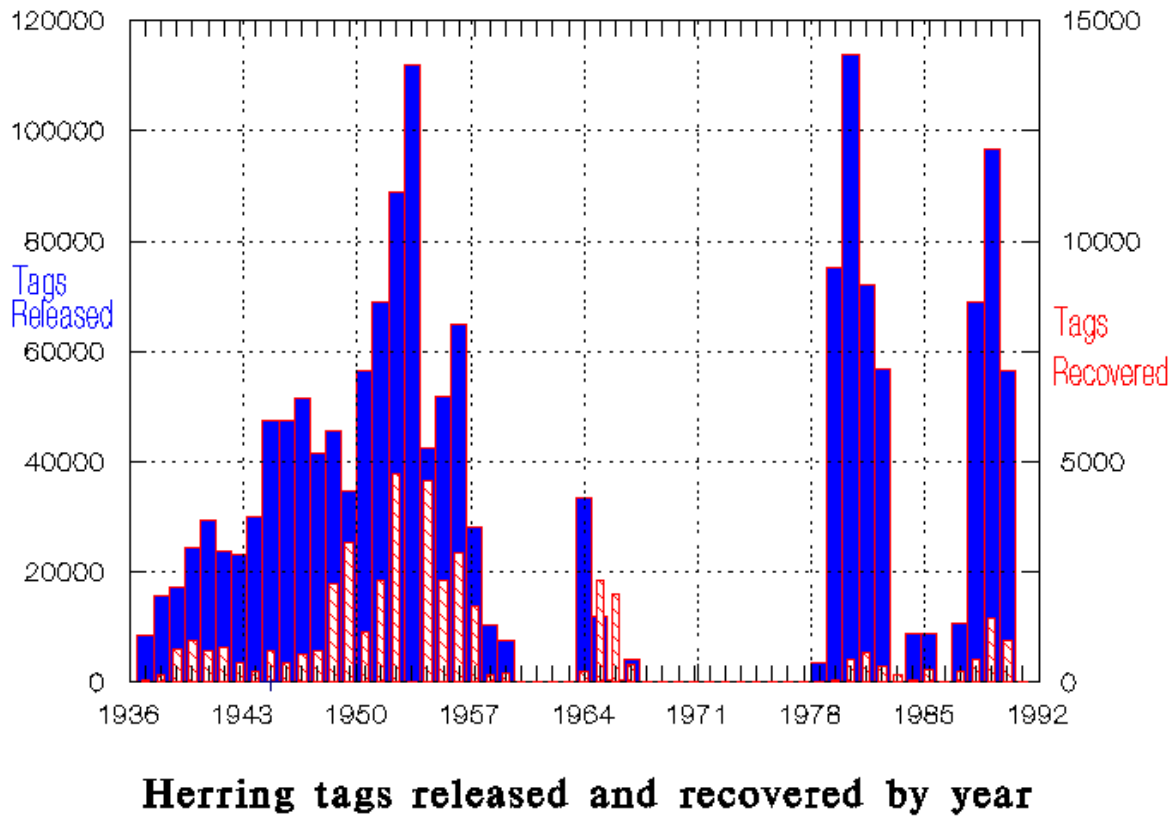


Figure 10. Total number of herring tags released and recovered each year (note different scales on y-axes).

Please refer to hard copy publication for Appendix Tables