

Fifty Years of Standardized Surveys: A History of the Maritimes Region Ecosystem Survey Program 1970-2020 and Guidelines for Data Use

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ABSTRACT

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Scientists have conducted marine surveys for over a century to estimate fish population abundance trends in the Northwest Atlantic Ocean. Staff at the St. Andrews Biological Station, with what is today the Department of Fisheries and Oceans (DFO), have led and coordinated DFO's Maritimes Region Ecosystem Surveys Program since the surveys began in the mid-1950s. The two surveys currently managed by this program are the summer survey of the Scotian Shelf and Bay of Fundy (NAFO 4VWX5Zc; July-August; 1970 to present) and the spring (sometimes called "winter") survey of Georges Bank and the Scotian Shelf (NAFO 4X5Z; February-March 1986 to present), which has also included 4VW. The summer survey is the longest-running standardized Canadian survey, making it the most complete fisheries-independent data time series available in the country. The scope and goals of these surveys have since broadened, and though they remain fisheries-independent tools to estimate the status of commercial fish and invertebrate species over time, they are also used for monitoring secondary commercial and bycatch species and to contribute to ecosystem analysis.

This report is an effort to formalize institutional memory and document the history, past protocols, and status of the Maritimes Region Ecosystem Surveys Program during the first fifty years of standardized surveys (1970-2020). Published and unpublished DFO documents related to the survey were consulted to provide an accurate depiction of the Maritimes Ecosystem Surveys Program's design and methods over time. The result is a history and a guide for data users that includes the background information necessary to make best use of survey data. Appendices are also included as quick references to previously published survey documents, comparative fishing information, the ORACLE data table structure and sample queries, and species-specific considerations.

RÉSUMÉ

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Depuis plus d'un siècle, des relevés marins sont réalisés pour estimer les tendances d'abondance des populations de poissons dans l'Atlantique Nord-Ouest. Le personnel de la Station biologique de St. Andrews, aujourd'hui au sein de Pêches et Océans Canada (MPO), dirige et coordonne depuis le milieu des années 1950 le Programme des relevés écosystémiques de la Région des Maritimes. Deux relevés principaux y sont actuellement gérés : le relevé d'été du plateau néo-écossais et de la baie de Fundy (OPANO 4VWX5Zc; juillet-août; 1970 à aujourd'hui) et le relevé de printemps (parfois appelé « d'hiver ») du banc Georges et du plateau néo-écossais (OPANO 4X5Z; février-mars 1986 à aujourd'hui), qui inclut également le 4VW. Le relevé d'été est le plus ancien relevé canadien standardisé et représente la série temporelle de données indépendantes de la pêche la plus complète au pays.

La portée et les objectifs de ces relevés se sont élargis : ils servent toujours à estimer l'état des espèces commerciales de poissons et d'invertébrés, mais aussi à suivre les espèces secondaires et accessoires, et à alimenter les analyses écosystémiques.

Ce rapport vise à formaliser la mémoire institutionnelle et à documenter l'histoire, les protocoles passés et l'état du Programme au cours des cinquante premières années de relevés standardisés (1970-2020). Des documents publiés et non publiés du MPO ont été consultés pour décrire fidèlement l'évolution de la conception et des méthodes du Programme. Le document constitue à la fois un historique et un guide pour les utilisateurs de données, avec des annexes fournissant des références rapides et des considérations spécifiques aux espèces.

1. INTRODUCTION

Scientists have conducted marine surveys for over a century to estimate fish population abundance trends in the Northwest Atlantic Ocean. Staff at the St. Andrews Biological Station, with what is today the Department of Fisheries and Oceans (DFO), have led and coordinated DFO's Maritimes Region Ecosystem Surveys Program since the surveys began in the mid-1950s. The two surveys currently managed by this program are the summer survey of the Scotian Shelf and Bay of Fundy (NAFO 4VWX5Zc; July-August; 1970 to present) and the spring (sometimes called "winter") survey of Georges Bank and the Scotian Shelf (NAFO 4X5Z; February-March 1986 to present), which has also included 4VW (Figure 1; Figure 2; Figure 3). The summer survey is the longest-running standardized Canadian survey, making it the most complete fisheries-independent data time series available in the country.

Over time, the surveys have been known as "Research Vessel Surveys," "Multi-Species Bottom Trawl Surveys," and most recently, "Ecosystem Research Vessel Surveys," a title that reflects the program's widening scope and goals. Primarily, the surveys are fisheries-independent tools to estimate the status of commercial fish and invertebrate species over time: Atlantic Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Atlantic Pollock (*Pollachius virens*), Atlantic Halibut (*Hippoglossus hippoglossus*), offshore American Lobster (*Homarus americanus*), Northern Shrimp (*Pandalus borealis*), and others. Survey data are combined with commercial catch, port sample, and at-sea observer data for analytical assessments of commercial stocks. These assessments provide estimates of abundance, recruitment, and mortality rates that are used to generate catch advice. Annual survey review documents are produced to summarize the survey results and are provided to DFO Fisheries Management to assist them in deciding which stocks require more complete assessments (Appendix A, p. 89).

The survey data are also used for monitoring secondary commercial and bycatch species. Stocks with no detailed Canadian assessments are reviewed with the data. Examples include Winter Flounder (*Pseudopleuronectes americanus*), Northern Sand Lance (*Ammodytes dubius*), Spiny Dogfish (*Squalus acanthias*), White Hake (*Urophycis tenuis*), American Plaice (*Hippoglossoides platessoides*), Monkfish (*Lophius americanus*), Longhorn Sculpin (*Myoxocephalus octodecemspinosus*), and various skate species (*Rajiformes* O.). In addition, the surveys are a source of data for species reviews by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and under the Species at Risk Act (SARA). Additional information is collected to contribute to ecosystem analysis: data on non-commercial fish species, the physical and chemical properties of seawater, and the type and abundance of phytoplankton and zooplankton. Finally, the surveys are used for a myriad of biological studies on individual species and species assemblages. Government and academic research programs may submit special sampling requests that are completed as logistics and time allow.

Many national, transboundary, and international science and management groups are directly involved in or rely on the data from the Maritimes Region Ecosystem Surveys Program:

- DFO Maritimes Region
 - Science – Strategic Planning and Program Integrity
 - Science – Population Ecology – Stock Assessments, Acoustics, Food Habits, Species at Risk Science, the Lobster Survey

- Oceans and Ecosystem Science – Ocean Monitoring and Modelling (physical, chemical, and biological oceanography), Team Whale (marine mammal observation), Offshore Benthic Ecology, Corals, and Sponges Project
- Oceans and Aquaculture Management – Marine Spatial Planning, Marine Protected Areas
- Ecosystems Management – Species at Risk Management
- Fisheries Management – Resource Management
- DFO Atlantic Zone – the Atlantic Zonal Monitoring Program (AZMP), the Atlantic Zonal Ecosystem Surveys (AZES) Working Group, Comparative Surveys Working Group
- DFO National – the State of the Ocean (SOTO) Report
- Environment and Climate Change Canada (ECCC) Canadian Wildlife Service – Eastern Canada Seabirds at Sea Program
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC)
- Canada-US Joint Committees -- Transboundary Resource Assessment Committee (TRAC; until 2024 but survey data continues to be provided to the US), Transboundary Management Guidance Committee (TMGC), Transboundary Resources Steering Committee; Canada-United States Ecosystem Science (CAUSES)
- US National Oceanic and Atmospheric Administration (NOAA) Fisheries – domestic stock assessment working groups including Atlantic Cod, Haddock, Yellowtail Flounder, and Shortfin Squid
- International Commission for the Exploration of the Sea (ICES) – Working Group on Northwest Atlantic Ecosystem Observations (WGNAEO); Working Group on the Northwest Atlantic Regional Sea (WGNARS)

This report is an effort to formalize institutional memory and document the history, past protocols, and status of the Maritimes Region Ecosystem Surveys Program during the first fifty years of standardized surveys (1970-2020). Three changes have occurred recently that indicate that the timing is appropriate for such a document: the 2021 introduction of the CCGS *Jacques Cartier* to replace the CCGS *Alfred Needler* as the surveys' primary vessel, 2021-2022 staffing changes in the survey program, and the 2022 establishment of the Maritimes Region Ecosystem Surveys Working Group. This document includes detailed background information with three purposes:

1. To assist with the appropriate use of previously collected survey data
2. To facilitate the continuation of an important and long-standing data time series
3. To provide a base for continued direction towards an Ecosystem Approach

2. MATERIALS AND METHODS

Published and unpublished DFO documents related to the survey were consulted to provide an accurate depiction of the Maritimes Ecosystem Surveys Program's design and methods over time. Though data reports and analyses exist, the literature consulted was mainly focused on histories and descriptions of the survey program, manuals for survey personnel, protocol documents, software user guides, gear specifications, and "grey literature" published before peer review within DFO became standard for all stock assessment documents. Institutional knowledge held by the authors in memory, emails, and memos were included. Emphasis was

placed on information that was previously unpublished or unavailable in publications from DFO's regular report series: changes over time to vessels, gear, fishing, sampling, and data collection protocols.

To focus this document, only detailed information from the inception of the surveys to the launch of the CCGS *Jacques Cartier* in 2020 was included. Select anticipatory information about the CCGS *Jacques Cartier* and its protocols was included, with the assumption that complete information about protocols and gear specifications will be available in future publications. This document is also spatially restricted to surveys in the current DFO Maritimes Region (NAFO areas 4VWX5YZ). Although surveys in 4T were initially included in the Maritimes Region (1971-1982), they have been managed separately since the Gulf Region was created in 1983.

An additional caveat is that this document is a history and a guide, not a data review or analysis. Survey data have been reviewed and analyzed in other documents, including the annual Georges Bank Winter Report Series and the annual Scotian Shelf Summer Survey Report Series, both published by the Maritimes Region Ecosystem Surveys (Appendix A). Additional analyses, including trawl mensuration studies and comparative fishing experiments, are included in the bibliography available in Appendix B. Finally, oceanographic data were summarized in research documents until 2001 (Appendix A) and since then, are routinely included in the Atlantic Zonal Monitoring Program's annual [State of the Ocean condition Reports](#).

3. RESULTS

3.1. HISTORY

3.1.1. Initial Surveys, 1950-1970

Halliday and Koeller (1981) divided the early part of survey history into two periods: before and after 1970, when standardization occurred. The initial period began in 1950 with the establishment of the International Commission for the Northwest Atlantic Fisheries (ICNAF). In response to the research priorities and recommendations of the Commission, early surveys conducted from the St. Andrews Biological Station in St. Andrews, New Brunswick were exploratory with the goal of describing the basic biological information of commercial species: for example, species distribution and stock biomass. This was



An early fisheries survey conducted from the St. Andrews Biological Station in St. Andrews, New Brunswick.

a continuation of the sparsely conducted surveys that took place from 1945 to the mid-1950s, devoted to improving the efficiency of the fishing industry and exploring underutilized stocks. Study topics included tagging, bait selectivity, gear selectivity, and others.

When mesh regulations were put in place in 1957, the need for fisheries-independent indicators in ICNAF Subarea 4 (today's NAFO area 4TVWX) was identified. Surveys were mounted to address this need, with purposes and executions that varied widely and which were not consistent across years. Some surveys aimed to provide growth and population information about specific species, while others were exploratory. Some focused on topics beyond strict population assessment: diurnal behaviour, species associations, feeding, trawl engineering, and hydro-acoustics development. Surveys in this earliest period were valuable in that the data they collected were used in short-term population estimates and established biological knowledge about commercial species. However, they were not consistent enough in coverage and methodology, or objective enough to be included in current stock assessment methodologies that assume a random sampling design. For a full list of early surveys in ICNAF Divisions 4VWX between 1951 and 1972, see Table 1.

3.1.2. Maritimes Region Summer Survey, 1970 to present

The second period of survey history described in Halliday and Koeller (1981) began in 1970 with the establishment of coordinated annual surveys. In July 1969, the first Canadian stratified random summer survey was conducted by *E.E. Prince* with a Yankee 36 (Y36) trawl in strata 54-59, 62-65, and 81; in 1970, it was expanded to include all strata on the Scotian Shelf (40-95; Figure 2) and was conducted by *A.T. Cameron* with the same trawl. Current stock assessments include summer survey data since 1970 as a result. Other vessel and gear configurations have since been used; more details are available in Section 3.3.3. The methods for the summer survey were adopted and approved by the ICNAF and later by the Northwest Atlantic Fisheries Organization (NAFO). The survey was intended to provide unbiased fishery independent indices of groundfish and commercial invertebrate abundance and recruitment for the Scotian Shelf and Bay of Fundy.

The depth range surveyed included waters down to 200 fm (366 m) along the Scotian Shelf edge and down to 150 fm (274 m) on the eastern Scotian Shelf in 4V. Deeper waters of the Laurentian Channel in 4V were not covered. At the western end of the survey, strata extended to the 4X/5Z line in the Fundian Channel, and to 67° 40' W in the Gulf of Maine. Once the Canada-US boundary was defined in the Gulf of Maine in the early 1980s, the spatial extent of coverage in this area was reduced and the survey covered only Canadian waters. In the most recent years, the summer survey has included some coverage of Eastern Georges Bank including strata 5Z9 (2011–2020), 5Z1 (2011–2013, 2016–2017, 2019–2020), and 5Z2 (2016–2017, 2019–2020). Reduced coverage of other strata has been largely due to limited time and complicated vessel logistics. In some years, like 2018 and 2022, the coverage was reduced significantly, prioritizing the collection of data from NAFO Subareas 4X and 5Z that are currently required for groundfish stock assessments. A map of the current survey area and strata is available in Figure 3. A full list of Maritimes Region Summer Surveys is available in Table 2.

3.1.3. Maritimes Region Spring and Fall Surveys, 1978-1986

In 1978, additional spring (March) and fall (October-November) surveys began to survey groundfish in 4VWX, with a special interest in spawning cod in 4X (Halliday and Koeller 1981). These surveys continued in strata 470-495 (4X) until 1986, with station allocation and methods the same as for the summer survey (Chadwick et al. 2007). A full list of standardized Fall Surveys is available in Table 3. The *Lady Hammond* and the *CCGS Alfred Needler* conducted these surveys with the Western IIA (WIIA) trawl; the results from these older spring surveys are, therefore, directly comparable to those from more recent surveys at the same time of year.

3.1.4. Maritimes Region Spring Survey, 1986/1987 to present

In 1986, the spring survey that had begun in 1978 was redesigned to have two parts that were completed together: a 4VsW survey on the eastern half of the Scotian Shelf and a 5Z survey on Georges Bank. A full list of Maritimes Region Spring Surveys is available in Table 2.

Spring 4VsW Survey. The spring 4VsW survey was conducted from 1986 to 2010 on the eastern half of the Scotian Shelf (Clayton et al. 2014). It occurred primarily in March, but the data also includes sets in February and April. Unlike the summer survey, the spring survey excluded 4Vn and used a different stratification scheme that was meant to optimize the abundance estimates for 4VsW Cod (Figure 4). It was not conducted in 1998 and 2004, and in 2009 was incomplete. The *CCGS Alfred Needler* conducted the survey using the WIIA trawl in all years except 2007 and 2008. The *CCGS Wilfred Templeman* conducted the 2007 survey and the *CCGS Teleost* conducted the 2008 survey, both using the WIIA gear. Deep-water strata 397-400 (365-549 m) in the Laurentian Channel were added in 1993. Although these strata were not used in the analytical assessments in 4VW, they were included in analyses supporting developing fisheries and COSEWIC assessments. Coverage of eastern strata was restricted in some years due to ice cover. After the March 2010 survey, 4VsW coverage was discontinued as the data are not included in stock assessments and the spatial coverage was too restricted to adequately capture the extent and distribution of most stocks, including Atlantic Cod (Clayton et al. 2014). Though the stratification scheme was different, the spring 4VsW survey's biological sampling protocols were the same as the DFO summer survey and therefore they are discussed together later in this document.

Spring 5Z Survey. The spring 5Z survey has been conducted since 1986 on and around Georges Bank, with the goal of providing age-specific abundance trends for groundfish species, especially Cod and Haddock. In 1986, it covered the Bank as well as the deeper waters that surrounded it, primarily in the US Gulf of Maine waters (Figure 5; Gavaris and Waiwood 1986). When it was confirmed that catches of Cod and Haddock in these deeper waters were highly variable during the spring, and it was documented that covering these deeper waters provided limited useful information but cost a considerable amount of time, the area of coverage was restricted to depths up to 183m in 1987 (Gavaris 1987). The 1987 stratified random design is part of a Canada/USA co-management agreement for transboundary groundfish stocks (Chadwick et al. 2007). Stratum boundaries were repositioned to reflect the location of the Canada/USA international boundary and the area of coverage was expanded west towards Cape Cod and Nantucket Shoals (Figure 2). Data from 1986 is excluded from most analyses as a result but was routinely included in age-specific indices of abundance calculated for Cod and Haddock for the Canada-US joint TRAC assessments (Stone and Gross 2012).

3.2. CONTRIBUTION TO ATLANTIC ZONAL ECOSYSTEM SURVEYS

The Maritimes Region surveys are part of a network of fisheries surveys conducted in the Northwest Atlantic Ocean. Perhaps the longest continuous standardized annual monitoring survey in North America is the United States Northeast Fisheries Science Center (NEFSC) Bottom Trawl Survey (1963 to present), conducted from Woods Hole, Massachusetts, which began in response to European distant water fleets that had begun to exploit Northwest Atlantic fish stocks (Azarovitz 1981). It was alongside the NEFSC Bottom Trawl Survey that DFO's Maritimes Region summer survey – the longest running standardized Canadian survey – took its place in 1970. NEFSC's survey is currently split: the spring survey has been conducted in February to April since 1968 with coverage from North Carolina to Nova Scotia; the fall survey has been conducted in September to November since 1963 with coverage from New York to Nova Scotia (NEFSC 2023a, 2023b). Adjacency and overlap between NEFSC surveys and DFO surveys has always been important for transboundary stock analysis and remains a topic for the ICES WGNAEO (ICES 2023). NEFSC survey data are used in conjunction with data from DFO Maritimes' spring survey for the Eastern Georges Bank groundfish assessments conducted by TRAC (Stone and Gross 2012).

Each of the other DFO regions in the Atlantic Zone established their own stratified random survey programs in the 1970s or later. The Gulf Region's September survey in the Southern Gulf of St. Lawrence (4T) began in 1971, originally part of the Maritimes Region Ecosystem Surveys Program but now managed separately. The same year, Newfoundland and Labrador Region began their spring survey on the Grand Banks and Offshore (3LNOP); they added St. Pierre Bank one year later. In 1977, Newfoundland and Labrador Region added a fall survey for the Grand Banks, Labrador Sea, and Offshore (2HJ3LNO). Quebec Region began their August survey of the Northern Gulf of St. Lawrence and St. Lawrence Estuary (4RST) in 1990. Including the spring and summer Maritimes Region surveys, these six annual stratified random surveys are the largest and most comprehensive biological surveys in the Atlantic Zone. Together, they extend along the continental shelf from Labrador, south to Georges Bank, and throughout the Gulf of St. Lawrence (Figure 6).

Primary survey objectives for ecosystem surveys in the four Regions closely mirror those outlined by ICES (2004):

1. Mapping the species distribution over the entire range of the stock
2. Providing an estimate of average fish density (relative or absolute) over the entire spatial range of the stock.
3. Detecting changes in stock size between time periods, and if possible, detecting changes in the size of year classes or cohorts
4. Quantifying the number of young fish (pre-recruits)
5. Collecting ancillary data - biological (e.g., maturity, sex-ratio, weight, stomach contents) or physical (e.g., temperature and salinity)
6. Providing information on diet for all species
7. Conducting Ecosystem Approach to Fisheries Management (EAFM) surveys

The current, shared objectives for all six surveys in the Canadian Atlantic are:

1. Monitor annually the distribution, biomass, and abundance of fish and invertebrate species within the survey area

2. Provide indices (numbers at age, growth, condition) for stocks of commercial importance (e.g., cod, haddock, redfish), and those species reviewed by COSEWIC.
3. Use a stratified random design to ensure adequate coverage across the survey area, at a minimum concentration of 1/200 nm²
4. Identify and conduct detailed biological sampling (total weight, count, length, individual weight, sex, maturity) from all fish species caught, and collect age determination material, as per standard sampling protocols
5. Provide a census of the species/taxa captured within the study area
6. Environmental evaluation of the survey area
7. Collect samples and data for specific projects or individual researchers, as requested.

The surveys in 4T, 4VWX, and 4VW5Z have the following additional objectives

1. Collect hydrographic information for the surface, water column, and near-bottom, including temperature, salinity, oxygen, T-S profiles, and nutrient levels, to contribute to the Atlantic Zonal Monitoring Program (AZMP).
2. Evaluate and monitor the abundance and composition of phytoplankton and macrozooplankton in the survey area, contributing to the AZMP.

The surveys in 4VWX and 4VW5Z have the goal of providing diet data for marine fish for use in ecosystem analyses. The surveys in 2HJ3KLNO, 3LNOP, and 4RST have the supplementary goal of detailed shrimp sampling to support stock assessments for Northern Shrimp.

Comparability with the other stratified-random Atlantic Zonal Ecosystem Surveys, but especially those adjacent, is an ongoing goal of the Maritimes Region Survey Program. The Maritimes Region summer survey and Southern Gulf of St. Lawrence survey were initially combined, and continued to use the same vessel, gear, and sampling procedures even when the DFO regions split. With the introduction of the new *CCGS Jacques Cartier* and the Northeast Fisheries Science Center Ecosystem Survey Trawl (NEST) gear in both regions – effectively a return to the use of a consistent vessel and gear among the regions following a period of vessel substitutions due to unavailability – there is the potential of improved comparability for distributional information and stock movement. Similarly, the Maritimes Region summer survey initially used the Yankee 36 trawl like the US NEFSC bottom trawl surveys, which allowed the surveys to be compared because they also had similar sampling procedures. The Maritimes diverged when the WIIA trawl was adopted, but introduction of the NEST gear, used by the NEFSC surveys since 2009, signifies a return. Specifically, the expansion of the spatial range of the Canadian spring survey (see 3.3.1. Stratification and Spatial Coverage), allows for tracking of changes in distribution through the Canadian and US survey ranges. When an increase in abundance is seen in part of the Canadian range, US data can help to determine whether the fish are shifting their distribution or if it is an actual increase in abundance for a stock in the area. Overall, as long as temporal and spatial adjacency are both considered, the consistent deployment of the NEST gear facilitates comparability of data collected from Cape Hatteras, North Carolina to Anticosti Island, QC.

3.3. SURVEY DESIGN AND LOGISTICS

3.3.1. Stratification & Spatial Coverage

The Maritimes Region Ecosystem Surveys employ a stratified random design. Stratified random is the preferred sampling design for marine surveys in comparison to other designs because it allows for the possibility of sampling in any location within the range surveyed and has a robust statistical design that permits estimates of variance (Smith 1999; Chadwick et al. 2007). In contrast, for example, fixed station sampling excludes the possibility of sampling in any but the initially selected locations and provides a biased sample from which no meaningful estimate of variance can be calculated. In a stratified random design, depth, bottom type, and hydrographic characteristics are the most influential factors in determining strata boundaries, although geographic regions or management units are also used occasionally (Smith 1999). Areas in which there is considerable variation in these factors, like at the edge of a shelf, will have many strata to capture the variability in the available ecosystems.

There is an important difference between a stratified random design used in a single-species survey and a stratified random design used in a multi-species survey (D. Keith, pers. comm.). When optimized for a single species or a small group of similar species, areas are divided into strata whose definitions capture geographic differences in species abundance, in order to reduce the uncertainty of the survey overall (D. Keith, pers. comm.). When meant to survey multiple species, areas are divided into strata that are not easily optimized and which are meant to assure good coverage of the survey domain overall (D. Keith, pers. comm.). This is an important distinction for the Ecosystem Surveys because they were originally designed to survey groundfish but have become multi-species surveys over time. As a result, the original strata reflect differences in haddock and cod abundance, though there have been additions and alterations to better reflect the distribution other species.

To be of use in monitoring abundance and distribution of fish and invertebrate populations, a survey should cover as much of the stock area as practicable. Observed changes in survey indices should then reflect changes in the population, rather than changes to the proportion of the stock residing in the area of coverage. The initial spatial extent of regional surveys in the 1970s was suitable for species that are found primarily in shallower water on and around the banks of the Scotian Shelf and in the Bay of Fundy. For deeper water or wider ranging species - like Pollock, Redfish or White Hake -- the survey was not broad enough to cover the entire stock areas or depth range (Claytor et al. 2014). Similarly, the spring survey of Georges Bank covered the areas important for species like Cod, Haddock and Yellowtail Flounder, but did not extend deep enough to include areas important to species like Barndoor Skate, Smooth Skate, and White Hake. The latter group are captured in commercial fisheries on the Bank in summer but move into deeper water in the Fundian Channel in the winter (DFO 2020a). Coverage has expanded over time so that more reliable information is now available for most marine fish species in the Maritimes Region ecosystems, apart from shallow water coastal residents.

Summer Survey: The stratification scheme for the Maritimes Region divides the survey areas into strata based on geography (recognizing the biogeography of fish stocks) and depth zones, with strata described by depth ranges of <50 fm (<91 m), 50 to 100 fm (91 to 183 m), or 100 to 200 fm (183 to 366 m) (Chadwick et al. 2007). The scheme for the Scotian Shelf and Bay of Fundy (Figure 2) was developed in 1969 by Canadian, U.S., and U.S.S.R. scientists based on a stratification scheme that the U.S. had been using to survey strata 73-92 yearly since 1963. Changes to spatial coverage have since occurred:

- In 1995, new strata (496, 497, and 498) on the edge of the Scotian Shelf were added to the survey to extend the depth coverage to 400 fm (732 m). This expansion was

intended to ensure that the spatial coverage extended deep enough to cover the range for redfish stocks along the shelf edge (Neilson et al. 1995).

- In 2011, coverage was extended to the Canadian portion of Georges Bank (5Z1 and 5Z9) to ensure that one of the seasonal surveys covered the spatial extent of the Pollock stock off southwestern Nova Scotia. It was further extended to include 5Z2 in 2016, as it became clear Pollock were not restricted to the deeper water of Georges Bank in the summer (Andrushchenko et al. in press).
- In 2011, deep water strata were created along the shelf edge (strata 501 – 505), extending the survey range down to 2000 m (1094 fm). It was intended that these strata would receive minimal sampling in most years (as time permitted), with higher sampling once every five years.
- In 2014, the survey was further extended to cover strata in the Laurentian Channel at depths > 100 fm, (183 m; strata 558 and 559) (Wilson et al. in press). This was identified as a gap in Atlantic Zonal sampling coverage and a Maritime Regional survey review recommended extending sampling into this area (Claytor et al. 2014). Stratum 558 was new and had not received any previous effort, but 559 was an area sampled from 1991-2010 during the Spring 4VsW Survey as part of Strata 396-399. Newfoundland Region surveys covered the Laurentian Channel in NAFO Div. 3, but Maritimes Region surveys were not sampling the 4V portion of the channel. With the addition of this area, the summer survey now covers all offshore Maritime Region waters to a depth of 400 fm (732 m) and there are no longer any gaps between areas covered by the surveys in Atlantic Zonal waters.
- In 2014, exclusion areas were defined in 4Vs, 4Vn, and 5Z (Wilson et al. in press). In these areas, surveying is not possible and therefore they should be excluded from calculations that estimate populations based on the area of the strata. Strata 5Z3 and 5Z4 were also sub-divided. See bullet three in the next section for explanation.

Spring Survey: When the spring survey was designed in 1986, a new set of strata were used to cover Georges Bank and most of the Gulf of Maine. In 1987, strata were altered to cover depths less than 100 fathoms in 5Z from south of Cape Cod to the NE peak of Georges Bank (strata 5Z1 – 5Z8). Changes to spatial coverage have since occurred:

- In 2009, stratum 5Z9 was added to cover the area in the Fundian Channel in 5Z that was not sampled in either seasonal survey. This stratum includes depths >100 fathoms.
- In 2010, vessel time previously used for the 4VsW Cod survey became available and sampling was added in 4X (470 – 495). Completion of Georges Bank remains the priority, so sampling in 4X is completed when time permits.
- In 2014, exclusion areas in 5Z3 and 5Z4 were defined and their strata were split into four parts (5Z31, 5Z32, 5Z33, and 5Z34) and two parts (5Z41 and 5Z42) respectively. The subdivisions reflect the geographic boundaries used for Eastern Georges Bank cod and haddock stock assessments, the NAFO division line between 5ZEm and 5Zen; they also exclude areas that are too dangerous or inaccessible to trawl (Wilson et al. in press).

In 2007, the Transboundary Resource Assessment Committee (TRAC) science review recommended developing a proposal for synoptic survey coverage for the total geographic range of DFO Maritimes and American NEFSC survey coverage (O'Boyle and O'Brien 2007). This was also a recommendation of the Maritimes Regional survey review that was carried out once the timing of a DFO vessel change became clearer (Claytor et al. 2014). A proposal was

developed to more closely align spring surveys for the two organizations, which would allow for monitoring of wide-ranging species and shifts in species distribution among the Scotian Shelf, Georges Bank and Gulf of Maine. As a result of the proposal, both organizations have adopted the same bottom trawl (NEST) for use on their Ecosystem Surveys. The change in trawl for each organization was coordinated with the introduction of new research vessels, the *Henry Bigelow* in 2007 for NEFSC surveys and the *CCGS Captain Jacques Cartier* in 2021 for DFO Maritimes surveys. The harmonization of the two surveys will greatly simplify interpretation of changes in distribution and abundance for species over this broad area. Ongoing coordination planning is managed through ICES Working Group on Northwest Atlantic Ecosystem Observations (WGNAEO).

In 2014, a project to create authoritative Maritimes Region strata boundaries and update exclusion zones was undertaken. Although the same strata, with the additions listed above, were used consistently since 1970, they were digitized from paper charts of varying data availability and resolution. Some errors in the boundary definitions were recognized, as well as the need for a quantitative determination of exclusion zones rather than the qualitative determination that had taken place previously. The analysis was conducted using bathymetry and survey data, and the full results are available in a Technical Report that is complimentary to this Survey History. The revised authoritative strata and exclusion zones have been used since 2014 (Wilson et al. in press).

3.3.2. Station Allocation & Sampling Intensity

While there is no clear national or international standard for the sampling intensity that should be employed in a survey, a sampling intensity of 1 set per 200nm² was proposed at a DFO-sponsored Bottom Trawl Surveys Workshop in 1980 (Azarovitz 1981). This intensity has been used for US surveys, and for a number of Canadian surveys. Surveys of waters off Newfoundland and in the Gulf of St. Lawrence have used this as the target for the number of sets in each stratum, with higher sampling intensity in very small strata. In Maritimes Region, this sampling intensity was the overall target for the spring survey of Georges Bank, with the 100 original sets then allocated among strata with the goal of minimizing variance for Haddock abundance estimates. For the summer survey, a sampling intensity of 1 set per 200nm² would require at least 350 sets given the size of the survey area. The survey has never realized this level of sampling, which would require more vessel time than is regularly available even in years without any delays or other issues that might impact available time at sea.

The sampling intensity proposed in Azarovitz (1981) is not the same as the minimum number of sets per stratum, sometimes called “minimum survey coverage.” For all Atlantic Zonal Surveys except Quebec, minimum survey coverage is at least two sets per stratum. Quebec Region surveys target a minimum of three sets per stratum. Multiple sets per stratum allows for variance in the data, permitting precision to be estimated.

Summer Survey: When the summer survey began in 1970, the number of stations allocated to each stratum was generally proportional to the stratum surface area: larger strata received more stations than smaller strata. The total number of sets made annually during the 1970s was 145,

with many strata allocated the minimum of two sets. The current set allocation is available in Table 4, including primary and alternate stations. Changes to sampling intensity include:

- In 1987 and again in 1990, strata in areas of high commercial fish abundance were allocated additional stations. In 1987, these strata included 465, 472, 476, 477, 481, and 482; in 1990, these strata included 444, 447, 448, 455, 456, 458, and 480.
- In 1999, further additional stations were allocated in 4V, particularly strata 440-445, to increase sampling intensity in the areas used for 4Vn stock assessments.

Spring Survey: For the spring survey in 5Z, 100 sets were initially allocated -- one set for each 200 nmi² of the entire area (Table 5). The sampling intensity varied in each stratum, with allocation intended to minimize variability in indices for Haddock. This resulted in much higher sampling intensity in 5Z1 and 5Z2 and lower intensity in 5Z3-5Z8. The main objective for the survey was to ensure indices of abundance were available for 5Z1-5Z4; the area used for Transboundary Resource Assessment Committee (TRAC) cod and haddock stock assessments. The total number of sets was increased to 140 and the distribution by stratum was altered for the spring survey of 1992 in order to improve the precision of abundance estimates for Cod and Haddock (Hunt 1992). It was reduced to the initial 100 sets in 1993. As vessel reliability became an issue for completing the survey, station selection was modified to include primary, secondary, and alternate stations, all with the same sampling protocols. The geography of the area is such that the survey vessel travels across the area moving west towards Cape Cod, then returns along a similar path east to port in Nova Scotia. The intention is that primary stations are sampled early in the survey and secondary stations are completed as the vessel returns to the east. This reduces the likelihood that entire strata are unsampled if there are difficulties in completing all stations. Given the low sampling intensity in 5Z5-5Z8, all sets were designated primary. One-third of stations in 5Z1- 5Z4 were designated secondary, and only completed if time permitted. As they had the lowest priority and required the farthest travel, sampling on western Georges Bank in 5Z5-5Z8 was discontinued in 2020. The current station allocation is available in Table 6.

The original method for station allocation is that described in Grosslein (1969) and Doubleday (1981). Random selection was accomplished with a two-stage approach. First, each stratum was divided into rectangles of 5' latitude x 10' longitude (a major sampling unit), each of which required one tow to characterize it. Second, the major sampling units were divided into ten minor sampling units, each 2.5' latitude x 2' longitude, each of which was approximately as long as the distance trawled during a set. Minor sampling units were numbered throughout the entire strata, and a table of random numbers was used to select station locations without replacement. When the number of stations required for a given strata were chosen, that strata was removed from the selection. In 2014, a new station selection process was created and today, the R function `setSelect` (McMahon 2025) is used, incorporating a default buffer of 4 nm around each station (Wilson et al. in press). The buffer of 4 nm is relatively arbitrary, and results in a larger distance between tows than the previous selection protocol. The absolute minimum distance that is required between sets to prevent overlap and therefore autocorrelation is the tow distance (1.75 nm for Y36 and WIIA; 1 nm for NEST) plus the distance the vessel continues to move while the trawl is retrieved.

Two metrics are available to measure the number of stations completed: the number completed per fishing day (defined as any day in which one or more sets were completed) and the number

completed per survey (Figure 7; Figure 8). With inclusion of new strata and the increased station allocation in some strata, there has been an increase in the total number of stations completed per summer survey. There is, however, no clear increase in the number of stations completed per spring survey or per day during either the spring or summer survey. Changes in vessel operating procedures in some years reduced the number of sets completed each day in the 2000s. Over time, the number of days lost to vessel breakdown has increased, as has the number of days lost to procedural requirements such as Coast Guard crew changes. In a good year, the total number of sets completed is higher than in earlier years but the variability among years has increased as well. Both current surveys have shown a decrease in the number of sets completed per day since the 1990s, rarely reaching 8 sets/day in the 2010s (Figure 8). With a new vessel taking over the survey, the mechanical issues contributing to this decrease may become less common.

3.3.3. Vessels and Gear

The Maritimes Region Ecosystem Surveys are currently conducted using Canadian Coast Guard Ship (CCGS) offshore fishery science vessels and employ a mobile bottom otter trawl as the primary sampling instrument. A bottom trawl was chosen, as it was for all the other long-running Atlantic Zone surveys, because the surveys were originally intended primarily to provide abundance indices for commercial fish stock assessments. Bottom trawl surveys monitor the distribution, abundance, biomass, and condition of marine species susceptible to capture by that method. The main advantages of a bottom trawl over other gear types is that it captures a wide range of species which can provide a multispecies perspective and allow the assumptions inherent in survey design to be satisfied relatively easily (Rago 2005).



A side trawl is deployed from the A.T. Cameron.

In the Maritimes Region, there have been several changes in vessels and the gear that they deploy over the span of the survey time series (Table 7; Table 8). The major change in gear between 1970 and 2020 was the switch from the Yankee 36 (Y36) trawl to the Western IIA (WIIA) trawl (Figure 9; Figure 10). Carrothers (1974; 1988) compares the eight commercial trawls that were used on early groundfish surveys (1960-72), including the Y36 and WIIA. The Yankee series of trawls were most commonly used in the groundfish fishery at that time, with the smallest size being the 36. The WIIA trawl was developed in response to declining groundfish stocks and echo-sounder traces of fish above the headline of traditional two-seam trawls like the Y36; it was meant to provide additional headline height with similar wing spread. It was easier to maintain at sea than the Y36. Both trawls were generally used on smaller inshore vessels, although they were also deployed commercially offshore. Modifications over time to these trawls during the surveys are discussed in Section 3.3.5.

Measurements of trawl dimensions at sea were rare before the late 1980s, when acoustic gear mensuration equipment started to become more readily available. As such, the gear dimensions generally used for the Y36 and WIIA trawls were assumed to be those documented in the trawl design rather than those measured in a broad set of fishing conditions. The

wingspread generally used for analyses of Yankee 36 catch data was 35' (10.7m), while for the WIIA it was 41' (12.5m). Data collected more recently for the Yankee 36, as used for NEFSC bottom trawl surveys from 1963 to 2008, indicates a spread of 11-12 m and headline height of 1.9-2 m (Brown et al. 2007). Trawl mensuration data for the WIIA shows a wingspread ranging from 10.5-18m, with spread dependent on depth and substrate firmness, and headline height of 3-4 m (Koeller 1991).

Summer survey: When the survey began in 1970, it was with the *A.T. Cameron*, a side trawler, and the Y36 trawl. The Y36 was small for the *A.T. Cameron*, but it was chosen to provide comparable results to those of the *E.E. Prince*, a smaller vessel that was already deploying the Y36 (Carrothers 1988). In addition, the Y36 was used at the time on NOAA surveys, which extended east from U.S. waters and covered all of 4X. In 1982, the Y36 two-seam trawl was replaced with the WIIA box trawl. The WIIA was selected because its higher headline height made it better at catching fish that were a few



The Western IIA trawl is deployed from the CCGS Alfred Needler in August 2007.

meters off the bottom, and it had larger rollers in the footgear to reduce damage on rough bottom but that also increased the space for fish to escape capture below the footrope. In 1982, the *Lady Hammond* and the WIIA were used; in 1983, the *CCGS Alfred Needler*, designed like a commercial stern trawler, and the WIIA trawl became the primary survey vessel and gear. The *Needler* and sister ship the *CCGS Wilfred Templeman* were purpose-built in Pictou N.S. as scientific survey vessels. When the *Needler* was unable to sail due to mechanical problems or refits, or when comparative fishing was necessary, the *CCGS Teleost* (2004, 2005, 2007, 2018) was employed. In 2005, the *Teleost* completed both comparative and standard sets during periods of the survey when the *Needler* was unavailable. In 2008, the *CCGS Templeman* completed the summer survey.

Spring survey: The *CCGS Alfred Needler* and WIIA trawl were the primary survey vessel and gear for the spring survey since its inception in 1986. When the *Needler* was unable due to mechanical problems or refits, or when comparative fishing was necessary, the *CCGS Teleost* (2005, 2006, 2008 – 4VsW only, 2016, 2017, 2020), *CCGS Templeman* (1993, 2004, 2007, 2008 – 4WX5Z only), and the commercial sister ship to the *Teleost*, the *Mersey Venture* (2018) were employed. In 2005 and 2006, the *Teleost* completed both comparative and standard sets during periods of the surveys when the *Needler* was unavailable.

For both surveys, the *CCGS Capt. Jacques Cartier* deploying a Northeast Fisheries Science Center Ecosystem Survey Trawl (NEST) will become the primary survey vessel and gear when ongoing comparative fishing (2021-2024) is completed. The NEST gear is advantageous because it is a small mesh trawl with a codend liner that better captures invertebrates and

secondary species than the Y36 and WIIA and so provides a more complete view of the ecosystem. It is also deployed by the adjacent NEFSC spring and fall bottom trawl surveys which extend from Cape Hatteras to Southwest Nova Scotia, the Southern Gulf of St. Lawrence Survey, and the Maritimes Region Inshore Lobster Survey. The broad use of this sampling tool provides opportunities for aligning or combining survey indices for transboundary stocks and for monitoring changes in species distribution throughout much of the Northwest Atlantic.

Ideal Survey Trawl Design: Bottom trawling is the internationally preferred method for surveying demersal fish and invertebrates, but not all trawls are equally well-suited for the purpose. The ICES Study Group on Survey Trawl Standardization defined the characteristics of an ideal standard survey gear design (ICES Fisheries Technology Committee 2005). An ideal survey trawl should sample consistently in all geographic areas where it is used and should provide as unbiased a sample of the species assemblage as possible. To achieve this, a trawl should have the same dimensions in all conditions of depth, current, and bottom type. It should also reduce herding as much as possible, as distinct species respond in different ways to herding. Finally, it should eliminate escape under and over the net. While a net cannot sample the entire water column, it should sample the area from the benthos to the headline as efficiently as possible.

There have been some attempts to design “the ideal survey trawl,” but the attempts have not been entirely successful. The NEST is a purpose-designed science trawl that was created with an advisory panel of scientists, managers, fishery stakeholders, and gear designers to achieve the objectives of a multi-species bottom trawl survey including the characteristics described by ICES (Brown et al. 2007). It was designed to improve consistency of performance and representativeness of fish assemblages. The NEST uses a rockhopper ground gear, which leaves no space below the fishing wire for fish to escape. It has a high headline for a fairly small trawl net, and uses small trawl doors. The small trawl doors have limited spreading force, meaning there is very little change in the wing and door spread as fishing depth increases. It may be the best attempt at an ideal survey trawl that is currently in use, and its use by both the NEFSC and DFO bottom trawl surveys offers the future opportunity for international survey coordination. This coordination is managed by the ICES Working Group on Northwest Atlantic Ecosystem Observations, established in 2020.

3.3.4. Comparative Fishing

The purpose of comparative fishing is to determine whether changing vessels and gear influences the species caught and the data collected. Comparative fishing that collects data about vessel and net effects together is generally accomplished by having the old vessel and gear fish side-by-side with the new vessel and gear. Fishing different gears with the same vessel, or different vessels with the same gear, would yield comparative data about net or vessel effects individually. When the data have been collected, conversion factors are calculated by species as the effect may differ depending on the species’ individual anatomies and behaviours. Ultimately, having conversion factors allows the survey time series to continue uninterrupted and be useful over time, despite vessel or gear changes.

The Surveys Program has completed three comparative fishing studies: the first was conducted from 1979-1981 between the *Cameron* with the Y36 and the *Hammond* with the WIIA; the second was conducted in 1983 between the *Hammond* and the *Needler*, both fishing the WIIA

trawl; the third was conducted from 2005-2006 between the *Needler* and the *Teleost*, both fishing the WIIA. A fourth zonal comparative fishing study was planned between the *Needler* and the *Cartier*, but the *Needler* went out of service before it was complete. The summer comparative work was completed over two years using the *Teleost* and *Cabot* (2022) and *Teleost* and *Cartier* (2023); the *Teleost* fished the WIIA and the *Cartier/Cabot* fished the NEST. The spring comparative work was completed in 2024 when the *Teleost* fished the WIIA and the *Cabot* fished the NEST. The results of the spring comparative survey are not yet available, but the results of the summer comparative survey will be published in Yin et al. (in press). The statistical methodology is available in Yin and Benoît (2022).

It is important to note some considerations for including comparative fishing data in stock assessments. Only Type 1 standard stratified random sets are included in stock assessments at this time. In some comparative fishing experiments, both tows in a given pair are Type 5 comparative because the set location was not random. In these cases, neither vessel collected data according to the survey's standard design and therefore it cannot be included in typical survey indices. However, in other experiments, the primary survey vessel conducted the regular survey (Type 1 sets) while the other vessel conducted a parallel comparative set (Type 5 sets). These data, if converted as recommended, might be interesting to include in analyses, depending on the analytical methods. They might not be useful for traditional stratified methods because they may cause autocorrelation or other patterns that are not representative of the ecosystem, but they could be of interest if spatial methods are employed. In cases where presence and absence data is needed, both Type 1 and Type 5 sets may be useful if a stratified random design is not assumed. Ultimately, no matter the analytical method, work would be required to ensure that it is statistically acceptable to include both set types. Data users should also read the "Sampling Protocols" portion of this document (3.4) to ensure appropriate use, as protocols have varied over time.

Another important note is that there is a difference between the recommendation of a conversion factor of 1 and the recommendation of no conversion factor. If a conversion factor of 1 is recommended, there is enough certainty in the results that we can state that one vessel and net combination is equal to the other. If no conversion factor is recommended, there is too much uncertainty to have confidence in the results. Various issues in the collected data or methodology are possible, but the recommendation of no conversion factor does not eliminate the possibility of a real difference between one vessel and net combination and the other.

Studies 1 and 2: *Cameron* with Y36 vs. *Hammond* with WIIA (1979-1981); *Hammond* with WIIA vs. *Needler* with WIIA (1983).

Two comparative fishing experiments bridged the gap between the first primary survey vessel and gear -- the *Cameron* with Y36 -- and the second, the *Needler* with WIIA. Between the *Cameron*'s decommissioning and the *Needler*'s commissioning, the charter vessel *Hammond* with WIIA gear was employed. The *Hammond* was a stern trawler and similar in size and horsepower to the *Needler*, so with both these vessels fishing the WIIA trawl, there was not expected to be any difference in their catches (Koeller and Smith 1983). Three studies used these data: Koeller and Smith (1983), Fanning (1984), and Fanning (1985). Koeller and Smith (1983) presented an initial analysis of the first experiment, the results of which were not meant for application; however, the study was useful because the authors discuss the many

considerations of designing comparative fishing experiments generally and the problems and limitations associated with the data from the first experiment in particular. Fanning (1984) also presented an initial analysis, this time only of silver hake data from the second experiment. Fanning (1985) is the third and most comprehensive analysis, which calculated conversion factors for 10 commercial species: Cod, Haddock, White Hake, Silver Hake, Pollock, Redfish, American Plaice, Witch Flounder, Yellowtail Flounder, and Winter Flounder. The results from Fanning (1985) are what was considered for application in fisheries assessments.

Koeller and Smith (1983) identified several problems that introduced uncertainty related to the first study's results. For example, problems with vessel speed monitoring meant that the *Hammond* consistently towed farther and faster than the *Cameron*. This may have had an impact on data standardization, as well as fish and trawl behaviour. Another issue was that the trawl design for the WIIA had not been finalized and may have since changed (see "Trawl Modifications" section in this document), affecting the forward application of conversion factors calculated using data from the first comparative fishing experiment. There were also small sizes, differences in catch composition between vessels, and poorly distributed data for some species. Some of these problems persisted in the second experiment, while others were remediated in the sampling methodology or in the analysis (Fanning 1985). The conversion factors calculated in Fanning (1985) for Pollock (*Cameron-Hammond* and *Hammond-Needler*), Silver Hake (*Cameron-Hammond*), Redfish (*Cameron-Hammond*), and Winter Flounder (*Hammond-Needler*) were identified specifically as unreliable. Fanning (1985) indicated an intention to perform another experiment between the *Hammond* and the *Needler* in 1985, with the purpose of supporting or rejecting the results, but this third experiment did not materialize.

Despite uncertainties, the results of the first two comparative fishing studies were generally consistent with what was expected. The WIIA is a larger trawl net than the Y36, with a greater wingspan (1.2x greater in shallow tows and more in deeper water) and headline height, that was designed to better capture a diversity of groundfish species (Carrothers 1988). As such, it was expected to better catch species that live higher from the bottom and those that are better captured when there is a wider wingspan and a greater area swept. In practice, there were higher catches of Redfish and Silver Hake, which tend to be distributed farther up from the substrate and will be more effectively caught by a trawl with a higher headline height. Catches of Haddock, which tend to remain closer to bottom and produce higher catches with wider trawls with greater swept areas, were also slightly higher with the WIIA. The WIIA has larger rollers on the footrope, leaving more space under the trawl for escape by species or size classes which tend to respond to threat by hiding at the substrate, including some small juvenile fish and many flatfish and skate species. The comparative fishing results indicated that, for some flatfish, the Yankee caught more than the WIIA, perhaps due to this phenomenon.

For most species, no attempt was made to calculate conversion factors for the changes in trawl and vessel, while for some species, the precision of calculated conversion factors was not sufficient to recommend them for use (Fanning 1985). Given the range of observed differences in the catch of the two trawls, and the differences in their design, assuming a conversion factor of 1 where nothing has been recommended is unlikely to be appropriate for all species and care should be exercised in deciding how to integrate data from the two time periods in any analyses. Spring surveys from 1978-1985 always used the WIIA trawl, so including these data in analyses

of species abundance that bridge this time span may be helpful in determining if a conversion factor of some nature may be advisable.

Whether or not the conversion factors from Fanning (1985) were applied in fisheries assessments was determined on a species-by-species basis by each species' assessment lead. The general rule is that if a conversion factor is applied in a species' assessment, it is also applied in the survey report series. Briefly, some decisions that were made about these conversion factors include:

- Cod – The suggested conversion factor was initially applied to the 4X5Y and 4VsW Cod data collected before 1981, but in the 1990s, the decision was made to only use data collected since 1983 due to uncertainty caused by residual patterns in previous assessments that were attributed to the changes in vessel and gear (Clark et al. 1995; Mohn et al. 1998). In the summer survey report series, the conversion factor of 1.2 was applied instead, equivalent to the change in wingspread between the two nets and roughly equivalent to the difference in catchability coefficients for cod from the two nets calculated through population modelling (Clark 1997). The conversion factor is no longer used in the survey report to be consistent with the assessments.
- Haddock – The suggested conversion factor of 1.2 has been applied to 4X5Y Haddock data collected before 1981 since it was suggested, with the latest decision to continue applying the conversion factor in the 2016 framework assessment (Wang et al. 2017).
- Pollock – A large conversion factor (>2) was calculated but considered unreliable. Due to this, and comparisons that showed that Pollock catches were similar among vessel, no conversion factor was applied to data collected before 1981 (Trippel and Brown 1993). Since the 2004 framework assessment, data from before 1983 have since been omitted from Pollock assessments, in part because of concerns about the appropriateness of conversion factors (Stephenson 2004).
- Silver Hake – A large conversion factor (>2) was calculated for data collected before 1981 but considered unreliable. Biomass data for Silver Hake are only used since 1982 as a result.
- Redfish – While the Fanning analysis was not sufficiently precise to recommend a specific conversion factor for Redfish, it did indicate higher catch by the new trawl and vessel, as was expected based on trawl design. A conversion factor of 1.8 (the combined Fanning conversion factors for *Cameron-Hammond* and *Hammond-Needler*) was applied in the survey report to Redfish data collected before 1981 for a period of time in the mid-2000s, but removed to be consistent with the stock assessments. There is no specific recommended conversion factor calculated from these comparative data.
- Flatfish – Fanning (1985) recommended a conversion factor of 0.8 for Witch Flounder and Yellowtail Flounder. This conversion factor continues to be applied for all flatfish (American Plaice, Witch Flounder, Yellowtail Flounder, and Winter Flounder) included in the summer survey report except for Halibut.

Study 3: *Needler* with WIIA vs. *Teleost* with WIIA (2005-2006).

A variety of logistical factors prompted the third comparative fishing study. In 2003, there was a fire aboard the *Needler* that resulted in the requirement for extensive repairs; it was not available for the 2004 spring or summer surveys which were completed by the *Templeman* and the *Teleost* respectively. Previously, the *Templeman* replaced the *Needler* when it was



The CCGS Teleost as photographed from the deck of the CCGS Alfred Needler during the summer 2005 comparative fishing experiment.

unavailable without needing conversion factors because the two were sister ships. However, in 2004, the decision was made to reduce the number of offshore fisheries research vessels in the Atlantic from three (*Needler*, *Templeman*, and *Teleost*) to two (*Needler* and *Teleost*). It was also recognized that the *Needler* was near retirement. When the *Templeman* was retired and only the *Teleost* was available to replace the *Needler*, the comparability of the two vessels' data was unknown and comparative fishing was necessary between the *Needler* and the *Teleost*. Comparative fishing was conducted on the summer survey in 2005 and the spring surveys in 2005 and 2006. Only the results from the summer 2005 data were analyzed and published, but the spring 2005 and 2006 data were explored; that exploration

determined that results were consistent with summer 2005. In 2024, the summer 2005 comparative data were reanalyzed separately (Yin et al. 2025b), with the spring 2005-2006 data anticipated to be analyzed separately as well.

Several analyses were conducted using the summer 2005 data and the results were ambiguous. An unpublished analysis indicated that there was a trip effect, variation in which of the two vessels caught more for most species among trips, suggesting that there were differences in how the gear was rigged or fished among trips that were more influential than any differences related to the vessels (D. Clark, pers. comm.). Calculation based on the data from Maritimes trips suggested conversion factors might have the opposite direction from conversion factors for the same vessel change calculated for the Southern Gulf survey, which begins only one month after the summer survey ends (Benoît 2006; Fowler and Showell 2009). A third analysis at the strata-level indicated that conversion factors were not necessary (Hanke and Clark 2007). Given the inconsistency among results from different trips, and the fact that no permanent change in primary survey vessel was planned, no conversion factors were recommended between the *Teleost* and the *Needler*. A reanalysis of these data in 2024 confirmed these results and concluded that for all species included in the initial analysis except for Redfish and American Plaice, no conversion factor was necessary (Yin et al. 2025b). The reanalysis included many secondary fish and invertebrate species; refer to that document for a full list of recommended conversions.

Not Studied: Sister Ships *Needler* and *Templeman*, and *Teleost* and *Mersey Venture*

Two sets of sister ships have been used for research vessel surveys in the Maritimes Region. 'Sister ships' in this case refers to vessels built to identical specifications by the same shipyards, at the same time or sequentially. The *Needler* and the *Templeman* were stern trawlers built together and brought into service in 1981-1982. When the *Needler* was unavailable (spring surveys in 1993 – 5Z only, 2004, 2007, and 2008), the *Templeman* was employed using the same WIIA gear. The data were assumed to have no vessel effect due to their similarities, and no conversion factor was deemed necessary. The *Teleost's* sister ship, the privately owned *Mersey Venture*, was chartered for a shortened spring survey in 2018, when neither the *Needler* nor the *Teleost* could be brought into service in time for the spring survey. The *Mersey Venture* was chartered again for the spring survey in 2023. The data were assumed to have no vessel effect, and no conversion factor was deemed necessary.



Sister ships CCGS Alfred Needler and CCGS Wilfred Templeman at the Bedford Institute of Oceanography.

Unanalyzed data: Western IIA vs NEST (2012-2016)

In 2009, the US NEFSC's bottom trawl surveys switched from the Yankee 36 trawl that they had used since the beginning of their times series in the 1960s to the NEST. For a short discussion and description of the NEST gear, see "Section 3.3.3. Vessels and Gear" and Table 8. In the interest of achieving ecosystem monitoring objectives and collaborating further on transboundary resources, DFO Maritimes decided to employ the NEST gear. Comparative fishing took place from 2012-2016 in anticipation of the NEST being the trawl that the new vessel would use when it came into service and to assess whether or not the NEST gear was suitable for use in this Region.

From 2012-2016, comparative tows using the WIIA and the NEST were completed by the *Needler* to test the NEST, train vessel deck crews, and determine whether it could capture the full size range of commercial groundfish species. This comparative fishing design was different than all other experiments completed in the Maritimes because it used only one vessel. The *Needler* had extremely experienced crews who could change from net to net within 30 minutes, so the two trawls were deployed one after the other. At each station, the ship would trawl once with the WIIA, then return to the beginning of the trawl track and trawl with the NEST in parallel. The tracks of the two trawls did not overlap. The number of comparative sets completed each survey varied (Table 9), with the most on the 2013 summer survey (n=91).

The data from the 2012-2016 comparative fishing experiments have not been fully analyzed. An unpublished analysis of the 2013 summer data determined that the NEST was capable of capturing the full size range of commercial groundfish whose assessments depend on survey indices (D. Clark, pers. comm.). In general, the results showed that the NEST caught as much or more of almost all fish species in a 1 nm tow than the WIIA did in a 1.75 nm tow. It also

indicated that catches of large fish with the NEST were equivalent to catches with the WIIA, despite a slower towing speed. On this basis, the NEST was selected as the new trawl for Maritime and Southern Gulf surveys. Similar results were observed for the other comparative data. As they have not been published elsewhere, we have included details about the comparative sets from the 2013 survey and the length frequency plots in Appendix C. A wider analysis is possible, and there is potential to quantify the NEST's net effect separate from the vessel effect, which may be useful for aligning the DFO and NEFSC bottom trawl surveys that both now use the NEST gear but with different vessels. Current comparative fishing (*Cartier* with NEST vs *Needler* with WIIA) only allows vessel and net effects to be explored together.

3.3.5. Trawl Modifications

The standardized trawls, as designed for the Maritimes Region's trawl surveys, are detailed in Carrothers (1988). The Y36 trawl was identical to the trawl used for NEFSC surveys for decades, until they adopted a new vessel (NOAA ship *Henry B. Bigelow*) and trawl (the NEST) in 2009. The Y36 was used unmodified, in the design included in Carrothers (1988), on DFO vessels between 1970 and 1981.

Unlike the Y36, the WIIA trawl has been modified since it was first deployed on the surveys in 1982. Carrothers established the initial design for the WIIA in 1979. The design was modified by Ships Branch (now the Canadian Coast Guard) before it was put into service on DFO surveys. The changes were documented in internal memos beginning in 1984, but not included in Carrother's 1988 document. For example, some components were difficult to source, so they were replaced. Other changes were made to reduce the frequency of trawl damage, to floats, to the thickness of combination wire used in several parts of the trawl, and to the codend liner. As these changes were clearly made prior to the net being employed for surveys, they have no impact on the continuity of the survey data.

Since the WIIA trawl was first deployed in Maritimes Region surveys in 1982, several other changes have been made or noted. Several of these were noted in internal memos between Ships Branch and Science in 1988. These and some others were noted in Strong (1992) but others have not yet been included in a published document. The most recent WIIA trawl design was formalized in the *Survey Trawl Reference Manual* (DFO and Marine Institute 2007).

Differences between the published design and the net used on the survey vessel that were noticed and documented internally in 1989-1990 (Croft 1989; Strong 1989, 1990), included in Strong (1992), and formalized in memos in 1994 (Strong 1994; Wheelhouse 1994) include:

- The codend mesh used since the trawl was adopted was 3", rather than 3.5" as specified. To achieve the correct length, the codend is 95 meshes deep instead of 75. As the length of the codend was the same and the mesh was similarly sized, this was unlikely to have impacted the catch.
- The belly extensions were reduced from 42 meshes to 39 meshes, a simplification that made the panels and riblines shorter. The change was made by suppliers to reduce cost and increase the ease of replacement. It was unlikely to have impacted the catch.
- The bunt bobbin at the end of the footrope was changed to an 18" "half-egg" from a 21" round bobbin. This reduced weight and the extent to which the trawl would sink into soft substrate. This change was made at some point in the early 1980s. On muddy areas,

this would have reduced the degree to which the footgear dug into the substrate and thus reduced the amount of benthic matter in the trawl. It would have had negligible impact on sets not made on mud.

- The doorleg/sweepline extensions were reduced to 21' from 34'. This meant the warp out was 13' longer on the *Hammond* than the *Needler*. Strong (1990) consulted vessel staff and concluded that this had been done since the beginning of the *Needler's* use. It is unlikely this would have resulted in a noticeable difference in gear spread, and, hence, in fish catch, in any but the shallowest of tows.
- 19-ft removable wedges of netting that closed in the lower wing area for flatfish capture on smooth bottoms were eliminated because they caused tear-ups and fouling. Strong (1992) states that these wedges were never used on the *Hammond* or the *Needler*.

Fishing Wire: Very soon after comparative fishing was done in 1982, a section of fishing wire that repeatedly caused tearing in the trawl wings was removed. This section of wire would have been used as the attachment line for the removable wedge, had the wedge been used. The removal of this section of wire impacted how the net hangs on the footrope, and thus the catch. As the date of this change was unclear, the Fishing Master on the *Needler*, who had sailed on the vessel since it was delivered, was consulted in the 2010s; his recollection was that the fishing wire was removed after the *Needler's* first trip, and thus after comparative fishing.

Toggle Chains: In the late 1990s or before, the toggle chains connecting the fishing wire to the footrope were altered from their original configuration (21" toggle chains with ten links in the chain) to the current configuration, as the original parts were no longer available. Currently, 24" chains with seven links to the chain are used, meaning that the trawl hangs farther back from the footrope than it did in the past. However, the change does not leave any additional vertical gap for fish to escape between the footrope and fishing wire since the toggle chains are horizontally oriented.

Floatation: There have been changes to the number of floats and their total buoyancy on the headrope. When the trawl was adopted, steel floats were employed. In 2000, the number of floats was increased from 68 to 78, when plastic replaced steel. This change was based on the manufacturer's buoyancy information. In 2004, new floats were purchased, and the number of floats required to provide the appropriate buoyancy was recalculated using the manufacturers specifications for the floats. The number of floats was reduced to 63. Later testing determined that the manufacturer had misrepresented the buoyancy, and in 2007, the number of floats was increased from 63 to 68, with the same distribution as in the 1980s. Furthermore, the 78 floats used for 1990-1993 were too many for the required floatation, and it is likely that 68 should have been used for all years. Changes to the floatation of the trawl over time are documented in internal faxes and emails (Dominix 1996; Strong 1996; Abbott 1996; Hurlbut 2000, 2007; Clark 2007; Reid 2007).

Whether or not changes in floatation impacted trawl performance is difficult to determine, as there was no monitoring of trawl parameters for most of the survey history. Headline height is directly related to wingspread, and wingspread is determined by the spreading force of the trawl doors, which increases in deeper water and softer substrates (Clark 1993). Forces from the floats are inconsequential in comparison to the larger forces from the trawl doors. If the number of floats is sufficient to keep the headline up, the floats are unlikely to impact gear dimensions,

so changes to the number of floats likely did not have a substantial impact on headline height or trawl catch.

2004 Summer Survey: In 2004, the responsibility for the maintenance of the trawl gear was divested from CCG vessel crew to DFO Science staff. The person given responsibility for gear maintenance was unaware of the differences between the trawl as documented in Carrothers (1988) and the trawl design used in practice, and so the trawl was fished with the fishing line in place and 21" round bobbins at the ends of the footrope for the 2004 summer survey. The Carrothers configuration ensures that the fishing line (the bottom of the trawl) rides above the footgear, separated by the length of the toggle-chains which connect the fishing line and footgear. The modified configuration used in all other years, where the 19' section of fishing line is removed, results in the net hanging behind the footrope with the toggle chains horizontal instead of vertical. As a result, during the 2004 survey, Science staff noted that they caught far fewer benthic invertebrates and detritus.

While the change had an obvious impact on catch of sessile benthic organisms, it is not clear if it had an impact on many other species. Indices from 2004 have been used in assessments with no issues flagged. No systematic effort has been made to compare catches from 2004 with those from adjacent years to see if there were any anomalies. A review of data from 2003 – 2005 for species which are strongly associated with the substrate -- such as skates, flounders, sculpins, pouts, blennies and shannies -- could help determine if there were any systematic changes in catches in 2004 that may be related to the changes in the trawl in that year. This would also help determine whether modifications in trawl design in the early 1980s had an impact on the utility of comparative fishing results from 1983.

3.3.6. Fishing Protocols

Standard fishing protocols were documented in Koeller (1981) and (Chadwick et al. 2007). A standard set for both the Yankee 36 trawl and the WIIA trawl is a 30-minute tow at a speed of 3.5 knots for a standard distance of 1.75 nautical miles, timed from when all warp is out, and the winches are locked to the start of the haulback. Tows of less than 20 minutes or greater than 40 minutes duration are not considered to be valid sets. Alternate stations, selected before the survey begins, may be substituted depending on circumstances (e.g., presence of fixed fishing gear, untrawlable bottom at a station, etc.). Set positions may, in general, be moved up to a maximum of 1.75 nautical miles to avoid unfishable bottom. The original protocol allowed for a set to be made along the path to the next station at the first position where it appears possible to make a successful tow. The Chief Scientist has some discretion to exceed 1.75 nautical mile deviation where circumstances require it. Tows must not cross stratum boundaries. For stations in the Georges Bank area, tows should not cross the 5Zjm NAFO boundaries as these are used as dividing lines for some species assessments.

Warp-to-depth Ratios. Before 2005, the amount of warp deployed was determined by the officer on the bridge. A standard ratio of 3:1 was used since 1981, dropping to 2.5:1 in depths > 150fm (~280m) (Strong 1992). The exact amount of warp to ensure the doors remained upright and did not lift off bottom was left to the discretion of the Bridge crew on the vessel. Often, this meant that they used less warp than was recommended in deeper tows and on rougher bottom. Warp deployed has been recorded for survey sets since 1991 and data from the 1990s show a much greater variability in warp-to-depth ratios than in recent years (Clark 2005). It also shows

variation in warp-to-depth ratios used by day and night crews on the same trip, along with inter-annual differences among surveys. There was a general tendency to lower ratios at depths less than 100 fathoms in recent years. This pattern began to change around 1999, and since 2005, a warp-to-depth ratio table for the WIIA trawl has been used consistently to determine the amount of warp deployed (Table 10). The move to using a consistent warp-to-depth ratio table reduced overall variability, variability among vessel crews, and inter-annual variability. More warp will increase door spread in depths less than about 200m, but this is also influenced by bottom type and currents (Clark 1993). On average, there is now slightly greater spread and lower headline height, the change may also have improved bottom contact and door stability in shallower sets. Spread is generally slightly higher in shallower depths than the average in earlier years, but it falls within the range of what was used in the past.

SCANMAR™ trawl geometry data were collected from 1990-1994 and since 2005. In the earlier period, data were logged every 20 seconds, while more recently it is every second. These data were not used to adjust net performance after the net began to tow on the bottom, or to determine the duration of the tow. Older data are kept in Oracle tables in the 'GROUNDFISH' schema; more recent data are stored in flatfiles. The 1990-1994 data and collection protocols are summarized and reviewed in Koeller et al. (1994). Uses for the data which have been collected include: describing the variability in trawl performance, calculating actual swept areas and evaluating the success of the swept area method of abundance estimation, and quality control (Koeller 1991; Strong 1992; Koeller et al. 1994; Strong n.d.). SCANMAR™ is used by the vessel crew to assist in deploying the trawl to a precise location to avoid obstructions on the bottom. Besides this use, these data have not been analyzed since 1995. Tolerance ranges, used to set limits beyond which the catch will not be accepted, have not been developed for the WIIA. Approximate ranges for the WIIA are ~3-4 m in height/opening, ~11-15 m in wing spread (up to 18 m on soft substrate), and ~40-80 m in door spread (Koeller 1991; Clark 1993). Door spread peaked at 50-60 m on harder bottom (cobble and sand) and ranged from 70-80 m on mud (Clark 1993). Headline height is negatively correlated with wing and door spread; wingspread is largely driven by doorspread and apart from in muddy areas, correlates strongly with depth (Clark 1993).

3.3.7. Staffing

West Coast Canadian surveys and many ICES surveys only collect data by daylight, but surveys in Atlantic Canada, along with NOAA surveys in the adjacent US waters, conduct trawling 24 hours a day; this requires two shifts of staff, each working 12 hours total per day. As a result, it is necessary to note that the survey data includes diurnal variability in catch for species that vertically migrate, such as redfish or zooplankton (Pitt et al. 1981).

The CCGS *Alfred Needler* carried as many as eleven science staff. All surveys have a Chief Scientist and two watches with four general samplers, one of which is a watch leader. Until the mid-2010s, there were instead two data recorders and two general samplers. Today, the four samplers rotate through data entry and sampling tasks. One benefit of this is that it allows more staff to be fully trained on all biological data collection tasks. The two remaining berths are allocated to oceanographers who each work 12 hours per day; one staff person is provided by the AZMP and the other is provided by the surveys program.

The surveys employ additional special samplers and observers when possible. Previously, two of the general samplers on the spring and summer surveys were also trained stomach samplers, collecting and analyzing diet information at-sea for inclusion in the Food Habits Database (Cook and Bundy 2010). Currently, general samplers collect and freeze required stomach specimens for analysis on shore. Seabird observers from Environment and Climate Change Canada's Canadian Wildlife Service and marine mammal observers from DFO have participated in the survey intermittently as well. While on the *Needler*, an observer replaces a general sampler, the observers often assist in the fish lab between visual observation transects, since their transects occur between fishing stations when the vessel is steaming. The CCGS *Teleost* can accommodate as many as thirteen science staff; when employed, the usual eleven science staff plus additional seabird and marine mammal observers have participated. It is anticipated that this level of staffing will also be possible in future onboard the CCGS *Jacques Cartier*, providing an opportunity to expand the level of ecosystem observations on a consistent basis.

It is important to emphasize the participation of Federal Science Workplace Employment Program (FSWEP) students in the Maritimes Region's surveys. The summer survey regularly takes FSWEP students to sea to supplement the indeterminant and term employees available during the survey program. Students tend to be keen and energetic participants which more than offsets any challenge resulting from lack of at-sea experience and familiarity with the survey protocols. Having one or two students on each watch along with more experienced staff has been beneficial to the program. Few students can participate in the spring survey because it takes place during the school year.

3.4. SAMPLING PROTOCOLS

3.4.1. Fish and Invertebrate Sampling Protocols

Standardized protocols for sampling fish and invertebrates used from the inception of the summer survey in 1970 onwards were documented by Halliday and Koeller (1981) and Koeller (1981). Previously, sampling protocols varied from survey to survey, but all groundfish surveys in the region, including special purpose surveys, used the at-sea standing orders and protocols described in these documents from 1970 to 1994 (Chadwick et al. 2007). The protocols were updated in 1995 to record increased sampling details (Strong and Gavaris 1995). The most recent complete documentation is the Groundfish Bottom Trawl Surveys Manual (Clark and Hatt 2007). All of these are unpublished documents meant primarily for internal use in onshore planning and aboard the survey vessels. A detailed guide to survey procedures was published for the Gulf Region surveys after the Scotia-Fundy Region was divided into Gulf and Maritimes (Hurlbut and Clay, 1990). The information is accurate for the Maritimes Region from 1970-1983, prior to the split.



*Large cod are sorted into baskets in July 2002.
Pictured: D. Clark.*

The general process for fish and invertebrate sample collection, used from 1970 to the present on both the spring and summer surveys, is as follows:

1. For each fishing set, the catch is brought on board.
2. If the set is valid, which almost all sets are, the entire catch is sorted into baskets by species and weighed. When the catch for a species is large (>30- 40 baskets), a subset of baskets (10 – 15) are weighed and other full baskets are counted. The average weight for baskets from that set is used for unweighted baskets.
3. Biological data are collected on individual fish from the weighted baskets: length, weight, sex, maturity, and others depending on the requirements for the individual species. Biological samples (otoliths, scales, tissue, and others) are taken if needed. At a minimum, basic data including total numbers, total weight caught, length frequencies, and individual fish weights should be collected from each successful set, according to instructions in the *Groundfish Bottom Trawl Surveys Manual* (2007). Maturity codes are available in Table 11.



A catch of Spiny Dogfish in the Western IIA trawl aboard the CCGS Teleost (top left). Baskets of Atlantic Cod await detailed sampling (top right). Detailed data is taken from Yellowtail Flounder, which are tagged for release as part of a special sample (bottom left). Once sampled, fish and invertebrates are discarded or released (bottom right).

While sample collection has followed the same general process since 1970, the specifics of the tools used, species identified, and measurements collected have changed over time, these changes include:

Above-deck to below-deck sorting. From 1970-1981, the catch was brought on board and put in wooden pens on the deck and then sorted into wicker baskets. This meant that there was a possibility of small fish species been overlooked and washing away. Since 1981, with the change in vessels from the *Cameron* to the *Hammond* in 1982 and then the *Alfred Needler* in 1983, the catch has been placed into a hopper that directs it below-decks to a scientific laboratory where the sorting is done on a sorting belt, making it easier to sort fish species and enhancing the likelihood that small fish species are not overlooked.

Dial face scales to electronic scales for baskets of fish. From 1970 to 1994, baskets of fish were weighed on a dial face scale in 1 kg increments. Total catches of a species that were less than 0.5 kg were recorded as zero. This means that basket weight of zero means that the species was present. For fish species, if there was no subsample, the length frequency and a length:weight relationship might be used to approximate the basket weight, keeping in mind that the length:weight relationship has changed over time for many species. For invertebrate

species, making a correction is much more difficult without a length:weight relationship and since individuals were not always counted if there were more than 25 present. In these cases, the zeros are likely only useful to indicate presence. In 1995, an electronic platform scale replaced the old scale; this scale is accurate to ± 0.01 kg (Chadwick et al. 2007).

Spring scales to electronic scales for individual fish. The transition from spring scales to electronic balances allowed greater precision in the determination of fish weights. From 1970 to 1990, spring scales were used to weigh individual fish. These scales were accurate to ± 25 g and any weight less than 25 g was not recorded. In 1991, electronic scales accurate to ± 5 g were first used; in 1992, electronic scales accurate to ± 2 g were used; finally, in 1996 a scale accurate to ± 0.1 g was installed on the vessel, intended for use on individual specimens less than 5 g (Chadwick et al. 2007).

Changes to detailed sampling for fish species. Sampling requirements for fish species over time is detailed in Appendix F. All fish species have always needed to be identified to the species level. If it is not possible to identify them at sea, unidentified specimens must be frozen and brought ashore for positive identification. For every fish species, total numbers, total weight, and length frequency data have been collected in all years. The only exceptions are Myctophids, which is a group of species, and Redfish, which includes two species; in both cases, the different species are very difficult to distinguish at sea. Over time, the following changes to detailed sampling for fish species have occurred:

- From 1970 to 1985, length stratified samples were required from 3 fish per 3 cm length group for Atlantic Cod, Cusk, Spiny Dogfish, Halibut, White Hake, Monkfish, Pollock, all skates, and wolffishes; 2 fish per 2cm length group for Haddock; and 1 fish per 1 cm group for all other species. Length stratified sampling was conducted by sex for Silver Hake, Redfish, American Plaice, Yellowtail Flounder, Witch Flounder, Winter Flounder, Halibut, all skates, and Spiny Dogfish. Detailed sampling for selected species included observations of length, weight, sex, maturity, and collection of otoliths.
- From 1986 to 1994, detailed observations were collected only for Atlantic Cod, Pollock, Haddock, Silver Hake and American Plaice, with data on maturity collected only for Silver Hake. During this period only length frequencies were required for all other fish species.
- In 1995, the summer survey resumed the practice of recording individual fish weights from a length stratified sample for every species of fish and selected commercial invertebrates. From 1995 to 1997, the summer survey again recorded maturity stages for species where detailed observations were made, but since 1998 only Silver Hake maturities have been required in the summer, due to the difficulty in differentiating immature and resting stages.
- The spring survey continued to follow the protocol of collecting individual fish weights only from the primary commercial species (Atlantic Cod, Haddock, Pollock, and Yellowtail Flounder) until 2006.
- Since 2007, the standard data collection protocols for spring and summer surveys have been nearly identical. The only major difference is that maturity data are collected for more species in the spring, as there is less problem with visually distinguishing important maturity stages at that time of year.

- Since 2014, when the new Ecosystem Science Entry (ESE) system was introduced, it has been easier for samplers to determine how many weighted baskets are “enough” to sample biologically. Generally, a length frequency that is representative of all the lengths in the catch of a given species is required. Before the ESE, samplers would sample all weighted baskets, which could be hundreds of fish and amount to oversampling. The ESE introduced a function that provided the length frequency to samplers. However, many samplers continued to prefer being instructed to collect a specific number of individuals. The suggested number is usually between 100 and 200, depending on the magnitude of the catch and the length range captured.

Currently, standard data collection protocols dictate that length stratified samples are required for all fish species from each set with 3 sampled per 3 cm length grouping for Atlantic Cod, White Hake, Cusk, Pollock, Halibut, Wolffish, Barndoor Skate, Thorny Skate, Winter Skate, and Spiny Dogfish; 2 per 2 cm for Haddock, and 1 per 1 cm stratification for most other species. Otolith collection is restricted within groups of strata. The defined limits are selected to provide at least as many otoliths as will be aged for a stock, with samples available from all areas, while avoiding the collection of far more otoliths than will be analyzed.

Detailed observations required from stratified samples are:

- Individual specimen length and weight for all fish species.
- Length, sex, weight and otoliths for Atlantic Cod, Haddock, White Hake, Cusk, and Pollock, with maturity also included in spring surveys.
- Length, sex, weight, maturity and otoliths for Atlantic Halibut and Silver Hake, with maturity and otoliths omitted from Silver Hake collections during spring surveys.
- Observations by sex (1 per 1 cm per sex) for Silver Hake, Redfish, all flatfish, and some skates.

Changes to food habits (diet) information collected. Stomach sampling was not originally part of the surveys program. Data were first collected from 1999-2002 from the spring and summer surveys, as part of the Comparative Dynamics of Exploited Ecosystems in the Northwest Atlantic project. Stomachs were collected at sea, frozen, and then processed on land. The program paused, and then from 2005 a new protocol was put in place where staff were trained to dissect and analyze stomachs at sea. Since 2016, stomachs have again been frozen for processing on land. A summary of the methods and data collected and stored in the Food Habits Database is available in Cook and Bundy (2010). It is necessary to note that, like all other biological data collected on the survey, the length (1 per 5 cm) and spatial stratification must be accounted for in any analysis. Cook and Bundy (2010) include a method for converting the raw data that accounts for stratified sampling.

Changes to detailed sampling for invertebrate species. Sampling requirements for invertebrate species over time is detailed in Appendix F. With the exceptions of Shortfin Squid (*Illex illecebrosus*) and American Lobster (*Homarus americanus*), sampled since the beginning of the survey, invertebrates have been added to the sampling objectives over time. The greatest increases occurred from 1999-2005, 2007, and 2017. Increases in the number of species sampled roughly align with these dates (Figure 11). Today, many species are identified to a greater level of taxonomic detail than they were originally (Figure 12); to capture these increases, data can be queried by taxonomic level as exemplified in Appendix G.

- From 1970-1998, the only invertebrate species that were consistently identified to the same taxonomic level were Shortfin Squid (*Illex illecebrosus*) and American Lobster (*Homarus americanus*). While sampling of *P. borealis* and Snow Crab (*Chionoecetes opilio*) was included in the original survey plans, these sampling requirements were quickly discontinued in the early 1970s. Data for many other invertebrate species, especially commercial species, was collected either as part of a special sample (as in the case of Snow Crab) or at the discretion of the survey staff if it was not specifically requested.
- Beginning in 1999, increased sampling of invertebrate as “special sampling”, meaning sampling to be completed as time permitted, was introduced for the summer survey. This requested details for large decapods and selected other invertebrate species, along with total weight and total number for a larger list of species or species groups (Appendix F). While this new initiative was immediately embraced by staff on the second leg of the summer survey (in 4VW) and appears to have been conducted consistently, staff on the first leg (4X and western 4W) treated it as sampling to be completed only as time permitted. It was not until 2003 that collection of data for the shrimp *P. montagui*, for example, became consistent on the first leg of this survey. Similarly, data for starfish (Asteroidea) were not collected consistently on the first leg of the survey until 2002. Sampling of this list of invertebrate species became a standard requirement, as distinct from “special sampling” in 2005. Interpretation of distribution information for newly sampled invertebrates between 1999 and 2005 should acknowledge the phasing in of this protocol in the western half of the survey range in these years.
- Recording for corals was sporadic before 2000. In the early 2000s, samples were retained for detailed work onshore and added to the database post-survey. Starting in 2006, all corals have been sorted and weighed by species, and identifications have been corroborated onshore.
- As of 2007, the sampling goal for invertebrates for both spring and summer surveys has been to identify all invertebrates as precisely as possible. This led to a steady increase for several years after 2007 in the number of taxa of invertebrates recorded. When reviewing survey biomass estimates for groups of invertebrates, which would have been lumped into higher taxonomic groupings in the past, records for all higher taxa would need to be summed in recent years. Identifications were not regularly quality controlled, so species identifications for echinoderms and less common shrimp should be questioned if they are recorded from well outside their usual habitat. If collected before 2017, there are no pictures available for quality control and so very unusual species could be misidentifications.
- In 2017, the quality-controlled level of taxonomic precision required for invertebrate species increased, particularly for species of sponges and corals that were previously grouped in a large category such as order or phylum. Most invertebrate species are today identified to the genus or species and photos taken for all invertebrates for quality control onshore. In addition, since 2017, a picture of all the invertebrates from each set is taken, in order that identifications can be checked later, if questions arise.

Changes to sampling protocols for macro-algae. Macro-algae (e.g., seaweed) was occasionally recorded, generally depending on the survey staff’s interest, before 2021. In 2021, when identification guides were provided, it began to be recorded more systematically. Currently, whether or not it is recorded is inconsistent but better than before 2021.

Changes or problems with species identifications

- From 1970 to 1978, White Hake (*Urophycis tenuis*) and Red Hake (*Urophycis chuss*) were not distinguished from one another because the standard identification reference document at the time grouped the two species together (Leim and Scott 1966). From 1978 on, the species have been identified separately with confidence using the individualized characteristics eventually published in Scott and Scott (1988).
- Two species of redfish that are difficult to distinguish at sea are included under one species code (23): Deepwater Redfish (*Sebastes mentella*) and Acadian Redfish (*Sebastes fasciatus*). The two species occur in different habitats and can be somewhat distinguished by depth.
- Little Skate (*Leucoraja erinacea*) and Winter Skate (*Leucoraja ocellata*) cannot be visually distinguished at lengths <40 cm. In 2011, a new code (1191) was added to the database for Little and Winter Skates <40 cm. A review of length frequency data collected using the new code found that nearly all individuals between 35 and 40 cm were Little Skate but that when the cutoff was changed to <35 cm, nearly all skates of lengths 35-40 cm were identified as Winter Skate because they were immature (DFO 2015). As a result, Little and Winter Skates <40 cm continue to be combined and specimens >40 cm continue to be separated on the surveys. Data collected from Little and Winter Skates <40 cm before the new code was created or that is included in the individual species codes (203 and 204) should be treated as a mix of the two species, as uncertainty in the identifications is high.
- Fowler and Showell (2009) identify several species whose identifications may have been confused during the 2005 comparative fishing experiment: sea cucumbers, sand dollars, sea urchins, starfish, Iceland Scallops (confused with Sea Scallops), Jonah crabs (confused with Rock Crabs), *Pandalus borealis*, and *Pandalus montagui*. Generally, these are species whose identifications were phased in from 1999-2005 (Appendix F). Confidence in our identifications of these species has improved significantly since 2005, and data since that time can generally be trusted. Confidence in data before 2005 can be increased if analysis is performed at a higher taxonomic level than species. If there is concern about two species, like Jonah Crab and Rock Crab, that occupy different habitats, the data could be validated using depth or strata information.

Changes to the measurements required for certain species.

- For most fish species, fork length is measured on an offset measuring board. Until 2015, fork lengths for herring were taken on a non-offset measuring board to the nearest centimeter at sea. Two per centimeter were retained for onshore sampling, which included measurement to the nearest half centimeter and otolith collection. However, herring were not labelled individually so data collected onshore could not directly be merged with data collected at-sea. The age-length key could be used against the survey lengths but the individual fish that were aged could not be identified in the survey data. Since 2017, total length (pinched caudal fin in millimeters) has instead been taken on a non-offset measuring board. Retained fish, which are individually labelled with a fish number, have their otoliths extracted onshore and the ages are added to individual fish records in the survey database.
- Initially, the sampling requirement for grenadiers and chimaerids was total length, as it was for other species with heterocercal caudal fins, such as dogfish. However, because

grenadiers and chimaerids' tails often break in the trawl, it has been a requirement since 2019 for samplers to take pre-anal fin length to the nearest mm on a herring board. In 2011 on the deep sea leg of the summer survey, pre-anal fin length to the nearest cm was also taken. This requirement can be seen in the length-weight data (Figure 13). Correction of errors and a length-weight relationship conversion between the two measurement types is required for the time series to be useable, though caution should still be applied when using total length data as incomplete specimens may have been measured.

- Lobster and crabs are measured to the nearest mm using calipers: carapace length for lobster and carapace width for crabs. Shell height (mm) is measured for scallops using calipers or a scallop measuring board. Squid mantle lengths (cm) are measured on the regular measuring board. Individual weights are taken for squid, but not regularly for scallops since they can retain water and sand. For lobsters and crabs, individual weights were recorded until summer 2021; from 2015 to spring 2021, weights were recorded for intact specimens only.
- Glass sponges (Russian Hats) have had total length (mm) recorded since 2016. Width (mm) and osculum diameter (mm) measurements are also available since 2017.

Changes to which otoliths are collected at sea and how they are stored. Groundfish otoliths (Atlantic Cod, Haddock, Pollock, Halibut, White Hake and Cusk) otoliths have always been collected at sea and stored dry in envelopes for processing on shore. Silver Hake otoliths have also always been collected at sea. Until 2017, they were stored wet in glycerin but since then they have been stored dry in envelopes. Yellowtail otoliths were collected on the summer survey from 1970-1985. On the spring survey, yellowtail scales were collected from 2004 to 2019, but otoliths have been collected and stored dry since 2020. Whole herring were collected at sea until 2008 with most biological sampling done on shore. Since 2009, length stratified sampling for herring is done at sea. Individual numbered fish are retained for otolith removal onshore and ages are then recorded in the survey database. Dissecting herring for their otoliths on land is intended to eliminate breakage as the otoliths are small and more difficult to remove than groundfish otoliths.

Changes to unidentified species collection. Before 1999, unidentified species codes 1091-1095 were made available so that unidentified specimens could be frozen for later identification on land. Since 1995, unidentified species codes 9991-9999 have been available. These new codes have been used consistently on both surveys since 2007, when the goal of identifying all specimens as precisely as possible was put in place. Prior to 2010, Huntsman Marine Science Centre staff at the Atlantic Reference Centre identified these specimens. Since 2010, DFO staff have identified them. Since about the same time, unidentified species have been photographed before they were frozen, if possible. The photo number was recorded in the comments of the electronic record, to aid identification. By area (e.g. nm²), there tend to be more unidentified species along the edges of the Scotian Shelf or Georges Bank because species that the survey does not encounter as often are seen in these deeper waters (Figure 14). Two years are anomalies: 2010, when the deep water strata from 750 m to 2000 m along the shelf edge (in 2011, named strata 501-505) down to 2000 m were surveyed systematically for the first time; 2017, when sponges were first identified to the species following protocols from DFO's Corals and Sponges Program and specimens were collected for onshore verification of at-sea identifications. From 2018 to the present, these species have been identified at-sea only.

3.4.2. Oceanographic Sampling Protocols

Hydrographic sampling has been conducted on the RV surveys since their inception in 1970 (Pepin et al. 2005). While the inclusion of oceanographic data collection during the surveys was motivated primarily by the need to incorporate information on thermal habitat ranges in fisheries assessments (Harrison et al. 2004), it also illustrated the initial motivation to study the wider ecosystem and the broader shift in the survey towards ecosystem-based sampling objectives.



A bathythermograph (BT) cast is made on an early survey.

Special attention has been consistently paid to the timing and position of the hydrographic observations that are paired with trawl sets (Hurlbut and Clay 1990). They are made within the depth range of the set, preferably close to the mean depth of the tow and therefore, generally after the trawl set is complete. If the vessel reverses its engines to assist in the haul back, it must move several hundred meters back along the tow path to move out of the zone of 'mixed' water.

Since 1970, there have been numerous changes to the oceanographic sampling protocols, with most changes accompanying the introduction of new technology.

Unfortunately, these changes are not very well documented. Some early descriptions are available in Koeller (1981), Hurlbut and Clay (1990), Strong and Gavaris (1995), and Harrison et al. (2004), and are described below.

Period 1: Bathythermograph (BT) Casts – 1970-1989

From 1970 to 1989, standard survey protocol included the collection of a minimum suite of hydrographic observations at a subset of fishing stations (Harrison et al. 2004). Vertical profiles of temperature were collected using a mechanical bathythermograph (MBT), and temperature and salinity samples were collected using surface buckets and Knudsen reversing bottles. Hydrographic sample collection was expanded to between one-third and half of all fishing stations by 1988, and included a MBT cast plus temperature readings and water samples taken at standard ICNAF depths (surface, 10m, 20m, 30m, 50m, 75m, 100m, 150m, 200m, 250m, etc.). Additional temperature data were collected between widely spaced stations using expendable bathythermographs (XBTs). Instruments were consecutively and manually deployed on a single wire. Wire angles have been measured, recorded, and compensated for since at least 1981. Prior to this, samples were taken at depths shallower than recorded, resulting in poor correspondence between water bottle bottom temperature observations and bottom temperature observations from MBT casts (Koeller 1981).

Period 2: SEABIRD™ CTD Casts – 1990-1998

Beginning on the summer survey of 1990, Sea-Bird CTDs were introduced to collect full water column profiles of temperature, conductivity (salinity) and oxygen concentration (Losier and Perry 1990; Losier 1990). Water sampling bottles with reversing thermometers were also added at 10 m depth or the bottom to obtain water samples used for sensor calibration. If the sea was too rough or the CTD malfunctioned, an XBT cast with surface bucket temperature and salinity was used. If the XBT was not available, only surface and bottom temperature and salinity were collected.

Throughout the 1990s, dissolved oxygen, fluorescence and PAR sensors were added to the CTD. Water sampling bottles were added at 5 m, mid-depth, and near-bottom for salinity, nutrients, chlorophyll, and dissolved oxygen determination. Starting in 1999, VEMCO™ depth/temperature MINILOGGERS were attached to the trawl during each set to monitor the temperature and to provide a back up to the bottom temperatures measured by the CTD.



The CTD Rosette is retrieved aboard the Teleost in July 2004.

Period 3: Atlantic Zonal Monitoring Program (AZMP), 1999 to present

In 1998, the Atlantic Zonal Monitoring Program (AZMP) was formed to detect, track, and predict changes in the state and productivity of Atlantic Canadian waters (Therriault et al. 1998). The program was designed to build upon existing regional monitoring activities in order to meet the minimum requirements necessary to characterize and understand the causes of oceanographic variability on seasonal, interannual, and decadal timescales, and establish multidisciplinary, baseline datasets that could be used to evaluate the relationships among biological, chemical, and physical variables and how they influence predator-prey dynamics of marine resources (Therriault et al. 1998; Mitchell et al. 2002). At its inception, the Maritimes Region RV surveys were identified as an extremely important source of oceanographic and fisheries data because they cover a broad area and allow for the acquisition of data during seasons when there are few other observations in the Maritimes Region. A brief overview of the data and sample collection in support of the AZMP on the RV surveys is provided below, and a full overview of the program is documented in Therriault et al. (1998).

With the establishment of the AZMP in 1998, oceanographic data collection was expanded and standardized, and three additional days were added to ship-time requests starting in the late 1990s to account for the additional sampling (Harrison et al. 2004). Vertical net tows were

added to the surveys, where a conical ring net of 202 μm mesh size with an aperture of 75 cm in diameter (filtering ratio of 1:5) are towed from near-bottom to surface (or from a maximum depth of 1000 m) for evaluation of mesozooplankton biomass and abundance. At present, ring nets are deployed at approximately 40 primary fishing stations during the summer survey, and between 20-22 primary fishing stations during the winter Georges Bank and 4X survey. Fishing stations located close to the AZMP's core hydrographic lines on Browns Bank (Browns Bank Line), and off Halifax (Halifax Line), Louisbourg (Louisbourg Line), and in Cabot Strait are targeted for net tows on the summer survey along with other geographic and environmental features of interest, while net deployments are allocated to each planned sampling strata during the winter Georges Bank and 4X surveys. Ring nets are equipped with a KC Denmark flow meter, which is used to record the start and end flow for each tow.

In 2002, oceanographic sampling on the surveys was further modernized with the addition of a CTD-rosette with 4 modified bottles for water sampling. At present day, the vertical profiles of temperature, conductivity (salinity), oxygen concentration, chlorophyll fluorescence, irradiance (PAR extinction), and pH (starting in 2015) are obtained using a SBE-25 or SBE-25*plus* CTD fitted on a 12-bottle carousel rosette frame. CTD-rosette deployments occur at all fishing locations on the summer survey, but occur on only a subset of fishing stations on the winter Georges Bank and 4X survey. The following water samples are collected from 4 depths (5 m, 25 m, 50 m, and 'bottom', where bottom is when the CTD/Rosette package is ~2 m above the seabed based on the altimeter):

- 5m: nutrients, chlorophyll-*a*, and oxygen determination
- 25m: nutrients, chlorophyll-*a*
- 50m: nutrients, chlorophyll-*a*
- Bottom: salinity, nutrients, chlorophyll-*a*, and oxygen determination

Chlorophyll, nutrient, and dissolved oxygen samples are collected in duplicate. At stations greater than ~200 m depth, an additional bottle may be closed at 100 m depth for the collection of water samples for nutrient and chlorophyll-*a* determination. More recently, sampling has occasionally included measurements to evaluate the carbonate chemistry system (total inorganic carbon/total alkalinity and partial pressure of carbon dioxide), as well as water samples for eDNA monitoring trials across DFO's marine conservation areas on the Scotian Shelf (L. Beazley, pers. comm.).

The AZMP's high-frequency station Halifax-2, often referred to as the Halifax Hydro station, is usually occupied several times during the course of each survey as the vessel returns and departs from port between legs. On each occasion the following sampling is conducted:

- CTD-rosette vertical profiles of the water column



A vertical net tow, used to sample mesozooplankton, is completed in August 2008.

- Two vertical ring net zooplankton tows from near-bottom to surface (with flow meter); one with each of the 76 and 202 μm nets.
- Secchi depth measurement
- Niskin bottle samples at 10 depths through the water column. Samples analyzed for oxygen, nutrients, salinity, and chlorophyll-*a*
- Depth-integrated phytoplankton sample for microscopic analysis

Several post-processing tasks are completed while on board the vessel (L. Beazley, pers. comm.). Preliminary post-processing of all CTD data is done at sea using the CTD Data Acquisition and Processing System (CTDDAP), a wrapper application developed in-house at the Bedford Institute of Oceanography to facilitate the downloading and processing of CTD data collected by various SBE CTD instruments. Until 2015, water samples collected for dissolved oxygen determination were measured using an ORION 842 bench meter probe. Beginning on the summer survey of 2015, a winkler titration system installed on board has been used for oxygen determination of collected samples. Salinity determinations are made using a Guildline Portasal 8410A salinometer, while chlorophyll-*a* samples are processed using a Turner Designs fluorometer. Nutrient samples collected on the surveys are frozen immediately and analyzed ashore.

3.4.3. Seabird and Marine Mammal Sampling Protocols

Seabird observers from Environment and Climate Change Canada and marine mammal observers from DFO have participated the surveys intermittently: seabird observers on spring surveys and marine mammal observers on summer surveys to capitalize on migration patterns. The survey program does not manage the sampling protocols used by these observers or store and manage the data that they collect.

Seabird Observers. If there is space, the survey is able to accommodate one seabird observer who follows a standardized protocol (Gjerdrum et al. 2012). The protocol requires a series of five-minute observation periods while the ship is steaming (4-19 knots), with as many consecutive observation periods completed as possible. Information about the ship's position, environmental variables, species, and other biological details are recorded. The data are stored in databases owned by Environment and Climate Change Canada's Canadian Wildlife Service.

Marine Mammal Observers (MMO). If there is space, the survey can accommodate a single MMO. The MMO is on watch during daylight hours and clear weather conditions (visibility >1km, Beaufort Sea State <6). They collect data on constant watch while in transit or using periodic scans while on station or during poor visibility. As well as information on the marine mammals that they sight, they record information on sightings (location, date/time, species, etc.), environmental conditions, and their search effort. The data are later stored in databases owned by DFO's Team Whale.

3.4.4. Acoustic Sampling Protocols

Acoustics were trialed on the *Needler* in 1991 and 1992, but was not until 2011 that data were recorded consistently and retained. From 2011 on, data were continuously recorded from the EK-60 during surveys on the *Needler* and the *Teleost*. The purpose of collecting acoustics data was for population analysis of pelagic and semi-pelagic species like Herring, Mackerel, and

Pollock. Debertin (2020) developed acoustic biomass indices for six target species using these data; the index for Pollock was used in a Management Strategy Evaluation (Andrushchenko et al. in press).

3.5. BIOLOGICAL DATA & REPORTING PROTOCOLS

3.5.1. At-Sea Data Collection

1950s and 1960s. Various data sheet formats were used to collect and store data from Maritimes Region surveys. These surveys were not standardized, and neither were the ways that their data were stored over time. The species codes used for data entry were developed in the 1950s and remained in use until 1984 (Losier and Waite 1989).

1970s and 1980s. Standardized paper data collection formats were introduced when standardized surveys were established in 1970. A revision of data formats, the introduction of at-sea standing orders or protocols, and a revision of computer methods and formats occurred. These methods, protocols and formats were applied to all groundfish surveys including special purpose surveys conducted in what was then referred to as the Maritimes Region (Scotian Shelf, Bay of Fundy, and southern Gulf of St. Lawrence). They are described in Halliday and Koeller (1971) and Koeller (1981). The five linked forms that were used for at-sea data collection were a station and set sheet, a deck sheet, a length-frequency tally sheet for each species, a fish sheet for detailed information from individual specimens and a length-frequency transfer sheet that was also a computer coding form. These forms were related to the database structure. Data from the “fish sheet” were recorded in the database, including length to the nearest cm. The length-frequency tally sheet recorded fish lengths by cm, which were then summed for each length-grouping. These summed values are recorded on the transfer sheet and these totals recorded in the database as number observed per length group. When paper records were eliminated in 1995, the protocol of recording numbers observed by length group was eliminated and the length frequency records for all species became number observed per cm. In 1984, a new species code list was put in place. It was developed in conjunction with the Atlantic Reference Centre, and included most species that could be expected to occur observed on the Bay of Fundy and Scotian Shelf (Losier and Waite 1989).

1990s. When microcomputers were developed, the possibilities for at-sea data collection expanded. The first system, the Groundfish Surveys Entry (GSE) System, was developed in the 1990s at the St. Andrews Biological Station and implemented in 1995 (Strong and Gavaris 1995). It allowed the direct entry of scientific information into a database at-sea using a networked PC server and PC clients, and an Oracle



Skates are measured and their lengths recorded on paper on a spring survey in the early 1990s. Pictured are L. Brown and H. Sampson.

database application. Data were entered into a form menu on the clients, located at the sampling stations. Automatic error checks were built into the system to assist in detecting erroneous data at the time of entry, when it is easiest to determine what the problem is and correct it. For example, if a length and weight of an individual do not correspond well with the system's length-weight curve for the species, an error will result so that the typist may double check their entry. Data collected on a survey were loaded to a production master database and further error checked. Functionality evolved through different versions, but basic validation procedures did not change. The survey manual was updated to describe the new procedures (Strong and Gavaris 1995), and a guide for using the GSE was developed to describe standard procedures, and to assist in trouble-shooting when computer problems were encountered (Gale 2011). Overall, the GSE enabled data to be available for analysis within a week of completing a survey. It was used by other survey programs and was the basis for data entry systems used broadly in Canada and the US.

2010s. In response to increased requirements for annual changes to sampling details, to accommodate focused sampling requests, the GSE was rewritten as the Ecosystem Surveys Entry (ESE) System to allow any sampling objective to be added. The ESE was introduced for the summer survey in 2014. It was based in Microsoft Access 2010 (Gale 2014). There were two parts, the frontend forms entry application and a backend data file for each mission that was archived in the production database. Like the GSE, the entry forms in the ESE followed the same format as the Oracle database where the data is finally stored: a Mission form with trip details, a Set form with information from the Bridge about the fishing set, a Catch form with the total weight of each species caught, and Observation forms for the detailed biological information collected from individual specimens. Sampling objectives that fit the table structure were saved to the production database for future surveys, while data from sampling requests that did not fit the standard data structure was stored in auxiliary tables. A function for sub-sampling mixed species (e.g., 'shrimp') and using these data to calculate the total number of each species caught was included in the ESE. An end-of-set process created a summary report, including error messages for manual checks, and a set backup file. The ESE further simplified data entry and eliminated errors by prompting for data for each sampling objective in sequence. It also allowed trips with multiple sets of sampling requirements for different areas or gear types to switch between requirements easily. The most recent length-weight relationship values used for error checks were published in 2019 (Noble and Clark 2019a, 2019b, 2019c).

2020s. A new system, the Another Data Entry System (ANDES), developed by the DFO's Gulf Region Research Vessel Survey Program, is in



Data is entered in the GSE system aboard the *Needler* in July 2010. Pictured: B. MacEachern and C.M. Clark.

use on the CCGS *Jacques Cartier* and any other vessels employed by the Maritimes Region (spring 2022 to present). ANDES is a flexible web-based system accessible on any DFO networked device. It allows data to be entered from multiple terminals (the Bridge, the fish lab, the hydrographic lab, the acoustic lab, etc.) simultaneously without lags, and provides even simpler procedure than the ESE for specific sampling requirements to be pre-programmed. The basic data entry forms are like the ESE, and it also includes the sub-sampling function to speed up the catch sorting process. ANDES stores additional data types, including SCANMAR™ data.

Ongoing implementation: direct data capture. Since the introduction of the ESE, direct data capture has been trialed on shore and at-sea including tools such as electronic measuring boards, and direct weigh scale entry using TWedge software (TEC-IT 2023), electronic caliper entry, and touch screen monitors. Presently, the use of these tools is at the discretion of the individual sampler. In the future, it is anticipated that electronic instruments and other methods of direct data capture will become routine at sea. Direct data capture can allow samplers to work individually rather than in pairs, presenting opportunities for future improvements to sampling efficiency.

3.5.2. Data Post-Processing and Storage

Data post-processing occurs before the final upload that makes the data accessible to all DFO staff with permission to view survey data. This includes a series of final error checks. Over time, data post-processing has varied.

1950s and 1960s. At the end of the mission, the data were key punched to fixed format 80 column cards, edited and stored at the St. Andrews Biological Station (Branton et al. 2000).

1970-1995. From the introduction of standardized paper data collection formats in 1970 to the implementation of the GSE in 1995, data continued to be keypunched after the survey was finished. Magnetic tapes replaced punch cards in the mid-1980s. Throughout this period, a batch validation process included error checks of this keypunched data. The process took three people two months to complete. In the 1980s, it was comprised of three edits (Gavaris 1986):

1. The primary edit checked the values on the station and set record against known values within the program tables and reported any variance.
2. The secondary edit checked the values on the catch, length frequency, and fish records against known values within the program tables and reported any variance.
3. The tertiary edit calculated the age and year class of the fish from the number of annuli present and automatically filled in these values on the fish record.

1995 to present. With the introduction and progression of computerized at-sea data entry systems, error checks have been incorporated into the onboard software and therefore manual editing tasks have decreased. Error reports are generated and checked after each set, flagging outstanding issues. Scripts have been developed to automatically make the three edits listed above. As a result of these changes, the time necessary for post-processing has decreased.

3.5.3. Data Storage

1950s to 1970s. Bottom trawl data was keypunched and stored in two formats: original data sheets and punch cards. The data were transferred to magnetic tapes from punch cards in the

1980s, and the punch cards were destroyed. The magnetic tapes, including those with data from the 1950s to 1970s, were incorporated into the SABS archive with subsets sent to the Bedford Institute of Oceanography (BIO) and the Gulf Fisheries Centre (GFC) (Branton et al. 2000). With the closure of the SABS archive in 2013, its contents were moved to BIO. The original data sheets are stored in filing cabinets in SABS heated storage.

1980s. Data on original data sheets was keypunched and stored on magnetic tapes rather than on punch cards. The magnetic tapes are now stored at BIO and original data sheets are stored in filing cabinets in SABS heated storage.

1990s and 2000s. In 1995, the GSE shipboard data entry and quality control system was developed, eliminating the need for at-sea data entry sheets. The Oracle relational database schema 'GROUND FISH' for standardized survey data was developed next and is still used today (Appendix D). For the years when the GSE was in use, the original record is the electronic record, and the paper record is a printed copy. The electronic records are stored in the GSE archive at SABS, while the paper copies are stored at SABS in heated storage and in the surveys lab. The file box or cabinet name for the paper forms for each survey from 1951 to 2007 is available in the 'GROUND FISH' schema table 'GSCRUISELIST.' It is important to retain original electronic and paper copies as occasional data entry errors persist in the database that can be resolved by referring to the paper records.

2010s to present. In 2014, when the ESE was developed, set backups were no longer printed after each set and instead processed electronically. The newest system, ANDES, also does not require printed backups. Digital copies of data from this period, including set backups, are stored in the ESE and ANDES archive at SABS and GFC.

Current databases. Standardized bottom trawl data collected from fish and invertebrates on the surveys is stored in the Oracle schema 'PTRAN' in tables under the user 'GROUND FISH' (a tabular description is available in Appendix D). Hydrographic data from before the participation of the AZMP is available in the table GROUND FISH.GSHYD. GSHYD contains basic temperature and salinity data for surveys until 2015. Warp deployed is available in GROUND FISH.WARPOUT. For a list of 'GROUND FISH' tables available and the relationships between them, see Appendix D. Data tables (undstandardized) and views (standardized) present the survey data in formats that are straightforward to access are available (GROUND FISH.ES*) . The views can be used to recreate length and weight means and totals from the STRANAL and the Mar.stratify R Package (McMahon 2017). For a full description of the ES* data tables and views, as well as examples of SQL code that can transform them into STRANAL/Mar.stratify output, see Appendix E.

The 'GROUND FISH' database is managed by DFO's Population Ecology Division. Data are also available via the Government of Canada's Open Government portal (DFO 2023a). SCANMAR™ data are stored in two places: older data are kept in Oracle tables in the 'GROUND FISH' schema, while more recent data are stored in flatfiles managed by the surveys program. Detailed diet data is stored in a different PTRAN schema, also managed by the Population Ecology Division. Acoustics data are stored and managed by the Acoustics Program at the St. Andrews Biological Station.

Data from unstandardized trawl surveys before 1970 are also available in the 'GROUND FISH' Oracle database. These data were transferred from original data sheets, punch cards, and magnetic tapes (Branton et al. 2000). The structure of the database is like that of the GROUND FISH schema (Appendix D), with tables including GSCRUP70 (missions), GSINFP70 (set), GSCATP70 (catch), GSDETP70 (detail), GSSEXP70 (sex codes), GSSPECP70 (sampling requirements by species), and GSVESP70 (vessels). However, these data must be understood differently because they are a collection of distinct surveys. The surveys were meant to obtain basic biological information, particularly on the distribution and stock boundaries of commercially exploited species. Each survey had its own methodology and goal and so the data cannot be viewed as a time series.

Oceanographic data from 1998 to present is stored in databases not managed by the survey program. AZMP CTD profile data are submitted to a local server managed by DFO's Ocean Data Information Section. Bottle measurements (pH, nutrients, chlorophyll, and dissolved oxygen) and plankton data (species counts and biomass measurements) are submitted to DFO's national Biological and Chemical Marine Data System (BioChem). The BioChem database is available through the Government of Canada's Open Government portal (DFO 2023b).

Two other data types are stored in databases not managed by the surveys program. Marine mammal observations are stored in DFO's Maritimes and Gulf Region Whale Sightings Database. Seabird observations are stored in an Environment and Climate Change Canada -- Canadian Wildlife Service database.

3.5.4. Reporting Protocols

Initially, data from the Maritimes Region Ecosystem Surveys Program were included only in assessments for individual groundfish species or in reports concerned with specific topics such as survey methodology. These documents were published by ICNAF (1965-1979), NAFO (1980-2001), or DFO (1977 to present). Yearly survey update documents were not originally published.

Summer Survey. In 1994, a survey update document for the summer survey of the Scotian Shelf and Bay of Fundy (4VWX) was created for the first time (O'Boyle et al. 1994). From then on, the summer survey's yearly update documents have provided stakeholders and fisheries managers with details on data collected and areas covered. From 1994 to 2004, trends in abundance, biomass, and area occupied were presented only for selected commercial species. From 2006 to 2011, trends in abundance, biomass, and area occupied were included for selected non-commercial species as well. During the same period, hydrographic trends in bottom temperature and salinity were included. In 2012, biological trends for both spring and summer surveys were reported together (DFO 2012). From 2013 to the present, biological trends for the summer survey have been reported on their own in a standardized document format created by DFO's Canadian Science Advisory Secretariat (CSAS).

Spring Survey. A review of data collected on the spring survey from 1987-2011 was conducted (Stone and Gross 2012). Then, in 2012, biological trends for the spring survey of Georges Bank (5Z) were reported alongside summer survey trends (DFO 2012). From 2013 to the present,

biological trends (abundance, biomass, and area occupied) for select commercial and non-commercial species have been published on their own in a standardized document format created by CSAS. The specific non-commercial species included are requested by DFO Resource Management for various reasons including conservation concerns.

A full list of spring and summer survey update documents is included in Appendix A.

4. DISCUSSION

The Maritimes Region Ecosystem Surveys have always incorporated basic ecosystem indicators, and the trajectory of the surveys has always been towards alignment with an Ecosystem Science Approach (DFO 2007). The requirement for population data to be used in groundfish stock assessments was a founding goal, but the collection of hydrographic data since the surveys began in 1970 and 1987 is an indicator of the wider perspective that the program and its scientific leads have always cultivated.

The focus today is on ecosystem monitoring: this broader ideal requires additional gear deployment that includes a broad suite of oceanographic and plankton sampling and requires the enumeration of all species in the trawl catch – not just fish species. This focus is consistent with other Canadian marine surveys, as well as surveys around the globe. Instead of concentrating on the status of single species, it integrates the entire ecosystem, as well as the humans who draw resources from the ecosystem. The purpose of the approach is both sustainable use of fisheries and ocean resources, and conservation of biological diversity, including commercial and non-commercial species (Shelton and Sinclair 2008). Meeting the increasing demands for long-term monitoring, a requirement for achieving the goal of managing ecosystems, is an ongoing goal of the Survey Program.

One of the major ways in which the surveys are aligning themselves with an Ecosystem Science Approach is by continuing to enhance sampling details. As the surveys have moved away from a focus solely on commercial groundfish, towards the collection of broader information on ecosystem status, detailed data collection has been expanded. Initially, detailed data was only collected for fish and select commercial invertebrates, but over time non-commercial species have been added to the sampling protocols. Before 1999, non-commercial invertebrates were inconsistently identified and recorded, but in 1999, a list of selected invertebrates was added to the sampling protocol (Tremblay et al. 2007). The list that was added in 1999 is available in Appendix E. On the Georges Bank survey in 2007, the protocol was again expanded. Since then, all species have been identified and recorded to as accurate a level of taxonomic data as possible, on both the spring and summer surveys. Before 2007, some species were broadly grouped by genus, family, or an even higher taxonomic level. Deepwater species' taxonomic resolutions were especially poor. As species have been identified, codes have been created for them. Other examples of enhanced sampling details include the collection of food habits (diet) data through stomach sampling, and the expansion of detailed biological sampling (lengths, weights, etc.) for select invertebrate species that were not previously sampled in detail. Beyond biological sampling, the expansion of hydrographic and plankton data collection described earlier in this document is another example of increased sampling that contributes to ecosystem monitoring.

A challenge with enhanced sampling protocols is the additional time that they require. One way to solve this problem is to add vessel time, but this has not been a possibility given that vessel malfunctions and changes to Coast Guard policies have reduced surveys' time at sea. Another method that is within the control of the survey program is ongoing improvements to the sampling efficiency in the wet lab. Improvements to efficiency – through the improvement of data entry systems and data collection technology – have freed up additional time that has allowed more detailed sampling requirements to be introduced. New objectives, including those that are ecosystem-based, have been accomplished as a result. Additionally, as the primary survey vessel's rate of mechanical failures grew and impacted available vessel time, increased efficiency has allowed more survey coverage to be achieved than would have been possible otherwise. The implementation of new, more efficient technology and the implementation of an Ecosystem Approach are closely tied.

A consideration for ecosystem monitoring is survey timing and spatial coverage. For some species and for some of the data collected on the survey, sampling at more than one season is advantageous. For example, Winter Flounder, Little Skate, and Winter Skate, which make seasonal migrations into coastal waters in the summer and are therefore outside the area covered by the summer survey; in spring, these species are in deeper water and therefore survey sampling is more representative of the entire population (Scott and Scott 1988). Similarly, species like Atlantic Mackerel and Gaspereau can be sampled effectively in the spring but are rarely caught in the summer (DFO 1997a; Claytor et al. 2014). Smooth Skate catches in spring are also much higher than in the summer (DFO 2022a). The overall survey catch is also seasonally influenced: there was a sizeable increase in the catch of the spring survey in 4X from the late 1970s to the 2020s, which was not seen by the summer survey in the same area.

Sampling the same geographic areas in both spring and summer has occurred in a limited capacity over the surveys' history. For example, there has always been summer coverage in 4VW, but from 1986 to 2010, there was also spring coverage. From 1979-1984, there was spring, summer and fall coverage in 4X. Currently, there is both spring and summer coverage in 5Zjm and 4X. The summer coverage in 5Z has been limited when vessel time is lost as the Bay of Fundy and Scotian Shelf are a higher priority. Similarly, coverage of 4X in the spring has been sporadic due to vessel delays following winter refits, which have left limited sea days to complete priority areas in 5Z. Reducing the coverage of western Georges Bank in recent years has provided more sea days to sample 4X during the spring.

Sampling a broad geographic range in the Maritime Region in the spring, when the NEFSC bottom trawl survey is also underway using the same trawl as is used in the DFO survey, allows for tracking of distribution and abundance trends throughout the very broad area covered by both surveys. This provides a means to determine if changes in survey catch reflect overall changes in abundance or just distributional changes in or out of the area covered by each of the surveys. Seasonal changes in species distribution also make sampling in one season more effective than another. Zooplankton sampling at this time of year can also provide broad spatial monitoring of the distribution of spawning for many species.

A final aspect to consider is the potential for coordinated zonal and transboundary surveys. Stratified random multi-species bottom trawl surveys occur in every region in the DFO Atlantic Zone, but among zones, methods and gear vary. In zonal assessments, differences in

methodologies usually require surveys to remain siloed as separate indices. The Atlantic Zonal Ecosystem Surveys (AZES) Working Group was started to share information and work towards zonal coordination. Surveys across the Atlantic Zone with directly comparable data remain a possibility, particularly for those with very similar protocols. With the adoption of the *Cartier* and NEST gear in both Maritimes and Gulf Regions on spatially and temporally adjacent surveys, resulting in a consistent deployment of the same vessel and gear, comparability has increased. In addition, the ICES WGNAEO is working towards transboundary coordination of spring DFO and NEFSC surveys on Georges Bank, both of which have adopted the NEST gear. Currently, distributional information and stock movement can be compared as long as survey timing and location are considered. In the future, further comparability – enough to combine separate survey indices in some cases -- would be ideal. This is even possible for surveys with different trawl gears – Quebec and Gulf Regions share data for some species in common assessments. However, combining data for species across the Laurentian Channel would require modelling approaches.

5. CONCLUSIONS & RECOMMENDATIONS

The Maritimes Region Ecosystem Surveys Program has a long history of contributing valuable information to multiple DFO programs and initiatives. As the program with the longest-running survey time series in Canada, it has grown from one groundfish-focused survey with a hydrographic component into a full-fledged semiannual look at the marine ecosystems of the Bay of Fundy, Scotian Shelf, and Georges Bank. In this document, we have formalized the program's undocumented history and changes over time to design, at-sea data collection, and onshore data processing. In our view, this document is required reading for those who use the survey data, those who are continuing to steward the program in the present, and those who will continue to steward the program in the future.

RECOMMENDATIONS

- Macro-algae. Macro-algae (e.g., seaweed) has been recorded inconsistently since about 2021, depending on the survey participants. Collection of this data could become more consistent, to further round out the ecosystem data that the survey currently collects.
- Ghost gear. While the fact that a set was unsuccessful is currently recorded, the reason that it was not successful is not consistently. It might be recorded in the 'remarks' column but not always. On occasion, the reason is that the trawl net is entangled with abandoned fishing gear -- usually lobster traps but sometimes other fixed gear. To better understand the presence of this 'ghost gear,' the reason that the set was unsuccessful, as well as the amount and type of gear that was entangled should be recorded systematically.
- Gear specifications. When comparative fishing of the *Needler/Teleost* with WIIA trawl, and *Cartier/Cabot* with NEST is complete, the complete NEST net design, gear, and other specifications should be documented and published if there have been any changes from the NEFSC specifications.
- Error checking changes to sampling protocols. When a change to a sampling protocol is made, it should be error checked as part of the onshore data processing for several years thereafter. Checking that the sampling requirements are being followed and

reinforcing the requirements to staff are necessary to ensure consistency in the database.

- Retention of WIIA trawl gear. At least three trawls, along with doors and other required trawl components, should be retained in storage. Use of this gear should be considered for any future surveys in deep water (>732m). The NEST gear is light and very difficult to use in deep water. In addition, it is unlikely that suitable conversion factors will be available for species at these depths.

FUTURE RESEARCH

- Western IIA vs NEST net effect. From 2012-2016, the *Needler* deployed both the WIIA and NEST gear at many stations on both spring and summer surveys, to provide a practical but also a biological comparison between the gears. The biological data have not been analyzed. Therefore, there is potential to explore net effect separate from vessel effect, as current comparative fishing with the new vessel (*Cartier* with NEST vs *Needler* with WIIA) can only compare vessel and net effect together. This may be particularly useful for the coordinated Canada-US surveys on Georges Bank.
- Western IIA trawl configuration. As a follow-up to the summer survey in the year 2004, when the Carrothers (1988) configuration of the WIIA trawl was deployed erroneously, a review of data from the 2003-2005 surveys would determine if there were systematic changes in catches in 2004 related to the change in trawl. This would also determine whether modifications to trawl design in the early 1980s may have impacted the utility of comparative fishing results in 1982.
- SCANMAR™ data. These data have not been analyzed since 1995. As the *Cartier* will deploy the NEST gear and not the WIIA, previously collected data may not be as useful as could have been previously. However, going forward, there is the potential for useful studies related to the variability in trawl performance, calculating actual swept areas, evaluating the success of the swept area method of abundance estimation, quality control, and other topics.

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7. REFERENCES

- Abbott, L. 1996, September 9. Trawl floats. Fax.
- Andrushchenko, I., Clark, D.S., Irvine, F., MacEachern, E., Martin, R., and Wang, Y. 2022. 2018 4X5Y Atlantic Cod Framework Data Inputs. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/006.
- Andrushchenko, I., Legault, C.M., and Barrett, M. 2019. Alternative Methodologies for Providing Interim Catch Advice for Eastern Georges Bank Cod. TRAC Ref. Doc. 2019/02. Available from <https://repository.library.noaa.gov/view/noaa/24821>.
- Andrushchenko, I., Martin, R., Doherty, P., Debertin, A., McCurdy, Q., MacEachern, E., Clark, D.S., and Clark, C.M. in press. Western Component Pollock - Data Inputs. DFO Can. Sci. Advis. Sec. Res. Doc. 2025/nnn.
- Andrushchenko, I., Yin, Y., Clark, C.M., Martin, R.M., and Barrett, T.J. in press. Western Component Pollock Management Strategy Evaluation – Population Modeling, Operating Model Conditioning and Reference Points. DFO Can. Sci. Advis. Sec. Res. Doc. 2025/nnn.
- Azarovitz, T.R. 1981. A Brief Historical Review of the Woods Hole Laboratory Trawl Survey Time Series. *In* Bottom Trawl Surveys - Proceedings of a Workshop Held at Ottawa November 12-14, 1980. DFO Can. Spec. Publ. Fish. Aquat. Sci. 58: 62-67. *Edited by* W.G. Doubleday and D. Rivard.
- Barrett, M. 2023. Framework Review for the Stock Assessment of the Offshore Whelk (*Buccinum undatum*) in the 4Vs and 4W Exploratory Fishery. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/091.
- Benoît, H.P. 2006. Standardizing the southern Gulf of St. Lawrence bottom trawl survey time series: Results of the 2004-2005 comparative fishing experiments and other recommendations for the analysis of the survey data. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/008.
- Branton, R., Zwanenburg, K., and Smith, J. 2000. Pre 70 Groundfish Research Trawl Data Base Draft Development Plan. Unpubl. Available from the authors.
- Brooks, E.N., and Politis, P.J. 2014. Evaluating age and length composition data for inference about selectivity shape. TRAC Working Paper 2014/017.
- Brown, R.W., Fogarty, M., Legault, C., Miller, T., Nordahl, V., Politis, P., and Rago, P. 2007. Survey Transition and Calibration of Bottom Trawl Surveys along the Northeastern Continental Shelf of the United States. ICES CM2007/Q:20.
- Carrothers, P.J.G. 1974. Descriptions of trawl-gear used for demersal species by the Canadian fleet in Subarea 5 and Statistical Area 6 during the period 1969 through 1972. ICNAF Res. Doc. 74/28.
- Carrothers, P.J.G. 1988. Scotia-Fundy Groundfish Survey Trawls.
- Cassista-Da, M., and Cosham, J. 2020. Eastern Scotian Shelf Shrimp (*Pandalus borealis*): 2018-2019. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/045.
- Chadwick, E.M.P., Brodie, W., Colbourne, E., Clark, D., Gascon, D., and Hurlbut, T. 2007. History of Annual Multi-Species Trawl Surveys on the Atlantic Coast of Canada. *In* DFO AZMP Bulletin PMZA No. 6. pp. 25–42.
- Clark, D., Trippel, E.A., and Brown, L.L. 1995. Assessment of Cod in Division 4X in 1994.

- Clark, D.S. 1993. The influence of depth and bottom type on area swept by groundtrawl, and consequences for survey indices and population estimates.
- Clark, D.S. 1997. Assessment of Cod in Division 4X in 1997. DFO Can. Stock Assess. Sec. Res. Doc. 97/110. Available from <https://science-catalogue.canada.ca/record=3960418~S6>.
- Clark, D.S. 2005. Analysis of warp:depth ratios in Maritimes Region survey for 1991-2004 (Working Paper). DFO Atlantic Zonal Trawl Survey Working Group Meeting. Available from the authors.
- Clark, D.S. 2007, January 4. RE: Urgent Western 2A Floats Buoyancy Issue. Email.
- Clark, D.S., and Hatt, B. 2007. Groundfish Bottom Trawl Surveys Manual. Unpubl. Available from the authors.
- Clayton, R., Clark, D., McIntyre, T., Stone, H., Cook, A., Harris, L., Simon, J., Emery, P., and Hurley, P. 2014. Review of Surveys Contributing to Groundfish Assessments with Recommendations for an Ecosystem Survey Program in the Maritimes Region. DFO Can. Tech. Rep. Fish. Aquat. Sci. 3083.
- Cook, A.M., and Bundy, A. 2010. The Food Habits Database: an update, determination of sampling adequacy and estimation of diet for key species. DFO Can. Tech. Rep. Fish. Aquat. Sci. 2884.
- Cook, A.M., Hubley, P.B., and Denton, C. 2018. Assessment of the Offshore American Lobster (*Homarus americanus*) in Lobster Fishing Area (LFA) 41. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/034.
- COSEWIC. 2012a. COSEWIC Assessment and Status Report on the Cusk (*Brosme brosme* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.
- COSEWIC. 2012b. COSEWIC assessment and status report on the thorny skate (*Amblyraja radiata*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.
- COSEWIC. 2012c. COSEWIC assessment and status report on the Smooth Skate (*Malacoraja senta*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.
- COSEWIC. 2015. COSEWIC Assessment and Status Report on the Winter Skate (*Leucoraja ocellata*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
- Croft, A. 1989, October 17. Western 2A trawl specifications. Memo.
- Debertin, A.J. 2020. Estimating the biomass of a mixed species complex using hydroacoustics and catch data from the Bay of Fundy and Scotian Shelf summer ecosystem survey. Can. J. Fish. Aquat. Sci. **77**(7): 1101–1116. doi:10.1139/cjfas-2019-0152.
- DFO. 1996. Eastern Scotian Shelf Greenland Halibut (Turbot). DFO Atlantic Fisheries Stock Status Report 96/73E.
- DFO. 1997a. Proceedings of Peer Review and Client Consultations for Diadromous Fish Stocks (Gaspereau) in the Maritimes Provinces in 1996. DFO Can. Stock Assess. Proc. Series 97/10.
- DFO. 1997b. Southwest Nova Winter Flounder, American Plaice, and Yellowtail Flounder.

- DFO. 2002a. American Plaice and Yellowtail Flounder on the Eastern Scotian Shelf (Div. 4VW). DFO Stock Status Report A3-34(2002).
- DFO. 2002b. Monkfish on the Scotian Shelf and Northeast Georges Bank (4VWX and 5Zc). DFO Sci. Stock Status Report A3-30(2002).
- DFO. 2004. Scallop Production Areas (SPAs) in the Bay of Fundy. DFO Stock Status Report 2004/051.
- DFO. 2007. A New Ecosystem Science Framework in Support of Integrated Management. DFO/2007-1296.
- DFO. 2008. Recovery Potential Assessment for Cusk (*Brosme brosme*). DFO Can. Advis. Sec. Sci. Advis. Rep. 2008/024.
- DFO. 2009. Assessment of Jonah Crab in Lobster Fishing Area 41 (4X + 5Zc). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/034.
- DFO. 2010. Occurance, sensitivity to fishing, and ecological function of corals, sponges, and hydrothermal vents in Canadian waters. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/041.
- DFO. 2012. Maritimes Research Vessel Survey Trends. DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/004.
- DFO. 2015. 2014 Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/013.
- DFO. 2017. Delineation of Significant Areas of Coldwater Corals and Sponge-Dominated Communities in Canada's Atlantic and Eastern Arctic Marine Waters and their Overlap with Fishing Activity. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/007.
- DFO. 2018. Status of the Hagfish (*Myxine glutinosa*) Fishery in the Maritimes Region. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/048.
- DFO. 2020a. Biophysical and Ecological Overview of the Fundian Channel – Browns Bank Area of Interest (AOI). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/034.
- DFO. 2020b. Recovery strategy for Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*), and management plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada. Fisheries and Oceans Canada, Ottawa.
- DFO. 2022a. 2021 Maritimes Winter Research Vessel Survey Trends on Georges Bank.
- DFO. 2022b. Stock Status Update of Unit 3 Redfish for 2022. DFO Can. Sci. Advis. Sec. Sci. Resp. 2023/022.
- DFO. 2023a. Maritimes Research Vessel Surveys. Available from <https://open.canada.ca/data/en/dataset/8ddcaeea-b806-4958-a79f-ba9ab645f53b>.
- DFO. 2023b. Biological and chemical marine data: BioChem database. Available from <https://www.dfo-mpo.gc.ca/science/data-donnees/biochem/index-eng.html>.
- DFO. 2023c. Stock Status Update of Atlantic Halibut (*Hippoglossus hippoglossus*) on the Scotian Shelf and Southern Grand Banks in NAFO Divisions 3NOPS4VWX5ZC for 2022. DFO Can. Sci. Advis. Sec. Sci. Resp. 2023/020.
- DFO, and Marine Institute. 2007. Survey Trawl Reference Manual. Unpubl. Available from the authors.
- Dominix, J. 1996, August 21. Fax re: floats. Fax.

- Doubleday, W.G. 1976. Contribution to Manual on ICNAF Groundfish Survey. ICNAF Res. Doc. 76/VI/99.
- Doubleday, W.G. 1981. Manual on Groundfish Surveys in the Northwest Atlantic. NAFO Scientific Council Studies, No. 2.
- Emberley, J., and Clark, D.S. 2011. Update of the 2011 Summer Scotian Shelf and Bay of Fundy Research Vessel Survey. Can. Data Rep. Fish. Aquat. Sci. 1240.
- Fanning, L.P. 1985. Intercalibration of Research Survey Results Obtained by Different Vessels.
- Fanning, P. 1984. Preliminary Analysis of *Alfred Needler* - *Lady Hammond* Comparative Fishing Experiments (Silver Hake, 1983). NAFO SCR Doc. 84/VI/82.
- Fowler, G.M., and Bowlby, H.D. 2022. Changes to survey indices and implications for assessment of spiny dogfish, *Squalus acanthias*, in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/024.
- Fowler, G.M., and Showell, M.A. 2009. Calibration of Bottom Trawl Survey Vessels: Comparative Fishing Between the Alfred Needler and Teleost on the Scotian Shelf during the Summer of 2005. DFO Can. Tech. Rep. Fish. Aquat. Sci. 2824.
- Gagnon, J.-M., and Gilkinson, K.D. 1994. Discrimination and distribution of the sea urchins *Strongylocentrotus droebachiensis* (O.F. Müller) and *S. pallidus* (G.O. Sars) in the Northwest Atlantic. Sarsia **79**(1): 1–11. doi:10.1080/00364827.1994.10413542.
- Gale, J. 2011. Groundfish Survey Entry User Guide. Version 6.8. Unpubl. Available from the authors.
- Gale, J. 2014. Ecosystem Survey Entry User Guide. Version 9.0. Unpubl. Available from the authors.
- Gale, J. 2019, March 25. ES objects. Email.
- Gavaris, S. 1986. Manual groundfish bottom trawl surveys, Marine Fish Division, Scotia Fundy Region. Draft 2.4. Unpubl. Available from the authors.
- Gavaris, S. 1987. Assessment of haddock in NAFO Division 5Z. CAFSAC Research Document 1987/101.
- Gavaris, S., and Waiwood, K.G. 1986. Assessment of haddock in NAFO division 5Z. CAFSAC Research Document 1986/087.
- Gjerdrum, C., Fifield, D.A., and Wilhelm, S.I. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region.
- Grosslein, M.D. 1969. Groundfish Survey Methods. Commer. Fish. Rev. **31**(8–9): 22.
- Guénette, S., and Clark, D.S. 2016. Information in Support of Recovery Potential Assessment for White Hake (*Urophycis tenuis*) from the Scotian Shelf (NAFO Divs. 4VWX5Z). DFO Can. Sci. Advis. Sec. Res. Doc. 2016/100.
- Halliday, R.G., and Clark, K.J. 1995. The Scotia-Fundy Region Groundfish Hook and Line Fisheries: a Digest of Quantities and Sizes Landed, and Comparisons with Other Gear Types. DFO Can. Man. Rep. Fish. Aquat. Sci. 2271.
- Halliday, R.G., and Koeller, A.C. 1971. Groundfish Survey Programmes of the St. Andrews Biological Station, Fisheries Research Board of Canada - Objectives and Characteristics. ICNAF Res. Doc. 71/35.

- Halliday, R.G., and Koeller, P.A. 1981. A History of Canadian Groundfish Trawling Surveys and Data Usage in ICNAF Divisions 4TVWX. *In* Bottom Trawl Surveys - Proceedings of a Workshop Held at Ottawa November 12-14, 1980. Can. Spec. Pub. Fish. Aquat. Sci. 58:27-41.
- Hanke, A.R., and Clark, D.S. 2007. Comparative Fishing Power: A Two-Sample Problem. Unpubl. Available from the authors.
- Harris, L.E., Somers, G., and Clark, D.S. 2012. Reference Points for Cusk (*Brosme brosme*) in NAFO Divisions 4VWX5Z Under the Precautionary Approach Framework. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/026.
- Harrison, G., Colbourne, E., Gilbert, D., and Petrie, B. 2004. Oceanographic Observations and Data Products Derived from Large-Scale Fisheries Resource Assessment and Environmental Surveys in the Atlantic Zone. DFO AZMP Bulletin PMZA No. 4.
- Hubley, B., Heaslip, S.G., and Stanley, R.R.E. 2018. Assessment of the Arctic Surfclam (*Mactromeris polynyma*) Stocks on Banquereau and Grand Bank. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/063.
- Hunt, J.J. 1992, January 7. Set allocation for 5Ze survey. Memo.
- Hurlbut, T. 2000, December 12. New Headline Floats on the Western IIA Trawl. Email.
- Hurlbut, T. 2007, January 8. RE: Urgent Western 2A Floats Buoyancy Issue. Email.
- Hurlbut, T., and Clay, D. 1990. Protocols for Research Vessel Cruises within the Gulf Region (Demersal Fish) (1970-1987). DFO Can. MS Rep. Fish. Aquat. Sci. No. 2082.
- ICES. 2004. Report of the Workshop on Survey Design and Data Analysis (WKSAD) - 2-25 June 2004, Aberdeen UK. ICES CM 2004/B:07, Ref. D,G.
- ICES. 2023. Working Group on Northwest Atlantic Ecosystem Observations. Available from <https://www.ices.dk/community/groups/Pages/WGNAEO.aspx> [accessed 6 October 2023].
- ICES Fisheries Technology Committee. 2005. Report of the Study Group on Survey Trawl Standardisation (SGSTS). ICES CM 2005/B:02, International Commission for the Exploration of the Sea, Rome, Italy.
- Kenchington, E., Beazley, L., Lirette, C., Murillo, F.J., Guijarro, J., Wareham, V., Wilkinson, K., Koen-Alonso, M., Benoît, H., Bourdages, H., Sainte-Marie, B., Treble, M., and Siferd, T. 2016. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada Using Kernel Density Analyses and Species Distribution Models. DFO Can. Sci. Advis. Res. Doc. 2016/093.
- Kenchington, E., Lirette, C., Cogswell, A., Archambault, D., Archambault, P., Benoît, H., Bernier, D., Brodie, B., Fuller, S., Wilkinson, K., Levesque, M., Power, D., Siferd, T., Treble, M., and Wareham, V. 2010. Delineating Coral and Sponge Concentrations in the Biogeographic Regions of the East Coast of Canada Using Spatial Analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/041.
- Koeller, P. 1981. Manual for groundfish survey personnel - cruise preparation, conduct and standing orders. DFO Marine Fish Division Laboratory Ref. No. 81/3. Available from the authors.
- Koeller, P., McCallum, B., Swain, D., Strong, M., Archambault, D., and Walsh, S. 1994. Accuracy and Precision of Scanmar Data Recorded on Canadian Groundfish Surveys. DFO Can. Tech. Rep. Fish. Aquat. Sci. No. 1983.

- Koeller, P., and Smith, S.J. 1983. Preliminary analysis of *A.T. Cameron - Lady Hammond* comparative fishing experiments 1979-81. CAFSAC Res. Doc. 83/59.
- Koeller, P.A. 1991. Approaches to Improving Groundfish Survey Abundance Estimates by Controlling the Variability of Survey Gear Geometry and Performance. *J Northw Atl Fish Sci* **11**: 51–58.
- Legault, C.M., Alade, L., Busawon, D., and Stone, H.H. 2015. Stock Assessment of Georges Bank Yellowtail Flounder for 2015. TRAC Ref. Doc. 2015/01.
- Leim, A.H., and Scott, W.B. 1966. Fishes of the Atlantic Coast of Canada. Fisheries Research Board of Canada Bulletin No. 155.
- Losier, R. 1990, December 10. Cruise Program. Memo.
- Losier, R., and Perry, I. 1990, May 17. Hydrographic Data Collection on Groundfish Surveys. Memo.
- Losier, R.J., and Waite, L.E. 1989. Systematic Listing of Scientific and/or Common Names of Invertebrates, Vertebrates and Marine Plants and their Respective Codes Used by Marine Fish Division, Fisheries and Oceans, Scotia Fundy Region (Revised). DFO Can. Data Rep. Fish. Aquat. Sci. No. 721.
- McMahon, M. 2017. Mar.Stratify [R Package]. R, Fisheries and Oceans Canada. Available from <https://github.com/Maritimes/Mar.stratify>.
- McMahon, M. 2018. Mar.utils R Package. R, Fisheries and Oceans Canada. Available from <https://github.com/Maritimes/Mar.utils> [accessed 11 October 2023].
- McMahon, M. 2023. GROUND FISH.GSSPECIES_ANDES Table. SQL, Fisheries and Oceans Canada. [accessed 11 October 2023].
- McMahon, M. 2025. set_select.R. R, Fisheries and Oceans Canada, Dartmouth, NS. Available from https://github.com/Maritimes/Mar.utils/blob/main/R/set_select.R.
- Mitchell, M.R., Harrison, G., Pauley, K., Gagne, A., Maillet, G., and Strain, P. 2002. Atlantic Zonal Monitoring Program Sampling Protocol. DFO Can Tech Rep Hydro Ocean Sci 223.
- Mohn, R.K., Lambert, T.C., Wilson, S., and Black, G.A.P. 1998. Assessment of Status of 4Vn Cod (May - Oct.): 1997.
- Murillo, F.J., Kenchington, E., Clark, D.S., Emberley, J., Regnier-McKellar, C., Guijarro, J., Beazley, L., and Wong, M.C. 2018. Cruise Report for the CCGS Alfred Needler Maritimes Region Research Vessel Summer Multispecies Survey, June 28 to August 14, 2017: Benthic Invertebrates. DFO Can. Tech. Rep. Fish. Aquat. Sci. 3262.
- NEFSC. 2023a. Fall Bottom Trawl Survey. Available from <https://www.fisheries.noaa.gov/inport/item/22560>.
- NEFSC. 2023b. Spring Bottom Trawl Survey. Available from <https://www.fisheries.noaa.gov/inport/item/22561>.
- Neilson, J.D., Clark, D., Trippel, E., Annand, C., Branton, R., Fanning, P., Hurley, P., McRuer, J., and Zwanenburg, K. 1995. Survey Update for Selected Scotia-Fundy Groundfish Stocks. DFO Atlantic Fisheries Res. Doc. 95/113.
- Neilson, J.D., and Hurley, P. 1986. Stock structure of American plaice, witch and winter flounder in the Gulf of Maine area: implications for management. CAFSAC Res. Doc. 86/63.

- Noble, V.R., and Clark, D.S. 2019a. Seasonal Length:Weight Relationships of Grenadiers, Chimaeras and Atlantic Herring Caught by Fisheries and Oceans Canada Maritimes Region Ecosystem Surveys Using Different Measurement Techniques At-Sea. DFO Can. Data Rep. Fish. Aquat. Sci. 1291.
- Noble, V.R., and Clark, D.S. 2019b. Seasonal Length:Weight Relationships of the Fish Species Caught by Fisheries and Oceans Canada Maritimes Region Ecosystem Surveys from 2001-2014 and Deep Water Species from 2001-2017. DFO Can. Data Rep. Fish. Aquat. Sci. 1292.
- Noble, V.R., and Clark, D.S. 2019c. Seasonal Length:Weight Relationships of the Invertebrate Species Caught by Fisheries and Oceans Canada Maritimes Region Ecosystem Surveys from 2001-2017. DFO Can. Data Rep. Fish. Aquat. Sci. 1293.
- O'Boyle, R., Annand, C., Branton, R., Hurley, P., Mohn, R., Zwanenburg, K., Clark, D., Neilson, J., and Trippel, E. 1994. Survey Update for Selected Scotia-Fundy Groundfish Stocks, 12 September 1994. DFO Atlantic Fisheries Res. Doc. 94/76.
- O'Boyle, R., and O'Brien, L. 2007. Transboundary Resources Assessment Committee (TRAC) Report of Meeting held 12–15 June 2007. TRAC Proceedings 2007/01. Available from https://www.bio.gc.ca/info/intercol/trac-cert/documents/proceedings/TRAC_pro_2007_01.pdf.
- Pepin, P., Petrie, B., Frank, K.T., Chassé, J., Colbourne, E.B., Gilbert, D., Gregory, D., Harvey, M., Maillet, G.L., Mitchell, M., and Starr, M. 2005. The Atlantic Zone Monitoring Program (AZMP): Review of 1998-2003. DFO Can. Tech. Rep. Hydrogr. Ocean Sci. 242.
- Pitt, T.K., Wells, R., and McKone, W.D. 1981. A critique of research vessel surveys by the St John's Research and Resource Services. *In* Bottom Trawl Surveys - Proceedings of a Workshop Held at Ottawa November 12-14, 1980. Can. Spec. Publ. Fish. Aquat. Sci. 58. *Edited by* W.G. Doubleday and D. Rivard. pp. 42–61.
- Politis, P., Galbraith, J.K., Kostovick, P., and Brown, R.W. 2014. Northeast Fisheries Science Center Bottom Trawl Survey Protocols for the NOAA Ship Henry B. Bigelow. Northeast Fish Sci Cent Ref Doc. 14-06.
- Rago, P. 2005. Fishery independent sampling: survey techniques and data analyses. *In* Management techniques for elasmobranch fisheries. FAO Fisheries Technical Paper 474. *Edited by* J.A. Musick and R. Bonfil. Food and Agriculture Organization of the United Nations, Rome.
- Reid, J.G. 2007, January 4. Urgent Western 2A Floats Buoyancy Issue. Email.
- Robichaud, D.A., and Frail, C. 2006. Development of the Jonah Crab, *Cancer borealis*, and Rock Crab, *Cancer irroratus*, Fisheries in the Bay of Fundy (LFAs 35-38) and off Southwest Nova Scotia (LFA 34): Exploratory to Commercial Status (1995-2004). DFO Can. MS Rep. Fish. Aquat. Sci. 2775.
- Scott, J.S. 1977. Distribution of Squid (*Illex illecebrosus*) on the Scotian Shelf 1970-1976. CAFSAC Res. Doc. 77/19.
- Scott, W.B., and Scott, M.G. 1988. Atlantic Fishes of Canada. DFO Can. Bull. Fish. Aquat. Sci. 219.
- Shelton, P.A., and Sinclair, A.F. 2008. It's time to sharpen our definition of sustainable fisheries management. Can. J. Fish. Aquat. Sci. **65**(10): 2305–2314. doi:10.1139/F08-151.

- Simon, J.E., Frank, K.T., and Kulka, D.W. 2002. Distribution and abundance of Barndoor skate (*Dipturus laevis*) in the Canadian Atlantic based upon research vessel surveys and industry/science surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/070.
- Simon, J.E., Harris, L.E., and Johnston, T.L. 2003. Distribution and Abundance of Winter Skate, *Leucoraja ocellata*, in the Canadian Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/028.
- Simon, J.E., Rowe, S., and Cook, A. 2011. Status of Smooth Skate (*Malacoraja senta*) and Thorny Skate (*Amblyraja radiata*) in the Maritimes Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/080.
- Singh, R., Knox, D., MacIntyre, A., and Melvin, G.D. 2020. 2018 Evaluation of Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX Herring. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/062.
- Smith, S.J. 1999. Survey Methods for Fisheries: Challenges and Statistical Issues. SSC Annual Meeting, June 1999: Proceedings of the Survey Methods Section, Statistical Society of Canada.
- Smith, S.J., Nasmith, L.E., Glass, A., Hubley, B., and Sameoto, J.A. 2014. Framework assessment for SFA 29 West scallop fishery. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/110.
- Stephenson, R.L. 2004. Proceedings of the Pollock Framework Assessment 1 May 2003; 16-18 June 2003; and 6-8 April 2004. DFO Can. Sci. Advis. Sec. Proceedings Series 2004/030.
- Stone, H.H. 2021. Assessment of St. Mary's Bay Longhorn Sculpin (*Myoxocephalus octodecemspinosus*), 1999-2019. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/073.
- Stone, H.H., Brooks, E.N., Busawon, D., and Wang, Y. 2015. Assessment of Haddock on Eastern Georges Bank for 2015. TRAC Ref. Doc. 2015/02.
- Stone, H.H., and Gross, W.E. 2012. Review of the Georges Bank Research Vessel Survey Program 1987-2011. DFO Can. Man. Rep. Fish. Aquat. Sci. 2988.
- Stone, H.H., Themelis, D., Cook, A.M., Clark, D.S., Showell, M.A., Young, G., Gross, W.E., Comeau, P.A., and Alade, L.A. 2013. Silver Hake 2012 Framework Assessment: Data Inputs and Exploratory Modelling. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/008. Available from <https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/350223.pdf>.
- Strong, M. 1989, October 26. A. Croft's Memo re Western 2A Trawl Specifications. Memo.
- Strong, M. 1990, September 27. Doorleg extension lengths. Memo.
- Strong, M. 1992. Variability of trawl performance on Scotia-Fundy groundfish surveys. CAFSAC Res. Doc. 92/58.
- Strong, M. 1994, January 6. Atlantic Western II A Trawl Specifications. Memo.
- Strong, M. 1996, August 29. Fax re: floats. Fax.
- Strong, M. n.d. Graphical Atlas of Wing Spread, Door Spread and Trawl Opening for the Atlantic Western IIA Trawl from Scotia-Fundy Bottom Trawl Surveys, 1990 to present. Unpubl. Available from the authors., Fisheries and Oceans Canada.
- Strong, M., and Gavaris, S. 1995. Manual bottom trawl surveys marine Scotia-Fundy Region. Draft 2.4. Unpubl. Available from the authors.

- TEC-IT. 2023. TWedge Data Collection Software - Universal Keyboard Wedge. Available from <https://www.tec-it.com/en/software/data-acquisition/twedge/keyboard-wedge/Default.aspx>.
- Therriault, J.-C., Petrie, B., Pepin, P., Gagnon, J., Gregory, D., Helbig, J., Herman, A., Lefaiivre, D., Mitchell, Pelchat, B., Runge, J., and Sameoto, D. 1998. Proposal for a Northwest Atlantic Zone 1 Monitoring Program. DFO Can. Tech. Rep. Hydrogr. Ocean Sci. 194.
- Tremblay, M.J., Black, G.A.P., and Branton, R.M. 2007. The distribution of common decapod crustaceans and other invertebrates recorded in annual ecosystem surveys of the Scotian Shelf 1999-2006. DFO Can. Tech. Rep. Fish. Aquat. Sci. 2762.
- Trippel, E.A., and Brown, L.L. 1993. Assessment of Pollock (*Pollachius virens*) in Divisions 4VWX and Subdivision 5Zc for 1992. DFO Atlantic Fisheries Res. Doc. 93/60.
- Wang, Y., Stone, H.H., and Finley, M. 2017. 4X5Y Haddock 2016 Framework Assessment: Modelling and Reference Points. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/026.
- Wheelhouse, J. 1994, January 19. Atlantic Western II A Trawl Specifications. Memo.
- Wilson, B.M., Clark, D.S., Greenlaw, M.E., Clark, C.M., and McMahon, M. in press. Maritimes Region Ecosystem Survey Program: Geospatial Database and Station Allocation Routine. DFO Can. Tech. Rep. Fish. Aquat. Sci. XXXX.
- WoRMS Editorial Board. 2023. World Register of Marine Species. doi:doi:10.14284/170.
- Yin, Y., and Benoît, H. 2022. A Comprehensive Simulation Study of a Class of Analysis methods for Paired-Tow Comparative Fishing Experiments. Can. Tech. Rep. Fish. Aquat. Sci. 3466.
- Yin, Y., Benoît, H., and Martin, R. 2025a. Calibration of bottom trawl survey vessels: results of comparative fishing between the CCGS Teleost and CCGS John Cabot/ CCGS Captain Jacques Cartier on the Scotian Shelf and Bay of Fundy in 2022 and 2023. DFO Can Sci Advis Sec Res Doc 2025025.
- Yin, Y., Benoît, H., and Martin, R. 2025b. Calibration of Bottom Trawl Survey Vessels: Re-analysis of Comparative Fishing Experiment Between the CCGS Alfred Needler and CCGS Teleost on the Scotian Shelf and Bay of Fundy in 2005. DFO Can Sci Advis Sec Res Doc 2025026.

8. TABLES

Table 1. Trawling Surveys Conducted by Canada in ICNAF Divisions 4TVWX between 1951 and present. Vessels include *A. T. Cameron* (A), *E.E. Prince* (P), *Cape Argos* (C), *Lady Hammond* (H), *CCGS Alfred Needler* (N or NED), *CCGS Wilfred Templeman* (T or TEM), *Teleost* (TEL), *Mallotus* (Mall.), *J.J. Cowie* (J.J.C.), *Harengus* (H.), and others. Stratified random surveys that are part of the ongoing spring and summer survey series (Table 2), or the fall series (1978-1986; Table 3) are excluded. Reproduced from Halliday and Koeller (1981) and information in the GROUND FISH.GSCRUISELIST table.

Year	Div.	Vessel & Cruise	Dates	No. of Sets	Purpose
1951	T	Mall.	Aug. – Nov.	50+	Expl., dist., abund., groundfish, Northumberland Strait to St. Georges Bay.
	W	J.J.C.	19 Nov. – 4 Dec.	12	Expl., redfish, Canso
1952	X	J.J.C.	26 Feb. – 20 Mar.	7	Expl., groundfish, Digby Neck
1953	S,T	J.J.C.	18 June – 20 Oct.	7	Redfish, seasonal, geog. & vertical dist., biology, Gaspé to Anticosti
1954	S,T	J.J.C.	17 May – 30 Sept.	?	Redfish, dist., biology, Gaspé to Anticosti
1957	T	J.J.C.	22 May – 24 Oct.	245(?)	Cod, seasonal, geogr., dist., population structure, pre-recruitment abund., S.W. Gulf
1958	T	J.J.C.	24 May – 28 Nov.	156(?)	-
	W	H8	13-28 Aug.	48(?)	Haddock, dist., pop. structure, pre-recruit abund., Emerald and Sable I. banks
1959	T	H12	4-12 June	29(15)	Cod, dist., abund., S.W. Gulf
		H15	21 Aug. – 1 Sept.	28(14)	
		H17	8-15 Oct.	26(14)	
	T,Vn	H9	6-22 May	61(31)	Cod, dist., abund., Cape Breton coast
		H18	7 Nov. – 3 Dec.	49(25)	
	Vs,W	AS7	22 Feb. – 27 Mar.	102	Haddock, cod, plaice, expl., dist., abund. Banquereau, Sable I., Emerald Banks
		H13	3-29 July	29(15)	
	W,X	A15	4-30 Nov.	29	Redfish, dist., abund., Shelf edge
1960	T	A16	18-24 Jan.	26	Cod, plaice, dist., abund., S.W. Gulf
		A21	19-38 May	17	Plaice, dist., abund., Magdalens
		H22	2-9 June	39(19)	Cod, dist., abund., S.W. Gulf
		H27	23-29 Sept.	41(21)	Cod, dist., abund., S.W. Gulf
	T,Vn	H20	6-16 May	37(25)	Cod, dist., abund., Laurentian Channel
		A17	28 Jan. – 9 Feb.	21	Cod, dist., abund., Laurentian Channel

Year	Div.	Vessel & Cruise	Dates	No. of Sets	Purpose
	W	A19	29 Feb. – 7 Mar.	31	Haddock, dist., abund., Middle & Misaline
		A21	24-30 Mar.	32(20)	Haddock, dist., abund., Sable I, Western Emerald
		H24	5-20 July	55(44)	Haddock, dist., abund., Emerald
		H25			was comp. fishing with Cowie
1961	T	A32	14-20 Jan.	24	Plaice, cod, dist., S.W. Gulf
		H34	30 May – 9 June	56(16)	Plaice, cod, dist., abund., S.W. Gulf
		H35	19-21 June	9(15)	Haddock, dist., abund., Cape Breton
		H38	2-12 Oct.	50(21)	Cod, dist., abund., S.W. Gulf
	T,Vn	H32	8-11 May	18(9)	Plaice, cod, dist., abund., Gulf and Cape Breton
	Vn	A33	29 Jan. – 1 Feb.	13	Cod, dist., abund., Cape Breton
	W	A37	29 Apr. – 10 May	78	Haddock, dist., abund., Sable I. and Western Emerald
1962	T	H42	28 May – 5 June	34(31)	Cod, dist., abund., Gulf, L. Channel
		H46	1-25 Oct.	77(43)	Cod, dist., abund., L Channel and Magdalens
	T,Vs	A54	18-26 Apr.	54	Cod, dist., abund., Laurentian Channel
	VsW	A52	17-27 Mar.	89	Halibut, groundfish. dist., abund., Gully
	W	A53	4-12 Mar.	85	Haddock, cod, abund., Sable I., Western Emerald
1963	T	H52	24-29 Sept.	25(13)	Cod, dist., abund., S.W. Gulf
	T,Vn	H53	7-16 Oct.	28(23)	Witch, dist., abund., Cape Breton Shore
	Vn,VsW	A65	23 Feb. – 4 Mar.	30	Cod, dist., Scatari, Banquereau, Western
	W	A66	8-14 Mar.	22	Haddock, groundfish. dist., abund., Western, Emerald
	X	A67	19-27 Mar.	54	Haddock, groundfish. dist., abund., Browns, LaHave, S.W. Nova Scotia
	X	A73	6-11 Aug.	30	Haddock, groundfish. dist., abund., Browns, Bay of Fundy Mouth
1964	T	H63	15-25 Sept.	40(14)	Cod, dist., abund., S.W. Gulf
	Vr	A80	19-25 Jan.	25	Cod, dist., Sydney Bight, L. Channel
	Vn,Vs	H64	5-14 Oct.	19	Witch,. dist., abund.
	Vn,W	A81	30 Jan. – 6 Feb.	26	Witch,. dist., biology, Scatarie, Middle, Emerald
		H61	20-29 July	41	Witch,. dist., abund., Cape Breton
1965	T	H71	21-28 Sept.	25(13)	Cod, abund., S.W. Gulf
	Vs,W	A99	16-24 Mar.	32	Witch,. dist., biol., Canso-Gully
		A100	19 Mar. – 4 Apr.	34	Haddock, unutilized groundfish, dist., abund., Western Emerald
	W	H69	24-28 June	22	Silver hake, argentine, dist., abund., Sable I.
1966	T	H75	6-15 June	48	Hake, dist., abund., S.W. Gulf
		H81	23-29 Aug.	22	Yellowtail, dist., abund., Magdalens

Year	Div.	Vessel & Cruise	Dates	No. of Sets	Purpose
		H83	13-22 Sept.	29(15)	Cod, abund., S.W. Gulf
	Vs,W,X	A122	31 Aug. – 7 Sept.	45	Yellowtail, dist., abund., Browns-Banquereau
	V,W,X	A126	7 Nov. – 6 Dec.	?	Redfish, dist., abund.,
		A113	24 Feb. – 1 Mar.	32	Haddock, cod, dist., abund., Sable, Emerald
		H77	6-13 July	52	Groundfish, dist., abund.
1967	T	P14	27 Sept. – 1 Oct.	24(13)	Cod, abund., S.W. Gulf
	Vs,W	A127	20-26 Jan.	32	Yellowtail, groundfish, dist., abund., Banquereau, Sable I.
	W	P8	11-19 July	45	Haddock, dist., abund., Emerald-Banquereau
1968	T	P35	12-25 Sept.	70(19)	Cod, abund., S.W. Gulf, comp. fish
	Vs,W	P26	10-17 May	37	Silver hake, sand lance, groundfish, dist., abund.,
	Vs,W,X	P36	24-30 Oct.	36	
	WX	A142	13-17 Feb.	25	Argentine, silver hake, sand lance, haddock, groundfish, dist., abund., N.S. Banks
	X	P30	4-13 July	59	
1969	T	P53	12-18 Sept.	30(17)	Cod, abund., S.W. Gulf
	T,Vn	A155	14-23 Jan.	42	Cod, abund., acoustic, trawling, Laurentian Channel
	Vs,W,X	A156	28 Jan. – 3 Feb.	71	Groundfish, dist., Banquereau-Browns
	W,X	P49	3-16 July	59	Groundfish, strata, random
		P54	25 Sept. – 3 Oct.	149	Groundfish, dist., abund., Browns
1970	T	P79	15-24 Sept.	39	Groundfish, strata 15-24, 26-28
	V,WX	A175-176	6-30 July	143	Groundfish, strata, random
	W,X	P73	18-23 June	31	Sand lance, groundfish, dist., abund.
		A170	14-21 Mar.	36	Haddock, spawning survey, strata 62-65, 80, 81, 83
1971	T	P91	7-30 Sept.	67	Cod, abund., strat., random and fixed stations
	T,V,W,X	A188-189	29 June – 22 July	126	Groundfish, strat., random
	W,X	A184	23-30 Mar.	32	Haddock, spawning, strat. 61-65
1972	T	P106	6-25 Sept.	73	Groundfish, strat., random and fixed stations
	V,W,X	A200-201	23 June – 19 July	150	Groundfish, strat., random
		A196	5-11 Mar.	29	Haddock spawning, groundfish dist., and biology
1973	T	P122	Sep 5-Sep 24	74	Stratified Random Groundfish Survey plus fixed stations
	V	A205	Jan 22-Jan 31	42	Stratified Random Groundfish Survey plus fixed stations
	X	P138	Jun 4-Jun 29	24	To test bottom referencing underwater towed instrument vehicle (BRUTIV) at sea
	V,W	B1	Nov 14-Mar 24	83	Groundfish survey using fixed stations

Year	Div.	Vessel & Cruise	Dates	No. of Sets	Purpose
	X	HGS113	Jun 11-Jul 3	103	To tag cod on main trawling grounds
1974	T,Vn	P143	Sep 4-Sep 26	70	Stratified Random Groundfish Survey plus fixed stations
	W,X	A219	Mar 1-Mar 21	18	Stratified Random Groundfish Survey plus fixed stations
	V,W,X	P140	Jul 23-Aug 2	40	Stratified Random Groundfish Comparative Survey
1975	T	P152	May 20-May 28	41	Groundfish Survey using fixed stations
	T	P157	Sep 3-Sep 21	67	Stratified Random Groundfish Survey plus fixed stations
	W,X	A232	Feb 15-Feb 22	48	Groundfish population abundance
	T	P158	Oct 1-Oct 6	6	
	W	P159	Oct 15-Oct 18	15	Haddock gas bladder infection survey
1976	T	P172	Sep 8-Sep 26	66	Stratified Random Groundfish Survey plus fixed stations
	W,X	A243	Feb 20-Feb 22	36	Haddock distribution and abundance also fixed stations
	W	P164	Apr 28-May 1	16	Haddock gas bladder infection survey
	W	P169	Jul 14-Jul 22	20	
	W	P173	Oct 5-Oct 9	27	Haddock gas bladder infection survey
	Vs	C1	Nov 18-Nov 20	6	Charter otter and midwater trawl survey
	W,X,Z	C2	Nov 26-Dec 5	69	Charter otter and midwater trawl survey
	W,X	C3	Dec 10-Dec 19	49	Charter otter and midwater trawl survey
	T	GG1	Aug 13-Aug 30	58	Groundfish survey fixed stations
	T	HI7	Oct 16-Nov 15	66	Groundfish survey fixed stations
1977	T	P188	Sep 7-Sep 28	66	Stratified Random Groundfish Survey plus fixed stations
	W,X	P181	Apr 19-Apr 28	41	Groundfish survey with fixed stations
	W	P189	Oct 5-Oct 8	22	Groundfish survey with fixed stations
	V,W,X	A259	Mar 22-Mar 30	52	Groundfish distribution and abundance
1978	W,X	A274	Mar 12-Mar 18	21	Groundfish distribution and abundance
	T	P204	Sep 9-Oct 6	63	Stratified Random Groundfish Survey plus fixed stations
	W,X	P194	Apr 7-Apr 11	26	Groundfish survey using random stations
	T	H2	Jul 1-Jul 6	25	Trial run for Lady Hammond
	W	P196	Apr 26-Apr 27	7	Dual beam echosounder trials
	NA	CC78	Nov 13-Nov 22	63	Groundfish survey with random stations for pollock
1979	T	P229	Sep 5-Oct 2	74	Stratified Random Groundfish Survey plus fixed stations
	W,X	A288	Mar 21-Mar 30	60	Stratified Random Groundfish Survey plus fixed stations
	W	H11	Jan 23-Feb 2	3	Bottom Trawl
	W,X	VN3	Sep 14-Sep 30	75	Groundfish inventory and feeding study
1980	T	P244	Sep 4-Sep 25	70	Stratified Random Groundfish Survey plus fixed stations

Year	Div.	Vessel & Cruise	Dates	No. of Sets	Purpose
1981	T	P260	Sep 2-Sep 20	70	Stratified Random Groundfish Survey plus fixed stations
		NED			Hamish Scott Survey
1982	V,W	N5	Nov 17-Nov 26	98	Redfish survey, fixed stations
	V,W,X	N3	Oct 1-Oct 24	48	Stratified Random Groundfish Comparative Survey
		NED			Hamish Scott Survey
	V,W,X	N2	Oct 2-Oct 31	10	Stratified Random Groundfish Comparative Survey
	V,W,X	H73	Mar 29-Apr 7	90	Stratified Random Redfish survey
	X	RE1	Jun 22-Jul 2	34	Pollock inshore charter cruise
	W	N6	Nov 26-Nov 27	13	Redfish survey using fixed stations
1983		NED			Hamish Scott Survey
		NED			Hamish Scott Survey
	X	N10	May 25-Jun 4	89	Collection of Haddock tissues
	W	N14	Jul 27-Jul 28	13	Groundfish survey using fixed stations
	X	H88	Jan 6-Jan 18	93	Collection of haddock tissues
	W	P285	Mar 3-Mar 7	12	Groundfish for establishing EG classification standards
	W	H103	Jul 27-Jul 28	13	Stratified Random Groundfish Comparative Survey
	X	N15	Aug 30-Sep 8	87	Dist. and collection of tissues
	V,W	N20	Nov 16-Nov 30	99	Redfish survey using fixed stations
	V,W,X	H110	Nov 28-Dec 7	20	Pollock survey using fixed stations
1984		NED			Hamish Scott Survey
	V,W,X	H129	Nov 22-Dec 10	57	Pollock survey using fixed stations
1985	V,W	H144	Oct 21-Oct 30	109	Stratified Random Groundfish Comparative Survey
	W,X	H147	Dec 4-Dec 13	9	Pollock survey using fixed stations
	V,W,X	N53	Oct 7-Oct 17	94	Redfish survey using fixed stations
		NED			Hamish Scott Survey
	V,W	N54	Oct 21-Oct 30	104	Stratified Random Groundfish Comparative Survey
1986	W	N57	Feb 10-Feb 20	16	Shelf edge survey
	V,W	N69	Sep 29-Oct 10	82	Redfish survey using fixed stations
1987	X	N82	Jun 2-Jun 11	37	Pollock survey using fixed stations
	Z	P355	Jul 13-Jul 23	61	Stratified Random Groundfish Survey
	V,W,X	N92	Feb 20-Feb 28	94	Redfish survey using fixed stations
1988	W,X,Y	N103	Jun 1-Jun 6	23	Pollock survey using fixed stations
2002	4W	NED62	Oct 3-Oct 9	82	NON STANDARD
2006	4X	NED3	Mar 21-Mar 23	21	UNKNOWN

Year	Div.	Vessel & Cruise	Dates	No. of Sets	Purpose
2007	4X	TEM687	Mar 22-Mar 24	17	UNKNOWN

* Numbers in parentheses represent the number of locations fished on surveys where more than one set was made at a location.

Table 2. Trawling Surveys Conducted by Canada in NAFO Divisions 4VWX5ZY as part of the ongoing Maritimes Region spring survey series (1986-2020) and summer survey series (1970-2020). Vessels include ATC – *A.T. Cameron*, HAM – *Lady Hammond*, NED – *CCGS Alfred Needler*, TEM – *CCGS Wilfred Templeman*, TEL – *CCGS Teleost*, and VEN – *Mersey Venture*.

SPRING SURVEYS				SUMMER SURVEYS			
YEAR	NAFO	MISSION	NOTES	YEAR	NAFO	MISSION	NOTES
1986	4X5Z	NED1986059		1970	4WX5Y	ATC1970175	
	4VW	NED1986060			4VW	ATC1970176	
1987	4X5Z	NED1987077		1971	4WX5Y	ATC1971188	
	4VW	NED1987078			4TVW	ATC1971189	
1988	5Z	NED1988097		1972	4WX5Y	ATC1972200	
	4VW	NED1988098			4VW	ATC1972201	
1989	5Z	NED1989116		1973	4WX5Y	ATC1973212	
	4VW	NED1989117			4VW	ATC1973213	
1990	5Z	NED1990133		1974	4WX5YZ	ATC1974225	
	4VW	NED1990134			4VWX	ATC1974226	
1991	5Z	NED1991148		1975	4WX5Y	ATC1975236	
	4VW	NED1991149			4VW	ATC1975237	
1992	5Z	NED1992165		1976	4WX5Y	ATC1976250	
	4VW	NED1992166			4VW	ATC1976251	
1993	4VW	NED1993182		1977	4WX5Y	ATC1977265	
	5Z	TEM1993134			4VW	ATC1977266	
1994	5Z	NED1994200		1978	4WX5YZ	ATC1978279	
	4VW	NED1994201			4VW	ATC1978280	
1995	5Z	NED1995216		1978	4WX5Z	HAM1978003	Includes only ATC/HAM comp. sets
	4VW	NED1995217			4VW	HAM1978004	Includes only ATC/HAM comp. sets
1996	5Z	NED1996237		1979	4WX5Y	ATC1979292	
	4VW	NED1996238			4VW	ATC1979293	
1997	5Z	NED1997254		1979	4WX5Y	HAM1979020	Includes only ATC/HAM comp. sets
	4VW	NED1997255			4VW	ATC1980306	
1998	5Z	NED1998773		1980	4VW	ATC1980307	
1999	5Z	NED1999871			4WX5Y	HAM1980037	Includes ATC/HAM comp. sets
	4VWX	NED1999872			4VW	HAM1980038	Includes only

SPRING SURVEYS				SUMMER SURVEYS			
YEAR	NAFO	MISSION	NOTES	YEAR	NAFO	MISSION	NOTES
							ATC/HAM comp. sets
2000	5Z	NED2000965		1981	4WX5YZ	ATC1981321	
	4VW	NED2000966			4VW	ATC1981322	
2001	5Z	NED2001003			4X5YZ	HAM1981059	Includes only ATC/HAM comp. sets
	4VW	NED2001004			4VW	HAM1981060	Includes ATC/HAM comp. sets
2002	5Z	NED2002002		1982	4WX5Y	HAM1982080	
	4VW	NED2002003			4VW	HAM1982081	
2003	5Z	NED2003002		1983	4X5Y	HAM1983101	Includes ATC/HAM comp. sets
	4VW	NED2003003			4VW	HAM1983102	Includes ATC/HAM comp. sets
2004	5Z	TEM2004004			4WX5Y	NED1983012	
2005	5Z	NED2005001			4VW	NED1983013	
	4VW	NED2005002		1984	4WX5Y	NED1984031	
	5Z	TEL2005545	Includes NED/TEL comp. sets with WIIA		4VW	NED1984032	
	4VW	TEL2005546	Includes NED/TEL comp. sets with WIIA	1985	4WX5Y	NED1985048	
2006	5Z	NED2006001			4VW	NED1985049	
	4VW	NED2006002		1986	4WX5Y	NED1986065	
	5Z	TEL2006614	Includes NED/TEL comp. sets with WIIA		4VW	NED1986066	
	4VW	TEL2006615	Includes NED/TEL comp. sets with WIIA	1987	4WX5Y	NED1987085	
2007	5Z	TEM2007685			4VW	NED1987086	
	4VWX	TEM2007686			4VW	NED1987087	
2008	4VsW	TEL2008805		1988	4WX5YZ	NED1988105	
	4WX5YZ	TEM2008775			4VW	NED1988106	
2009	4W	NED2009002		1989	4WX5YZ	NED1989123	
	4W5Z	NED2009841			4VW	NED1989124	
2010	4W5Z	NED2010001		1990	4WX5YZ	NED1990139	

SPRING SURVEYS				SUMMER SURVEYS			
YEAR	NAFO	MISSION	NOTES	YEAR	NAFO	MISSION	NOTES
	4VW	NED2010002			4VW	NED1990140	
2011	4WX5Z	NED2011002		1991	4VW	HAM1991231	
2012	4WX5YZ	NED2012002	Includes NEST/WIIA comp. sets		4WX5Y	NED1991154	
2013	4WX5Z	NED2013002	Includes NEST/WIIA comp. sets	1992	4WX5YZ	NED1992173	
2014	4WX5Z	NED2014002			4VW	NED1992174	
	4X5Y	NED2014101		1993	4WX5Y	NED1993189	
	4X5Y	NED2014102	Includes NEST/WIIA comp. sets		4VW	NED1993190	
2015	4WX5Z	NED2015002		1994	4WX5Y	NED1994221	
2016	4W5Z	TEL2016002			4VW	NED1994222	
	4WX5Y	TEL2016003		1995	4WX5Y	NED1995226	
2017	4WX5Z	NED2017002			4VW	NED1995227	
	4WX	NED2017102		1996	4WX5Y	NED1996246	
2018	4X5Z	VEN2018002			4VWX	NED1996247	
2019	5Z	NED2019002		1997	4WX5Y	NED1997726	
	4WX5Y	NED2019102			4VW	NED1997734	
2020	4W5Z	TEL2020002		1998	4WX5Y	NED1998827	
	4WX5Y	TEL2020102			4VW	NED1998832	
				1999	4WX5Y	NED1999925	
					4VW	NED1999929	
				2000	4WX5Y	NED2000426	
					4VW	NED2000431	
				2001	4WX5Y	NED2001032	
					4VW	NED2001037	
				2002	4WX5Y	NED2002037	
					4VW	NED2002040	
				2003	4VWX5Y	NED2003036	
					4VW	NED2003042	
				2004	4WX5Y	TEL2004529	
					4VW	TEL2004530	
				2005	4WX5Y	NED2005027	
					4VW	NED2005034	
					4WX5Y	TEL2005605	Includes NED/TEL comp. sets with WIIA
					4VW	TEL2005633	Includes only

SPRING SURVEYS				SUMMER SURVEYS			
YEAR	NAFO	MISSION	NOTES	YEAR	NAFO	MISSION	NOTES
							NED/TEL comp. sets with WIIA
				2006	4WX5Y	NED2006030	
					4VW	NED2006036	
				2007	4VWX	TEL2007745	
				2008	4VWX5Y	TEM2008830	
				2009	4VWX5Y	NED2009027	
				2010	4VWX5YZ	NED2010027	Greater coverage in deepwater strata 501- 505
				2011	4VWX5YZ	NED2011025	Greater coverage in deepwater strata 501- 505
				2012	4VWX5YZ	NED2012022	
				2013	4VWX5YZ	NED2013022	
					4VWX	NED2013028	Includes NEST/WIIA comp. sets
				2014	4VWX5YZ	NED2014018	
				2015	4VWX5YZ	NED2015017	
				2016	4VWX5Z5YZ	NED2016016	
					4VW	NED2016116	Includes NEST/WIIA comp. sets
				2017	4VWX5YZ	NED2017020	Greater coverage in deepwater strata 501- 505
				2018	4WX5YZ	TEL2018023	
				2019	4VWX5YZ	NED2019030	
				2020	4VWX5YZ	NED2020025	

Table 3. Stratified random bottom trawl surveys conducted by Canada as part of the Maritimes Region Survey Program's 4VWX5Y standard fall survey series (1978-1984; 1986). Vessels include HAM – *Lady Hammond* and NED – *CCGS Alfred Needler*.

YEAR	NAFO	MISSION
1978	4VWX	HAM1978009
	4VW	HAM1978010
1979	4VW	HAM1979026
	4WX5Y	HAM1979027
1980	4WX5Y	HAM1980042
	4VW	HAM1980043
1981	4VW	HAM1981064
	4WX5YZ	HAM1981065
1982	4VW	HAM1982084
	4WX5Y	HAM1982085
1983	4VW	NED1983017
	4WX5Y	NED1983018
1984	4VW	NED1984036
	4WX5Y	NED1984037
1986	4X	NED1986070

Table 4. Current set allocation on the Maritimes Region Research Vessel summer survey of the Bay of Fundy, Scotian Shelf, and Georges Bank (4VWX5Z).

Stratum	Depth (fm)	Trawlable Units (WIJA)	Area (nm ²)	1 per 200 nm ²	1 per 350 nm ²	Primary	Alternate	Total	Comment
440	100-200	78301.1 1	924	5	3	4	2	6	4V, additional stations in 1999
441	50-100	84741.4 6	1000	5	3	6	3	9	4V, additional stations in 1999
442	<50	121773. 5	1437	7	4	6	3	9	4V, additional stations in 1999
443	<50	111689. 2	1318	7	4	5	4	9	4V, additional stations in 1999
444	50-100	332610. 2	3925	20	11	12	4	16	Additional stations in 1990; 4V, additional stations in 1999
445	100-200	86690.5 2	1023	5	3	4	4	8	
446	100-200	41608.0 6	491	2	1	3	2	5	
447	<50	136942. 2	1616	8	5	7	3	10	Additional stations in 1990
448	<50	122790. 4	1449	7	4	7	3	10	Additional stations in 1990
449	50-100	12202.7 7	144	1	1	2	2	4	
450	50-100	32455.9 8	383	2	1	3	2	5	
451	100-200	12457	147	1	1	2	2	4	
452	100-200	29235.8	345	2	1	3	2	5	
453	100-200	21948.0 4	259	1	1	2	2	4	
454	50-100	42285.9 9	499	2	1	2	2	4	
455	<50	179821. 4	2122	11	6	9	4	13	Additional stations in 1990
456	<50	80928.1	955	5	3	6	3	9	Additional stations in 1990

Stratum	Depth (fm)	Trawlable Units (WIA)	Area (nm ²)	1 per 200 nm ²	1 per 350 nm ²	Primary	Alternate	Total	Comment
457	50-100	68725.33	811	4	2	3	2	5	
458	<50	55759.88	658	3	2	5	3	8	Additional stations in 1990
459	0-200	266766.1	3148	16	9	7	3	10	
460	50-100	113892.5	1344	7	4	5	2	7	
461	100-200	97791.65	1154	6	3	3	2	5	
462	50-100	179312.9	2116	11	6	5	2	7	
463	<50	25591.92	302	2	1	2	2	4	
464	<50	109909.7	1297	6	4	6	3	9	
465	50-100	201938.9	2383	12	7	9	3	12	Additional stations in 1987
466	100-200	19151.57	226	1	1	2	2	4	
470	50-100	77962.15	920	5	3	3	2	5	
471	100-200	85080.43	1004	5	3	3	2	5	
472	50-100	105842.1	1249	6	4	4	2	6	Additional stations in 1987
473	<50	22456.49	265	1	1	2	2	4	
474	<50	13643.38	161	1	1	2	2	4	
475	<50	13219.67	156	1	1	2	2	4	
476	50-100	125247.9	1478	7	4	5	2	7	Additional stations in 1987
477	50-100	104401.5	1232	6	4	5	2	7	Additional stations in 1987

Stratum	Depth (fm)	Trawlable Units (WIA)	Area (nm ²)	1 per 200 nm ²	1 per 350 nm ²	Primary	Alternate	Total	Comment
478	100-200	19744.76	233	1	1	2	2	4	
480	<50	55505.66	655	3	2	9	3	12	
481	50-100	158890.2	1875	9	5	9	3	12	
482	100-200	88300.6	1042	5	3	4	2	6	Additional stations in 1987
483	100-200	45082.46	532	3	2	3	2	5	
484	100-200	191854.7	2264	11	6	7	2	9	
485	50-100	134061	1582	8	5	6	3	9	
490	<50	50929.62	601	3	2	4	2	6	
491	50-100	58217.39	687	3	2	4	2	6	
492	50-100	92029.23	1086	5	3	4	2	6	
493	<50	45167.2	533	3	2	4	2	6	
494	<50	35337.19	417	2	1	4	2	6	
495	<50	49489.01	584	3	2	4	2	6	
496	200-400	26354.6	311	2	1	2	2	4	Slope, added 1995
497	200-400	43048.66	508	3	1	2	2	4	Slope, added 1995
498	200-400	40336.94	476	2	1	2	2	4	Slope, added 1995
501	410-547	42455.47	501	3	1	4	3	7	Deepwater, added 2011
502	547-584	23812.35	281	1	1	4	3	7	Deepwater, added 2011
503	584-820	102028.7	1204	6	3	4	3	7	Deepwater, added 2011

Stratum	Depth (fm)	Trawlable Units (WIIA)	Area (nm ²)	1 per 200 nm ²	1 per 350 nm ²	Primary	Alternate	Total	Comment
504	820-957	59912.2 1	707	4	2	4	3	7	Deepwater, added 2011
505	957-1094	57624.2	680	3	2	4	3	7	Deepwater, added 2011
558	200-400	189905. 6	2241	11	6	2	2	4	Laurentian Channel, added 2014
559	200-400	196600. 2	2320	12	7	2	2	4	Laurentian Channel, added 2014
560	100-400	11016.4	130	1	1	2	2	4	Strata unused and has never been sampled
5Z1	50-100	67369.4	795	4	2	7	3	10	Georges Bank, added 2011
5Z2	<50	106096. 3	1252	6	4	10	5	15	Georges Bank, added 2016
5Z9	100-200	57708.9 4	681	3	2	3	3	6	Georges Bank, added 2011
Total (without 560)		5521500	63489	317	181	272	154	426	

Table 5. Set allocation on the Maritimes Region Research Vessel spring survey of 5Ze (Georges Bank) from 1987-1992. Reproduced from Hunt (1992).

Stratum	Per 100 sets 1987-1991	Per 140 sets 1992 only
5Z1	10	14
5Z2	35	49
5Z3	15	21
5Z4	15	21
5Z5	5	7
5Z6	12	17
5Z7	5	7
5Z8	3	4
Total	100	140

Table 6. Current set allocation on the Maritimes Region Research Vessel spring survey of Georges Bank (5Z).

Stratum	Depth (fm)	Trawlable Units (WIIA)	Area (nm ²)	1 per 200 nm ²	1 per 350 nm ²	Primary	Secondary	Alternate	Total	Comment
5Z1	50-100	67369.4	795	4	2	6	4	3	13	
5Z2	<50	106096.3	1252	6	4	20	15	6	41	
5Z31	<50	102367.6	1208	6	3	5	2	2	9	
5Z32	<50	40336.9	476	2	1	4	2	2	8	
5Z33	<50	32371.2	382	2	1	NA	NA	NA	0	Exclusion for shoals
5Z34	<50	36693.0	433	2	1	NA	NA	NA	0	Exclusion for shoals
5Z41	<50	107791.1	1272	6	4	5	2	2	9	
5Z42	<50	156517.4	1847	9	5	5	2	2	9	
5Z5	50-100	197956.0	2336	12	7	5	NA	3	8	No longer completed as of 2020
5Z6	<50	138806.5	1638	8	5	8	4	4	16	No longer completed as of 2020
5Z7	<50	271087.8	3199	16	9	5	NA	3	8	No longer completed as of 2020
5Z8	50-100	170669.2	2014	10	6	3	NA	3	6	No longer completed as of 2021
5Z9	100-200	57708.94	681	3	2	4	NA	3	7	Added in 2010
470	50-100	77962.15	920	5	3	2			10	
471	100-200	85080.43	1004	5	3	2			10	
472	50-100	105842.1	1249	6	4	4			14	
473	<50	22456.49	265	1	1	2			4	
474	<50	13643.38	161	1	1	2			4	
475	<50	13219.67	156	1	1	2			4	
476	50-100	125247.9	1478	7	4	4			15	
477	50-100	104401.5	1232	6	4	6			16	
478	100-200	19744.76	233	1	1	2			4	
480	<50	55505.66	655	3	2	6			11	
481	50-100	158890.2	1875	9	5	7			21	
482	100-200	88300.6	1042	5	3	4			12	

483	100-200	45082.46	532	3	2	2			7	
484	100-200	191854.7	2264	11	6	5			22	
485	50-100	134061	1582	8	5	5			18	
490	<50	50929.62	601	3	2	4			9	
491	50-100	58217.39	687	3	2	4			9	
492	50-100	92029.23	1086	5	3	3			11	
493	<50	45167.2	533	3	2	3			8	
494	<50	35337.19	417	2	1	2			5	
495	<50	49489.01	584	3	2	2			7	
Total 4X						73	0	0		73 stations in 4X
Total 5Z1-9						70	31	33		134 stations in 5Z1-9
Total 5Z1-4 & 9						49	27	20		96 stations in 5Z1-4 & 9

Table 7. DFO and CCGS vessels used in the Maritimes Vessel Research Vessel Survey Program from 1970-2020. Based on a table from Fanning (1985).

Name	Type	Tonnage	Length	Science Staff	Labs	Trawl
AT Cameron	Side trawler	753	53m	9 (+1)*	On-deck sorting only Sheltered above-deck lab Hydrographic sampling	Yankee 36
Lady Hammond	Stern trawler	897	58m	Est. 9	On-deck sorting only Wet (Fish Lab) Hydrographic sampling	Western IIA
CCGS Alfred Needler	Stern trawler	925	50m	11	Wet (Fish Lab) Dry Oceanography Acoustics	Western IIA
CCGS Wilfred Templeman	Stern trawler	925	50m	11	Wet (Fish Lab) Dry Oceanography	Western IIA
CCGS Teleost	Stern trawler	2405	63m	13	Wet (Fish Lab) Dry Oceanography Acoustics	Western IIA
CCGS Captain Jacques Cartier	Stern trawler	2675	63m	13	Wet (Fish Lab) Dry Oceanography Acoustics	NEST

* The ATC provided one ships technician to assist primarily with hydrographic sampling.

Table 8. Summary of trawl gear used in the Maritimes Research Vessel Survey Program from 1970-2020. NEST measurements are SCANMAR tolerance limits and optimal ranges (E. MacEachern, pers. comm.). Tolerance limits and optimal ranges were not developed for the Western IIA or for the Yankee 36 as used on Maritimes Region Surveys, so net specifications are listed instead. Based on tables and information from Halliday and Koeller (1981), Fanning 1985, Carrothers 1988, Brown et al. 2007, Brooks and Politis 2014, Politis et al. 2014).

Gear Characteristic	Yankee 36	Western IIA	NEST
Design	2-bridle, 2-seam trawl	2-bridle, 4-seam (box) trawl with flying wing	3-bridle, 4-seam trawl with 3 wings/jibs
Purpose	Commercial trawl with scientific modifications	Commercial trawl with scientific modifications	Science trawl
Wingspread (m)	10.7 m	13.5 m	11-15m (13m optimal)
Doorspread (m)	22 m	45 m	28-40m (32m optimal)
Headline Height (m)	2.7 m	3.2	2.7-4.7m (3.2-4.1m optimal)
Codend Linear Mesh (m)	¼" (6.4mm) rect.	¾" (19mm) Square	1" (25.4mm) Diamond
Door Type & Weight	Steel-bound wood – 453 kg	Portuguese Euronete (all steel) – 950 kg	Poly-Ice 2A – 2.2m ² , 550 kg
Sweep	Roller (35.6 cm)	Bobbin (48.2 cm/29.2 cm)	Rock Hopper (40.6 cm/35.6 cm)
Standard Tow Speed	3.5 kts	3.5 kts	3.0 kts
Standard Tow Duration	30 min	30 min	20 min
Standard Tow Distance	1.75 nm	1.75 nm	1 nm

Table 9. Comparative tows (Type 5 paired sets) completed with the Western IIA trawl and NEFSC Science Trawl (NEST) gear aboard the CCGS Alfred Needler from 2012-2016.

Year	Season	Mission	No. Paired Sets
2012	Spring	NED2012002	51
2013	Spring	NED2013002	8
2013	Summer	NED2013028	91
2014	Spring	NED2014102	41
2016	Summer	NED2016116	21

Table 10. Warp-to-depth ratio table for the Western IIA trawl, used since 2005, to consistently determine the amount of warp deployed at a given depth.

Depth (m)	Warp Length									
	0	1	2	3	4	5	6	7	8	9
10	3.29	3.32	3.35	3.37	3.39	3.29	3.31	3.33	3.35	3.37
20	3.38	3.31	3.32	3.34	3.35	3.36	3.30	3.32	3.33	3.34
30	3.29	3.30	3.31	3.32	3.33	3.29	3.30	3.31	3.32	3.28
40	3.29	3.30	3.31	3.27	3.28	3.29	3.30	3.27	3.28	3.28
50	3.29	3.26	3.27	3.28	3.28	3.26	3.26	3.27	3.25	3.25
60	3.26	3.27	3.24	3.25	3.26	3.23	3.24	3.25	3.23	3.23
70	3.24	3.24	3.22	3.23	3.24	3.22	3.22	3.23	3.21	3.22
80	3.22	3.20	3.21	3.22	3.20	3.20	3.21	3.19	3.20	3.20
90	3.19	3.19	3.18	3.18	3.19	3.17	3.18	3.18	3.17	3.18
100	3.18	3.17	3.17	3.16	3.16	3.17	3.16	3.16	3.15	3.15
110	3.16	3.15	3.15	3.14	3.14	3.12	3.14	3.14	3.13	3.13
120	3.14	3.13	3.13	3.12	3.13	3.13	3.12	3.12	3.11	3.12
130	3.11	3.11	3.10	3.11	3.11	3.10	3.10	3.10	3.10	3.09
140	3.09	3.09	3.09	3.08	3.08	3.09	3.08	3.08	3.08	3.08
150	3.07	3.07	3.07	3.07	3.06	3.07	3.06	3.06	3.05	3.06
160	3.05	3.05	3.05	3.05	3.04	3.05	3.04	3.04	3.04	3.04
170	3.03	3.04	3.03	3.03	3.03	3.03	3.02	3.03	3.02	3.02
180	3.02	3.01	3.01	3.01	3.01	3.00	3.01	3.00	3.00	3.00
190	3.00	3.00	2.99	2.99	2.99	2.99	2.98	2.99	2.98	2.98
200	2.98	2.97	2.98	2.97	2.97	2.97	2.96	2.97	2.96	2.97
210	2.96	2.95	2.96	2.95	2.96	2.95	2.95	2.95	2.94	2.95
220	2.94	2.94	2.94	2.93	2.94	2.93	2.93	2.93	2.93	2.93
230	2.92	2.92	2.92	2.92	2.91	2.92	2.91	2.91	2.91	2.91
240	2.91	2.91	2.90	2.90	2.90	2.89	2.90	2.89	2.89	2.89
250	2.89	2.88	2.89	2.88	2.88	2.88	2.88	2.87	2.88	2.87
260	2.87	2.87	2.87	2.86	2.87	2.86	2.86	2.86	2.86	2.85
270	2.85	2.85	2.85	2.85	2.85	2.85	2.84	2.84	2.84	2.84
280	2.83	2.84	2.83	2.83	2.83	2.83	2.83	2.82	2.82	2.82
290	2.82	2.81	2.82	2.81	2.81	2.81	2.81	2.81	2.80	2.81
300	2.80	2.80	2.80	2.80	2.80	2.79	2.79	2.79	2.79	2.79
310	2.78	2.79	2.78	2.78	2.78	2.78	2.78	2.77	2.77	2.77
320	2.77	2.77	2.76	2.76	2.76	2.76	2.76	2.76	2.75	2.76
330	2.75	2.75	2.75	2.74	2.75	2.74	2.74	2.74	2.74	2.74
340	2.74	2.73	2.73	2.73	2.73	2.73	2.73	2.72	2.72	2.72
350	2.72	2.72	2.72	2.71	2.72	2.71	2.71	2.71	2.71	2.70

360	2.71	2.70	2.70	2.70	2.70	2.69	2.70	2.69	2.69	2.69
370	2.69	2.69	2.68	2.69	2.68	2.68	2.68	2.68	2.67	2.67
380	2.67	2.67	2.67	2.67	2.67	2.66	2.66	2.66	2.66	2.66
390	2.66	2.66	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.64
400	2.64	2.64	2.64	2.64	2.64	2.64	2.63	2.63	2.63	2.63
410	2.63	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.61
420	2.61	2.61	2.61	2.61	2.61	2.61	2.60	2.60	2.60	2.60
430	2.60	2.60	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
440	2.58	2.58	2.58	2.58	2.58	2.58	2.57	2.57	2.57	2.57
450	2.57	2.57	2.57	2.57	2.56	2.56	2.56	2.56	2.56	2.56
460	2.56	2.55	2.55	2.55	2.55	2.55	2.55	2.54	2.54	2.54
470	2.54	2.54	2.54	2.54	2.53	2.53	2.53	2.53	2.53	2.53
480	2.53	2.53	2.53	2.52	2.52	2.52	2.52	2.52	2.52	2.52
490	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.50	2.50	2.50
500	2.50	2.50	2.50	2.50	2.50	2.49	2.49	2.49	2.49	2.49

Depth (m)	0	10	20	30	40	50	60	70	80	90
500	2.50	2.49	2.47	2.46	2.45	2.44	2.42	2.41	2.40	2.39
600	2.37	2.36	2.35	2.34	2.33	2.32	2.31	2.30	2.29	2.28
700	2.27	2.26	2.25	2.24	2.23	2.22	2.21	2.20	2.19	2.18
800	2.18	2.17	2.16	2.15	2.14	2.14	2.13	2.12	2.11	2.11
900	2.10	2.09	2.09	2.08	2.07	2.07	2.06	2.06	2.05	2.05
1000	2.04	2.04	2.03	2.03	2.02	2.02	2.02	2.01	2.01	2.01
1100	2.00	2.00	2.00	1.99	1.99	1.99	1.99	1.99	1.98	1.98
1200	1.98	1.98	1.98	1.98	1.98	1.98	1.97	1.97	1.98	1.97
1300	1.97	1.97	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98
1400	1.99	1.99	1.99	1.99	2.00	2.00	2.00	2.00	2.01	2.01
1500	2.01	2.02	2.02	2.03	2.03	2.04	2.04	2.04	2.05	2.05

Table 11. Definition of maturity stages for Atlantic Cod and Haddock, as used on Maritimes Region Surveys.

	Female	Male
Stage 1 – Immature	Ovaries small and firm; pale pink or reddish and somewhat transparent.	Testes slender; appear as a clear, crimped and slender string.
Stage 2 – Ripening 1	Ovaries slightly larger than in Stage 1 but still small and firm; contains microscopic, yellow or reddish yellow, opaque eggs; blood capillaries showing.	Testes grow gradually in size; pinkish or flesh coloured; blood capillaries showing.
Stage 3 – Ripening 2	Ovaries occupy about half of ventral cavity; reddish and numerous blood vessels; opaque eggs are now visible to naked eye and give the ovaries a granular appearance.	Testes occupy about half ventral cavity; begin to turn white, with fine, rather conspicuous blood vessels; no milt runs when pressure is applied.
Stage 4 – Ripe	Has a few clear eggs at the earliest stage progressing to having mainly clear eggs but eggs do not extrude freely with slight pressure. Spawning has not started.	Testes distinctly wavy white and quite distended; large lobes; a small amount of milt may be forced out by pressure.
Stage 5 – Spawning	As Stage IV but eggs running freely on slight pressure.	Testes very white and fully extended; milt runs freely at the slightest pressure.
Stage 6 – Spent	Ovaries soft; flabby and bloody; practically no eggs remain; purple in colour.	Testes shrunken and reddish; vas deferens prominent against irregular surfaces of testes; some blood left in organ.
Stage 7 – Recovering	Membrane purplish and ovaries fairly baggy, no eggs visible.	Testes resume pale pink colour; traces of blood in organ; vas deferens wrinkled and string-like.
Stage 8 – Resting	Looks very much like Stage 1, but is found in large fish; ovary larger than in 1, also membrane thicker and not as transparent as in 1.	Testes larger than in 1; surface regular, some greyish pink in colour.

9. FIGURES

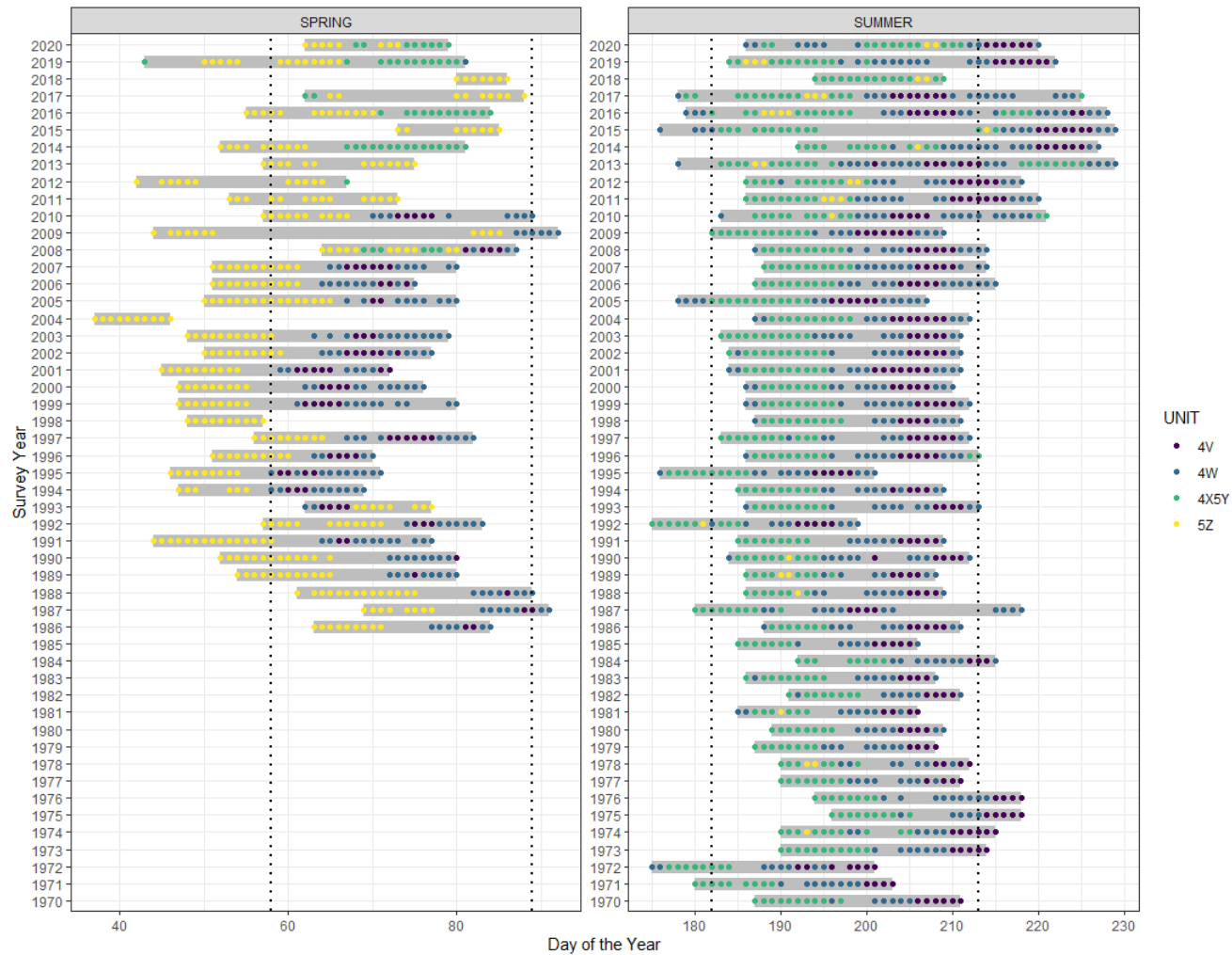


Figure 1. Survey timing by year. Grey bars represent the time period between the first and last successful standardized sets of the survey. Points represent days with successful sets during the survey; colours represent NAFO unit area in which the day's sets occurred.

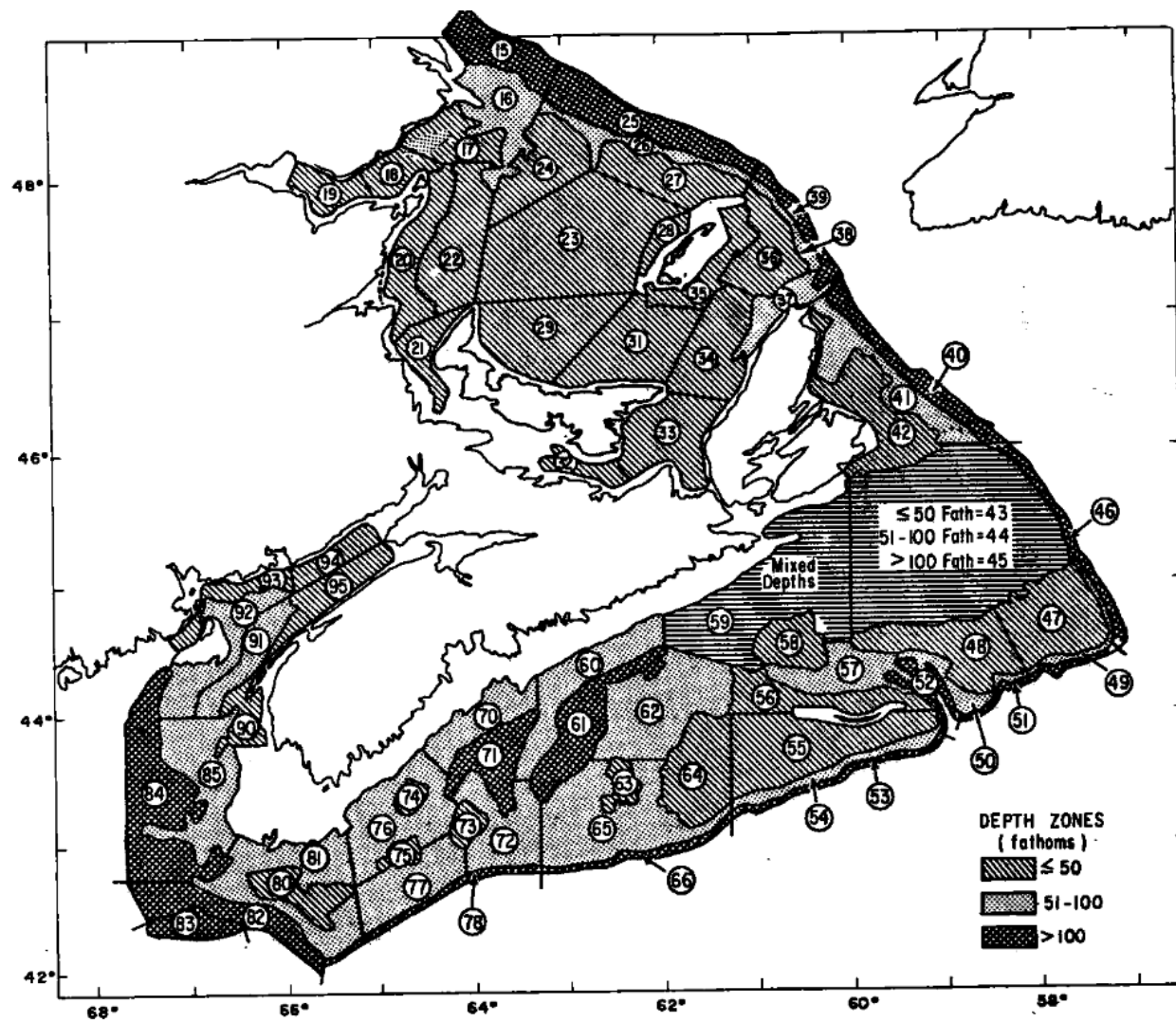


Figure 2. Original stratification and numbering system of ICNAF Div. 4T-V-W-X adopted January 1970 (Doubleday 1976).

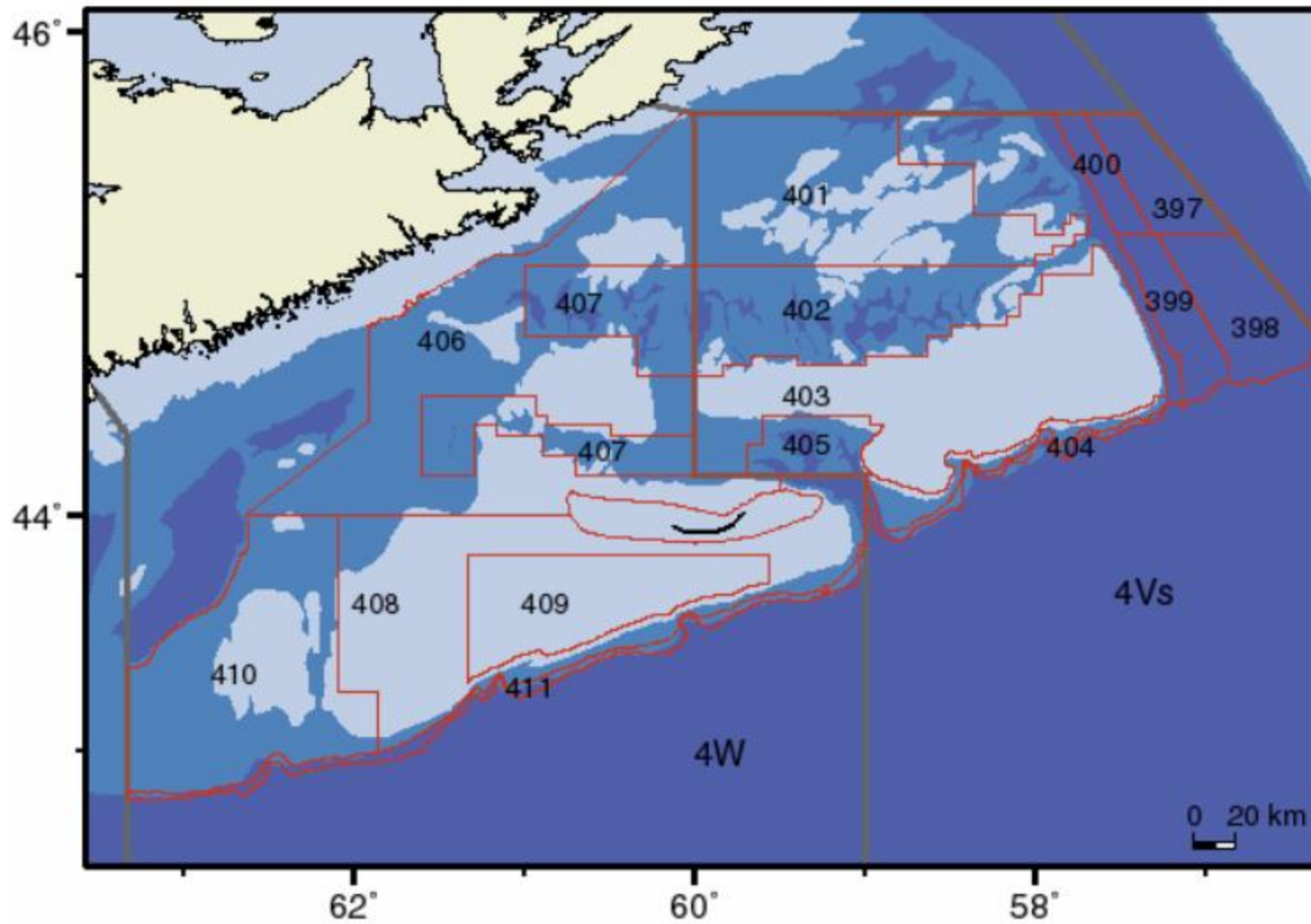


Figure 4. DFO Eastern Scotian Shelf (4VsW) March 4VsW RV survey strata and area of coverage (Claytor et al. 2014).

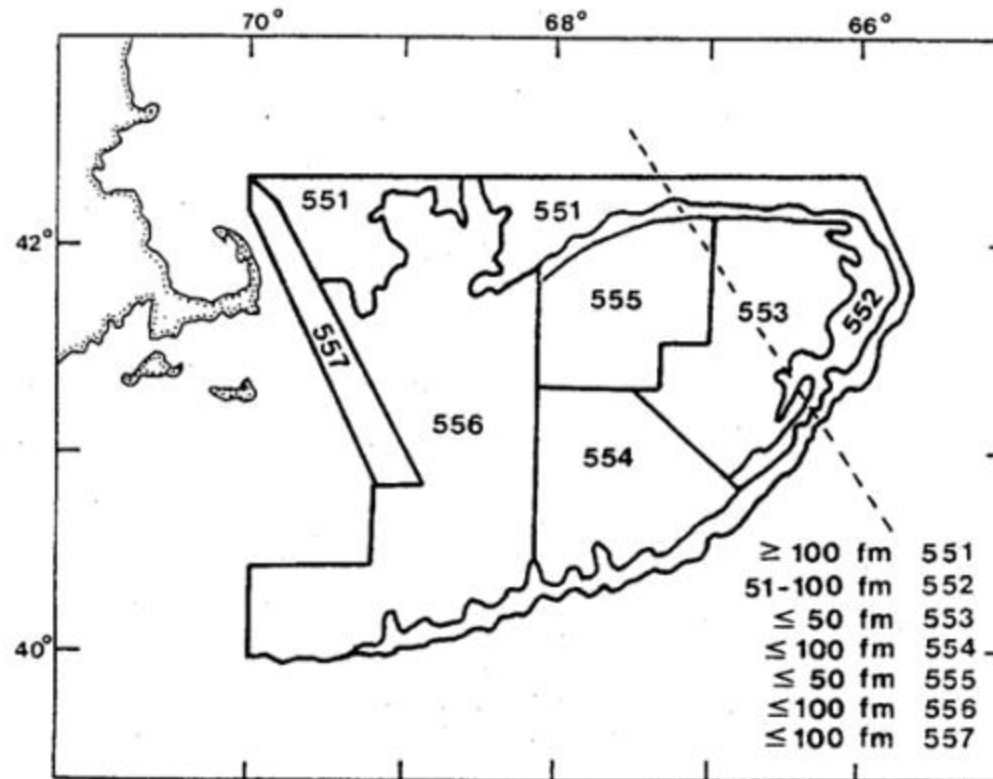


Figure 5. Stratification scheme used for the 1986 Georges Bank survey (Gavaris and Waiwood 1986).

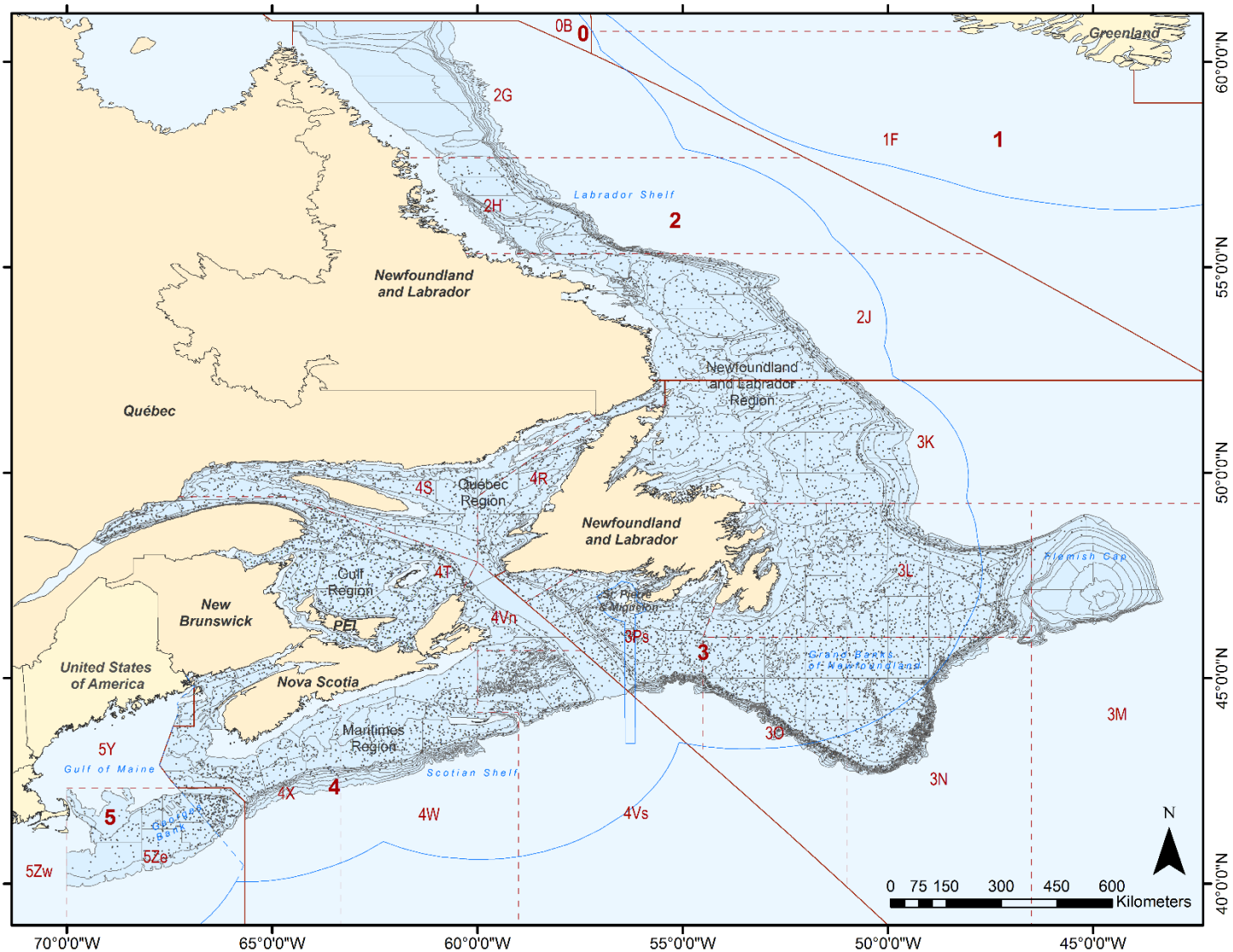


Figure 6. Station distribution for DFO surveys in the Atlantic Zone in the year 2011 (Wilson et al. in press)

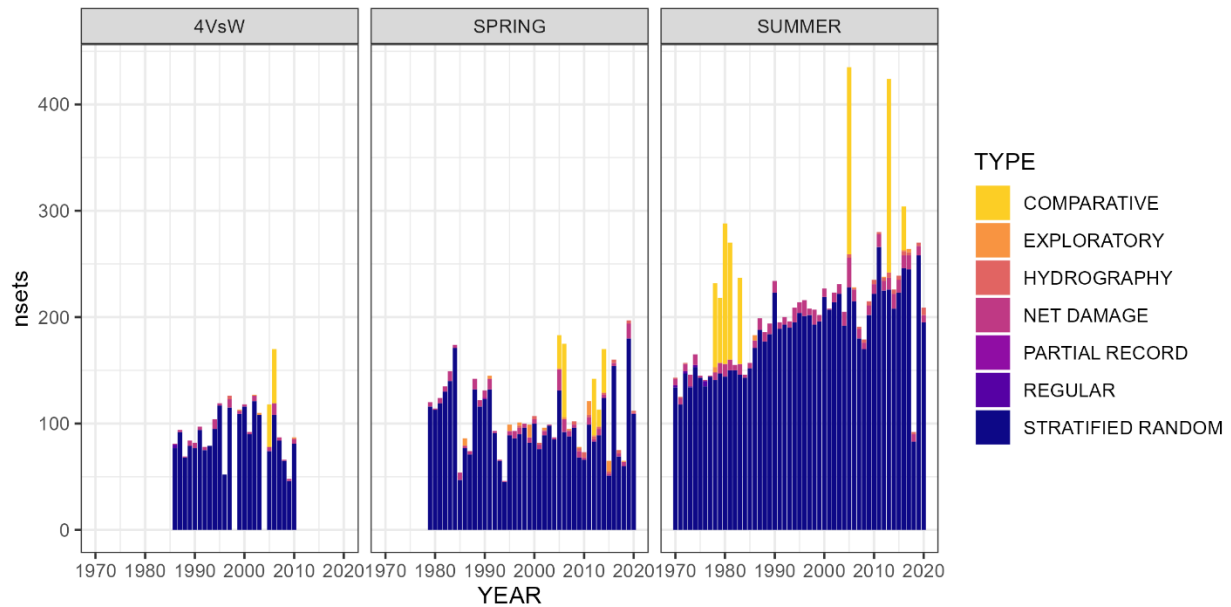


Figure 7. Fishing sets per year for the Maritimes Ecosystem Surveys' spring 4VsW, spring 4X5Z (1986-2020) and summer 4VWX5YZ (1986-2020) surveys of the Scotian Shelf, Bay of Fundy, and Georges Bank.

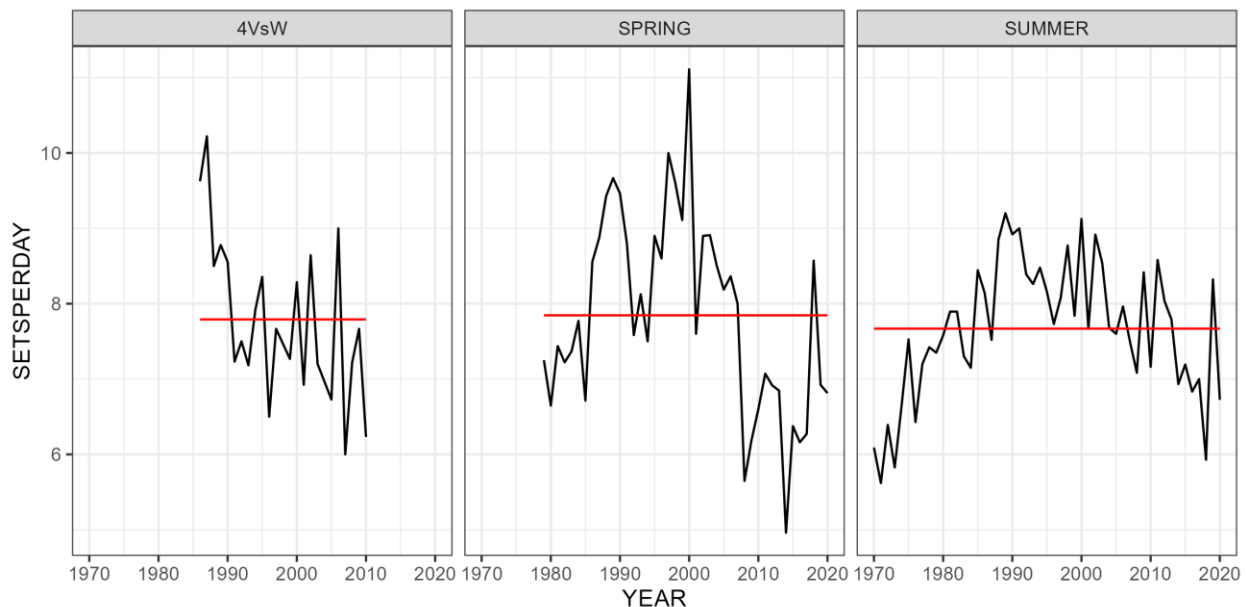


Figure 8. Mean stratified random survey sets per fishing day per year for the Maritimes Ecosystem Surveys' spring 4VsW, spring 4X5Z, and summer 4VWX5YZ surveys of the Scotian Shelf, Bay of Fundy, and Georges Bank. Fishing day is defined as any day in which one fishing set occurred. Horizontal red line is the mean sets per day for each time series. Variability is generally caused by weather, vessel malfunction, or other adverse effects beyond the control of the survey program.

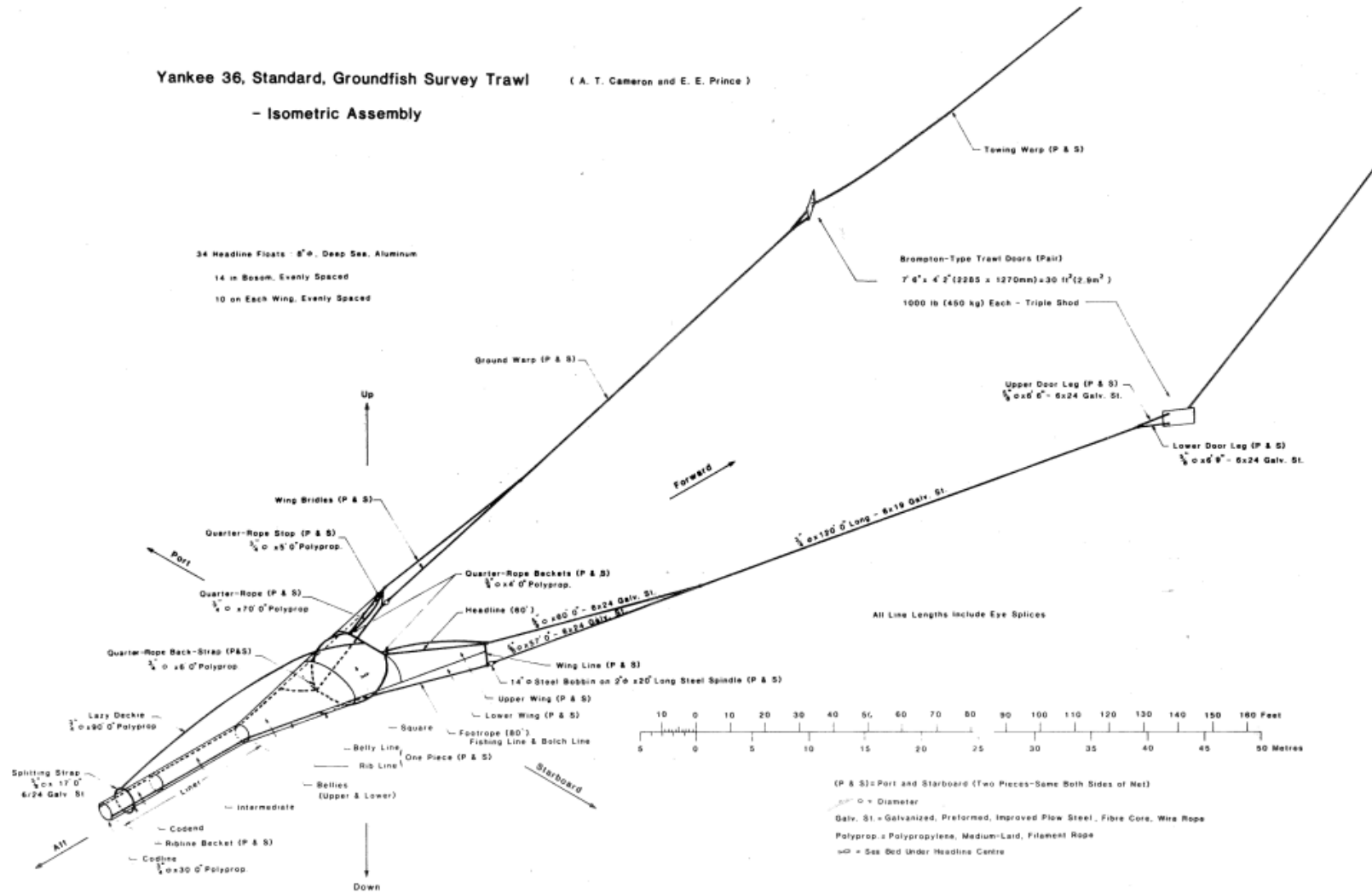


Figure 9. Yankee 36 trawl as documented in Carrothers (1988). The design, as pictured, was used on the DFO Maritimes Region summer survey from 1970-1981, before it was replaced with the Western IIA trawl.

(Lady Hammond and Alfred Needler)

88 Headline Floats : 6" Ø, Deep Sea, Aluminum

Static Buoyancy 6.32 lb (2.87 kg) Each

Working Depth to : 550 fm (1000m)

18 on Bosom

10 on Each Wedge (P & S)

15 on Each Flying Wing (P & S)

 $2850 \times 1550\text{mm} (9'4" \times 5'1\frac{1}{2}"); 4\text{m}^2 (43\text{ m}^2)$

☞ • See Bed Under Centre of Headline

85

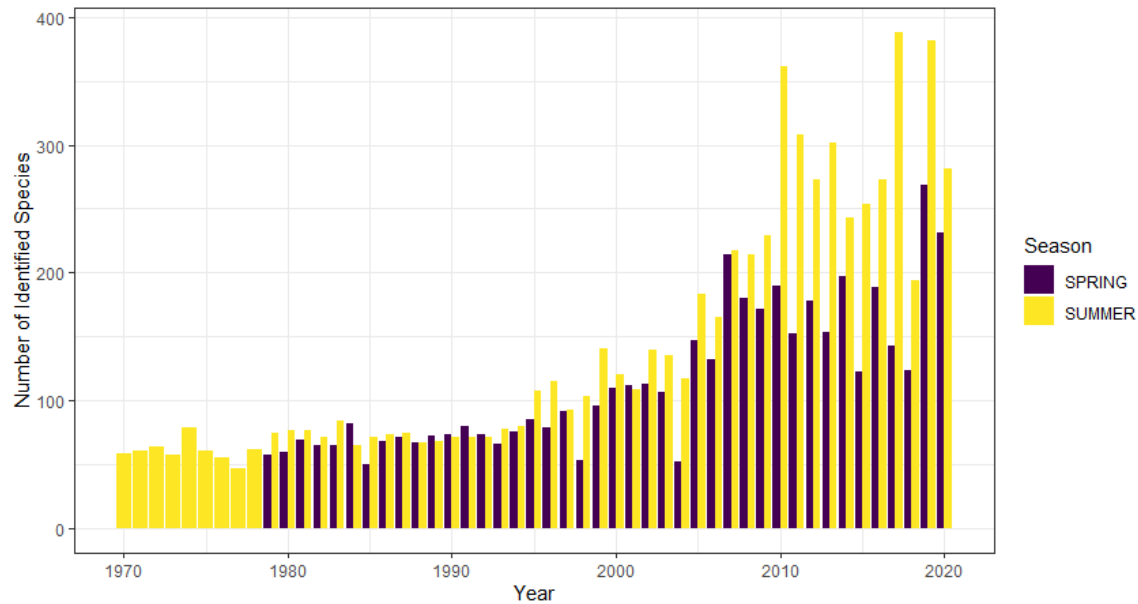


Figure 11. Number of species identified per survey year (1970-2020) during the summer (4VWX) and spring (4VWX5Z) surveys conducted by the Maritimes Region Ecosystem Surveys Program.

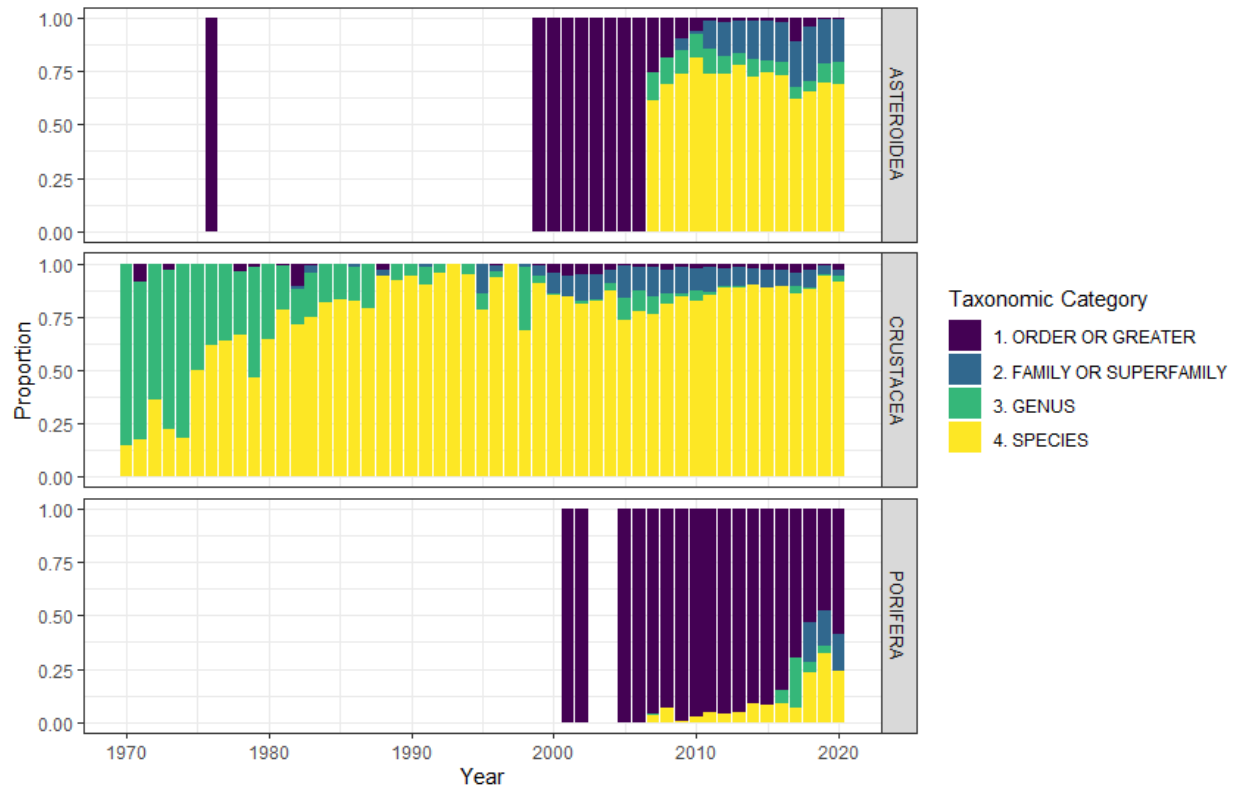


Figure 12. Proportion of specimens identified by taxonomic category per survey year (1970-2020) during the combined summer (4VWX) and spring (4VWX5Z) surveys conducted by the Maritimes Region Ecosystem Surveys Program. Three common taxonomic categories are featured: seastars (Asteroidea class), crustaceans (Crustacea subphylum), and sea sponges (Porifera phylum).

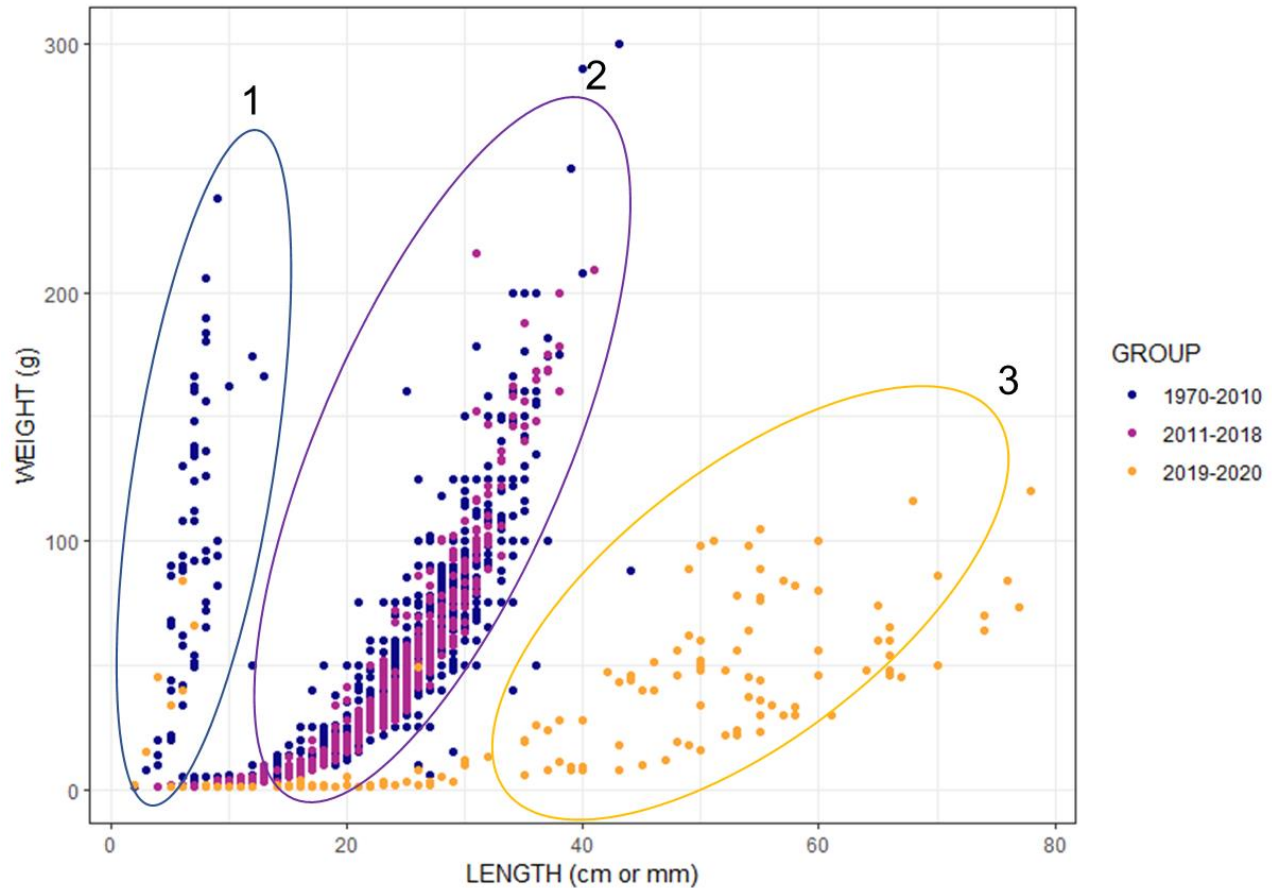


Figure 13. Lengths and weights of Marlin Spike Grenadiers (*Nezumia bairdii*) collected from 1970-2020 during the summer (4VWX) surveys conducted by the Maritimes Region Ecosystem Surveys Program. There are three clusters of data. Group 1 (left) have pre-anal fin length recorded in cm, including data from the 2011 deep sea summer survey and data recorded since 2019 in error. Group 2 (centre) are total length data recorded in cm. Group 3 (right) are pre-anal fin length data recorded in mm.

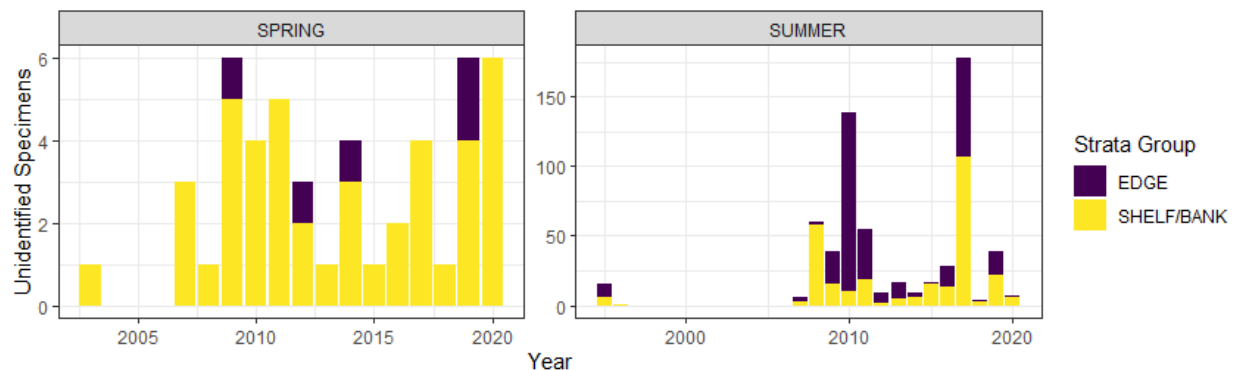


Figure 14. Number of unidentified specimens collected per survey year from 1970-2020 during the summer (4VWX) and spring (4VWX5Z) surveys conducted by the Maritimes Region Ecosystem Surveys Program. Collection of sponges for species verification in 2017 are excluded. Deeper shelf or bank “edge” strata are 449-454, 466, 478, 496-498, 501-505, 560, and 5Z8.

10. APPENDICES

APPENDIX A. SURVEY UPDATE DOCUMENT SERIES

Scotian Shelf (4VWX) Summer Survey Report Series (1979 to 1982; 1994 to present)

- Branton, R., and G. Black. 2000. "2000 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Can. Stock Assess. Sec. Res. Doc. 2000/129.
- . 2001. "2001 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Can. Sci. Advis. Sec. Res. Doc. 2001/096.
- Branton, R., and G. Black. 2002. "2002 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Can. Sci. Advis. Sec. Res. Doc. 2002/089.
- Branton, R., and G. Black. 2003. "2003 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Can. Sci. Advis. Sec. Res. Doc. 2003/089.
- . 2004. "2004 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Can. Sci. Advis. Sec. Res. Doc. 2004/108.
- Branton, R., and J. Black. 1998. "1998 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Can. Stock Assess. Sec. Res. Doc. 98/133.
- . 1999. "1999 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Can. Stock Assess. Sec. Res. Doc. 99/151.
- Branton, R., J. Black, and M. Showell. 1997. "1997 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks Including a Revised Projection of Silver Hake Catch Using the Survey Estimate of the 1996 Yearclass." DFO Can. Stock Assess. Sec. Res. Doc. 97/104.
- Clark, D., and J. Emberley. 2008. "Summer Scotian Shelf and Bay of Fundy Research Vessel Survey Update for 2007." DFO Can. Sci. Advis. Sec. Res. Doc. 2008/053.
- . 2009. "Update of the 2008 Summer Scotian Shelf and Bay of Fundy Research Vessel Survey." DFO Can. Sci. Advis. Sec. Res. Doc. 2009/017.
- Clark, D., J. Emberley, C. Clark, and B. Peppard. 2010. "Update of the 2009 Summer Scotian Shelf and Bay of Fundy Research Vessel Survey." DFO Can. Sci. Advis. Sec. Res. Doc. 2010/008.
- Clark, D., and P. Perley. 2006. "Summer Scotian Shelf and Bay of Fundy Research Vessel Survey Update for 2006." DFO Can. Sci. Advis. Sec. Res. Doc. 2006/020.
- Clark, D.S., and J. Emberley. 2011. "Update of the 2010 Summer Scotian Shelf and Bay of Fundy Research Vessel Survey." DFO Can. Data Rep. Fish. Aquat. Sci. 1238.
- DFO. 2009. "2008 Groundfish Abundance and Biomass Index Trends from DFO's Scotian Shelf Summer Research Vessel Survey." DFO Can. Sci. Advis. Sec. Sci. Resp. 2009/010.

- . 2010. "Maritimes Summer Research Vessel Survey Trends." DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/013.
- . 2011. "Maritimes Research Vessel Survey Trends." DFO Can. Sci. Advis. Sec. Sci. Resp. 2011/003.
- . 2012. "Maritimes Research Vessel Survey Trends." DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/004.
- . 2013. "Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy." DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/004.
- . 2014. "Maritimes Research Vessel Summer Survey Trends." DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/017.
- . 2015. "2014 Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy." DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/013.
- . 2016. "2015 Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy." DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/011.
- . 2017. "2016 Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy." DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/004.
- . 2018. "Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy." DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/021.
- . 2019. "2018 Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy." DFO Can. Sci. Advis. Sec. Sci. Resp. 2019/012.
- . 2020. "Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy." DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/019.
- . 2021. "Maritimes Research Vessel Survey Trends on the Scotian Shelf and Bay of Fundy for 2020." DFO Can. Sci. Advis. Sec. Sci. Resp. 2021/022.
- Emberley, J., and D.S. Clark. 2011. "Update of the 2011 Summer Scotian Shelf and Bay of Fundy Research Vessel Survey." DFO Can. Data Rep. Fish Aquat. Sci. 1240.
- Koeller, P.A. 1979. "Biomass Estimates from Canadian Research Vessel Surveys, Div. 4VWX, 1970-78." CAFSAC Res. Doc. 79/14.
- . 1980. "Biomass Estimates from Canadian Research Vessel Surveys on the Scotian Shelf and in the Gulf of St. Lawrence from 1970 to 1979." CAFSAC Res. Doc. 80/18.
- . 1981. "Update of the Biomass Estimates from Canadian Research Vessel Surveys in NAFO Divisions 4TVWX to 1980." CAFSAC Res. Doc. 81/46.

———. 1982. "Update of Biomass Estimates from Canadian Research Vessel Surveys in NAFO Divisions 4TVWX to 1981." CAFSAC Res. Doc. 82/24.

Neilson, J.D., D. Clark, E. Trippel, C. Annand, R. Branton, P. Fanning, P. Hurley, J. McRuer, and K. Zwanenburg. 1995. "Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Atlantic Fisheries Res. Doc. 95/113.

O'Boyle, R., C. Annand, R. Branton, P. Hurley, R. Mohn, K. Zwanenburg, D. Clark, J. Neilson, and E. Trippel. 1994. "Survey Update for Selected Scotia-Fundy Groundfish Stocks, 12 September 1994." DFO Atlantic Fisheries Res. Doc. 94/76.

O'Boyle, R., R. Branton, and J. Black. 1996. "1996 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks." DFO Atlantic Fisheries Res. Doc. 96/102.

Georges Bank (5Z) Spring Survey Report Series (2012 to present)

DFO. 2012. "Maritimes Research Vessel Survey Trends." DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/004.

———. 2013. "Maritimes Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/005.

———. 2014a. "2014 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/045.

———. 2014b. "Maritimes Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/018.

———. 2016a. "2015 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/012.

———. 2016b. "2016 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/042.

———. 2017. "2017 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/035.

———. 2020a. "2018 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/011.

———. 2020b. "2019 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/032.

———. 2020c. "2020 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/048.

———. 2022. "2021 Maritimes Winter Research Vessel Survey Trends on Georges Bank." DFO Can. Sci. Advis. Sec. Sci. Resp. 2022/004.

Hydrographic Sampling Effort Report Series (1994 to 2001)¹

- Losier, R., F. Page, P. McCurdy, and J. McRuer. 2001. "Overview of 2000 Hydrographic Sampling Effort and Near-Bottom Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish Summer Surveys Conducted on the Scotian Shelf and in the Bay of Fundy (4VWX)." DFO Can. Sci. Advis. Sec. Res. Doc. 2001/062.
- Losier, R., F. Page, P. McCurdy, and M. Ringuette. 1999. "Overview of 1998 Hydrographic Sampling Effort and Near Surface Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish Summer Surveys Conducted on the Scotian Shelf and in the Bay of Fundy (4VWX)." DFO Can. Stock Assess. Sec. Res. Doc. 99/074.
- Losier, R., F. Page, P. McCurdy, M. Ringuette, and J. McRuer. 1999. "Overview of 1998 Hydrographic Sampling Effort and Near-Bottom Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish Summer Surveys Conducted on the Scotian Shelf and in the Bay of Fundy (4VWX)." DFO Can. Stock Assess. Sec. Res. Doc. 99/076.
- Losier, R., F. Page, M. Ringuette, P. McCurdy, and J. McRuer. 1999. "Overview of 1998 Hydrographic Sampling Effort and Near-50 Meter Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish Summer Surveys Conducted on the Scotian Shelf and in the Bay of Fundy (4VWX)." DFO Can. Stock Assess. Sec. Res. Doc. 99/75.
- Page, F., and R. Losier. 1994. "Overview of Temperature and Salinity Conditions within the Scotia-Fundy Region, NAFO Areas 4VWX and 5Z, during 1993 Groundfish Research Vessel Surveys." DFO Atl. Fish. Res. Doc. 94/94.
- . 1995. "Overview of Temperature and Salinity Conditions Within the Scotia-Fundy Region, NAFO Areas 4VWX and 5Z, During 1994 Groundfish Research Vessel Surveys." DFO Atl. Fish. Res. Doc. 95/138.
- . 1996. "Overview of Near-Bottom Water Temperature and Salinity Conditions Observed During the Groundfish Research Vessel Surveys Conducted Within the Scotia-Fundy Region, NAFO Areas 4VWX and 5Z in 1995." DFO Atl. Fish. Res. Doc. 96/20.
- . 1997a. "Overview of 1996 Hydrographic Sampling Effort and Near-Bottom Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish Summer Surveys Conducted on the Scotian Shelf and in the Bay of Fundy (4VWX)." DFO Can. Stock Assess. Sec. Res. Doc. 97/13.
- . 1997b. "Overview of 1996 Hydrographic Sampling Effort and Near-Bottom Water Temperature and Salinity Conditions During the Canadian Spring Research Vessel Groundfish Surveys Conducted on the Eastern Scotian Shelf (4VsW) and Georges Bank (5Z)." DFO Can. Stock Assess. Sec. Res. Doc. 97/12.
- . 1997c. "Overview of 1997 Hydrographic Sampling Effort and Near-50 Meter Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish

¹ Since 2000, the Atlantic Zonal Monitoring Program has produced annual [State of the Ocean Reports](#) that include hydrographic data collected on the Maritimes Region Ecosystem Surveys.

Summer Surveys Conducted on the Scotian Shelf and in the Bay of Fundy (4VWX)." DFO Can. Stock Assess. Sec. Res. Doc. 97/129.

———. 1997d. "Overview of 1997 Hydrographic Sampling Effort and Near-Bottom Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish Summer Surveys Conducted during the Spring on the Scotian Shelf and in the Bay of Fundy (4VWX) ." DFO Can. Stock Assess. Sec. Res. Doc. 97/128.

———. 1997e. "Overview of 1997 Hydrographic Sampling Effort and Near-Bottom Water Temperature and Salinity Conditions During the Canadian Research Vessel Groundfish Surveys Conducted during the Spring on the Eastern Scotian Shelf (4VsW) and Georges Bank (5Z)." DFO Can. Stock Assess. Sec. Res. Doc. 97/127.

Page, F.H., and R.J. Losier. 1994. "Temperature Variability during Canadian Bottom-Trawl Summer Surveys Conducted in NAFO Division 4VWX, 1970-1992." ICES Mar. Sci. Symp., 198, 323–31.

Table A1. Trends included in the Georges Bank (5Z) Summer Survey Report Series, by species. The report may include a trend report for the entire survey area or for a species' relevant stock area at the time of publication.

		Spring Survey Year					
		2012-2013	2014	2015	2016-2018	2019	2020
<i>Trends by Species</i>	<i>Code</i>						
Cod, Atlantic	10	Y	Y	Y	Y	Y	Y
Haddock	11	Y	Y	Y	Y	Y	Y
Hake, White	12		Y	Y			
Pollock	16	Y	Y	Y	Y	Y	Y
Flounder, Yellowtail	42	Y	Y	Y	Y	Y	Y
Wolffish, Striped Atlantic	50	Y					
Skate, Barndoor	200	Y	Y	Y	Y	Y	Y
Skate, Thorny	201	Y	Y	Y	Y	Y	Y
Skate, Smooth	202	Y	Y	Y	Y	Y	Y
Skate, Little	203	Y	Y	Y	Y	Y	Y
Skate, Winter	204	Y	Y	Y	Y	Y	Y
Longhorn Sculpin	300	Y				Y	Y
Sea Raven	320	Y					
Monkfish	400	Y					
Ocean Pout	640	Y				Y	Y
American Lobster	2550						Y

Table A2. Summaries and trends included in the Scotian Shelf (4VWX) Summer Survey Report Series, by species. The report may include a trend report for the entire survey area or for a species' relevant stock area at the time of publication.

		Summer Survey Year													
		1978-1980	1981	1994-1995	1996-1997	1998-2004	2006	2007	2008	2009	2010	2011	2012-2016	2017-2019	2020
Summary Tables and Figures															
Station Locations				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bottom Temperature & Salinity*							Y	Y	Y	Y	Y	Y			
All Invertebrate Species Caught							Y	Y	Y	Y	Y	Y			
All Fish Species Caught							Y	Y	Y	Y	Y	Y			
Special Samples							Y	Y	Y	Y	Y	Y			
Trends by Species	Code														
Cod, Atlantic	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Haddock	11	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hake, White	12	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hake, Red	13						Y	Y	Y	Y	Y	Y		Y	Y
Hake, Silver	14	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cusk	15				Y	Y		Y	Y	Y	Y	Y			
Pollock	16		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Redfish	23	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Flatfish, grouped (includes halibut, turbot)		Y	Y												
Halibut, Atlantic	30			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Halibut, Greenland (Turbot)	31					Y	Y	Y	Y	Y	Y	Y			
Flounder, American Plaice	40			Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
Flounder, Witch	41			Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
Flounder, Yellowtail	42			Y	Y	Y				Y	Y	Y	Y	Y	Y

		Summer Survey Year													
		1978-1980	1981	1994-1995	1996-1997	1998-2004	2006	2007	2008	2009	2010	2011	2012-2016	2017-2019	2020
Flounder, Winter	43			Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
Wolffish, Striped Atlantic	50				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wolffish, Spotted	51											Y			
Wolffish, Northern	52											Y			
Pelagics, grouped			Y												
Herring, Atlantic	60						Y	Y	Y	Y	Y	Y			
Blackbelly Rosefish	123						Y	Y	Y	Y	Y	Y			Y
Argentine	160						Y	Y	Y	Y	Y	Y			
Skates, grouped		Y	Y												
Skate, Barndoor	200											Y	Y	Y	Y
Skate, Thorny	201						Y	Y	Y	Y	Y	Y	Y	Y	Y
Skate, Smooth	202											Y	Y	Y	Y
Skate, Little	203											Y	Y	Y	Y
Skate, Winter	204				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Spiny Dogfish	220	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hagfish	241						Y	Y	Y	Y	Y	Y			
Longhorn Sculpin	300								Y	Y		Y	Y	Y	Y
Sea Raven	320													Y	Y
Monkfish	400		Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Roundnose Grenadier	414										Y				
Lumpfish	501					Y									
Sand Lance	610							Y	Y	Y	Y	Y			
Ocean Pout	640						Y	Y	Y	Y	Y	Y		Y	Y
<i>Pandalus borealis</i>	2211						Y	Y	Y	Y	Y	Y			
<i>Pandalus montagui</i>	2212						Y	Y	Y	Y	Y	Y			
Snow Crab	2526						Y	Y	Y	Y	Y	Y			
American Lobster	2550						Y	Y	Y	Y	Y	Y			

		Summer Survey Year													
		1978-1980	1981	1994-1995	1996-1997	1998-2004	2006	2007	2008	2009	2010	2011	2012-2016	2017-2019	2020
Sea Scallop	4321							Y	Y	Y	Y	Y			
Shortfin Squid	4511	Y	Y			Y	Y	Y	Y	Y	Y	Y			
Sea Cucumber	6611							Y	Y	Y	Y	Y			

* From 1992-2000, bottom temperature and salinity were included in a separate Hydrographic Report Series.

APPENDIX B. ADDITIONAL PUBLISHED SURVEY DOCUMENTS

The following is a list of published documents that use data or other information from the DFO Maritimes Ecosystem Surveys, beyond the annual survey reports listed in Appendix A. Here, the documents are divided by topic: biological data analyses, comparative fishing, survey design and execution, and trawl specifications and mensuration. Though complete to the authors' knowledge, this list may not be exhaustive. It does not include fisheries assessments, unpublished internal reports, or documents published by the Atlantic Zonal Monitoring Program using oceanographic data collected on the Ecosystem Surveys.

Acoustics Data Analyses

Debertin, A.J. 2020. "Estimating the Biomass of a Mixed Species Complex Using Hydroacoustics and Catch Data from the Bay of Fundy and Scotian Shelf Summer Ecosystem Survey." *Canadian Journal of Fisheries and Aquatic Sciences* 77 (7): 1101–16. <https://doi.org/10.1139/cjfas-2019-0152>.

Biological Data Analyses and Reviews

- Benoît, H.P., A. Dunham, P. Macnab, R. Rideout, V. Wareham, D. Clark, N. Duprey, et al. 2020. "Elements of a Framework to Support Decisions on Authorizing Scientific Surveys with Bottom Contacting Gears in Protected Areas with Defined Benthic Conservation Objectives." DFO Can. Sci. Advis. Sec. Res. Doc. 2020/011.
- Cook, A.M., and A. Bundy. 2010. "The Food Habits Database: An Update, Determination of Sampling Adequacy and Estimation of Diet for Key Species." DFO Can. Tech. Rep. Fish. Aquat. Sci. 2884.
- Clark, C.M., D.S. Clark, B. Wilson, and F. Mowbray. 2014. "Atlantic Zonal Working Group Report On the Status of Stratified Random Surveys in Canadian Waters of the Northwest Atlantic (DRAFT)." Unpubl. Available from the authors.
- Clayton, R., D.S. Clark, T. McIntyre, H. Stone, A. Cook, L. Harris, J. Simon, P. Emery, and P. Hurley. 2014. "Review of Surveys Contributing to Groundfish Assessments with Recommendations for an Ecosystem Survey Program in the Maritimes Region." DFO Can. Tech. Rep. Fish. Aquat. Sci. 3083.
- DFO. 2018. "Framework to Support Decisions on Authorizing Scientific Surveys with Bottom-Contacting Gears in Protected Areas with Defined Benthic Conservation Objectives." DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/043.
- Losier, R.J., and L.E. Waite. 1989. "Systematic Listing of Scientific and/or Common Names of Invertebrates, Vertebrates and Marine Plants and Their Respective Codes Used by Marine Fish Division, Fisheries and Oceans, Scotia Fundy Region (Revised)." DFO Can. Data Rep. Fish. Aquat. Sci. No. 721.
- Mahon, R. 1997. "Demersal Fish Assemblages from the Scotian Shelf and Bay of Fundy, Based on Trawl Survey Data (1970-1993)." DFO Can. Man. Rep. Fish. Aquat. Sci. No. 2426.
- Mahon, R., S.K. Brown, K. Zwanenburg, D.B. Atkinson, K.R. Buja, L. Claflin, G.D. Howell, M.E. Monaco, R.N. O'Boyle, and M. Sinclair. 1998. "Assemblages and Biogeography of Demersal Fishes of the East Coast of North America." *Canadian Journal of Fisheries and Aquatic Sciences* 55 (7): 1704–38. <https://doi.org/10.1139/f98-065>.
- Murillo, F.J., E. Kenchington, D.S. Clark, J. Emberley, C. Regnier-McKellar, J. Guijarro, L. Beazley, and M.C. Wong. 2018. "Cruise Report for the CCGS Alfred Needler Maritimes

- Region Research Vessel Summer Multispecies Survey, June 28 to August 14, 2017: Benthic Invertebrates." DFO Can. Tech. Rep. Fish. Aquat. Sci. 3262.
- Noble, V.R., and D.S. Clark. 2019a. "Seasonal Length:Weight Relationships of Grenadiers, Chimaeras and Atlantic Herring Caught by Fisheries and Oceans Canada Maritimes Region Ecosystem Surveys Using Different Measurement Techniques At-Sea." DFO Can. Data Rep. Fish. Aquat. Sci. 1291.
- . 2019b. "Seasonal Length:Weight Relationships of the Fish Species Caught by Fisheries and Oceans Canada Maritimes Region Ecosystem Surveys from 2001-2014 and Deep Water Species from 2001-2017." DFO Can. Data Rep. Fish. Aquat. Sci. 1292.
- . 2019c. "Seasonal Length:Weight Relationships of the Invertebrate Species Caught by Fisheries and Oceans Canada Maritimes Region Ecosystem Surveys from 2001-2017." DFO Can. Data Rep. Fish. Aquat. Sci. 1293.
- Smith, S.J., I. Perry, and L.P. Fanning. 1991. "Relationships between Water Mass Characteristics and Estimates of Fish Population Abundance from Trawl Surveys." *Environmental Monitoring and Assessment* 17: 227–45.
- Stone, H.H., and W.E. Gross. 2012. "Review of the Georges Bank Research Vessel Survey Program 1987-2011." DFO Can. Man. Rep. Fish. Aquat. Sci. 2988.
- Strong, M., and A. Hanke. 1995. "Diversity of Finfish Species in the Scotia-Fundy Region." DFO Can. Tech. Rep. Fish. Aquat. Sci. 2017.
- Tremblay, M.J., G.A.P. Black, and R.M. Branton. 2007. "The Distribution of Common Decapod Crustaceans and Other Invertebrates Recorded in Annual Ecosystem Surveys of the Scotian Shelf 1999-2006." DFO Can. Tech. Rep. Fish. Aquat. Sci. 2762.

Comparative Fishing

- Benoît, H.P. 2006. "Standardizing the Southern Gulf of St. Lawrence Bottom Trawl Survey Time Series: Results of the 2004-2005 Comparative Fishing Experiments and Other Recommendations for the Analysis of the Survey Data." DFO Can. Sci. Advis. Sec. Res. Doc. 2006/008.
- Fanning, P. 1984. "Preliminary Analysis of Alfred Needler - Lady Hammond Comparative Fishing Experiments (Silver Hake, 1983)." NAFO SCR Doc. 84/VI/82.
- . 1985. "Intercalibration of Research Survey Results Obtained by Different Vessels." CAFSAC Res. Doc. 85/3.
- Fowler, G.M., and M.A. Showell. 2009. "Calibration of Bottom Trawl Survey Vessels: Comparative Fishing Between the Alfred Needler and Teleost on the Scotian Shelf during the Summer of 2005." DFO Can. Tech. Rep. Fish. Aquat. Sci. 2824.
- Hanke, A.R., and D.S. Clark. 2007. "Comparative Fishing Power: A Two-Sample Problem." Unpubl. Available from the authors.
- Koeller, P.A., and S.J. Smith. 1983. "Preliminary Analysis of A.T. Cameron - Lady Hammond Comparative Fishing Experiments 1979-81." CAFSAC Res. Doc. 83/59.
- Thiess, M.E., H. Benoit, D.S. Clark, K. Fong, L.G.S. Mello, F. Mowbray, P. Pepin, et al. 2018. "Proceedings of the National Comparative Trawl Workshop, November 28-30, 2017, Nanaimo, BC." DFO Can. Tech. Rep. Fish. Aquat. Sci. 3254.

Survey Design and Execution

- Chadwick, E.M.P., W. Brodie, E. Colbourne, D.S. Clark, D. Gascon, and T. Hurlbut. 2007. "History of Annual Multi-Species Trawl Surveys on the Atlantic Coast of Canada." In DFO AZMP Bulletin PMZA No. 6., 25–42.

- Doubleday, W.G. 1976. "Contribution to Manual on ICNAF Groundfish Survey." ICNAF Res. Doc. 76/VI/99.
- Doubleday, W.G. 1981. "Manual on Groundfish Surveys in the Northwest Atlantic." NAFO Scientific Council Studies, No. 2.
- Doubleday, W.G., and D. Rivard. 1981. "Bottom Trawl Surveys - Proceedings of a Workshop Held at Ottawa November 12-14, 1980." DFO Can. Spec. Pub. Fish. Aquat. Sci. 58.
- Gavaris, S., and S.J. Smith. 1987. "Effect of Allocation and Stratification Strategies on Precision of Survey Abundance Estimates for Atlantic Cod (*Gadus Morhua*) on the Eastern Scotian Shelf." *Journal of Northwest Atlantic Fishery Science* 7 (December): 137–44. <https://doi.org/10.2960/J.v7.a16>.
- Halliday, R.G., and A.C. Kohler. 1971. "Groundfish Survey Programmes of the St. Andrews Biological Station, Fisheries Research Board of Canada - Objectives and Characteristics." ICNAF Res. Doc. 71/35.
- Halliday, R.G., and P.A. Koeller. 1981. "A History of Canadian Groundfish Trawling Surveys and Data Usage in ICNAF Divisions 4TVWX." In *Bottom Trawl Surveys - Proceedings of a Workshop Held at Ottawa November 12-14, 1980*, by W.G. Doubleday and D. Rivard. Can. Spec. Pub. Fish. Aquat. Sci. 58:27-41.
- Hurlbut, T., and D. Clay. 1990. "Protocols for Research Vessel Cruises within the Gulf Region (Demersal Fish) (1970-1987)." DFO Can. MS Rep. Fish. Aquat. Sci. No. 2082.
- Smith, S.J. 1999. "Survey Methods for Fisheries: Challenges and Statistical Issues." SSC Annual Meeting, June 1999: Proceedings of the Survey Methods Section. Statistical Society of Canada.

Trawl Specifications & Mensuration

- Carrothers, P.J.G. 1974. "Descriptions of Trawl-Gear Used for Demersal Species by the Canadian Fleet in Subarea 5 and Statistical Area 6 during the Period 1969 through 1972." ICNAF Res. Doc. 74/28.
- Carrothers, P.J.G. 1980. "Estimation of Trawl Door Spread from Wing Spread." *J. Northw. Atl. Fish. Sci.* 1 (81–89).
- . 1988. "Scotia-Fundy Groundfish Survey Trawls." DFO Can. Tech. Rep. Fish. Aquat. Sci. No. 1609.
- Clark, D.S. 1993. "The Influence of Depth and Bottom Type on Area Swept by Groundtrawl, and Consequences for Survey Indices and Population Estimates." DFO Atlantic Fisheries Res. Doc. 93/40.
- Koeller, P.A. 1991. "Approaches to Improving Groundfish Survey Abundance Estimates by Controlling the Variability of Survey Gear Geometry and Performance." *J. Northw. Atl. Fish. Sci.*, 11: 51–58.
- Koeller, P.A., B. McCallum, D. Swain, M. Strong, D. Archambault, and S. Walsh. 1994. "Accuracy and Precision of Scanmar Data Recorded on Canadian Groundfish Surveys." DFO Can. Tech. Rep. Fish. Aquat. Sci. No. 1983.
- Strong, M. 1992. "Variability of Trawl Performance on Scotia-Fundy Groundfish Surveys." CAFSAC Res. Doc. 92/58.

APPENDIX C. COMPARATIVE FISHING – SUMMER 2013

Comparative fishing took place from 2012-2016 in anticipation of the NEST being the trawl that the new vessel would use when it came into service. It was meant to test the gear in the region, train vessel and science crews to deploy it properly, and to determine if the NEST captures the full size range of groundfish species whose assessments depend on the survey. While the data have been neither analyzed in detail nor published, the data from the summer 2013 survey, which had the most completed paired tows (n=92), was used to determine that the NEST is able to capture the full size range of groundfish species. The paired tows used in this determination are available in Table C1 and the length frequency plots are available in Figures C1-8.

Table C1. Paired tows from NED2013028, the 2013 comparative fishing experiment between the Western IIA (WIIA) trawl and the NEFSC Science Trawl (NEST). These are the valid tows that are included in the PTRAN table GROUND FISH.NED2013028.

COMP. SET	NEST SETNO	WIIA SETNO	STATION	STRAT	UNIT	DEPTH
1	1	2	279	441	4VN	93-183
2	4	3	280	440	4VN	>183
3	5	6	281	441	4VN	93-183
4	8	7	282	445	4VN	>183
5	9	10	283	445	4VN	>183
6	12	11	284	446	4VSB	>183
7	13	14	285	444	4VSB	93-183
8	16	15	286	447	4VSC	<93
9	17	18	287	447	4VSC	<93
10	20	19	288	448	4VSC	<93
11	21	22	289	457	4VSC	93-183
12	24	23	290	457	4WE	93-183
13	25	26	291	455	4WH	<93
14	28	27	292	464	4WJ	<93
15	33	32	235	470	4XM	93-183
16	34	35	236	470	4XM	93-183
17	37	36	237	470	4XM	93-183
18	38	39	238	471	4XM	>183
19	41	40	129	471	4XN	>183
20	42	43	239	472	4XN	93-183
21	45	44	136	473	4XN	<93
22	46	47	959	473	4XN	<93
23	49	48	240	473	4XN	<93
24	50	51	140	475	4XN	<93
25	54	53	963	475	4XN	<93
26	55	56	241	476	4XO	93-183
27	58	57	161	476	4XO	93-183

COMP. SET	NEST SETNO	WIIA SETNO	STATION	STRAT	UNIT	DEPTH
28	60	62	153	480	4XP	<93
29	64	63	152	480	4XP	<93
30	65	66	242	480	4XP	<93
31	68	67	243	480	4XP	<93
32	69	70	244	480	4XP	<93
33	72	71	245	481	4XP	93-183
34	73	74	246	481	4XP	93-183
35	76	75	247	484	4XP	>183
36	77	78	248	481	4XP	93-183
37	80	79	249	482	4XP	>183
38	81	82	174	484	4XP	>183
39	84	83	175	484	4XP	>183
40	85	86	250	482	4XP	>183
41	88	87	171	482	4XP	>183
42	89	90	251	483	4XP	>183
43	92	91	976	482	4XP	>183
44	93	94	252	481	4XP	93-183
45	96	95	253	481	4XP	93-183
46	97	98	971	480	4XP	<93
47	100	99	254	480	4XP	<93
48	101	102	255	482	4XP	>183
49	104	103	170	482	4XP	>183
50	105	106	155	480	4XP	<93
51	108	107	160	481	4XN	93-183
52	109	110	145	477	4XN	93-183
53	112	111	967	477	4XN	93-183
54	113	114	256	475	4XN	<93
55	116	115	964	475	4XN	<93
56	117	118	257	477	4XN	93-183
57	120	119	258	472	4XN	93-183
58	121	122	151	478	4XN	>183
59	124	123	260	466	4WL	>183
60	125	126	261	465	4WL	93-183
61	128	127	997	497	4WJ	366-732
62	129	130	109	464	4WJ	<93
63	132	131	110	464	4WJ	<93
64	133	134	113	464	4WJ	<93
65	136	135	111	464	4WH	<93
66	137	138	262	464	4WH	<93
67	140	139	78	456	4WH	<93

COMP. SET	NEST SETNO	WIIA SETNO	STATION	STRAT	UNIT	DEPTH
68	141	142	77	456	4WF	<93
69	144	143	263	456	4WF	<93
70	145	146	264	456	4WF	<93
71	148	147	265	456	4WF	<93
72	149	150	266	456	4WF	<93
73	152	151	267	456	4WF	<93
74	153	154	268	456	4WF	<93
75	156	155	58	452	4VSC	>183
76	157	158	59	452	4VSC	>183
77	160	159	269	448	4VSC	<93
78	161	162	44	448	4VSC	<93
79	164	163	270	448	4VSC	<93
80	165	166	50	448	4VSC	<93
81	168	167	271	457	4WE	93-183
82	169	170	272	459	4WE	0-366
83	172	171	273	459	4WE	0-366
84	174	173	274	458	4WE	<93
85	175	176	275	459	4WE	0-366
86	178	177	276	459	4WE	0-366
87	179	180	88	458	4WE	<93
88	182	181	277	458	4WE	0-366
89	183	184	935	458	4WE	0-366
90	186	185	278	458	4WE	0-366
91	187	188	936	458	4WE	0-366
92	190	189	932	456	4WE	<93

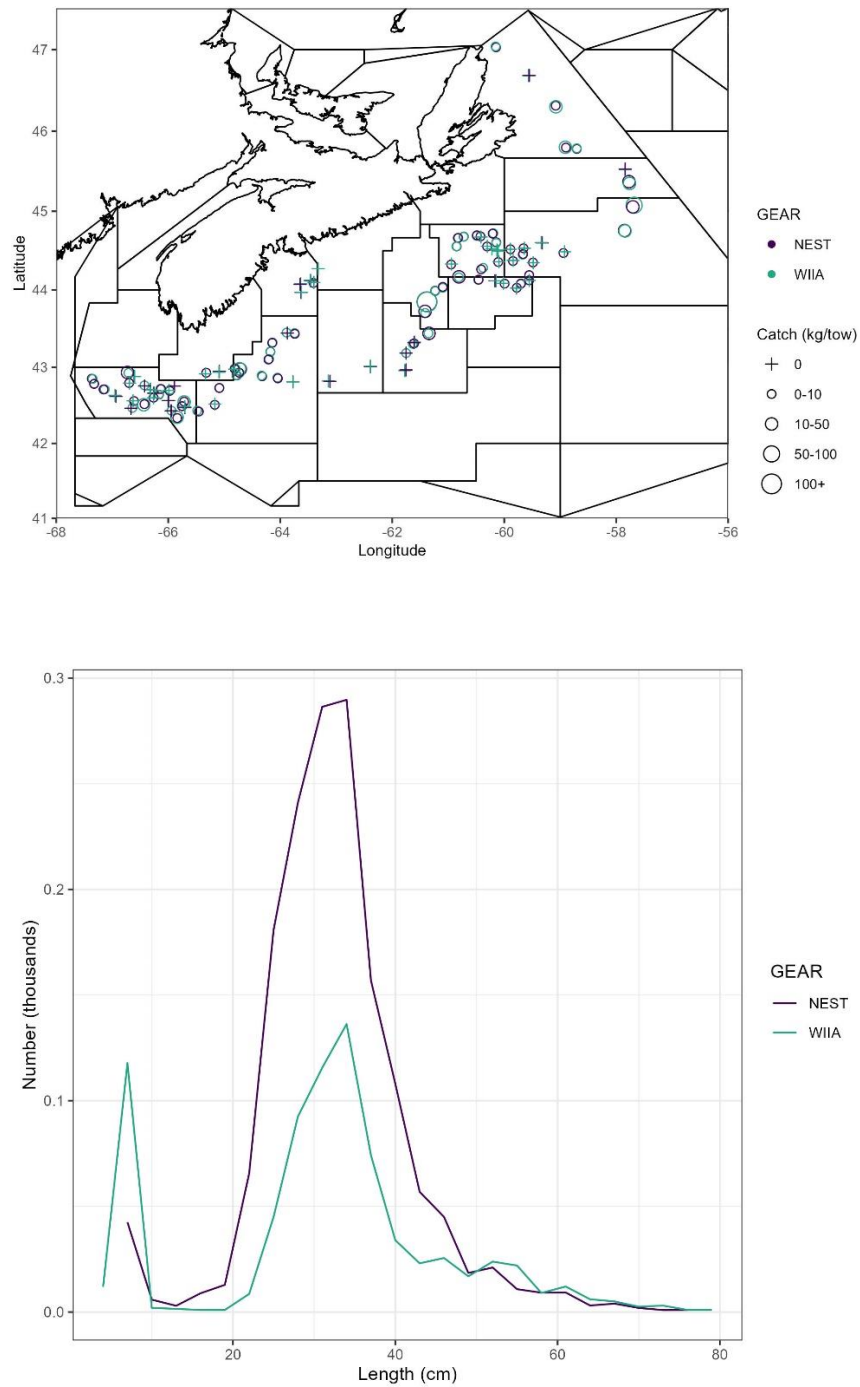


Figure C1. *Above*: Distribution of Atlantic Cod catches during the comparative tows (WIJA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIJA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below*: Length frequency indices from the same survey for Atlantic Cod. Numbers (thousands) at length are standardized for tow distance and binned by 3 cm.

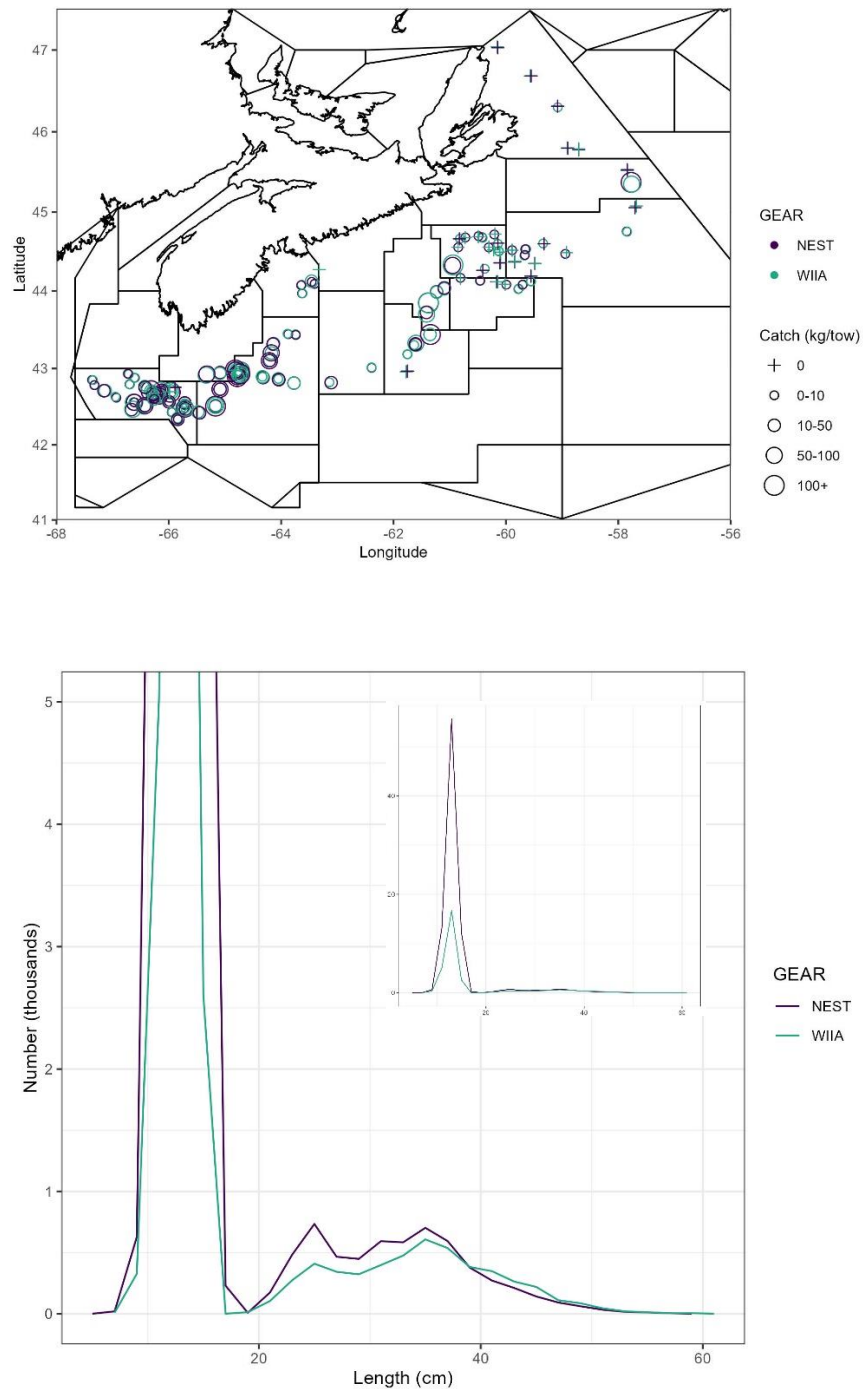


Figure C2. *Above:* Distribution of Haddock catches during the comparative tows (WIIA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIIA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below:* Length frequency indices from the same survey for Haddock. Numbers (thousands) at length are standardized for tow distance and binned by 2 cm.

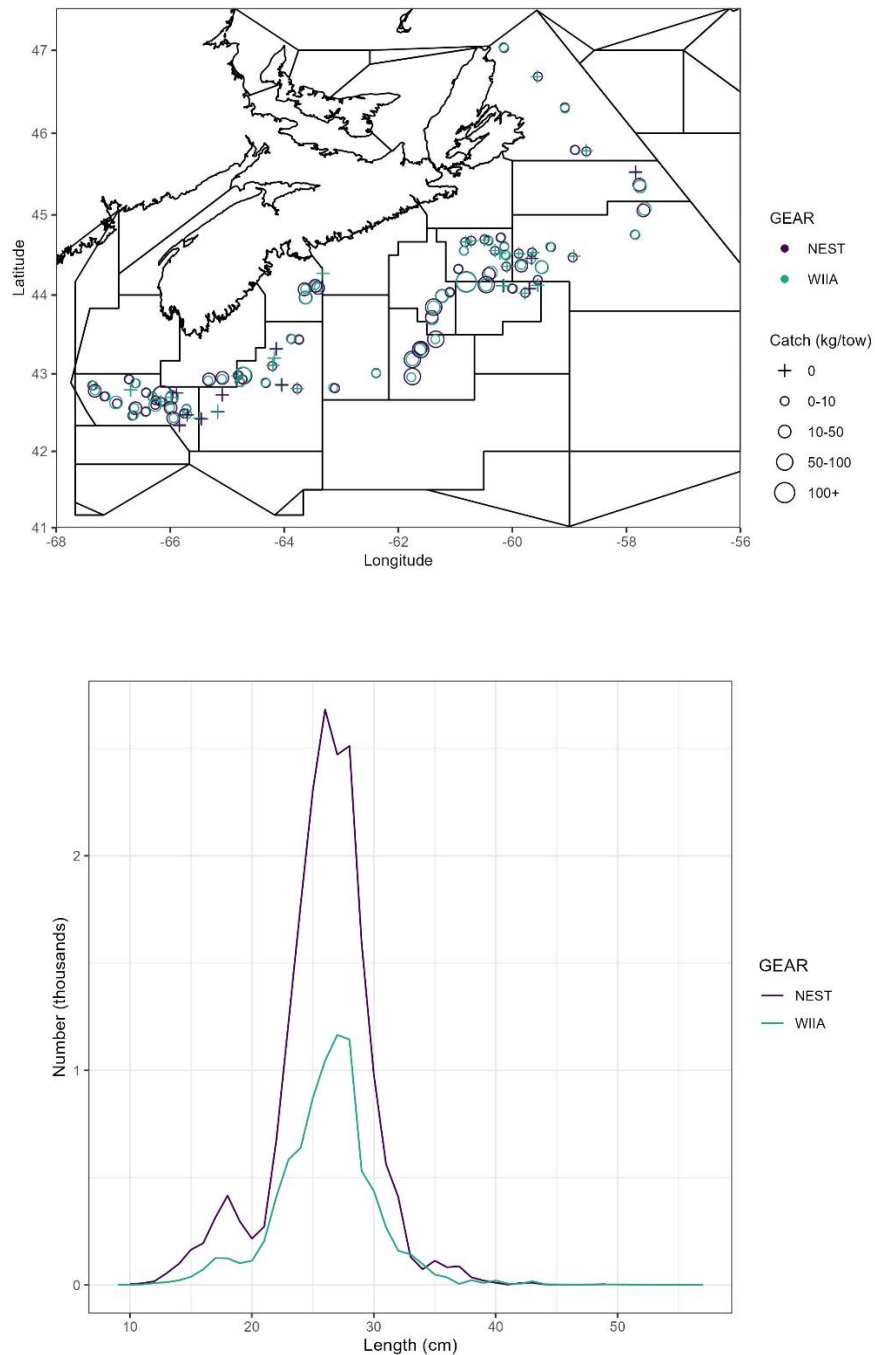


Figure C3. *Above:* Distribution of Silver Hake catches during the comparative tows (WIIA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIIA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below:* Length frequency indices from the same survey for Silver Hake Numbers (thousands) at length are standardized for tow distance and binned by 1 cm.

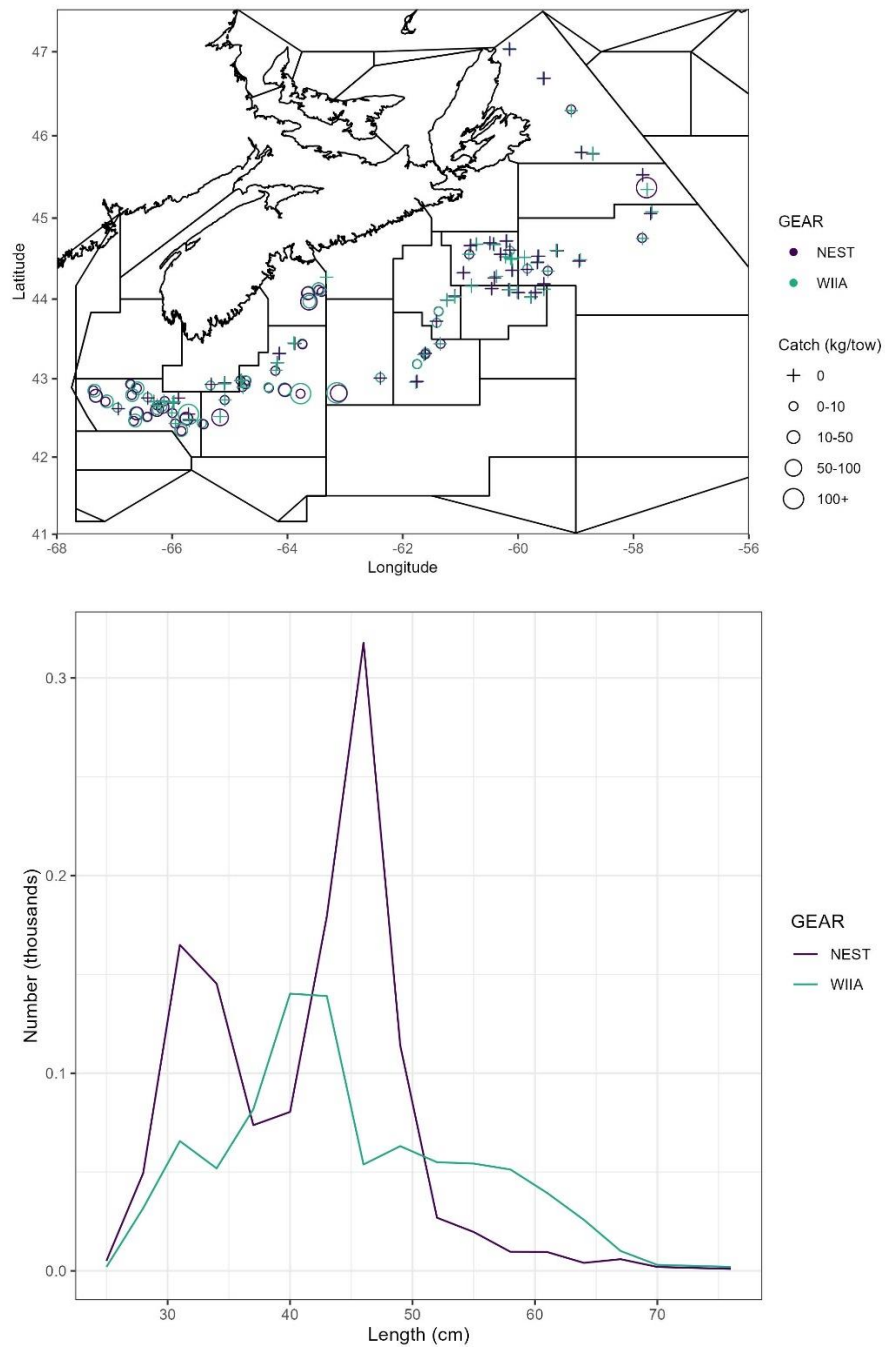


Figure C4. *Above*: Distribution of Pollock catches during the comparative tows (WIIA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIIA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below*: Length frequency indices from the same survey for Pollock Numbers (thousands) at length are standardized for tow distance and binned by 3 cm.

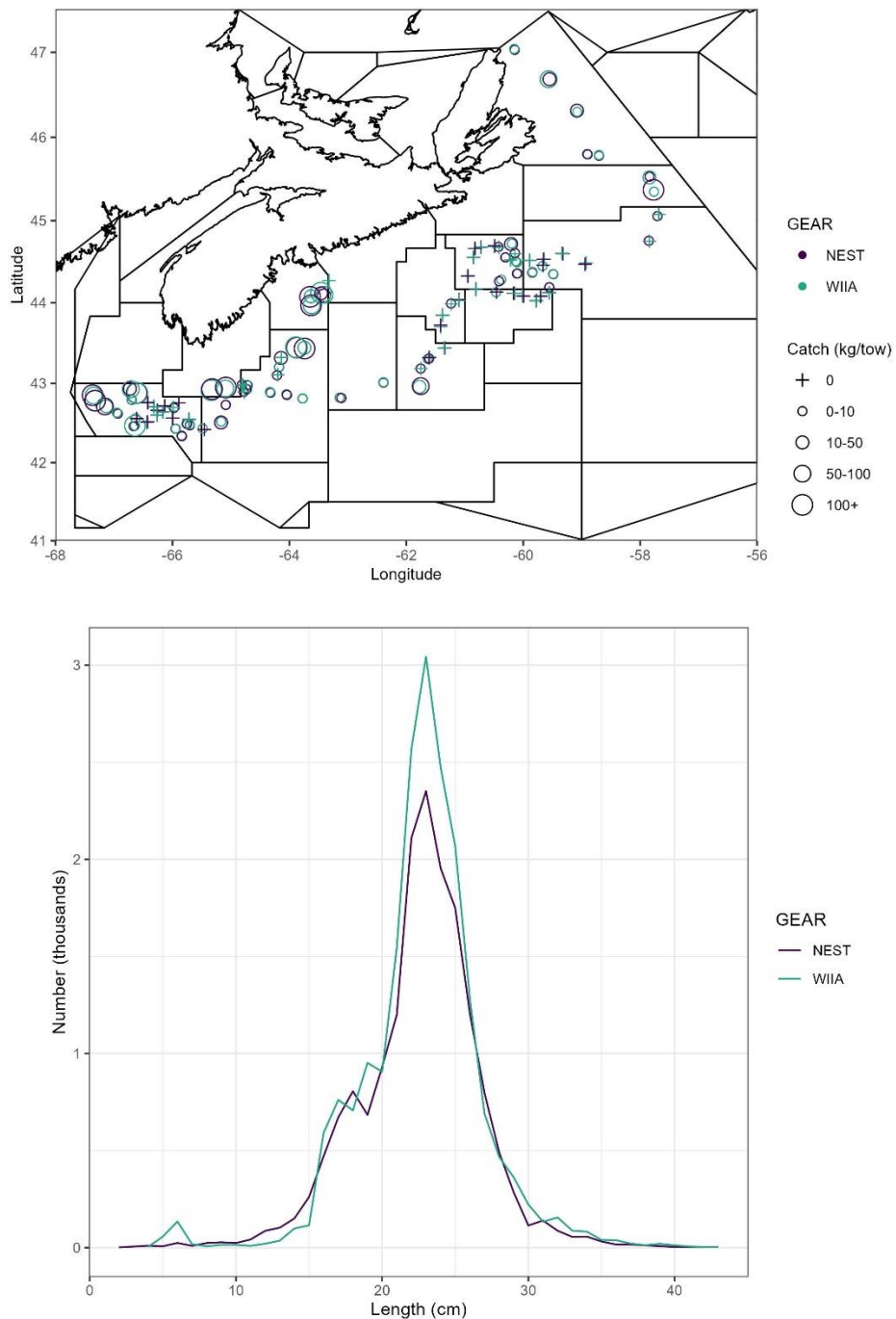


Figure C5. *Above*: Distribution of Redfish catches during the comparative tows (WIIA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIIA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below*: Length frequency indices from the same survey for Redfish Numbers (thousands) at length are standardized for tow distance and binned by 1 cm.

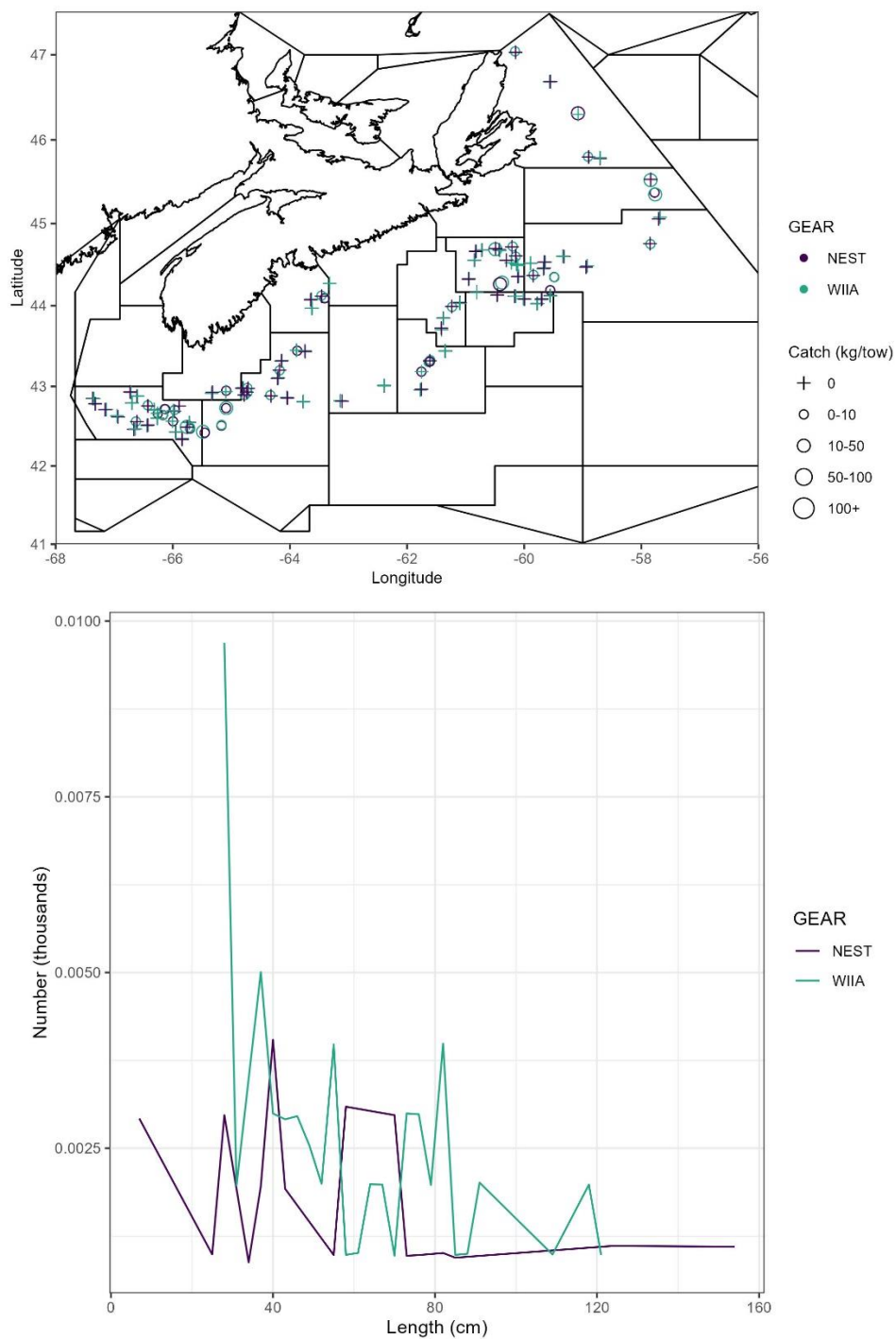


Figure C6. *Above*: Distribution of Halibut catches during the comparative tows (WIIA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIIA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below*: Length frequency indices from the same survey for Halibut Numbers (thousands) at length are standardized for tow distance and binned by 3 cm.

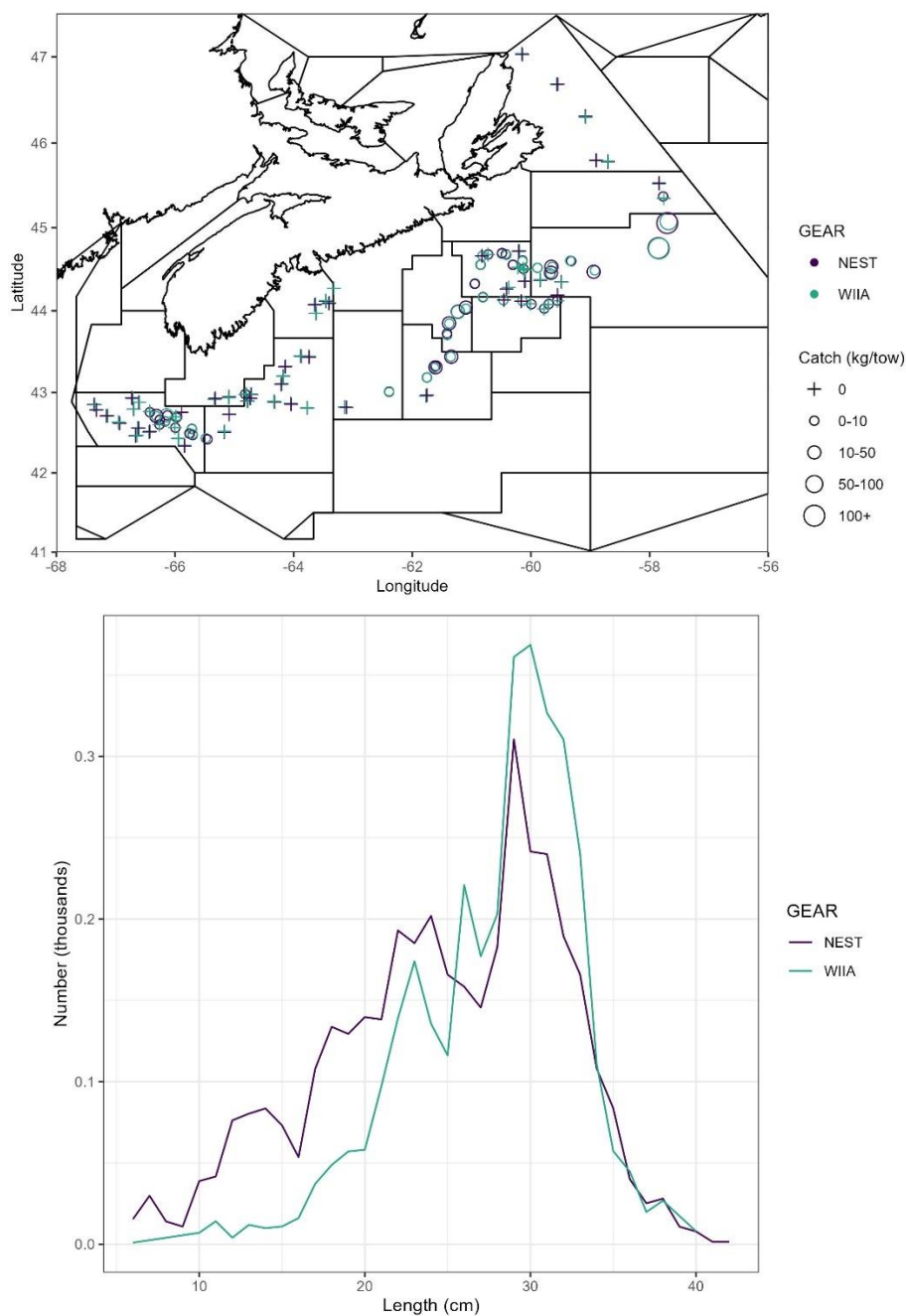


Figure C7. *Above*: Distribution of Yellowtail Flounder catches during the comparative tows (WIIA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIIA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below*: Length frequency indices from the same survey for Yellowtail Flounder Numbers (thousands) at length are standardized for tow distance and binned by 1 cm.

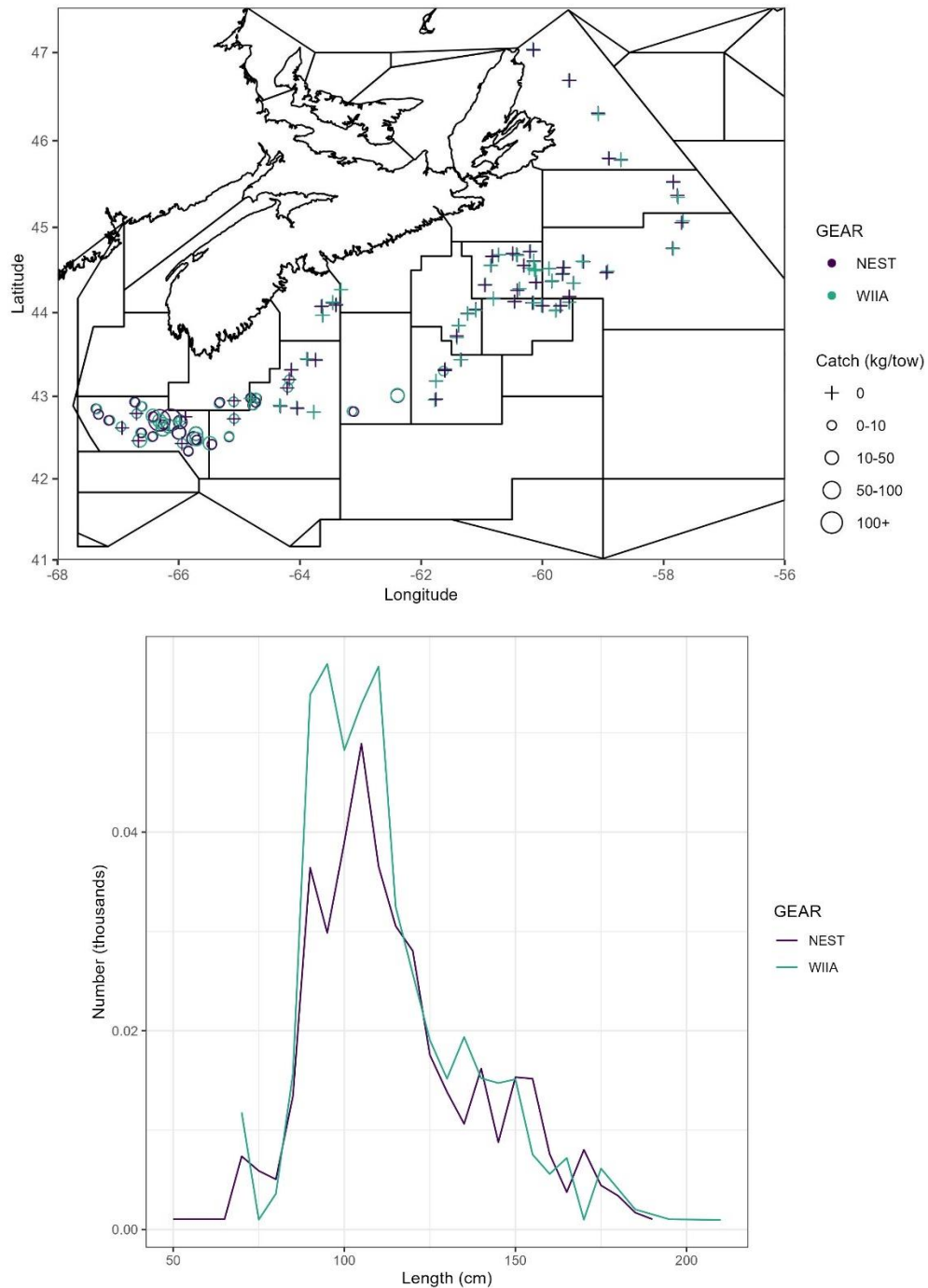


Figure C8. *Above*: Distribution of American Lobster catches during the comparative tows (WIIA vs NEST) from the 2013 DFO Summer Ecosystem RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size, standardized for tow distance (1.75 nm for WIIA; 1 nm for NEST). Black polygons represent NAFO boundaries. *Below*: Length frequency indices from the same survey for American Lobster Numbers (thousands) at length are standardized for tow distance and binned by 0.5 cm.

APPENDIX D. ORACLE DATA TABLES USED FOR SURVEY DATA, WITH EXAMPLE QUERIES

Table D1. Main bottom trawl and hydrographic data tables in the DFO ORACLE 'PTRAN' scheme, used for storage of bottom trawl data from the Maritimes Region Ecosystem Surveys Program (user 'GROUNDFISH'). The relationships between these tables are available in Table 3.

Table	Table Title	Description
GSMISSIONS	Missions	Mission (formerly called cruise) numbers and details for all surveys since 1970.
GSINF	Set Information	Set-level information for each sampling equipment deployment completed since 1970.
GSCAT	Catch	Catch-level information for each successful bottom trawl deployment completed since 1970 (e.g., total weights and/or abundances for identified species).
GSDET	Detailed Observations	All standard detailed observations (e.g., length, weight, etc.) since 1970 for individuals from identified species with the requirement for information beyond total weight or abundance.
GSHYD	Hydrographic Data	Hydrographic data from 1970-1998, before the participation of the AZMP program.
GS_LV1_OBSERVATIONS	Additional detailed observations	All additional detailed observations since 2014 for individuals requiring data beyond that included in the GSDET table.
GSWARPOUT	Warp deployed	The amount of warp deployed on each set since 1991.

Table D2. Select descriptive ORACLE tables in the DFO 'PTRAN' scheme, used for storage of bottom trawl data from the Maritimes Region Ecosystem Surveys Program (user 'GROUND FISH'). Join field(s) describes how to join the descriptive table to the main tables described in Table 1.

Table	Title	Description	Join Field(s)
GSAGEMAT	Age Materials	Codes for the age materials taken from individual specimens	CODE with FMAT in GSDET
GSAGER	Ager Name	Name of ager who read the age material	AGER with AGER in GSDET
GSAREA2	Area	NAFO units, area codes, and associated coordinates	AREA with AREA in GSINF
GSAUX	Auxiliary Equipment	Codes for auxiliary equipment deployed with the trawl	AUX with AUX in GSINF
GSCURNT	Current	Codes for the current or tide direction in relation to the vessel.	CURNT with CURNT in GSINF
GSEGE	Otolith Edge	Codes to identify the type of edge on an otolith	CODE with EDGE in GSDET
GSFORCE	Wind force	Codes for the force on the Beaufort scale	FORCE with FORCE in GSINF
GSGEAR	Gear	Codes for the fishing gear deployed	GEAR with GEAR in GSINF
GSSHOWOBT	Positioning Method	Codes for how the location of the vessel was obtained	HOWOBT with HOWD or HOWS in GSINF
GSMATURITY	Maturity	Codes for maturity level for individual specimens	CODE with FMAT in GSDET
GSMGT	Management Area	NAFO unit codes and strata numbers	STRAT with STRAT in GSINF
GSSEX	Sex	Codes for the sex of individual specimens	CODE with FSEX in GSDET
GSSPECIES	Species Codes	Codes for species, genres, families, etc.	CODE with SPEC in GSDET or GSCAT
GSSPECIES_ANDES	Species Codes	Species codes with taxonomic rank and information	CODE with SPEC in GSDET or GSCAT
GSSTRATUM	Stratum	Strata codes with area, depth, and NAFO unit	STRAT with STRAT in GSINF
GSVESSEL	Vessels	Codes for vessels	VESSEL with VESEL in GSMISSIONS
GSWIND	Wind Direction	Codes for wind direction	WIND with WIND in GSINF
GSXTYPE	Set Type	Codes for set type	XTYPE with TYPE in GSINF
ITIS_GS_TAXON	Taxonomy	ITIS taxonomic information and species code	GIVEN_SPEC_CODE with SPEC in GSDET or GSINF

Table D3. Data fields in bottom trawl data tables GSMISSIONS, GSINF, GSCAT, and GSDET.

Field	Description	Main Table(s)	Desc. Table(s)
AGE	Age of specimen	GSDET	
AGER	Ager code	GSDET	GSAGER
AGMAT	Code for the age material collected	GSDET	GSAGEMAT
AREA	Numeric code to identify the NAFO area	GSINF	GSAREA2
AUX	Numeric code to identify any auxiliary gear in use	GSINF	GSAUX
BOTTOM_SALINITY	Bottom salinity	GSINF	
BOTTOM_TEMPERATURE	Bottom temperature	GSINF	
CALWT	Not measured indicator	GSCAT	
CHKMRK	3 single character fields	GSDET	
CLEN	Count at length	GSDET	
CRUNO	Numeric identifier given to each mission	GSMISSIONS	
CURNT	Code to identify the direction of the tide in relation to the vessel	GSINF	GSCURNT
DATA_DESC	Comment field	GS_LV1_OBSERVATIONS	
DATA_VALUE	Value of data collected	GS_LV1_OBSERVATIONS	
DEPTH	Depth from oceanographic or CTD data	GSINF	
DIST	The distance towed in hundredths of nautical miles	GSINF	
DMAX	The maximum (deepest) bottom depth, in fathoms	GSINF	
DMIN	The minimum (shallowest) bottom depth, in fathoms	GSINF	
DUR	Tow duration in minutes	GSINF	
EDGE	Code to identify the edge type of an otolith	GSDET	GSEDGE
ELAT	The latitude at the end of a tow recorded in degrees, minutes, and decimal minutes	GSINF	
ELONG	The longitude at the end of a tow recorded in degrees, minutes, and decimal minutes	GSINF	
END_DEPTH	The bottom depth at end of a set, in fathoms	GSINF	
ETIME	The local date and standard time at the end of the tow	GSINF	
FLEN	Length of the specimen	GSDET	
FMAT	Code for the observed maturity stage	GSDET	
FORCE	Code to identify wind force on the Beaufort scale	GSINF	GSFORCE

Field	Description	Main Table(s)	Desc. Table(s)
FSEX	Sex of the specimen	GSDET	GSSEX
FSHNO	Unique number assigned to a specimen within each species and mission	GSDET	
FWT	The weight in grams of the specimen	GSDET	
GEAR	Code to identify the gear in use	GSINF	GSGEAR
HOWD	Code to identify the source of information for the distance.	GSINF	GSSHOWOBT
HOWS	Code to identify the source of information for the speed.	GSINF	GSSHOWOBT
LENGTH_TYPE	Type of length measurement (total, fork, mantle, etc.)	GSCAT	
LENGTH_UNITS	Units for length measurement	GSCAT	
LV1_OBSERVATION	Description of observation type	GS_LV1_OBSERVATIONS	
LV1_OBSERVATION_ID	Numeric identifier for observation type	GS_LV1_OBSERVATIONS	
MARKET	Market category	GSCAT	
MISSION	A 10-character field to identify the survey. The first 3 character identifies the vessel (e.g., NED), the next 4 characters identifies the year (e.g., 2000) and the last 3 characters identifies the survey number within the year. (e.g., 001). Example: NED2000001.	GSMISSIONS, GSINF, GSCAT, GSDET, GS_LV1_OBSERVATIONS	
NANN	Number of annuli on an otolith	GSDET	
REMARKS	Any comments about the set, species, or specimen	GSINF, GSCAT, GSDET	
SAMPWGT	Weight sampled	GSCAT	
SDATE	The local date and standard time at the beginning of the tow	GSINF	
SEASON	The season of the year	GSMISSIONS	
SETNO	Numeric set identifier assigned to each tow, starting with 1 for the first tow of the mission and then assigned consecutively	GSINF, GSCAT, GSDET, GS_LV1_OBSERVATIONS	
SIZE_CLASS	Size class of a specimen	GSCAT, GSDET, GS_LV1_OBSERVATIONS	
SLAT	The latitude at the start of a tow recorded in degrees, minutes, and decimal minutes	GSINF	
SLONG	The longitude at the start of a tow recorded in degrees, minutes, and decimal minutes	GSINF	

Field	Description	Main Table(s)	Desc. Table(s)
SPEC	Species code	GSCAT, GSDET, GS_LV1_OBSERVATIONS	GSSPECIES, GSSPECIES_ANDES, ITIS_GS_TAXON
SPECIMEN_ID	Specimen identifier	GSDET, GS_LV1_OBSERVATIONS	
SPEED	The average speed of the vessel over bottom, based on GPS, to the nearest tenth of a nautical mile	GSINF	
START_DEPTH	The bottom depth at start of a set, in fathoms	GSINF	
STATION	Label given to the randomly selected fishing location	GSINF	
STRAT	Numeric code to identify stratum	GSINF	GSSTRATUM
SURFACE_TEMPERATURE	Surface temperature	GSINF	
TIME	The local standard time at the beginning of the tow	GSINF	
TOTNO	Total number	GSCAT	
TOTWGT	Total weight (kg)	GSCAT	
TYPE	Numeric code to identify the experiment type.	GSINF	GSXTYPE
VESEL	Alphabetical code to identify the vessel.	GSMISSIONS	GSVESSEL
WEIGHT_TYPE	Type of weight measurement (e.g., total)	GSCAT	
WEIGHT_UNITS	Units of weight measurement	GSCAT	
WIND	Wind Direction in true degrees between 0 and 360.	GSINF	GSWIND
YEAR	The year of the survey.	GSMISSIONS	

Table D4. Links between the main tables (Table B1) in the DFO ORACLE 'PTRAN' scheme, used for storage of bottom trawl data from the PTRAN surveys schema (user 'GROUND FISH'). Descriptions of all fields are available in Table B3.

GSMISSIONS	GSINF	GSHYD	GSCAT	GSDET	GS_LV1_OBSERVATIONS
MISSION	MISSION	MISSION	MISSION	MISSION	MISSION
VESEL	SETNO	SETNO	SETNO	SETNO	SETNO
CRUNO	SDATE	SDEPTH	SPEC	SPEC	SPEC
YEAR	TIME	TEMP	SIZE_CLASS	SIZE_CLASS	SIZE_CLASS
SEASON	STRAT	SAL	MARKET	SPECIMEN_ID	SPECIMEN_ID
	SLAT	BID	SAMPWGT	FSHNO	LV1_OBSERVATION_ID
	SLONG	GEAR	TOTWGT	FLEN	LV1_OBSERVATION
	ELAT	EIND	TOTNO	FSEX	DATA_VALUE
	ELONG	OXYML	CALWT	FMAT	DATE_DESC
	AREA	TAGNO	REMARKS	FWT	
	DUR		LENGTH_TYPE	AGMAT	
	DIST		LENGTH_UNITS	NANN	
	HOWD		WEIGHT_TYPE	EDGE	
	SPEED		WEIGHT_UNITS	CHKMRK	
	HOWS			AGE	
	DMIN			AGER	
	DMAX			CLEN	
	WIND			REMARKS	
	FORCE				
	CURNT				
	TYPE				
	GEAR				
	AUX				
	DEPTH				
	ETIME				
	REMARKS				
	START_DEPTH				
	END_DEPTH				
	SURFACE_TEMPERATURE				
	BOTTOM_TEMPERATURE				

APPENDIX E. ORACLE ES* DATA TABLES AND VIEWS USED FOR SURVEY DATA

The GROUND FISH.ES* tables and views about can be used for calculations equivalent to STRANAL or the Mar.stratify R package (McMahon 2017). The scripts used to construct and query them are available (Gale 2019).

When data are queried from these views, data users should consider extracting the full time series rather than specific years. The GROUND FISH.ES* tables and views rely on the GROUND FISH schema, in which errors are routinely identified and corrected. Querying the time series rather than just the most recent year allows data users access to the most up-to-date and error-free calculations. Another reason to query the time series is that it is expected that conversion factors will be applied to GROUND FISH.ES* in the near future. However, a caution: if a data user is running an assessment model, extracting the entire time series might not reflect data decisions that were made as part of the assessment framework.

Table E1. GROUND FISH.ES* data views in the DFO ORACLE 'PTRAN' scheme, used for accessing unstandardized bottom trawl data from the Maritimes Region Ecosystem Surveys Program, without the need for table joins by the data user. ES_CATCHES and ES_SAMPLES are reliant on GS_VESSEL_NET_CONVERSIONS and GS_LENGTH_TYPE_CONVERSIONS , respectively, which can be expanded in the future. Based on information from Gale (2019).

Table	Description	Similar	Fields	Notes
ES_SETS	Set information	GSINF	AUXILIARY_GEAR BOTTOM_SALINITY BOTTOM_TEMPERATURE CURRENT_DIRECTION DEPTH_MAXIMUM DEPTH_MINIMUM END_DEPTH END_LATITUDE END_LONGITUDE END_TIME EXPERIMENT_TYPE GEAR GEAR_DEPTH HOW_DISTANCE_OBTAINED HOW_SPEED_OBTAINED MISSION NAFO_UNIT_AREA REMARKS SEASON SETNO SPEED START_DATE START_DEPTH START_LATITUDE START_LONGITUDE START_TIME STRATUM SURFACE_TEMPERATURE SURVEY_YEAR	- Includes sets that caught species codes <1000 (fish) and experiment type 1 (stratified random) only.

			TOW_DISTANCE TOW_DURATION WIND_DIRECTION WIND_FORCE	
ES_CATCHES	Catch	GSCAT	HOW_WEIGHT_CALCULATED LENGTH_TYPE LENGTH_UNITS MISSION REMARKS SAMPLE_WEIGHT SEASON SETNO SPECIES_CODE SPECIES_COMMON_NAME SPECIES_NAME STRATUM SURVEY_YEAR TOTAL_COUNT TOTAL_WEIGHT TOW_DISTANCE WEIGHT_TYPE WEIGHT_UNITS	- Uses the new table GS_HOW_WEIGHT_CALC_CODES - Total weight, sample weight, and total number are set to NULL if missing. No zeros. - Total weight and sample weight are calculated where possible if missing. If calculated, the HOW_WEIGHT_CALCULATED column will be set to "weight calculated using average weight at length." - Size classes combined and size class column removed. REMARKS set to "multiple size classes combined" if so.
ES_SAMPLES	Detailed observations	GSDET	COUNT_AT_LENGTH FISH_AGE FISH_LENGTH FISH_NUMBER FISH_SEX FISH_WEIGHT LENGTH_TYPE LENGTH_UNITS MISSION REMARKS SEASON SETNO SPECIES_CODE SPECIES_COMMON_NAME SPECIES_NAME SPECIMEN_ID STRATUM SURVEY_YEAR	- If entries exist in the GS_VESSEL_NET_CONVERSIONS table then the matching count at length is adjusted. There are currently no entries in that table, but accepted conversions could be added. - If entries exist in the GS_LENGTH_TYPE CONVERSIONS table then matching fish length is adjusted. Only Herring is converted from Fork Length to Total Length at the moment.

Table E2. GROUND FISH.ES* views in the DFO ORACLE 'PTRAN' scheme, used for accessing standardized bottom trawl data from the Maritimes Region Ecosystem Surveys Program, without the need for table joins by the data user. These have been thoroughly tested and are equivalent to tabs in output from STRANAL, and equivalency is noted. Based on information from Gale (2019).

Table	Description	Notes from J. Gale (2019)
ES_LENGTHS	Length counts by set	
ES_LENGTHS_SEXED	Length counts by set, sexed	
ES_LENGTHS_SEASON_STRATA	Stratified results by length and season within stratum	.

ES_LENGTHS_SEASON_STRATA_SEXED	Stratified results by length and season within stratum, sexed	
ES_LENGTHS_STRATA	Stratified results by length within stratum	
ES_LENGTHS_STRATA_SEXED	Stratified results by length within stratum, sexed	
ES_WEIGHTS	Weights by set	Total weight adjusted for tow distance
ES_WEIGHTS_SEASON_STRATA	Stratified weight results within stratum and season	
ES_WEIGHTS_STRATA	Stratified weight results within stratum	
ES_SETCOUNT_MISSION_STRATA	Number of sets completed in each strata on each mission	
ES_SPECIES_FIRST_RECORDED	Date on which each species was first recorded	

APPENDIX F. BOTTOM TRAWL DATA USERS QUICK GUIDE BY TAXA

Data users must consider the changes discussed in this document when they are accessing the survey database and performing analyses of their queries' results. The surveys follow standardized designs and their time series are unbroken, but changes to sampling and data collection protocols over time mean that the available data cannot always be taken at face value. This appendix is meant as a quick reference for those using bottom trawl data from the Maritimes Region's surveys, particularly if a data user is interested in a specific species.

1. Considerations for All Species

Spatial and Length-based Stratification. Spatial, sex-, and length-based stratification are integral to the survey design. *Raw data have extremely limited uses* because they are not representative of the ecosystem. Some of the only information that raw data can give a data user are (1) presence information – i.e. where a species was observed and (2) set-level information about lengths, weights, etc. To make this data useful for fisheries assessments and wider conclusions, it must be standardized for tow distance and strata area. The sex and length stratification for a given species (e.g. 3 fish per 3cm length group; 1 fish per sex per 1cm length group) should be retained in this calculation to preserve the integrity of the sampling design. For DFO staff, there are several options for standardizing survey data: the desktop APL tool STRANAL, the Mar.stratify R package, the ES* Views in the PTRAN Oracle schema GROUND FISH, or manual calculations. Currently, the database contains unconverted data and none of these methods incorporate recommended conversion factors for vessel and net changes, so these must be applied afterwards if they are accepted.

Data Suitability. One of the biggest determinations that must be made is whether data for a given species falls into one of four categories:

1. *Suitable for length-based population analysis.* The survey methodology, particularly the bottom trawl gear, is appropriate for a biological census of the species, and therefore all detailed data collected (lengths, weights, maturities, etc.) are able to be used in fisheries stock assessments and all other analyses. This occurs for any species captured well by trawl, especially groundfish and lobster.
2. *Suitable for biomass analysis.* The survey methodology, particularly the bottom trawl gear, does not allow the representational collection of detailed biological information for individual fish (lengths, weights, etc.) but is appropriate for the collection of set-level weights. This may occur, for example, when a fragile species is often or always damaged by the trawl gear and therefore unable to be measured individually.
3. *Suitable for "presence/absence" distribution analysis.* The survey methodology, particularly the bottom trawl gear, does not allow the representational collection of detailed biological information (lengths, weights, maturities, etc.) or set-level weights, but presence/absence data is trustworthy. This can occur, for example, if susceptibility to capture by trawl, including behaviour response and location in the water column or substrate, influence the species' catchability. The species is captured when present but not in a representative quantity.
4. *Suitable for "presence" distribution analysis only.* The survey methodology, including the bottom trawl gear, is only appropriate for the use of "presence" data. This can occur, for

example, if a species is very small and would slip through the mesh of an empty codend, but is captured when the codend is full of fish (e.g. krill). It could also occur if a species' catchability is generally low and it may or may not be captured by the trawl.

Standard Sampling vs. Special Sampling. The species-by-species information in this appendix refers to the standard sampling requirements. Biological data beyond these requirements are periodically collected through "special sampling" requests. In certain cases, especially for invertebrates, measurements that were initially collected as special samples were added to the standard sampling protocols. In others, measurements that were removed from the standard sampling protocols are collected intermittently. The database contains no indicator that distinguishes between standard and special sampling, so a query will yield data collected from both. Whatever the source, these data are valid and follow the standard survey design. However, if they were collected as part of a special sample, they may be restricted in numbers or by geographic area.

Scales Used for Weight Measurements:

- *Set-level basket weight measurements.* From 1970 to 1994 (summer survey) and 1986 to 1994 (spring survey), baskets of fish were weighted on a dial face scale in 1kg increments. Total catches of a species that were less than 0.5 kg were recorded as zero. In 1995, an electronic platform scale replaced the old scale; this scale is accurate to ± 0.01 kg (Chadwick et al. 2007).
- *Individual fish weight measurements.* From 1970 to 1990 (summer survey) and 1986 to 1990 (spring survey), spring scales were used to weigh individual fish. These scales were accurate to ± 25 g and any weight less than 25 g was not recorded. In 1991, electronic scales accurate to ± 5 g were first used; in 1992, electronic scales accurate to ± 2 g was used; finally, in 1996 a scale accurate to ± 0.1 g was installed on the primary survey vessel, intended for use on individual specimens less than 5 g (Chadwick et al. 2007).

2. Considerations for All Fish Species

The sampling requirements over time for fish on the spring and summer surveys are available in Tables F1 and F2 respectively. Additional details not included in the tables are:

- On the summer survey from 1970 to 1981, the catch was brought on board and put in wooden pens on the deck and then sorted into wicker baskets. This meant that there was a possibility of small fish, and species that are small, being overlooked and washing away off the side of the ship. Data users must consider that before 1981, some information about small fish and small species may be missing.
- Since 1998, only Silver Hake maturities have been required in the summer, due to the difficulty in differentiating immature and resting stages in other species.
- The standard data collection protocols for spring and summer surveys have been nearly identical since 2007.

3. Considerations for Primary and Secondary Fish Species

Code 10 – Atlantic Cod (*Gadus morhua*). Data collected for Atlantic Cod on both the summer and spring surveys have always been used in population analyses (e.g. Andrushchenko et al. 2022; Andrushchenko, Legault, and Barrett 2019), as well as in spring and summer survey

updates (Appendix A). For the summer survey, only data collected from 1983 to present is typically included because there is remaining uncertainty regarding conversion factors (Clark, Trippel, and Brown 1995; Mohn et al. 1998). Refer to Tables F1 and F2 for sampling requirements over time.

Code 11 – Haddock (*Melanogrammus aeglefinus*). Data collected for Haddock on both the summer and spring surveys have always been used in population analyses (e.g. Stone et al. 2015; Wang, Stone, and Finley 2017), as well as spring and summer survey updates (Appendix A). The suggested conversion factor of 1.2 has been applied to 4X5Y Haddock data collected before 1981 (Wang, Stone, and Finley 2017; R. Martin, pers. comm.). Refer to Tables F1 and F2 for sampling requirements over time.

Codes 12-14 – Hakes. From 1970 to 1978, White Hake (*Urophycis tenuis*; Code 12) and Red Hake (*Urophycis chuss*; Code 13) were not distinguished from one another because the standard identification reference document at the time grouped the two species together (Leim and Scott 1966). From 1978 on, the species have been identified separately with confidence using the individualized characteristics eventually published in W.B. Scott and M.G. Scott (1988). Data collected for White Hake and Silver Hake (*Merluccius bilinearis*; Code 14) have been used in population analyses (e.g. Stone et al. 2013; Guénette and Clark 2016). White Hake, Red Hake and Silver Hake are typically included in the summer survey update document (Appendix A). Summer biomass data for silver hake are only used from 1982 to the present because there is uncertainty regarding conversion factors (Emberley and Clark 2011). Silver Hake otoliths were stored in glycerin until 2016, and since then, have been stored dry. Refer to Tables F1 and F2 for sampling requirements over time.

Code 15 – Cusk (*Brosme brosme*). Ecosystem Surveys data for Cusk are not thought to be proportional to their total population abundance because the survey does not sample the preferred habitat or depths of Cusk (DFO 2008). An index from the Halibut Longline Survey is used instead (Harris et al. 2012). Cusk has a Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status of “Endangered” but is not listed on Schedule 1 of the Species at Risk Act (COSEWIC 2012a). When they were more abundant, Cusk comprised a larger part of the multi-species groundfish fisheries and catches were mainly by handline and longline, not trawl (Halliday and Clark 1995). Cusk data have never been included in the spring survey update documents, but were included in the summer updates from 1996-2004 and 2007-2011 (Appendix A). Refer to Tables F1 and F2 for sampling requirements over time.

Code 16 – Pollock (*Pollachius virens*). Data collected for Pollock on the Ecosystem Surveys is more variable than it is for other groundfish species because Pollock are a semi-pelagic rather than truly demersal species; another source of information besides the bottom trawl data are acoustic data collected in 2012 and 2016-2020 on the summer Ecosystem Survey (Andrushchenko et al. in press). Pollock are included in the spring and summer survey update reports (Appendix A). No conversion factor is applied to data collected before 1981, due to unreliability and similar catches among vessels (Trippel and Brown 1993), and since the 2004 framework, data before 1982 have not been used (Stephenson 2004). Refer to Tables F1 and F2 for sampling requirements over time.

Code 23 – Redfish (*Sebastes* sp.). Two species of redfish that are difficult to distinguish at sea are included under one species code: Deepwater Redfish (*Sebastes mentella*) and Acadian Redfish (*Sebastes fasciatus*). The two species occur in different habitats and can be somewhat distinguished by depth. Data collected for Redfish on the summer survey is used in population

analyses (e.g., DFO 2022b), as well as in the summer survey update reports (Appendix A). In terms of conversion factors, Fanning (1985) was not precise enough to recommend a specific conversion factor, but indicated a higher catch by the new vessel and trawl. A conversion factor of 1.8 (the combined conversion factors for *Cameron-Hammond* and *Hammond-Needler*) was applied in the survey report to Redfish data collected before 1981 for a period of time in the mid-2000s. Since then, it has been removed to be consistent with the stock assessments. There is no specific recommended conversion factor for Redfish. Refer to Tables F1 and F2 for sampling requirements over time.

Code 30 – Atlantic Halibut (*Hippoglossus hippoglossus*). Data collected for Halibut on the summer data is used in population analyses, as well as in the summer survey updates; halibut data are not included in the spring survey updates (Appendix A). Most Halibut is caught commercially using longlines and there is a separate Halibut Longline Survey; an abundance index from the summer Ecosystem Survey data is considered an index of recruitment (DFO 2023c). Refer to Tables F1 and F2 for sampling requirements over time.

Code 31 – Turbot (Greenland Halibut; *Reinhardtius hippoglossoides*) Turbot data from the summer Ecosystem Survey has been used in population analyses in the past (e.g. DFO 1996). Turbot is not currently included in either the spring or summer survey update reports, although it has been in the past (1998-2011; Appendix A). Refer to Tables F1 and F2 for sampling requirements over time.

Codes 40-43 – Small flatfishes. Yellowtail Flounder (*Limanda ferruginea*; Code 42) data from the winter Ecosystem Survey are used in population analyses for transboundary stocks on Georges Bank (e.g. Legault et al. 2015). Spring and summer data from the Ecosystem Survey has been used in past population analyses for American Plaice (*Hippoglossoides platessoides*; Code 40), Yellowtail Flounder, Witch Flounder (*Glyptocephalus cynoglossus*; Code 41) and Winter Flounder (*Pseudopleuronectes americanus*; Code 43) on the Scotian Shelf and in the Bay of Fundy and Gulf of Maine (e.g., Neilson and Hurley 1986; DFO 1997b, 2002a). All four species are included in the summer survey update reports; only Yellowtail Flounder is included in the spring survey update reports (Appendix A). Fanning (1985) recommended a conversion factor of 0.8 for Witch Flounder and Yellowtail Flounder, which continues to be applied for all flatfish included in the summer survey report except for Halibut (R. Martin, pers. comm.). Yellowtail otoliths were collected on the summer survey from 1970-1985. On the spring survey, yellowtail scales were collected from 2004 to 2019, but otoliths have been collected and stored dry since 2020. Refer to Tables F1 and F2 for sampling requirements over time.

Codes 50-51 – Wolffishes. Striped Atlantic Wolffish (*Anarhichas lupus*) are caught on both surveys in most years. Spotted Wolffish (*Anarhichas minor*) and Northern Wolffish (*Anarhichas denticulatus*) are caught regularly on the summer survey, but rarely on the winter survey. All three species are listed under the Species at Risk Act, and survey data is used for monitoring (DFO 2020b). Only Striped Atlantic Wolffish are regularly included in the summer survey updates (Appendix A). Refer to Tables F1 and F2 for sampling requirements over time.

Code 60 – Atlantic Herring (*Clupea harengus*). As a schooling pelagic species, trawl captures of Herring are variable. Herring are not currently included in the spring and summer survey updates and only size, maturity, and distribution data from the summer Ecosystem Survey have recently been considered in population analyses (e.g. Singh et al. 2020). Whole herring were collected at sea until 2008 with most biological sampling done on shore. Since 2009, length stratified sampling for herring is done at sea. Individual numbered fish are retained for otolith

removal onshore and ages are then recorded in the survey database. Dissecting herring for their otoliths on land is intended to eliminate breakage as the otoliths are small and more difficult to remove than groundfish otoliths. Until 2015, fork lengths for herring were taken on a non-offset measuring board. Since 2017, total length (pinched caudal fin in millimeters) has instead been taken on a non-offset measuring board. Refer to Tables F1 and F2 for more general sampling requirements over time.

Code 70 – Atlantic Mackerel (*Scomber scombrus*). As a schooling pelagic species, trawl captures of Mackerel are variable. Mackerel have never been included in the spring and summer survey update documents. Refer to Tables F1 and F2 for sampling requirements over time.

Codes in the low-200s - Skates. The five main species of skates captured on the surveys are Barndoor (*Dipturus laevis*; Code 200), Thorny (*Amblyraja radiata*; Code 201), Smooth (*Malacoraja senta*; Code 202), Little (*Leucoraja erinacea*; Code 203), and Winter (*Leucoraja ocellata*; Code 204). All of these species are typically included in the spring and summer updates (Appendix A). Smooth Skate (Laurentian-Scotian population) and Thorny Skate have a COSEWIC status of “Special Concern” while Winter Skate (Eastern Scotian Shelf-Newfoundland population) has a status of “Endangered”; none are listed on Schedule 1 of the Species at Risk Act (COSEWIC 2012b, 2012c, 2015). Survey data was used in the COSEWIC assessments for all three species, and has been used in past population analyses as well (e.g. Simon, Frank, and Kulka 2002; Simon, Harris, and Johnston 2003; Simon, Rowe, and Cook 2011). An important note is that Little Skate and Winter Skate are nearly impossible to identify when immature. The at-sea protocol for many years was to use the appearance of secondary sexual characteristics to distinguish the species, with any apparently maturing fish <60 cm coded as Little while all immature fish or mature fish >60 cm were coded as Winter Skate. A review of existing data indicated that this was not appropriate at lengths <40 cm (DFO 2015). In 2011, a new code (1191) was added to the database for Little and Winter Skates <40 cm. All data from either species <40 cm should be treated as a mix. Refer to Tables F1 and F2 for sampling requirements over time.

Code 220 - Spiny Dogfish (*Squalus acanthias*). Dogfish data from the summer Ecosystem Survey is included in the summer survey updates (Appendix A). It is also used in population analyses, although most recently as a secondary index of migration and local stock abundance (Fowler and Bowlby 2022). Refer to Tables F1 and F2 for sampling requirements over time.

Code 241 – Northern Hagfish (*Myxine glutinosa*). Hagfish data from the summer Ecosystem Survey has been used in population analyses, though Hagfish are poorly captured by survey gear because they burrow into the substrate; in the commercial fishery, they are captured with baited traps rather than by trawl (DFO 2018). Hagfish is not currently included in the spring or summer survey updates. Refer to Tables F1 and F2 for sampling requirements over time.

Codes in the low-300s – Sculpins (*Cottoidea* S.F.). Only Longhorn Sculpin (*Myoxocephalus octodecemspinosus*; Code 300) is included in the spring and summer survey updates (Appendix A). Longhorn Sculpin data from the survey is used in population analyses (Stone 2021). Fowler and Showell (2009) noted a concern with data for hookear sculpins; differentiation using the species-specific codes has improved since the 2005 data that was included in that document. Refer to Tables F1 and F2 for sampling requirements over time.

Code 400 – Monkfish (*Lophius americanus*). Monkfish data from the summer Ecosystem Surveys are included in the survey update documents and in population analyses completed in the past (DFO 2002b). Refer to Tables F1 and F2 for sampling requirements over time.

4. Considerations for Other Fish Species

Non-commercial fish. While the sampling protocol has always included the identification of all fish species, the taxonomic level to which infrequently caught non-commercial fish species have been identified has varied, although it has improved over time. For species that are more difficult to identify to the species level, data users should consider searching the database by genus or other taxonomic groupings according to the method outlined in Appendix G.

Deep-sea Species. Besides the general recommendation for rarely caught species above, data users should consider that the depth range of the summer survey has increased twice. In 1995, new strata (496, 497, and 498) on the edge of the Scotian Shelf were added to the survey to extend the depth coverage to 400 fathoms. In 2011, deep water strata were created along the shelf edge (strata 501 – 505), extending the survey range down to 2000 m. Strata 501-505 were first surveyed in 2010 (though they were named a year later). When looking at data from species that live at these depths, consider that it is the goal for strata 501-505 to only be surveyed systematically every five years.

Grenadiers (*Macrourinae* F.) and Chimaeras (*Chimaeriformes* O.). The length measurement for grenadiers has changed. Originally, a total length was taken, but these lengths were frequently inaccurate because grenadiers' tails are fragile and the tips often break in the trawl. In 2019, pre-anal fin lengths began to be recorded instead. Data users should consider that before that date, length data are not always accurate. In years when both types of measurements have been collected in error, a conversion using the length-weight relationships may be possible but has not been attempted. A similar conversion would also be necessary to view data from the whole time series. Furthermore, as many grenadier species live at greater depths, years with systematic coverage of deep-water strata (see above) may provide more consistent data about these species than other years.

Code 610 – Northern Sand Lance (*Ammodytes dobies*). Sand Lance data must be treated with caution because they are easily destroyed by the trawl and the catch may not be representative if the net is not washed down thoroughly. Total weight data, in particular, may be of questionable value since many squeeze out through the codend mesh and the catch will vary based on the diameter of the fish present at the time. Before about 2017, deck crews were less thorough in ensuring all Sand Lance and pieces of broken Sand Lance were washed off the net and deck, through the hopper to the lab. Individual length and weight data may also be untrustworthy before that time as weights were sometimes recorded for fish which were not intact. Code 609 (*Ammodytes* sp.) has been used interchangeably with Code 610 in the past. Catches recorded as American Sand Lance (*Ammodytes americanus* – Code 599) are also likely the more common *A. dubius*.

5. Considerations for Primary and Secondary Invertebrate Species

Code 2211 – Northern Shrimp (*Pandalus borealis*). Northern Shrimp was added to the standard sampling protocol for the summer survey in 1999, and as staff became consistent with identifying them over the course of several years, the data is generally of good quality since about 2005. When they were recorded periodically before 1999, *P. borealis* and *P. montagui* (Code 2212) were grouped as *Pandalus* sp. (Code 2210). Identification concern between *P. montagui* and *D. leptocerus* was identified in 2017 (Murillo et al. 2018), so *D. leptocerus* was likely present in *Pandalus* sp. data before 1999. Northern Shrimp were added to the spring survey sampling protocols in 2007. The data were included in the summer survey updates from 2006-2011, but are not currently included in updates for either survey (Appendix A). The summer survey is included in population analyses, along with other indexes (e.g. Cassista-Da Ros and Cosham 2020). Refer to Table F3 for sampling requirements over time.

Code 2250 – American Lobster (*Homarus americanus*). Lobster is one of two invertebrate species that was consistently sampled on the summer survey since the beginning of the time series in 1970. The use of Sex Code 3 for berried females was introduced in 1999. Lobster was added to the spring survey sampling protocol in 2007. Lobster carapace length is measured to the nearest mm using calipers. It was not until 2015 that no weight was recorded if the specimen was not intact; before that time, data included specimens that were missing claws, legs, etc. Lobster are no longer included in the summer survey updates, as they were from 2006-2011, and were added to the spring survey updates in 2020 (Appendix A). Lobster data from the survey is used alongside other indices in certain Lobster Fishing Areas, including offshore (e.g. Cook, Hubley, and Denton 2018). Refer to Table F3 for sampling requirements over time.

All crab species. The use of Sex Code 3 for berried females was introduced in 1999. Snow Crab was added to the spring survey sampling protocol in 2007. Crab carapace width is measured to the nearest mm using calipers. It was not until around 2015 that no weight was recorded if the specimen was not intact; before that time, data included specimens that were missing claws, legs, etc.

Code 2526 – Snow Crab (*Chionoecetes opilio*). Snow Crab was added to the standard sampling protocol for the summer survey in 1999, although it was consistently requested as a special sample before then. As a result, identifications from 1999-2005 are likely reliable. Snow Crab are no longer included in the summer survey updates, as they were from 2006-2011; they were never included in the spring survey updates (Appendix A). Data from the surveys have not been recently included in population analyses. Refer to Table F3 for sampling requirements over time.

Codes 2511 & 2513– Jonah Crab (*Cancer borealis*) and Atlantic Rock Crab (*Cancer irroratus*). Jonah Crab was added to the standard sampling protocol for the summer survey in 1999, and as staff became consistent with identifying them over the course of several years, the data is generally of good quality since about 2005. Before 2005, the Jonah Crab and Atlantic Rock Crab may have been confused, as identified in Fowler and Showell (2009). Depth could help quality control these data, as the two crabs occur at different depths (Robichaud and Frail 2006). Both species were added to the standard sampling protocol for the spring survey in 2007. Jonah Crab and Atlantic Rock Crab have not been included in an update document for either the spring or the summer survey. Data from the surveys has been used to monitor Jonah Crab in the offshore (e.g. DFO 2009). Refer to Table F3 for sampling requirements over time.

Codes 2523 & 2528 – Northern Stone Crab (*Lithodes maja*) and Porcupine Stone Crab (*Neolithodes grimaldii*). The two stone crab species was added to the standard sampling

protocol for the summer survey in 1999 and for the spring survey in 2007. It is difficult to get an accurate carapace width measurement for them, as they have spines that increase the measurement. Most carapace width measurements therefore include the length of the spines. As Porcupine Stone Crab occurs at greater depths, see the note about Deep-sea Species below. Neither species has been included in an update document for either the spring or the summer survey. Data from the surveys have not been included in any population analyses of which we are aware, or in any survey update document. Refer to Table F3 for sampling requirements over time.

Code 2532 – Deep Sea Red Crab (*Chaceon quinque-dens*). Deep Sea Red Crab was added to the standard sampling protocol for the summer survey in 1999. As they occur at greater depths, see the note about Deep-sea Species below. Data from the surveys have not been included in any population analyses of which we are aware, or in any survey update document. Refer to Table F3 for sampling requirements over time.

Code 4210 – Whelks (*Buccinum* sp.). Gastropoda O. (Code 4200) was added to the standard summer survey sampling protocol in 1999. In 2007, all invertebrates began to be identified as precisely as possible, including all species of whelk. While the use of survey data for monitoring whelk may be limited, they are used in the recent framework review for *Buccinum undatum* (Barrett 2023). No species of whelk has ever been included in a survey update document. Refer to Table F3 for sampling requirements over time.

Code 4317 – Surf Clam (*Spisula solidissima*). Surf Clam was added to the standard sampling protocol for the spring and summer surveys in 2007. They are best captured by dredge, so a dredge survey is used in population analyses instead of the trawl surveys (Hubley et al. 2018). Surf Clam has never been included in a survey update document. Refer to Table F3 for sampling requirements over time.

Code 4321 & 4322 – Sea Scallop (*Placopecten magellanicus*) and Iceland Scallop (*Chlamys islandica*). Sea Scallop was added to the standard sampling protocol for the summer survey in 1999 and for the spring survey in 2007. There are few species with which they can be confused, so confidence in identifications is relatively high from the beginning of their addition. In the opposite direction, Fowler and Showell (2009) identified a concern where Iceland Scallop may have been confused with Sea Scallop before about 2005. Shell height (mm) is measured for scallops using calipers or a scallop measuring board. Individual weights are not taken because scallops retain sand and water. As scallops are caught by dredge in the commercial fishery, a trawl is not the ideal gear with which to survey them, and survey data have not been included in recent population analyses (e.g. Smith et al. 2014) though they were previously (e.g. DFO 2004). Sea Scallop were included in the summer survey report from 2007-2011 only (Appendix A). Refer to Table F3 for sampling requirements over time.

Code 4511 – Shortfin Squid (*Illex illecebrosus*). Shortfin Squid is one of two species of invertebrates (the other being lobster) that have been sampled consistently on the summer survey since 1970. Mantle lengths (cm) are recorded. Summer survey data has been used to study squid distribution (Scott 1977) and are requested annually by NAFO for stock assessment. Squid were included in the summer survey updates from 1998-2011 (Appendix A). Refer to Table F3 for sampling requirements over time.

Code 6411 – Green Sea Urchin (*Strongylocentrotus droebachiensis* & *S. pallidus*). Sea urchins were added to the summer sampling protocol in 1999. In 2007, all invertebrates began to be identified as precisely as possible, including all species of sea urchins. Apart from *S.*

droebachiensis and *S. pallidus*, which are difficult to distinguish and are both recorded as Code 6411 (Gagnon and Gilkinson 1994), all other regular sea urchin species are rare and infrequently captured in depths <400 m. Where the general Code 6400 (*Strongylocentrotus* sp.) has been used, data can be grouped with Code 6411 in analyses. Data from the surveys have not been used in population analyses for Green Sea Urchin, and they have not been included in the survey updates. Refer to Table F3 for sampling requirements over time.

Code 6611 – Common Sea Cucumber (*Cucumaria frondosa*). Sea cucumbers were added to the summer sampling protocol in 1999. In 2007, all invertebrates began to be identified as precisely as possible, including all species of sea cucumbers. However, *Cucumaria frondosa* is by far the most common species of sea cucumber. Other sea cucumber species are rare, small, and infrequently captured at depths < 400 m. Therefore, where sea cucumbers have been recorded as Code 6600 (Holothuroidea O.), it can be assumed that the most are likely *C. frondosa*. Data from the surveys is not used in population analyses for sea cucumbers, but they were included in the summer survey reports from 2007-2011 (Appendix A). Refer to Table F3 for sampling requirements over time.

6. Considerations for Non-Commercial Species

Non-commercial invertebrates. Data users should consider that invertebrate species have been added to the sampling protocols over time, and that species identification has improved:

- From the surveys' inception to 1999, all non-commercial invertebrate species were recorded only when staff who were able or interested in identifying them were at sea. Observations of these species before 1999 should be considered incidental.
- From 1999 to 2007, the invertebrates contained in Appendix F were added to the sampling protocol. Data for these species during this period is complete, but data from this period for all other non-commercial invertebrate species should be considered incidental.
- From 2007 to the present, all species have been identified and recorded to as accurate a level of taxonomic detail as possible. There was an additional increase in invertebrate identifications in 2017, especially for corals and sponges, when improved ID guides were created. However, as specimens are not always identified to the species level, data users should consider searching the database by genus or other taxonomic groupings according to the method outlined in Appendix G. Additionally, as infrequently caught species have had codes added to the database over time, survey staff may have recorded the species or genus name in the comments of the catch record. When data users query the database, they should search the comment section in the GSCAT table for the species, genus, or common name..

Deep-sea Species. Besides the general recommendation for rarely caught species above, data users should consider that the depth range of the summer survey has increased twice. In 1995, new strata (496, 497, and 498) on the edge of the Scotian Shelf were added to the survey to extend the depth coverage to 400 fathoms. In 2011, deep water strata were created along the shelf edge (strata 501 – 505), extending the survey range down to 2000 m. Strata 501-505 were first surveyed in 2010 (though they were named a year later). When looking at data from

species that live at these depths, consider that it is the goal for strata 501-505 to only be surveyed systematically every five years.

Codes 2521 & 2523 – Lesser Toad Crab (*Hyas coarctatus*) and Greater Toad Crab (*Hyas araneus*). Toad crabs were added to the summer survey sampling protocol in 1999 and to the spring survey sampling protocols in 2007. They are similar, and past documents have noted identification concerns (Fowler and Showell 2009). Since the 2005 data included in that analyses, confidence in species-level identifications has improved over time. An additional code, 2520 – *Hyas* sp., includes both species of toad crab. The two species occupy different habitats and depths, presenting a possibility for quality controlling the data from the three codes. For an overview of changes to sampling requirements over time, see Table F3.

Codes 2555 & 2556 – Squat Lobsters (*Typhlonida valida* and *Iridonida iris*). Squat lobsters were added to the summer survey sampling protocols in 1999 and to the spring survey sampling protocols in 2007. They are similar, but species-level identifications have improved over time. Identifications have been consistent since about 2005. For an overview of changes to sampling requirements over time, see Table F3.

Codes in the 6100s – Seastars. Code 6100 (Asteroidea C.) was added to the summer survey sampling protocol in 1999. From 2007 on, it has been the protocol on both surveys to identify all species to the lowest taxonomic level possible. Species-level identifications for sea stars have improved consistently since 2007, with the addition of new identification posters around 2010 and then improved identification guides in 2017. Data users may want to search higher taxonomic levels (e.g. genus, family, or order) to get more data over a longer period of time. For an overview of changes to sampling requirements over time, see Table F3.

Codes 6200 & 6300 – Brittle Stars (Ophiuroidea C.) and Basket Stars (*Gorgonocephalus* sp.). Brittle stars and basket stars were added to the summer and spring survey sampling protocols in 2007. Genus- or species-level identifications have improved over time, particularly since 2017. Brittle stars and basket stars break apart easily in the trawl, so counts and weights may not always be accurate. For an overview of changes to sampling requirements over time, see Table F3.

Codes in the 8300s – Corals (Anthozoa S.P.). Recording for corals was sporadic before 2000. In the early 2000s, samples were retained for detailed work onshore and added to the database post-survey. In 2005, all corals began to be sorted and weighed by taxa, with identifications corroborated onshore via photographs. Some species were grouped at higher taxonomic levels but identifications have improved further since then. Distribution data from the surveys been used in a number of analyses (e.g., DFO 2010; Kenchington et al. 2010, 2016; DFO 2017). For an overview of sampling requirements over time, see Table F3.

Code 8500 – Jellyfish (Scyphozoa C.). All species have been required to be identified to the lowest taxonomic level possible since 2007. However, because jellyfish often break apart in the trawl, it can be difficult to identify them to the genus or species level. When they are unidentifiable, they are grouped under Code 8500. For an overview of changes to sampling requirements over time, see Table F3.

Code 8600 – Sponges (phylum Porifera). All species have been required to be identified to the lowest taxonomic level possible since 2007. However, many species of sponges remained grouped under the general Code 8600 until 2017. Since 2017, new species guides have been used to identify sponges, often to genus or species. Some sponges break into multiple pieces in the trawl, and therefore counts may not always be accurate. Distribution data from the surveys have been used in a number of analyses (e.g., DFO 2010; Kenchington et al. 2010, 2016; DFO 2017). For an overview of changes to sampling requirements over time, see Table F3.

Code 8601 - Russian Hat Sponges (*Vazella pourtalesii*). Glass sponges were added to the standard sampling protocol in 2007. Russian Hats have had total length (mm) recorded since 2016. Width (mm) and osculum diameter (mm) measurements are also available since 2017. Since 2007, Russian Hats have been consistently identified to the species level. Russian Hats generally stand up well to the trawl and do not generally break apart. Distribution data from the surveys been used in a number of analyses (e.g., DFO 2010; Kenchington et al. 2010, 2016; DFO 2017). For an overview of changes to sampling requirements over time, see Table F3.

Table F1. Sampling requirements for fish on the Maritimes Region Summer Ecosystem Survey (4VWX5Z) from 1970-2020.

		1970-1985					1986-1994					1995-1997					1998 to 2020				
Species	Code	LW	Sex	Maturity	Strat.	Otolith	LW	Sex	Maturity	Strat.	Otolith	LW	Sex	Maturity	Strat.	Otolith	LW	Sex	Maturity	Strat.	Otolith
All other fish		Y	N	N	1/1cm	N	Length only	N	N	1/1cm	N	Y	N	N	1/1cm	N	Y	N	N	1/1cm	N
Argentine		Y	Y	Y	1/1cm	Y		N	N	1/1cm	N	Y	Y	N	1/1cm	N	Y	N	N	1/1cm	N
Cod, Atlantic	10	Y	Y	Y	3/3cm	Y	Y	N	3/3cm	Y	Y	Y	Y	3/3cm	Y	Y	Y	N	3/3cm	Y	
Cod, Greenland		Y	Y	Y	1/1cm	N	Length only	N	N	1/1cm	N	Y	N	N	1/1cm	N	Y	N	N	1/1cm	N
Cusk	15	Y	Y	Y	3/3cm	Y		N	N	3/3cm	N	Y	N	N	3/3cm	N	Y	Y	N	3/3cm	Y
Dogfish, Spiny	220	Y	Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Dogfish, Black	221	Y	Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, American Plaice	40	Y	Y	Y	1/1cm/sex	Y	Y	N	1/1cm/sex	Y	Y	Y	Y	1/1cm/sex	Y	Y	Y	N	1/1cm/sex	N	
Flounder, Windowpane (Brill)		Y	Y	Y	1/1cm/sex	Y	Length only	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Winter	43	Y	Y	Y	1/1cm/sex	Y		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Witch	41	Y	Y	Y	1/1cm/sex	Y		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Yellowtail	42	Y	Y	Y	1/1cm/sex	Y		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Haddock	11	Y	Y	Y	2/2cm	Y	Y	N	2/2cm	Y	Y	Y	Y	2/2cm/sex	Y	Y	Y	N	2/2cm	Y	
Halibut, Atlantic	30	Y	Y	Y	3/3cm/sex	Y	Length only	Y	N	3/3cm/sex	N	Y	Y	Y	3/3cm/sex	N	Y	Y	N	3/3cm/sex	Y
Halibut, Greenland (Turbot)	31	Y	Y	Y	1/1cm/sex	Y		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Hake, Offshore		Y	Y	Y	1/1cm/sex	N		N	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	N	N	1/1cm	N
Hake, Red	13	Y	Y	Y	1/1cm	Y		N	N	1/1cm	N	Y	N	N	1/1cm	N	Y	N	N	1/1cm	N
Hake, Silver	14	Y	Y	Y	1/1cm/sex	Y	Y	Y	1/1cm/sex	Y	Y	Y	Y	1/1cm/sex	Y	Y	Y	Y	1/1cm/sex	Y	
Hake, White	12	Y	Y	Y	3/3cm	Y	Length only	N	N	3/3cm	N	Y	Y	N	3/3cm	Y	Y	Y	N	3/3cm	Y
Herring	60	Y	Y	Y	1/1cm	Y		N	N	1/1cm	N	Y	N	N	1/1cm	N	Y	N	N	1/5mm	N
Mackerel	70	Y	Y	Y	1/1cm	Y		N	N	1/1cm	N	Y	N	N	1/1cm	N	Y	N	N	2/1cm	N
Monkfish (Anglerfish)		Y	N	N	3/3cm	N		N	N	3/3cm	N	Y	N	N	3/3cm	N	Y	Y	N	1/1cm	N
Pollock	16	Y	Y	Y	3/3cm	Y	Y	N	3/3cm	Y	Y	Y	Y	3/3cm	Y	Y	Y	N	3/3cm	Y	
Redfish	23	Y	Y	Y	1/1cm/sex	Y	Length only	Y	N	1/1cm/sex	N	Y	Y	Y	1/1cm/sex	Y	Y	Y	N	1/1cm/sex	N
Skate, Barndoor	200	Y	Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Skate, Little		Y	Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Skate, Smooth		Y	Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Skate, Thorny		Y	Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Skate, Winter		Y	Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Wolffish, Striped Atlantic	50	Y	N	N	3/3cm	N		N	N	3/3cm/sex	N	Y	N	N	3/3cm/sex	N	Y	N	N	3/3cm	N
Wolffish, Northern	52	Y	N	N	3/3cm	N		N	N	3/3cm/sex	N	Y	N	N	3/3cm/sex	N	Y	N	N	3/3cm	N
* From 2014 to 2020, the Ecosystem Surveys Entry (ESE) System used for data collection. This system, like the new ANDES data entry aboard the CCGS Jacques Cartier, allow further groupings by length or area. As a result, these are the standard sampling protocols but their application may vary depending on the requirements of the assessment programs. For example, otolith collection may be turned 'off' in a specific area if collected otoliths would not be useful.																					

Table F2. Sampling requirements for fish on the Maritimes Region Spring Ecosystem Survey (5Z) from 1970-2020.

Species	1986					1987-2006					2007 to 2020*				
	LW	Sex	Maturity	Strat.	Otolith	LW	Sex	Maturity	Strat.	Otolith	LW	Sex	Maturity	Strat.	Otolith
All other fish	Y	N	N	1/1cm	N	Y	N	N	1/1cm	N	Y	N	N	1/1cm	N
Cod, Atlantic	Y	Y	Y	3/3cm	Y	Y	Y	Y	3/3cm	Y	Y	Y	Y	3/3cm	Y
Cusk	Length only	N	N	3/3cm	N	Length only	N	N	3/3cm	N	Y	Y	Y	3/3cm	Y
Dogfish, Spiny		Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Dogfish, Black		N	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, American Plaice		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Fourspot		Y	N	1/1cm/sex	N				1/1cm/sex		Y	Y	N	1/1cm/sex	N
Flounder, Summer		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Windowpane (Brill)		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Winter		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Witch		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Flounder, Yellowtail		Y	N	1/1cm/sex	N	Y	Y	Y	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Haddock	Y	Y	Y	2/2cm	Y	Y	Y	Y	2/2cm	Y	Y	Y	Y	2/2cm	Y
Halibut, Atlantic	Length only	Y	N	3/3cm/sex	N	Length only	Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	Y
Halibut, Greenland (Turbot)		N	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Hake, Silver		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Hake, White		N	N	3/3cm	N		N	N	3/3cm	N	Y	Y	Y	3/3cm	Y
Herring		N	N	1/1cm/sex	N		N	N	1/1cm/sex	N	Y	N	N	1/5mm	N
Mackerel		N	N	1/1cm/sex	N		N	N	1/1cm/sex	N	Y	N	N	2/1cm	N
Monkfish (Anglerfish)		N	N	1/1cm	N		N	N	1/1cm	N	Y	N	N	1/1cm	N
Pollock		N	N	3/3cm	N	Y	Y	Y	3/3cm	Y	Y	Y	Y	3/3cm	Y
Redfish		Y	N	1/1cm/sex	N	Length only	Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Skate, Barndoor		Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Skate, Little		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Skate, Smooth		Y	N	1/1cm/sex	N		Y	N	1/1cm/sex	N	Y	Y	N	1/1cm/sex	N
Skate, Thorny		Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Skate, Winter		Y	N	3/3cm/sex	N		Y	N	3/3cm/sex	N	Y	Y	N	3/3cm/sex	N
Wolffish, Striped Atlantic		N	N	3/3cm	N		N	N	3/3cm	N	Y	N	N	3/3cm	N
Wolffish, Northern		N	N	3/3cm	N		N	N	3/3cm	N	Y	N	N	3/3cm	N

* From 2014 to 2020, the Ecosystem Surveys Entry (ESE) System used for data collection. This system, like the new ANDES data entry aboard the *CCGS Jacques Cartier*, allow further groupings by length or area. As a result, these are the standard sampling protocols but their application may vary depending on the requirements of the assessment programs. For example, otolith collection may be turned 'off' in a specific area if collected otoliths would not be useful.

Table F3. Sampling requirements for invertebrates on the Maritimes Region Spring (5Z; 1986-2020) and Summer (4VWX5Z; 1970-2020) Ecosystem Surveys.

Survey	Year Added to Standard Sampling	Year First Recorded	Species or Species Group	Code	Total Weight	Total No.	LF	Sex	Notes
Summer	1970	1970	Lobster – <i>Homarus americanus</i>	2550	Y	Y	Y	Y	Carapace length in mm with calipers. Sex code 3 for berried females introduced in 1999. Since 2015, no weight is recorded for incomplete specimens.
		1970	Squid, Shortfin – <i>Illex illecebrosus</i>	4511	Y	Y	Y		Mantle length in cm
Summer	Phased in, 1999-2005	1998	Shrimp – <i>Pandalus borealis</i>	2211	Y	Y			When recorded before 1999, <i>Pandalus</i> sp. were grouped (Code 2210). Possible ID confusion between the two <i>Pandalus</i> sp. until ~2005, and <i>P. montagui</i> and <i>D. leptocerus</i> until ~2017, has been identified (Murillo et al. 2018).
		1999	Shrimp – <i>Pandalus montagui</i>	2212	Y	Y			
		1970	Shrimp – <i>Pandalus</i> sp.	2210	Y	Y			
		2002	Shrimp – <i>Crangon</i> sp.	2416	Y	Y			
		1999	Shrimp – Pandalidae F.	2200	Y	Y			
		1980	Crab, Jonah – <i>Cancer borealis</i>	2511	Y	Y	Y	Y	Carapace width in mm with calipers. Sex code 3 for berried females was introduced in 1999. Since 2015, no weight is recorded for incomplete specimens. Snow Crab was also recorded under the now obsolete Code 2522 <i>Chionoecetes</i> sp. before 1999.
		1980	Crab, Rock – <i>Cancer irroratus</i>	2513	Y	Y	Y	Y	
		1986	Crab, Spider – Majidae F.	2519	Y	Y	Y	Y	
		1991	Crab, Greater Toad – <i>Hyas araneus</i>	2527	Y	Y	Y	Y	
		1999	Crab, Lesser Toad – <i>Hyas coarctatus</i>	2521	Y	Y	Y	Y	
		1981	Crab, Northern Stone – <i>Lithodes maja</i>	2523	Y	Y	Y	Y	
		1980	Crab, Snow/Queen – <i>Chionoecetes opilio</i>	2526	Y	Y	Y	Y	
		1983	Crab, Porcupine/Stone – <i>Neolithodes grimaldii</i>	2528	Y	Y	Y	Y	
		1976	Crab, Deepsea Red – <i>Chaceon quinque-dens</i>	2532	Y	Y	Y	Y	
		1999	Crab, Hermit - Paguridae F.	2559	Y	Y			
		2000	Squat Lobster – <i>Iridonida iris</i>	2555	Y	Y			Possible ID confusion until ~2005.
		2003	Squat Lobster – <i>Typhlonida valida</i>	2556	Y	Y			
		2004	Sea Mouse – <i>Aphrodita</i> sp.	3212	Y	If < 25			
		2004	Snails and Slugs – Gastropoda O.	4200	Y	If < 25			
		2001	Bivalve – Bivalvia C.	4300	Y				
		1996	Scallop, Sea – <i>Placopecten magellanicus</i>	4321	Y	Y	Y		Possible ID confusion until ~2005 – Icelandic Scallops may have been recorded as Sea Scallops
		1999	Scallop, Icelandic – <i>Chlamys islandica</i>	4322	Y	Y	Y		
		1974	Squid, Longfin – <i>Loligo pealeii</i>	4512	Y	Y	Y		
		1996	Squid – Lolinidae, Ommastrephidae F.	4514	Y	Y			
		1976	Octopus – Octopoda O.	4521	Y	Y			
		2005	Squid, Bobtail – Sepiolodae F.	4536	Y	Y			

		1976	Seastars – Asteroidea C.	6100	Y	If < 25			
		2000	Sea Urchin, Green – <i>Stronglocentrotus droebachiensis</i>	6411	Y	If < 25			<i>S. droebachiensis</i> and <i>S. pallidus</i> are both recorded under Code 6411. Codes 6400 (<i>Stronglocentrotus sp.</i>) and 6411 can be analysed together.
		2000	Sea Urchin, Purple – <i>Arbacia punctulata</i>	6421	Y	If < 25			This species was recorded between 2000 and 2008. Since 2017, invertebrates in each set are photographed for quality control onshore and this species has never been found. No physical sample from these records is available for confirmation. Due to the southern distribution of this species, this records remain uncertain.
		2000	Sand Dollar – <i>Echinarachnius parma</i>	6511	Y	If < 25			
		1999	Sea Cucumber – Holothuroidea C.	6600	Y	If < 25			Code 6600 (<i>Holothuroidea</i> O.) iis likely comprised mostly of 6611 (<i>Cucumaria frondosa</i>).
Summer	2006	2005	Corals – Anthozoa C.	8332	Y	Y			All corals began to be sorted and weighed by taxa, with identifications corroborated onshore via photographs. Some species were grouped at higher taxonomic levels.
Spring and Summer	2007		All invertebrates		Y				The sampling goal on both surveys became to identify, weigh, and count all invertebrates as precisely as possible. Many taxa have been added to the database since 2007, with some having previously been identified at a higher level. Identifications for all species except corals were not quality controlled from 2007-2017.
Spring and Summer	2016	2007	Russian Hats – <i>Vazella pourtalesii</i>	8601	Y	Y	Y		Russian Hats have had total length (mm) recorded since 2016 and width (mm) and osculum diameter (mm) measurements recorded since 2017.
Spring and Summer	2017		All invertebrates		Y				Species previously grouped by order or phylum, such as order or phylum, began to be identified at lower taxonomic levels. From this point on, most invertebrates have been identified to the genus or species level. As a result, more taxa have been added to the database. Since 2017, invertebrates in each set are photographed for quality control onshore.

APPENDIX G. SAMPLE DATABASE QUERIES

To query the GROUND FISH database, access via a username and password is required. Access can be requested from the Population Ecology Division data manager. As most data-users currently access the GROUND FISH Oracle database using an SQL query embedded within an ROracle or RODBC query from RStudio, the following examples are presented in a format that can be copied and pasted into a script employing one of these packages. To set up a query in ROracle, for example, a basic format is:

```
library(ROracle)

channel <- ROracle::dbConnect(DBI::dbDriver("Oracle"), username=oracle.username,
password=oracle.password, oracle.dsn)

data <- dbGetQuery(channel, "SQL QUERY")
```

The new GSSPECIES_ANDES table allows the data to be searched using AphiaID, the unique identifier of the World Register of Marine Species (WoRMS Editorial Board 2023), or taxonomic rank ("kingdom", "phylum", "class", "order", "family", "genus", or species – "spec") (McMahon 2023). While this table was developed for use with the ANDES data entry system aboard the *Cartier*, it is included here as it enables taxonomic searches of the database, a useful tool especially for data users interested in invertebrates or less frequently caught vertebrate species.

Another useful tool is DFO's Mar.utils R package (McMahon 2018). The identifyArea function can take converted set latitude and longitude coordinates from the GROUND FISH database, and overlay them with shapefile (.shp) to indicate the polygon within the shapefile into which the point falls. While the strata numbers and NAFO areas are available in the GROUND FISH schema (Example 3), this function allows a data user to determine a set's location within other shapefiles of interest. Data users are cautioned against using polygons other than survey strata for statistical analysis, as abandoning the survey's stratified-random design in favour of post-stratification will affect the validity of the results. An example of a conversion of the latitude and longitude coordinates in the GROUND FISH database (SLAT and SLONG) to the decimal degrees format required by the package is:

```
data$LATITUDE <- as.numeric(substr(data$SLAT,1,2))+data$SLAT-
as.numeric(substr(data$SLAT,1,2))*100/60))

data$LONGITUDE <- as.numeric(substr(data$SLONG,1,2))+data$SLONG-
as.numeric(substr(data$SLONG,1,2))*100/60)*-1)
```

Additional example queries that use the GROUND FISH.ES* views to recreate stratified output like the STRANAL Length Mean, Length Total, Weight Mean, Weight Total, and associated standard errors, are available in Appendix E.

Example 1. Set-level total weight data by time series and species code

1a. Survey species code

```
select b.year, a.mission, a.setno, a.spec, a.totwgt, c.strat, c.slat, c.slong
      from groundfish.gscat a, groundfish.gsmissions b, groundfish.gsinf c
      where b.season in ('SUMMER')           --choose summer or spring
      and b.year > 1969                      -->1969 for summer; >1986 for spring
      and a.spec = 10                       --species code for Atlantic cod
      and c.type = 1                        --stratified random sets
      and a.mission=b.mission
      and a.mission=c.mission
      and a.setno=c.setno;
```

1b. AphiaID

```
select b.year, a.mission, a.setno, a.spec, a.totwgt, c.strat, c.slat, c.slong
      from groundfish.gscat a, groundfish.gsmissions b, groundfish.gsinf c,
      groundfish.gsspecies_andes d
      where b.season in ('SUMMER')           --choose summer or spring
      and b.year > 1969                      -->1969 for summer; >1986 for spring
      and d.aphia_id = 126436               --AphiaID for Atlantic cod
      and c.type = 1                        --stratified random sets
      and a.mission=b.mission
      and a.mission=c.mission
      and a.setno=c.setno
      and a.spec=d.code;
```

1c. Taxonomic rank

```
select b.year, a.mission, a.setno, a.spec, a.totwgt, c.strat, c.slat, c.slong
      from groundfish.gscat a, groundfish.gsmissions b, groundfish.gsinf c,
      groundfish.gsspecies_andes d
      where b.season in ('SUMMER')           --choose summer or spring
      and b.year > 1969                      -->1969 for summer; >1986 for spring
      and d.class in ('TELEOSTEI')          --class for teleost fish
      and c.type = 1                        --stratified random sets
      and a.mission=b.mission
      and a.mission=c.mission
      and a.setno=c.setno
      and a.spec=d.code;
```

Example 2. Detailed biological information by time series and species code

2a. Survey species code

```
select a.year, c.mission, c.setno, c.spec, c.flen, c.fwt, c.fmat, c.age
      from groundfish.gsmissions a, groundfish.gsinf b, groundfish.gsdet c
      where a.season in ('SUMMER')           --choose spring or summer
      and a.year > 1969                      -->1969 for summer; >1986 for spring
      and c.spec = 10                       --species code for Atlantic cod
      and b.type = 1                        --stratified random sets
      and a.mission=b.mission
      and a.mission=c.mission
      and b.setno=c.setno;
```

2b. AphiaID, the unique identifier of the World Register of Marine Species

```
select a.year, c.mission, c.setno, c.spec, c.flen, c.fwt, c.fmat, c.age
      from groundfish.gsmissions a, groundfish.gsinf b, groundfish.gsdet c,
      groundfish.gsspecies_andes d
      where a.season in ('SUMMER')           --choose spring or summer
      and a.year > 1969                      -->1969 for summer; >1986 for spring
      and d.aphia_id = 126436               --AphiaID for Atlantic cod
      and b.type = 1                        --stratified random sets
      and a.mission=b.mission
      and a.mission=c.mission
      and b.setno=c.setno
      and c.spec=d.code;
```

2c. Taxonomic rank

```
select a.year, c.mission, c.setno, c.spec, c.flen, c.fwt, c.fmat, c.age
      from groundfish.gsmissions a, groundfish.gsinf b, groundfish.gsdet c,
      groundfish.gsspecies_andes d
      where a.season in ('SUMMER')           --choose spring or summer
      and a.year > 1969                      -->1969 for summer; >1986 for spring
      and d.class in ('TELEOSTEI')          -- Class for Teleost fishes
      and b.type = 1                        --stratified random sets
      and a.mission=b.mission
      and a.mission=c.mission
      and b.setno=c.setno
      and c.spec=d.code;
```

Example 3. Station latitude, longitude, strata, and NAFO area for a given survey

```
select a.year, a.mission, b.setno, b.strat, b.area, b.slat, b.slong
      from groundfish.gsmissions a, groundfish.gsinf b
     where a.season in ('SUMMER')           --choose summer or spring
     and a.year = 2010                     --select one or multiple years
     and b.type = 1                       --stratified random sets
     and a.mission=b.mission;
```