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Description of the Historic US Atlantic Salmon (*Salmo salar* L.) Tagging Programs and Subsequent Databases

by Alicia S Miller, Timothy F Sheehan, Randall C. Spencer, Mark D Renkawitz, Kevin D Friedland, and Alfred L Meister

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Programs and Abstracts of the Maine Atlantic Salmon Forums 2002-2012

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ABSTRACT

Current knowledge of the Atlantic salmon (*Salmo salar* L.) marine distribution is based primarily on mark-recapture programs initiated in Europe and North America since the end of World War II. The discovery of non-native Atlantic salmon off Greenland prompted the initiation of a US Carlin tagging program in 1962, which revealed vast ocean transits to Canada and Greenland. Since its inception, over 1.5 million fish from New England rivers, primarily hatchery reared smolts, have been tagged and released. Carlin tag recoveries numbered 8,542 with a resulting recovery rate of 0.52%. Just over half (50.8%) of the recoveries have been in US waters (both freshwater and marine), primarily as pre-spawned adult river returns, while the remainder in distant waters off Atlantic Canada (23.2%) and Greenland (26.0%). A Coded Wire Tag (CWT) program was also initiated in the early 1980s to complement the Carlin tagging program. Since its inception, over 6 million tagged Atlantic salmon have been released. CWT recovery rate has been low compared to the Carlin tags given the requirement of trained operators and specialized detection equipment to identify tags. A total of 420 CWT tags were recovered in distant waters of Canada (22.9%) and Greenland (77.1%) through sampling efforts in fish processing plants. This report documents the US Atlantic salmon Carlin and CWT tagging programs, describes the current state of the two databases, and presents summary statistics of the resulting datasets.

INTRODUCTION

Atlantic salmon (*Salmo salar* L.) have greatly influenced American heritage through its use as a food source, significant recreational and commercial fisheries, and its importance to Native American culture in New England before and after colonization. While its cultural importance remains, documented declines in North American population abundance has prompted the listing of many populations are either under the US Endangered Species Act (74 Federal Register 29344, June 19, 2009) or Canadian Species at Risk Act (Species at Risk Act, SC 2002, c.29). These declines in abundance are primarily the result of habitat degradation, dam impoundments, overfishing, pollution, and climate shifts. More recent studies have identified mortality during the marine migration as the critical period leading to their reduced numbers of returns (Fay *et al.* 2006).

Anadromous Atlantic salmon are native to more than 2,600 watersheds worldwide (WWF 2001). The US range extends from Connecticut to Maine (Figure 1) and their marine residency occurs from coastal embayments to Greenland (Figure 2, Fay *et al.* 2006). The marine residence of US Atlantic salmon remained a mystery to scientists until studies of individual fish movements led to the creation of a large scale tagging program by the US. Tagging efforts were initiated in the early 1960s and continued through the mid 1990s. This Atlantic salmon tagging program became one of the longest and most comprehensive time series of tag-recovery data to date and helped document marine migrations during a historic time period of decline for the resource at home and abroad.

Programmatic changes have occurred over time to increase the program's scope. Tagging initially focused on returning adults and expanded to the smolt stage. Initially, Carlin tags were used but eventually coded wire tags (CWT) were introduced. Tagging efforts began with a focus on a few river systems, but eventually spread throughout New England. Information gained from these tagging efforts helped clarify the location of US Atlantic salmon at sea and the dynamics of the marine phase. These data justified US involvement in international salmon management and the eventual formation of the North Atlantic Salmon Conservation Organization (NASCO), an international treaty organization whose objective is to conserve, restore, enhance, and rationally manage Atlantic salmon using the best available science. These tagging data have been used in negotiating high seas fishery closures in Greenland and the Canadian Maritimes.

The US tagging effort required extensive resource allocation, interagency coordination, and international collaboration. The long time series of the tagging program spans international waters, remote fishing communities, management changes, and organizational shifts throughout the decades. The wealth of information obtained over four decades of research formed the basis of our understanding of salmon ecology in the marine phase and has irrevocably altered Northwest Atlantic salmon management at an international scale. Accordingly, the resultant database from the tagging effort may be considered a national treasure given the impact it has had on the resource. These data may be useful to future researchers, making it important for the data to be properly documented and archived.

History of the Marine Fisheries

Tag returns during the marine migration relied heavily on commercial fishery recaptures. Fisheries in Canada and Greenland accounted for the majority of at-sea tag recoveries, but tagged salmon were also intercepted in other fisheries not targeting salmon in the Gulf of Maine as well as in adult river traps in the US and Canadian rivers.

In Canada, commercial fishing efforts were reduced throughout the period of the tagging studies and a recreational approach became primary. Initially, commercial fisheries were dominated by fixed panel gill nets nearshore with the majority of the catch destined for export markets (Dunfield 1985; Taylor 1985). The fishing season varied by season and region, the highest yields coming from insular Newfoundland in the spring, coastal Labrador in the summer, and the north shore of Newfoundland in the fall. Gradual measures were taken including the closure of government run hatcheries and a major buyout of commercial salmon fishing licenses (Whoriskey and Glebe 2002). Closures began with Anticosti Island in 1960, shut down of the Maritimes in 1984, an inshore moratorium for Newfoundland in 1992, and a gradual closure of Quebec's Gulf of St. Lawrence fishery from 1991-2000 (Whoriskey 2009).

The first documentation of Atlantic salmon at Greenland occurred in 1780 when a small inshore gillnet fishery existed (Jensen 1990). Greenland's salmon fishery expanded rapidly with the addition of vessels from Denmark, Norway, Sweden, and the Faroe Islands during the 1960s and peaked in the early 1970s before a quota system was implemented in 1972 (Jensen 1990). Quotas remained rather steady and harvests were effectively reduced until the 1990s when harvest fell well below quota levels (Møller Jensen 1986). In 1993 and 1994, a private organization purchased the allotted quota for the Greenland export fishery, effectively suspending the fishery until an agreement was reached and a new quota was established in 1995 (Colligan et al. 2008). Previous studies have shown that nearly all Atlantic salmon catches off Greenland are of non-Greenland origin (Anon. 1980). Since then, many efforts have been made to identify country of origin of salmon captured off Greenland (Parrish and Horsted 1980), based on scale analysis (Lear and Sandeman 1980) and more recently genetic assignments (Reddin and Friedland 1999, ICES 2011).

Historic Documentation & Objective

Documentation of historic tagging programs in the US is diffuse with the majority of the background hidden in International Council for the Exploration of the Seas (ICES) Working Group on North Atlantic Salmon documents (http://www.ices.dk) and Annual Reports of the Council and Commissions of NASCO (http://www.nasco.int). The most detailed account of the core years of the Carlin tagging program was summarized by Meister (1984) and focused on recapture information.

This current document is an effort to compile, summarize, and synthesize all available sources of information related to the tagging program and subsequent database for future researchers to explore. The objective is to provide an overview and description of the databases, an outline of the auditing procedures undertaken to modernize them, and information related to the current state and location of the databases, supporting documentation, and available samples.

As recently as 1937 evidence of directed marine migration and homing capability in Atlantic salmon populations was equivocal (Huntsman, 1937). Huntsman (1938) looked at sea movements of kelts released in various rivers in Canada from 1913-1936 and was able to describe regional movements from different provinces within Canada. Belding (1939) was the first to note migration routes of Canadian Atlantic salmon within the Gulf of St. Lawrence. Menzies (1949) speculated that a common oceanic salmon feeding ground for European and North American salmon might exist in the waters somewhere near Iceland and Greenland. The first direct evidence for this feeding area was obtained in October 1956 when a tagged kelt released in the Blackwater River, Ross-shire, Scotland was recaptured 2,784 km away near Sukkertoppen (Maniitsoq), West Greenland (Menzies et al., 1957). Following World War II, more tagging studies on Atlantic salmon arose in Canada addressing marine migration and survival in the waters of the Gulf of St. Lawrence and coastal Newfoundland and Labrador (Lagueux 1953; Blair 1956, 1957a, 1957b; Murray 1968).

By 1960 tagging programs had expanded to several Canadian Rivers. In 1962, Carlin tags were applied to returning adult salmon in the Narraguagus River, Maine, US. The first reported recapture in Greenland of a Canadian tagged salmon occurred in October 1960 (Kerswill and Keenlyside, 1961) and the first US tagged salmon was recaptured in Greenland in 1963 (Cutting, 1964). A total of eighteen tagged salmon from Canada (Saunders et al. 1965) and two from the US were recaptured along the west coast of Greenland from 1961 through 1964. US tagged salmon had also been intercepted by Canadian fisheries, three in Nova Scotia and five in Newfoundland during 1963.

Early results of the Carlin tagging program after its commencement were reported by Meister and Cutting (1966). While Carlin tagging continued through 1996 (Table 1), CWT (Table 2) tagging also took place in various New England rivers from 1982-1994.

OVERVIEW OF ATLANTIC SALMON TAGGING IN THE NORTHWEST ATLANTIC

The earliest documented tagging study was conducted on kelts released in the Penobscot River, Maine, in 1873 (Atkins 1885). It focused mainly on evaluating various tag types and tagging methods. While it successfully documented a biennial spawning cycle for the Penobscot population, it provided minimal information on the extent of the marine migration. The following are descriptions of the US Carlin and CWT tagging programs and their subsequent databases.

US Carlin Program

Program Description

Carlin tagging of US Atlantic salmon commenced in the State of Maine in 1962 with initial efforts tagging only adult salmon upon their return to natal rivers. Subsequent high seas recoveries of these previous spawners became the first evidence of the vast marine migrations that Atlantic salmon undertake. Carlin tags suitable for smolts were developed and hatchery-reared smolts became the primary life stage tagged starting in 1966 (Table 1). Although tagging continued through 1996, recoveries declined after the late 1980s due to harvest restrictions and closures of distant water fisheries. No reported recoveries of tagged fish outside of US homewater river returns were seen from any batches released after 1991 as tagging efforts came to a close and closures occurred in the commercial fishery.

Atlantic salmon hatchery smolts stocked to augment wild populations were reared at the US Fish and Wildlife Services Craig Brook and Green Lake National Fish Hatcheries located in East Orland, ME, and Ellsworth Falls, ME, respectively (Figure 1). A state operation, Cobb State Hatchery, was located in Enfield, ME. Hatchery broodstock were primarily sea-run Atlantic salmon collected from wild salmon populations in Maine, including the Penobscot, Narraguagus, Machias, Union, and Orland Rivers. In 1967 and 1968, smolts for the tagging program in Maine were also produced from eggs from Miramichi River stocks in New Brunswick, Canada. In some cases, genetic strains from one river and cross hybrids from two rivers were stocked in nonsource rivers. When known, the origin of the broodstock for smolt releases was documented in the database.

Carlin tagging also existed sporadically on the Connecticut River from 1970-1978, but release and tag return data were poorly documented and no records exist in the database. A summary of Carlin tagging on the Connecticut River can be found in Rideout and McLaughlin (1985). Tagged hatchery smolt releases spanned the length of the Connecticut River including the states of Connecticut, Massachusetts, and Vermont. Most smolts originated from the Penobscot stock, but broodstock from other sources was also used including a variety of Canadian hatcheries, from Quebec and New Brunswick (Rideout 1981). With the formation of NASCO in 1984, the National Marine Fisheries Service (NMFS), in Woods Hole, MA, US assumed funding responsibility and oversight of the expanded Carlin tag program in the US.

Prior to the start of the tagging program, trials of various tag types (e.g. Peterson tags, bead-chain tags) were conducted (Alfred Meister, Maine Atlantic Sea-Run Salmon Commission (MASRSC), retired, personal communication). Starting in 1962 efforts focused on testing modifications to a tag type recently developed in Sweden and named for its creator, Börje Carlin (Carlin 1955). Carlin tags were a good choice for this study given that they were easy to use, relative low cost, and provided a unique identifier.

Several years of US trials with different tag attachment methods ensued (e.g. stainless steel wire, spaghetti tubing loped through the adipose fin) and eventually polypropylene carpet thread was proven superior in terms of cost, ease of application, tag retention, and reduced fouling of aquatic vegetation (Alfred Meister, MASRSC, retired, personal communication). Initially, tags applied to adults were attached to the base of the adipose fin plastic tubing. With the introduction of smolt tagging in 1966, tags were sewn to dorsal muscular tissue below the base of the dorsal fin using two needles inserted ~15mm apart. A different procedure, detailed in Saunders (1968), was adopted in 1972 and used a brass tagging tool, stainless steel tags, and stainless steel and/or polyethylene monofilament attachment. The standard for US Carlin tags applied after 1974 was a mass-produced polished plastic oval pendant (standard 4.8 x 14.3 mm, but larger 6.4 x 15.9 mm used for adults tagged in Maine) made of rigid VINYLITE with a 1.6 mm hole at one end for attachment (Figure 3b). Tags came in various colors but were typically green, stamped with a unique tag number (mass printed in consecutive order) on one side and a return address with instructions on the other. The tag was strung on an exposed 30 mm tether to permit fish growth. The entire tag was laminated for protection, measuring ~0.8mm thickness.

Occasionally, non-Carlin 'temporary' tags were applied to returning adults at fishway traps to accommodate radio telemetry studies and other home-river research. Though there were relatively few, these tag releases were included in the Carlin database in the event that any were reported from distant waters. A total of 1,304 Floy tags and 192 plastic streamer tags were applied to adult Atlantic salmon within the State of Maine between 1966 and 1994. Floy tag attachment methods are typically less persistent than Carlin tags and the only Floy-tagged fish recaptured (and identified) in distant waters was a single spent broodstock released into the Union River that was recaptured the following year off Newfoundland (NAFO area 3Ps).

Smolt tagging generally occurred from late March to early April although during some early years of the program smolts were also tagged from November through January. Variations in tagging procedures occurred during different periods of the program. For smolts, hatchery support personnel sorted fish for tagging by size (min 17 cm) and condition and then anesthetized them with tricaine methanesulfonate MS 222. A separate team of taggers (approximately 13 staff led by one supervisor) used foam lined clamps to stabilize fish as tags were applied. Experienced crews could tag over 10,000 smolts per day. Adult salmon were tagged at fishway traps and were not anesthetized, but rather held tightly in a burlap bag underwater to restrain the fish.

Tag Return Reporting

Tags from recovered Atlantic salmon were returned from offshore, inshore, and within rivers and fjords of US, Canadian, and Greenland waters. Tag loss prior to recapture has been estimated at a range of values. Gray (1973) reported tag loss rates of 0.35, 0.45, and 0.55 for 1-, 2-, and 3-sea-winter salmon, respectively. Pippy (1982) assumed a differential tag loss of 10% which was then modified by the ICES Working Group on North Atlantic salmon (WGNAS) to 9% for assessment purposes (Anon. 1987).

Tag reporting rate estimates have varied among years and countries. Pippy (1982) used a 70% reporting rate for tags returned from fishermen across all Atlantic salmon fisheries. Tag reporting rates in Canada were believed to vary from a value of 0.9 in the Labrador region to 0.7 for insular Newfoundland and Atlantic Canada. The tag reporting rate in Greenland was measured during the 1972 International Tagging Experiment and set at a level of 0.84 for vessels without observer coverage and assuming a 100% reporting rate when observers were on board (Møller Jensen 1980). After re-examining the reporting rate in Greenland, the ICES WGNAS concluded that reporting rate sagged during the period 1977 to 1983 (Anon. 1987). For assessment purposes, the reporting rate for Greenland was set at 0.8 for all years except 1977 to 1983 where it was 0.6, 0.5, 0.4, 0.5 and 0.6 for these years, respectively.

Tag returns were reported to the US by individuals and through government agencies. Canadian commercial fisherman normally mailed recovered tags (Figure 4) directly to the Maine Atlantic Sea-Run Salmon Commission (now Maine Department of Marine Resources (Maine DMR)), but some were forwarded through the Canadian federal government. Rewards (Figure 3a) for tag returns ranged over the years from 1-2 dollars initially to $8.00 in 1985 (Anon. 1985). Although not all reported tag recoveries included exact date of capture, fishing seasons were useful in approximating recapture to the month or seasonal level. During release years 1970-1982, an early (pre-September) and late (post-September) fishing season showed little or no difference in tag report timing and only about 4% could not be assigned a recovery date (Anon. 1985).

Tags returned to the US from Greenland waters were sent from government agencies in Greenland as well as Denmark and Norway, depending on where the fish were landed. Agencies made efforts to provide as much information as possible on the recovery location, method of fishing, and length and weight data for individual fish. Records of tag recoveries in US waters exist primarily from homewater returns and the occasional bycatch in other targeted fisheries.

US river returns were recorded as adult salmon passed through fishway traps placed at dams and weirs upon their spawning migration back to natal rivers. US recreational fisheries also provided homewater recapture data for tagged salmon through reward incentives and registration programs (initially voluntary, but eventually mandatory).

Fish length data including total length (TL) and fork length (FL) and weight data (to 0.1 kg precision) were recorded as available. In some locations, fish were beheaded and/or gutted prior to obtaining length and weight measurements so all records in the database are coded to identify the type of measurement taken. Scale samples were included with reported recoveries for nearly 25% of the Carlin tags returned and were used to confirm/identify sea age. Scale samples are currently archived at the NEFSC.

Auditing Process

Records of tag recoveries were kept on coded cards up until 1985 when they were compiled with release records and manually entered by the MASRSC into a relational database using RBase® software, to form what became known as the SALTAG database. Post entry, a line by line audit of database records was conducted to ensure data were accurately transferred into the electronic database.

Reporting rates are often problematic with respect to tagging studies, but additional difficulties exist in the accuracy of the associated information submitted with recovered tags. Reported recovery dates were carefully accessed. The recaptured year reported by the recoveree was occasionally inaccurate and was extrapolated as necessary to comply with contradictory physical evidence (scale-based age assignments, known year of release for tagged smolts, etc.). When scale samples were not submitted the calculated time-at-large and sea age at recovery were based on the reported recovery date if biologically plausible. Careful measures were taken in maintaining all original reported recovery dates while evaluating the accuracy of date with respect to elapsed time and fish age and size when available. Although missing months and days of recapture exist in the database, an examination of randomly selected years of data determined them to be minimal and not of major concern (Anon. 1985).

Questionable recovery dates preempted an additional column in the original database (RECYR) that provided a more accurate (albeit estimated) year of tag recovery when obvious reporting errors were discovered. Cases where day, month, and year were not reported and could not be estimated were given a “nine-fill” (e.g. 9999 for an unknown recovery year), in some cases both in the original reported recovery date as well as the RECYR. These were removed for the new database and replaced with blank cells when day, month, or year of recovery was unknown.

The majority of tag release and recovery locations were not documented in fine detail as precise latitude and longitude of distant water recaptures was typically lacking. To provide as much detail as possible, generalized recapture locations (e.g. Northwest Atlantic Fisheries Organization (NAFO) code, statistical area, state/province (Figures 2,5-7) were recorded using available recovery data including port of landing and knowledge of fishing grounds for local fisheries. Location data was much more reliable at the community and statistical area level and Community Codes were developed for fishing ports in Greenland (Figure 8) based on firsthand knowledge of where salmon boats were fishing (Alfred Meister, MASRSC, retired, personal communication). Community descriptions of fishing ports were less commonly reported in Canada and statistical areas (e.g. Fisheries Statistic District Boundaries) were much more heavily relied upon for recovery location.

In the early to mid 1990s, after RBase became outdated, the database was converted to Microsoft Access®. Once in Access, it went through additional auditing procedures in order to eradicate any importing errors that may have caused erroneous data. Records that contained obvious errors were altered when supplemental data was available and decisions were made utilizing current and historic knowledge.

The majority of changes made during the most recent auditing took place to address inconsistencies in the organization and assess and fix any spatial and temporal discrepancies. Most of the temporal problems were instances where a calculated time-at-large did not correspond to the listed sea age for both distant and homewater recoveries. New spatial errors were created when the database was transferred from RBase into Microsoft Access, resulting in one tag's reported position data to be copied into many other tags' location field where position data was never reported. With new technology through the use of GIS software, additional errors specific to reported position data were discovered (e.g., tag recoveries reported in areas where salmon and/or fishing would not occur or in locations of airports or post offices inland where the tags were mailed from).

Standard locations for distant waters were developed for the locations originally recorded in the original dataset (i.e. communities, statistical areas, NAFO zones, states/provinces, and countries) to provide additional geo-referencing capabilities for all tag recaptures. The majority of the standard locations developed for Canadian recoveries originated from Fisheries Statistic District Boundaries for all five of the reporting provinces and were chosen by selecting a centralized, nearshore position within each boundary. Community location was often included for Greenland tag recoveries, however problems arose when trying to determine exactly where some communities existed. This was particularly the case of communities in remote areas, where variations in spelling existed, and local Greenlanders were even unfamiliar with the community name reported.

Database Description

To prevent the loss of any historic documentation of the tagging data collected, the SALTAG database has been archived in its original, Microsoft Access format. Prior to the most recent audit and dataset organization, tagging records were kept in a number of tables. The main tables describing release and recapture information contained coded information to reduce space which could be decoded in smaller tables within the Access file. Column descriptions are included with each table to describe the various notation and coding. A lot of redundancy exists in the documentation. For this reason and in order to create a less complicated dataset, we have created an abbreviated format to be archived in the ORACLE database at the NEFSC. Differences between the two will be seemingly insignificant to the user, and the advantage of an abridged version is to prevent any misinterpretation of the original format and thus misuse of the data. The new ORACLE database has removed duplicated columns and replaced most coded data with textual descriptions. This created a more streamlined, all inclusive dataset that can be reduced to three tables. A log sheet documenting all changes made during the most recent audit from Access to Oracle will be archived at the NEFSC along with the Access database.

The three tables of the new version of the database consist of: (1) Releases (2) Distant Water Recoveries (3) Homewater River Returns. Column descriptions can be found in Tables 3-5 and will also be made available in the Data Dictionary, a web-based resource provided by the NEFSC to describe each of the available databases (http://nova.wh.whoi.edu/datadict/). Individual tag records are organized by unique tag number (TagNo) and a release batch number (BatchNo). Batch numbers were created for each grouping of Atlantic salmon released and use a four digit unique code with first two digits representing year released and the last two digits consecutively numbering the batch while describing lifestage (Table 3).

While great efforts went into finalizing this database, we recognize that new tags and records of tag recoveries continue to emerge. As new original documents surface and become archived, these tag recovery details will be added to the database. This may cause summary statistics discussed in this document to differ slightly from what exists in the database.

Summary Statistics

Throughout the duration of the Carlin tagging program in Maine (1962-1996), there were over 1.5 million tagged releases (Tables 1) with 8,542 total recoveries from distant water fisheries and homewater returns from adult and smolt releases combined (Tables 6-9). Although records include the last tags released in 1996, recoveries declined in the late 1980s as fishing efforts were reduced due to management restrictions and closures in distant waters. No reported recoveries of tagged fish outside of US homewater river returns were seen from any batches released after 1991 due to decreased harvest, commercial fishery closures, and a reduced number of fish released.

Distant water recoveries accounted for nearly half (4,231) of the total recoveries with the remaining recaptured as homewater river returns (4,311). Distant water recaptures resulted mainly from nearshore gillnet fisheries targeting salmon, with occasional recaptures as bycatch in other fisheries, recreational angling, fishway traps, and research surveys, although many records did not specify how fish were captured.

Of the distant water recaptures, 6.9% were post-smolts. Post-smolts were captured mainly in the Bay of Fundy in herring weirs and along the coast of Nova Scotia and Newfoundland, with a few recoveries as far as Labrador (Figures 9-13). One-sea-winter salmon made up the majority of all distant recaptures at 78.0%, with 2SW and 3SW salmon consisting of 5.1% and 0.4%, respectively. Previous spawners (post kelts) on their second marine migration made up 7.0% of all recaptures, including fish tagged as smolts that were not recovered until their second marine migration and a small number of fish recaptured twice. There were 113 tags (2.7%) returned without a discernible sea age. Sea ages by country and region generally reflected the timeline of their migration to and from foreign waters (Figures 14-15). Size at age marked growth as salmon progressed through the marine migration (Figure 16). The overwhelming majority of Carlin tagging occurred in the Penobscot River. Recoveries of tagged salmon in distant waters show that Penobscot fish were not only the majority of the tag recoveries overall, but their percentage of all recoveries increased with movement along the marine migration to Greenland (Figure 17).

Calculated days at large (when recapture date was reported) indicate that the earliest tagged smolt recoveries in Nova Scotia, Newfoundland, Labrador, and Greenland occurred at day 25, 47, 82, and 421. Days at large were longer for tagged adults except for one recaptured in Greenland 409 days after release. Aside from distinct patterns due to the timing of the fishery, time at large to did not appear to change over time.

Most homewater recaptures were recorded at fishway traps operated by government biologists, although recreational angling provided some recoveries. Of the 4,311 homewater returns, the majority (82.7%) were 2SW adult salmon. Grilse and 3SW returns made up an additional 10.7% and 1.1%, respectively. The remaining 5.4% of homewater returns were repeat spawners, the majority of which were adult releases.

Although historic reports include summaries of Connecticut River Carlin tag releases and recoveries, the SALTAG database does not include those records. Rideout and McLaughlin (1985) report summary tables on release year, hatchery strain, and the number of tagged salmon released and recaptured. In this report from 1970-1978, there was a total of 194,400 tagged salmon released in the Connecticut River and 113 total tag recoveries (10 homewater and 103 distant water). The number of tag returns varied among years with the lowest (4) occurring in 1970 and the greatest (58) in 1977. The majority (83) of tag recoveries occurred within the first nine months after release, the remaining 30 tags came from 1SW salmon.

Coded Wire Tag (CWT) Program

Program Description

Initially developed for Pacific salmon (Bergman et al. 1968), CWT tags are tiny magnetic, binary-coded, stainless steel wire tags typically injected into the snout of the fish. Beginning in 1974, Icelanders were the first to make use of CWT tags for large scale Atlantic salmon tagging studies that had previously been carried out with Carlin tags (Isaksson and Bergman 1978).

The primary function of the US CWT program was to identify the country of origin of salmon captured in commercial fisheries in Greenland and Atlantic Canada. The US CWT program began in 1982 using standard (1.1 x 0.25 mm) CWT tags with just over 208,000 releases in the Merrimack and Connecticut River combined (Table 2). Starting in 1986, CWT tagging expanded to Maine rivers, beginning with the Penobscot. The Aroostock River and the Narraguagus River followed in 1989 and 1992, respectively. The adipose fin clip was reserved in the US as a secondary mark to identify CWT tagged fish beginning in 1985. Tagged salmon released in larger batches were all hatchery smolts, but a limited number of 'wild' fish (parr/smolts) were tagged streamside on the Narraguagus using a portable CWT applicator.

Tag Return Reporting

Unlike Carlin tags that had a visible return address and required active reporting from fishermen, CWT tags could only be identified and recovered by scientific sampling efforts at fish processing centers, fishway traps, and recreational fisheries with the appropriate tag detection equipment. Scanning and biological sampling of commercial salmon catches began in 1985 at West Greenland by Canadian and Danish scientists (Potter et al. 1986). The US began providing scientific support for scanning in 1986 (Potter et al. 1987). Scanning locations at West Greenland initially took place in fish processing plants in three communities located in different NAFO areas Sisimiut (1B), Nuuk (1D), and Paamiut (1E) but was expanded to include Narssaq (1F) a year later in 1986. Other communities (Kangaamuit, (1C), Maniitsoq (1C), Qassimiut (1F), and Qeqertarssuarq (1A)) were also intermittently sampled.

The scanning program expanded over time to include greater number of fish sampled and more community locations along the coast of Canada and Greenland with variable methods for how the catch was identified to be scanned. Fish were typically scanned for CWT tags from June-September, the earlier months primarily in Canada and the latter in Greenland. In Newfoundland and Labrador, scanning dates were selected to target maximum catches or when US origin fish were expected to be encountered based on historical timing of returning salmon from the Carlin tagging study. For some scanning locations, the entire catch from one or combined fishing vessels was scanned while other locations maintained a goal of approximately 100 salmon per day. At Greenland, scanning at fish processing plants could occur on all or part of a vessel's catch, sometimes combining several boats' catches. Although detailed records are not consistently available, it was assumed that the proportion of the harvest which was sampled wasn't equal across all sampled communities. The proportion of the total number of fish with microtags that were sampled from each port varied. For example, in 1986, northern sampling locations, Sisimiut (0.34%) and Nuuk (0.32%), sampled three times as many as in the south at Paamiut (0.11%) and Narssaq (0.09%) (Potter et al.1987).

The catch was often sorted into one of three weight categories (<2.99 kg, 3.00-4.99 kg, and > 5.00 kg) by the plant staff before scanning and biological sampling. Any salmon with an adipose fin clip was scanned for a CWT tag. Scanning involved passing fish through a NMT

Field Sampling Detector. Although tag scanning removes some reporting problems associated with visible tags, scanning procedures of selected fish catches were not consistent among years and fish processing plants which may have caused a bias in sample collection.

Tags were removed from the nose with a coring device (2.5 cm diameter) and the sample stored in 95% alcohol. Records were kept on the location of the tag in the fish's head. Tags were dissected and decoded at Lowestoft Fisheries Laboratory in the UK. Tag readings were performed twice independently and the tag was returned to the country of origin for verification.

Auditing Process

The CWT database never existed as a comprehensive collection of all tag releases and recoveries from US rivers. Tag releases and recoveries were properly reported through ICES and documented at various levels of detail in annual NASWG reports. Therefore, the current auditing process consisted of organizing tagging records reported and validating them among various partially existing databases from various organizations; essentially creating a database of all US CWT tag releases and recoveries. The smaller scale effort of the CWT tagging program (compared to the Carlin tagging program) and inconsistent protocols may be cause for a lack of development to properly archive all the information.

Because CWT tags require being read at a fish processing plant, these sample locations act in a similar fashion to those standard locations described for the Carlin database. The benefit is that these recorded locations provide accurate information on where and when the fish was landed, but fishing locations and exact recovery locations are unknown. Scanned tag recovery locations only provide a generalized area of where fishing likely occurred.

Database Description

The final version of the CWT database will be kept separately from the Carlin database with two main tables of (1) Releases and (2) Recaptures. Column descriptions will also be made available in the Data Dictionary as well as in Tables 10-11. Similar to the Carlin database, release batches (BatchNo) were assigned to identify individual release groups. Fish did not receive an individual identifying tag number and groups of tags were coded with the same set of numbers. These group codes were often released from different rivers at different times making it difficult to identify exactly where and when a fish was released. All of these complex release aspects were captured within the created BatchNo. The majority of tag codes consist of three sets of numbers often leading with '07', a code that identified the tag as a US origin salmon. Created BatchNos begin with a single letter identifying release river (e.g. M for the Merrimack River) followed by a string of numbers of all tag numbers released in the batch (without the preceding '07'), and ending with a dash followed by the release year. This complexity was necessary because cases existed where tags with identical numbers were released in different locations and over several time periods.

Summary Statistics

The CWT tagging program released batches of tagged fish totaling over 6 million fish from 1982-1994. Scanned commercial catches resulted in 420 tag recoveries, 96 from Canada and 324 from West Greenland (Table 12). All recoveries were caught in commercial salmon gillnets. Canadian recoveries were exclusively from Newfoundland (77) and Labrador (19) and were recorded by statistical area (Table 12). West Greenland recoveries came from all NAFO zones (1, 87, 50, 131, 32, and 23 from NAFO zones 1A – 1F, respectively) and were also recorded by community location in the database (Figure 8).

All recovered tagged fish of known age were 1SW salmon. Scanning of tags coincided with the fishing seasons in Canada and Greenland. Similar to the Carlin tag recoveries, the majority of tags recoveries occurred in July for Newfoundland and parts of Labrador, with more northerly recoveries of Labrador occurring in August (Figure 18). The majority of Greenland recoveries occurred in August and September. Additional growth in the 1-2 months between salmon recovered in Canada and those in Greenland was seen (Figure 19), though on average, salmon caught in Greenland (63.5 cm) were only slightly larger than those caught in Canada (61.8 cm). The largest number of tagged fish releases came from the Connecticut River, however, distant water recoveries were dominated by fish originating from the Penobscot River (Figure 20). Similar to the Carlin recoveries by river origin, the percentage of Penobscot River recoveries increased as fish moved through the migratory path toward Greenland.

CONCLUSIONS

Historic tagging data for US Atlantic salmon has become increasingly valuable to salmon research and conservation. These data represent the most comprehensive documentation of Atlantic salmon during their marine migration. They also provide individual records of spatial, temporal, and biological characteristics during the marine residence phase, a critical period in their life history linked to their decline in the US. Compiling and archiving all available knowledge, records, and resources in an accurate format for future reference is a vital exercise to preserving what is known about US Atlantic salmon from a historical perspective. As native US populations struggle to rebound and oceans continue to change, these data may be the last remaining information available about a more vigorous era of Atlantic salmon.

The Carlin and CWT tagging studies have already provided an impetus for more in depth studies of the marine migration of Atlantic salmon in the US. The documentation of tag recoveries in distant waters has helped spatially and temporally guide current research efforts in Canada, the US, and Greenland. Prior to the tagging efforts, little was known about where North American Atlantic salmon migrated in the marine environment. Knowledge gained from these data has been used to guide our research efforts and build more concrete and sophisticated research plans to further investigate salmon in the marine phase.

The collaborative sampling of Atlantic salmon at Greenland is one example of how research has evolved as a result of the tagging studies and continued to expand marine research efforts. Greenland sampling began in 1969, originally based on research vessels, moving to commercial catch sampling in 1982, and continued as sampling of local consumption catch since 1998 (with the exception of 2001 which was commercial catch based). Jensen (1990) used tag recapture data to estimate the contribution of US stocks to the Greenland fishery. Scales collected during these sampling efforts have been used to determine continent of origin of migrating Atlantic salmon, noting any spatial patterns along West Greenland and an increase in North American populations at Greenland (Reddin and Friedland 1999). In an attempt to answer the bigger questions regarding marine survival, studies have addressed growth and energetics, diet composition, predator interactions, oceanographic effects, and climate change (Hogan and Friedland 2010; Renkawitz and Sheehan 2011; Friedland et al. 2012). Advances in tagging methods through the development of data storage tags (Reddin et al. 2004, 2006) and telemetry technology in both the US (Kocik et al. 2009; Holbrook et al. 2011) and Canada (Cooke et al. 2011) have provided information on migrating salmon. Additionally, ocean trawl surveys

(Sheehan et al. 2011; Sheehan et al. 2012) have added to the understanding of small scale observations of salmon leaving rivers and during initial entry to the ocean.

While the Carlin and CWT tagging programs have answered some questions of where US Atlantic salmon are migrating to and when, the completed database may provide new information for researchers to analyze. Recent studies have used the tagging dataset to access trends in current and past populations of Atlantic salmon in North America. Friedland et al. 2012 used the historic Carlin tag recoveries to describe migratory pathways based on time elapsed and ocean currents with respect to various predator fields salmon encounter during the marine migration. Miller et al. 2012 investigated the role of environmental variables and release aspects on river return rates of US Carlin tagged smolts. Reddin et al. 2012 also described spatial and biological patterns of historic Carlin tags recovered at Greenland. Much of the biological data collected during the tagging studies such as scale samples and length/weight measurements may help improve our knowledge of marine growth and condition factor in response to changing ocean environments. Detailed river-specific analyses of these data may allow for better estimates of survival, performance, and straying rates for some systems. By combining recent advances in Atlantic salmon research, these historical data will provide a more complete understanding of the causal mechanisms behind their decline in abundance and may help promote new ideas for future research.

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Table 1. Carlin tag releases by year, river, and release age/life stage. Numeric values indicate smolt age, A indicates adult (kelt) releases, and B indicates adult (brood stock) releases.

	Machias			Narraguagus			Orland		Penobscot					Saco	St. Croix	Union		
	1	2	A	1	2	A	1	A	1	2	3	A	B	A	A	2	A	B
1962						212												
1963						325												
1964						232												
1965						164												
1966	13692	19305	514	24460	24794	256		14										
1967	14701	11186	219	15830	19112	282	19888											
1968	22782	8905	147	11760	11802	193	18523											
1969	4999	19768	167	9877	15926	91			898	25147		64						
1970		9800	184		9893	73				27439	1080	133						
1971			117			51			29828			72						
1972		4369	164			160				48153		129						
1973						152				38030		83						
1974						86			11150	30600		333					16	
1975										28960		530					62	
1976									9980	15000		461					211	
1977										48575	324	288					184	
1978												1166					106	
1979										29829		550				29914	9	
1980									49759			1527					42	
1981										49950		328					106	276
1982										49360		261						484
1983									49615									447
1984									99342			892						
1985									99400									
1986									100000									
1987									100000									
1988									99896			52		32	28			
1989									52000	115		396		18				
1990									49754	116		247	368	23				
1991						62			49754				371					
1992						54			50000			68						
1993									186			82						
1994									192			5						
1995																		
1996									49316									
Totals	56174	73333	1512	61927	81527	2393	38411	14	901070	391274	1404	7667	739	73	28	29914	736	1207

Table 2. CWT tag releases by year, river, and life stage.

	Aroostook	Connecticut				Conneticut/Narragansett Bay	Merrimack			Narragansett Bay		Narraguagus	Penobscot
	smolt	smolt	parr	unknown	smolt/parr	smolt/parr	smolt	parr	smolt/parr	smolt	smolt/parr	parr	smolt
1982							46935						
1983		93815					42977		19900				
1984		121185					43800	9800					
1985		24954	25618	25124			125300						
1986		219186					64100		71422				101179
1987					352210			40100	137300				100784
1988		5970	25300		378299		159841		60500				101141
1989	20266				240400	52135		66800	68530		28150		252984
1990	17204	117500			381700		70250	91700		3000			202906
1991	19764	7000			135000		120076			3100			200230
1992		231600			93200		80156		16345			1193	201128
1993		259100			101400		58986						199844
1994		343545			27800		85002						199544
Totals	57234	1423855	50918	25124	1710009	52135	897423	208400	373997	6100	28150	1193	1559740

Table 3. Column names and descriptions from the Carlin database's Releases table.

Column Name	Description
BatchNo	4 digit unique code for all release groups (first two digits represent year released and the last two digits consecutively numbering the batch while describing lifestage (0-20 indicates smolt releases, 21 and greater indicates adult releases, and 30 indicates the rerelease of a fish previously caught – see comments for details on first recapture)
BatchType	Life stage category of fish at release (i.e. Adult, Hatchery Smolt, Broodstock)
TagType	Type of tag used in release batch (i.e. Carlin, Floy, etc.)
TagColor	Color of tag applied (i.e. Yellow, Blue, etc.)
UpPrefix	Text or character printed immediately above the tag numbers on the face of the tag in this batch. Originally used to identify batches with same numbers (i.e. USA, etc.), but kept in database because it indicates which batches had REWARD tags. If no Upper Prefix = None
MinTagNum	Minimum tag number used in release batch
MaxTagNum	Maximum tag number used in release batch
TotalNumTags	Total tags applied in release batch at the hatchery
TotalTagsReleased	Total tags released to river (TotalNumTags minus hatchery mortalities, shed tags, etc.)
ReleaseYear	Release year of fish in this batch
ReleaseMonth1	Month of earliest release of fish in this batch
ReleaseDay1	Day of earliest release of fish in this batch
ReleaseMonth2	Month of last release of fish in this batch
ReleaseDay2	Day of last release of fish in this batch
State	State where batch was released
River	River where batch was released
SiteName	Name/description of the release site
Hatchery	Hatchery of origin of batch (if known)
Strain	Strain of origin of batch (i.e. Penobscot, Machias x Narraguagus cross, etc.)
LifeStage	Name of lifestage of batch (i.e. smolt, adult)
AgeClass	Age of fish at release (river age for smolts, typically unknown for adults)
AvgWeight_gm	Average weight of individuals (in grams) in batch
HatcheryTempC	Hatchery water temperature at time of tagging (Degree Celsius)

Table 4. Column names and descriptions from the Carlin database's Distant Water Recoveries table.

Column Name	Description
BatchNo	4 digit unique code for all release groups (first two digits represent year released and the last two digits consecutively numbering the batch while describing lifestage (0-20 indicates smolt releases, 21 and greater indicates adult releases, and 30 indicates the rerelease of a fish previously caught – see comments for details on first recapture)
TagNo	Tag number recovered/recaptured
BatchType	Life stage category of fish at release (i.e. Adult, Hatchery Smolt, Broodstock)
State	State, province, or oceanic region where tag was recaptured
River	River where tag was recaptured
CountryReporting	Name of country reporting tag information
CountryLocation	Name of country where tag was recovered
StatArea/CommunityCode	Statistical area (e.g., NAFO Division, Canadian Statistical Divisions) or CommunityCode (Greenland only) where tag was recaptured
StatArea/CommunityCodeDesc	Description of StatArea and CommunityCode location
NAFOCode	NAFO Code of area that the tag was recaptured in
Lat	Latitude where tag was reportedly recaptured or of standard location indicated in LocationUsed
Long	Longitude where tag was reportedly recaptured or of standard location indicated in LocationUsed
LocationUsed	Recapture location used in reference to latitude and longitude listed (i.e. reported location or standard location - StatArea, CommunityCode, NAFOCode, State, Country, etc.)
CapWater	Descriptor of physical environment of tag recovery (e.g., river, offshore, etc.)
SeaAge	Marine age of this fish at the time of recapture
RecaptureMonth	Month of tag recapture
RecaptureDay	Day of tag recapture
RecaptureYear	Year of tag recapture
DateEstimated	Was the RecaptureMonth, RecaptureDay, or RecaptureYear estimated (Y/N)?
RecDateType	Indicates where recapture date came from
Gear	Type of gear used to capture tagged salmon
LengthType	Type of length measurement taken (Total length,Fork length,Pectoral (headed),Total (1) & Fork (2),Total or Fork (unknown), Length unknown)
Length1_cm	Measured length (in cm) based on LengthType
Length2_cm	Fork Length (in cm) when LengthType = Total (1) & Fork (2)
WeightType	Type of weight measurement taken (Total weight, Gutted, Dressed (headed & gutted), Weight type unknown)
Weight_kg	Weight of fish in kilograms based on condition identified in WeightType
Sex	Sex assigned at recapture based on external mophological characteristics (if available)
ScaleSamp	Identifies if a scale sample from the time of recapture is available
ReturnSource	Category for source of tag return data (i.e. fisherman, government, etc.)
Comments	Comments of data or tag

Table 5. Column names and descriptions from the Carlin database's Homewater River Returns table.

Column Name	Description
TagNo	Tag number recovered/recaptured
BatchNo	4 digit unique code for all release groups (first two digits represent year released and the last two digits consecutively numbering the batch while describing lifestage (0-20 indicates smolt releases, 21 and greater indicates adult releases, and 30 indicates the rerelease of a fish previously caught – see comments for details on first recapture)
BatchType	Life stage category of fish at release (i.e. Adult, Hatchery Smolt, Broodstock)
State	State or provence where tag was recaptured
River	River where tag was recaptured
GearType	Type of gear used to recover the tagged salmon
LengthType	Type of length measurement taken (Total length,Fork length,Pectoral (headed),Total (1) & Fork (2),Total or Fork (unknown), Length unknown)
TotalLen_cm	Measured length (in cm) based on LengthType
ForkLen_cm	Fork Length (in cm) when LengthType = Total (1) & Fork (2)
Weight_kg	Total weight of fish in kilograms
SeaAge	Marine age of this fish at the time of recapture
Sex	Sex assigned at recapture based on external mophological characteristics (if available)
Fate	Disposition of the tagged salmon following capture (i.e. released, killed)
Comments	Comments of data or tag
ReleaseYear	Year of tag release
RecaptureYear	Year only of tag recapture
RecaptureMonth	Month only of tag recapture
RecaptureDay	Day only of tag recapture
RecaptureJDay	Julian Day (day-of-the-year) of tag recapture
RecaptureStWeek	Standard Week of tag recapture
DataEntryDate	Date of data entry into database

Table 6. Distant water Carlin tag recoveries by statistical area and life stage.

	Post-smolt	1SW	MSW	Kelts	Unknown	Totals
US OFFSHORE						
Georges Bank	1	-	1	-	1	3
Gulf of Maine	9	1	16	1	-	27
Other	-	-	1	-	-	1
NEW BRUNSWICK						
North Shore	-	-	1	-	-	1
Bay of Fundy	12	14	13	9	-	48
NOVA SCOTIA						
East Coast	24	4	1	5	-	34
South Coast	97	15	8	14	-	134
Bay of Fundy	112	20	27	4	-	163
Unknown	1	-	-	-	-	1
QUEBEC	1	4	1	1	-	7
NEWFOUNDLAND						
North Coast (A-B)	6	628	26	43	7	710
East Coast (C-F)	1	207	24	29	1	262
South Coast (G-J)	19	57	5	140	1	222
Insular (K-N)	1	5	2	2	1	11
Unknown	-	2	-	-	-	2
LABRADOR						
Stat. Area 50	1	13	2	2	1	19
Stat. Area 51	1	61	5	3	-	70
Stat. Area 52	1	22	5	-	-	28
Stat. Area 53	1	232	14	5	4	256
Unknown	-	4	2	1	-	7
NFLD/LAB Unknown	3	4	-	2	1	10
GREENLAND						
East Greenland (XIV)	-	29	1	-	-	30
West Greenland						
NAFO Area 1A	-	98	6	2	2	108
NAFO Area 1B	-	423	27	16	16	482
NAFO Area 1C	-	456	15	5	45	521
NAFO Area 1D	-	318	5	4	8	335
NAFO Area 1E	-	217	5	2	17	241
NAFO Area 1F	-	158	3	4	3	168
Unknown	-	307	15	1	3	326
LOCATION UNKNOWN	-	2	-	-	2	4
Totals	291	3301	231	295	113	4231

Table 7. Distant water Carlin tag recoveries by year and life stage.

	Post-smolt	1SW	MSW	Kelts	Totals
1963	0	0	0	9	9
1964	0	0	0	4	4
1965	0	0	0	7	7
1966	23	0	0	10	33
1967	22	83	0	31	136
1968	48	7	37	38	130
1969	10	11	5	9	35
1970	8	89	2	7	106
1971	4	440	19	9	472
1972	126	94	25	8	253
1973	3	157	27	25	211
1974	13	468	17	14	512
1975	1	231	24	13	269
1976	0	132	2	14	148
1977	2	28	7	4	41
1978	0	15	3	7	25
1979	7	0	1	25	33
1980	4	398	1	10	413
1981	5	82	12	19	118
1982	2	138	14	14	168
1983	1	34	7	8	50
1984	4	64	1	1	70
1985	2	157	3	1	163
1986	0	95	6	1	102
1987	5	213	0	3	221
1988	0	137	8	1	146
1989	1	160	6	3	170
1990	0	23	2	0	25
1991	0	35	2	0	37
1992	0	10	0	0	10
Totals	291	3301	231	295	*4117

*Total number does not include 113 recoveries of Unknown sea age.

Table 8. Homewater river Carlin tag recoveries by river and life stage.

	1SW	2SW	3SW	Repeat Spawner	Totals
Androscoggin	1	10	0	0	11
Kennebec	0	23	0	0	23
Machias	10	98	4	60	172
Narraguagus	26	164	10	62	262
Penobscot	393	3115	34	108	3650
Saco	0	2	0	0	2
St. Croix	2	1	0	0	3
Union	28	154	1	5	188
Totals	460	3567	49	235	4311

Table 9. Homewater river Carlin tag recoveries by recovery year and life stage.

	1SW	2SW	3SW	Repeat Spawner	Totals
1964	0	0	0	7	7
1965	0	0	0	2	2
1966	0	0	0	6	6
1967	25	0	0	13	38
1968	2	140	0	45	187
1969	7	6	6	25	44
1970	1	11	0	4	16
1971	5	58	1	7	71
1972	0	269	9	7	285
1973	3	172	2	5	182
1974	8	181	14	11	214
1975	10	379	3	20	412
1976	12	156	1	1	170
1977	2	81	0	8	91
1978	3	82	2	11	98
1979	0	30	0	3	33
1980	85	0	0	22	107
1981	24	392	0	11	427
1982	50	237	1	14	302
1983	7	113	1	4	125
1984	8	53	0	1	62
1985	23	159	0	0	182
1986	28	263	1	0	292
1987	47	101	5	1	154
1988	41	271	0	0	312
1989	33	161	1	4	199
1990	2	145	2	2	151
1991	3	24	0	0	27
1992	25	24	0	0	49
1993	2	31	0	0	33
1994	0	7	0	0	7
1995	0	0	0	1	1
1997	4	0	0	0	4
1998	0	21	0	0	21
Totals	460	3567	49	235	4311

Table 10. Column names and descriptions from the CWT database's Releases table.

Column	Description
BatchNo	Batch number of the release batch (1st letter indicates release river, followed by all DetailedTagCodes released in the batch, then a dash followed by release year)
ReleaseYear	Release year of fish in this batch
Origin	Identifies release batches where fish were of hatchery origin
TagType	Type of tag used in release batch (e.g. flat, round)
DetailedTagCodes	Tag codes released within the release batch (tags beginning with '07' indicate US origin)
River	River where batch was released
TotalNumberReleased	Total number of tags released
Stock	Strain of origin of batch
Clip	Identifies any type of fin clip marking that was placed on fish in this batch
ReleaseMonth1	Month of earliest release of fish in this batch
ReleaseDay1	Day of earliest release of fish in this batch
ReleaseMonth2	Month of last release of fish in this batch
ReleaseDay2	Day of last release of fish in this batch
State	State where batch was released
ReleaseLocation	Name/description of the release site (e.g. town, river branch, etc.)
LifeStage	Name of lifestage of batch (i.e. smolt, parr)
RiverAge	Age of fish at release
Comments	Comments of data or tag

Table 11. Column names and descriptions from the CWT database's Recaptures table.

Column	Description
BatchNo	Batch number of the release batch (1st letter indicates release river, followed by all DetailedTagCodes released in the batch, then a dash followed by release year)
ReleaseYear	Release year of fish in this batch
TotalNumberReleased	Total number of tags released
River	River where batch was released
RecaptureYear	Year of tag recapture
RecaptureMonth	Month of tag recapture
RecaptureDay	Day of tag recapture
TagCode	Tag code from recovered/recaptured salmon
Gear	Type of gear used to capture tagged salmon
Country	Name of country where tag was recovered
NAFOCode	NAFO Code of area that the tag was recaptured in
StatArea	Statistical area where tag was recaptured
Community	Community where tag was recaptured
Latitude	Latitute position of a standard location for the Community or StatArea where tag was recaptured
Longitude	Longitude position of a standard location for the Community or StatArea where tag was recaptured
ForkLength_cm	Fork length (in cm) of recovered salmon
GuttedWeight_kg	Weight (in kg) of gutted, recovered salmon
SeaAge	Marine age of this fish at the time of recapture
Comments	Comments of data or tag

Table 12. Distant water CWT tag recoveries by statistical area (Newfoundland and Labrador) and NAFO Division (Greenland) and recovery year.

	1986	1987	1988	1989	1990	1991	1992	Totals
NEWFOUNDLAND								
North Coast (A-B)	0	5	14	19	24	0	0	62
East Coast (C-F)	0	0	0	0	15	0	0	15
LABRADOR								
Stat. Area 51	0	1	1	6	0	0	0	8
Stat. Area 53	0	4	6	0	0	0	0	10
Unknown	1	0	0	0	0	0	0	1
GREENLAND								
NAFO Area 1A	0	0	1	0	0	0	0	1
NAFO Area 1B	6	27	21	33	0	0	0	87
NAFO Area 1C	0	0	0	0	12	14	24	50
NAFO Area 1D	1	35	30	33	24	8	0	131
NAFO Area 1E	0	7	8	7	1	4	5	32
NAFO Area 1F	0	15	1	0	0	0	7	23
Totals	8	94	82	98	76	26	36	420

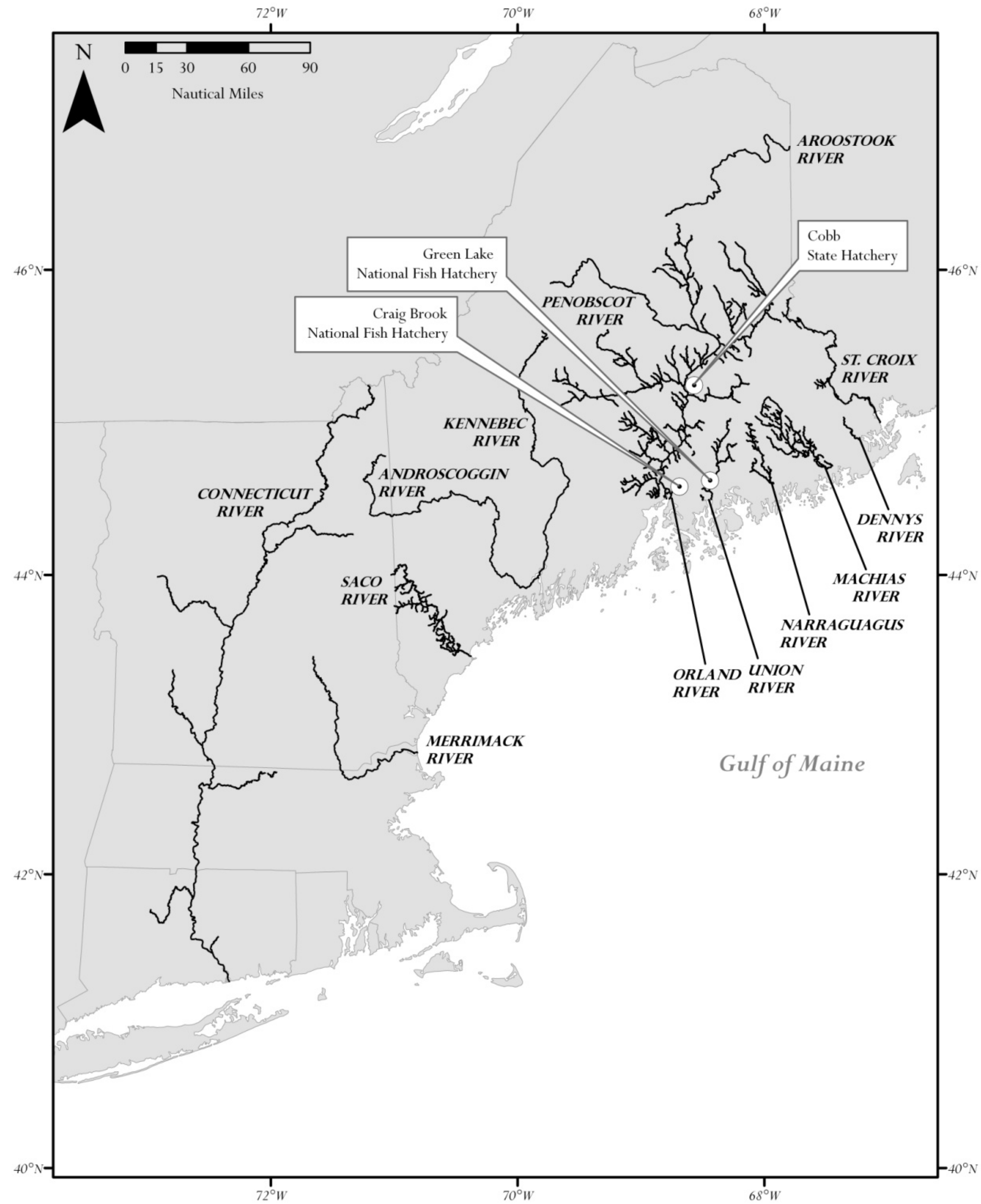

Figure 1. River systems where US Atlantic salmon were tagged and released including state and federal hatchery locations.

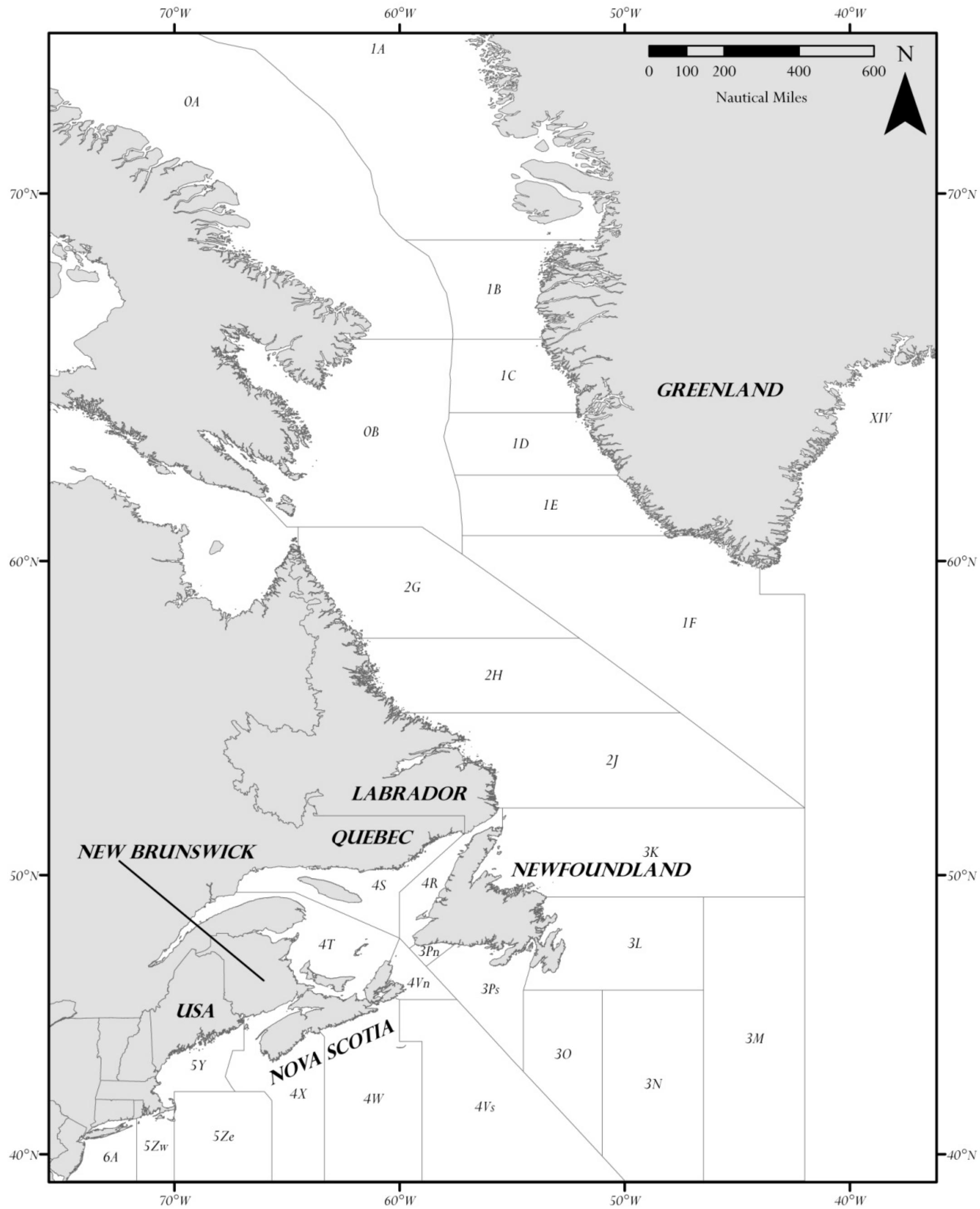

Figure 2. Geographic range of US Atlantic salmon from coastal New England to the island of Greenland with NAFO statistical area boundaries.

a. b.

Figure 3. (a) Reward poster for Scottish tags showing examples of Carlin tag variations and (b) an example of a US tag used in the Carlin program.

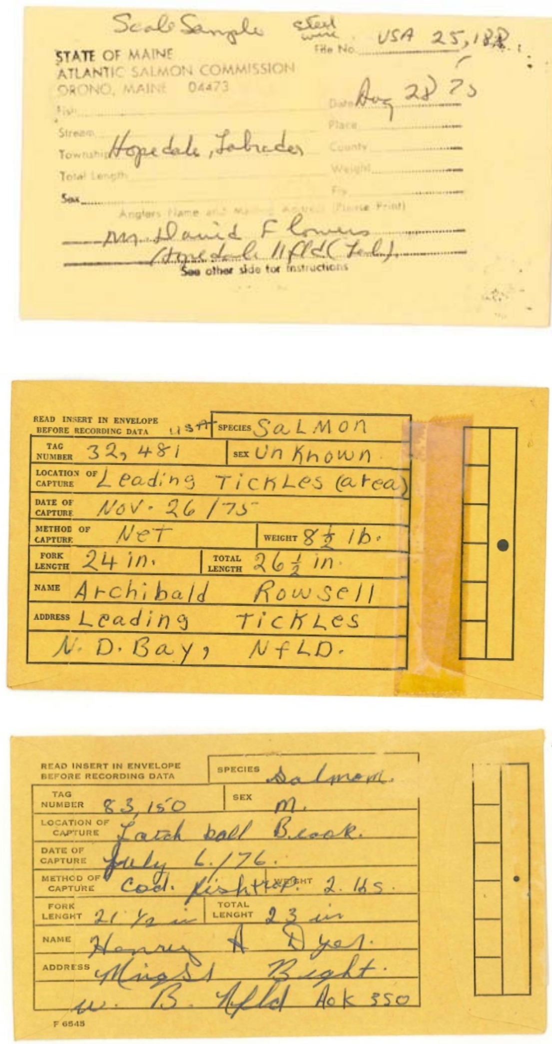

Figure 4. Examples of scale and data envelopes illustrating the variation in reporting of Carlin tags.

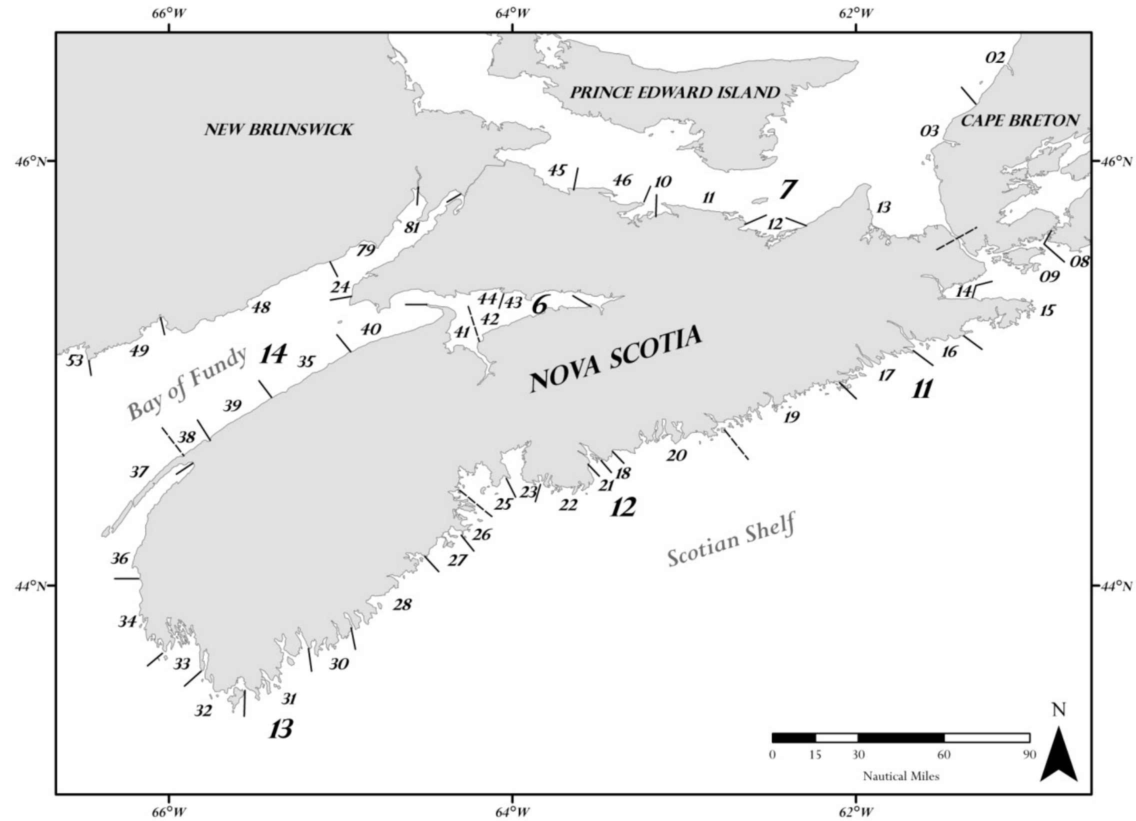

Figure 5. Canadian Fisheries Statistical Districts for Nova Scotia and New Brunswick.

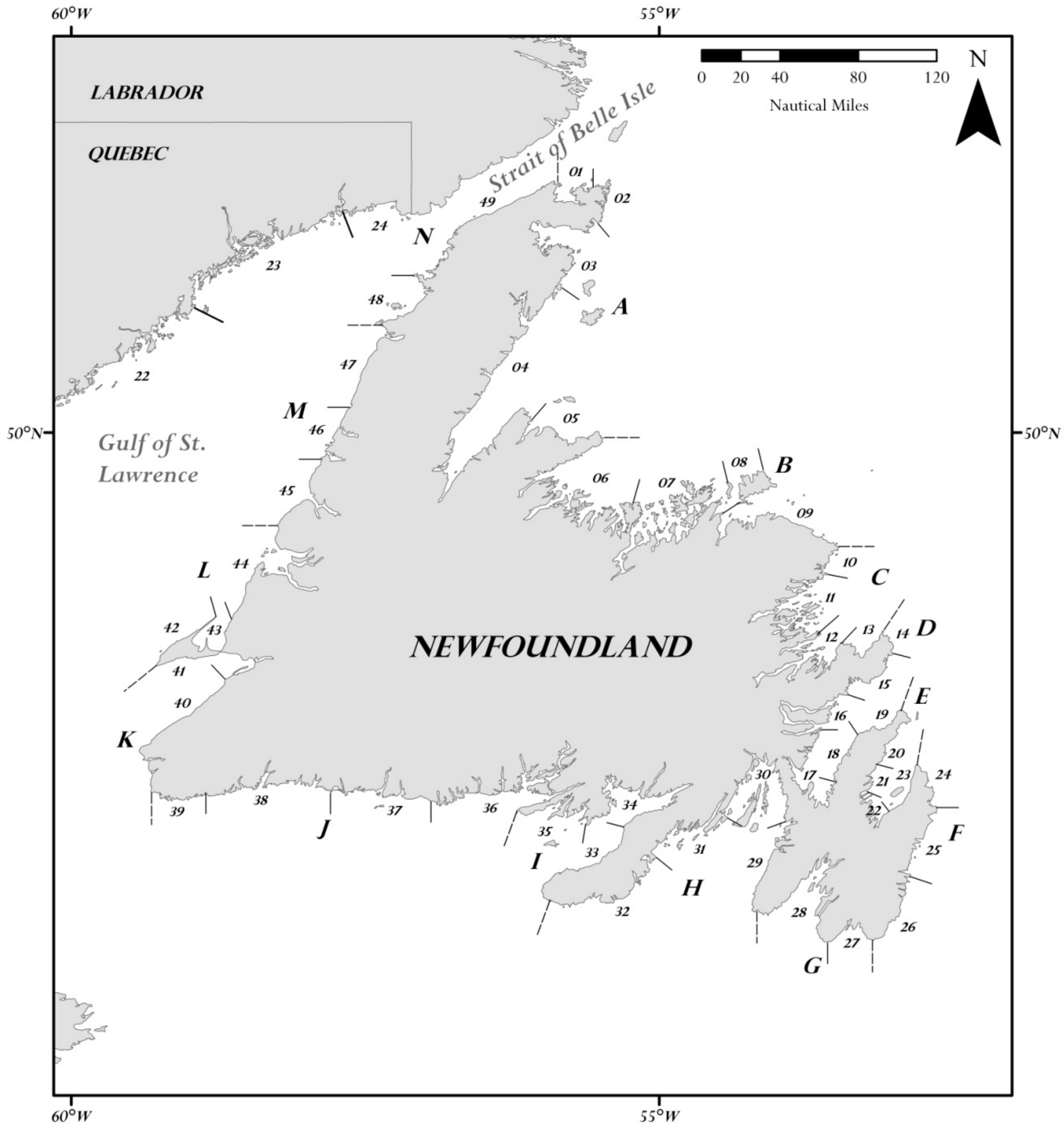

Figure 6. Canadian Fisheries Statistical Areas for Newfoundland and a portion of Quebec where tag recoveries occurred.

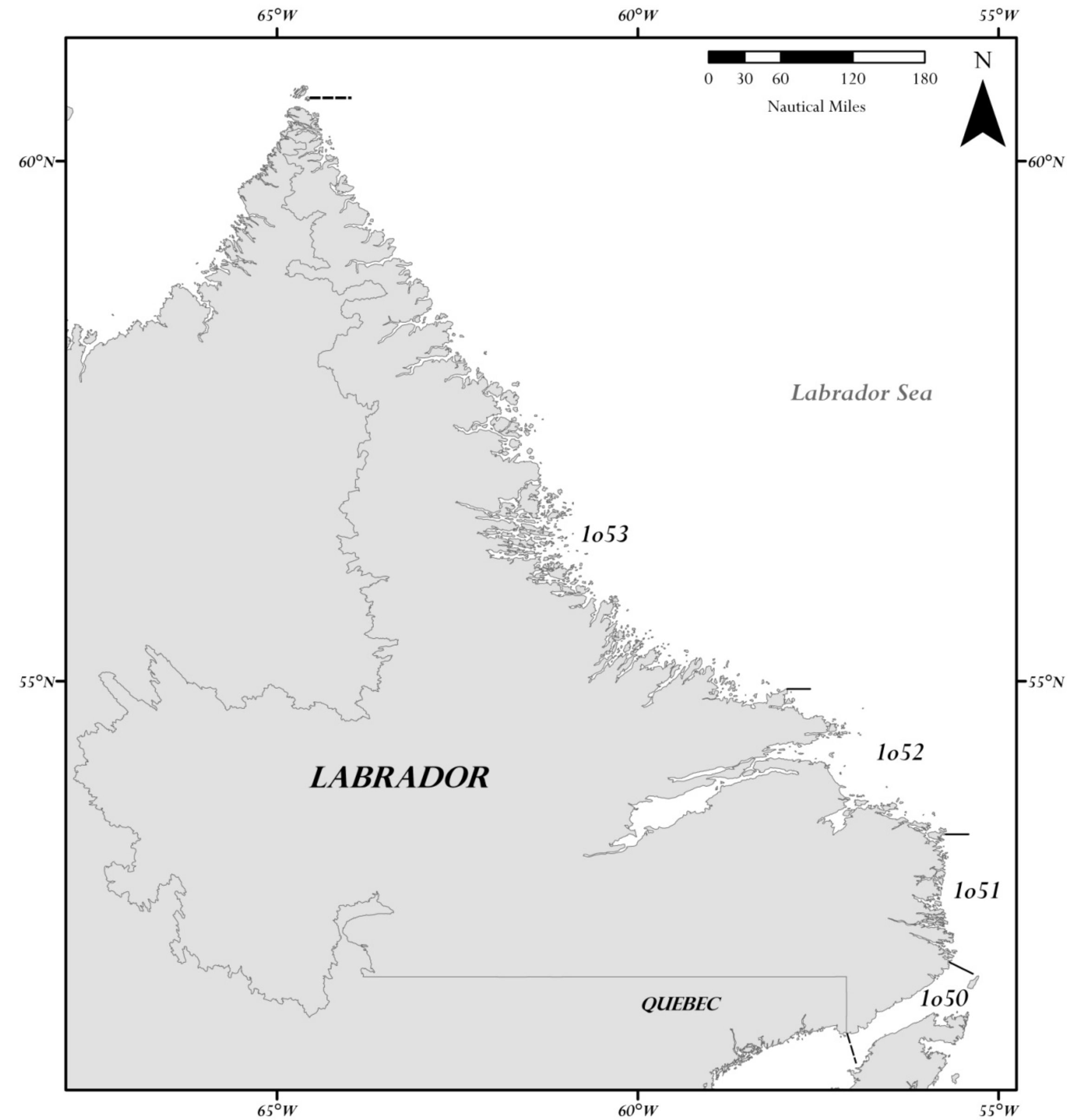

Figure 7. Canadian Fisheries Statistical Areas for Labrador.

Figure 8. Greenland communities (with NAFO boundaries included) where Carlin and CWT tag recaptures were recorded.

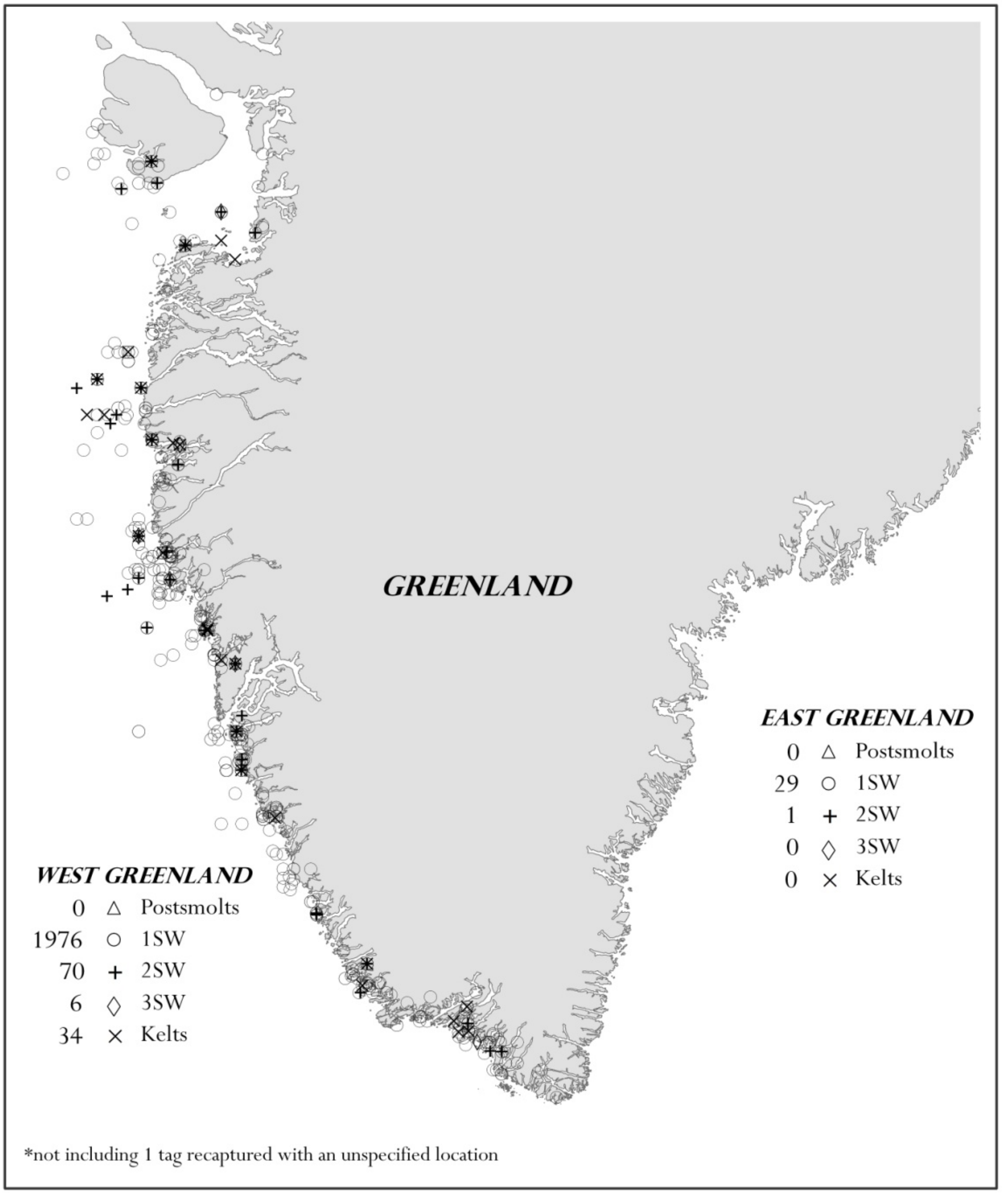

Figure 9. All Greenland Carlin tag recaptures (1963-1992) by life stage.

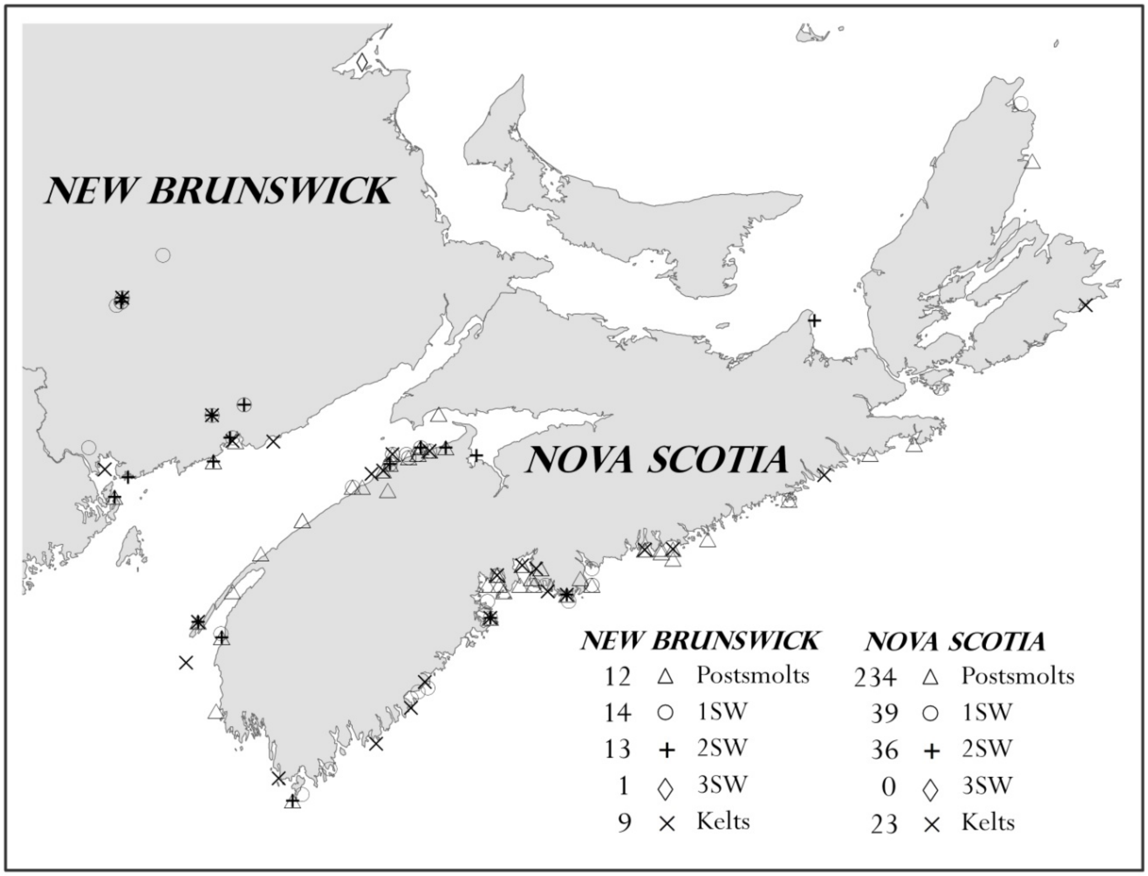

Figure 10. All Canadian Carlin tag recaptures (1963-1992) for New Brunswick and Nova Scotia by age category.

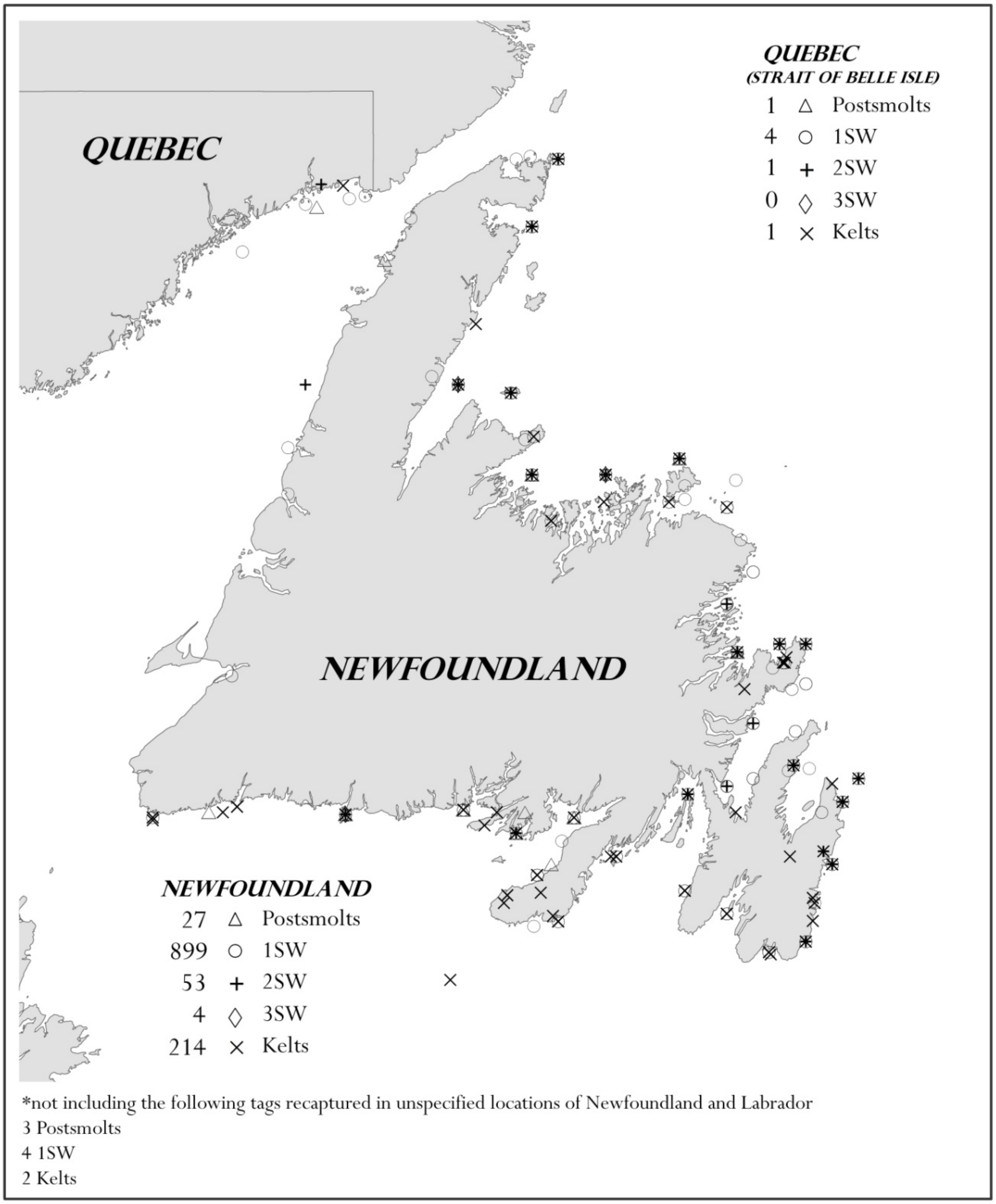

Figure 11. All Canadian Carlin tag recaptures (1963-1992) for Quebec and Newfoundland by age category.

*not including the following tags recaptured in unspecified locations of Newfoundland and Labrador
3 Postsmolts
4 1SW
2 Kelts

Figure 12. All Canadian Carlin tag recaptures (1963-1992) for Labrador by age.

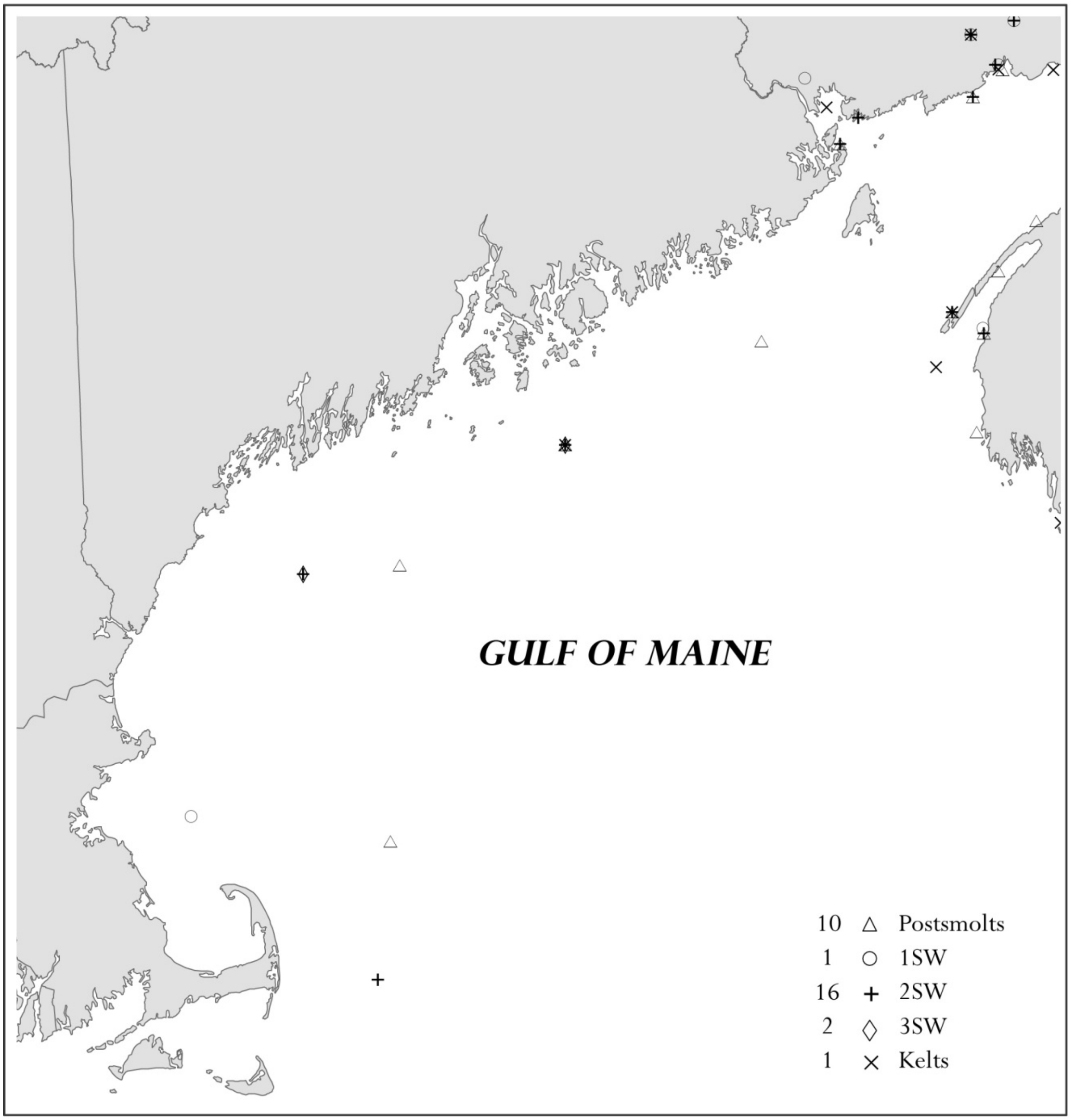

Figure 13. Off-shore Gulf of Maine recaptures by age category throughout the duration of the Carlin tagging program.

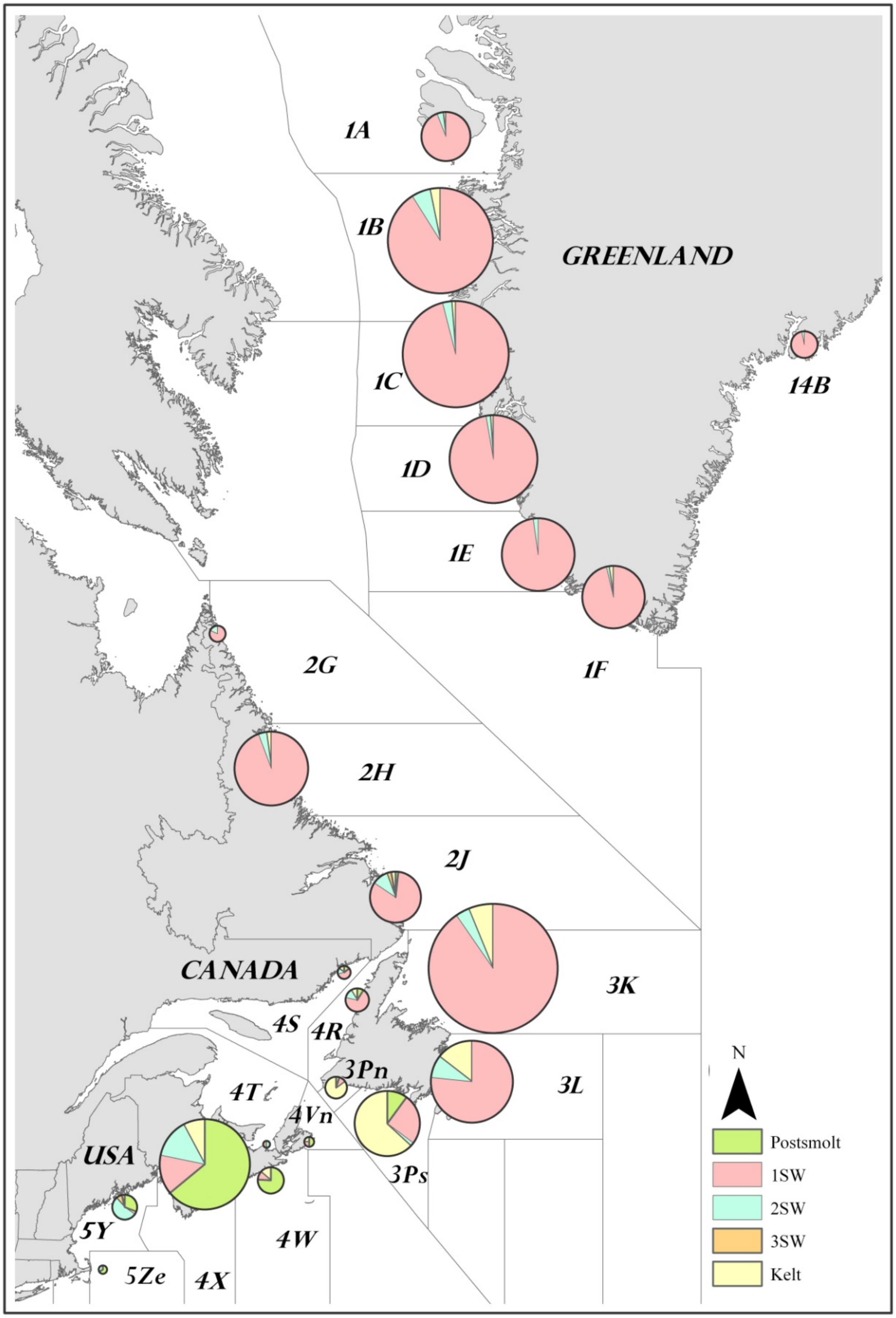

Figure 14. Geographic distribution of Carlin tag recoveries by sea age.

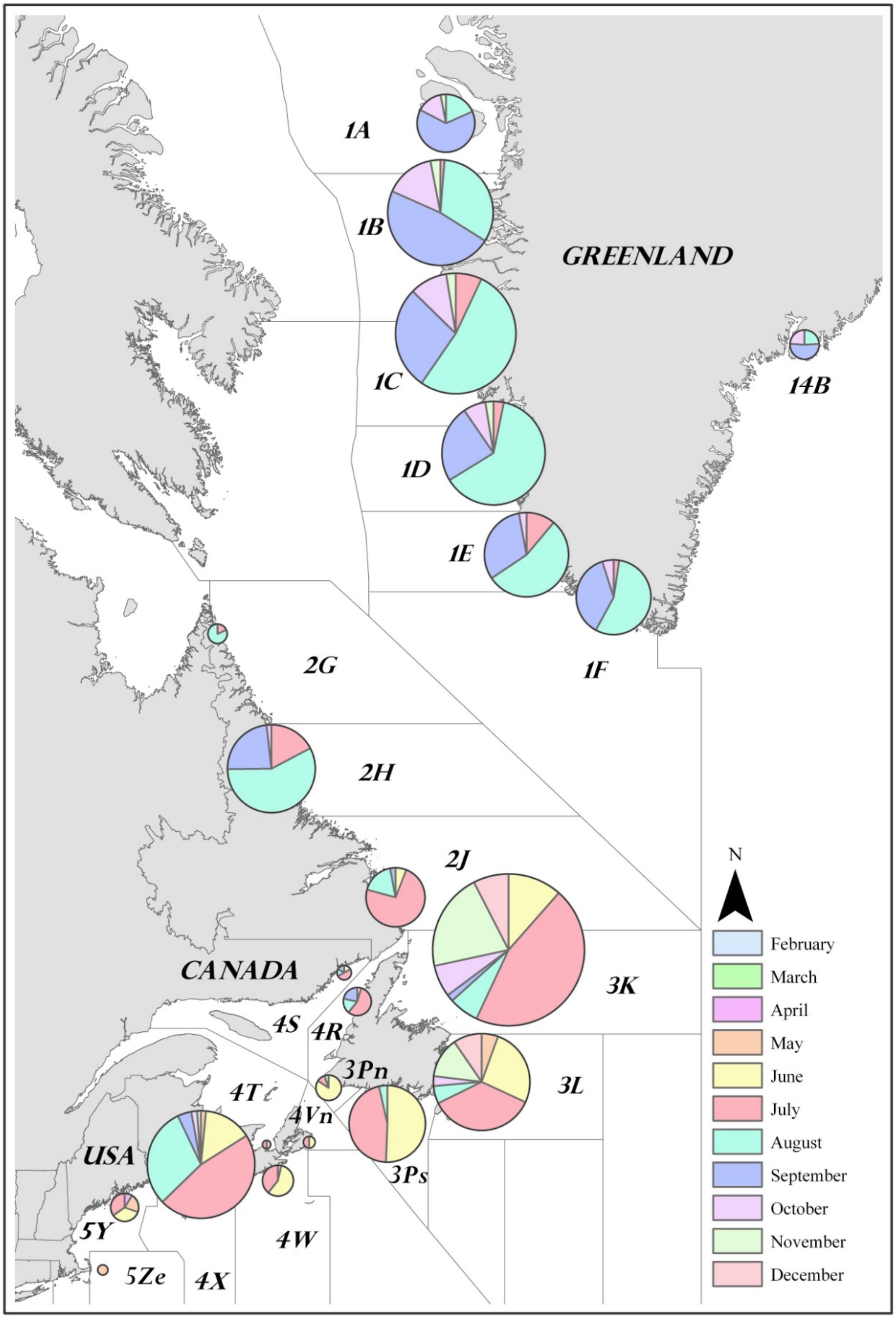

Figure 15. Geographic distribution of Carlin tag recoveries by month of tag recovery.

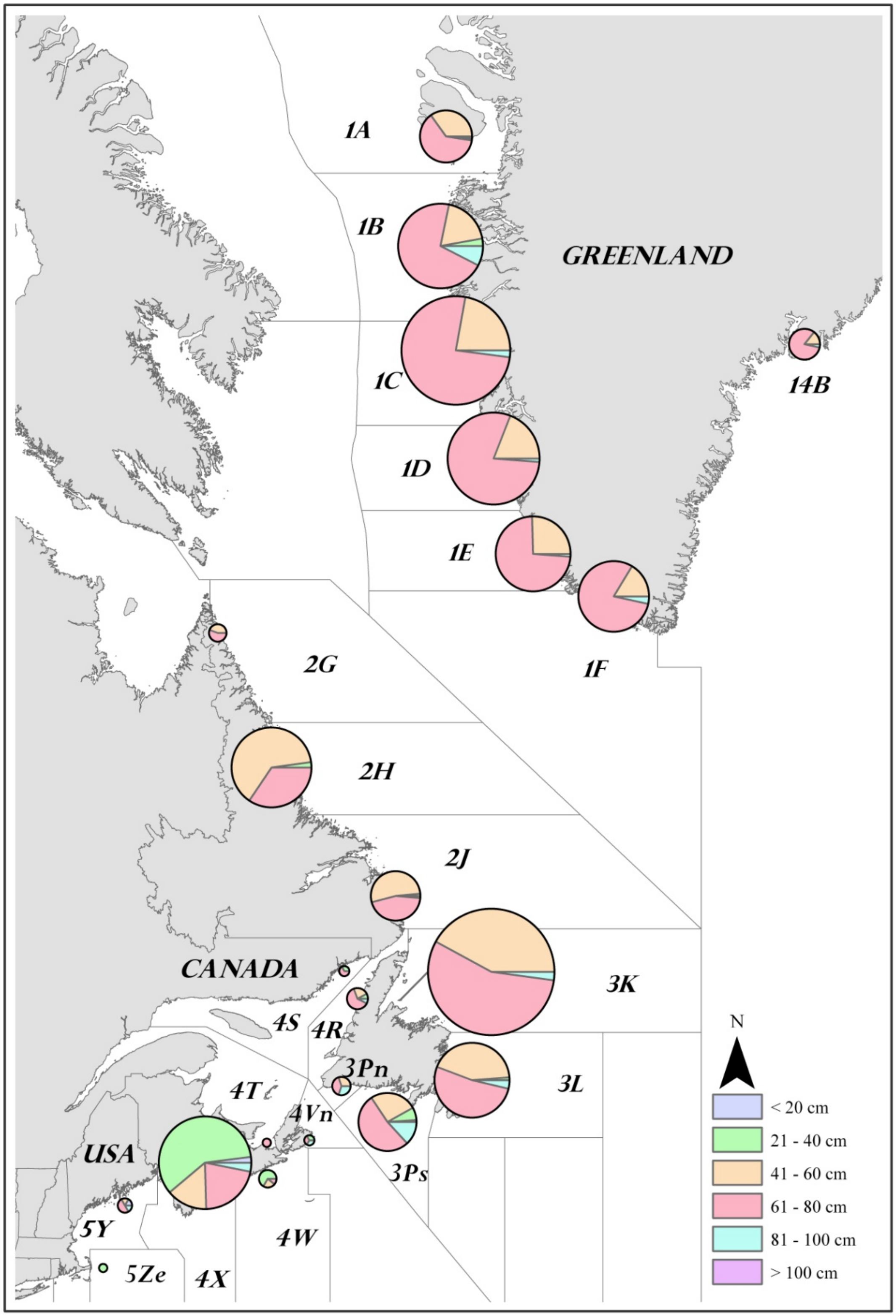

Figure 16. Geographic distribution of Carlin tag recoveries by fish length (total length) at recovery.

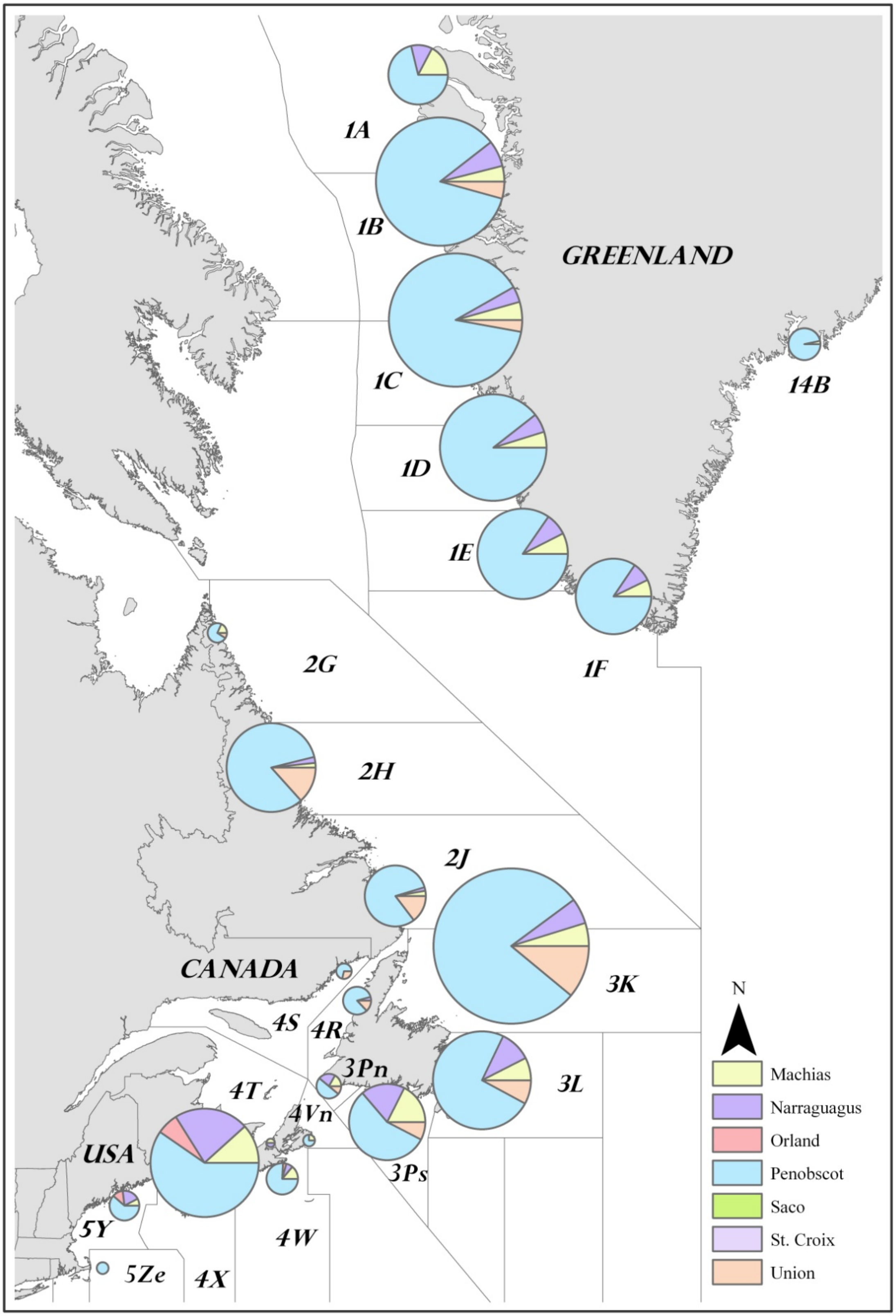

Figure 17. Geographic distribution of Carlin tag recoveries by river origin.

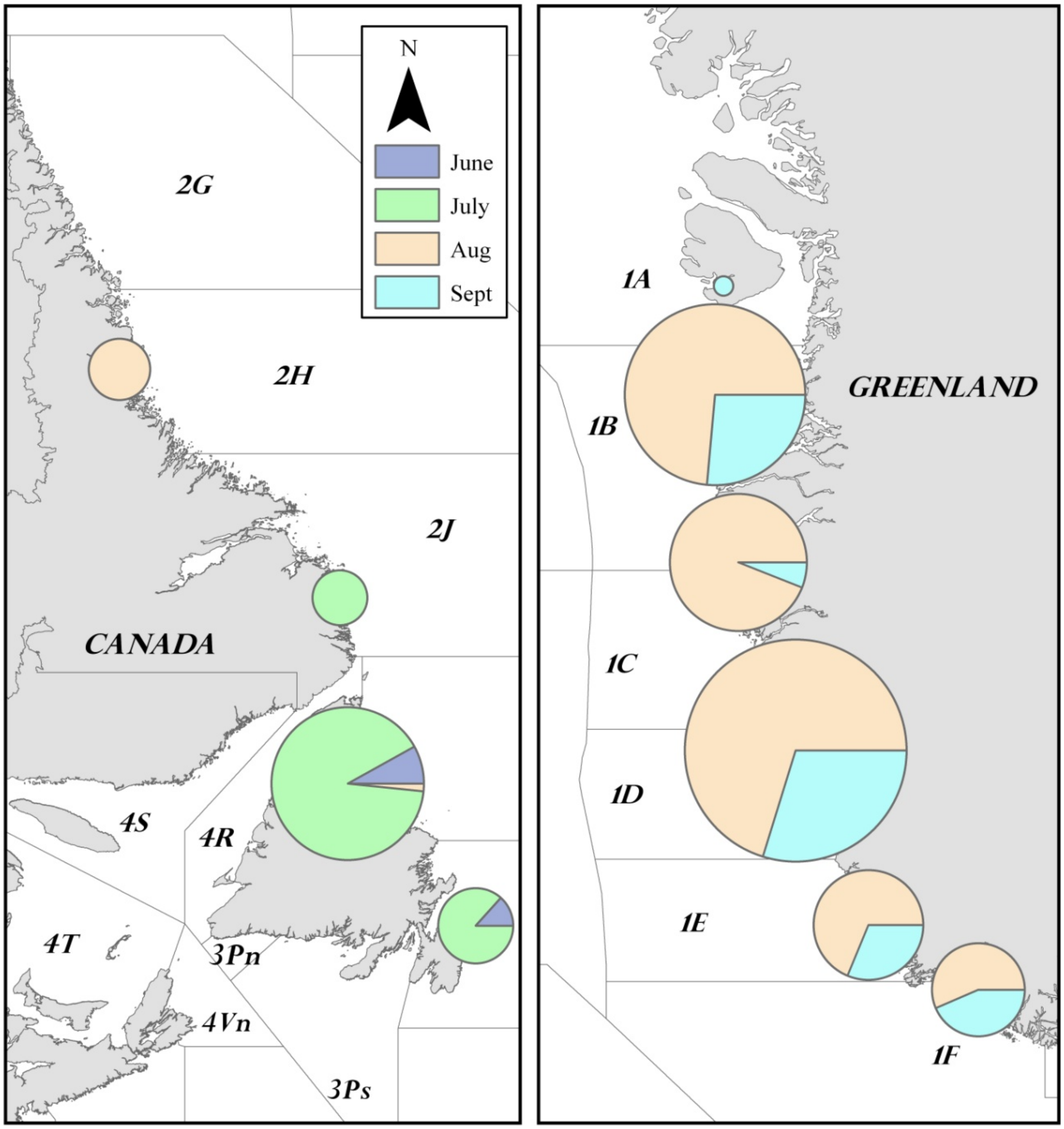

Figure 18. Geographic distribution of CWT tag recoveries by recapture month.

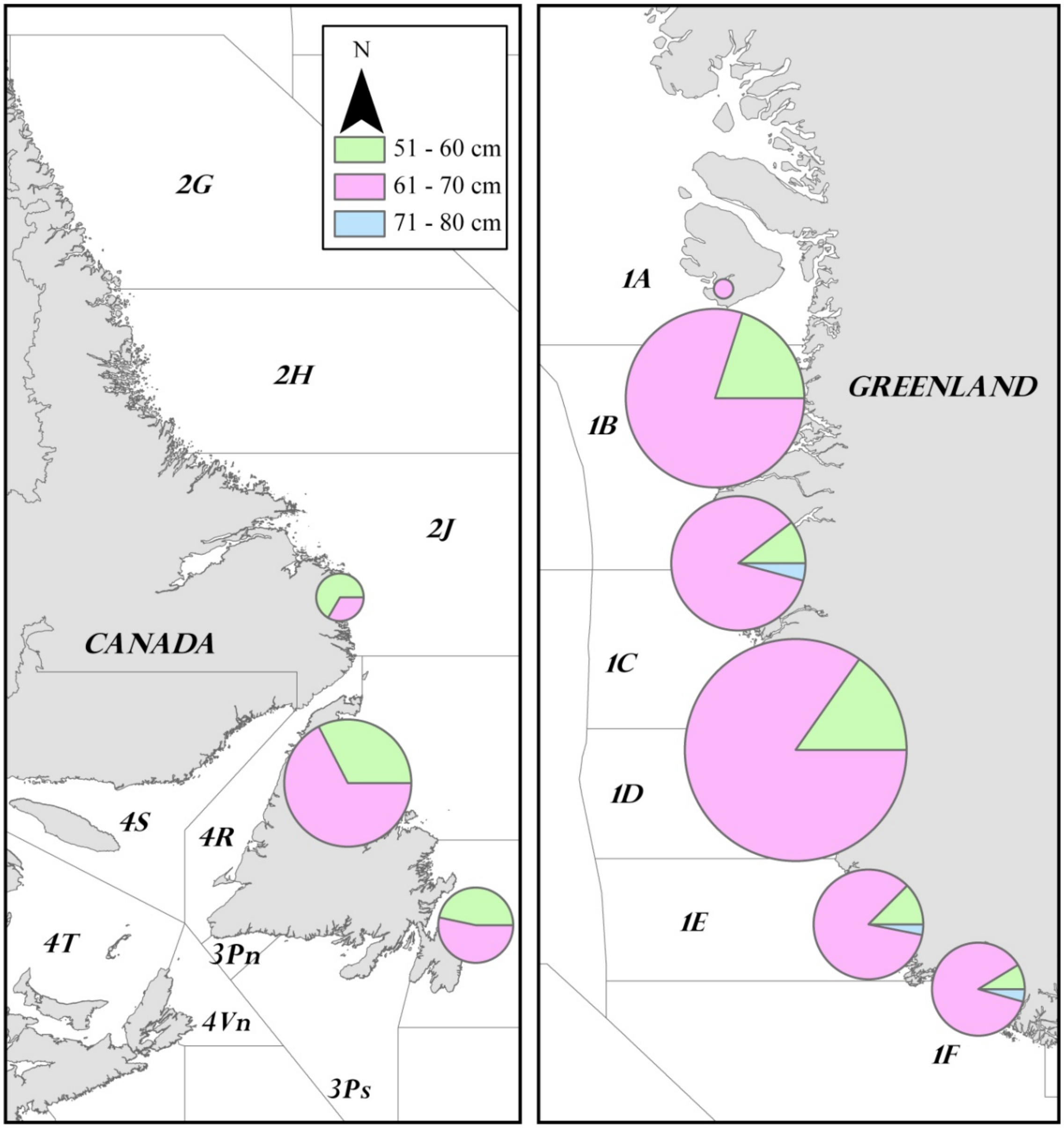

Figure 19. Geographic distribution of CWT tag recoveries by length (fork length) increment.

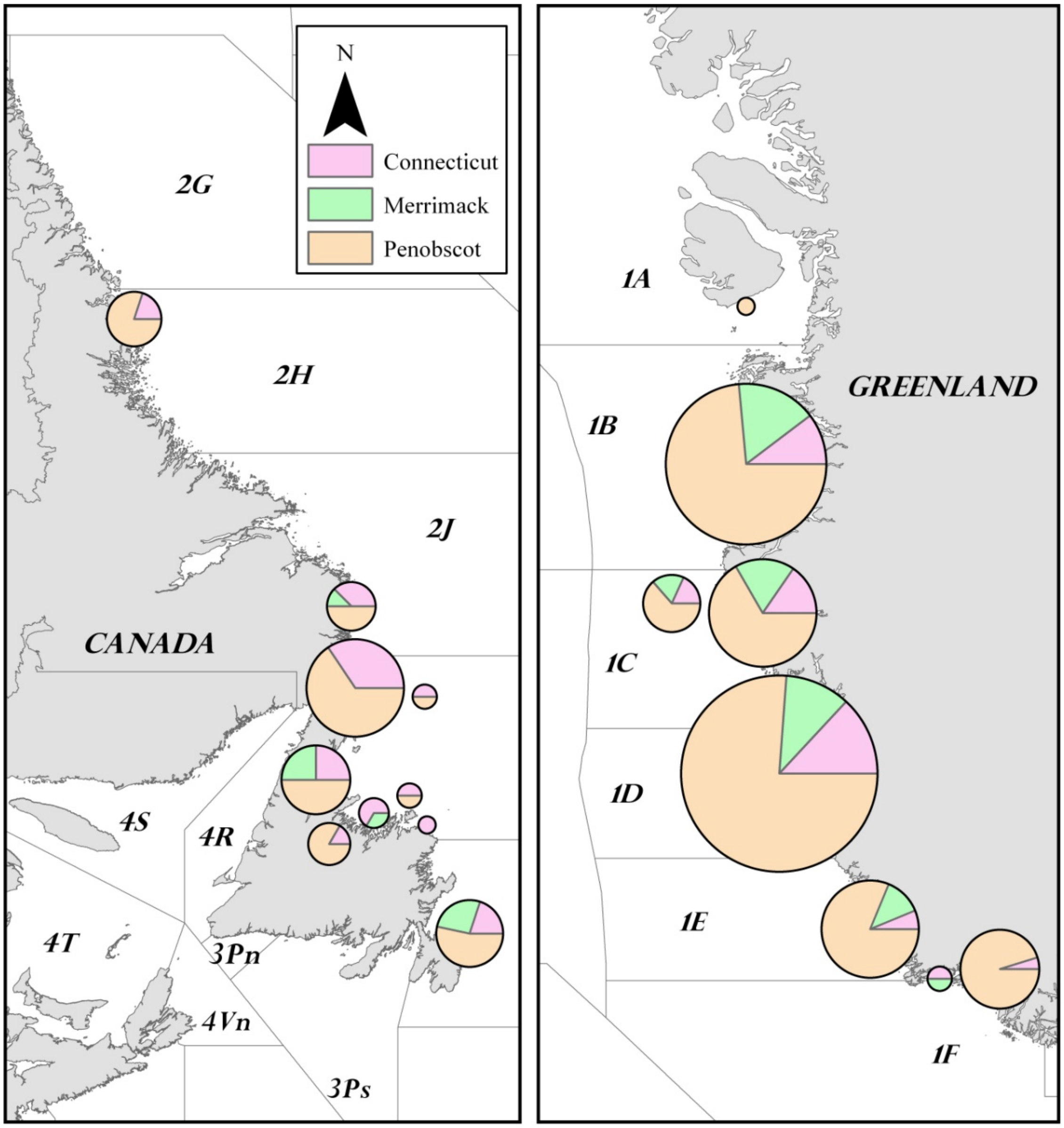

Figure 20. Geographic distribution of CWT tag recoveries by river origin.

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