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Assessment of Newfoundland East and South Coast Atlantic Herring (*Clupea harengus*) Stock Complexes to 2018

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Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

The assessment of Newfoundland east and south coast Atlantic herring (*Clupea harengus*) stock complexes considered data to the spring of 2018. Stock status index updates were provided for the Bonavista Bay-Trinity Bay (BBTB), St. Mary's Bay-Placentia Bay (SMBPB), and Fortune Bay (FB) stock complexes; biological updates were provided for White Bay-Notre Dame Bay (WBNDB) and Conception Bay-Southern Shore (CBSS) stock complexes. All Newfoundland stock complexes are comprised of a mix of spring and fall spawning herring. Spring spawners historically dominated in all areas, but with increased fall spawner recruitment in the late 1990s and through the early 2000s, stock composition in most areas shifted to largely fall spawners by the 2010s. However, a decline in fall spawner recruitment and the presence of several strong spring spawner year classes entering the fishery at the time of this assessment led to an increase in the percentage of spring spawners in recent years relative to the last decade.

Stock status is assessed using the spring research gillnet program, which provides the only fishery-independent index of abundance for the BBTB and FB stock areas. Since 2018, a similar program has also been run in Placentia Bay (PB) through DFO's Coastal Environmental Baseline Program, the results of which were used to update stock status for this assessment. The stock status index in BBTB decreased in 2017, largely due to below average catch rates; however, there are indications of positive future prospects with strong recruitment of incoming spring spawner year classes. Given these diverging trends, the stock status evaluation for BBTB is uncertain. In FB, the stock status index declined throughout the 2000s as spring recruitment was poor and fall recruitment did not increase in this stock area as it did in others. The index improved slightly in 2017 due to the strong recruitment of the 2012 year class, however at the time of this assessment there were no indications of subsequent strong recruitment. Based on these indices the stock status of FB is negative. In PB, catch rates from the 2018 gillnet program were above average, but the catch was dominated by a single year class, giving an uncertain stock status.

STOCK COMPLEXES AND ECOSYSTEM CONSIDERATIONS

STOCK STRUCTURE

Herring on the south and northeast coasts of Newfoundland are divided into five stock complexes (Fig. 1): White Bay-Notre Dame Bay (WBNDB), Bonavista Bay-Trinity Bay (BBTB), Conception Bay-Southern Shore (CBSS), St. Mary's Bay-Placentia Bay (SMBPB), and Fortune Bay (FB). These complexes were delineated via tagging studies in the 1970s and 1980s, based on spring spawning locations (Winters and Wheeler 1984). Herring also occur along the south coast of Newfoundland and southern Labrador; the stock affinity of these populations is currently unknown. Genetic analysis of northwest Atlantic herring stocks is ongoing to further investigate stock complex structure through a research project at Dalhousie University (Lamichhaney et al. 2017).

Atlantic herring stocks can be comprised of multiple spawning components – typically spring spawners (SS) and fall spawners (FS) in the Northwest Atlantic. Historically, NL stocks were dominated by SS, whereas FS were more prevalent to the south of the species' range. However, during the late 1990s and 2000s the composition of many Northwest Atlantic stocks changed, with increasing recruitment of FS and in some cases lower recruitment of SS (Melvin et al. 2009). This shift was evident in Newfoundland herring stocks, where the percentage of FS in most stock complexes increased from typical levels of 5–15% in most areas, to 50–80% through the 2000s, with the exception of FB (Fig. 2).

ENVIRONMENTAL DRIVERS OF RECRUITMENT

In the NL region, as with other Northwest Atlantic herring stocks (Melvin et al. 2009), the percentage of FS in most stocks increased with warming conditions during the late 1990s and early 2000s (Fig. 2). The FS recruitment index derived from the BBTB research gillnet program is most strongly correlated with increasing January sea temperatures at oceanographic monitoring Station 27 ($R^2 = 0.51$) when newly spawned fish are overwintering as larvae (Fig. 3) – note that FS recruitment was lagged by a year for this analysis as larvae that hatch in the fall are considered 1 year old for aging purposes as of January 1. Melvin et al. (2009) hypothesized that temperature alone was not responsible for the observed shifts in recruitment, and that it was likely a proxy for other environmental drivers.

Subsequent work by Brosset et al. (2018) found that decreasing SS recruitment in the Gulf of St. Lawrence was associated with the coinciding decline in abundance of cold water copepods, while increasing FS recruitment was dependant on warmer environmental conditions combined with adequate plankton availability. Similar analysis has not been performed on NL herring stocks due to data limitations; however it is likely that zooplankton dynamics also play an important role in this region.

FISHERY

FISHERY OVERVIEW

Atlantic herring are fished along the coasts of Newfoundland and southern Labrador, both commercially and for bait. The commercial herring fishery peaked in the late 1970s at over 30,000 t total catch, when the presence of several strong year classes and the introduction of purse seiners allowed intensive exploitation. All stocks were placed under quota regulation by the early 1980s as landings decreased sharply. Since then, combined total allowable catch (TAC) for all stock areas has not been met (Fig. 4, Table 1). The TAC is comprised of a commercial quota and bait allocation; the 2018 combined TAC from southern Labrador to Cinq Cerf Bay was 14,842 t (13,242 t commercial quotas and 1,600 t bait allocations).

Commercial fisheries generally occur in both spring and fall in all stock areas except FB, where there is no fall fishery. Because SS and FS do not segregate, the fishery targets mixed aggregations. The commercial fishery is carried out via both mobile and fixed gear, with purse seines currently accounting for the largest proportion of total commercial landings, followed by tuck seines, traps, bar seines, and gillnets (Fig. 5). Predominant gear types can vary by locality, for example there is no purse seine fishery in Labrador or FB; traps, tuck and bar seines account for most landings in these areas.

The herring bait fishery takes place largely in the spring, preceding the lobster fishery; however, bait landings have not been included in commercial landing statistics since 1996. Bait allocations are included in TACs (Fig. 6). An annual telephone survey is currently used to estimate bait removals, however previously voluntary (2006–16) bait logbooks were becoming mandatory in 2017 and may provide more accurate estimates going forward.

COMMERCIAL LANDINGS AND CATCH AT AGE

Commercial catch at age is calculated using samples collected from processors; an effort is made to collect a sample of 55 randomly selected fish per 500 t of landings by gear, month, and bay. An annual commercial catch numbers-at-age vector, by stock area and spawning type, is calculated by converting the catch weight to fish numbers using the mean whole weight from the sample being applied to that portion of the catch. Those numbers are then apportioned by age using the sample numbers-at-age. Age and spawning type are determined through otolith examination and maturity stage; at the time of this assessment, ages and spawning type designations were available for all samples up to and including 2017.

Total commercial landings were 5,722 t and 5,615 t in 2017 and 2018 respectively (based on preliminary landings data), representing approximately 45% of the overall TAC, similar to previous years (Table 1a-f, Fig. 4).

There has been a commercial herring fishery in Labrador since 2013, with a 500 t fixed gear commercial quota. Landings increased substantially from 18 t in 2017 to 412 t in 2018 (Table 1a, Fig. 7). Most landings occur in the fall. The stock affiliation of these herring is currently unknown. There was only one commercial sample collected from Labrador in 2016, which was dominated by FS (82%) with age 11+ fish comprising 50% of the catch and the rest broadly distributed between ages 4–10 (Fig. 8a). No commercial samples were obtained in 2017. Efforts will be made going forward to collect more representative samples from this area.

In WBNDB, the highest landings since the early 1990s occurred in 2017 at 2,367 t (92% of the TAC) and decreased slightly to 2,178 t in 2018 (85% of the TAC) (Table 1b, Fig. 7). Six commercial samples obtained in 2016 were largely from NDB; the catch was dominated by age 2 and 3 SS (2013 and 2014 year classes). This trend continued in 2017, with age 2, 3 and 4 SS (2013, 2014 and 2015 year classes) comprising approximately 55% of the catch (based on 3 samples). A further 20% was comprised by age 11+ FS, however this was largely based on a single sample with 90% age 11+ fish and may not have been representative of the entire fishery (Fig. 8b). The percentage of FS in the commercial catch fell below 50% in 2016 for the first time since 2006, and remained low relative to the 2010s in 2017 (Fig. 2).

In BBTB, the commercial quota was increased in 2017 from 5,810 t to 5,990 t. Landings decreased from previous years, with 1,277 t in 2017 and 750 t in 2018, 21% and 13% of the TAC respectively (Table 1c, Fig. 7). Fishers reported that this was due to high numbers of undersized fish (below the legal size limit of 270 mm total length). The age distribution of the commercial catch in 2016 was broad, based on 6 samples, with age 4 herring (2012 year class) and age 11+ herring accounting for 25% and 33% respectively. Five samples were collected in 2017; the 2012 year class dominated the catch at 60%, comprised of both SS and FS (Fig. 8b). As with WBNDB, the percentage of FS decreased in 2016 and 2017 to around 55% (Fig. 2).

Commercial landings in CBSS have increased over the last 6 years; the TAC was raised from 600 t to 700 t in 2015, and again to 895 t in 2017. Landings increased to 609 t in 2017 but decreased to 114 t in 2018, just 13% of the TAC (Table 1d, Fig. 7). As with BBTB, fishers reported that this was due to high numbers of undersized fish in 2018. All landings occurred in Conception Bay. The 2016 commercial catch at age was based on a single spring purse seine sample and was broadly distributed, with a strong age 4 (2012 year class) SS cohort. In 2017 two fall samples were collected and the catch was dominated by age 5 (2012 year class) spring and FS (Fig. 8b).

In SMBPB landings continued to increase in 2017 and 2018 to the highest levels since the late 1990s, with 1,295 t and 1,327 t landed respectively, representing 62% and 63% of the TAC (Table 1e, Fig. 7). Landings are largely via purse seine, with a small percentage attributable to gillnets. The age distribution from 4 commercial samples collected in 2016 was broad, however in 2017 the distribution, based on 2 samples, was dominated by age 5 (2012 year class) SS (Fig. 8b). The percentage of FS has fluctuated more in this stock area than those to the north, with approximately 50% FS in 2016 and 2017 (Fig. 2).

Landings in FB remained low in 2017 at 156 t (20% of the TAC) but increased substantially in 2018, with 834 t landed - the entire 789 t TAC and the reserve (Table 1f, Fig. 7). Landings are largely by bar seine and the entire fishery occurs in the spring. Due to issues with processing and obtaining samples, the age distribution of the 2016 and 2017 catch is unknown. Three commercial bar seine samples were obtained in 2018 and the catch was dominated by age 6 (2012 year class) SS, comprising over 90% of the samples (Fig. 8c). This fishery was sustained for the past several years by a single (2002) year class (Bourne et al. 2018) and this seems to be the case again, with a 10 year gap in strongly recruited year classes in this stock area. Unlike other areas, SS continue to dominate in FB (Fig. 2).

SEINER SURVEY

The seiner telephone survey has been conducted twice a year since 1996 to collect information from purse seine fishers who were active in the spring and/or fall fisheries. Survey respondents are asked to provide estimates of their total landings, discards, percent survival, and number of sets for the season, as well as their observations of overall abundance, which are used to update the Cumulative Change index (see below). Attempts are made to contact all fishers who reported purse seine landings each season; response rates are generally 90% or higher. The survey has included fishers in WBNDB, BBTB, and SMBPB since 1996, and CBSS since 2013 when purse seine landings began to increase in that area. There is no purse seine fishery in FB, however a bar seine survey was implemented in the stock area in 2015 to provide comparable industry perspective.

The majority of estimated discards in this survey are attributed to undersized herring, as management measures restrict the landing of small herring. Due to the variable recruitment of Atlantic herring, strong cohorts tend to be separated by a number of years. This causes a ‘pulse’ of undersized fish to enter the fishery and often dominate the catch for a period of time. Until that cohort reaches the minimum size for the fishery there will likely be issues with high percentages small herring and thus discards and mortality. To help mitigate this issue, the tolerance for undersized herring was increased from 10% to 20% in 2017 (DFO 2019).

In WBNDB, purse seine landings were up from previous years in 2017 and 2018, with 1,737 t and 1,758 t landed respectively. Estimated discards were down, with 20 t in 2017 and none in 2018. In contrast, purse seine landings were down from previous years in BBTB, with 873 t in 2017 and 466 t in 2018, and discard estimates were high. Fishers estimated 500 t of discards in 2017 and 1,500 t in 2018 – three times the landed amount, due to undersized fish. Purse seine landings in CBSS remained relatively high for the area in 2017 with 491 t landed, however this declined to 114 t in 2018; discards were estimated at 80 t in 2017 and none in 2018. SMBPB had consistent landings and discard estimates in 2017 and 2018, with 1,204 t and 1,287 t landings respectively, and an estimated 50 t and 10 t discards (Fig. 9).

In FB, bar seine fishers have been surveyed since 2015. Total landings declined from 800 t in 2015 to below 150 t in 2016 and 2017, but increased to 733 t in 2018. The estimated discards from 2015–17 were 110 t or below. Discards increased substantially in 2018 to 2,450 t, exceeding the TAC – harvesters attributed this to issues with management of the fishery which led to herring being ‘barred’ by seines in a small area when they could not be landed (Fig. 10).

Fisher estimates of discard survival vary widely each year, ranging from 10% to 100%. It is extremely difficult to determine survival post-release, as fish may die immediately or later due to scale loss and injury (e.g., Olsen et al. 2012; Tenningen et al. 2012). It is important that discards in seine fisheries are minimized to prevent excessive mortality.

BAIT FISHER TELEPHONE SURVEY

The herring gillnet bait fisher telephone survey was implemented in 2006 in order to obtain estimates of the number of active bait fishers and total bait removals, which are not included in landings data. The survey is also used to get fishers’ perceptions of changes in abundance in their areas (see Cumulative Change Index below), and since 2013, collect information about bycatch in the herring bait fishery.

Each fall, a random subset of herring fixed gear licence and bait permit holders are selected for the survey within each stock area to provide a 10% margin of error, assuming an 80% response rate. The CBSS stock area was added to the survey in 2016. The total number of licence and permit holders has decreased during the time series from 2,465 in 2006 to 1,515 in 2018. Overall, the percentage of licence holders actively fishing bait gillnets has remained near 30-40% on average, but this varies by stock area; currently there are an estimated 363 active bait fishers in all stock areas combined (Table 2a-e).

In 2017 and 2018 the survey achieved a 75% response rate, with 366 fishers successfully contacted in 2017 and 344 in 2018 (Table 2a-f). The majority of bait fishers were active in May, June, and July, with a small percentage in the fall/winter on the northeast coast. Based on survey results, Atlantic cod and ‘other cod’ (Greenland cod/rock cod) typically accounted for most bycatch in the bait fishery; however, in 2018 a large proportion of bycatch was Atlantic Mackerel (based on catches in WBNDB), as well as ‘other fish,’ which was largely flounder (Fig. 11). In addition to fish, bycatch of nine seabirds, five seals, and one porpoise were reported by fishers during the 2018 survey.

As of 2016 bait nets were required to be set parallel to land to mitigate salmon bycatch (DFO 2019). During the 2017 phone survey active bait fishers were asked if they felt this practice was negatively impacting their catch rates, as several harvesters had stated this in the previous year’s survey and during stakeholder meetings. Of the 91 fishers who answered the question, 53 felt it did have a negative impact, the remaining 38 did not.

In WBNDB the number of active bait fishers generally declined throughout the survey, however there was an increase from an estimated 166 in 2016 to 203 in 2017, this estimate went back down to 180 in 2018 (Table 2a). Estimated bait removals for this area increased with the number of active fishers, with approximately 259 t and 297 t landed in 2017 and 2018 respectively – still well below the 500 t bait allocation (Fig. 12). Most bait fishers in this stock area were active in Notre Dame Bay. Comments made by fishers were varied, with some perceiving increases in abundance while others felt the stock had declined; some felt that seiners were overfishing in their areas and that seals were impacting herring populations.

The estimated number of active bait fishers in BBTB declined in 2017 and 2018, with 137 and 92 respectively (Table 2b). Estimated bait removals increased to 338 t in 2017 (vs 281 t in 2016), exceeding the bait allocation of 300 t, but declined to 128 t in 2018, the lowest estimate in the time series (Fig. 12).

CBSS was added to the telephone survey in 2016. The estimated number of bait fishers in the stock area has remained about the same since, with 31 in 2017 and 34 in 2018 (Table 2c). Estimated bait removals declined from 51 t in 2016 to 37 t in 2017, but increased again to 60 t in 2018, exceeding the bait allocation of 50 t (Fig. 12).

The number of active bait fishers and removals in SMBPB increased sharply in 2016 and remained high in 2017, with an estimated 80 active fishers and 226 t of removals (exceeding the 150 t bait allocation). However, these numbers declined in 2018 with only 36 estimated active fishers and 68 t of bait removals (Table 2d, Fig. 12). Fishers in this stock area were largely active in PB and many commented that seiners were doing too much dumping due to undersized fish and harming the resource.

In FB, the number of active bait fishers increased from 94 to 109 in 2017, but decreased to 54 in 2018 (Table 2e). The bait removal estimates were 333 t in 2017 and 122 t in 2018, below the bait allocation of 400 t (Fig. 12). As has been typical for this area since the survey began, most fishers commented that the stock was low and bar seiners in Long Harbour have been removing too many fish.

LOGBOOKS

In addition to the telephone survey, all herring bait permit holders have also been sent voluntary logbooks since 1996. Return rates of these logbooks were poor throughout the time series (Fig. 13) and since 2013 have been used only to collect data on the timing of the fishery (active months) and perceptions of abundance.

Bait logbooks were made mandatory in 2017 (DFO 2019) and Fisheries Management followed-up with bait fishers via a telephone survey in the winters of 2018 and 2019 to promote compliance. In 2017 there were 70 herring bait logbooks returned from 3KLPs fishers, approximately 13% of active fishers in those areas (based on the bait fisher telephone survey); in 2018 there were 53 logbooks returned as of early February 2019, representing about 15% of active fishers (Fig. 13), though follow up calls were still ongoing at the time of this assessment and it is likely that more logbooks were subsequently returned; these values will be updated in the next assessment. It is hoped that in time compliance will increase as fishers are made aware of the logbook requirement in the bait fishery and data obtained from logbooks will provide a more accurate estimate of bait removals and discards.

CUMULATIVE CHANGE INDEX

All fishers who complete logbooks and take part in telephone surveys are asked to provide their perception of annual changes in herring abundance by answering the following question:

“Using a scale of 1 to 10 (1 being lowest, 10 highest), how abundant were herring in your fishing area in (current year) compared to (previous year)?”

The answers are used to calculate the Cumulative Change Index. The 1 to 10 scale of abundance is converted to a scale of -4.5 to 4.5, where 0 is average (no change). A mean value is derived from all fishers' responses for each stock area; as of the 2013 stock assessment, these indices were further split into fixed and mobile gear, as perceptions of abundances often differ significantly between the two. The index was expanded in 2015 to include bar seine fishers from FB, as there is no purse seine fishery in the area and the index had previously only included gillnet fishers, which did not provide a complete perspective from the industry in the area. In 2016 the index was further expanded to include gillnet and purse seine fishers in CBSS. The requirement for bait nets to be set parallel to land as of 2016 likely impacted this index (Bourne et al. 2018) so the fixed gear Cumulative Change Index is now divided into pre- and post-2016 periods, with the exception of CBSS where the index began in 2016 (Fig 15).

Fixed gear fishers in WBNDB reported no perceptible change in abundance on average from 2016 to 2017, but an increase in 2018; whereas purse seine fishers have noted a perceived increase in abundance since 2015. In BBTB fixed gear fishers perceived a decline in abundance from 2016 to 2017, with a slight increase in 2018; but as with WBNDB, purse seine fishers indicated increasing abundance over the past several years. Fixed gear and purse seine fishers in CBSS have reported increasing perceptions of abundance from 2016–18. In SMBPB, fixed gear fishers reported an increase in their perception of abundance from 2016 to 2017, but a decline in 2018; however, purse seine fishers in the area reported increasing abundance for the past three years. In FB the perception of abundance by fixed gear fishers has declined throughout the time series, both pre- and post-2016; in contrast, bar seine fishers have reported increasing abundance since the bar seine survey began in 2013 (Fig. 14).

RESEARCH GILLNET PROGRAMS

OVERVIEW

The DFO Science spring herring research gillnet program provides the only industry-independent index of abundance for this assessment. Fishers contracted for the project set their nets in the same location and, when possible, at the same time of year each spring. The same fishers are contracted each year; if a fisher can no longer take part in the program, efforts are made to replace them with another local fisher who is able to set the fleet of gillnets in the same general location to preserve the integrity of the historical time series. Fishers set a standardized fleet of 5 gillnets of varying mesh size for a 45 day period between April 1 and July 31. The timing of the program is intended to intercept SS during their annual inshore spawning migrations, but it does also provide a reliable index of FS recruitment for BBTB (Bourne et al. 2018). Currently the program only operates in BBTB and FB, with 4 fishers in each bay. In the past, the program has also been active in other stock areas and in some cases during the fall, but the scope has since been reduced (Bourne et al. 2015).

In 2018 a similar program was run in PB as part of the Coastal Environmental Baseline Program, under the Oceans Protection Program. This program is intended to gather baseline data on the status of herring in PB and also provide data to update the research gillnet indices and stock status for the area. Four fishers within the bay were contracted to fish using the same methods and in the same locations as in the past, allowing the previous time series (1982–2013) to continue. The program will continue in 2019 and provide further information to update catch at age and year class strength indices.

CATCH RATES AND AGE STRUCTURE

In BBTB the combined catch rate (both SS and FS) in 2015 was the second highest in the time series, largely due to the strong 2008 FS and 2009 SS year classes; however, catch rates declined sharply in 2016 and have remained below both the decadal mean and time series reference period (1990–2005) since (Fig. 15). The timing of peak catches in the program shifted later throughout the 2000s, into early summer (Fig. 16). This may have negatively impacted combined catch rates, with herring potentially arriving and spawning later in the season. The proportion of FS in BBTB increased during the 2000s and remained relatively high, accounting for 46% and 52% of the catch in 2016 and 2017 respectively; however, this is a decline from previous years when percentages climbed into the 60–75% (Fig. 15). This decrease in the proportion of FS is due to the dominance of SS in recent year classes – SS accounted for all age 3s and most age 4s, as well as over 50% of age 5 and 7s in the 2016 catch at age (Fig. 17). In 2017, all age 3 and almost all age 4 fish were once again SS, as well as 50% of age 5s. The strong 2008 FS year class continued to comprise a large proportion of older fish as age 9s, however the strong 2009 spring year class was not predominant as expected as age 8s, comprising less than 50% of the year class (Fig. 17).

In FB the combined catch rate has been well below the reference period mean (1990–2005) since 2002, with slight increases from 2016–18 (Fig. 18). Unlike the other stock areas, FS recruitment did not increase during the 2000s in FB; SS numbers remain relatively low but they still dominate the catch, comprising 90% in 2018 (Fig. 18). The catch at age in FB was highly skewed during recent stock assessments, with age 11+ SS accounting for most of the catch as the 2002 year class supported virtually the entire fishery (Bourne et al. 2018). In 2016, the 2012 year class recruited to the research gillnet program, with age 4 SS accounting for nearly 40% of the catch, an equal proportion to the age 11+ group; in the following year the 2012 year class dominated the catch as age 5 fish, with the 11+ age group (largely the 2002 YC) depleting (Fig. 19).The age structure of the FB stock is not considered to be robust, as once again a single year class is dominating the fishery.

The research gillnet program was run in the SMBPB stock area from 1982–2013. In 2016 an acoustic survey was conducted in PB, the results of which were used to update the research gillnet program catch rate time series, using a conversion based on previous acoustic surveys in that area (Bourne et al. 2018). In 2018, the time series was again updated, based on the catch rates from 4 research gillnet fishers contracted in PB as part of the Coastal Baseline Program. Because this program only includes PB, the St. Mary's Bay portion of the stock area was not included. The catch rate generated from the 2016 acoustic survey was just above what was observed in the research gillnet program in 2012 and 2013, falling below the reference period mean for SMBPB but just at the mean for PB only. The catch rate from 2018 was slightly higher than the 2016 estimate, falling just below the SMBPB mean and above the PB mean (Fig. 20). The age structure in 2018 was similar to that seen in FB in 2017, with the 2012 year class dominating; however, there is a higher percentage of FS (36%) in PB which accounted for most other age classes, including age 11+ which comprised 20% of the catch (Fig. 21).

RECRUITMENT AND YEAR CLASS STRENGTH

In BBTB, the recruitment index (natural logarithm of age 4 catch numbers) for FS was well above the reference period mean (1990–2005) for the 2008–12 year classes, however it fell well below for the 2013 year class. Recruitment of SS has been at or above the reference period mean since 2008 with the exception of the 2010 year class (Fig. 22). Relative year class strength (natural logarithm of mean catch rates of ages 4–6) of FS has been at or above the reference period mean since 1998. SS year class strength has varied through the 2000s, with most year classes at or below average; however, the 2009 year class was well above and based on the catch rates of ages 4 and 5, the 2012 year class is also above average (Fig. 22).

In FB, the recruitment index and relative strength of the 2002 SS year class was well above the reference period mean and sustained the fishery for over a decade (Bourne et al. 2018). The recruitment of all subsequent year classes, with the exception of 2006, was well below average, as was year class strength (Fig. 23). The recruitment and initial strength (based on ages 4 and 5) of the 2012 year class are both well above the reference period means, however the recruitment of the 2013 year class was well below (Fig. 23). FS are not assessed in FB as they represent only a small proportion of the stock and the research gillnet program does not provide a reliable index of abundance for the spawning component (Bourne et al. 2018).

STOCK STATUS

Since regular acoustic surveys ceased in 2000, stock status has been reported via performance tables using a 'traffic light' approach of red (-), yellow (?) or green (+) 'lights' to categorize the stock status evaluation as 'cause for concern', 'uncertain', or 'positive,' respectively. In the past, multiple parameters were used to evaluate stock status, including telephone survey and logbook data; however, during the 2015 stock assessment meeting it was decided that while all parameters would be presented in performance tables, only quantitative metrics from the research gillnet program should be used to update the stock status index and future prospects, which are considered when providing the 'traffic light' evaluation (Bourne et al. 2015). Three metrics are evenly weighted in the stock status index calculation: overall catch rates in the research gillnet program (scored as a percentage of the long-term mean), catch rates of mature year classes (ages 7–11, scored as a percentage of the long-term mean), and the number of mature year classes that are of above average strength. At the 2017 stock assessment meeting it was recommended that these metrics should be derived using a fixed reference period mean (1990–2005), rather than that of the time series (Bourne et al. 2018); this method was implemented for the current assessment. In addition, the recruitment strength of the incoming age 4 year class and relative strength of age 5 year class are used to evaluate 'future prospects.' As the calculation of stock status and evaluation of future prospects is dependent on indices derived from the research gillnet program, WBNDB and CBSS could not be evaluated during this assessment.

In BBTB commercial landings decreased in 2017 and 2018 to well below the TAC (Fig. 7). Purse seine fishers reported increasing abundance but high discards due to undersized herring, while gillnet fishers reported a decrease in abundance in 2017 and only a slight increase in 2018 (Fig. 9, Fig. 14); however, it should be noted that parallel gillnets were mandatory from 2017 onward and this may have impacted perceptions of abundance. The commercial catch was largely dominated by the 2012 cohort in 2016 and 2017 (Fig. 8b), while the age composition from the spring research gillnet program was more widespread with indications of strong incoming SS year classes (Fig. 17). FS accounted for 46% and 52% of the research gillnet catch in 2016 and 2017 respectively (Fig. 17), down from previous years. Stock status was calculated for both spawning components separately (Fig. 24), and these values were then combined by weighting them by the percentage of the stock each component comprised to provide an overall stock status value. For this assessment, the combined stock status was calculated using both the previous method based on the time series mean and revised method using the reference period mean (1990–2005). Using the reference period mean led to a general reduction in the stock status value but a similar trend overall (Fig. 24). Using both methods, the combined stock status declined substantially in 2016 and went down again slightly in 2017 (Fig. 24). This was largely attributable to declining catch rates of both SS and FS in the area. Future prospects for this stock are positive, as the strength of the 2012 year class and the recruitment of the 2013 year class are both above average (Fig. 22). Given the negative trend in the stock status index but positive future prospects, the stock status evaluation for BBTB in uncertain (Table 3a-d).

Though there is no longer a research gillnet program in SMBPB, the stock status was evaluated based on the results of the 2018 PB Coastal Baseline research gillnet program and available biological data. Commercial landings increased substantially in 2017 and 2018 (Table 1e, Fig. 7). Gillnet fishers reported decreasing abundance whereas purse seine fishers reported increases (Fig. 9, Fig. 14); as with BBTB, the requirement to set gillnets parallel may have impacted perceptions of abundance. The commercial catch was broadly distributed in 2017 but dominated largely (60%) by the 2012 year class in 2018, comprised of both SS and FS (Fig. 8b), this was also the case for the gillnet program catch at age for 2018, with the 2012 year class comprising a large proportion of the catch (~65%) (Fig. 21). Catch rates in the gillnet program were above the series mean for the PB stock area and higher than the estimated rate for 2016, based on the acoustic survey conducted that year (Fig. 20). The stock status index could not be calculated for this area given the large gaps in the time series and the inability to evaluate year class strength. Based on the available information, with catch rates above the reference period mean (Fig. 20), but a single year class comprising most of the catch (Fig. 21), the stock status evaluation for this area is uncertain (Table 4a-d).

In FB commercial landings declined throughout the 2010s but increased in 2018 (Table 1f, Fig. 7). Gillnet fishers continued to report declining abundance while bar seiners reported perceived increases (Fig. 14). The 2002 year class dominated the catch in this stock area for over a decade (Bourne et al. 2018) but is now largely diminished (Fig. 19). The 2012 year class is now sustaining the fishery, accounting for over 70% of the 2017 research gillnet catch and 90% of 2018 commercial landings (Fig. 8c, Fig. 19). There are no indications of another strong year class entering the fishery at this point, with the recruitment index for the 2013 year class being well below the reference period mean (Fig. 23). SS continue to account for over 95% of the landings in this stock area and FS are not evaluated as the research gillnet program does not provide a reliable index of abundance for that spawning component (Bourne et al. 2018). As with BBTB, the stock status for FB was calculated using both the time series and reference period mean for this assessment; similarly, using the reference period mean lowered the stock status index but the trend remained largely the same. However, there was no longer an increase in 2012 and the value for 2017 increased slightly with the reference period mean vs a further decline with the time series mean (Fig. 25). Given the declining trend in the stock status index through the 2000s, with only a slight increase in 2017, and that a single year class is largely driving increased catch rates, the stock status evaluation for FB is negative (Table 5a-d).

AREAS OF UNCERTAINTY

The inability to estimate spawning stock biomass and exploitation rates continues to be a major source of uncertainty for this stock assessment.

The lack of a fishery-independent abundance index in two of five stock areas makes it impossible to update the standardized stock status index unless an acoustic survey is completed, otherwise only biological updates could be provided, based on limited data from the commercial fishery.

The inability to estimate population sizes has precluded (to date) the calculation of reference points. This severely limits the implementation of the precautionary approach in fisheries management decisions.

RESEARCH RECOMMENDATIONS

- Try to model recruitment of spring and fall spawners using AZMP data similar to Brosset et al. (2018).
- Collect samples of small fish from seiners to update L50.
- Investigate the possibility of having observers assist with collecting samples during the commercial fishery.
- Analyze changes in size at age in more detail, as well as condition (e.g., by stock, by season).
- Examine existing inshore temperature time series data series and/or add temperature loggers to nets in the Research Gillnet Program to investigate differences between bays.
- Age the most recent Research Gillnet Program samples in advance of the assessment.
- Restore Research Gillnet Program to WBNDB and CBSS; potentially begin a similar program in Labrador.
- Reinstate regular acoustic surveys.
- Investigate stock delineation further to 1970s/1980s tagging studies through other methods (e.g., genetics, acoustic tagging) as there have been significant changes in stock composition and previous study results may no longer be valid.
- Analyze effort in the commercial fishery through logbooks, telephone surveys, etc.
- Develop a pre-recruit index (age 1 to 3).
- Look into using acoustic data collected during multispecies surveys to identify herring.

REFERENCES CITED

Bourne, C., Mowbray, F., Squires, B., and J. Croft. 2015. 2014 Assessment of Newfoundland East and South Coast Atlantic Herring (*Clupea harengus*). DFO Can. Sci. Advis. Sec. Res. Doc. 2015/055. v + 61 p.

Bourne, C., Mowbray, F., Squires, B., and M. Koen-Alonso. 2018. 2017 Assessment of Newfoundland East and South Coast Atlantic Herring (*Clupea harengus*) Stock Complexes. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/026. v + 45 p.

Brosset, P., Doniol-Valcroze, T., Swain, D.P., Lehoux, C., Van Beveren, E., Mbaye, B.C., Emond, K., and S. Plourde. 2018. Environmental variability controls recruitment but with different drivers among spawning components in Gulf of St. Lawrence herring stocks. Fish. Ocean. 28(1): 1–17.

DFO. 2019. Herring - Newfoundland and Labrador Region 2+3 (Herring Fishing Areas 1-11) - Effective 2017. Integrated Fisheries Management Plan (IFMP).

Lamichhaney, S., Fuentes-Pardo, A.P., Rafati, N., Ryman, N., McCraken, G.R., Bourne, C., Singh, R., Ruzzante, D.E., and L. Andersson. 2017. Parallel adaptive evolution of geographically distant herring populations on both sides of the North Atlantic Ocean. PNAS. 114(17): E3452–E3461.

Melvin, G.D., Stephenson, R.L., and M.J. Power. 2009. Oscillating reproductive strategies of herring in the western Atlantic in response to changing environmental conditions. ICES J. Mari. Sci. 66: 1784–1792.

Olsen, R.E., Oppedal, F., Tenningen, M., and A. Vold. 2012. Physiological response and mortality caused by scale loss in Atlantic herring. Fish. Res. 129–130: 21–27.

Tenningen, M., Vold, A., and R.E. Olsen. 2012. The response of herring to high crowding densities in purse seines: survival and stress reactions. ICES J. Mar. Sci. 69(8): 1523–1531.

Winters, G.H., and J.P. Wheeler. 1987. Recruitment dynamics of spring-spawning herring in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 44: 882–900.

APPENDIX I: TABLES

Table 1a: Commercial landings of Atlantic herring Labrador 2013–18.

Year	Landings (tonnes)	TAC	% of TAC
2013	146	500	29
2014	45	500	9
2015	111	500	22
2016	11	500	2
2017	18	500	4
2018*	412	500	82

*2018 data preliminary

Table 1b: Commercial landings of Atlantic herring in White Bay-Notre Dame Bay 1998–2018.

Year	Total Landings (tonnes)	TAC	% of TAC
1998	661	2,500	26
1999	1,018	2,500	41
2000	1,093	1,100	99
2001	26	1,100	3
2002	357	1,100	32
2003	332	1,100	30
2004	265	1,100	24
2005	891	1,100	81
2006	309	1,100	28
2007	361	1,700	21
2008	714	1,700	42
2009	424	1,700	25
2010	526	2,140	25
2011	1,474	2,140	69
2012	1,228	2,140	58
2013	1,238	2,140	58
2014	367	2,140	17
2015	617	2,140	29
2016	1,872	2,140	87
2017	2,367	2,568	92
2018*	2,178	2,568	85

*2018 data preliminary

Table 1c: Commercial landings of Atlantic herring in Bonavista Bay-Trinity Bay 1998–2018.

Year	Total Landings (tonnes)	TAC	% of TAC
1998	972	2,500	39
1999	1,432	2,500	57
2000	1,090	2,500	44
2001	486	3,500	14
2002	566	3,500	16
2003	490	3,000	16
2004	509	3,000	17
2005	2,640	3,000	88
2006	1,916	3,000	64
2007	2,777	4,000	69
2008	2,829	4,000	71
2009	3,182	4,200	76
2010	2,132	4,650	46
2011	823	4,650	18
2012	2,255	4,650	49
2013	4,112	4,650	88
2014	3,864	4,650	83
2015	4,446	5,810	77
2016	3,670	5,810	63
2017	1,277	5,990	21
2018*	750	5,990	13

*2018 data preliminary

Table 1d: Commercial landings of Atlantic herring in Conception Bay 1998–2018.

Year	Landings (tonnes)	TAC	% of TAC
1998	40	600	7
1999	0	600	0
2000	0	600	0
2001	0	600	0
2002	0	600	0
2003	0	600	0
2004	0	600	0
2005	11	600	2
2006	7	600	1
2007	94	600	16
2008	258	600	43
2009	145	550	26
2010	39	550	7
2011	9	550	2
2012	5	550	1
2013	222	550	40
2014	408	550	74
2015	149	700	21
2016	513	700	73
2017	609	895	68
2018*	114	895	13

*2018 data preliminary

Table 1e: Commercial landings of Atlantic herring in St. Mary's Bay-Placentia Bay 1998–2018.

Year	Total Landings (tonnes)	TAC	% of TAC
1998	2,299	2,000	115
1999	331	2,000	17
2000	492	2,000	25
2001	702	2,000	35
2002	1,568	2,000	78
2003	1,029	2,250	46
2004	1,389	2,250	62
2005	1,426	2,250	63
2006	1,529	2,500	61
2007	759	2,500	30
2008	1,148	2,500	46
2009	1,407	2,100	67
2010	1,006	2,100	48
2011	42	2,100	2
2012	56	2,100	3
2013	212	2,100	10
2014	338	2,100	16
2015	351	2,100	17
2016	520	2,100	25
2017	1,295	2,100	62
2018*	1,327	2,100	63

*2018 data preliminary

Table 1f: Commercial landings of Atlantic herring in Fortune Bay 1998–2018.

Year	Landings (tonnes) Fortune Bay	TAC	% of TAC
1998	0	5,400	0
1999	455	5,400	8
2000	842	5,400	16
2001	1,782	2,700	66
2002	2,259	2,700	84
2003	3,307	3,700	89
2004	2,930	3,700	79
2005	2,652	3,700	72
2006	2,341	3,700	63
2007	2,448	3,200	77
2008	2,550	3,200	80
2009	2,360	2,480	95
2010	2,624	2,480	106
2011	1,524	2,480	62
2012	1,685	2,480	68
2013	968	1,860	52
2014	797	1,860	43
2015	802	789	102
2016	137	789	17
2017	156	789	20
2018*	834	789	106**

*2018 data preliminary; **reserve taken

Table 2a: Results of the annual telephone survey of herring gillnet fishers by stock area – WBNDB.

Year	Total # Licences and Bait Permits	# Fishers Phoned	Response Rate (%)	% of Fishers Actively Fishing Gillnets	Estimated # Active Bait Fishers for Stock Area	Estimated Bait Landings per Fisher (kg)	Estimated Bait Landings (t) for Stock Area
2008	959	113	81	32	334	1,420	**474**
2009	930	113	84	37	362	1,127	**408**
2010	-	-	-	-	-	-	**282**
2011	876	83	71	18	282	585	**165**
2012	831	112	82	32	343	704	**242**
2013	770	111	77	22	226	1,097	**248**
2014	765	107	80	21	213	1,274	**272**
2015	673	109	75	23	189	802	**151**
2016	610	101	87	24	166	725	**121**
2017	579	108	79	30	203	1,280	**259**
2018	565	104	69	34	180	1,651	**297**

*no survey in 2010; bait landing estimate is average of 2009 and 2011

Table 2b: Results of the annual telephone survey of herring gillnet fishers by stock area – BBTB.

Year	Total # Licences and Bait Permits	# Fishers Phoned	Response Rate (%)	% of Fishers Actively Fishing Gillnets	Estimated # Active Bait Fishers for Stock Area	Estimated Bait Landings per Fisher (kg)	Estimated Bait Landings (t) for Stock Area
2008	560	106	87	47	262	1,645	**431**
2009	547	106	84	49	270	1,888	**511**
2010	-	-	-	-	-	-	**392**
2011	527	95	83	44	233	1,173	**274**
2012	523	105	84	41	214	1,312	**281**
2013	476	103	80	51	244	1,740	**424**
2014	472	98	85	39	182	888	**162**
2015	461	101	80	43	199	1,463	**291**
2016	421	91	74	45	189	1,493	**281**
2017	416	102	81	33	137	2,460	**338**
2018	400	92	85	33	92	1,390	**128**

*no survey in 2010; bait landing estimate is average of 2009 and 2011

Table 2c: Results of the annual telephone survey of herring gillnet fishers by stock area – CBSS.

Year	Total # Licences and Bait Permits	# Fishers Phoned	Response Rate (%)	% of Fishers Actively Fishing Gillnets	Estimated # Active Bait Fishers for Stock Area	Estimated Bait Landings per Fisher (kg)	Estimated Bait Landings (t) for Stock Area
2016	316	102	62	12	38	1,351	**51**
2017	313	97	79	10	31	1,173	**37**
2018	301	94	85	19	34	1,760	**60**

Table 2d: Results of the annual telephone survey of herring gillnet fishers by stock area – SMBPB.

Year	Total # Licences and Bait Permits	# Fishers Phoned	Response Rate (%)	% of Fishers Actively Fishing Gillnets	Estimated # Active Bait Fishers for Stock Area	Estimated Bait Landings per Fisher (kg)	Estimated Bait Landings (t) for Stock Area
2008	444	102	76	22	97	1,315	**127**
2009	415	101	85	22	92	1,343	**123**
2010	-	-	-	-	-	-	**148**
2011	375	62	77	33	125	1,380	**172**
2012	358	98	73	21	75	1,801	**134**
2013	343	97	80	17	57	1,797	**103**
2014	340	94	78	15	51	569	**29**
2015	316	93	81	16	51	382	**19**
2016	309	89	89	38	117	1,646	**193**
2017	307	93	70	26	80	2,827	**226**
2018	300	87	80	30	36	1,877	**68**

*no survey in 2010; bait landing estimate is average of 2009 and 2011

Table 2e: Results of the annual telephone survey of herring gillnet fishers by stock area – FB.

Year	Total # Licences and Bait Permits	# Fishers Phoned	Response Rate (%)	% of Fishers Actively Fishing Gillnets	Estimated # Active Bait Fishers for Stock Area	Estimated Bait Landings per Fisher (kg)	Estimated Bait Landings (t) for Stock Area
2008	304	94	89	60	181	2,184	**395**
2009	298	94	81	62	184	1,636	**301**
2010	-	-	-	-	-	-	**277**
2011	278	74	91	64	178	1,411	**252**
2012	275	97	72	60	165	3,273	**540**
2013	260	90	63	47	123	812	**100**
2014	255	88	74	35	90	585	**53**
2015	235	68	100	35	83	842	**70**
2016	232	75	79	41	94	1,484	**140**
2017	227	74	76	48	109	3,055	**333**
2018	215	86	58	42	54	2,250	**122**

*no survey in 2010; bait landing estimate is average of 2009 and 2011

Table 3a: Bonavista Bay-Trinity Bay performance table– summary of fishery.

The Fishery	***Observation***
Reported Landings: 2017/2018	Landings in 2015 were the highest since the early-1990s but decreased in 2017 and 2018, with only 23% and 13% of the TAC taken respectively.
Bait Removals: 2017/2018	Estimated bait removals were 338 t in 2017, exceeding the 300 t bait allocation, and decreased to 128 t in 2018.
Estimated Discards: 2017/2018	Fishers estimated that 500 t were discarded in the purse seine fishery in 2017, and 1,500 t in 2018, three times the landed amount in the fishery.

Table 3b: Bonavista Bay-Trinity Bay performance table – indices and interpretations.

Cumulative Indices	***Observation***	***Interpretation***
Gillnet Fisher Observations 1996-2018 from telephone surveys and logbooks	Gillnet fishers reported a decrease in abundance in 2017 and 2018, however the requirement to set nets parallel to land as of 2017 may have impacted index	Decreasing trend in abundance.
Purse Seine Fisher Observations 1996–2018	Purse seine fishers reported a general increasing trend in abundance since 2010.	Increasing trend in abundance.
Commercial catch at age 2017	The age distribution was dominated (60%) by the 2012 year class and comprised of both spring and fall spawners	Age structure is stable. Catch was split between spring and fall spawners.
Length and weight at age	Lengths and weights at age have remained stable through the 2000s for both spawning components.	Size at age is stable.

Table 3c: Bonavista Bay-Trinity Bay performance table – research gillnet program.

Research Gillnet Program	***Observation***	***Interpretation***
Research gillnet catch rates	Catch rates declined sharply in 2016 after peaking in 2015. They remained low in 2017–18, below the decadal and time series mean.	Decreasing trend.
Research gillnet age composition and recruitment	The age distribution was broad in 2016 and 2017, with approximately half the catch comprised of fall spawners. The 2012 and 2013 spring year class had above average recruitment.	Population structure stable, good recruitment.

Table 3d: Bonavista Bay-Trinity Bay performance table– stock status.

Stock Status Index	***Evaluation***
The stock status index declined sharply in 2016 and remained low in 2017. However, the 2013 spring spawner year class is of above average strength and recruitment of the 2012 spring spawner year class is high, indicating positive future prospects. Given these diverging trends, stock status is "Uncertain."	**?**

Table 4a: St. Mary's Bay-Placentia Bay performance table– summary of fishery.

The Fishery	***Observation***
Reported Landings: 2017/2018	Landings increased in 2017 and 2018 to the highest levels since the late-1990s, with ~65% of the TAC taken each year.
Bait Removals: 2017/2018	Estimated bait removals were 226 t in 2017, exceeding the 150 t bait allocation. This decreased to 68 t in 2018.
Estimated Discards: 2017/2018	Purse seine fishers estimated relatively low discards, 50 t in 2017 and 10 t in 2018.

Table 4b: St. Mary's Bay-Placentia Bay performance table – indices and interpretations.

Cumulative Indices	***Observation***	***Interpretation***
Gillnet Fisher Observations 1996–2018 from telephone surveys and logbooks	Gillnet fishers reported an increase in perceived abundance in 2016–17, but a decline in 2018	Decreasing trend in abundance.
Purse Seine Fisher Observations 1996–2018	Purse seine fishers reported increasing abundance for the past three years.	Increasing trend in abundance.
Commercial catch at age 2017	The age distribution of samples was broad in 2016, but dominated by age 5s in 2017 with some older fish.	Age structure stable with a strong year class dominating the fishery.
Length and weight at age	Lengths and weights at age have remained stable through the 2000s for both spawning components.	Size at age is stable.

Table 4c: St. Mary's Bay-Placentia Bay performance table– research gillnet program.

Research Gillnet Program	***Observation***	***Interpretation***
Research gillnet catch rates	Catch rates from PB only were above average for PB and just below average for SMBPB; the overall catch rate was above the estimate from the 2016 acoustic survey.	Increasing trend.
Research gillnet age composition	The age distribution in 2018 was dominated by a single year class.	-

Table 4d: St. Mary's Bay – Placentia Bay performance table– stock status.

Stock Status	***Evaluation***
With increasing/above average catch rates, but an age distribution that is dominated by a single year class, the stock status for this area is uncertain.	**?**

Table 5a: Fortune Bay performance table to the spring of 2016 – summary of fishery.

The Fishery	***Observation***
Reported Landings: 2017/2018	Landings decreased through the 2010s with only 22% of the TAC taken in 2017, however the entire 789 t TAC was landed in 2018.
Bait Removals: 2017/2018	Estimated bait removals were 226 t in 2017 and 68 t in 2018, well below the 400 t bait allocation. However, there were reports of very high bait landings in 2018 by Enforcement.
Estimated Discards 2017/2018	Bar seine fishers surveyed estimated about 110 t discards in 2017 but this increased with landings in 2018 to 2,450 t, representing substantially more than the landed amount.

Table 5b: Fortune Bay performance table – indices and interpretations.

Cumulative Index	***Observation***	***Interpretation***
Gillnet Fisher Observations 1996–2018 from telephone surveys and logbooks	Gillnet fishers have reported decreasing abundance since 2000.	Decreasing trend in abundance.
Bar Seine Fisher Observations 2014–18	Bar seine fishers indicated increasing abundance since the survey was implemented.	Increasing abundance.
Commercial catch at age	The age distribution in 2018 was dominated by age 6 spring spawners.	Age distribution is highly skewed toward a single age class, not stable. Spring spawners dominate the catch.
Length and weight at age	Lengths and weights have remained stable through the 2000s.	Size at age is stable.

Table 5c: Fortune Bay performance table– research gillnet program.

Research Gillnet Program	***Observation***	***Interpretation***
Research gillnet catch rates	Catch rates have been well below the reference period mean since 2002, with slight increases from 2016–18	No change in abundance/abundance low.
Research gillnet age composition and recruitment	The age distribution is dominated by a single strong year class (2012). Spring spawners comprise over 90% of the catch.	Age distribution is unstable.

Table 5d: Fortune Bay performance table – stock status.

Stock Status Index	***Evaluation***
The age distribution is unstable, dominated by a single strong year class. Recruitment of incoming 2013 year class is well below average. Stock status did improve slightly in 2017. Stock status evaluation is negative.	**-**

APPENDIX II: FIGURES

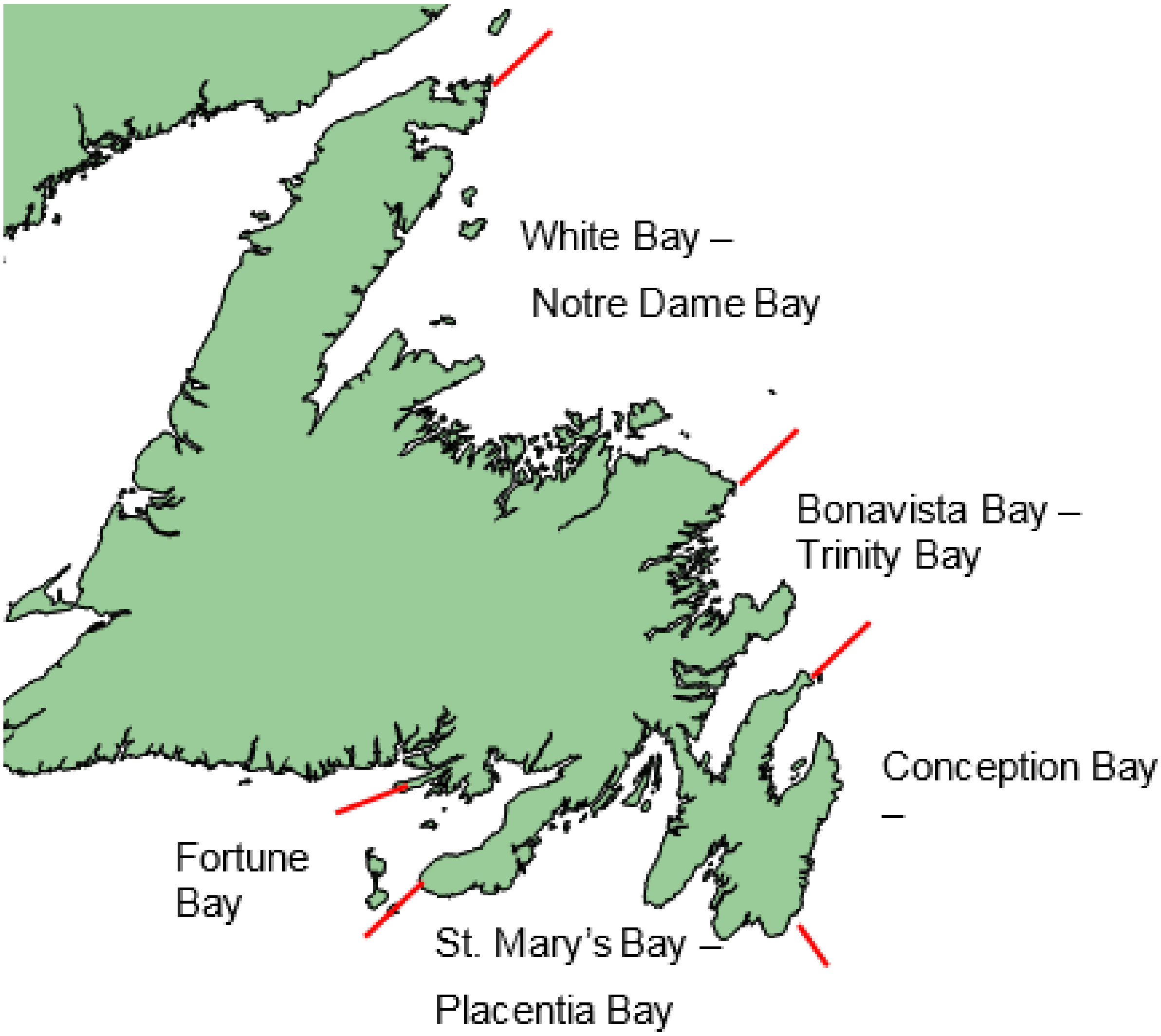

Figure 1: Map of Newfoundland east and south coast Atlantic Herring stock complexes.

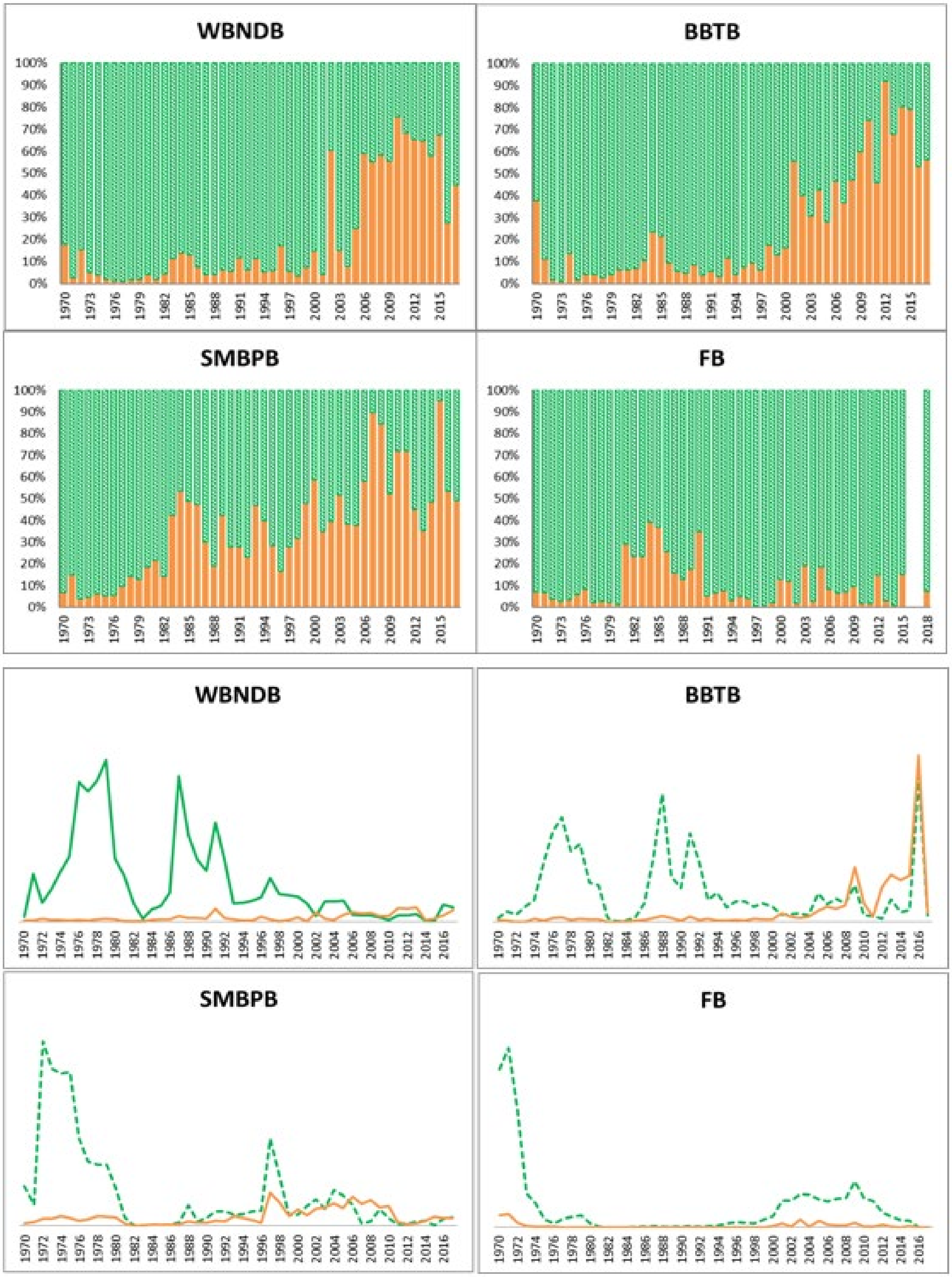

Figure 2: Compostion of commercial catches 1970–2017 by spawning type (top/green bars and dashed lines=spring spawners; bottom/orange bars and solid lines=fall spawners) by stock area, percentage (top panel) and numbers caught (bottom panel).

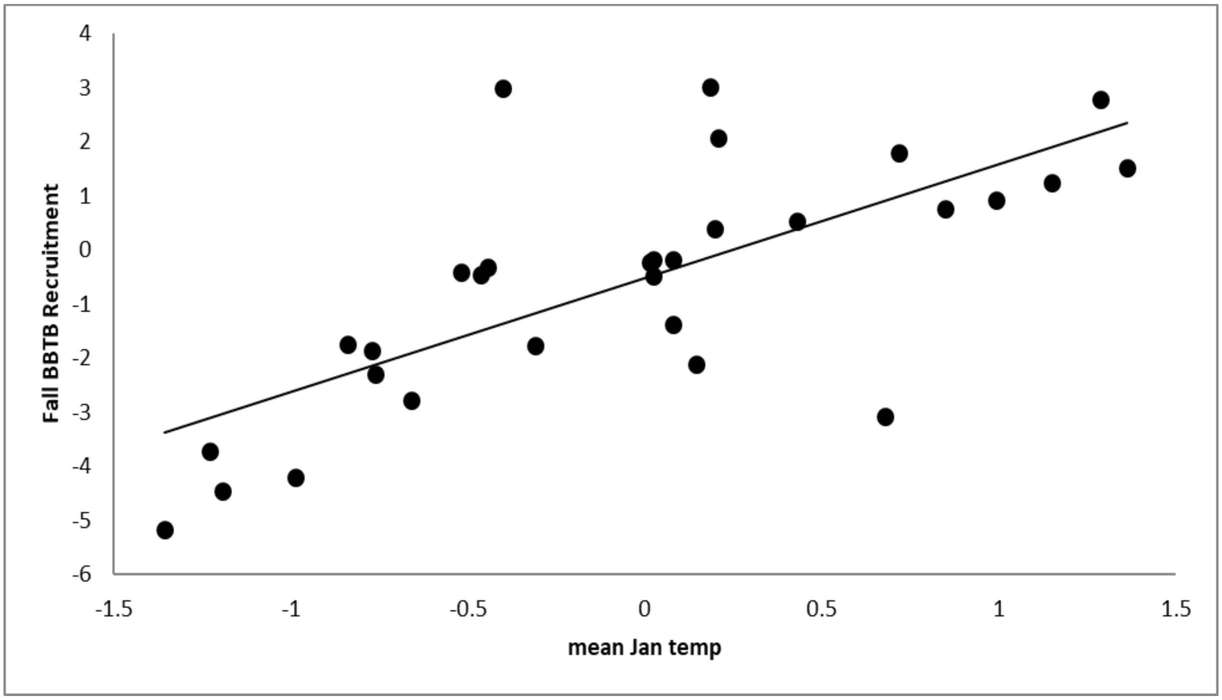

Figure 3: Average fall spawning herring recruitment in BBTB (ln age 4 catch rate – lagged by one year) versus mean January temperature at Station 27; $R^2 = 0.5104$.

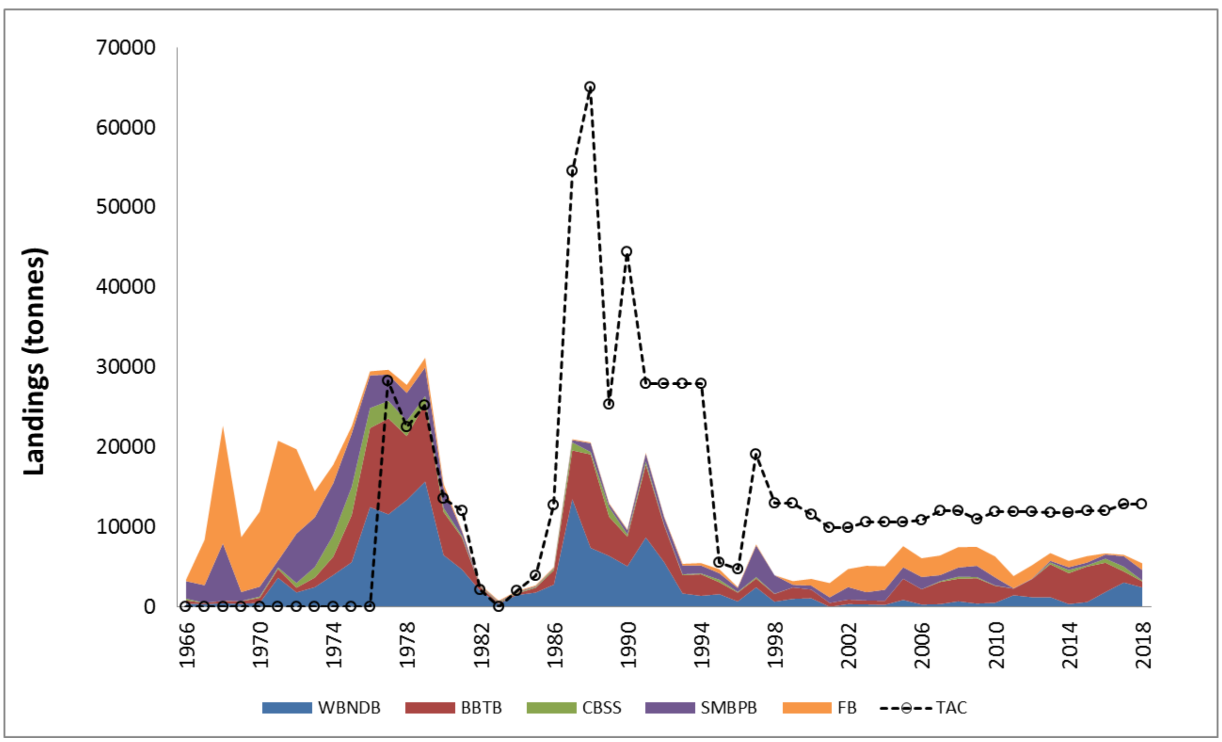

Figure 4: Commercial landings and total TAC (dashed line) for all stock areas combined from 1966–2018 (*note 2018 data preliminary).*

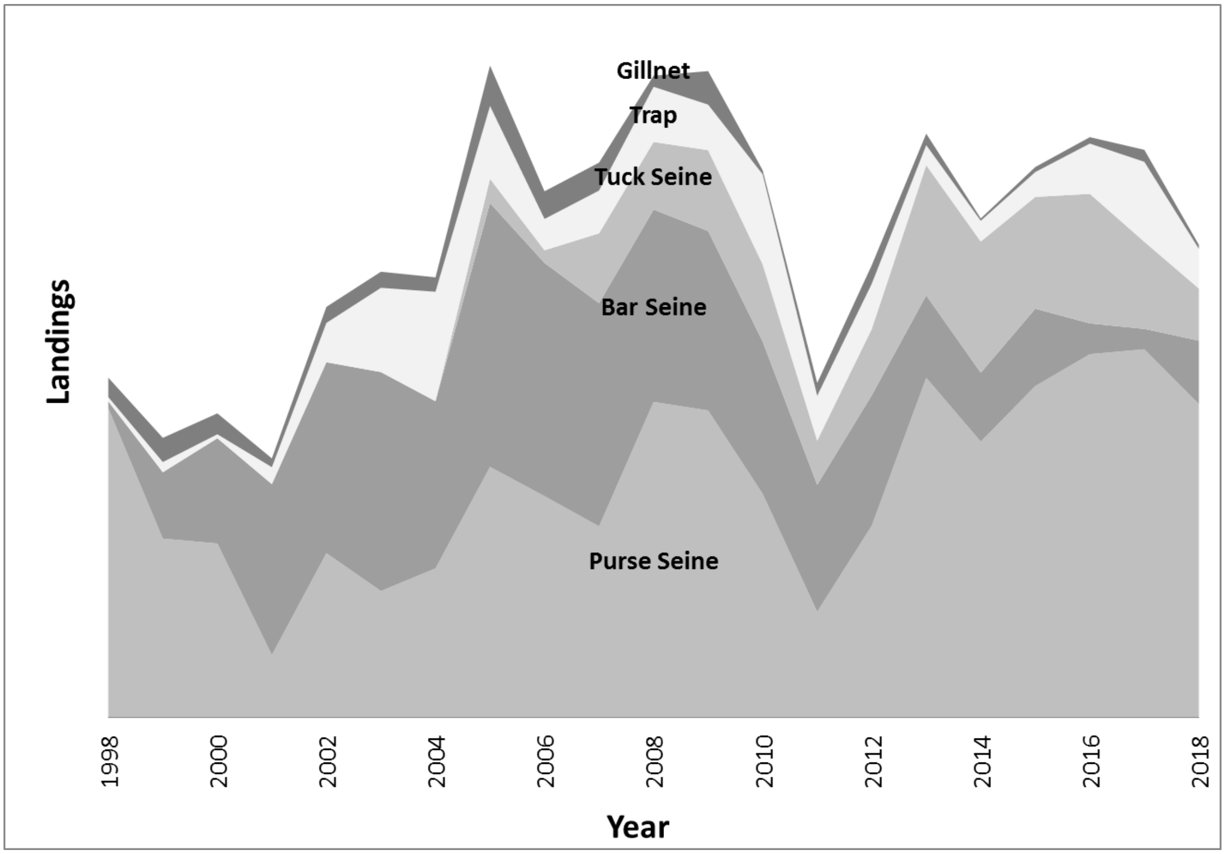

Figure 5: Total commercial landings by gear type from 1998–2018 (*note 2018 data preliminary).*

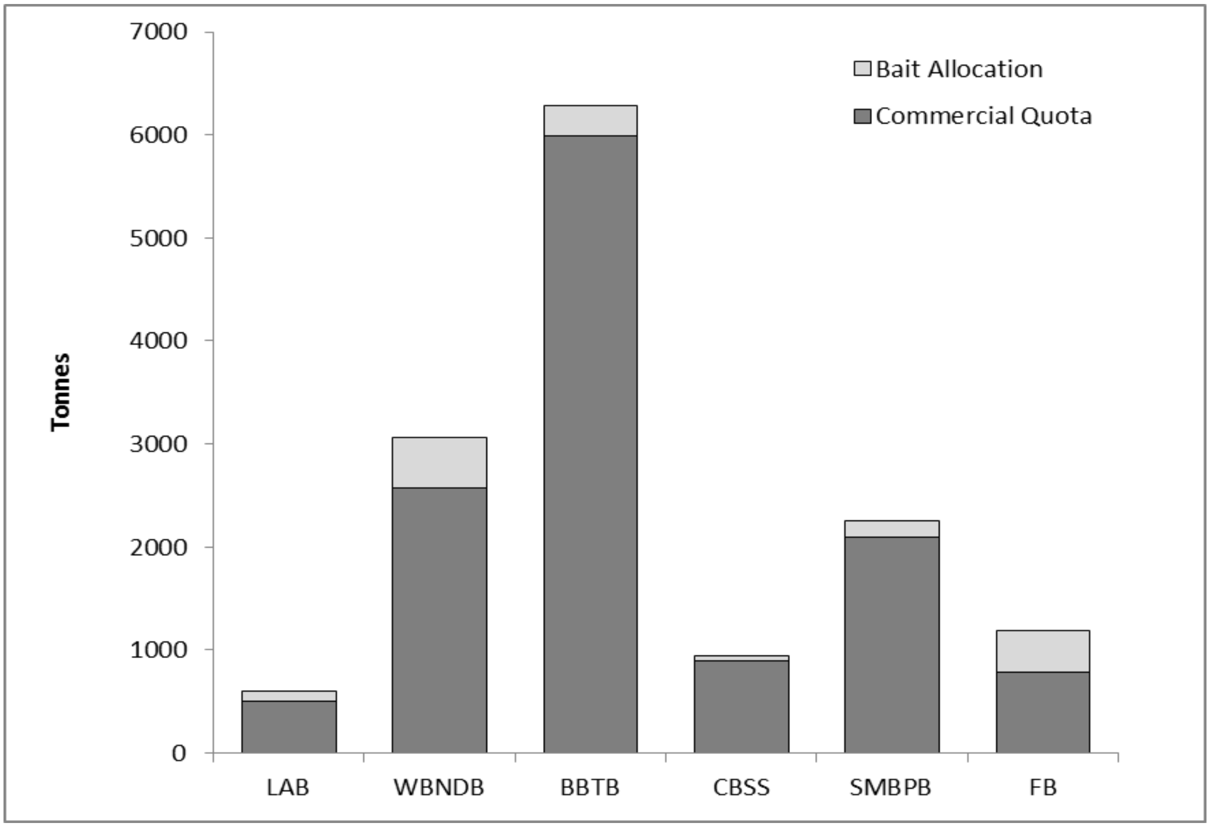

Figure 6: Atlantic herring Total Allowable Catch (TAC) composition (tonnes) by stock area including commercial quotas (dark bars) and bait allocations (light bars).

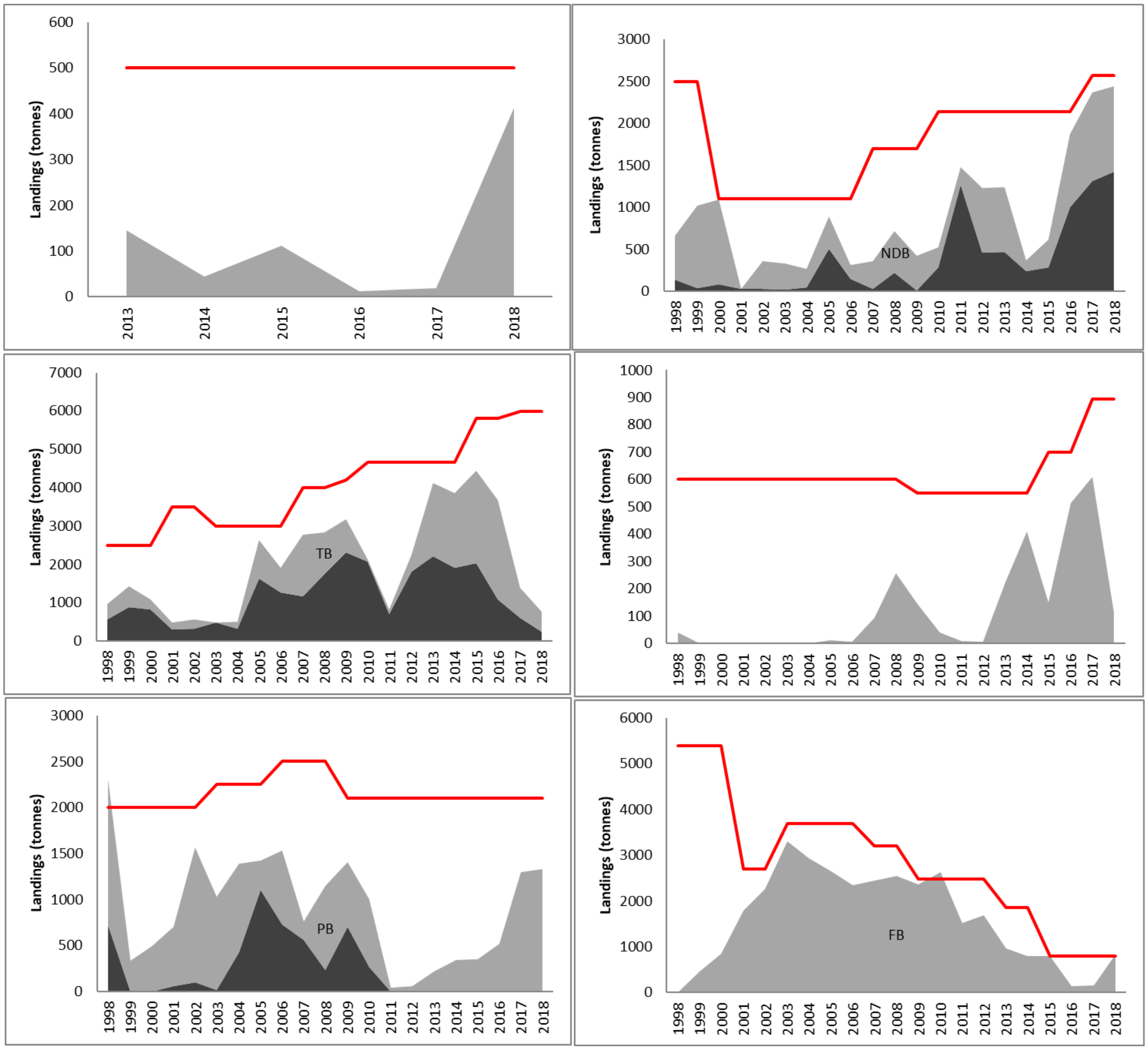

Figure 7: Landings and commercial quotas in Labrador 2013–18 (top left) and, WBNDB (top right), BBTB (middle left), CBSS (middle right), SMBPB (bottom left), FB (bottom right) with TAC (red line) from 1998–2018 (all 2018 data preliminary).

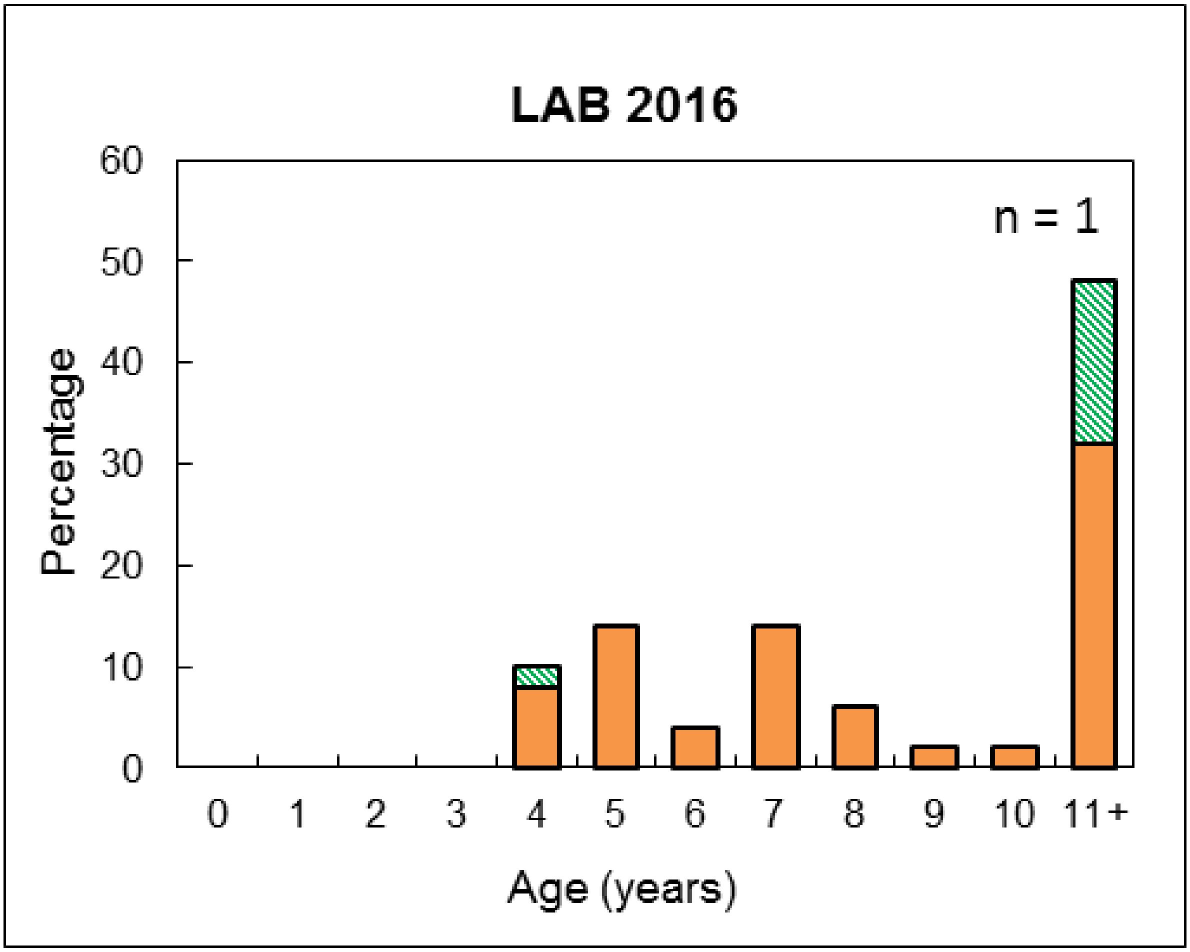

Figure 8a: Age and spawning type (orange=fall spawners, green=spring spawners) composition of commercial sample collected in southern Labrador, 2016.

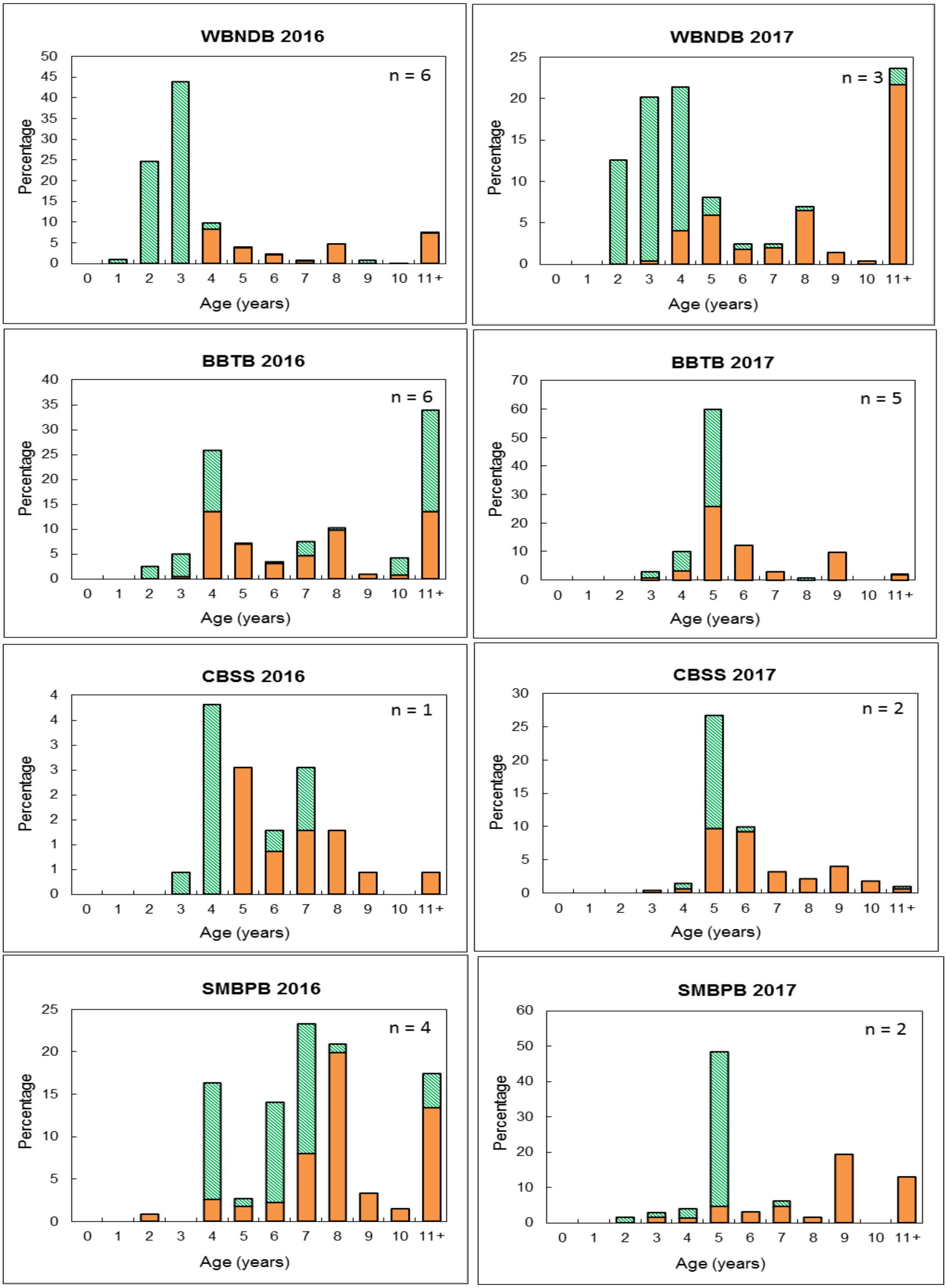

Figure 8b: Age and spawning type composition of commercial samples collected in WBNDB, BBTB, CBSS and SMBPB in 2016 and 2017 (orange bars=fall spawners, green bars=spring spawners).

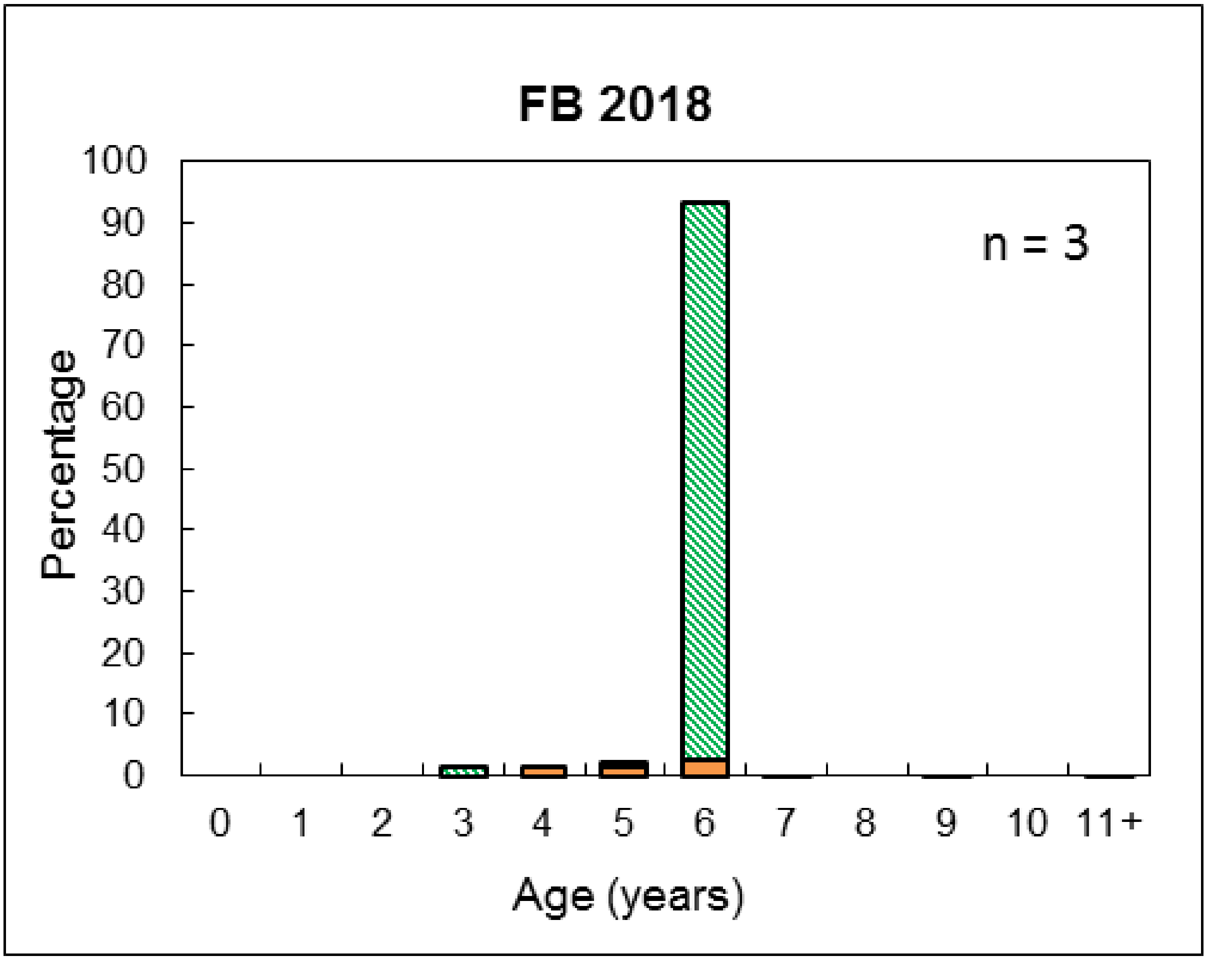

Figure 8c: Age and spawning type composition of commercial samples collected in FB in 2018 (orange bars=fall spawners, green bars=spring spawners).

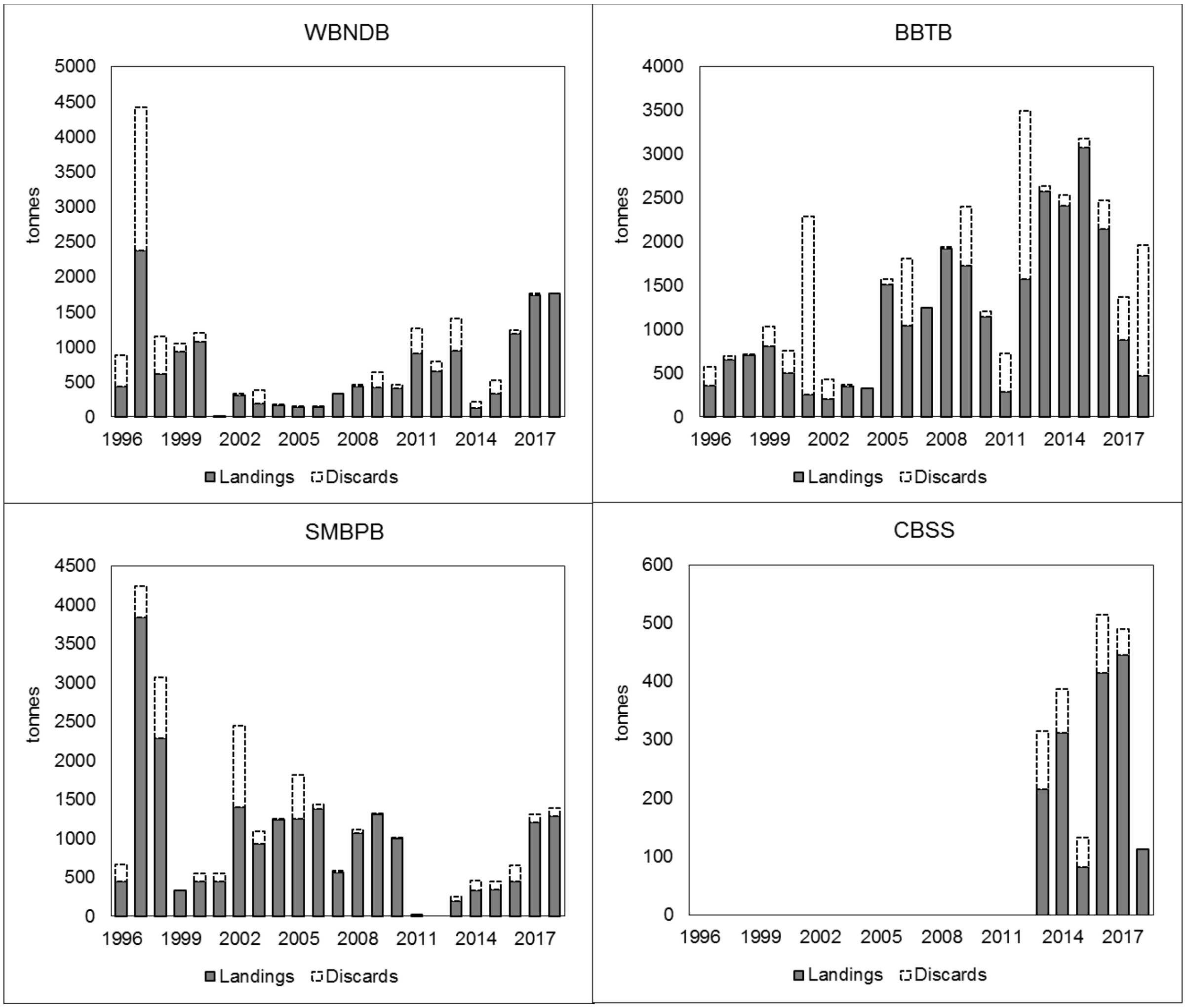

Figure 9: Commercial purse seine landings (grey bars) and estimated discards (white bars) from annual seiner telephone survey, by stock area.

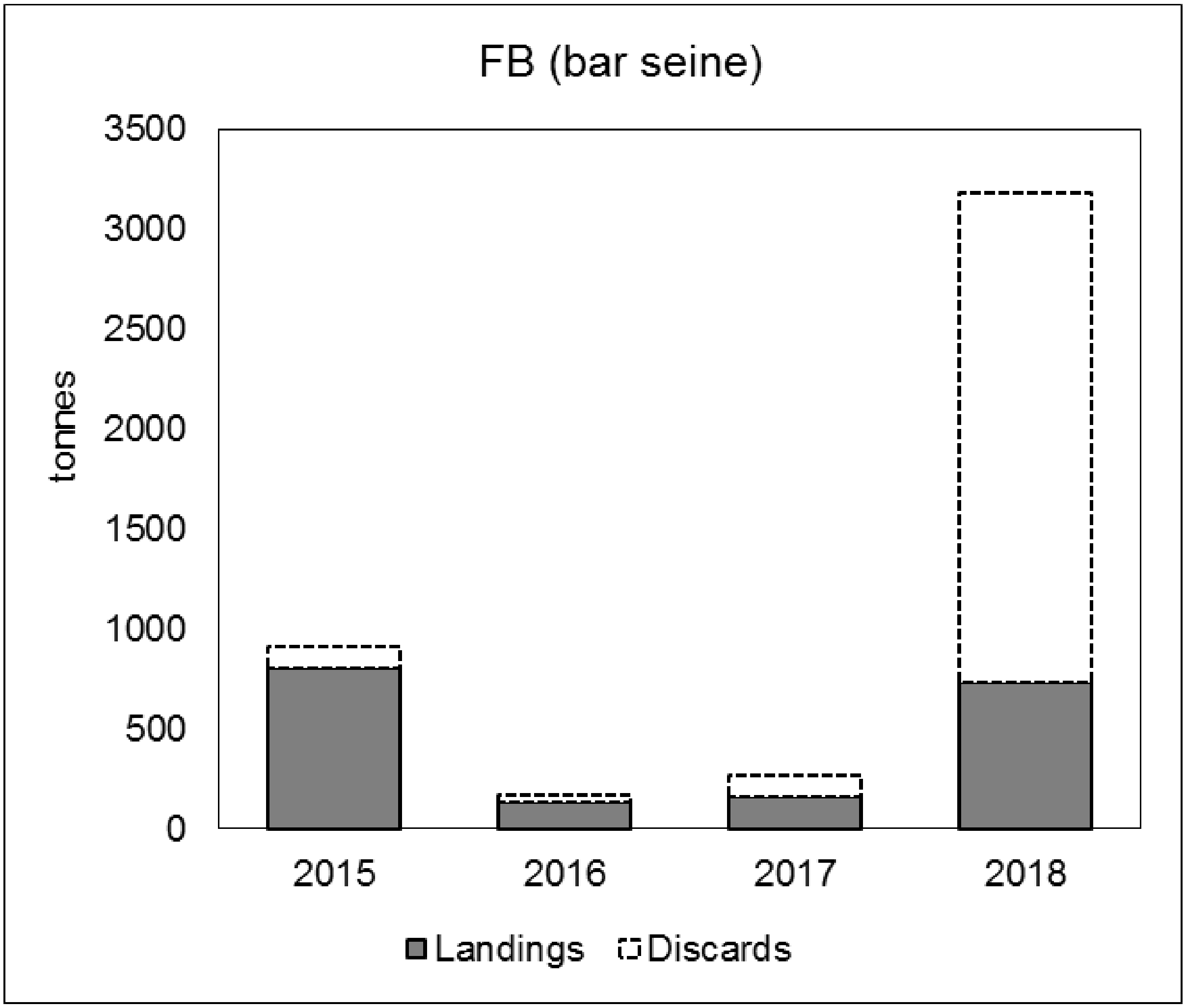

Figure 10: Commercial bar seine landings (grey bars) and estimated discards (white bars) from annual bar seine telephone survey in Fortune Bay.

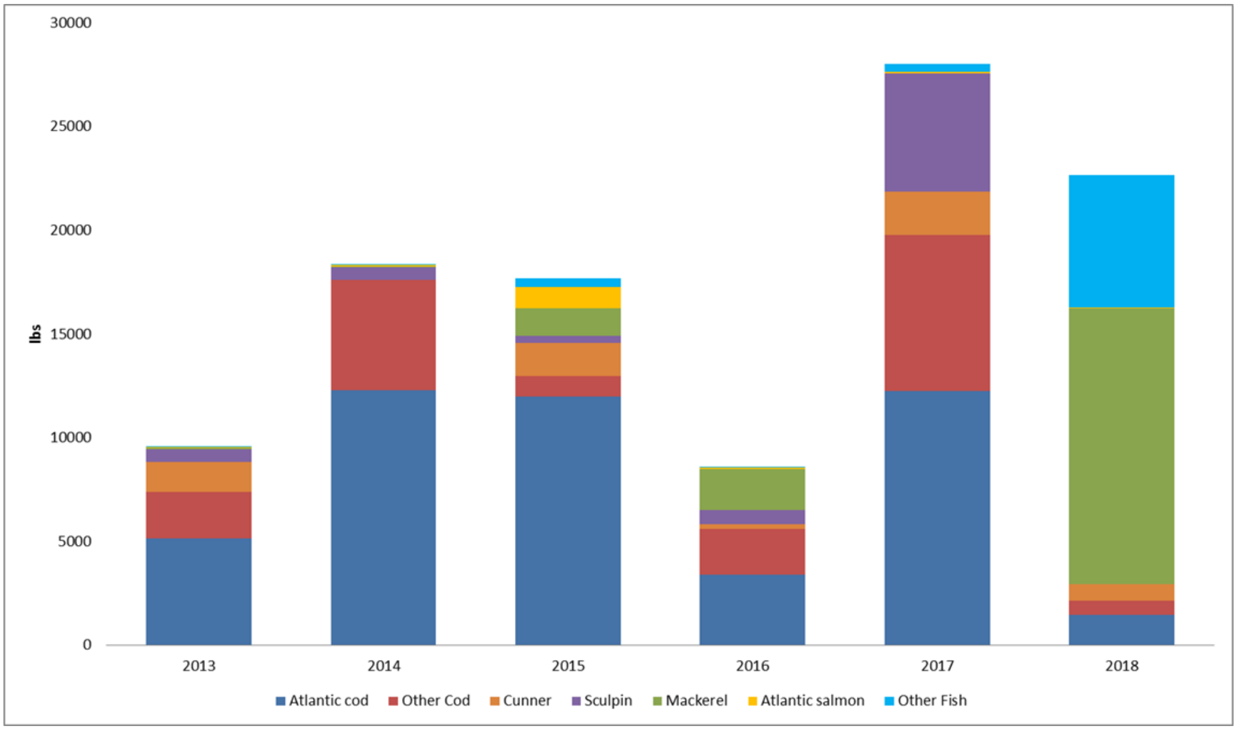

Figure 11: Estimated amount (lbs) and species composition of bycatch in the herring gillnet bait fishery based on annual bait fisher telephone survey.

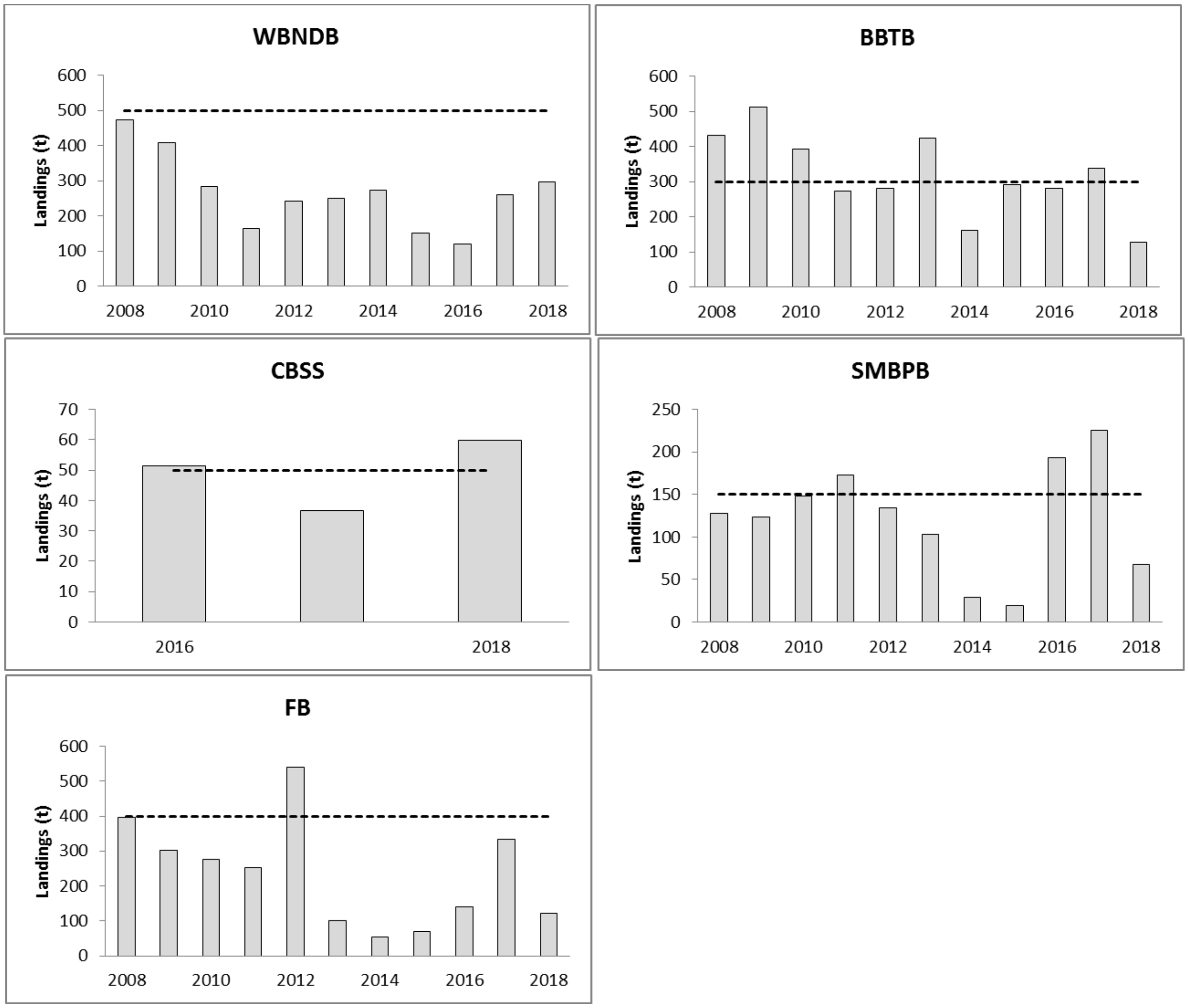

Figure 12: Bait allocations (broken line) and estiamted bait removals (grey bars) by stock area based on annual bait fisher telephone survey.

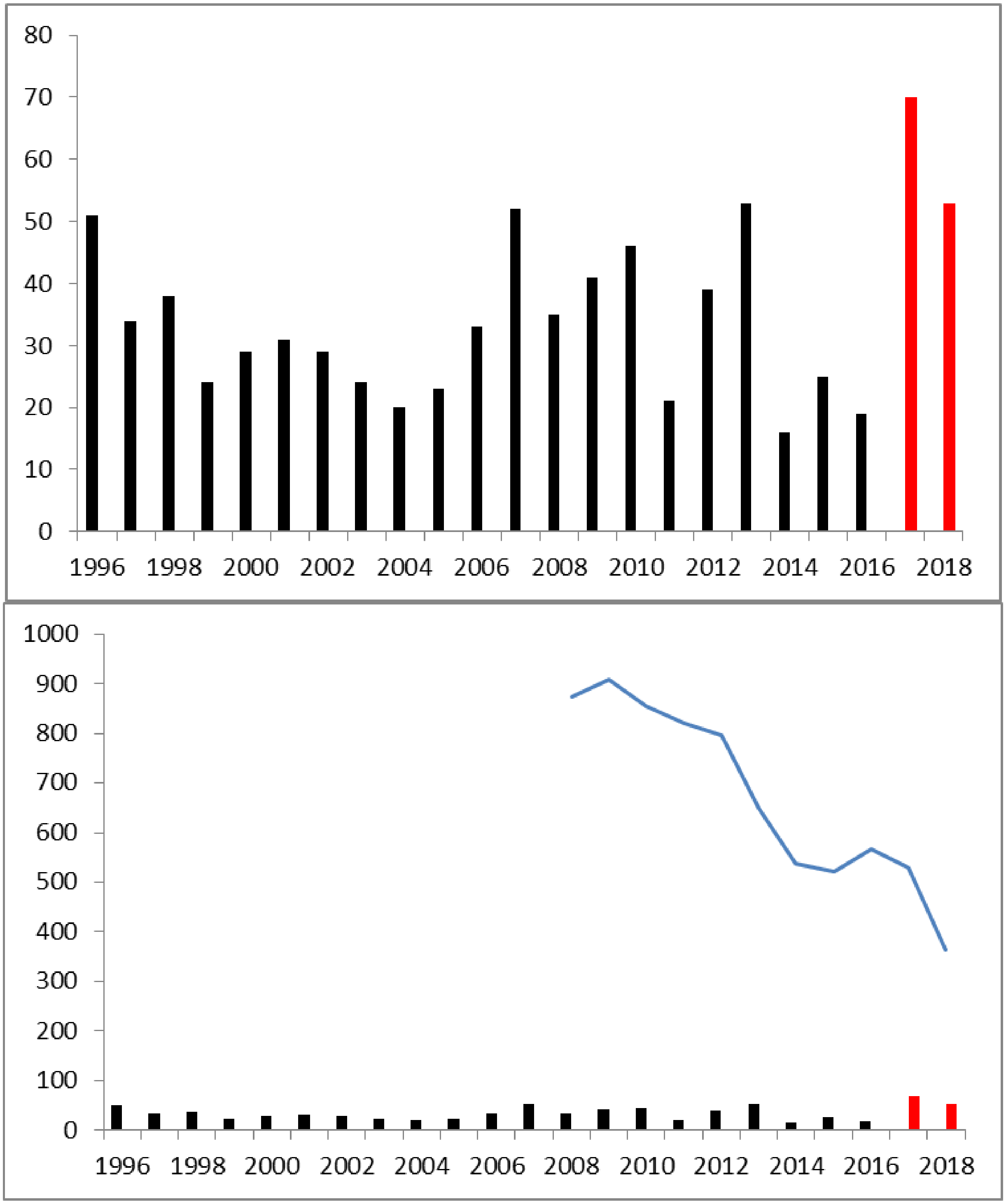

Figure 13: Number of herring bait logbooks returned (top panel) and number of estimated active bait fishers vs number of logbooks returned (bottom); black bars represent voluntary logbooks, red are mandatory (note that not all 2018 logbooks had been received and processed at the time of this assessment).

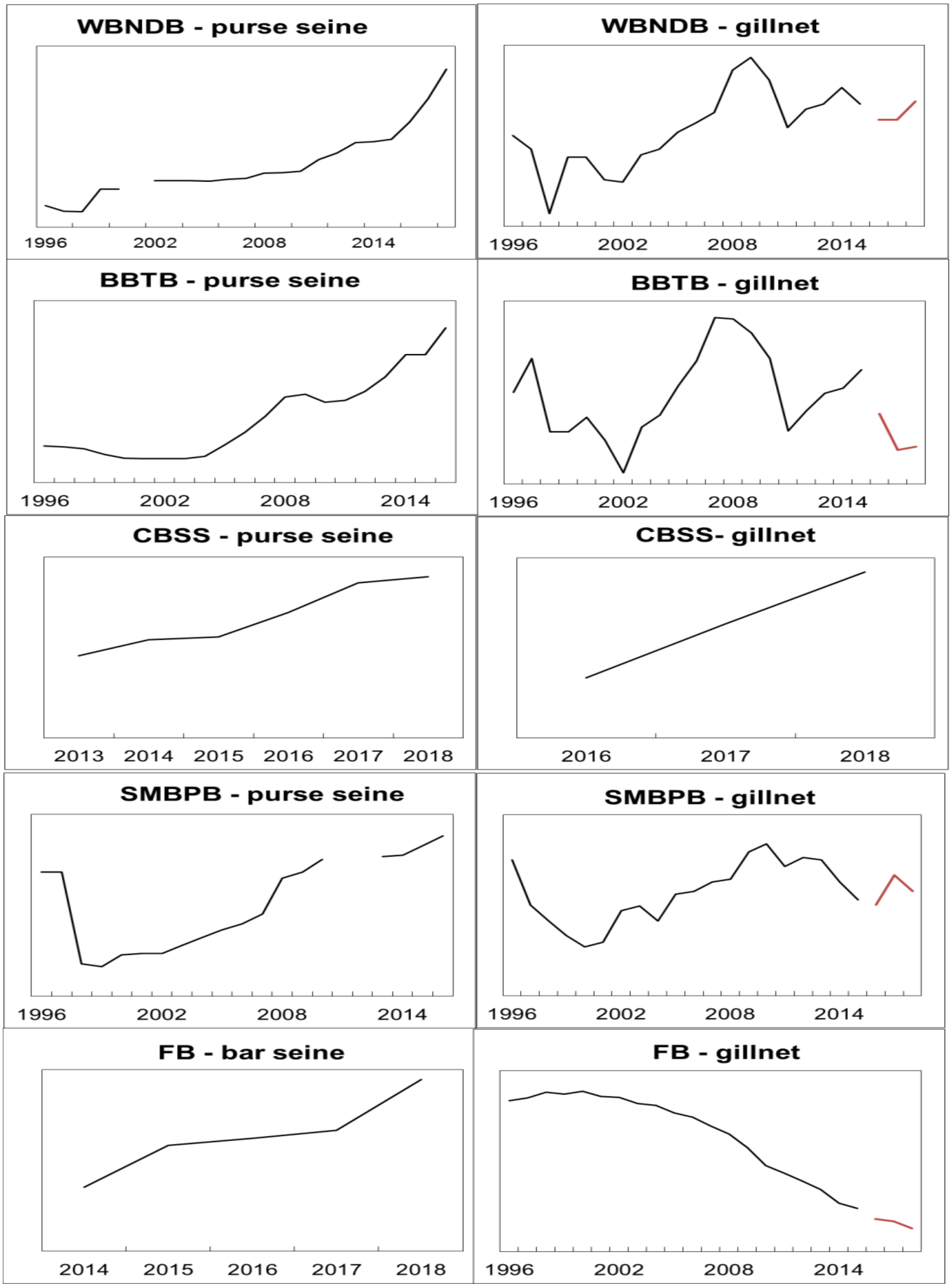

Figure 14: Cumulative Change Index by stock area and gear type based on responses given in logbooks and during annual telephone surveys. Red lines on gillnet plots represent responses given after nets were required to be set parallel to land.

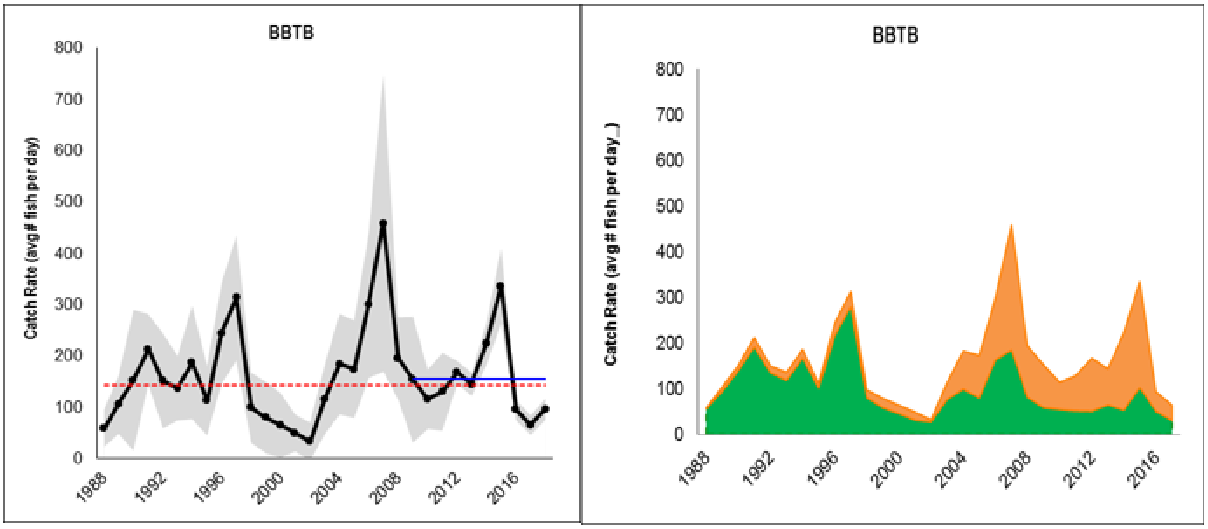

Figure 15: Combined catch rate in Bonavista Bay-Trinity Bay Research Gillnet Program to 2018 (left) with reference period mean (1990–2005, red/broken line) and decadal mean to 2018 (blue/solid line) and catch rates of spring (green) and fall spawners (orange) to 2017 (right).

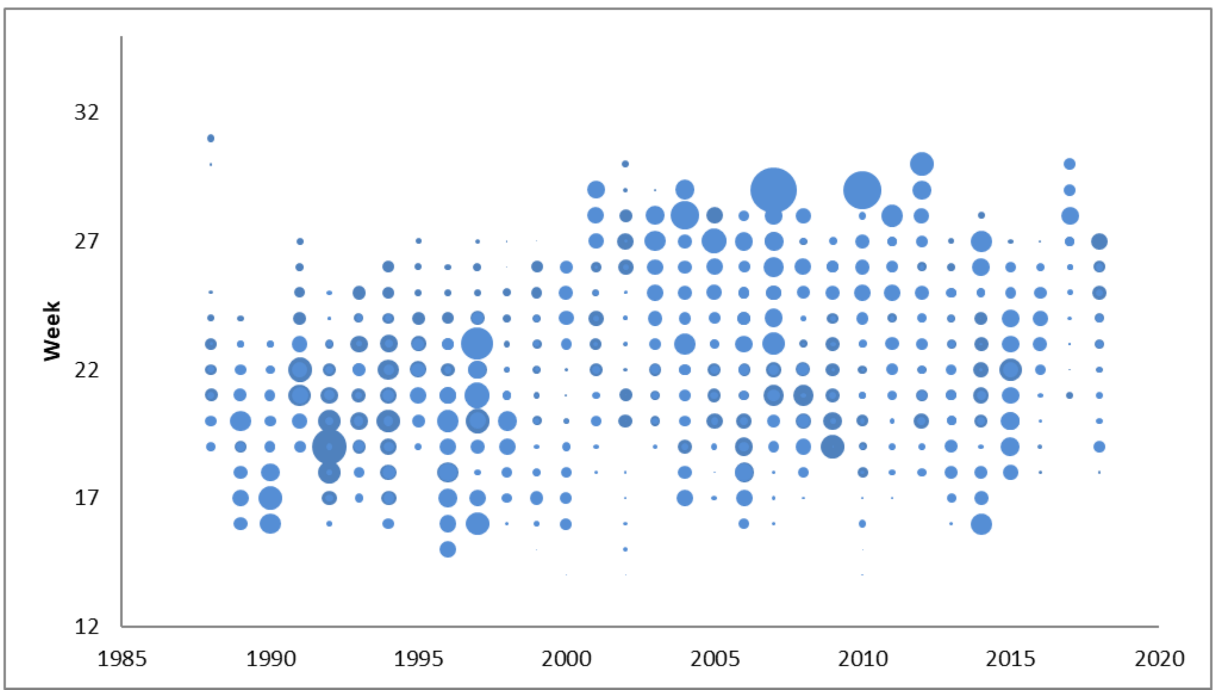

Figure 16: Catch size (numbers) in BBTB research gillnet program by week.

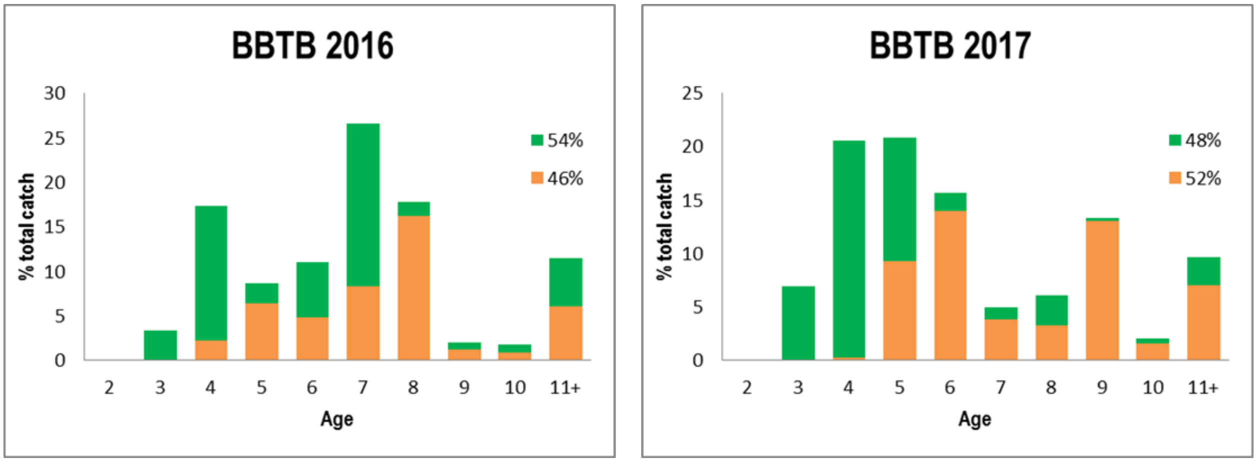

Figure 17: Age and spawning type composition of the spring research gillnet program catch in BBTB in 2016 and 2017 (green/upper bars=spring spawners; orange/lower bars=fall spawners).

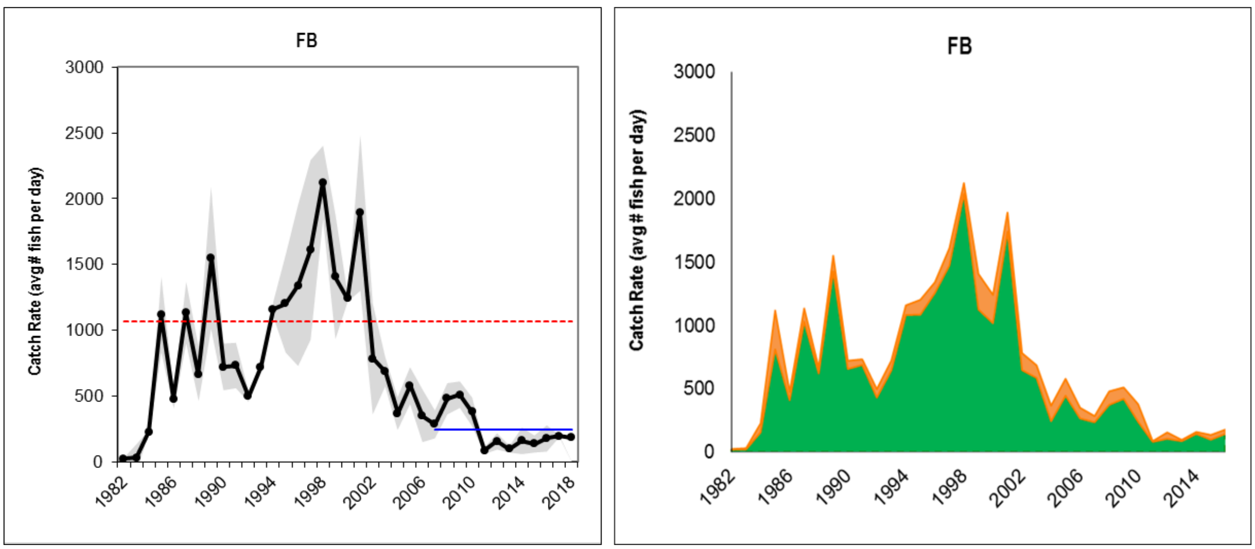

Figure 18: Combined catch rate in the Fortune Bay Research Gillnet Program to 2018 (left) with reference period mean (1990–2005, red/broken line) and decadal mean to 2018 (blue/solid line) and catch rates of spring (green) and fall spawners (orange) to 2017 (right).

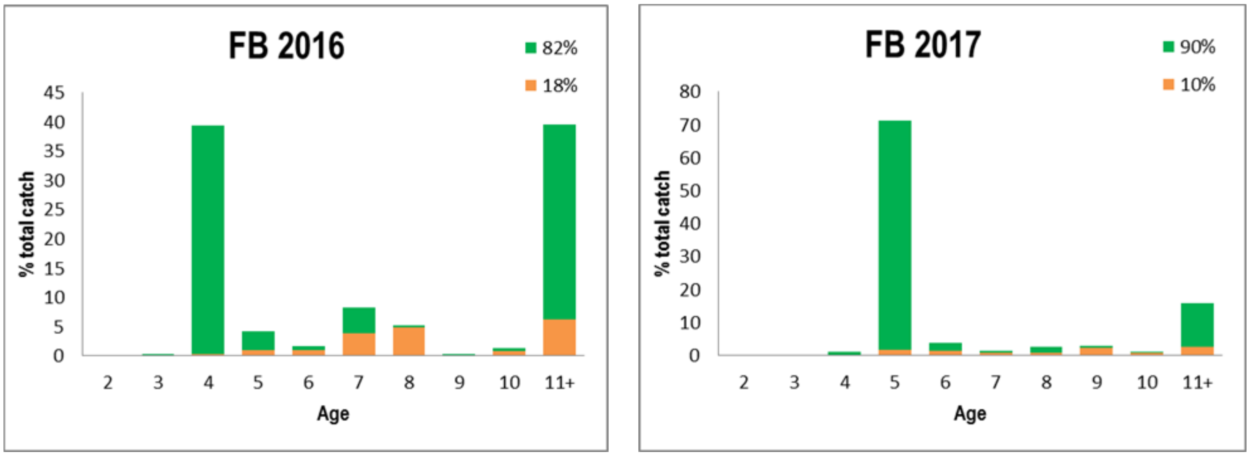

Figure 19: Age and spawning type composition of the spring research gillnet program catch in Fortune Bay in 2016 and 2017 (green/upper bars=spring spawners; orange/lower bars=fall spawners).

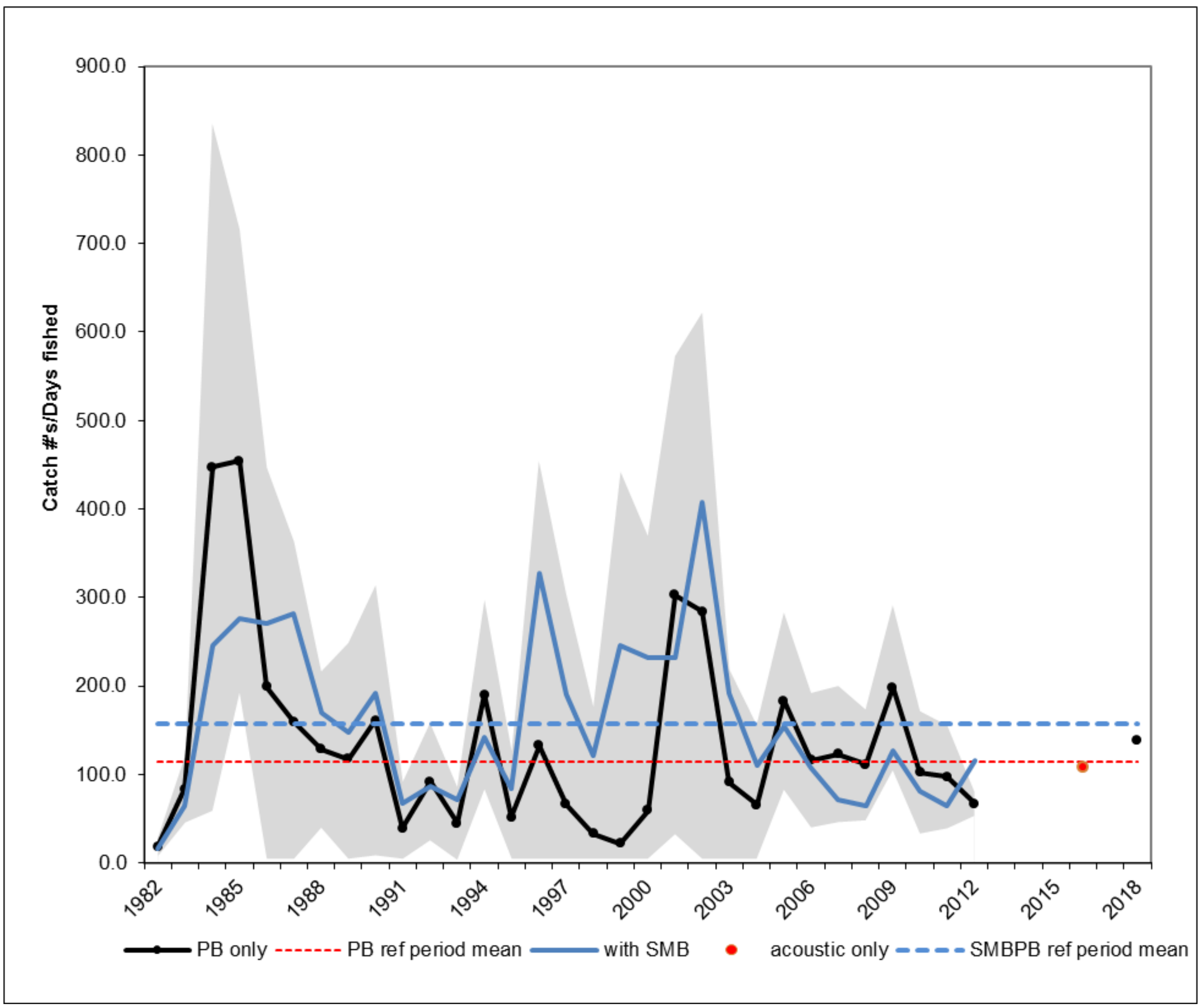

Figure 20: Catch rates in SMBPB combined (solid blue line) and PB only (black line) Research Gillnet Program 1982–2013, SMBPB reference period mean (blue broken line), PB reference period mean (red broken line), estimated series value based on 2016 PB acoustic survey (red point) and 2018 PB-only catch rate from OPP herring research gillnet program (black point).

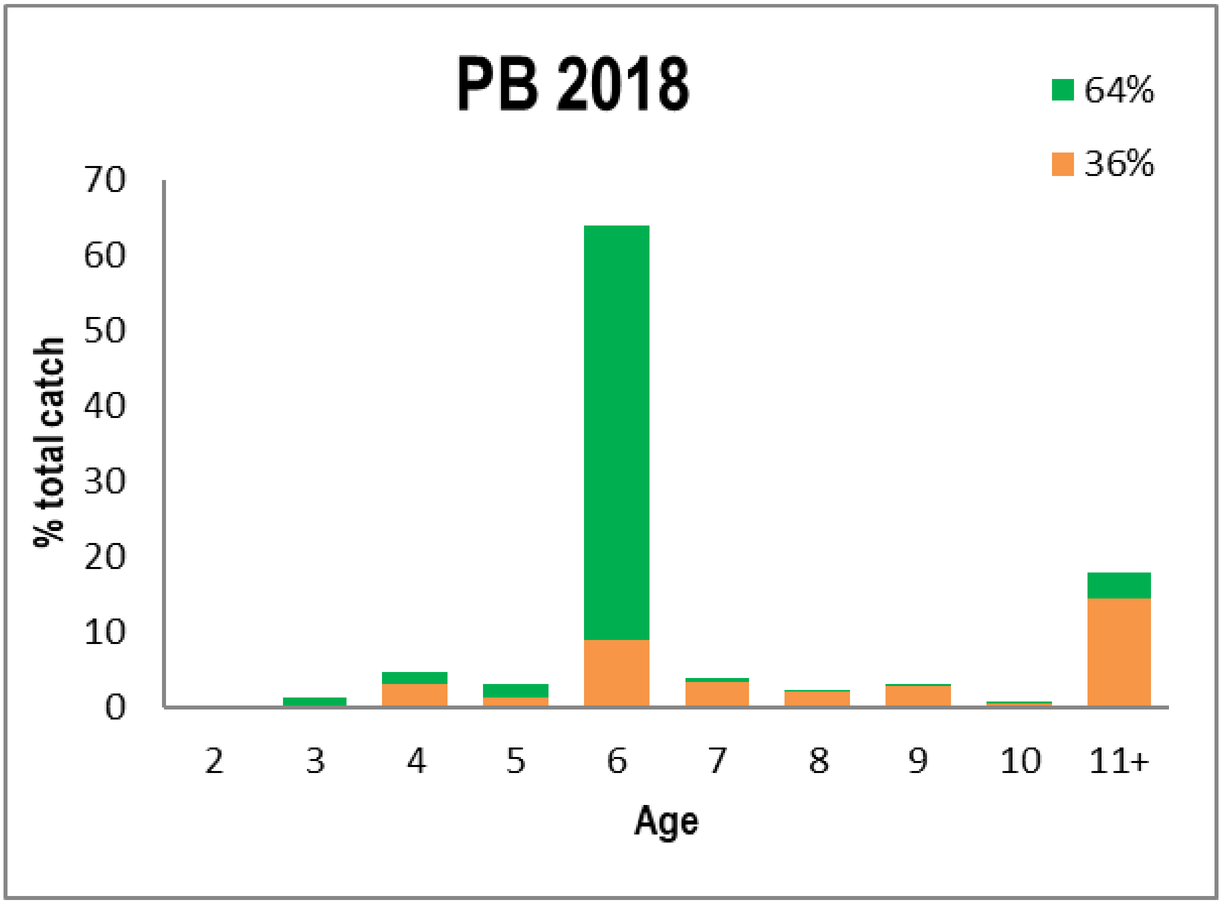

Figure 21: Age and spawning type composition of the research gillnet program catch in Placentia Bay in 2018 (green/upper bars=spring spawners; orange/lower bars=fall spawners).

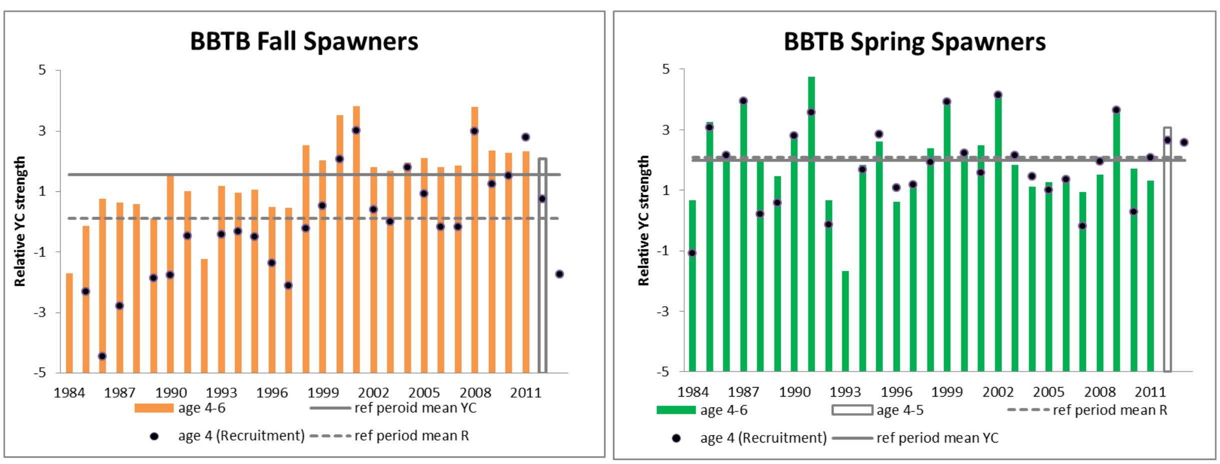

Figure 22: Recruitment index of age 4 herring (black points), year class strengh of ages 4–6 herring (bars), mean recruitment strength (dashed line) and year class strength (solid line) for the 1990–2005 reference period for fall and spring spawners in the BBTB spring research gillnet program.

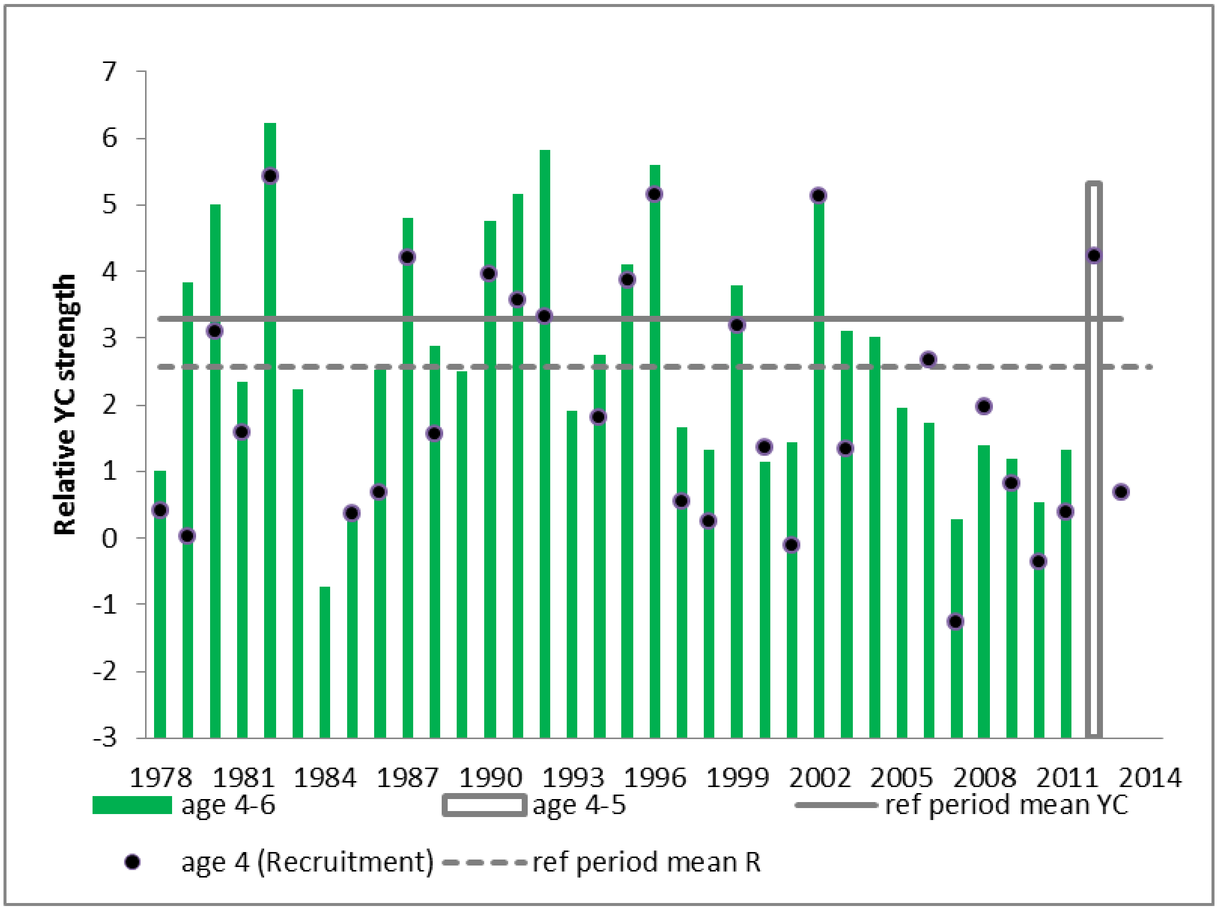

Figure 23: Recruitment index of age 4 herring (black points), year class strengh of ages 4–6 herring (bars), mean recruitment index value (dashed line) and year class strength (solid line) for 1990–2005 reference period for spring spawners in the FB spring research gillnet program.

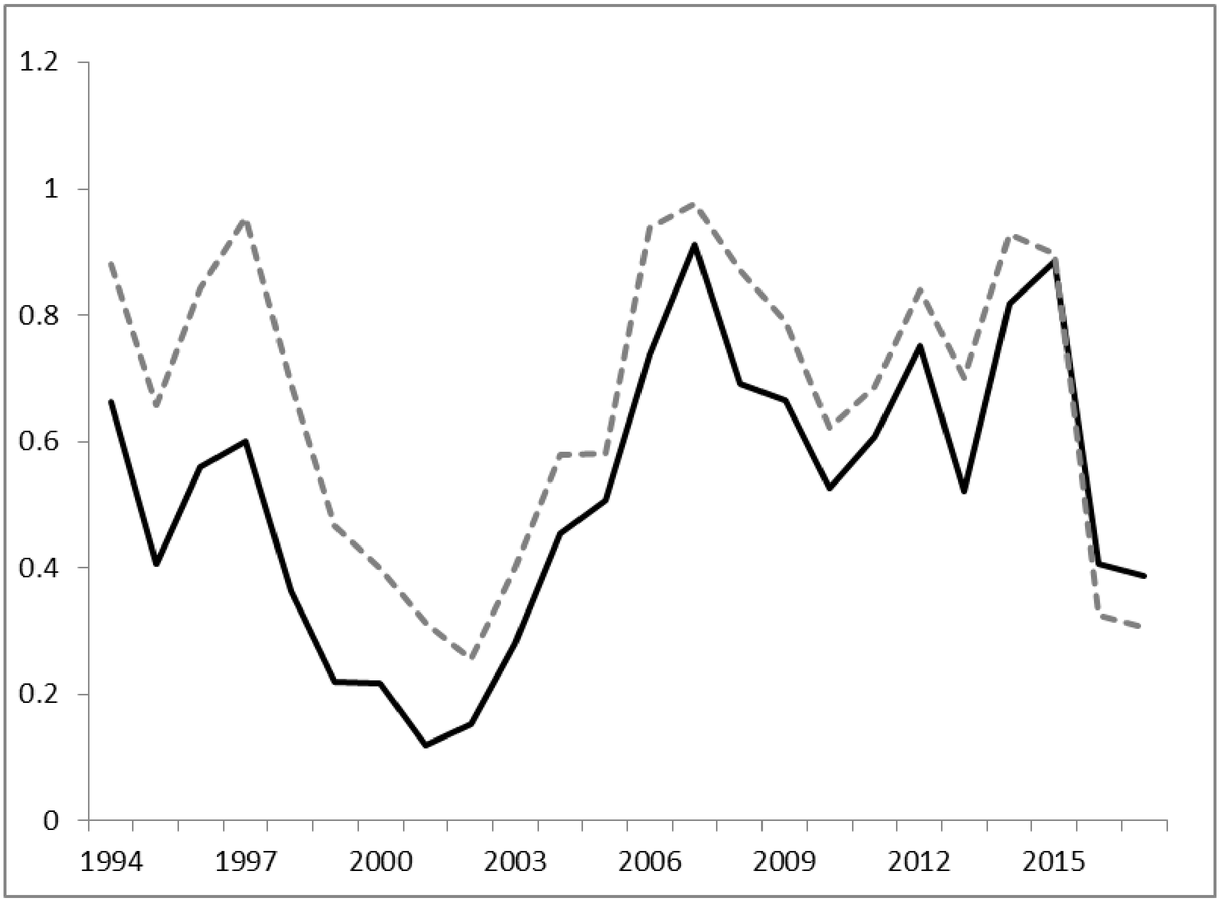

Figure 24: Stock status of both spawning components combined for BBTB based on the spring research gillnet program using the time series mean (dashed line) and reference peroid (1990–2005) mean (solid line).

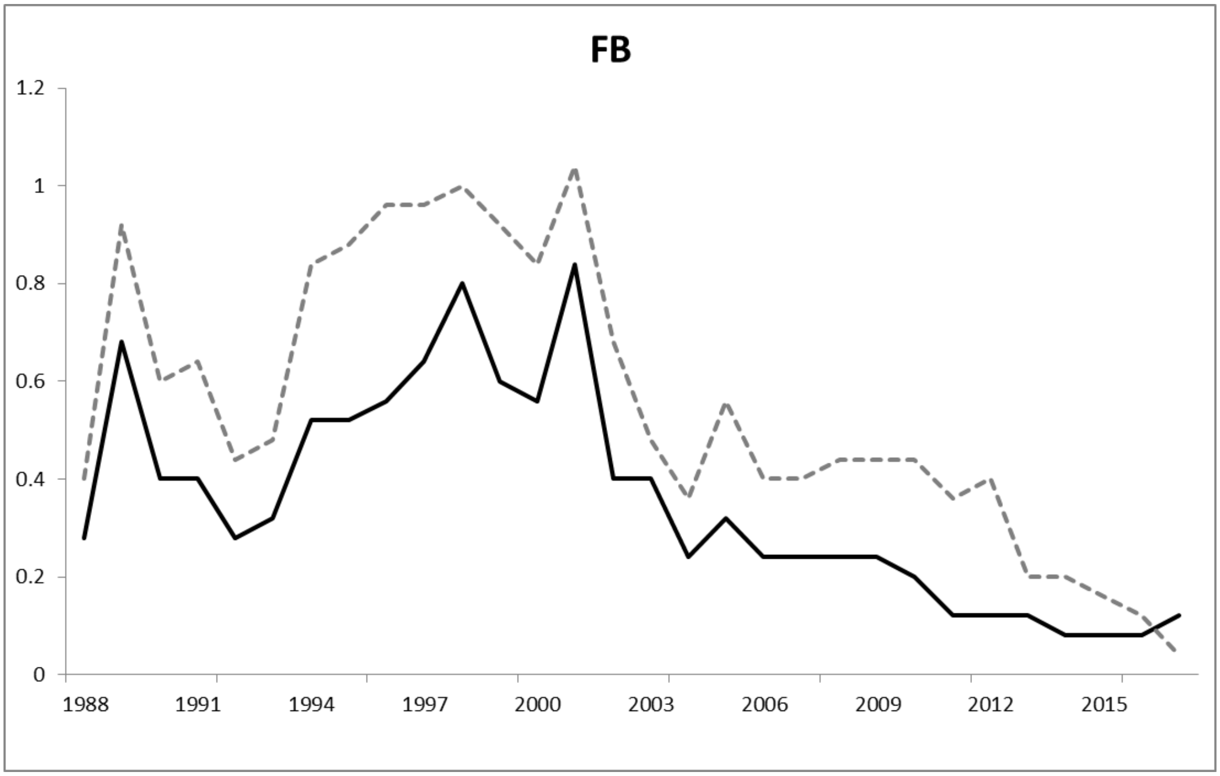

Figure 25: Stock status for FB based on the spring research gillnet program using the time series mean (dashed line) and reference period (1990–2005) mean (solid line).