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An assessment of the witch flounder resource in NAFO Divisions 3NO

by

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Abstract

In 2018 Canadian catch was estimated at 478 t and non-Canadian catch estimated at 163 t for a total catch of 641 t of an available 1,116 t quota. Spring survey indices in NAFO Divs. 3NO increased from 2010 to 2013 before a sharp decline in both biomass and abundance from 2013 to 2015 to levels approaching the time series mean for biomass. Spring survey indices for NAFO Divs. 3NO have increased slightly or remained stable since 2016. The fall survey indices for NAFO Divs. 3NO declined sharply from 2012 to 2016 to values approaching the lowest of the time series . Fall survey indices for NAFO Divs. 3NO have increased or remained stable since 2016 . A Bayesian surplus production model is used to provide TAC advice for this stock. The surplus production model results indicate that stock size decreased from the late 1960s to the late 1990s and then increased from 1999 to 2013. There was a large decline from 2013 to 2015, with a subsequent small increase since. The model suggests that a maximum sustainable yield (MSY) of 3 781 (3 054 – 4 755) tonnes can be produced by total stock biomass of 60 020 (45 879 – 73 561) tonnes (Bmsy) at a fishing mortality rate (Fmsy) of 0.063 (0.05-0.09). In 2019, the stock is at 41% Bmsy with a 0.2 risk of being below Blim. Median F was estimated to be 46% of Fmsy with a very low probability (0.02) of being above Fmsy in 2018. The population was projected to 2022 under varying levels of fishing and using two assumptions about the catch in 2019. Under the assumption that the TAC of 1175 t is taken in 2019. The probability of projected biomass being below Blim by 2022 was 13 to 17% in all catch scenarios examined and was 10% by 2022 in the F=0 scenario. Assuming that the catch in 2019 was equal to the average catch of 2017 and 2018 (662 t) the probability of projected biomass being below Blim by 2022 was 12 to 16% in all catch scenarios examined and was 8% by 2022 in the F=0 scenario.

Key words: 3NO witch, surplus production model, assessment

Fisheries and Management

As noted in previous reports (Lee et. .al. 2014 and Brodie et.al. 2011), species-specific catch statistics for flatfish prior to 1973 were largely developed from breakdowns of unspecified flounders and therefore should be considered with caution. Catches in the 1960s peaked at 11,000-12,000 tons in 1967-68 and remained relatively high during the next several years (Table 1; Fig. 1). Catch peaked at a time series high of 15,000 tons in 1971 and subsequently declined over the next decade to levels between 2000 and 4000 tons in the early 1980s (Table1; Fig 1).

The first total allowable catch (TAC) for witch flounder was introduced by ICNAF in 1974 at a level of 10,000 tons, largely based on average historical catches (Table 1; Fig. 1). This remained in effect until 1979 when it was reduced to 7,000 tons in consideration of declining commercial catch rates. It was further reduced to 5,000 tons in 1981 and remained at that level until 1993. The Scientific Council advised that for 1994, catches from this stock should not exceed 3,000 tons. A TAC of 3,000 tons was agreed by the NAFO Fisheries Commission, however, it was also agreed that no directed fishery would be conducted for witch flounder in 1994 to permit rebuilding due to the poor state of the stock. The NAFO Fisheries Commission introduced a complete moratorium for directed fishing in 1995, which was continued through 2014. There was no directed fishing on this stock from 1994 to 2014. A 1,000 t TAC was adopted for 3NO Witch Flounder beginning in 2015 with a TAC increase to 2,172 t and 2,225 t in 2016 and 2017 respectively, but decreasing to 1,116 t in 2018. Despite the 1,000 ton quota available, the catch reported for 2015 (359 t) was consistent with the bycatch range (300-400 t) reported since 2010. In 2018 the catch was estimated utilizing the CDAG methodology with the 2018 Canadian catch estimated at 478 t and non-Canadian catch estimated at 163 t for a total estimated catch of 641 t of an available 1,116 t quota (Table 1; Fig. 1). Not all Contracting Parties with quota have resumed directed fishing for witch flounder.

Annual catches rose rapidly to around 9,000 tons in 1985 and 1986 as a result of an increase in fishing effort in the NAFO Regulatory Area, primarily on the "tail" of the Grand Bank in Division 3N. Catches remained relatively high in 1987 and 1988 at around 7,500 tons. During 1990-93 estimated catches were in the range of 4,200-5,000 tons. The estimated catch for 1994 was in the order of 1,100 tons. A moratorium was introduced for this stock in 1995 (Table 1; Fig. 1). The catch dropped to 300 tons in 1995 likely as a result of a substantial reduction in fishing effort for Greenland halibut where witch flounder comprises a bycatch. Bycatch then increased steadily and by 1999 was about 800 tons, although it declined again to an estimated 450 tons in 2002. In 2003 several sources of catch data were available and a single source could not be considered as the most valid. As a result, catches were estimated to be 1544 t in 2003 (midpoint of a range of estimates) which declined to about 200 t in 2007, increased to 421 t in 2010 then declined slightly to about 335 t in 2014 (Table 1; Fig. 1).

Historically, the fishery was conducted primarily by Canada and the former Soviet Union. Canadian catches fluctuated from between 1,200 and 3,000 tons from 1985-91 but increased to about 4,300 tons in 1992 and 1993 (Table 1). Canadian catches during the 1995-2014 moratorium averaged 34 t per year. Catches by the Russian vessels declined from between 1,000 and 2,000 tons in the period 1982-88 and averaged 39 t per year during the 1995-2014 moratorium. Combined catch from other countries since 1995 has been in the range of 170 (2007) to 1500 t (2003) with an average annual catch of about 325 t (Table 1).

Data from commercial fisheries

Length frequencies were available from observer data for Canadian and Spanish witch flounder fisheries in NAFO Divs. 3NO in 2018**.** Canadian catches for this stock in 2017 were 478 t. Canadian data in 2018 indicated the catch ranged between 32 and 56 cm with a mean length of approximately 45 cm (Fig. 2). Spanish catches

for this stock in 2017 were 28 t. Most of the Canadian and Spanish catches were taken in a direct fishery and as by-catch of the Redfish and Greenland halibut fisheries (95%) and to a lesser degree in the skate fishery (5%). The bulk of Spanish catches were in the range of 22-47 cm (Fig. 2).

Research Vessel Surveys

Canadian RV surveys

Spring Surveys

Stratified-random research vessel surveys have been carried out by Canada on the Grand Banks in NAFO Divs. 3NO during spring since 1971, although during the early period coverage was limited and, in fact, for most years up to 1990, only surveyed depths to 366 meters (Tables 2-5). However, since 1991, depth coverage was extended to 731 meters. In 1993 only, spring surveys were completed to a depth of 914 m. During the course of the 2006 Canadian spring survey, operational difficulties lead to incomplete coverage of the survey in Divs. 3NO (Tables 2-5). Otherwise, spring surveys in Div. 3N were completed for most strata in all years from 1991 to 2016 to a depth of 731 m except for 1997, 2008, 2012, and 2017 which were each missing one stratum (Tables 2 & 4). Spring surveys in Div. 3O were completed for most strata in all years from 1991 to 2016 to a depth of 731 m except for 2011 which was missing one stratum and 2016 and 2017 which were missing two strata in the 367 to 731 m depth range (Tables 3 & 5).

Fall Surveys

In addition to spring surveys, a time series of fall surveys was begun in 1990 to investigate seasonal variation in stock distribution and abundance of various groundfish species (Tables 6-9). Note that due to operational difficulties there was no fall survey of NAFO Divs. 3NO in 2014. From fall 1998 the survey depth range in Div. 3N was further extended occasionally from the previous maximum depth range of 731 m to 1463 m (Tables 6 & 8). Only four fall surveys have covered the Div. 3N deeper strata completely (2000, 2001, 2002, and 2007) or partially (2 missing in 1998, 4 missing in 2005, 8 missing in 2009, and 11 missing in 2010) (Tables 6 & 8). Fall surveys in Div. 3N were limited to 366 m in 1990, and limited to 731 m from 1991 to 1997, in 1999, 2003, 2004, and 2008, and from 2010 to 2013 (Tables 6 & 8). From fall 2000 the survey depth range in Div. 3O was extended occasionally from the previous maximum depth range of 1097 m to 1463 m (Tables 7 & 9). Only six fall surveys since then have covered the Div. 3O deeper strata completely (2000 to 2002, 2005, 2007, and 2009) or partially (8 missing in 2003; Tables 7 & 9). Except for 1990 (549 m) and 1998 (1097 m) Div. 3O fall surveys have primarily been limited to a depth range of 731 m (1991 to 1996, 1999, 2003, 2004, 2006, 2008, and 2010 to 2017) (Tables 7 & 9).

Beginning with the fall survey in 1995, the survey gear was changed from an *Engel 145* groundfish trawl with steel bobbin footgear to a *Campelen 1800* shrimp trawl with rockhopper footgear. The data from the earlier Engel surveys have been converted to Campelen 1800 trawl catch equivalents. Only the converted survey data are presented but some caution should be used in comparing converted Engel data with data from the Campelen trawl series.

Survey Stock Indices 3N and 3O

Biomass (Tables 2, 3, 6, & 7) and abundance (Tables 4, 5, 8, & 9) estimates by stratum are presented for the spring and fall surveys in NAFO Divs. 3N and 3O respectively. Graphical plots to better illustrate the comparative trends in stock biomass and abundance by season/year are presented for NAFO Divs. 3N and 3O separately and combined, in Figures 3-4. The time series from 1984 to 2018 indicates that the majority of the

stock resides in NAFO Div. 3O, with biomass and abundance estimates up to 10 times the estimates for NAFO Div. 3N during spring surveys and approximately 1.5 to 2.5 times the estimates for NAFO Div. 3N during fall surveys (Figs. 3 and 4).

Spring stock indices in NAFO Div. 3N indicate a high degree of variability over the time series with an upward trend from 2008 to 2011 followed by a sharp decline to 2013 and an increase from 2013 to 2014 to the highest biomass levels of the entire time series (Fig. 3). Indices declined in 2015, increased slightly from 2015 to 2016, and increased sharply in 2017 to the highest levels of the time series (Fig 3). Both biomass and abundance spring survey indices for 3N have declined in 2018. Spring stock indices in NAFO Div. 3O, which are also highly variable, indicate a downward trend from 2004 to 2010, a sharp increase from 2010 to 2013 equivalent to the highest levels of the time series. This is followed by a sharp decline in spring stock indices from 2013 to 2015 to levels at or below the mean levels for the time series, a slight increase from 2015 to 2016 and a small decrease from 2016 to 2017. Spring 3O indices increased slightly in 2018 (Fig. 3).

Due to operational difficulties there was no fall survey of NAFO Divs. 3NO in 2014. Fall stock indices in NAFO Div. 3N were for the most part consistently low from 1990 to 2006 followed by a sharp increase from 2007 to 2009, a steep decrease from 2010 to 2011, a steep increase in 2012, a sharp decrease from 2012 to 2016, and a continued increase from 2016 to 2018 (Fig. 4). Fall stock indices in NAFO Div. 3O were quite variable from 1990 to 2004 followed by a moderate decline from 2005 to 2007, a sharp increase to 2009, a fairly consistent sharp decline from 2009 to 2015 and a slight increase from 2015 to 2016 followed by relatively flat biomass and abundance indices from 2016 to 2018 (Fig 4).

3NO Combined

For spring surveys in NAFO Divs. 3NO the stock indices trends are primarily driven by the higher overall abundance and biomass estimated for NAFO Div. 3O. The NAFO Divs. 3NO combined indices for spring show a slow decline in biomass and abundance from 1984 to the late-1990s (Fig. 3) and although fluctuations continue to occur, some minor improvement in the estimates had occurred from 1998 to 2003 until a decline in levels from 2003 to 2005. Values from 2007-2010 have fluctuated around the long-term mean, however from 2010 to 2013 estimates of both biomass (7000 to 24000 t) and abundance (20 to 70 million fish) increased substantially, with the time series highest values in 2013 peaking at about 3 times the long term mean (Fig. 3). This increase from 2010 to 2013 was followed by a sharp decline in both biomass and abundance from 2013 to 2015 to levels approaching the time series mean for biomass and to levels approximately 1.5 times the time series means for abundance. Spring survey indices for NAFO Divs 3NO increased slightly or remained stable since 2016 (Fig. 3).

Due to operational difficulties there was no fall survey of NAFO Divs. 3NO in 2014. The fall survey series for Divisions 3NO combined is less variable with a generally increasing trend in biomass and abundance from about 1997 until 2004 (Fig. 4). Variability increases substantially from 2006 to 2013. There was a decline in 2006 and 2007, and a large increase in the 2008-2010 estimates, to levels between 1.7 and 2.8 times the mean. This peak (the highest in the time series) is followed by a decrease in 2011, an increase in 2012 and a decrease in 2013. Although the values from 2008 to 2013 exhibit substantial variability the overall mean from this period is still 1.5 to 2 times greater than the mean for the time series (Fig 4). The fall survey indices for NAFO Divs. 3NO declined sharply from 2012 to 2016 to values approaching the lowest of the time series encountered in the 1990's (Fig. 4). Fall survey indices for NAFO Divs. 3NO have increased or remained stable since 2016 (Fig. 4).

Depth distribution

Witch flounder have been described as a relatively deep water species, having been captured at depths of up to 1500 m. However, in the Newfoundland & Labrador area, they are thought to prefer depths of 184-366 m (Bowering and Brodie 1991). Because it was previously thought that witch flounder may not be adequately covered by the survey depths, the issue was examined by analyzing the Canadian survey data (Dwyer 2008). It was concluded that the preferred depth of Divs. 3NO witch flounder differs by division and by time of year. A higher percentage of the biomass in 3N is found in deeper strata, but there is still a large percentage found in depths of less than 100m, especially in the fall. In Div. 3O where the main component of the stock is distributed, a large proportion of the biomass is found in depths less than 183 m in either spring or fall. This is despite the fact that in a number of years, the survey covered depths of up to 1500 m in the fall. The percent abundance by depth showed similar patterns.

Depths covered by the surveys have changed over the years as stated above. In the spring series, only 1994 was surveyed to 914 m, but only 1.4% of the Divs. 3NO biomass index value was found in these strata (Tables 3 and 4), although it was 17% for Div. 3N alone. For the fall surveys, in years and divisions where coverage was complete in depths 731 to 1462 m, between 15 and 25% of biomass estimates in Div. 3N were contained in these depths (Table 6). However, in Div. 3O, there were very few fish found in this depth range, generally less than 5% (Table 7). Because Div. 3O contains the majority of the biomass estimate in the fall surveys (83% on average), the percentage of the total Div. 3NO biomass in the deeper strata is similarly low.

As discussed in Dwyer (2008), distribution plots indicated more witch flounder are distributed on the shallower, shelf area of the Grand Banks in some years, especially in Div. 3O and especially in the fall. Therefore, it seems likely that the RV survey coverage does adequately cover the depth distribution of witch flounder, particularly in the fall. The variation in the survey indices may be due to the movement of flounder onto and off of the shelf areas depending on water temperatures and spawning aggregations. Bowering and Orr (1996) suggested that the movement of witch flounder onto the shallow parts of the bank in large strata cause the high variability in annual stock size estimates. It is also likely that some witch flounder may be distributed outside the survey area, particularly in the spring, following spawning in deeper waters, and this may also contribute to variability in survey estimates.

A NAFO scientific council working paper prepared by Lee in 2015 (SCWP 15-014) examined the biomass distributions of witch flounder in NAFO Divs 3N and 3O in both spring and fall with respect to depth strata. The analysis indicated that for 3N, both spring and fall biomass proportions were fairly evenly distributed within depths ranging from 57 to 914 m. Although biomass proportions were low in both spring and fall in depths less than 56 m. For 3O spring and fall biomass proportions were highest in depths ranging from 57 to 183 m and uniformly low at depths ranging from 184 to 914 m. Both 3N and 3O fall distributions indicated low biomass proportions in depths ranging from 915 to 1463 m.

Distribution Plots

Geographic distributions of witch flounder from 1996-2007 spring and fall surveys (mean weight per tow) were plotted in Dwyer (2008), distributions (mean weight per tow) from 2008 to 2013 were plotted in Lee et al. (2014). For recent years 2012-2017 (no fall survey in 2014), the spring and fall abundance and biomass distribution plots are presented in Figures –5-8. The witch flounder stock for Div. 3NO is mainly distributed in Div. 3O along the southwestern slope of the Grand Bank. In most years the distribution is concentrated along this slope but in most years during the fall it has a wider distribution in the shallower parts of the bank. It is

this variation in distribution from deeper to shallower strata in conjunction with the survey timing that is often responsible, in part, for the high variability in the annual biomass and abundance indices (Bowering and Orr 1996).

Length frequencies

Canadian and Spanish RV survey length frequency data for individual years from 2003 to 2018 are presented in Figure 9. Length frequencies of 30-50 cm fish increase from 2003 to 2005, decrease to pre-2002 levels from 2006 to 2007, and are then consistently higher from 2008 to 2014 (note there was no survey data collected in the fall of 2014) with a mode generally within the mode of 40 cm (Fig. 9). The increase in 30-50 cm fish is generally more pronounced in the fall survey data as opposed to the flatter distributions of the spring surveys.

There have been a few identifiable peaks in the time series (presumably year classes) that could be followed in successive years (e.g. peak at 9 cm in 1997, 11 cm in 1998, and 20 cm in 1999; peak at 13 cm in 2011, and 20 cm in 2013), in 2002 a peak at 12 cm was not observed subsequently (Fig. 9). There have been less distinctive peaks, usually in the 10-20 cm range, observed in 2007, 2011, 2015, and 2017 although they were not identified in subsequent years (Fig. 9). It should be noted that no ageing information for this stock has been available from Canadian RV surveys since the mid 1990's, making the tracking of cohorts from length frequency data all but impossible given the relatively slow growth of witch flounder.

Abundance at length in the Canadian spring RV surveys appears to be fairly consistent since 2003 with few fish greater than 50 cm, and a mode generally around 38-40 cm (Fig. 9). However, since 2007 there has been an increase in the number of larger fish in the 40-45 cm range except for an anomalous 30-35 cm range encountered in 2014 (Fig. 9). Abundance at length in the Spanish spring RV surveys was fairly consistent at 33-35 cm from 2003 to 2007 (a smaller range than the Canadian surveys during the same time period). From 2008 to 2016 the size range has generally increased with more fish in the 38-40 cm range. In 2018 the mode was in the 38-40 cm range (Fig. 9).

There were a small number of distinctive peaks in the 5-15 cm range (recruitment year classes) in both surveys that were evident and could be followed through successive years. This included the periods from 2007 to 2009, and 2017 in the Canadian series and from 2002-2003, and 2005 -2006 in the Spanish series (Fig.14).

Recruitment

Figure 10 shows the abundance index for fish less than 21 cm (a recruitment proxy) for NAFO Divs. 3NO combined, as measured in the spring and fall Canadian RV surveys. Highest spring levels were in 1997, highest fall levels were in 1998 and 1999. Values since 2002 for the fall have been consistently below the mean of the time series. Spring values were occasionally above the time series mean in 2003, 2005, 2009, and 2013. Recruitment in spring and fall surveys in 2016 approached the lowest values of the time series (Fig. 15). Recruitment in 2017 surveys increased in the fall to a value just above the time series mean while those in the spring increased to a value just below the time series mean (Figure 10). In 2018, fall recruitment indices dropped below the long-term average whereas spring recruitment indices increased to the second highest level in the time series.

The distributions of juvenile (< 21 cm) witch flounder over the spring and fall Canadian surveys indicate a marginal pattern of fish being more widely distributed over the shallower depths in the larger strata during the fall. It is also possible that the weak pattern may be related to the distributions previously presented for the entire population which indicated a movement of fish to the shallower, larger strata during the fall.

During the 2018 assessment of 3NO Witch Flounder, a research recommendation was formulated regarding where pre-recruit (<21cm) witch flounder were coming from, as there was limited evidence for recruitment pulses in the DFO RV survey data. In an effort to explain the discrepancy between the length distribution of 3NO witch flounder and the lack of any substantial recruitment, we examined correlations between the 3NO recruitment index and recruitment indices of adjacent management areas as well as distribution of pre-recruit witch flounder within and across several adjacent management areas. Pre-recruit witch flounder distribution seems to be more or less continuous along the shelf edge in NAFO Divs. 3NOP, but results indicated very little evidence of pre-recruit witch flounder in 3NO coming from adjacent stock areas (Figs 11 & 12). Correlations of the number of pre recruits in each area showed that the number of pre recruits in Div. 3N and 3O were correlated with one another while the number of pre recruits in Div. 3O was not correlated with that in the adjacent Subdiv. 3Ps. There was also no correlation between Div. 3N or Div. 3O and Div. 3L (Figure 12). However, length frequency distributions showed a consistent gap between about 20 cm and 30 cm (Figure 2). It is not known why this size fish are not caught in the stock area.

Surplus production model

A surplus production model in a Bayesian framework was used for the assessment of this stock. This model was developed and accepted by the Scientific Council in 2015 (Morgan et al 2015). The updated surplus production model used in this assessment is fully described and diagnostics provided in Morgan and Lee (2017). The input data were catch from 1960-2017, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2017 (no 2006) and the Canadian autumn survey series from 1990-2017 (no 2014).

The priors used in the model were:

Median initial population size (relative to carrying capacity)	Pin~dunif(0.5, 1)	uniform(0.5 to 1)
Intrinsic rate of natural increase	r ~ dlnorm(-1.763,3.252)	lognormal (mean, precision)
Carrying capacity	K~dlnorm(4.562,11.6)	lognormal (mean, precision)
Survey catchability	q =1/pq pq ~dgamma(1,1)	gamma(shape, rate)
Process error (sigma=standard deviation of process error in log-scale)	For 1960-2013 and 2017-2018 sigma ~ dunif(0,10) precision:isigma2= $sigma^{-2}$ For 2014-2016 sigmadev <-sigma+1 precision: isigmadev2=$sigmadev^{-2}$	uniform(0 to 10)
Observation error (tau=variance of observation error in log-scale)	tau~dgamma(1,1) precision:itau2 = 1/tau	gamma(shape, rate)

Resource Status

The surplus production model results indicate that stock size decreased from the late 1960s to the late 1990s and then increased from 1999 to 2013. There was a large decline from 2013 to 2015, with a subsequent small increase since. The model suggests that a maximum sustainable yield (MSY) of 3 781 (3 054 – 4 755) tonnes can be produced by total stock biomass of 60 020 (45 879 – 73 561) tonnes (Bmsy) at a fishing mortality rate (Fmsy) of 0.063 (0.05-0.09).

The analysis showed that relative population size (median B/Bmsy) was below Blim=30%BMSY from 1993-1997. The stock size increased since 1994 to 2013 and then declined from 2013-2015 and has since increased slightly. In 2019 the stock is at 41% Bmsy with a 0.2 risk of being below Blim (Fig. 13). Relative fishing mortality rate (median F/Fmsy) was mostly above 1.0 from the late 1960s to the mid-1990s. F has been below Fmsy since the moratorium implemented in 1995. Median F was estimated to be 46% of Fmsy with a very low probability (0.02) of being above Fmsy in 2018 (Fig. 14)

The posterior distributions (13 500 samples) for r, K, sigma, and biomass and the production model equation were used to project the population to 2022. All projections assumed that the catch in 2019 was equal to the TAC of 1 175 t. This was followed by constant fishing mortality for 2020 and 2021 at several levels of F (F=0, F2018, 2/3 FMSY, 85% FMSY, and FMSY).

The probability that F > Flim in 2019 is 26% at a catch of 1 175 t. The probability of F>Flim ranged from 4 to 50% for the catch scenarios tested (Table 10 and 11). The population is projected to grow under all scenarios and the probability that the biomass in 2022 is greater than the biomass in 2019 is greater than 60% in all scenarios. The population is projected to remain below BMSY through to the beginning of 2022 for all levels of F examined with a probability of greater than 90%. The probability of projected biomass being below Blim by 2022 was 13 to 17% in all catch scenarios examined and was 10% by 2022 in the F=0 scenario.

A second set of projections assuming that the catch in 2019 was equal to the average catch of 2017 and 2018 (662 t) was also conducted. The results were essentially the same as those assuming that the catch in 2019 equals the TAC. The probability of projected biomass being below Blim by 2022 was 12 to 16% in all catch scenarios examined and was 8% by 2022 in the F=0 scenario.

References

Bowering, W.R., and Brodie W. 1991. Distribution of commercial flatfishes in the Newfoundland-Labrador region of the Canadian Northwest Atlantic and changes in certain biological parameters since exploitation. Neth. J. Sea Res. 27(3/4):407-422.

Bowering, W. R. and D. Orr. 1996. Distribution and trends in stock size of witch flounder in NAFO Divisions 3NO. NAFO SCR Doc. 96/70.

Brodie, W., Parsons, D., Murphy, E., and Dwyer, K. 2011. An assessment of the witch flounder resource in NAFO Divisions 3NO. NAFO SCR Doc. 11/029.

Brodie, W. and Stansbury, D. 2007. A brief description of Canadian Multispecies surveys in SA2 + Divisions 3KLMNO from 1995-2006. NAFO SCR Doc. 07/18.

Dwyer, K. 2008. An assessment of witch flounder in NAFO Divisions 3NO. NAFO SCR Doc. 08/39., Ser. No. N5540.

Fomin, K. and Pochtar M. 2017. Russian research report for 2016. NAFO SCS Doc. 17/11, Serial No. N6686.

Fomin, K. and Pochtar M. 2018. Russian research report for 2017. NAFO SCS Doc. 18/13, Serial No. N6824

Fomin, K. , Khlivnoy, V., Mishin T., and Zavoloka P. 2015. Russian research report for 2014. NAFO SCS Doc. 15/07, Serial No. N6433.

Gonzalez-Costas, F., Ramilo, G., Roman, E., Gago, A. Sacau, M. Gonzalez-Troncoso, D., Casas, M., and Lorenzo, J. 2017. Spanish Research Report for 2016. NAFO SCS Doc. 17/04, Ser. No. N6656.

Gonzalez-Costas, F., Ramilo, G., Roman, E., Gonzalez-Troncoso, D., Casas, M., Sacua, E., and Lorenzo, J. 2015. Spanish Research Report for 2014. NAFO SCS Doc. 15/05, Ser. No. N6423.

Lee E., Morgan J., Rideout R. M. 2015. An assessment of the witch flounder resource in NAFO Divisions 3NO. NAFO SCR Doc. 15/038. Ser. No. N6465.

Lee E., Morgan J., Rideout R. M., Ings D., and Wheeland L. 2017. An assessment of the witch flounder resource in NAFO Divisions 3NO. NAFO SCR Doc. 17/049. Ser. No. N6709.

Lee E., Regular, P., Brodie B., Rideout R. M., Dwyer K., Ings D., and Morgan J. 2014. An assessment of the witch flounder resource in NAFO Divisions 3NO. NAFO SCR Doc.14/029, Ser. No. N6325.

Morgan, J. Lee, E. 2017. Surplus production model in a Bayesian framework applied to witch flounder in NAFO Divs. 3NO. NAFO SCR 17/047, Ser. No. N6707

Morgan, M.J., C. Hvingel and M. Koen-Alonso. 2015. Surplus production models in a Bayesian framework applied to witch flounder in NAFO Div. 3NO. NAFO SCR 15/37.

NAFO, 2013. Report of Scientific Council Meeting, 7-20 June 2013.

NAFO, 2012. Canadian Request for Scientific Advice on management in 2013 of certain stocks in subareas 0

to 4. NAFO SCS Doc. 12/04., Ser. No. N6014.

Power, D. and Richards, D. 2017. Canadian research report for 2016 Newfoundland and Labrador Region 2016. NAFO SCS Doc. 17/13, Ser. No. N6704

Torra, T., Sirp,s. 2015. Estonian Research Report for 2015. NAFO SCS Doc. 15/04, Ser. No. N6420

Vargas, J., R. Alpoim, E. Santos and A. M. Ávila de Melo. 2015. Portuguese Research Report for 2014. NAFO SCS Doc. 15/06, Ser. No. N6426.

Vargas, J., R. Alpoim, E. Santos and A. M. Ávila de Melo. 2017. Portuguese Research Report for 2016. NAFO SCS Doc. 17/05, Ser. No. N6658.

Table 1. Catches and TACs (t) of Witch flounder in Div. 3NO from 1960 to 2018.

Year	Canada	Russia	Other	Total	TAC
1959	-	-	-		
1960	-	-	-	5799	0
1961	-	-	-	4627	0
1962	-	-	-	1228	0
1963	895	485	803	2183	0
1964	1055	-	11	1066	0
1965	1324	849	4	2177	0
1966	3644	3828	50	7522	0
1967	2863	8565	75	11503	0
1968	1503	9078	18	10599	0
1969	479	4215	6	4700	0
1970	723	6039	1	6763	0
1971	178	14774	13	14965	0
1972	3419	5738	20	9177	0
1973	4943	1714	34	6691	0
1974	2807	5235	3	8045	10000
1975	1137	5019	12	6168	10000
1976	3044	2991	-	6035	10000
1977	3013	2742	4	5759	10000
1978	1165	2275	33	3473	10000
1979	1193	1868	16	3077	7000
1980	425	1994	1	2420	7000
1981	381	2044	-	2425	5000
1982	1760	1969	3	3732	5000
1983	1674	1942	-	3616	5000
1984	834	1955	13	2802	5000
1985	2746	1908	4117	8771	5000
1986	2937	1724	4470	9131	5000
1987	2829	1425	3342	7596	5000
1988	1927	1037	4361	7325	5000
1989	1241	81	2366	3688	5000
1990	2654	9	1516	4179	5000
1991	2624	-	2223	4847	5000
1992	4328	-	632	4960	5000
1993	4337	3	250	4414	5000
1994	2	-	1117	1119	3000
1995	-	-	300	300	0
1996	64	-	294	358	0
1997	19	-	493	512	0
1998	2	5	605	612	0
1999	6	86	671	763	0
2000	12	50	483	545	0
2001	13	34	647	694	0
2002	26	112	312	450	0
2003	62	59	1423	1544	0
2004	58	60	509	627	0
2005	49	8	200	257	0
2006	94	2	385	481	0
2007	21	27	174	222	0
2008	46	17	201	264	0
2009	41	22	313	376	0
2010	39	28	354	421	0
2011	11	2	337	350	0
2012	2	10	303	315	0
2013	62	54	212	328	0
2014	11	57	267	335	0
2015	221	36	102	359	1000
2016	799	26	237	1062	2172
2017	397	-	259	656	2225
2018	478	77	86	641	1116
2019					1175

Although a TAC of 3000 tons was agreed by the Fisheries Commission (FC), it was also agreed that no directed fishing on witch flounder in NAFO Divs. 3NO take place during 1994 due to the poor state of the stock.

Canadian catch prior to 2017 was derived from combining Newfoundland and Maritimes commercial data. Canadian, Russian, and "Other" catch since 2017 has been derived from the CDAG (Catch Data Advisory Group).

* A 1,175 ton quota for 3NO witch flounder was adopted by the Fisheries Commission for 2019.

Table 2. Estimated biomass (tonnes) of Witch flounder (M+F) in each stratum from surveys in Div. 3N during spring of 1984-2018. (Engel 145 data converted to Campelen Units for 1984-95).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
<=56	1593	1593	375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	35	0	21	0	0	0	0	0	0	0	0	0
	1499	1499	376	0	0	0	19	0	0	0	0	0	0	0	0	0	0	8	18	0	0	0	0	0	0	0	89	0	0	0	0	0	0	0	0	0	0	0
57 - 92	2992	2992	360	1715	89	629	461	1519	175	0	0	29	165	0	0	0	115	33	120	266	0	0	19	97	983	264	543	85	0	395	156	72	188	135	0	0	118	1072
	1853	1853	361	119	0	0	39	50	0	20	0	0	0	0	39	0	0	0	0	242	45	0	0	0	35	139	0	18	72	0	131	0	92	75	0	0	0	0
	2520	2520	362	0	82	23	18	147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	0	0	0	0	17	0	0	0	0	0	0	0
	2520	2520	373	0	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	15	20	0	0	0	0	0	0
	931	931	374	0	0	0	0	0	0	0	0	0	18	34	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	674	674	383	0	57	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	23	0	0	0	0	0	0	0
93 - 183	421	421	359	231	47	99	43	306	121	0	0	0	19	0	0	0	0	0	67	149	58	13	0	0	334		52	0	593	719	1365	299	83	835	612	117	3622	14
	100	100	377	8	0	0	72	3	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	38	0	0	0	0	0	9
	647	647	382	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40		0	0	0	0	0	0	0	42	0	0	0	0
184 - 274	225	225	358	40	308	42	137	20	29	57	0	44	132	106	7	51	49	134	6	9	154	14	168	0	42		316	68	237	156	241	86	189	135	24	884	194	86
	139	139	378	22	19	32	155	31	42	0	0	29	0	0	0	0	3	0	0	0	5	8	1	0	0		0	0	0	0	14	55	0	0	6	0	0	0
	182	182	381	21	7	32	101	69	0	28	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0		53	13	18	0	0	30	0	23	267	0	0	0
275 - 366	164	164	357	8	87	154		4	60	21	0	31	49	81	20	36	12	159	21	75	17	26	65	42	0		19	0	4	31	83	134	25	42	94	56	17	0
	106	106	379	36	12	23	173	44	20	35	3	18	0	4	0	0	9	2	26	4	4	0	4	0	6		0	0	7	12	23	101	88	237	5	0	7	0
	116	116	380	6	53	0	134	24	7	4	0	0	0	0	0	0	0	0	6	0	0	0	3	0	0		0	5	0	0	0	22	5	12	4	0	0	15
367 - 549	155	155	723								90	102	79	36	51	16	25	53	33	36	23	130	60	34	108		50	82	13	137	54	42	125	245	87	171	44	12
	105	105	725								62		40	44	0	5	28	4	20	32	8	3	7	0	103		15	3	36	4	18	28	8	68	56	25	55	498
	160	160	727								0	5	38	17	0	0	3	9	13	12	3	0	0	23	41		11	27	0	14	32	34	99	43	10	179	514	120
550 - 731	124	124	724								327	181	218	51	36	29	157	53	105	106	127	96	101	54	65		207		146	82	61		76	150	10	121		56
	72	72	726								81	25	22	28	3	12	42	96	59	65	84	18	50	21	8		19	25	41	105	46	32	23	77	93	104	21	41
	156	156	728								92	19	82	22	152	21		15	32	45	98	43	53	75	42		34	175	748	164	117	142	187	371	202	266	72	97
732 - 914	.	134	752											27																								0
	.	106	756											33																								0
	.	154	760											26																								0
Grand Total				2205	761	1078	1401	2218	485	164	655	484	862	510	308	170	443	566	525	1042	632	380	532	346	1807	577	1442	502	1936	1818	2395	1135	1188	2489	1470	1922	4664	2020
Biomass >366 m				0	0	0	0	0	0	0	652	333	480	284	242	84	255	230	262	296	343	289	272	207	366		335	313	984	505	328	278	517	953	458	865	706	825
Percent >366 m				0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.5	68.8	55.7	55.7	78.6	49.2	57.6	40.6	49.9	28.4	54.2	76.0	51.0	59.9	20.3		23.2	62.4	50.8	27.8	13.7	24.5	43.5	38.3	31.2	45	15	41

Table 3. Estimated biomass (tonnes) of Witch flounder (M+F) in each stratum from surveys in Div. 3O during spring of 1984-2018. (Engel 145 data converted to Campelen Units for 1984-95).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
57 - 92	2089	2089	330	0	0	0	0	22	0	0	0	0	0	0	0	0	0	21	121	111	0	0	0	117	129	569	0	278	0	0	875	55	36	294	0	0	0	33
	456	456	331	1912	302	36	18	444	0		0	0	0	0	0	74	0	36	537	28	375	102	0	0	292		1301	425	1124	17	212	81	10	352	20	0	108	225
	1898	1898	338	134	7806	1108	1184	3075	1827	434	0	109	295	0	228	870	0	357	780	183	1354	121	320	1171	646	1675	1016	450	990	769	948	2569	2641	455	804	119	289	794
	1716	1716	340	40	146	0	21	0	0	15	0	147	0	0	0	0	0	0	0	83	0	0	0	0	26	90	0	0	182	0	0	0	4	45	0	0	0	17
	2520	2520	351	688	211	385	222	978	217	109	0	0	0	0	0	0	0	0	21	22	0	0	0	0	0	0	0	65	0	0	21	0	0	0	0	0	0	0
	2580	2580	352	82	951	225	1275	1330	664	1426	40	105	60	40	63	59	100	53	1196	130	53	693	27	628	551	1199	733	555	102	562	791	1754	298	85	30	0	123	262
	1282	1282	353	4519	1122	1067	1609	7208	2486	1637	0	243	209	0	42	23	2	272	2209	1300	469	688	470	572	430	3390	576	529	172	299	1078	2982	1265	1264	413	0	279	2639
93 - 183	1721	1721	329	0	0	0	0	789	48	27	494	0	0	5071	193	0	11	51	240	26	0	0	2209	0	147		559	215	983	559	752	1117	7541	66	495	0	857	122
	1047	1047	332	3779	8589	2485	3367	6829	1485	4599	2426	2182	359	58	1791	1180	235	460	981	407	3025	2458	10236	7945	1075		641	3188	2005	1669	1270	911	9766	4888	629	2120	970	1389
	948	948	337	50	4129	1415	1506	1061	1543	1627	1581	580	675	50	654	330	163	321	879	936	1823	752	715	233	655		333	1211	563	630	198	1958	1007	140	453	1704	766	161
	585	585	339	335	0	16	223	136	0	0	0	0	0	0	0	1	0	0	1	0	5	2	0	0	189	825	4	37	284	2	58	0	14	56	0	0	0	17
	474	474	354	495	105	1231	233	345	47	240	144	149	841	0	0	36	0	226	1062	826	914	553	163	496	640		393	1148	430	147	968	164	378	429	478	56	398	154
184 - 274	151	147	333	10	48	10	0	67	16	129	498	79	80	5196	162	7	109	25	27	30	122	375	63	36	39		27	9	32	20	6	9	42	0	2	155	28	140
	121	121	336	12	7	43	25	63	0	53	492	1374	100	1057	62	180	293	23	47	27	163	598	211	61	51		44	61	16	16	26	10	38	18	15	74	310	3
	103	103	355	45	181	38	71	0	97	126	136	16	34	129	43	86	48	50	18	14	87	193	340	117	12		27	34	67	44	12	26	14	3	24	797	62	11
275 - 366	92	96	334	0	42	42	18	22	23	26	20	108	20	860	15	150	362	4	7	11	2	143	133	29	3		11	5	14	6	6	1	10	4	2	92	2	3
	58	58	335	0	98	18	2	51	22	92	42	1107	65	103	43	78	109	2	62	128	8	8	53	10	11		2	1	4	3	3	17	12	8	0	3	11	1
	61	61	356	5	83	17	23	18	29	55	39	129	77	75	62	40	11	29	23	14	34	38	49	13	18		3	6	6	5	0	4	29	2	9	73	49	7
367 - 549	93	166	717								11	120	35	2375	53	465	4353	44	19	17	41	201	142	5	17		10	12	55	12	6	16	16	7	28		26	9
	76	76	719								148	1024	49	14	18	137	601	15	16	25	12	95	39	3	14		15	11	6	7	38	8	7	3	17	1	8	8
	76	76	721								76	48	31	72	18	16	19	38	37	28	85	38	26	9	4		10	11	25	11	15	6	4	3	0	5	4	0
550 - 731	111	134	718								35	29	104	221	80	71	37	33	38	15	57	55	43	13	13		20	43	157	22	36	18	62	38	24		76	28
	105	105	720								217	134	182	95	15	21	150	32	21	40	38	7	23	9	69		9	9	9	9		4	6	43	6	1	18	8
	93	93	722								18	49	150	217	206	89	87	31	71	47	121	62	64	12	27		11	21	17	15	30	18	8	9	7	11	5	0
732 - 914	.	105	764											60																								
	.	135	772											75																								
Grand Total				12108	23820	8136	9799	22438	8503	10594	6415	7734	3364	15769	3748	3915	6691	2121	8411	4448	8786	7182	15323	11479	5057	7747	5746	8323	7243	4821	7349	11727	23208	8212	3457	5211	4390	6031
Biomass >366 m				0	0	0	0	0	0	0	504	1405	550	3128	390	800	5247	192	201	172	354	459	336	51	144	0	75	107	268	75	124	70	104	102	82	18	137	53
Percent >366 m											7.9	18.2	16.4	19.8	10.4	20.4	78.4	9.1	2.4	3.9	4.0	6.4	2.2	0.4	2.9	0.0	1.3	1.3	3.7	1.6	1.7	0.6	0.4	1.3	2.4	0.4	3	1

Table 4. Abundance (000s) of witch flounder (M+F) in each stratum from surveys in Div. 3N during spring of 1984-2018 (Engel 145 data converted to Campelen units for 1984-95).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
<=56	1593	1593	375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	44	0	44	0	0	0	0		0	0	0	0
	1499	1499	376	0	0	0	26	0	0	0	0	0	0	0	0	0	0	34	34	0	0	0	0	0	0	0	88	0	0	0	0	0	0		0	0	0	0
57 - 92	2992	2992	360	2234	129	728	741	2641	220	0	0	59	224	0	0	0	132	65	224	613	0	0	82	123	1555	480	741	103	0	823	288	165	329	206	0	0	235	1770
	1853	1853	361	153	0	0	32	36	0	28	0	0	0	0	36	0	0	0	0	212	85	0	0	0	36	255	0	51	85	0	203	0	170	64	0	0	0	0
	2520	2520	362	0	95	25	27	173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	173	0	0	0	0	39	0	0		0	0	0	0
	2520	2520	373	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	39	39	0		0	0	0	0
	931	931	374	0	0	0	0	0	0	0	0	0	43	43	0	0	0	0	0	0	0	85	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
	674	674	383	0	62	0	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	46	0	46	0	0		0	0	0	0
93 - 183	421	421	359	405	58	232	58	985	203	0	0	0	29	0	0	0	0	0	203	405	58	29	0	0	695		87	0	1448	1953	3475	608	115	1371	1158	174	6850	39
	100	100	377	14	0	0	186	7	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	55	0		0	0	0	14
	647	647	382	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89		0	0	0	0	0	0	0	45	0	0	0	0
184 - 274	225	225	358	77	557	93	279	31	46	93	0	93	294	232	31	77	83	261	15	41	325	28	296	0	110		681	151	542	303	566	186	330	230	50	1593	312	139
	139	139	378	48	29	48	354	86	115	0	0	96	0	0	0	0	8	0	0	0	8	33	8	0	17		0	0	0	0	19	112	0		17	0	0	0
	182	182	381	25	13	42	163	75	0	25	0	0	0	0	0	0	0	13	0	0	11	0	0	0	0		81	25	33	0	22	51	38	38	438	50	0	0
275 - 366	164	164	357	23	180	553		11	237	56	0	90	124	102	23	40	30	373	259	293	63	55	150	45	0		23	0	23	98	361	317	45	64	180	97	26	0
	106	106	379	66	36	68	423	102	44	109	7	44	0	22	0	0	18	6	102	28	13	0	16	0	40		0	0	7	29	49	284	192	515	7	0	14	0
	116	116	380	8	88	0	247	32	8	8	0	0	0	0	0	0	0	0	8	0	0	0	8	0	0		0	7	0	0	0	54	11	21	8	0	24	16
367 - 549	155	155	723								288	341	256	53	181	45	51	149	96	171	88	322	152	96	313		107	245	33	364	99	107	353	582	199	380	171	64
	105	105	725								166		101	87	0	13	235	26	51	72	19	6	17	0	264		40	10	110	13	26	51	18	154	116	36	147	982
	160	160	727								0	11	55	22	0	0	11	33	33	21	10	0	0	31	68		31	73	0	20	82	77	179	69	11	260	830	275
550 - 731	124	124	724								1134	580	597	188	119	128	432	144	550	500	516	267	283	145	171		645		407	262	176		206	395	55	312	0	111
	72	72	726								213	59	30	114	5	33	183	322	213	198	346	65	134	63	18		59	73	112	238	128	74	62	178	181	202	69	106
	156	156	728								182	21	139	29	172	134		64	158	145	258	136	143	161	64		70	319	1409	383	225	268	326	558	296	469	172	204
732 - 914	.	134	752											37																								
	.	106	756											87																								
	.	154	760											95																								
Grand Total				3053	1246	1837	2595	4180	954	320	1991	1394	1892	1110	567	470	1184	1491	1947	2701	1799	1027	1289	664	3440	981	2696	1057	4299	4484	5844	2446	2374	4489	2716	3573	8849	3719
Abundance >366 m				0	0	0	0	0	0		1984	1013	1178	712	477	353	913	738	1100	1107	1236	797	728	496	898		952	719	2071	1279	737	577	1144	1937	857	1659	1389	1742
Percent >366 m				0.0	0.0	0.0	0.0	0.0	0.0		99.6	72.7	62.3	64.1	84.1	75.0	77.1	49.5	56.5	41.0	68.7	77.6	56.5	74.6	26.1		35.3	68.1	48.2	28.5	12.6	23.6	48.2	43.2	31.6	46.4	15.7	47

Table 5. Abundance (000s) of witch flounder (M+F) in each stratum from surveys in Div. 3O during spring of 1984-2018 (Engel 145 data converted to Campelen units for 1984-95).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
57 - 92	2089	2089	330	0	0	0	0	32	0	0	0	0	0	0	0	0	73	36	210	242	0	0	0	146	205	1490	0	411	0	0	1797	123	82	575	0	0	0	82
	456	456	331	3555	376	94	31	1004	0		0	0	0	0	0	63	0	94	1104	63	721	94	0	0	784	0	2885	1129	2478	63	526	188	28	784	31	0	282	605
	1898	1898	338	209	11894	1509	1944	5418	2480	587	0	131	479	0	305	1417	0	671	1973	348	2263	305	609	2990	2089	5106	1697	870	1915	1480	2166	5669	6397	1044	2089	218	835	2306
	1716	1716	340	59	210	0	26	0	0	52	0	142	0	0	0	0	0	0	0	142	0	0	0	0	47	118	236	0	330	0	0	0	94	79	0	0	0	47
	2520	2520	351	924	231	495	267	1317	240	116	0	0	0	0	0	0	0	0	39	43	0	0	0	0	0	0	0	87	0	0	43	0	0		0	0	0	0
	2580	2580	352	101	1807	431	2048	1839	928	1775	51	89	51	44	71	79	197	35	1814	197	44	1952	44	1183	1065	2484	1198	843	152	1020	1252	4396	532	142	51	0	237	532
	1282	1282	353	9347	1234	1713	2146	13050	3880	2910	0	265	353	0	35	35	265	459	5055	2539	901	831	1102	957	872	7616	794	1058	309	573	2405	6393	2214	2381	823	0	588	8509
93 - 183	1721	1721	329	0	0	0	0	1454	53	34	763	0	0	12263	521	0	35	68	623	47	0	0	5303	0	742		1292	710	2320	1357	1768	2909	18229	158	1231	0	2036	379
	1047	1047	332	11018	16592	6529	7230	16023	2852	10572	4513	5761	504	432	3925	2927	5665	1085	5045	2232	8354	6769	32886	24519	5041		2496	12866	8652	6273	5803	4225	31302	25717	2256	5905	3361	4695
	948	948	337	130	9181	2634	3543	2641	2556	2608	3182	815	2087	87	1239	826	469	848	3709	3260	6738	1826	1565	764	2454		1565	3912	2434	2536	1043	7079	3086	848	1826	3977	2282	522
	585	585	339	443	0	80	268	134	0	0	0	0	0	0	0	161	36	80	36	80	282	241	0	0	443	1753	851	322	1609	80	72	0	282	241	0	0	0	121
	474	474	354	1174	239	3282	456	619	196	359	261	261	1663	0	0	98	33	563	3208	2739	2100	1467	359	913	1960		1239	2282	1043	406	2402	652	1076	1345	1402	65	978	265
184 - 274	151	147	333	21	156	35	0	145	52	332	1361	187	301	13447	425	30	277	140	267	261	576	940	215	225	273		174	72	253	117	54	37	192	30	10	536	149	819
	121	121	336	25	17	175	67	208	0	158	1365	3287	266	3029	125	432	682	150	173	219	583	1273	524	258	368		233	275	214	158	144	33	226	92	50	147	788	25
	103	103	355	92	418	128	135	0	383	510	340	28	99	340	99	168	195	157	38	41	220	569	945	246	57		106	85	173	120	53	74	156	21	50	1884	186	92
275 - 366	92	96	334	0	95	165	63	95	44	51	38	272	63	2238	40	462	880	7	161	167	30	376	533	238	20		69	33	132	71	38	32	53	46	18	255	7	7
	58	58	335	0	203	40	8	148	68	331	109	2340	223	215	108	192	243	12	169	368	60	47	131	35	78		22	7	18	30	57	68	35	60	0	12	52	8
	61	61	356	17	214	38	55	109	80	126	92	348	319	189	126	88	40	90	54	50	67	78	131	25	82		16	15	24	20	10	17	194	17	25	147	88	13
367 - 549	93	166	717								32	371	166	5960	228	1362	11566	710	237	162	273	651	468	46	181		91	117	682	167	59	46	278	85	284		171	175
	76	76	719								288	2535	267	37	42	364	1161	150	112	228	97	268	89	19	131		81	80	28	28	284	102	50	16	74	6	33	91
	76	76	721								235	209	94	193	42	42	63	214	152	112	204	139	84	31	19		60	56	251	26	244	42	52	21	0	10	37	5
550 - 731	111	134	718								282	122	512	1161	535	518	507	517	324	138	525	1189	578	66	177		240	357	2050	345	652	170	1290	387	303		850	359
	105	105	720								361	376	1026	498	43	101	518	186	104	351	309	50	104	41	765		62	75	72	75		22	25	508	53	10	125	65
	93	93	722								45	166	512	518	601	274	819	177	364	207	361	198	210	53	154		176	133	96	106	245	102	73	65	26	61	26	6
732 - 914	.	105	764											217																								
	.	135	772											501																								
Grand Total				27114	42867	17347	18286	44236	13811	20520	13317	17705	8983	41372	8508	9639	23724	6449	24969	14238	24707	19265	45880	32754	18004	18567	15584	25796	25236	15051	21118	32377	65947	34654	10601	13268	13111	19729
Abundance >366 m				0	0	0	0	0	0	0	1243	3779	2576	9086	1491	2661	14634	1954	1293	1198	1769	2495	1533	255	1425	0	711	819	3179	747	1484	483	1769	1081	740	87	1242	702
Percent >366 m				0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	21.3	28.7	22.0	17.5	27.6	61.7	30.3	5.2	8.4	7.2	13.0	3.3	0.8	7.9	0.0	4.6	3.2	12.6	5.0	7.0	1.5	2.7	3.1	7.0	0.7	9.5	4

Table 6. Estimated biomass (tonnes) of Witch flounder (M+F) in each stratum from surveys in Div. 3N during fall of 1990-2018 (Engel 145 data converted to Campelen units for 1990-94).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
<=56	1593	1593	375	0	73		0	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0		0	0	25	0
	1499	1499	376	0	0	0	0	0	14	0	22	0	0	0	0	38	28	0	0	0	0	0	67	0	0	59	202		23	0	303	121
57 - 92	2992	2992	360	265	171	1297	173	75	888	23	427	431	177	535	326	520	586	836	2364	100	0	4788	10335	1627	1311	11991	7294		736	566	542	3515
	1853	1853	361	28	467	463	0	32	0	0	14	0	268	28	170	148	99	0	168	38	584	25	0	410	190	188	78		0	28	228	366
	2520	2520	362	400	221	87	0	0	0	0	0	0	32	0	0	0	136	0	0	40	0	0	46	192	55	70	90		0	31	0	0
	2520	2520	373	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
	931	931	374	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	29	0
	674	674	383	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	27		23	0	0	0
93 - 183	421	421	359	0	0	278	0	0	22	0	0	1213	1	0	121	42	110	139	43	151	192	442	1080	288	398	190	156		523	42	339	56
	100	100	377	0		0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	31	10	94	0		0	0	12	7
	647	647	382	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
184 - 274	225	225	358	0	20	66	24	0	74	0	11	30	19	40	45	0	145	22	107	144	28	141	86	83	104	374	98		0	28	129	83
	139	139	378	0	41	15	0	0	0	0	1	0	0	0	3	5	0	0	0	93	4	7	4		22	56	191		446	24	11	11
	182	182	381		0		0	0	0	0	1	0	0	0	7	0	0	0	0	0	0	0	3	0	0	0	0		0	0	0	0
275 - 366	164	164	357	0	234	9	187	43	85	0	27	0		52	18	21	41	27	37	103	59	90	17	39	5	93	31		166	7	17	25
	106	106	379	4		4	0	0	0	1	7	0	0	2	111	33	8	867	0	3	0	156	13	29	662	18	4		40	6	55	0
	116	116	380		0		0	0	0	0	0	1	2	5	0	0	0	9	11	0	0	0	0	0	0	0	0		12	0	0	3
367 - 549	155	155	723		41		163	180	57	15	28	74	27	28	66	16	123	20	98	38	17	98	93	27	62	37	38		1278	4	42	7
	105	105	725			15	376	46	19	0	135	10	33	19	7	5	10		7	7	11	21	40		12	12	71		83	17	600	43
	160	160	727				0	38	0	0	29	7	4	0	10	0	0	7	21	0	0	143	82	21	22	32	17		70	0	45	77
550 - 731	124	124	724		172		414	180	104	60	197	72	181	87	70	90		70	95	206	127	455	204	117	143	72	79		10	40	36	24
	72	72	726				310	54	48	40	21	38	34	16	22	59	52	32	19	49	45	42	105	6	17	23	4		57	53	149	309
	156	156	728					153	35	21	76	78	106	153	103	286	178	93	19	122	191	269	404	434	51	125	213		108	145	0	222
732 - 914	.	134	752									120		23	0	1					6											
	.	106	756									124		51	83	9			82		67											
	.	154	760									88		41	78	173			18		110		221									
915 -1097	.	138	753									0		0	0	3					0											
	.	102	757									0		0	37	7			0		0											
	.	171	761									46		147	42	10			118		7		102									
1098 -1280	.	180	754									0		0	0	0					0			0								
	.	99	758									0		0	0	0			0		0											
	.	212	762											0	109	0			15		28		40									
1281 -1463	.	385	755									0		0	0	0					0											
	.	127	759									0		0	2	0			0		0											
	.	261	763											19	5	10			0		0		3									
Grand Total				696	1441	2235	1647	808	1346	160	993	2333	884	1244	1435	1511	1516	2122	3221	1093	1475	6703	12986	3306	3064	13432	8590		3575	991	2563	4869
Biomass >366 m				0	213	15	1263	651	263	137	485	657	385	582	634	669	363	222	491	423	609	1029	1294	606	307	300	420		1606	259	872	682
Percent >366 m				0.0	14.8	0.7	76.7	80.5	19.5	85.6	48.8	28.2	43.5	46.8	44.2	44.3	23.9	10.5	15.2	38.7	41.3	15.4	10.0	18.3	10.0	11.4	4.9		44.9	26.1	34.0	14

Table 7. Estimated biomass (tonnes) of witch flounder (M+F) in each stratum from surveys in Div. 3O during fall of 1990-2018 (Engel 145 data converted to Campelen units for 1990-94).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
57 - 92	2089	2089	330	122	67	79	0	0	247	0	72	168	208	48	284	342	438	74	312	383	362	508	1087	344	708	49	837		983.7	431	1100	212
	456	456	331	22	315	134	0	0	108	0	0	256	946	243	468	775	306	14	394	108	144	114	564	1219	793	75	688		83.43	48	102	31
	1898	1898	338	2226	438	837	3966	2193	4684	503	1329	483	2736	375	943	976	2666	3899	1931	604	543	1407	2044	5483	2554	643	1222		884.1	231	831	403
	1716	1716	340	173	280	63	0	0	204	0	22	0	415	104	172	123	57	28	116	654	1	494	116	81	142	575	959		131.7	154	324	23
	2520	2520	351	1690	284	72	0	0	0	0	0	37	205	0	172	0	25	35	54	369	158	165	28	75	65	234	0		33.67	89	0	120
	2580	2580	352	1415	896	1352	946	228	379	273	573	374	1491	920	430	789	964	3377	1663	1109	558	1409	5915	2305	2597	1335	1635		475.6	63	880	3423
	1282	1282	353	2405	343	477	0	732	538	789	168	1066	2996	2379	1360	1490	1204	2657	3710	1587	1121	1431	8037	8234	3098	4323	1446		1204	3689	731	271
93 - 183	1721	1721	329	99	85	0	18	0	417	0	173	305	0	0	282	732	97	484	250	2974	0	4484	1977	171	1616	1518	1096		0	465	121	275
	1047	1047	332	2102	155	1724	813	321	1114	4569	190	245	1664	544	343	1155	807	1512	2061	3887	708	2453	500	1393	284	3372	283		485.4	963	924	690
	948	948	337	1333	188	954	563	2132	421	492	322	479	978	344	67	211	352	114	1721	190	576	1592	352	989	158	328	150		222.1	100	213	700
	585	585	339	1132	224	651	119	742	1911	0	481	261		344	338	1927	457	3755	1854	1070	1060	1147	2405	2693	2359	882	320		1273	489	891	303
	474	474	354	1291	23	316	75	210	191	4647	215	201	103	766	258	470	967	438	316	505	694	306	1320	544	312	78	294		531.4	65	369	23
184 - 274	151	147	333	221	11	22	30	92	26		4	6	33	4	20	17	48	0	3	24	3	2	5	6	14	0	3		1.314	6	19	119
	121	121	336	82	151	76	298	13	35	32	19	19	67	31	37	23	10	5	35	3	53	142		22	18	8	13		17.48		32	18
	103	103	355		497	93	120	25	16	343	6	14	110	35	5	6	6	21	2	5	17	72	23	20	15	41	3		1.862	8	2	3
275 - 366	92	96	334	24	16	0	9	17	4		5	1	7	5	14	9	8	0	16	0	0	0	10	2	4	4	8		0.198	12	1	5
	58	58	335	194	25	25	30	18	1	23	0	1	23	8	3	9	1	5	3	3	1	6	0	0	0	7	0		0.816	1	2	0
	61	61	356		11	7	430	98	7	60	3	4	32	22	7	3	6	2	7	0	0	0	10	1	8	4	3		0		1	0
367 - 549	93	166	717	30			0	32	37		12	42	260	0	13	11	54	9	2	14	9	102	40	14	37	52	59		16.96	8	45	27
	76	76	719	110	2		65	6	1	226	19	9	10	14	29	6	15	3	6	10	4	8	16	4	8	0	12		6.9	14	6	3
	76	76	721		18		169	67	21	54	6	14	67	17	2	14	17	2	15	3	30	11	1	7	8	13	2		2.987	1	5	4
550 - 731	111	134	718				22	68	8		68	47	53	34	50	54	161	48	130		68	162	80	110	63	50	11		95.08	23	149	29
	105	105	720				73	0	13	68		2	17	4	83	26	31	10	39	1	1	12	1	4	10	0	20		63.15	17	17	24
	93	93	722		9		81	21	14	39	12	12	26	8	15	5	7	14	29	8	9	11	15	11	4	8	13		11.27	1		
732 - 914	.	105	764									75		12	21	36			4		11		41									
	.	99	768									18		7	18	38			4		1		5									
	.	135	772									173		62		49	29		50		22		26									
915 -1097	.	124	765									24		3	20	55			10		11		25									
	.	138	769									17		5	28	59			20		16		26									
	.	128	773									4		13	32	89	12		8		10		5									
1098 -1280	.	144	766											24	2	37			57		24		29									
	.	128	770											4	23	67			13		16		2									
	.	135	774											4	31	15	27		43		4		0									
1281 -1463	.	158	767											15	0	0			0		3		2									
	.	175	771											0	17	0			10		0		0									
	.	155	775											0	0	0	28		21		3		13									
Grand Total				14671	4036	6884	7827	7013	10397	12117	3698	4356	12446	6396	5586	9619	8798	16510	14911	13512	6240	16036	24721	23733	14876	13601	9077		6526	6878	6766	6706
Biomass >366 m				140	29	0	410	193	95	386	116	436	433	224	384	562	381	87	460	35	241	306	328	150	131	124	116		196	64	222	88
Percent >366 m				1.0	0.7	0.0	5.2	2.8	0.9	3.2	3.1	10.0	3.5	3.5	6.9	5.8	4.3	0.5	3.1	0.3	3.9	1.9	1.3	0.6	0.9	0.9	1.3		3.0	0.9	3.3	1.3

Table 8. Abundance (000s) of witch flounder (M+F) in each stratum from surveys in Div. 3N during fall of 1990-2018 (Engel 145 data converted to Campelen units for 1990-94).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
<=56	1593	1593	375	0	55		0	0	0	0	0	0	0	0	0	55	0	0	0	0	0	0	0	0	0	0	0		0	0	55	0
	1499	1499	376	0	0	0	0	0	23	0	19	0	0	0	0	59	59	0	0	0	0	0	69	0	0	103	258		52	0	464	103
57 - 92	2992	2992	360	382	206	1646	320	103	1232	41	672	755	360	926	514	1080	1022	1132	4888	154	0	9290	17639	3224	2381	22490	17384		1286	1029	978	6380
	1853	1853	361	32	425	701	0	42	0	0	23	0	306	51	204	255	102	0	211	51	1020	85	0	561	249	262	153		0	51	408	663
	2520	2520	362	441	277	116	0	0	0	0	0	0	50	0	0	0	198	0	0	50	0	0	58	297	99	149	149		0	50	0	0
	2520	2520	373	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
	931	931	374	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	43	0
	674	674	383	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	0	93		46	0	0	0
93 - 183	421	421	359	0	0	608	0	0	87	0	0	2722	29	0	405	116	232	203	87	145	524	1216	2635	869	956	331	270		844	58	434	116
	100	100	377	0		0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	44	21	110	0		0	0	14	7
	647	647	382	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
184 - 274	225	225	358	0	46	108	31	0	234	0	31	93	46	69	136	0	307	31	251	252	31	230	190	174	155	650	120		0	58	234	185
	139	139	378	0	105	19	0	0	0	0	8	10	0	0	8	10	0	0	0	200	9	19	8		38	112	359		765	51	19	19
	182	182	381		0		0	0	0	0	7	13	0	0	11	0	0	0	0	0	0	0	11	0	0	0	0		0	0	0	0
275 - 366	164	164	357	0	384	23	338	135	180	0	60	0		124	33	20	102	34	98	242	116	259	29	72	11	143	68		346	11	35	50
	106	106	379	7		15	0	0	0	19	22	0	0	6	296	91	26	1915	13	6	15	350	24	81	1500	51	10		87	10	101	0
	116	116	380		0		0	0	0	0	0	8	8	24	0	0	0	16	24	0	0	0	0	0	0	0	0		24	7	0	14
367 - 549	155	155	723		53		330	394	117	21	88	313	85	104	190	57	347	43	299	72	38	227	239	94	153	87	96		2644	117	91	11
	105	105	725			36	701	173	49	0	237	29	101	71	22	14	29		21	15	32	58	91		37	29	155		166	39	1297	117
	160	160	727				0	44	11	0	55	11	11	0	13	0	11	11	59	0	0	307	163	66	57	77	33		127	0	78	132
550 - 731	124	124	724		443		1126	512	223	178	571	326	640	337	264	270		177	247	629	384	1651	771	381	432	245	213		26	119	102	92
	72	72	726				669	114	119	99	40	92	125	40	37	176	129	84	42	106	125	102	91	20	44	78	11		116	113	278	566
	156	156	728					268	195	129	212	215	311	417	223	633	351	161	73	204	343	428	303	860	118	245	354		204	230	311	335
732 - 914	.	134	752									165		28	0	74					9											
	.	106	756									255		149	182	22			175		185											
	.	154	760									244		229	409	530			53		339		618									
915 -1097	.	138	753									0		9	0	33					0											
	.	102	757									0		0	96	92			7		0											
	.	171	761									106		578	202	24			412		24		277									
1098 -1280	.	180	754									0		0	0	12					0			0								
	.	99	758									0		0	0	8			0		0											
	.	212	762											0	483	0			58		97		204									
1281 -1463	.	385	755									0		0	0	0					0											
	.	127	759									0		0	9	0			0		0											
	.	261	763											72	18	88			0		0		18									
Grand Total				863	1995	3272	3515	1793	2470	488	2046	5355	2073	3233	3756	3717	2912	3806	7017	2126	3289	14269	23473	6742	6251	25163	19725		6732	1943	4943	8789
Abundance >366 m				0	497	36	2825	1506	714	427	1203	1755	1274	2033	2148	2032	866	475	1446	1026	1575	2773	2775	1421	841	762	863		3282	618	2158	1253
Percent >366 m				0.0	24.9	1.1	80.4	84.0	28.9	87.6	58.8	32.8	61.5	62.9	57.2	54.7	29.7	12.5	20.6	48.3	47.9	19.4	11.8	21.1	13.5	3.0	4.4		48.8	31.8	43.7	14.3

Table 9. Abundance (000s) of witch flounder (M+F) in each stratum from surveys in Div. 3O during fall of 1990-2018 (Engel 145 data converted to Campelen units for 1990-94).

Depth Range (m)	Old Stratum Area	New Stratum Area	Stratum	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
57 - 92	2089	2089	330	131	144	72	0	0	517	0	96	335	383	192	575	588	766	123	479	718	671	1149	2062	899	1197	144	2086		2402	1006	2477	527
	456	456	331	42	502	125	0	0	408	0	0	596	4799	533	1066	1850	1004	31	1098	345	439	345	1296	3907	2729	215	2164		220	125	251	63
	1898	1898	338	3264	627	1436	6893	4700	8459	522	2872	1723	7572	609	1984	2245	6893	11652	4774	1567	1044	3220	5817	13606	7989	1816	3290		2141	574	2350	835
	1716	1716	340	262	330	118	0	0	295	0	47	0	1652	189	378	189	94	47	243	1416	47	1014	320	140	236	1054	2041		202	330	755	47
	2520	2520	351	1837	347	58	0	0	0	0	0	50	347	0	198	0	50	50	99	495	297	231	99	154	99	347	0		50	149	50	198
	2580	2580	352	1597	1242	2011	1115	355	371	355	1141	754	1825	1668	1065	1448	2296	6584	2484	1787	811	2419	11915	3712	4817	2789	2563		862	152	2339	6186
	1282	1282	353	2822	485	941	0	1176	999	882	573	5467	5996	6172	2954	9523	3395	5291	6525	3357	1950	2469	16690	17768	7186	11243	4144		2381	6922	1631	1209
93 - 183	1721	1721	329	132	101	0	47	0	663	0	616	852	0	0	805	1989	379	703	710	8181	0	10750	6155	300	4972	4856	2736		0	1184	237	758
	1047	1047	332	3625	396	5281	2064	960	5233	11954	1248	2544	7393	3249	1392	4342	3738	6145	8381	13093	2939	8910	2603	5770	1509	14968	1632		2016	3649	3601	2785
	948	948	337	2347	424	2347	1043	5216	1434	717	1130	1613	3738	1623	348	714	1434	397	5067	696	1956	3775	1546	4482	782	1198	729		609	391	782	2434
	585	585	339	1556	241	724	121	966	2776	0	1086	356		3943	563	3822	684	7559	4507	2374	4064	2070	4529	5754	4547	1927	885		2052	885	1742	966
	474	474	354	1891	33	685	359	424	489	8955	489	782	391	2478	630	1415	1989	1150	978	1206	2195	663	4492	1992	978	261	978		1304	359	2305	98
184 - 274	151	147	333	582	52	83	62	312	187		192	147	152	27	118	90	243	30	51	153	81	108	27	54	57	30	18		10	73	152	870
	121	121	336	222	466	216	633	42	549	208	100	215	300	141	150	58	75	50	300	150	422	518		72	83	50	72		50		164	166
	103	103	355		1459	298	425	85	63	768	28	170	411	85	21	28	21	92	35	27	50	246	94	64	50	101	16		8	28	99	14
275 - 366	92	96	334	76	70	0	21	57	56		33	20	58	18	36	35	53	65	122	0	7	0	24	18	65	75	47		40	32	13	36
	58	58	335	371	100	112	68	52	64	64	4	40	48	37	8	39	12	18	7	24	18	18	0	11	0	27	0		7	4	27	4
	61	61	356		25	8	1254	252	40	113	13	34	75	55	19	17	34	31	45	0	7	0	37	4	56	8	4		0	0	18	4
367 - 549	93	166	717	122			0	96	703		46	833	2166	0	91	203	351	117	10	93	41	1214	360	100	340	670	434		91	157	449	161
	76	76	719	209	42		277	10	52	612	183	178	99	75	183	37	96	96	78	95	14	41	167	50	43	12	132		47	58	63	33
	76	76	721		47		444	183	102	131	17	125	311	98	10	84	81	11	135	9	273	68	19	62	38	161	24		30	10	40	125
550 - 731	111	134	718				107	428	164		535	618	581	396	488	1432	1483	575	1040		479	2013	959	1039	507	489	126		1155	374	1559	180
	105	105	720				339	0	105	316		29	202	39	762	298	302	206	336	6	6	141	7	14	31	0	165		581	116	162	195
	93	93	722		26		243	58	64	134	51	103	122	70	94	34	50	90	199	51	61	117	89	65	77	44	128		41	19		
732 - 914	.	105	764									357		72	144	217			29		72		355									
	.	99	768									217		24	163	374			34		6		34									
	.	135	772									1514		669		383	190		390		111		162									
915 -1097	.	124	765									165		31	119	289			77		64		157									
	.	138	769									180		38	237	380			142		133		218									
	.	128	773									35		136	346	708	94		62		79		37									
1098 -1280	.	144	766											113	11	146			307		158		188									
	.	128	770											36	185	460			88		132		18									
	.	135	774											28	241	119	244		297		35		0									
1281 -1463	.	158	767											65	0	0			0		10		12									
	.	175	771											0	132	0			60		0		0									
	.	155	775											0	0	0	213		107		28		96									
Grand Total				21086	7158	14515	15517	15369	23795	25731	10499	20054	38620	22908	15520	33557	26262	41114	39294	35843	18702	41498	60585	60036	38388	42483	24415.3		16298	16597	21267	17893
Abundance >366 m				331	114	0	1411	774	1191	1193	831	4354	3480	1890	3210	5163	3103	1095	3390	254	1704	3593	2879	1331	1036	1376	1009.3		1945	734	2274	694
Percent >366 m				1.6	1.6	0.0	9.1	5.0	5.0	4.6	7.9	21.7	9.0	8.3	20.7	15.4	11.8	2.7	8.6	0.7	9.1	8.7	4.8	2.2	2.7	3.2	4.1		11.9	4.4	10.7	3.9

Table10. Projected yield (t) and the risk of F> F_{lim}, B<B_{lim} and B<B_{MSY} and probability of stock growth (B2022>B2019) under projected F values of F=0, F2018, 2/3 F_{MSY}, 85% F_{MSY}, and F_{MSY}.

Projections with catch in 2019 = 1 175 t											
	Yield 2020	Yield 2021	P(F>F_{lim})		P(B<B_{lim})			P(B<B_{MSY})			P(B_{2022}>B_{2019})
			2020	2021	2020	2021	2022	2020	2021	2022	
F=0	0	0	0	0	18%	13%	10%	96%	94%	91%	73%
F2018=0.0229	745	792	4%	4%	18%	15%	13%	96%	94%	92%	67%
2/3 Fmsy=0.042	1081	1144	18%	19%	18%	16%	14%	96%	94%	92%	65%
85%Fmsy=0.054	1379	1443	36%	36%	18%	17%	16%	96%	94%	93%	63%
Fmsy=0.063	1622	1681	50%	50%	18%	18%	17%	96%	95%	93%	61%

Projections with catch in 2019 = 662 t											
	Yield 2020	Yield 2021	P(F>F_{lim})		P(B<B_{lim})			P(B<B_{MSY})			P(B_{2022}>B_{2019})
			2020	2021	2020	2021	2022	2020	2021	2022	
F=0	0	0	0	0	16%	12%	8%	96%	93%	91%	75%
F2018=0.0229	760	808	4%	4%	16%	14%	12%	96%	94%	92%	69%
2/3 Fmsy=0.042	1102	1166	17%	18%	15%	15%	13%	96%	94%	92%	67%
85%Fmsy=0.054	1405	1470	35%	36%	16%	15%	15%	96%	94%	92%	65%
Fmsy=0.063	1653	1713	50%	50%	16%	16%	16%	96%	94%	93%	63%

Table 11. Medium-term projections for witch flounder under two different assumptions of catch in 2019. The 5th, 50th and 95th percentiles of catch and relative biomass B/B_{msy}, are shown, for projected F values of $F=0$, F_{2018}, 2/3 F_{msy}, 85% F_{msy} and F_{ms}

	Projections with catch in 2019 = 1 175 t	
	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
F=0	Median	Median (80% CI)
2020	0	0.44 (0.26, 0.79)
2021	0	0.48 (0.28, 0.88)
2022		0.52 (0.30, 0.97)
F_{2018}=0.029	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	745	0.44 (0.26, 0.79)
2021	792	0.47 (0.27, 0.86)
2022		0.50 (0.28, 0.94)
2/3 F_{msy}=0.042	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	1081	0.44 (0.26, 0.79)
2021	1144	0.46 (0.26, 0.86)
2022		0.48 (0.27, 0.92)
85% F_{msy}=0.054	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	1379	0.44 (0.26, 0.79)
2021	1443	0.46 (0.26, 0.85)
2022		0.47 (0.26, 0.91)
F_{msy}=0.063	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	1622	0.44 (0.26, 0.79)
2021	1681	0.45 (0.25, 0.85)
2022		0.46 (0.25, 0.90)

	Projections with catch in 2019 = 662 t	
	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
F=0	Median	Median (80% CI)
2020	0	0.45 (0.26, 0.80)
2021	0	0.49 (0.29, 0.89)
2022		0.53 (0.31, 0.98)
F_{2018}=0.029	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	760	0.45 (0.26, 0.80)
2021	808	0.47 (0.28, 0.88)
2022		0.50 (0.29, 0.95)
2/3 F_{msy}=0.042	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	1102	0.45 (0.26, 0.80)
2021	1166	0.47 (0.27, 0.87)
2022		0.49 (0.28, 0.93)
85% F_{msy}=0.054	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	1495	0.45 (0.26, 0.80)
2021	1470	0.46 (0.27, 0.86)
2022		0.48 (0.27, 0.92)
F_{msy}=0.063	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
2020	1653	0.45 (0.26, 0.80)
2021	1713	0.46 (0.26, 0.86)
2022		0.47 (0.26, 0.91)

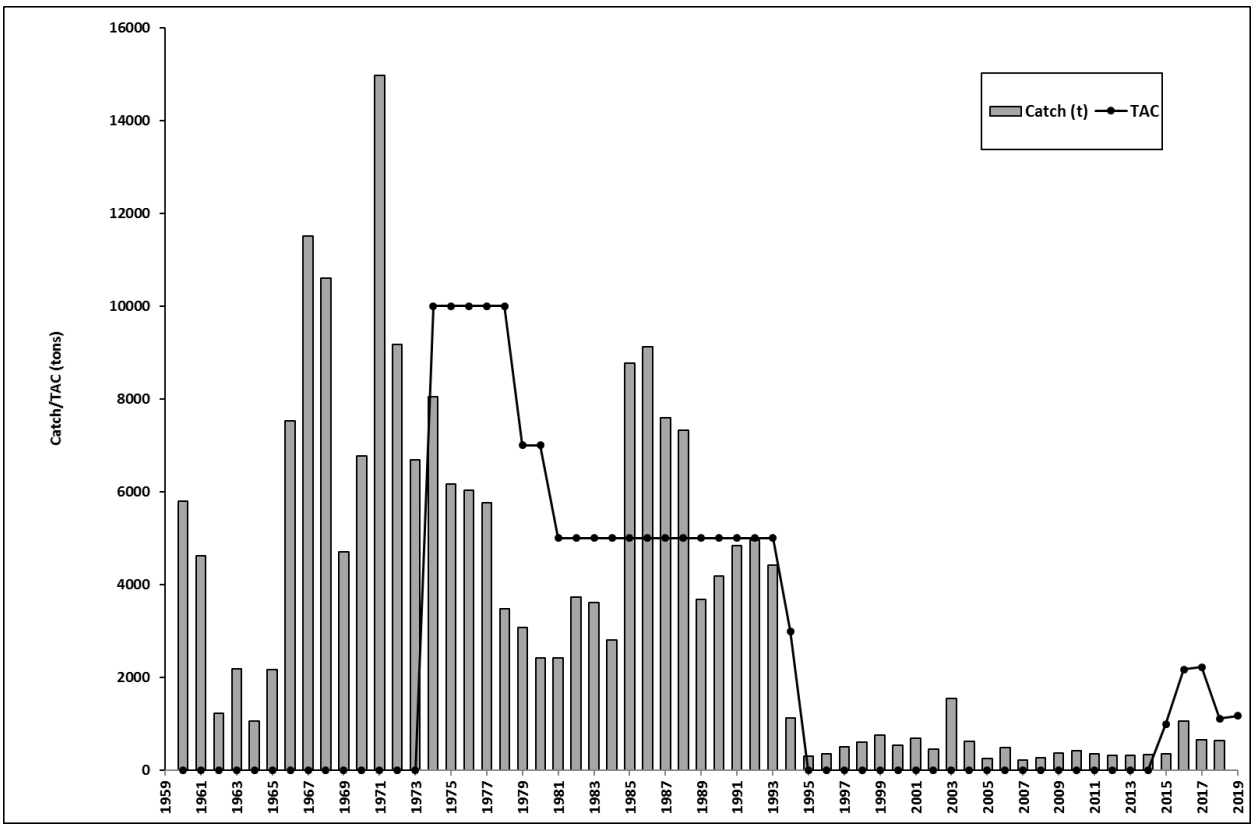

Figure 1. Commercial catch of witch flounder in NAFO Divs. 3NO from 1960-2018 and total allowable catch (TACs).

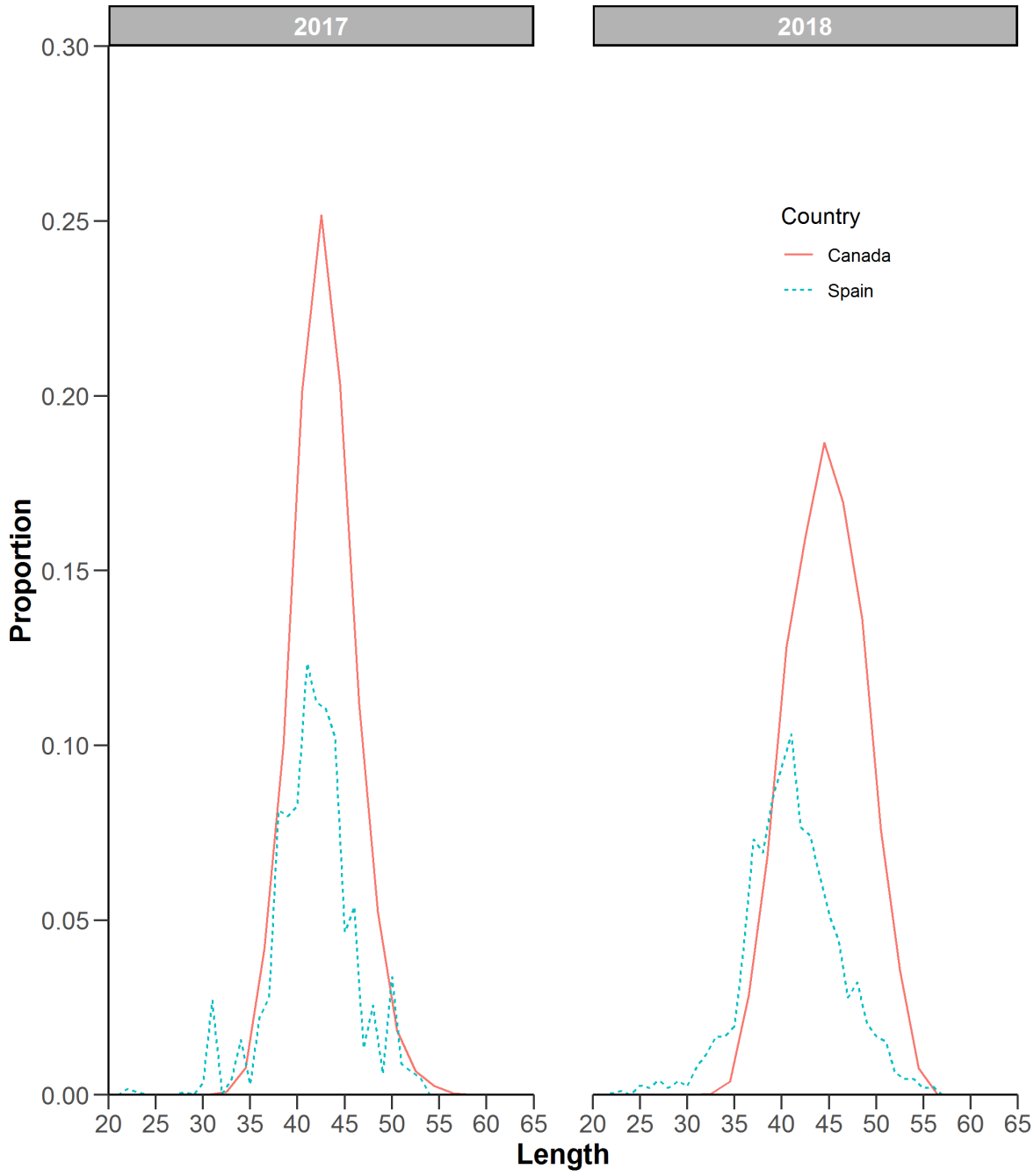

Figure 2. Witch flounder length frequency (cm) distributions for Spain and Canada commercial fisheries in NAFO Divs. 3NO in 2017 and 2018.

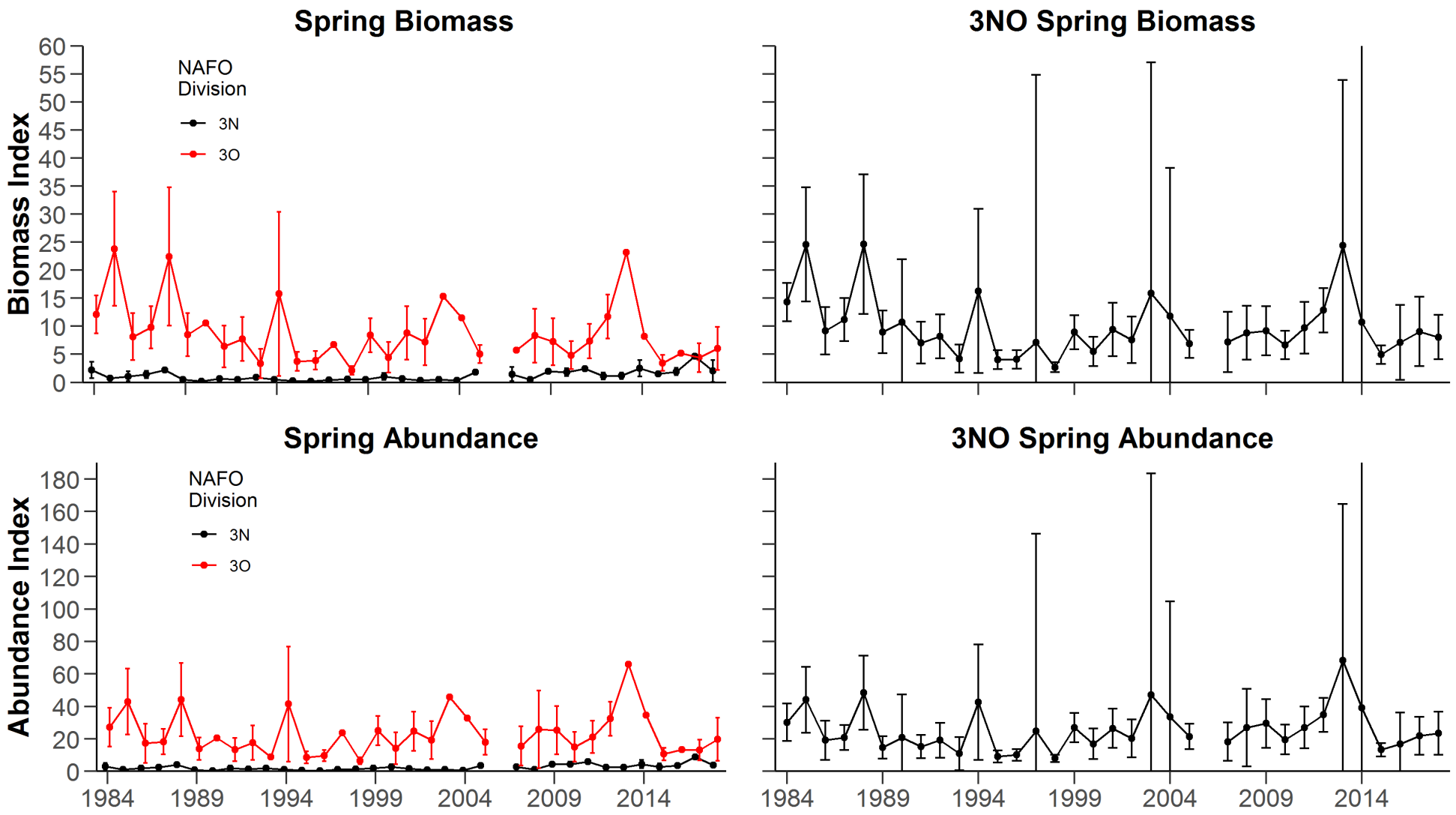

Figure 3. Biomass ('000s tons), abundance (millions), with associated 95% confidence intervals, for witch flounder from Canadian spring RV surveys in NAFO Divs. 3N and 3O during 1984-2018. No data was available for spring 2006.

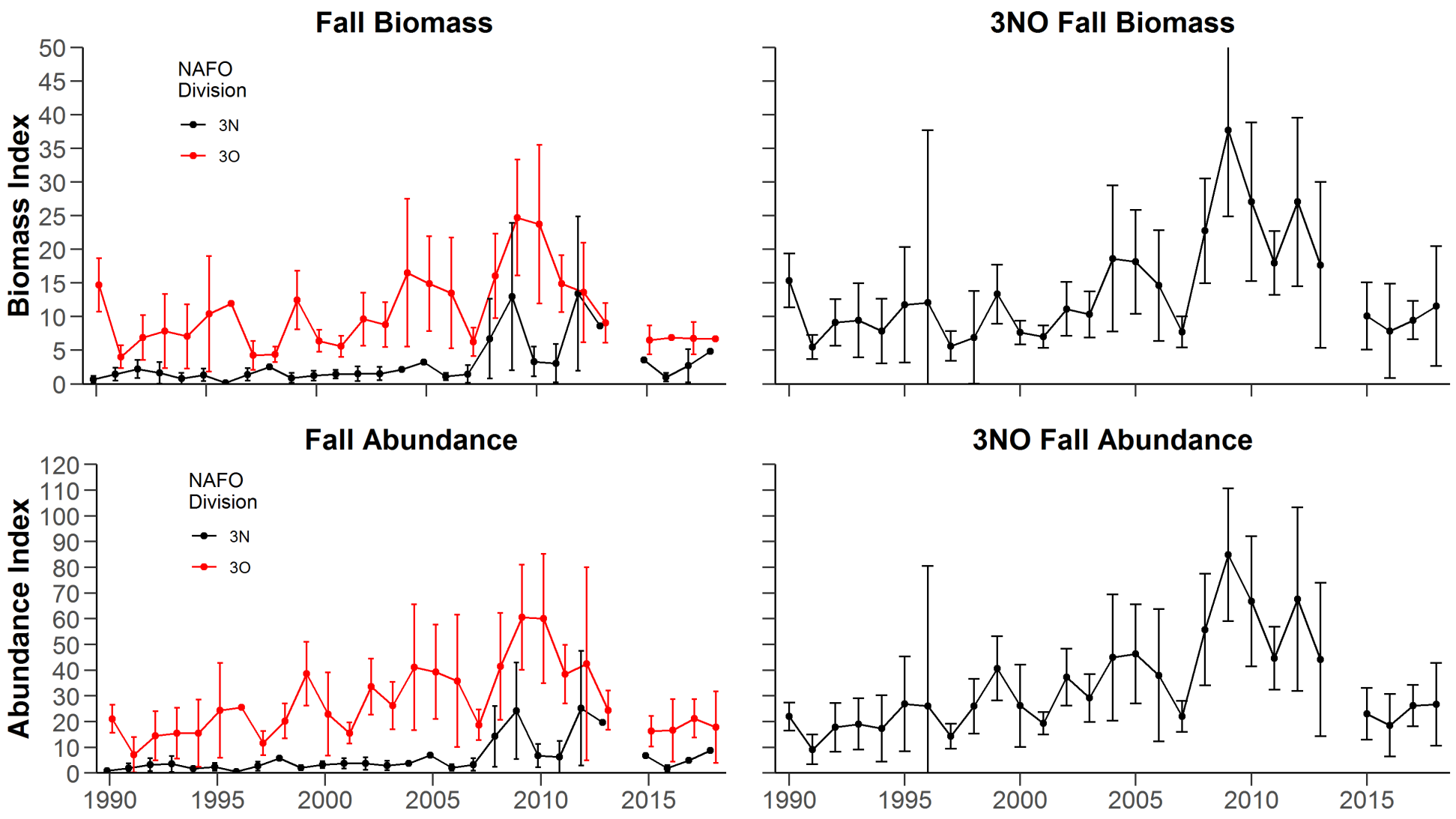

Figure 4. Biomass ('000s tons), abundance (millions), with associated 95% confidence intervals, for witch flounder from Canadian fall RV surveys in NAFO Divs. 3N and 3O during 1984-2018. No data was available for fall 2014.

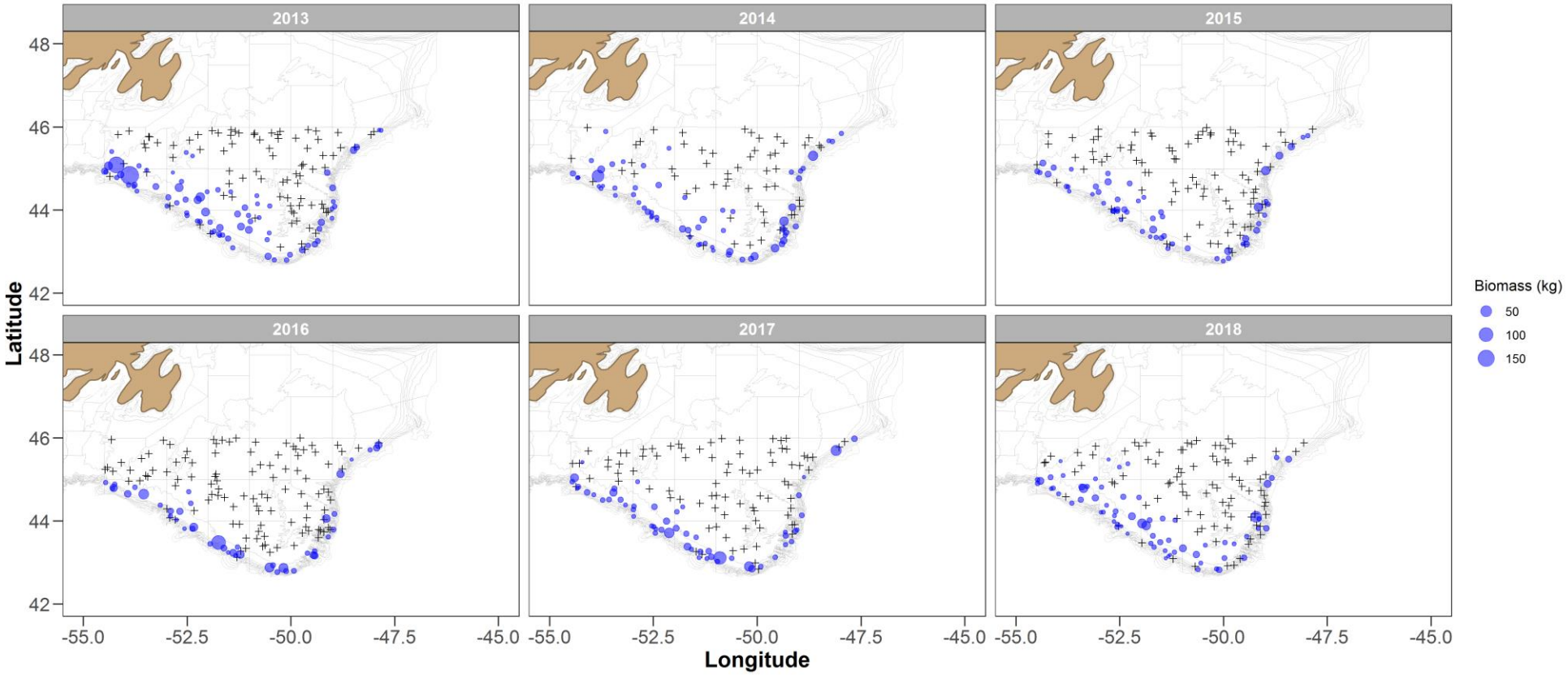

Figure 5. Distribution of witch flounder (total weight (kg) per tow) from Canadian spring RV surveys in NAFO Divs. 3NO from 2013 to 2018.

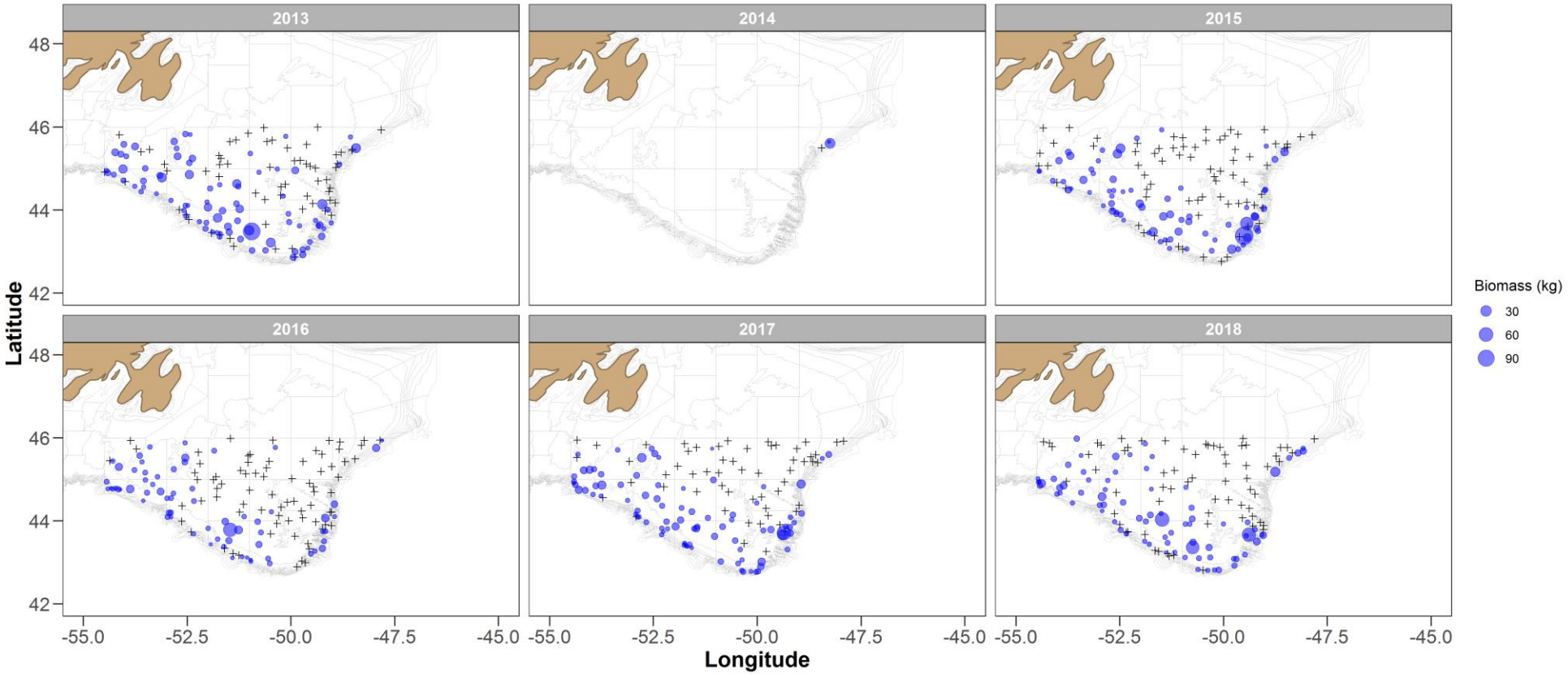

Figure 6. Distribution of witch flounder (total weight (kg) per tow) from Canadian fall RV surveys in NAFO Divs. 3NO from 2013 to 2018 (note there was no fall survey in 2014).

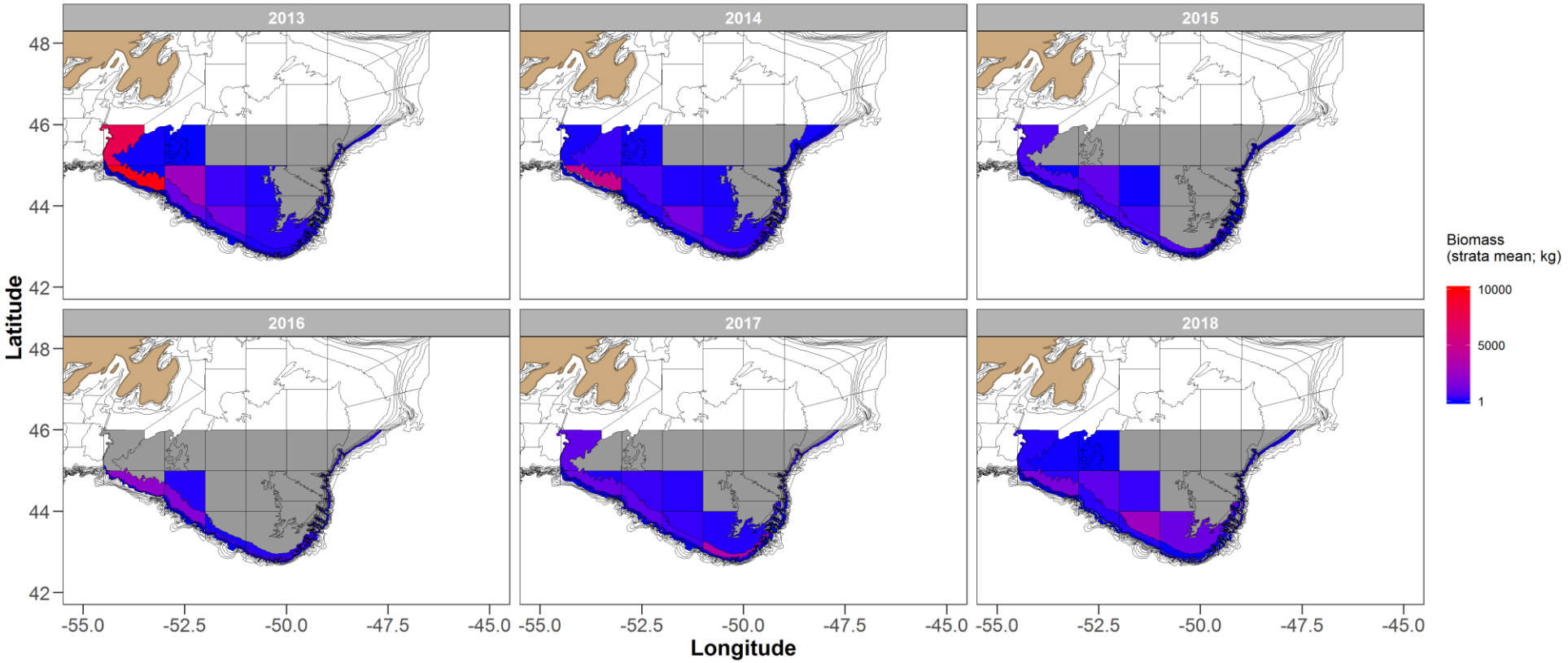

Figure 7. Distribution of witch flounder biomass (t) from Canadian spring RV surveys in NAFO Divs. 3NO from 2013 to 2018.

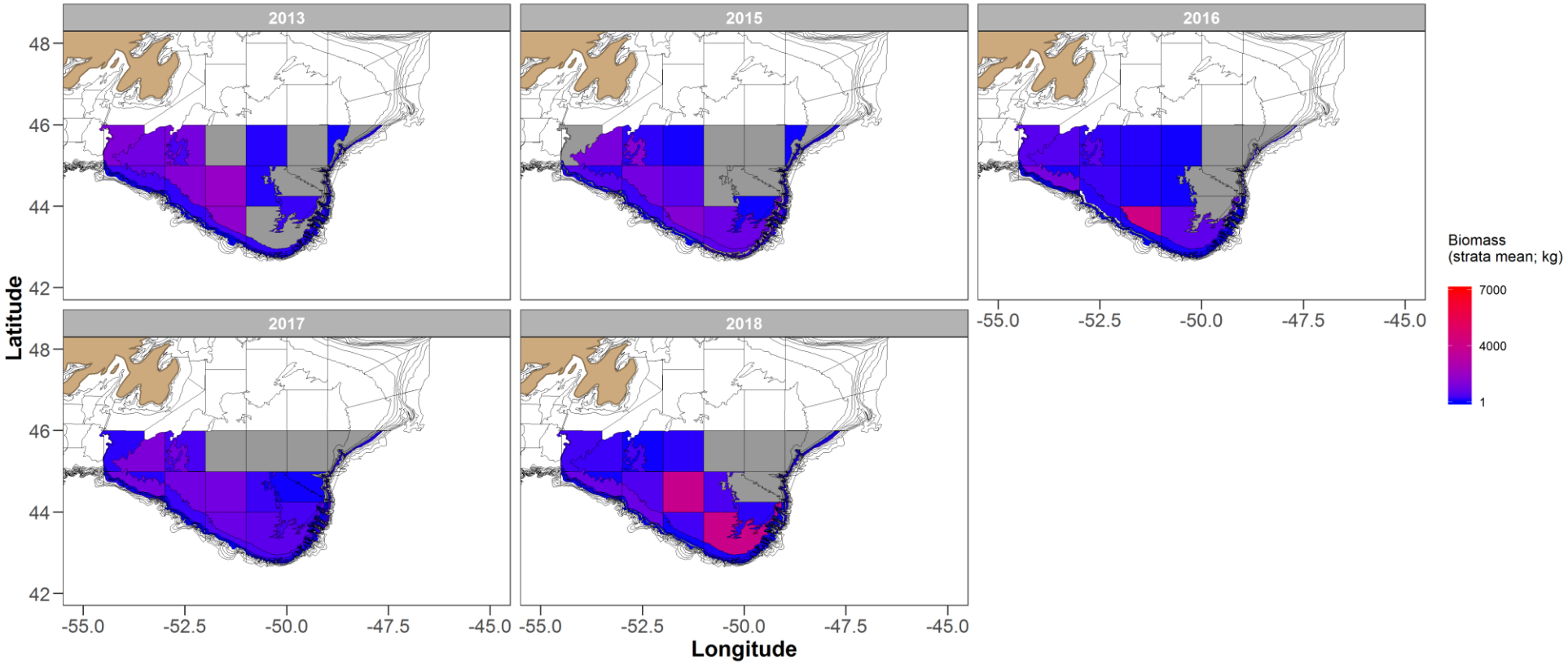

Figure 8. Distribution of witch flounder biomass (t) from Canadian fall RV surveys in NAFO Divs. 3NO from 2013 to 2018 (note there was no fall survey in 2014).

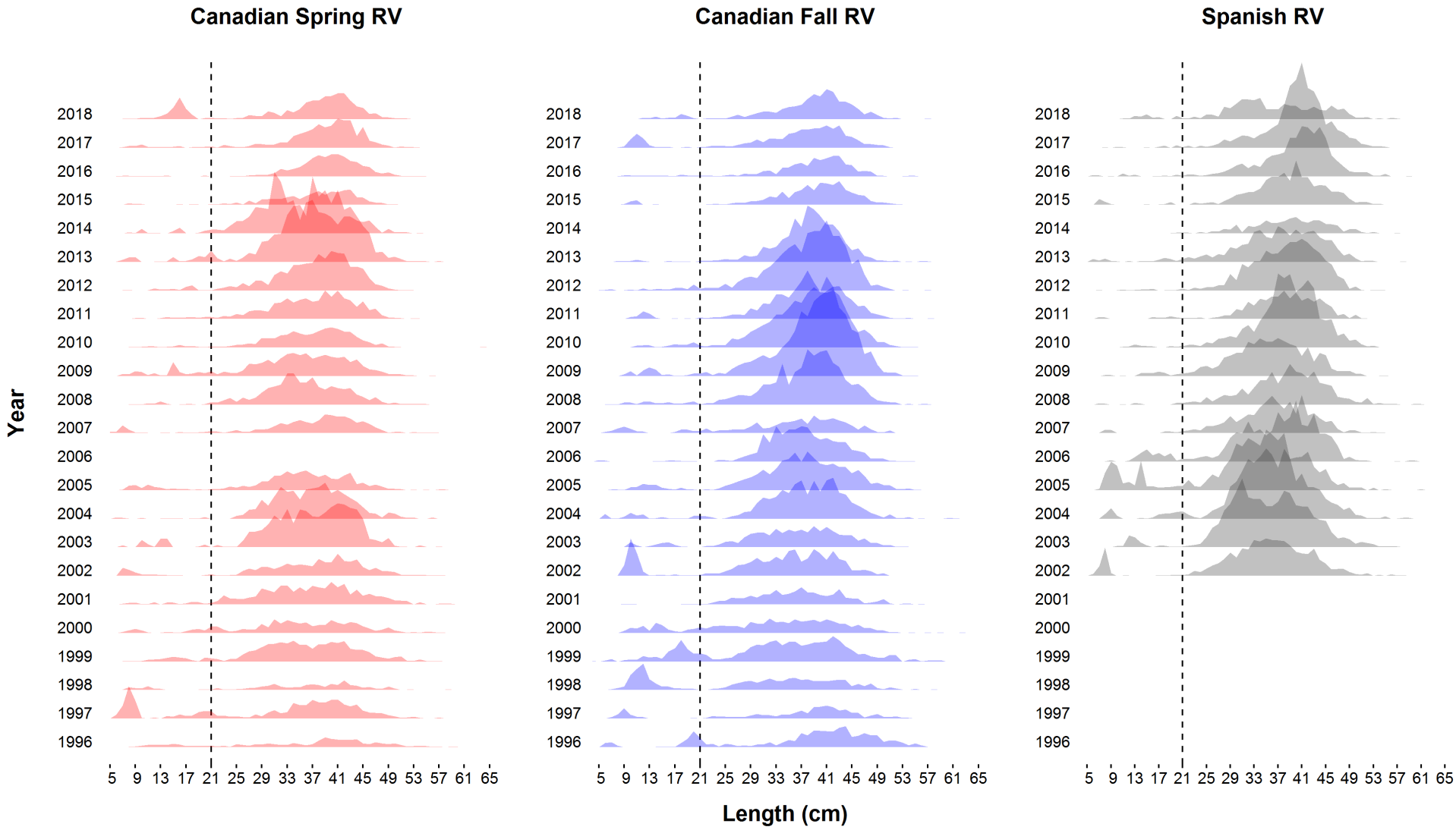

Figure 9. Length frequency distributions of witch flounder from Canadian spring and fall and Spanish spring surveys (2002-2018) using the Campelen 1800 shrimp trawl. Estimates represent abundance at length (cm) of the surveyed area. All distributions are for NAFO Divs. 3NO combined.

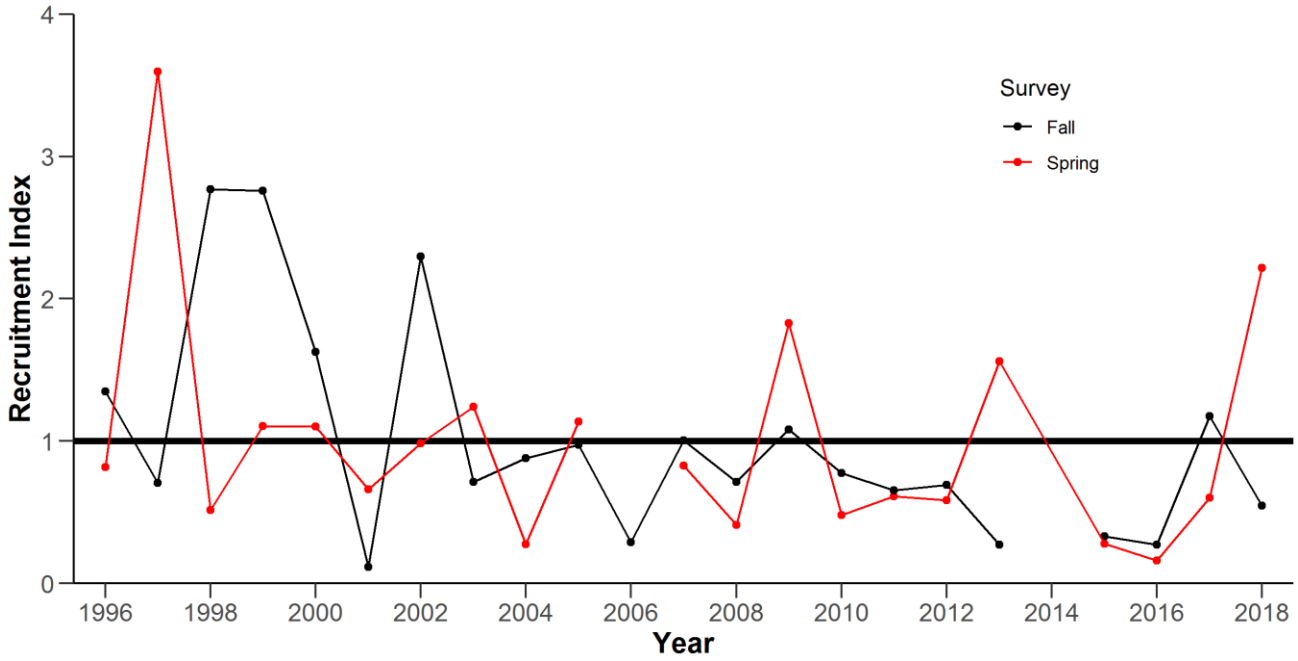

Figure 10. Recruitment index means proportioned to 1 of witch flounder <21cm in length from spring and fall Canadian RV surveys in NAFO Divs. 3NO 1996-2017. Note there was no fall survey in 2014 or spring survey in 2006.

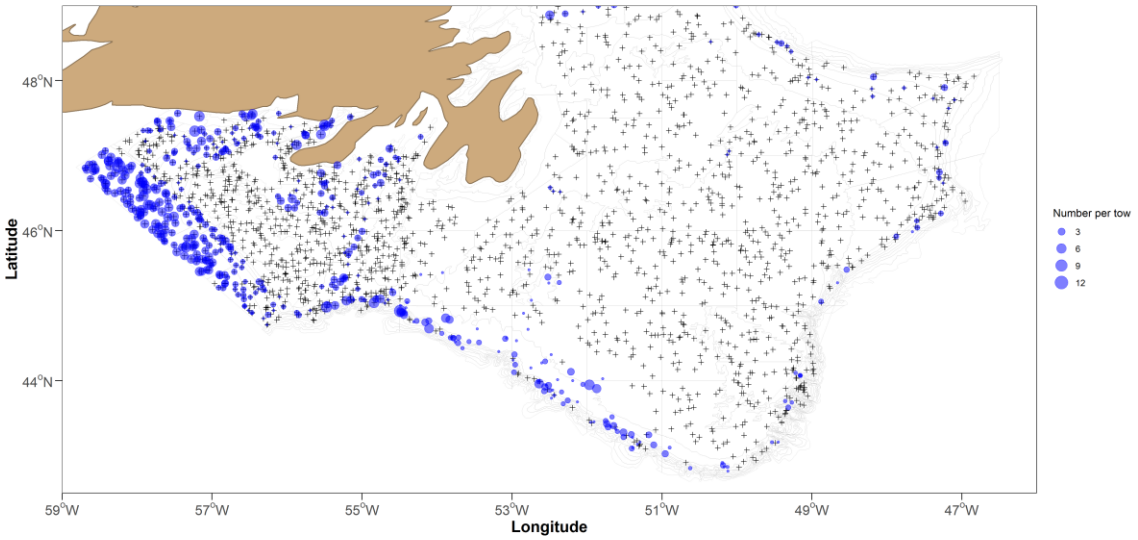

Figure 11. Distribution of pre-recruit (<21cm) witch flounder in NAFO Divisions 3LNOPs. Sets without witch flounder are denoted by "+".

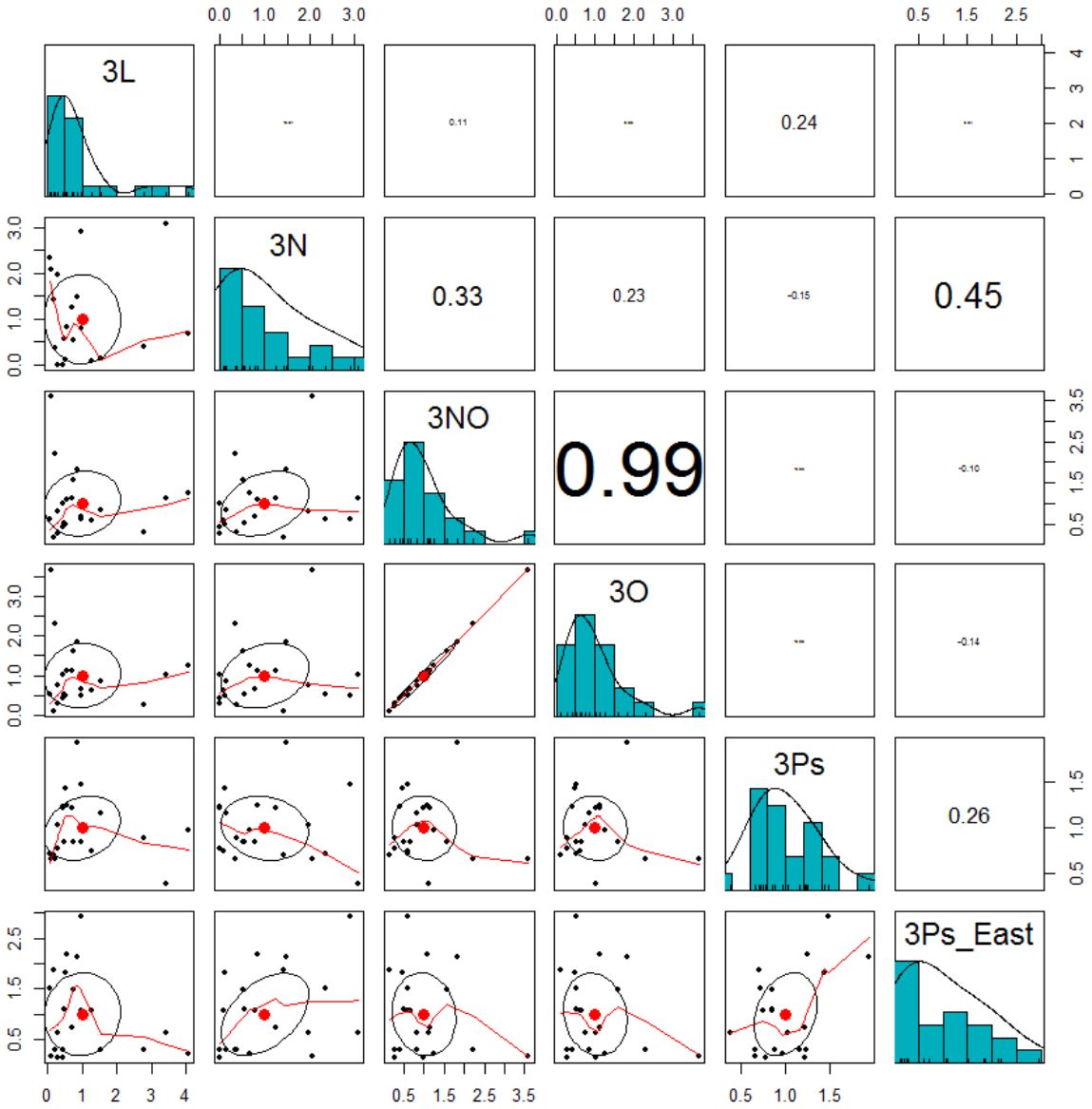

Figure 12. Correlation (Spearman) between 3NO recruitment indices and recruitment indices from adjacent stocks. Correlation values are available in the upper half of the matrix and are scaled to the absolute values of the correlation (i.e. very small correlations have very small text size). 3Ps_East represents survey strata from Eastern 3Ps, primarily those in the Halibut Channel area.

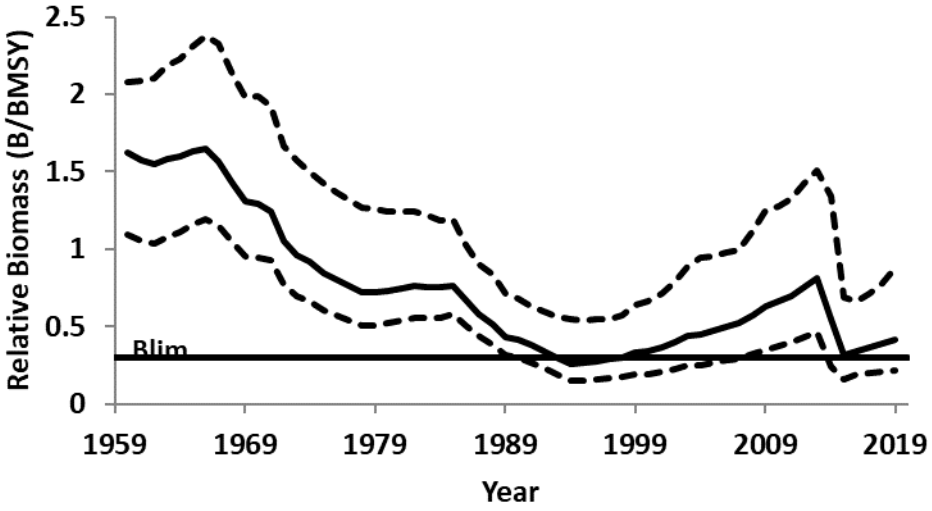

Figure 13. Witch flounder in Divs. 3NO. Median relative biomass (*Biomass/B_{MSY}*) with 90% credible intervals from 1960-2018. The horizontal line is *B_{lim}=30%B_{MSY}*.

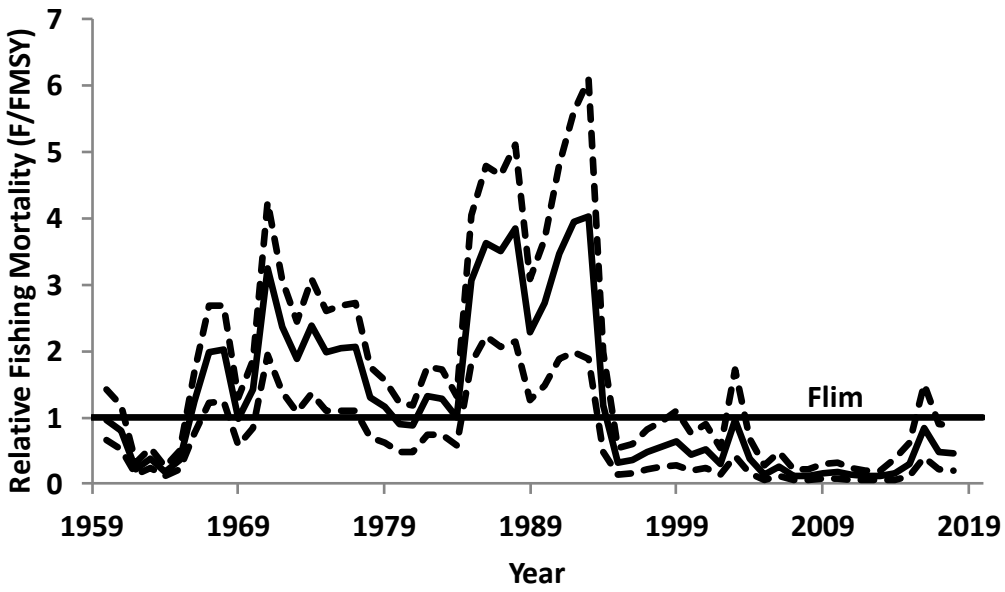

Figure 14. Witch flounder in Divs. 3NO. Median relative fishing mortality (F/F_{MSY}) with 90% credible intervals from 1960-2018. The horizontal line is $F_{lim}=F_{MSY}$.